

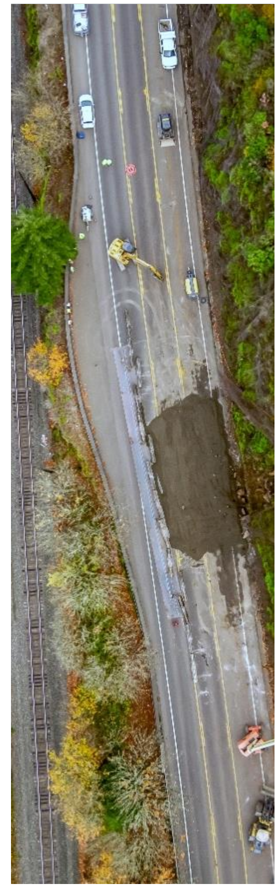



Oregon

NATURAL HAZARDS MITIGATION PLAN

❶ OREGON COAST
❷ NORTHERN WILLAMETTE VALLEY/PORTLAND METRO
❸ MID/SOUTHERN WILLAMETTE

❹ SOUTHWEST
❺ MID-COLUMBIA
❻ CENTRAL
❼ NORTHEAST
❽ SOUTHEAST

FEMA

EFFECTIVE SEPTEMBER 24, 2020
THROUGH SEPTEMBER 23, 2025

 Clockwise from top left: Breached irrigation ditches resulted in flooding and freeway closures in eastern Oregon on I-84 near Echo, February 8, 2020; Burning underbrush, Milepost 97 Fire, July 29, 2019; Overhead view of rock scaling on OR 99 E near Oregon City, November 10, 2018; ODOT snow plowing, October 25, 2010; An ODOT incident responder keeps an eye on the road during a snowstorm, October 23, 2012; Crews begin to make repairs to U.S. 101 north of Brookings at the Hooskanadan Slide, winter 2018-19; Rock fall, OR 99E Canemah, Oregon City, November 4, 2018.

OREGON
NATURAL HAZARDS
MITIGATION PLAN

Approved by FEMA September 24, 2020

Effective through September 23, 2025

Funding for the Oregon Natural Hazards Mitigation Plan Update
was provided in part by a grant from the Federal Emergency Management Agency.

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KATE BROWN
Governor

September 10, 2020

Mr. Mike O'Hare
Federal Emergency Management Agency
US Department of Homeland Security
Federal Regional Center
130 228th Street, SW
Bothell, WA 98021-8627

Dear Mr. O'Hare,

The State of Oregon is pleased to submit the updated *Oregon Natural Hazards Mitigation Plan*.

The plan's stated mission, "*Create a disaster-resilient State of Oregon*," is supported by its vision that, ultimately, "*Natural hazard events result in no loss of life, minimal property damage, and limited long-term impacts to the economy*." The plan contains the most complete and up-to-date description of Oregon's natural hazards and their probability, the State's vulnerabilities, its mitigation strategies, and implementation capability. It is the result of a coordinated effort overseen by the State Interagency Hazard Mitigation Team, a collaborative body providing expertise and support for natural hazard mitigation planning and implementation statewide.

The *Oregon Natural Hazards Mitigation Plan* meets the requirements of Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended, as well as those of 44 CFR 201 and 206, maintaining the State of Oregon's eligibility for Stafford Act assistance and non-disaster hazard mitigation programs. The plan includes a Repetitive Loss Strategy, meeting the requirements of 44 CFR §201.4(c)(3)(v), which qualifies the state to request increased funding for mitigating repetitive loss properties under the Flood Mitigation Assistance Program.

I hereby adopt the *Oregon Natural Hazards Mitigation Plan* and assure that the State of Oregon will continue to comply with all applicable federal statutes and regulations in effect with respect to the periods for which it receives grant funding in compliance with 44 CFR 13.11(c), and will amend this plan as necessary to reflect changes in state or federal statutes and regulations as required in 44 CFR 13.11(d).

Sincerely,

Kate Brown

Governor Kate Brown

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Federal Emergency Management Agency Approval

U.S. Department of Homeland Security
FEMA Region 10
130 – 228th Street, SW
Bothell, Washington 98021

FEMA

September 21, 2020

Honorable Kate Brown
Governor, State of Oregon
160 State Capitol
900 Court Street
Salem, Oregon 97301-4047

Reference: Updated Approval of the State of Oregon Hazard Mitigation Plan

Dear Governor Brown:

The United States Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region 10 has approved the updated State of Oregon Hazard Mitigation Plan as a Standard Mitigation Plan effective September 24, 2020, through September 23, 2025, in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, the Water Infrastructure Improvements for the Nation Act, and Title 44 Code of Federal Regulations (CFR) Part 201.

A FEMA-approved State Mitigation Plan is a condition of receiving certain non-emergency Stafford Act assistance and FEMA mitigation grants from the following programs:

- Public Assistance Categories C-G
- Fire Management Assistance Grants
- Hazard Mitigation Grant Program
- Pre-Disaster Mitigation Grant Program
- Flood Mitigation Assistance
- Rehabilitation of High Hazard Potential Dam Grant Program

FEMA Region 10 has determined that the State Mitigation Plan addresses all dam risks for high hazard potential dams and the State of Oregon (State) is therefore eligible for the Rehabilitation of High Hazard Potential Dams Grant Program.

FEMA has determined that the State Mitigation Plan includes a Repetitive Loss Strategy that meets the requirements set forth in 44 CFR §201.4(c)(3)(v) and qualifies the State to request an increased Federal share for repetitive loss properties under the FMA program.

State Mitigation Plans must be updated and resubmitted to FEMA Region 10 for approval. If the plan is not updated by the date indicated on this FEMA approval letter, the plan is considered lapsed and FEMA will not obligate funds for the programs listed above until the State Mitigation Plan is approved by FEMA.

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Governor Brown
September 21, 2020
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If at any time over the plan approval period, FEMA determines that the State is not complying with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives funding or is unable to fulfill mitigation commitments, FEMA may take action to correct the noncompliance (44 CFR §201.3(b)(5) and 201.4(c)(7)).

The State is responsible for communicating with local and tribal officials, as applicable, interested in applying through the State for FEMA assistance. FEMA encourages states to communicate with the appropriate officials regarding mitigation plan status and eligibility requirements. At a minimum of every six months, FEMA will provide to the State written information on mitigation plans, including but not limited to:

- Local and tribal, as applicable, mitigation plan expiration dates;
- Consequences of not having a FEMA-approved local or tribal, as applicable, mitigation plan with respect to eligibility for HMA programs;
- Availability of mitigation planning training and technical assistance; and
- Upcoming funding opportunities.

The State is responsible for reviewing and submitting approvable mitigation plans to FEMA. If the State is not submitting approvable mitigation plans, FEMA will provide feedback as well as technical assistance or training, as needed.

In addition, FEMA will provide a reminder to the State, at a minimum, 12 months prior to the plan expiration date, of the consequences of not having a FEMA-approved mitigation plan with respect to eligibility for the FEMA assistance programs that require FEMA-approved mitigation plan as a condition of eligibility. To maintain eligibility for the programs listed above, and the State must submit a draft of the next plan update prior to the end of the approval period and allow sufficient time for the review and approval process, including any revisions, if needed, and for formal adoption by the State of Oregon following determination by FEMA that the plan has achieved a status of "Approvable Pending Adoption."

We look forward to continuing a productive relationship between FEMA, Region 10, and the State of Oregon. Please contact our Mitigation Division Director, Kristen Meyers, at 425-487-4543 with any questions or for further assistance.

Sincerely,

VINCENT J MAYKOVICH
Digitally signed by VINCENT J MAYKOVICH
Date: 2020.09.21 15:51:02 -07'00'

Michael F. O'Hare
Regional Administrator

cc: Major General Michael E. Stencel, The Adjutant General, State of Oregon Military Department
Andrew Phelps, Director, Oregon Emergency Management
Amie Bashant, State Hazard Mitigation Officer, Oregon Emergency Management

Enclosure

Executive Summary

Introduction

The Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) was signed into law on November 23, 1988 and provides the legal authority for most federal disaster response activities, particularly Federal Emergency Management Agency (FEMA) activities and programs. The Disaster Mitigation Act of 2000 (DMA 2000) amended the Stafford Act, emphasizing the need for state, local, and Indian Tribal entities to coordinate hazard mitigation efforts. It made the existing requirement for states to have natural hazard mitigation plans a prerequisite for disaster assistance and provided an incentive in the form of additional funding for states that enhance coordination and integration of mitigation planning and activities. The State of Oregon's Natural Hazard Mitigation Plan (NHMP) was such an "enhanced plan." While Oregon has received and made good use of funding following past disasters and continues to advance coordination and integration of natural hazard mitigation planning with other state plans and programs, the 2020 Oregon NHMP is not an "enhanced plan." The State intends to regain "enhanced plan" status during the effective period of the 2020 Oregon NHMP.

The Code of Federal Regulations Title 44, Part 201 (44 CFR Part 201) implements DMA2K by establishing requirements for developing and updating state, local, and Indian Tribal natural hazard mitigation plans (NHMPs). An amendment to 44 CFR Part 201 effective May 27, 2014, extended the state and Indian Tribal NHMP planning cycle from 3 to 5 years. The first Oregon NHMP was completed in 1992; it was updated in 2000, 2004, 2006, 2009, 2012, 2015, and now 2020.

The stated mission of this Plan is to *Create a disaster-resilient state of Oregon*, which is elucidated by its vision that ultimately *Natural hazard events result in no loss of life, minimal property damage, and limited long-term impacts to the economy.* From this guidance and the Plan's risk assessment flow 14 goals and well over one hundred specific actions calibrated to advance disaster resilience through natural hazard mitigation in the State of Oregon.

Disasters occur as a predictable interaction among three broad systems: natural systems, the built environment, and social systems. What is not predictable is exactly when natural hazards will occur or the extent to which they will affect communities within the state.

Hazard mitigation is defined at 44 CFR 201.2 as *any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards.* Benefits of hazard mitigation activities include fewer injuries and deaths; less damage to buildings, critical facilities, and infrastructure; diminished interruption in essential services; reduced economic hardship; minimized environmental harm; and quicker, lower-cost recovery.

The Oregon NHMP contains the most complete and up-to-date description of Oregon's natural hazards and their probability, the state's vulnerabilities, its mitigation strategies and implementation capability. Oregon's counties and cities can rely upon this information when preparing local natural hazard mitigation plans.

The Oregon NHMP is one component of the first volume of the Oregon Emergency Management Plan, administered by the Oregon Military Department's Office of Emergency Management.

Risk Assessment

Introduction

The purpose of the Oregon NHMP Risk Assessment is to identify and characterize Oregon's natural hazards, determine which jurisdictions are most vulnerable to each hazard and estimate potential losses to vulnerable structures and infrastructure and to state facilities from those hazards.

Assessing the state's level of risk involves three components: characterizing natural hazards, assessing vulnerabilities, and analyzing risk. Characterization involves determining cause and characteristics, documenting historic events, and evaluating future probability of occurrence while accounting for the potential shifts in probability and presentation that may manifest as Oregon's climate changes.

A vulnerability assessment combines information from the hazard characterization with an inventory of the existing (or planned) property and population exposed to a hazard, and attempts to predict how different types of property and population groups will be affected by each hazard.

A risk analysis involves estimating the damages, injuries, and costs likely to be incurred in a geographic area over a period of time. Risk has two measurable components: (a) the magnitude of the harm that may result, defined through vulnerability assessments; and (b) the likelihood or probability of the harm occurring. For the 2020 Oregon NHMP update, the state risk assessment has been reorganized to flow from the discussion of hazards directly into the discussion of vulnerability, and then for the first time for the two to culminate in a brief discussion of risk.

Regional risk assessments begin with a description of the region's natural environment, demographics, economy, infrastructure, and built environment followed by a region-specific hazard characterization, vulnerability assessment, and risk analysis.

Oregon Hazards Overview

Oregon is subject to 11 natural hazards:

- Coastal Hazards
- Droughts
- Earthquakes
- Extreme Heat
- Floods
- Landslides
- Tsunamis
- Volcanoes
- Wildfires
- Windstorms
- Winter Storms

For the 2020 Oregon NHMP, dust storms were determined to have been adequately mitigated and is therefore not addressed. Extreme heat was determined to be increasing and expected to continue to increase, and therefore added as one of the state's natural hazards for the first time in 2020. Each hazard is analyzed statewide and at a regional level. The regions used for this analysis are shown in **Figure ES-1** and are physiographic regions delineated specifically for the purposes of the Oregon NHMP risk assessment. The hazards impacting each region are identified in **Table ES-1**. All of the hazards except coastal hazards and tsunamis impact all of the regions; however, the degree of impact of each hazard varies from region to region.

Figure ES-1. Oregon NHMP Natural Hazard Regions

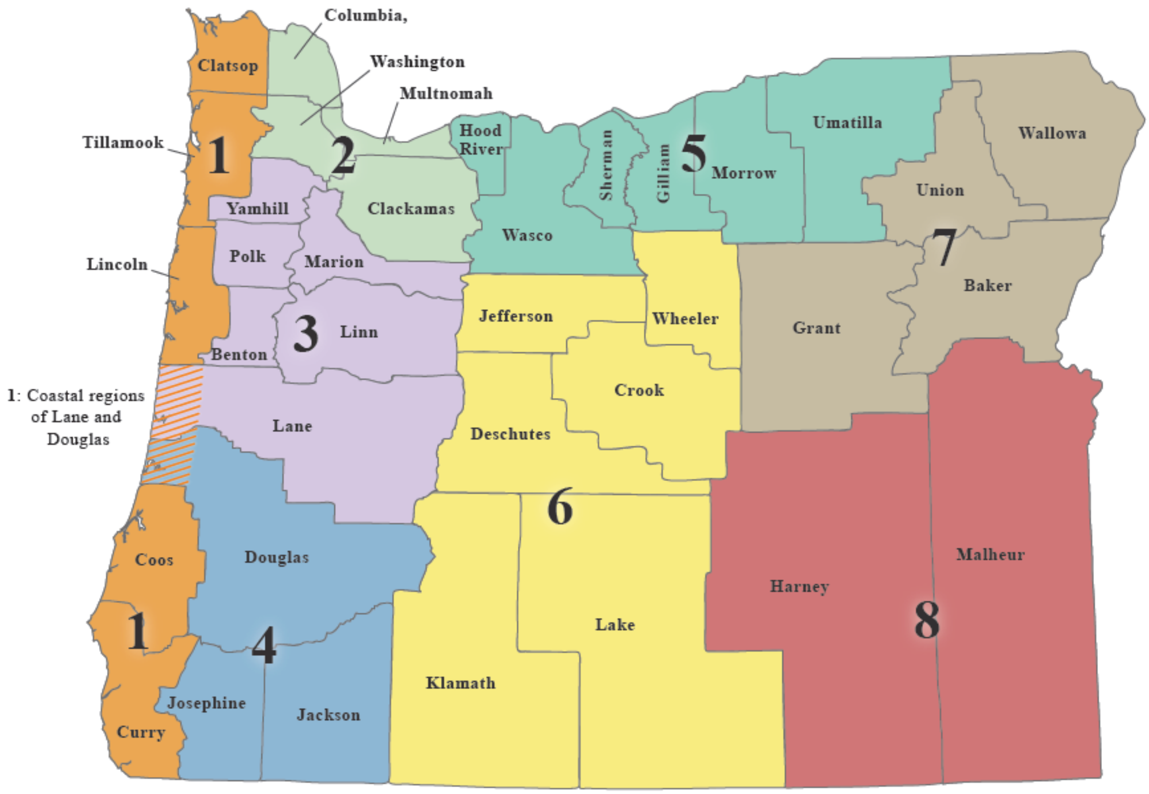

Table ES-1. Hazards Impacting Natural Hazard Mitigation Regions

	Region							
Hazard	1	2	3	4	5	6	7	8
Coastal Hazards	✓							
Droughts	✓	✓	✓	✓	✓	✓	✓	✓
Earthquakes	✓	✓	✓	✓	✓	✓	✓	✓
Extreme Heat	✓	✓	✓	✓	✓	✓	✓	✓
Floods	✓	✓	✓	✓	✓	✓	✓	✓
Landslides	✓	✓	✓	✓	✓	✓	✓	✓
Tsunamis	✓							
Volcanoes	✓	✓	✓	✓	✓	✓	✓	✓
Wildfires	✓	✓	✓	✓	✓	✓	✓	✓
Windstorms	✓	✓	✓	✓	✓	✓	✓	✓
Winter Storms	✓	✓	✓	✓	✓	✓	✓	✓

Introduction to Climate Change in Oregon

Climate is an important element in certain natural hazards, even though in itself, climate is not a distinct natural hazard.

Climate change is an important stressor that significantly influences the incidence — and in some cases the location — of natural hazards and hazard events. Climate change is anticipated to affect the frequency, magnitude, or both of some natural hazards in Oregon. Over the period 1895–2011 (the observed record), temperatures across the Pacific Northwest have increased by 1.3°F while annual precipitation amounts have remained within the normal range of annual variability. During the same period, Cascade Mountain snowpacks have declined, and higher temperatures are causing earlier spring snowmelt and spring peak stream flows. On the coast, increasing deep-water wave heights in recent decades are likely to have increased the frequency of coastal flooding and erosion. In Oregon's forested areas, large areas have been impacted by disturbances that include wildfire in recent years, and climate change is probably one major factor. A three-fold increase in heat-related illness has been documented in Oregon with each 10 ˚F rise in daily maximum temperature.

Every climate model shows an increase in temperature for the Pacific Northwest, with the magnitude of the increase depending on rate or magnitude of global greenhouse gas emissions. Each season will be warmer in the future, and the largest amount of warming will occur in the summer.

Sea levels and wave heights are the primary climate-related drivers that influence rates of coastal erosion. Recent research indicates that sea levels along Oregon's coast are rising and that significant wave heights off the Oregon coast are increasing. Rising sea levels and increasing wave heights are both expected to increase coastal erosion and coastal flooding. Increased coastal erosion can lead to loss of natural buffering functions of beaches, tidal wetlands, and dunes, and will likely increase damage to private property and infrastructure situated on coastal shorelands.

Warmer, drier conditions are projected to increase the incidence of drought, wildfire, and extreme heat in all eight regions in the state, and particularly in southwest, central, and eastern Oregon. More frequent droughts are likely to cause significant economic damage to the agriculture industry through reduced yields and quality of some crops. Droughts can also significantly increase demand for groundwater and surface water, impacting drinking water supply and aquatic systems. Drought-dried soils increase the potential for wildfire. More frequent and intense wildfires are likely to damage larger areas, posing greater risk to human health through exposure to smoke and greater ecosystem and habitat damage. Increased risk of wildfire also leads to increased potential for economic damage (e.g., property infrastructure, commercial timber, recreational opportunities) at the urban-wildland interface.

The projected increase in extreme precipitation is expected to result in a greater risk of flooding in certain basins. Generally, western Oregon basins (Oregon NHMP Natural Hazard Regions 1–4) are projected to experience increased flood risk in future decades. In other areas of the state, flood risk may decrease in some basins and increase in others. Areas thought to be outside the floodplain may begin to experience flooding, increasing vulnerability of structures not built to floodplain management standards. Increased rainfall and extreme precipitation events are also likely to trigger more landslides. More floods and landslides will increase damage to property and infrastructure. Transportation systems may also be affected, potentially impacting distribution of water, food, and essential services.

Table ES-2 shows which hazards in each Oregon NHMP Natural Hazard Region are expected to be impacted by climate change.

Table ES-2. Climate Change Impacts Projected for Each Oregon NHMP Natural Hazard Region

	Region							
Hazard	1	2	3	4	5	6	7	8
Coastal Erosion / Sea Level Rise	X							
Droughts	X	X	X	X	X	X	X	X
Extreme Heat	X	X	X	X	X	X	X	X
Wildfires	X	X	X	X	X	X	X	
Winter Storms	unknown							
Floods	X	X	X	X				
Landslides	X	X	X	X				
Windstorms	unknown							

Three important Oregon initiatives address climate change across the state. The Oregon Climate Assessment Report (Dello & Mote, 2010) was the first ever comprehensive scientific assessment of climate change in Oregon. This report was updated by the 2013 Northwest Climate Assessment Report (Dalton, Mote, & Snover, 2013). In addition, the Oregon Climate Change Adaptation Framework (2010) was a collaborative effort among state agencies and institutes to begin to establish a rigorous framework for addressing the effects of climate change in Oregon. Oregon's framework is the first state-level adaptation strategy based on *climate risks* as opposed to *affected sectors*. It is currently being updated, and the current draft (Appendix 9.1.23) together with the Oregon Climate Change Workshop Summary Report (Appendix 9.1.24) bring the interplay between climate risks and natural hazard events into sharp focus. Together, these bodies of work inform the state about changing climate conditions in Oregon and their principal effects on the natural hazards addressed in the Oregon NHMP.

Climate change is intentionally treated separately from hazards in this Plan, except for describing how climate change is predicted to impact the probability of a hazard occurring in the future. For the 2020 Oregon NHMP, data was able to be downscaled to the county level.

State and Regional Risk Assessments

Methodology

Currently, to identify the probability of each hazard and the communities most vulnerable to each hazard, each is assessed at the county level and statewide. Local emergency program managers, usually with the assistance of a team of local public safety officials, perform county-level assessments. At the state level, state agencies' subject matter experts perform the assessments. The local and state assessments are presented together in the Regional Risk Assessments.

Local risk assessments (with an exception or two) employ the same methodology statewide. FEMA developed the methodology and together with the state adjusted it for Oregon. The local risk assessment team first identifies the community's relevant hazards, then scores each one in four categories: history, probability, vulnerability, and maximum threat. Total scores range from

24 (low) to 240 (high). This method provides local jurisdictions with a sense of hazard priorities, or relative risk. It is also intended to provide comparison of the same hazard between local jurisdictions statewide.

Although this methodology is consistent statewide, the reported raw scores for each county are based on partially subjective rankings for each hazard. Because the rankings are used to describe the relative risk of a hazard within a county, and because each county conducted the analysis with a different team of people using slightly different assumptions, comparisons between local risk assessments must be treated with caution.

The state relies on subject matter experts in one or more agencies to determine the best method or combination of methods to establish probability of each hazard. Due to the wide range of data available for each hazard, the method used to assess probability varies from hazard to hazard. In general, each hazard is assessed using a combination of exposure, historical, and scenario analyses. Hazards for which more data exist have undergone a more robust analysis.

State and Local Vulnerability Comparison

Some state and local vulnerability assessments are quite consistent, while others are starkly inconsistent. Similarities and differences between state and local level vulnerability assessments have not been analyzed. The state has prioritized communication and education among state and local staff responsible for assessing vulnerability to improve understanding and consistency for future local and state plan updates.

New Risk Assessment Methodology

During the previous update, the Risk Assessment Sub-Committee of the State Interagency Hazard Mitigation Team conceptualized a new risk assessment methodology that would be standardized statewide and across all hazards. It is designed to identify the drivers of vulnerability and provide a comparison of vulnerability at the local level, improving the ability of the state to weigh various mitigation actions and direct resources to the most vulnerable areas. Despite several attempts, the state has not been able to secure funding to develop the model and implement it. Therefore, for 2020 update, the State piloted a much less sophisticated methodology to enable comparison of risk across the seven mapped hazards, using the value of state-owned and leased facilities and critical facilities and local critical facilities in hazard areas and the CDC’s social vulnerability index factors of vulnerability. Then the subject matter experts’ derived probability scores and the vulnerability scores were combined for an overall relative assessment of risk.

Profiles

The descriptions of the natural environment, demographics, economy, infrastructure, and built environment in each Regional Risk Assessment’s “Profile” section shows that region’s existing strengths and weaknesses, highlighting potential vulnerabilities to natural hazard events. Together with information about the natural hazards that may impact each region, this understanding better enables policy makers to develop and implement effective mitigation actions. Following is a brief, general summary of the eight Oregon NHMP Natural Hazard Regions’ social, economic, infrastructure, and built environment profiles.

Demographic Profile

The demographic profile of Oregon's population varies widely from region to region. The Coast and Willamette Valley in particular have high numbers of tourists who may not be aware of the type and degree of hazard risk or preparedness needs in the area. Other more remote regions do attract tourists to more remote locations putting them potentially at risk from natural hazard events. Homelessness is on the rise in portions of the Willamette Valley and Southwest Oregon. In all regions except the Northern Willamette Valley and some counties in Southeast Oregon, there are high percentages of seniors. Conversely, in the Northern Willamette Valley and other counties in Southeast Oregon, there are high percentages of children. Educational attainment among the populations of some coastal communities and in Southwest Oregon, the Mid-Columbia Region, and Northeast Oregon tends to be lower. The share of persons who do not speak English very well is greater for some communities in Willamette Valley, Mid-Columbia, and Southeast Oregon.

Economic Profile

Communities along the Oregon Coast and in Central, Southeast, and Southwest Oregon were hit particularly hard by the financial crisis that began in 2007 and are still experiencing low job recovery rates. In addition, in 2020 they have been impacted by the economic burdens of the novel coronavirus pandemic. Because these regions have few key industries, rebounding is especially difficult. In general, wages are higher in the Northern Willamette Valley. Unemployment rates are higher in the regions outside the Coast and Willamette Valley.

Infrastructure Profile

Counties in all eight regions have transportation, energy, and water facilities or conveyance systems that are vulnerable to natural hazard events. The state's energy hub in the Portland Harbor area of the lower Willamette River is highly vulnerable to a seismic event due to liquefiable soils and to the age and poor condition of many facilities.

Built Environment Profile

Populations tend to cluster around transportation corridors. The majority of growth is occurring in the Willamette Valley. Each region outside the Willamette Valley has at least one county with a high proportion of manufactured homes, which are inherently vulnerable to natural hazards. Also, in at least one county, half or more of the structures were built prior to current floodplain management or seismic standards.

Hazards and Vulnerability

Coastal Hazards

Wave-induced coastal erosion (both short- and long-term), wave runup and wave-induced flood hazards, wind-blown sand, coastal landslides, earthquakes, and potentially catastrophic tsunamis generated by the Cascadia Subduction Zone (CSZ) all affect Oregon's coastal strip. The region's natural landforms have restricted development to low-lying areas, chiefly along dunes, barrier spits, or along coastal bluffs subject to varying rates of erosion, and to low-lying areas adjacent to the numerous estuaries. Intense chronic storms at the coast gradually cause damage over time, impacting property, infrastructure, and ecosystem services.

Counties most vulnerable to coastal hazards: Tillamook, Lincoln, Clatsop, and Curry

Other communities considered vulnerable to coastal hazards: A few communities scattered through Coos County and the coastal area of Lane County, for example, adjacent to the south Coquille jetty in Bandon, along Lighthouse Beach near Cape Arago, Heceta Beach, and adjacent to the mouth of the Siuslaw River.

State-owned/leased facilities in the coastal erosion zone: In Region 1, there is a potential loss of over $232M in state building and critical facility assets to a CSZ event.

Droughts

Oregon is continuously confronted with drought and water scarcity issues, despite its rainy reputation. Droughts can occur in Oregon in both summer and winter months. These events generally affect areas east of the Cascades and some specific locales across the state. Severe or prolonged drought can impact Oregon's public health, infrastructure, facilities, economy, and environment.

Counties most vulnerable to droughts: Klamath and Baker

Other counties considered vulnerable to droughts: Lake, Malheur, Sherman, Gilliam, and Morrow

Earthquakes

Oregon is susceptible to four types of earthquakes: subduction zone, crustal, intraplate and volcano-induced earthquakes. The greatest threat to Oregon is a Cascadia Subduction Zone (CSZ) event. A CSZ event will primarily impact western Oregon. The heavily populated metropolitan areas of Portland, Salem, and Eugene will experience major damage and loss of life.

In the period between 2013 and 2014, five major initiatives took place that boosted the state's understanding of its earthquake risk.

First, the Oregon Department of Transportation (ODOT) conducted the **Statewide Loss Estimates: Oregon Highways Seismic Options Report** project that identified priority state-owned lifelines in a CSZ event. A three-tier roadway system was devised:

- Tier 1 provides access from Central Oregon, Washington, and California, and provides access to each region within the study area
- Tier 2 extends the reach of the Tier 1 system throughout seismically vulnerable areas of the state and provides lifeline route redundancy in the Portland Metro Area and Willamette Valley
- Tier 3, together with Tiers 1 and 2, provides an interconnected network with redundant paths to serve all of the study area

Second, DOGAMI published Open File Report O-13-09, Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub (Wang, Bartlett, & Miles (2013); http://www.oregongeology.org/sub/earthquakes/cei-hub-report.pdf). This report highlights the concentration of critical energy facilities in the Portland area and the potential statewide impacts of a seismic event affecting this hub.

Third, in 2013 the Cascadia Region Earthquake Workgroup (CREW) issued an updated scenario for a CSZ magnitude 9.0 event (Appendix **9.1.25**). It explains the latest science and expected impacts, and suggests mitigation strategies.

Fourth, the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) developed the **Oregon Resilience Plan** that was commissioned by a legislative resolution. The ORP estimated the impacts of a magnitude 9.0 CSZ earthquake on the state's population, buildings, and infrastructure. According to the ORP, recovery time estimates for coastal infrastructure in a Medium CSZ event will be:

- Electricity and natural gas, 3–6 months
- Drinking water and sewer systems, 1–3 years
- Healthcare facilities, 3 years

The ORP does not estimate recovery times for police and fire stations or the coastal transportation system. Recovery of the transportation system will no doubt be measured in years. Because the coast's economy is dependent on the transportation system, economic recovery would also be many years.

The ORP recommends actions for improving resilience to the CSZ event and that they be implemented over a 50-year period. Some examples:

- Comprehensively assessing key structures and systems
- Retrofitting Oregon's public buildings
- Helping Oregon's private sector improve resilience
- Revising public policies to streamline recovery and increase public preparedness

Finally, SB 33 (2013) established the Oregon Resilience Task Force to develop a plan to implement the ORP. The Task Force reported to the Oregon Legislature in October 2014 (Appendix **9.2.4**).

The 10 counties projected to incur the most loss and damage due to a CSZ earthquake (most to least): Multnomah, Lane, Coos, Washington, Marion, Benton, Lincoln, Josephine, Clatsop, and Jackson

The 10 counties projected to incur the most loss and damage due to combined crustal earthquakes (most to least): Multnomah, Washington, Lane, Marion, Clackamas, Coos, Jackson, Benton, Linn, and Klamath

Other communities vulnerable to earthquakes: Seaside is the most vulnerable coastal town.

State-owned/leased facilities in an earthquake hazard zone: Of 5,350 state facilities evaluated, 838 building were flagged as extensively or completely damaged following a CSZ event (Regions 1–4) or a 2,500-year probabilistic scenario (Regions 5–8) totaling over $1.3 billion in potential damage to property. Among the 1,647 critical state facilities, 360 were flagged as extensively or completely damaged.

Extreme Heat

Extreme heat is associated with more fatalities than any other severe weather event in the United States. For the first time, extreme heat is included as a hazard in the 2020 Oregon NHMP. This is due to the recognition that as the climate continues to warm, extreme heat events will be an emerging hazard with implications for public health as well as infrastructure. Extreme heat events are expected to increase in frequency, duration, and intensity in Oregon due to continued warming temperatures.

Vulnerability to extreme heat is experienced by both rural and urban people. On a regional basis, areas that climatologically see the greatest number of very hot temperature days include inland areas at lower elevations in eastern Oregon, as well as parts of southern Oregon, particularly the Rogue River Valley. People who work outside (including construction workers, farmworkers, foresters, and fishers), as well as outdoor athletes face higher exposures to extreme heat. Extreme heat in urban areas poses risk to human health and safety, especially for those living and working in urban heat islands. People living outdoors or in the upper floors of multi-family housing units may be particularly vulnerable.

Vulnerability to this hazard is defined as the combination of sensitivity to extreme heat (or maximum effects) and level of adaptive capacity (frequency of air conditioning use, for example) in response to extreme heat. Risk combines vulnerability with the probability or likelihood of occurrence. Region 4, Region 5, and Region 8 face the greatest risk from extreme heat. Morrow County alone (Region 5) is at very high risk. The counties at high risk are: Linn, Yamhill, Douglas, Jackson, Josephine, Gilliam, Sherman, Umatilla, Wasco, Crook, Jefferson, Lake, Baker, Harney, and Malheur.

This is the first time the Oregon NHMP has addressed extreme heat. The state has not collected or developed statewide data on the potential dollar loss to state assets from extreme heat. This may be developed through a vulnerability assessment proposed for implementation of the draft, updated Climate Change Adaptation Framework.

Floods

Oregon has an extensive history of flooding, and there are localized risks of flooding across the state. Types of flooding in Oregon include riverine flooding, flash floods, coastal floods, shallow area flooding, urban flooding, playa flooding, and floods caused by ice jams and dam failure. In La Niña years, floods can be severe. In addition, channel migration has created hazardous conditions along developed river banks. The National Flood Insurance Program (NFIP) identifies 251 communities in Oregon as flood-prone including locations in all 36 counties, 212 cities, and three Indian Tribal Nations. Damage and loss of life occur when flood waters come into contact with the built environment or other areas where people congregate. In addition to taking lives and damaging property, floods can cause stream channels to migrate and erode and can precipitate landslides.

FEMA's Community Information Systems (CIS) database identifies a total of 268 buildings in Oregon that qualify as RL properties. The NFIP defines an RL property as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period since 1978.

Counties most vulnerable to floods based on number of National Flood Insurance Program (NFIP) claims are in order from highest to lowest: Clackamas, Tillamook and Lane. Counties the most vulnerable based on the dollar amount of National Flood Insurance Program (NFIP) claims are in order from highest to lowest: Clackamas, Tillamook, and Columbia.

Cities most vulnerable to floods based on number of National Flood Insurance Program (NFIP) claims are in order from highest to lowest: Portland, Vernonia, Salem, and Tillamook. Cities the most vulnerable based on the dollar amount of National Flood Insurance Program (NFIP) claims are in order from highest to lowest: Vernonia, Tillamook, Lake Oswego, Salem and Portland.

The 10 cities with the greatest percentage of land area in a 1% annual flood zone are (most to least): Helix, Scio, Burns, Warrenton, Seaside, Vernonia, Sheridan, Ione, Adams, and Athena

State-owned/leased facilities in a flood hazard zone: Of the 5,350 state facilities evaluated, 632 were located within a flood hazard zone and had an estimated total value of over $900M. Of these, 165 were identified as state critical facilities.

In addition, 683 local critical facilities were exposed to flood hazard, with a total value of $1.6B.

Landslides

Landslides occur across the state. In general, counties in Oregon have hundreds to thousands of existing landslides. Typically, areas with more relief and steeper slopes, such as the Coast Range and Cascade Mountains, tend to have more landslides. Three main factors influence an area's susceptibility to landslides: geometry of the slope, geologic material, and water. Landslides in Oregon are typically triggered by periods of heavy rainfall alone or with rapid snowmelt. Earthquakes, volcanoes, and human activities also trigger landslides. Average annual repair costs for landslides in Oregon exceed $10 million. As population increases in Oregon and development encroaches upon landslide-susceptible terrain, greater losses are likely to result. Major landslides have severed key transportation routes such as highways and rail lines causing temporary but significant statewide economic damage. Landslides that close US-101 or any of the highways connecting the I-5 corridor to the coast have a significant effect on commerce in the Oregon Coast Region.

Clatsop, Coos, Curry, Douglas Coastal, Lincoln, Tillamook, Lane Coastal, Clackamas, Columbia, Multnomah, Washington, Lane, Linn, Marion, Benton, Yamhill, Douglas, Jackson, Josephine, Hood River, Wasco, Jefferson, Wheeler and Wallowa Counties are listed by DOGAMI as having the highest hazard and risk to landslide in the state. Because of their importance to the state's economy, landslides occurring in Multnomah, Clackamas, and Washington Counties present the greatest vulnerability to impacts from this type of disaster. Landslides that close US-101 or any of the many highways connecting the I-5 corridor to the coast have a significant effect on commerce in the Oregon Coast Region.

State-owned/leased and local facilities in a landslide hazard area: Over $777.5M in value of state buildings, state and local critical facilities is exposed to landslide hazards statewide.

Tsunamis

The entire Oregon coast is at risk from distant and local tsunamis. Distant tsunamis caused by earthquakes on the Pacific Rim strike the Oregon coast frequently, but few have caused significant damage or loss of life. Local tsunamis caused by a Cascadia Subduction Zone (CSZ) event happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life. Most locally generated tsunamis will be higher and travel farther inland (overland and up river) than distant tsunamis. By the time a tsunami wave hits the coastline, it may be traveling at 30 mph and have heights of 20 to approximately 100 feet. The tsunami wave will break up into a series of waves that will continue to strike the coast for a day or more, with the most destructive waves arriving in the first 4-5 hours after the local earthquake. Significant loss of life and profound damage due to a local tsunami caused by a CSZ event is likely.

Counties most vulnerable to tsunami: All coastal counties. Clatsop and Tillamook counties have the greatest vulnerability. Gearhart, Cannon Beach, Rockaway Beach, Pacific City, Neskowin, Salishan Spit, Cutler City in Lincoln City, South Beach in Newport, and downtown Waldport are all extremely difficult to evacuate. The City of Seaside is a community where the school district constructed new facilities outside the hazard area. This is the subject of one of the success stories contained in the Plan.

State-owned/leased facilities in a tsunami hazard zone: . Over $248M in value of state buildings and state critical facilities are located in tsunami hazard areas, and 67% of that value is located in Clatsop County. More than $351K of value in local critical facilities is located in tsunami hazard areas. Again, most of that value, 49%, is located in Clatsop County.

Volcanoes

Volcanic activity can impact central Oregon, the Cascade Range, Southeast Oregon, and the Northern Basin and Range ecoregion (**Figure 2-295, Region 8 Ecoregions**). Potentially hazardous volcanoes in Oregon exist along the crest of the Cascade Range and to a lesser extent in the Northern Basin and Range ecoregion. Volcanic hazards that can impact the state include ashfall that can travel long distances, lahars (volcanic debris flows), lava flows (streams of molten rock), pyroclastic flows and surges (avalanches of rock and gas at temperatures of 600–1500°F), landslides, earthquakes, flooding, and channel migration.

Counties most vulnerable to volcanic hazards: Clackamas, Douglas, Deschutes, Hood River, Jackson, Jefferson, Klamath, Lane, Linn, Marion, Multnomah, and Wasco

State-owned/leased facilities in a volcanic hazard zone: Close to $306M in value of state buildings, state and local critical facilities is exposed to volcanic hazards statewide, all of it in Regions 2, 3, 5, and 6. The greatest amount of exposure is in Region 3, in Lane County. In addition, of the 58,872 historic buildings throughout the state, 693 are exposed to volcanic hazards: 140 in a high hazard area, 443 in a moderate hazard area, and 110 in a low hazard area.

Wildfires

Wildfires occur throughout the state and may start at any time of the year when weather and fuel conditions combine to allow ignition and spread. Wildfires impact primarily southwest, central, and northeast Oregon, with localized risks statewide. The majority of wildfires take place between June and October. Wildfires may be broadly categorized as agricultural, forest, range, or wildland-urban interface (WUI) fires. Common sources of wildfire in Oregon include lightning, equipment use, railroad activity, recreational activity, debris burning, arson, and smoking.

The US Forest Service recently completed the Quantitative Wildfire Risk Assessment (QWRA). The Oregon Department of Forestry (ODF) has recently taken this assessment data and worked with Oregon State University Extension and Pyrologix, LLC (http://pyrologix.com) to create a portal to maps that can identify wildfire risk in the state of Oregon. The Oregon Wildfire Risk Explorer (OWRE) project makes data available for the Pacific Northwest, replacing the West-Wide Risk Assessment (WWRA) of 2013. The WWRA identified that six Oregon counties each have over 1 million wildland acres at moderate risk of wildfire. 751,672 Oregonians live in wildland development areas that are at risk of wildfire. Over 12 million acres of forest are at moderate to high risk of wildfire in Oregon.

Based on the Communities At Risk analysis, the regions most vulnerable to wildfire are Region 4 and Region 7, followed by Region 6, Region 8, and Region 5.

With respect to probability of wildfire, counties with an exposure rating of Very High include: Baker, Deschutes, Douglas, Grant, Jackson, Jefferson, Union, , and Wasco. Counties rated as High Exposure include: Josephine, Morrow, Umatilla, Crook, Deschutes, Wheeler, Harney and Malheur.

Other counties vulnerable to wildfire: All other counties in Oregon

State-owned/leased facilities in a wildfire hazard zone: Of the 5,530 state facilities evaluated, 1,111 are within the High or Moderate wildfire hazard zone and total about $950 million in value. Three hundred sixty-five state critical facilities are within the High or Moderate wildfire hazard zone. Of the 8,757 local critical facilities evaluated, 955 were in High or Moderate hazard zones with a total value over $775 million.

Windstorms

The risk of windstorms is localized across the state. Windstorms are especially common in exposed coastal areas and in the mountains of the Coast Range, occur most frequently from October through March. Communities in the Willamette Valley and Columbia River Gorge also experience strong winds. The wind itself, the debris it carries, and the trees it may blow down cause injury and damage property and infrastructure. The harmful effects of windstorms may extend for distances of 100 to 300 miles from the storm's center of activity.

Counties most vulnerable to windstorms: Benton, Clatsop, Coos, Columbia, Curry, Douglas, Gilliam, Hood River, Lane, Lincoln, Linn, Marion, Morrow, Multnomah, Polk, Sherman, Tillamook, and Washington

Winter Storms

Winter storms bring freezing rain, sleet, black ice, heavy snow, ice accumulation, extreme cold, and snow avalanches to areas across the state. These storms may last several days and can paralyze a community. People can become homebound; motorists can become trapped in their vehicles; utilities and other services can be disrupted, and crops and other vegetation can be damaged by freezing temperatures. Airport and other transportation system closures can stop the flow of supplies and disrupt essential services.

Counties most vulnerable to winter storms: Linn, Benton, Marion, Polk, Yamhill, Columbia, Washington, Multnomah, Clackamas, Lane, Douglas, Josephine, and Jackson

Mitigation Strategy

Oregon's mission, vision, and goals for natural hazard mitigation are purposefully aspirational, providing the foundation for the state's overall mitigation strategy. Natural hazard mitigation planning in Oregon is funded by the state, post-disaster FEMA mitigation grants, and non-disaster FEMA grant funding.

Given the current economic climate, it is important to acknowledge that state resources are limited. Oregon is not unique in that regard. Even so, Oregon is committed to remaining at the forefront of mitigation planning and will continue to innovate and leverage limited resources to reduce losses resulting from natural hazards in our state. The mitigation strategy presented in this 2020 Oregon NHMP reflects that commitment.

MISSION Create a disaster-resilient state of Oregon.

VISION Natural hazard events result in no loss of life, minimal property damage, and limited long-term impacts to the economy.

GOALS
1. Protect life and reduce injuries resulting from natural hazards.
2. Minimize property damage from natural hazards.
3. Minimize damage to critical or essential infrastructure and services from natural hazards.
4. Enhance the ability of Oregon's economies to rebound quickly from the effects of natural hazard events.
5. Minimize project impacts to the environment and utilize natural solutions to protect people and property from natural hazards.

6 Enhance the state's capability to implement a comprehensive statewide natural hazards mitigation strategy.

7 Motivate the "whole community" to build resilience and mitigate against the effects of natural hazards through engagement, listening, learning, information-sharing, and funding opportunities.

8 Eliminate development within mapped hazardous areas where the risks to people and property cannot be practicably mitigated.

9 Minimize damage to historic and cultural resources from natural hazards.

10 Enhance communication, collaboration, and coordination among agencies at all levels of government, sovereign tribal nations, and the private sector to mitigate natural hazards.

11 Mitigate the inequitable impacts of natural hazards by prioritizing and directing resources and investments to build resilience in the most vulnerable populations and the communities least able to respond and recover.

12 Develop, integrate, and align natural hazards mitigation and climate adaptation efforts based on the evolving understanding of the interrelationships between climate change and climate-related natural hazard events.

13 Reduce repetitive and severe repetitive flood losses.

14 Minimize or eliminate potential impacts from dams posing the greatest risk to people, property, and infrastructure

Goals: Linking the Risk Assessment and Mitigation Actions

Natural hazard mitigation plan goals link the risk assessment and mitigation actions, guiding the direction of future natural hazard risk reduction and loss prevention activities.

The risk assessment speaks directly to protection of life and property, infrastructure and services, and local, regional, and state economic resilience, the topics of Goals 1, 2, 3 and 4. The vulnerability assessments for each hazard and the potential loss estimates highlight the importance of informing and educating citizens about the risks and what they can do to reduce potential losses, including eliminating development where risks cannot be practicably mitigated, the topics of Goals 7, 8, 9, and 10. New Goal 13 specifically calls out the need to reduce losses from structures that have been damaged repetitively by flooding, one of the hazards with the greatest risk statewide according to the 2020 risk assessment. New Goal 14 sets policy direction for addressing the flood hazard posed by high-hazard potential dams. Goal 8 sets policy direction for prohibiting development in or moving development out of hazard areas, a clear connection to the vulnerabilities established by the risk assessment. Environmental stewardship, the topic of Goal 5, plays a role in mitigating some hazards, and must be considered in designing mitigation projects.

New Goal 12 speaks to the connections between natural hazards and climate change—discussed in the risk assessment—and sets policy direction for aligning climate adaptation and natural hazard mitigation efforts. New Goal 11 underscores the inequitable impacts of natural hazards and the importance of prioritizing and directing resources to vulnerable populations and those communities least able to respond and recover from hazard events. This is also a focus of climate change adaptation. Both equity and climate change are among Governor Brown's priorities and gaining attention statewide.

Finally, Goal 6 focuses on the state's ability to implement the Plan, providing a policy foundation for state support of mitigation actions and activities.

The mitigation action tables (Priority, Ongoing, and Removed) demonstrate the link between the goals and mitigation actions by noting the goal(s) that each mitigation action addresses.

Mitigation Actions

Identification, Evaluation, Prioritization

Mitigation actions are detailed recommendations for activities that the state is considering implementing to reduce risk and prevent loss from natural hazards. Mitigation actions are sorted into one of three categories: priority, ongoing, or removed. Priority actions are those the state aspires to begin or complete. Ongoing actions are those the state is doing in the normal course of business, continually over a long period of time. Removed actions are those that have been completed; will not be completed for various reasons; have been replaced by other actions; are not mitigation actions; or have been determined not to be within the State's purview.

The first step in updating the tables was to document the status of each action included in the 2015 plan. Based on the status reports, some mitigation actions were removed from the Priority and Ongoing tables. The next task was to prioritize the remaining mitigation actions. We decided to prioritize only the mitigation actions remaining on the Priority table along with new mitigation actions suggested by subject matter experts and hazard leads via an online survey. Reviewers were asked to evaluate each mitigation action based on nine criteria drawn from the 2015 Plan goals and the results of the 2020 Risk Assessment. Scores were calculated and used to prioritize mitigation actions within hazard groups and two others: all hazards and multiple hazards. Climate change actions were placed in the multiple hazards group.

A second survey ranked the mitigation actions on three additional statutory criteria: cost effectiveness, technical feasibility, and environmental soundness. No changes were found to be necessary to the earlier mitigation action rankings. The results of the two surveys may be found in Appendix **9.2.1** and Appendix **9.2.2**, respectively.

Changes in Mitigation Action Priorities

With the exception of three statutory criteria, the 2015 and 2020 Oregon NHMP mitigation actions were evaluated using different methods and different criteria. This makes a direct comparison and assessment of changes in priorities very difficult. The 2015 Plan contained 78 priority actions and 71 ongoing actions for a total of 149. The 2020 Plan contains 107 priority actions and 73 ongoing actions for a total of 180.

Of the 2015 Plan's 149 actions:

- Twenty-two were completed

- Twenty-four are no longer being pursued.
- Ten are no longer being pursued due to lack of funding or other resources.
- Six are no longer being pursued because the intent is being met through other means.
- Four are no longer being pursued because they were dependent on another action that is no longer being pursed because it was determined no longer needed.
- The intent of two were incorporated into new mitigation actions and are therefore no longer being pursued.
- One is not actively being pursued but the State does engage upon request.
- One is not being pursued because it was linked to the State Risk MAP Coordinator, a position Oregon no longer has.

Of the ten no longer being pursued for lack of funding or other resources, only those that would establish new programs and therefore require large financial commitments would be unlikely to be reconsidered. The majority would probably be pursued once again were funding and other resources to become available. They could be generally categorized as outreach, education, data development, and capacity-building. Most of those no longer being pursued for other reasons have been addressed in other ways or determined unnecessary. Therefore, the removed items do not represent a major shift in mitigation priorities.

Funding Sources for Mitigation Actions

Oregon’s mitigation activities are funded directly and most visibly through sources such as FEMA’s Pre-Disaster Mitigation Grant, Flood Mitigation Assistance, Public Assistance, Hazard Mitigation Grant Program and High Hazard Potential Dam Grants, as well as NOAA grants with state, local, or private funds providing the non-federal cost share. The State’s Seismic Rehabilitation Grant Program is a direct funding source for earthquake mitigation projects. The Oregon Disaster Assistance Loan and Grant account provides post-disaster mitigation funds to local governments and school districts. Currently the state’s 2021-2023 budget is being re-evaluated based on the drastically reduced state revenue forecast resulting from the global pandemic. Final State budget decisions will be made by the Oregon Legislature. More indirect and less visible funding comes from state general funds through in-kind activities and other state funds.

Mitigation Successes

Oregon maintains documentation of “mitigation success stories.” These are completed mitigation actions that have shown to be successful by either (a) avoiding potential losses; or (b) demonstrating cost-effectiveness through benefit-cost analysis, qualitative assessment, or both. Likewise, actions that support mitigation efforts, like risk or vulnerability assessment studies, are included. Mitigation success stories are completed by or with input from the action’s coordinating agency. Eight mitigation success stories since 2015 are showcased in the 2020 Oregon NHMP.

Capability Assessment

State Capability Assessment

There have been a number of positive changes in Oregon's natural hazard mitigation capability since 2012. Among them are:

- Establishment of the Governor's Resilience Policy Office and hiring of a State Resilience Officer in 2016
- Establishment of the Governor's Council on Wildfire Response in January 2019
- Phase I of the Oregon Highways Seismic Plus Report received funding in 2017 that has allowed scoping for seismic work on I-5 near Eugene for the 2021-2024 State Transportation Improvement Program (STIP). Phase I also includes portions of I-84 that are planned for to be retrofitted moving from east to west. The 2021-2024 STIP funding includes $31M to address ODOT bridge seismic needs.
- DLCD stepped up to fill a need for directly assisting local governments with NHMP updates.
- DLCD began reaching out to special districts and inviting them to participate in multi-jurisdictional NHMP updates, develop or update stand-alone NHMPs.
- DLCD has worked with 13 counties on multi-jurisdictional plan updates covering about 36 cities, some for the first time, and a similarly large number of special districts. DLCD has also worked with one community on its stand-alone city plan update and with one Tribe on its plan update. This is the first time a tribe in Oregon has worked with the state rather than directly with FEMA.
- DLCD has assisted local governments with planning for tsunami mitigation, including adoption of tsunami overlay zones and development of vertical evacuation structures using its 2014 publication *Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities*.
- in 2016 DOGAMI published a statewide landslide susceptibility map.
- DOGAMI and DLCD partnered to produce *Preparing for Landslide Hazards: A Land Use Guide for Oregon Communities*, published in October, 2019
- DOGAMI and DLCD have continued to partner on coordinating multi-hazard risk assessments with local NHMP updates.
- Between 2016 and 2019, the following coastal jurisdictions adopted Tsunami Hazard Overlay Zones into their comprehensive plans: Coos County, Douglas County, Reedsport, Florence, North Bend, Rockaway Beach, Gearhart, Port Orford, and Tillamook County. Most of those jurisdictions have also completed Tsunami Evacuation Facilities Improvement Plans to identify evacuation routes and improvement projects.
- Coos County adopted new and updated provisions to their Natural Hazard Overlay Zone, which addressed mitigation actions identified in their NHMP.
- ODF has also developed and rolled out an online interactive web application called the *Oregon Wildfire Risk Explorer*. It employs a new wildfire risk assessment model, the *Quantitative Wildfire Risk Assessment* prepared by Pyrologix for the US Forest Service in 2018.

- DLCD has engaged OCCRI to develop downscaled, county-level future projection reports for the local NHMP updates with which it is assisting directly. They have been very well received and very helpful in assessing risk.
- OCCRI and DLCD have reprised their partnership on the 2010 Climate Change Adaptation Framework (CCAF) to produce an update.
- In August 2019, OCCRI hosted an event entitled *Oregon Climate Change Effects, Likelihood, and Consequences Workshop* during which subject matter experts convened and discussed topics relevant to both the CCAF and Oregon NHMP updates. The outcomes of this workshop were captured in a report of the same title and used for both efforts
- DAS's Chief Financial Office with DOGAMI's assistance in 2015 issued *DAS-CFO Facility Planning Guidelines for Development with Natural Hazards*.
- DAS-CFO and DOGAMI partnered to address seismic issues with state buildings and developed a plan (currently on hold) to build two new buildings that would house state government core functions and continue to be operational during and after a Cascadia subduction zone event.
- The Office of Emergency Management is the proud recipient of an ESRI 2020 Special Achievement in GIS award for its GIS system (https://oregon-oem-geo.hub.arcgis.com/) that provides data and information to emergency managers and decision makers about current and anticipated hazard events.

Oregon continues to maintain robust pre- and post-disaster natural hazard mitigation policy and program frameworks, coordinated through the State Interagency Hazard Mitigation Team.

Funding comes from FEMA and NOAA grant programs, as well as the state's Seismic Rehabilitation Grant Program, Oregon Disaster Assistance Loan and Grant Account. The federal grant programs require a non-federal cost share which is funded by the state, local governments, and private entities. The State General Fund covers in-kind services performed by state employees. State funding to support hazard mitigation and risk reduction remains limited. However, Oregon has an excellent track record of leveraging limited local resources to successfully complete mitigation planning and projects throughout the state.

Local Capability Assessment

Local natural hazard mitigation policies, programs, and capabilities along with a general assessment of their effectiveness are presented in table format as is the status of each community's NHMP and its participation in the National Flood Insurance Program and Community Rating System.

Coordinating State and Local Mitigation Planning

Direct State technical planning assistance for local NHMPs is provided primarily by OEM, DLCD, and DOGAMI. This assistance is funded by full or partial State support of FTE positions whose duties include providing technical assistance in mitigation planning and project implementation to local communities. Technical assistance is also provided indirectly, in the form of access to products and information.

At OEM, the State Hazard Mitigation Officer (SHMO) assists with mitigation project development, execution, and grant compliance. Others provide oversight of mitigation plans; public information and outreach, particularly for earthquake and tsunami hazards; and tsunami evacuation planning.

DLCD staff provide local governments assistance in complying with Statewide Planning Goal 7 which requires planning for hazard mitigation and integrating local NHMPs with comprehensive plans and implementing programs and regulations. It encourages implementing the NFIP minimum and higher standards. In 2014, DLCD staff began assisting local jurisdictions with updating and developing new NHMPs. DOGAMI continues to develop local risk assessments that underpin local NHMPs through the Risk MAP Program

Together, OEM and DLCD provide technical assistance to property owners and local governments for mitigating repetitive loss (RL) and severe repetitive loss (SRL) properties.

DLCD and OEM provide notification and information regarding mitigation grant options and opportunities to local communities. OEM provides assistance, to the degree possible, to communities to help them prepare grant subapplications.

In addition to the Risk MAP Program's products, specific hazard information, risk, and vulnerability assessment products are provided by DOGAMI on a funding-contingent basis.

Numerous other agencies — federal (e.g., FEMA, U.S. Geological Survey, U.S. Army Corps, etc.), State (e.g., ODF, ODOT, OHA, etc.) and local (counties, cities, councils of governments, special districts, etc.) — also contribute valuable technical information and support to local mitigation planning efforts.

A critical source of technical hazard mitigation planning assistance in Oregon, the Oregon Partnership for Disaster Resilience at the University of Oregon assists local jurisdictions with grant writing, local plan development, plan update, process facilitation, stakeholder engagement, public outreach, and hazard research services and serves as a liaison between local communities and state, federal and NGO partners during the mitigation planning process. OPDR strives to ensure that local communities: (a) receive the tools and resources to successfully facilitate and document plan development or plan update processes (b) establish regional partnerships to discuss collaborative projects and implementation strategies, and (c) engage with a variety of state and local agencies and organizations that can assist with local risk reduction strategies.

The Land Conservation and Development Commission oversees a grant program through which each biennium local governments are awarded general funds for purposes that support the statewide land use planning program. One of the grants in the program is the Technical Assistance Grant or TA Grant. It is a competitive grant that, starting with the 2015-17 biennium, included natural hazards planning as Priority #3 out of five. It was to support natural hazards mitigation planning and integrating NHMPs with comprehensive plans. In the 2017-19 biennium, the scope was expanded. Its title is now *Plan for resilience to natural hazards and climate change adaptation*. It reads, *This priority is for grants that provide assistance with: (a) creating local natural hazard mitigation plans; (b) other studies and activities supporting local resilience to natural hazards and climate adaptation; and (c) incorporating new hazards data, and the response to the data, into comprehensive plans and zoning regulations.* It appears this funding will be affected by the budget cuts being contemplated by the legislature in Summer 2020 as a result of the deep revenue losses resulting from the novel coronavirus pandemic.

Oregon delivers a robust calendar of training classes and events each year that support mitigation planning, project development and implementation, and risk reduction.

Oregon also sponsors the Oregon Prepared Conference in the spring of each year which brings together emergency managers and others for a few days of discussion, coordination, and networking around disaster cycle topics.

OEM and DLCD collaborated on an educational presentation to the Special Districts Association of Oregon in February 2018. The purpose of the presentation was to advise special district representatives about the requirement for having an NHMP to access HMA funding; the return on investment in mitigation; the process for developing NHMPs; and technical assistance available from the state. The presentation was well attended and appreciated.

Planning Process

Developing the Plan

The primary focus of this plan update was to improve the risk assessment by developing a single methodology to assess risk across all hazards statewide and use the results to inform and guide mitigation goals and actions. The goal was to connect hazard and vulnerability assessments to describe risk in a way that would identify the where and on which hazards the state should focus its mitigation efforts. The State identified a simple methodology that would be able to be implemented with a limited budget. A full description of the 2020 Risk Assessment methodology pilot is located in Section **2.1.2**.

Another focus of the 2020 update was to coordinate with the simultaneous update of Oregon's 2010 Climate Change Adaptation Framework (CCAF) and integrate the two documents to the extent possible. While the degree of integration initially contemplated has not yet been possible, the Oregon NHMP does include a goal addressing climate change adaptation and several mitigation actions from the CCAF

Another benefit of the coordination with the CCAF update is the incorporation of an equity lens in the Oregon NHMP goals. Governor Brown has brought the issue of equity to the fore, and all state agencies are working to incorporate it into their work.

The IHMT's interest in social vulnerability was addressed in the 2020 risk assessment for the first time. DLCD chose to use the CDC's index in the 2020 risk assessment because it is used by other state agencies. This will facilitate interagency coordination around issues of social vulnerability and equity.

DLCD worked with historic preservation and archaeology staff to incorporate an exposure analysis of historic and archaeological resources into the risk assessment for the first time and it was largely successful.

A decision was made that dust storms would be dropped from the Plan as it has been well addressed primarily through implementation of best practices in land tilling techniques. Another decision was made to add extreme heat as a new natural hazard in the Plan. As temperatures, drought and wildfire are increasingly experienced across the state, and several local governments have included it in their plans, the state decided to do the same.

The State applied for and received a FEMA High Hazard Potential Dams grant to undertake risk assessments and related work concerning state-regulated dams. The grant required that high hazard potential dams be addressed the same way the eleven recognized natural hazards are addressed. As the State has not to date considered dam safety a natural hazard, and as it is primarily associated with flood hazards, the State has met this requirement by incorporating dam safety into the state and regional flood hazard risk assessment sections and into other relevant chapters of the Oregon NHMP. The Dam Safety risk assessments mimic the structure of the eleven state-recognized natural hazard risk assessments, effectively treating it as a twelfth natural hazard, but without a discrete chapter.

Maintaining the Plan

DLCD will work with the State Hazard Mitigation Officer to conduct plan monitoring activities during and associated with each quarterly meeting of the IHMT. An expectation for IHMT members to participate in quarterly plan monitoring will be established. Plan monitoring activities will be guided by the mitigation goals and other evaluation criteria in Section **4.3.2.2**. DLCD will update the 2020 Plan after each IHMT meeting with the information gleaned through that quarter's monitoring activities and IHMT members will review the changes for accuracy. In this way the 2020 Oregon NHMP will become a living document, and the effort needed to perform the 5-year update will be reduced.

Further, at a regular quarterly meeting as soon as feasible following a declared disaster event in Oregon, the State IHMT will discuss the event in the context of the Oregon NHMP and provide any necessary direction for updating the Plan. OEM will document this discussion as usual in IHMT meeting minutes and following the meeting DLCD will make any directed plan revisions.

Enhanced Plan

In 2020, Oregon will lose enhanced plan status. Therefore, the 2020 Plan is being submitted as a standard plan. Oregon intends to make the changes necessary to regain enhanced plan status as quickly as possible. Chapter 5, Enhanced Plan is left in "placeholder" status, optimistic that Oregon will regain enhanced plan status during the effective period of the 2020 Oregon NHMP.

Enhanced plan approval constitutes FEMA's recognition that a state has demonstrated its commitment to maintaining a comprehensive natural hazard mitigation program and supporting that commitment through skilled and effective management of mitigation funding, projects, and planning; support of local mitigation plans and projects; integration of mitigation plans and projects with other state and federal plans, programs, and initiatives; and continual progress in implementation. This exceptional level of effort and demonstration of excellence yields dividends in the form of increased federal mitigation funding after disaster strikes.

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Chapter 1 INTRODUCTION TO THE PLAN

1.1 Background

The dramatic increase in the costs associated with natural disasters over the past decades fostered interest in identifying and implementing effective means of reducing vulnerability. On February 26, 2002, the Federal Emergency Management Agency (FEMA) published Interim Final Rule 44 CFR Part 201, which required all states and local governments to develop natural hazards mitigation plans to be eligible for certain hazard mitigation grant programs, and in the case of the states, to be eligible for certain categories of disaster assistance.

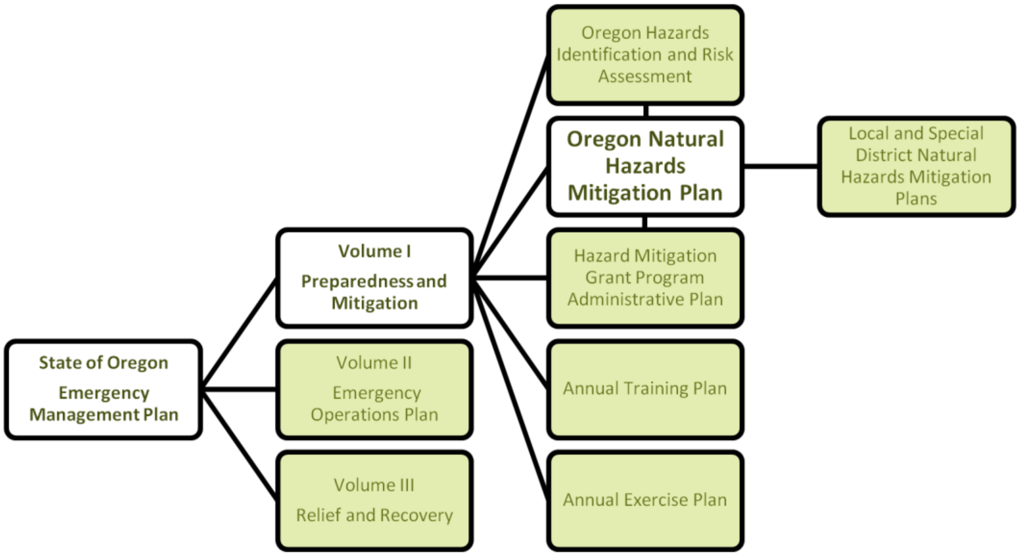
Disasters occur as a predictable interaction among three broad systems: natural systems (e.g., watersheds and continental plates), the built environment (e.g., cities and roads), and social systems (community organization infrastructure that includes demographics, business climate, service provision, etc.). What is not predictable is exactly when natural hazards will occur or the extent to which they will affect communities within the state. However, with careful planning and collaboration it is possible to minimize the losses that can result from natural hazards.

Hazard mitigation is defined at 44 CFR 201.2 as *any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards*. Hazard mitigation is the responsibility of individuals, private businesses and industries, state and local governments, and the federal government. Engaging in mitigation actions provides the state, counties, cities, businesses, and citizens with a number of benefits: fewer injuries and deaths; less damage to buildings, critical facilities, and infrastructure; diminished interruption in essential services; reduced economic hardship; minimized environmental harm; and quicker, lower-cost recovery.

The Oregon Natural Hazards Mitigation Plan (NHMP, Plan) guides mitigation actions throughout the state. It contains the most complete and up-to-date description of Oregon’s natural hazards and their probability, the state’s vulnerabilities, its mitigation strategies and implementation resources. Oregon’s counties and cities can rely upon this information when preparing local natural hazards mitigation plans. Similarly, local NHMPs provide the state with a deeper understanding of local and regional mitigation goals and issues, advancing alignment of mitigation goals and strategies statewide. Further, Oregon’s Natural Hazards Mitigation Plan meets FEMA eligibility requirements for enhanced hazard mitigation and disaster assistance funding, benefitting the state and local communities alike.

The Oregon NHMP is one component of the first volume of the *Oregon Emergency Management Plan,* administered by the Oregon Military Department’s Office of Emergency Management. **Figure 1-1** illustrates this organizational relationship.

Figure 1-1. The Oregon NHMP as a Component of the Oregon Emergency Management Plan



Source: Modified from Oregon Partnership for Disaster Resilience

1.2 Plan Structure

The Oregon Natural Hazards Mitigation Plan is a Standard Plan in 2020, meeting the requirements of both 44 CFR 201.4 (Standard State Mitigation Plans).

The Standard Plan contains three main chapters: (a) Risk Assessment, (b) Mitigation Strategy, and (c) Planning Process.

A list of acronyms, a glossary, and a list of references follow these chapters.

The Plan closes with links to appendices providing additional information illuminating the Risk Assessment, Mitigation Strategy, and Planning Process chapters.

1.3 Standard Plan

1.3.1 Risk Assessment

The Risk Assessment is presented on two levels: statewide and regional.

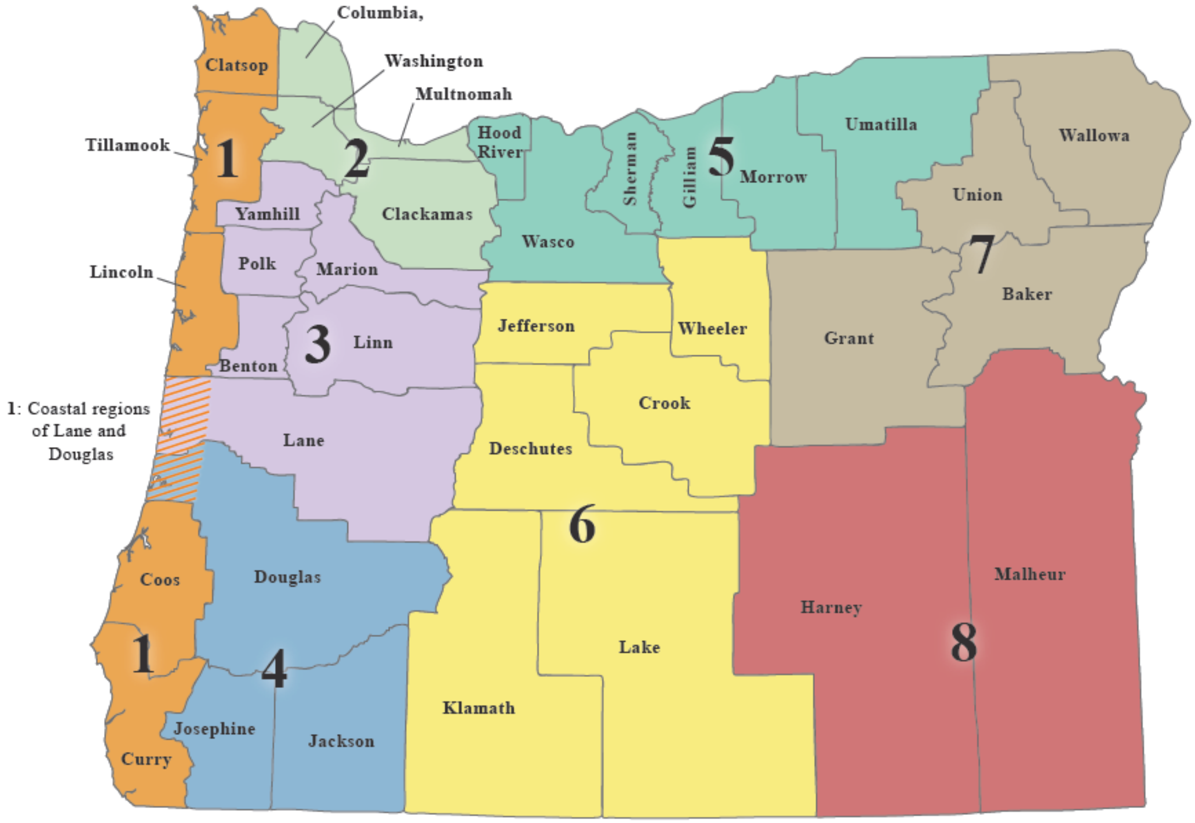
The State Risk Assessment profiles each of Oregon's 11 natural hazards and the predicted impacts of climate change on each of the hazards. It also discusses Oregon's vulnerabilities, including social vulnerabilities, to each hazard, and provides loss estimates for state-owned/leased buildings and critical/essential facilities as well as local critical facilities, and for the first time, historic resources and archaeological resources. The state risk assessment also presents a summary of the state of the science of climate change and how climate change is anticipated to influence the presentation of hazards, particularly in terms of probability.

The Regional Risk Assessment consists of eight separate risk assessments, one for each of the eight Oregon NHMP Natural Hazard Regions (**Figure 1-2**) established by the Oregon Military Department's Office of Emergency Management (OEM). Each Regional Risk Assessment begins with a summary, then profiles the region's unique demographic, natural environment, land use, and economic characteristics. Finally, each Regional Risk Assessment describes how each hazard presents in the region; discusses the influence of climate change on the presentation of each hazard, again, particularly in terms of probability; analyzes the region's vulnerabilities, including social and seismic lifeline vulnerabilities, to each hazard; and provides loss estimates for state-owned/leased buildings and critical/essential facilities as well as local critical facilities located in the region's hazard areas.

A new risk assessment methodology has been piloted with this update to better assess risk by considering probability and vulnerability together; to enable comparison across all hazards statewide; and then to better link the risk assessment with mitigation goals and actions. To facilitate this linkage, the state risk assessment chapters has been reorganized for this update. Instead of separate sections discussing hazards and vulnerability, the chapter has been organized like the previous regional risk assessment chapters with the hazards assessment followed directly by the vulnerability assessment. In both the state and regional risk assessments, these are now followed directly by a brief "Risk" section which attempts to synthesize their information and culminate in a risk assessment.

The State applied for and received a FEMA High Hazard Potential Dams grant to undertake risk assessments and related work concerning state-regulated dams. The grant required that high hazard potential dams be addressed the same way the eleven recognized natural hazards are addressed. As the State has not to date considered dam safety a natural hazard, and as it is primarily associated with flood hazards, the State has met this requirement by incorporating dam safety into the state and regional flood hazard risk assessment sections and into other relevant chapters of the Oregon NHMP. The Dam Safety risk assessments mimic the structure of the eleven state-recognized natural hazard risk assessments, effectively treating it as a twelfth natural hazard, but without a discrete chapter.

Figure 1-2. Oregon NHMP Natural Hazards Regions



1.3.2 Mitigation Strategy

The Mitigation Strategy establishes the state's mission, vision, and goals for natural hazard mitigation. A set of tables describe mitigation actions the state has completed, continues to perform, and desires to achieve over the life of this Plan. Current and potential funding sources for implementing mitigation actions are identified.

This chapter also assesses the state's ability to implement the mitigation strategy, both before and after a disaster, through its policies, programs, and funding sources. It also generally assesses the effectiveness of local mitigation policies, programs, and other capabilities.

Finally, the Mitigation Strategy describes the state's support of local mitigation planning, prioritization of funding for local mitigation plans and projects, and coordination of local NHMPs with the Oregon NHMP.

1.3.3 Planning Process

This chapter details the process of updating the Oregon NHMP and identifies the changes made to the Plan through the update process. It frames processes for tracking implementation progress, and for monitoring, evaluating, and eventually updating this edition of the Plan. It highlights how the Oregon NHMP is related to, coordinates with, or is integrated with other planning initiatives.

1.4 Enhanced Plan

The Enhanced Plan chapter is the state's opportunity to showcase its commitment to a comprehensive natural hazard mitigation program and its ability to support that commitment through skilled and effective management of funding, projects, and planning; support of local mitigation plans and projects; integration of mitigation plans and projects with other state and federal plans, programs, and initiatives; and continual progress in implementation. It contains detailed information about how funding was obtained and used during the life of the previous Plan; how funding decisions are made; how completed mitigation projects are evaluated; and how the state provides funding and technical assistance to cities and counties for developing and updating local NHMPs and accomplishing mitigation actions. This exceptional level of effort and demonstration of excellence earns dividends in the form of increased federal funding.

Because Oregon will lose enhanced plan status, this 2020 Oregon NHMP is being submitted as a standard plan. Oregon intends to make the changes necessary to regain enhanced plan status as quickly as possible. Chapter 5, Enhanced Plan is left in "placeholder" status, optimistic that Oregon will regain enhanced plan status during the effective period of the 2020 Oregon NHMP.

Chapter 2 RISK ASSESSMENT

In This Chapter

The Oregon NHMP Risk Assessment chapter is divided into three sections: (a) Introduction, (b) State Risk Assessment, and (c) Regional Risk Assessment. Following is a description of each section.

1. **Introduction:**
    - Overview: States the purpose and provides an overview of the components of the risk assessment and explains risk. Presents and compares local and state vulnerability assessments.
    - 2020 Risk Assessment Methodology: Describes the pilot method used for assessing risk in a consistent way across hazards.
    - Social Vulnerability: Describes the method used for incorporating social vulnerability into the 2020 Risk Assessment Methodology.
    - Introduction to Climate Change: Describes the state of climate change knowledge and how climate change is anticipated to affect hazard occurrence.
    - State-Owned/Leased Facilities, State Critical Facilities, and Local Critical Facilities Potential Loss Assessment: Describes the potential loss assessment and how it was integrated into the 2020 Risk Assessment Methodology.
    - Seismic Transportation Lifeline Vulnerabilities: Describes and updates ODOT's work on addressing transportation lifelines
    - Cultural Resources: Describes the value of Oregon's cultural and historic resources, establishes a vision and suggests actions for better protecting them over time.
2. **State Risk Assessment:** Includes the following components:
    - Profiles each of Oregon's hazards by identifying each hazard, its generalized location, and presidentially declared disasters; characterizes each hazard that impacts Oregon; lists historic events; identifies the probability of future events; and introduces how climate change is predicted to impact each hazard statewide.
    - Includes an overview and analysis of the state's vulnerability to each hazard by identifying which communities are most vulnerable to each hazard based on local and state vulnerability assessments; providing loss estimates for state-owned/leased facilities and critical/essential facilities, local critical facilities, historic and archaeological resources located in hazard areas; identifying seismic lifeline vulnerabilities; and describing social vulnerability.
    - Includes a brief description of risk based on the probability and vulnerabilities discussed.
3. **Regional Risk Assessment:** Includes the following components for each of the eight Oregon NHMP Natural Hazard Regions:
    - Summary: Summarizes the region's statistical profile and hazard and vulnerability analysis and generally describes projected impacts of climate change on hazards in the region.
    - Profile: Provides an overview of the region's unique characteristics, including a natural environment profile, social/demographic profile, economic profile, infrastructure profile, and built environment profile.
    - Hazards, Vulnerability, and Risk: Further describes the hazards in each region by characterizing how each hazard presents itself in the region; listing historic hazard events; and identifying probability of future events based on local and state analysis; and introduces how climate

change is predicted to impact each hazard. Also includes an overview and analysis of the region’s vulnerability to each hazard; identifies which communities are most vulnerable to each hazard based on local and state analysis; provides loss estimates for state-owned/leased facilities and critical/essential facilities, local critical facilities, historic and archaeological resources located in hazard areas; identifies the region’s seismic lifeline vulnerabilities;; and describes social vulnerability.

- Includes a brief description of risk based on the probability and vulnerabilities discussed.

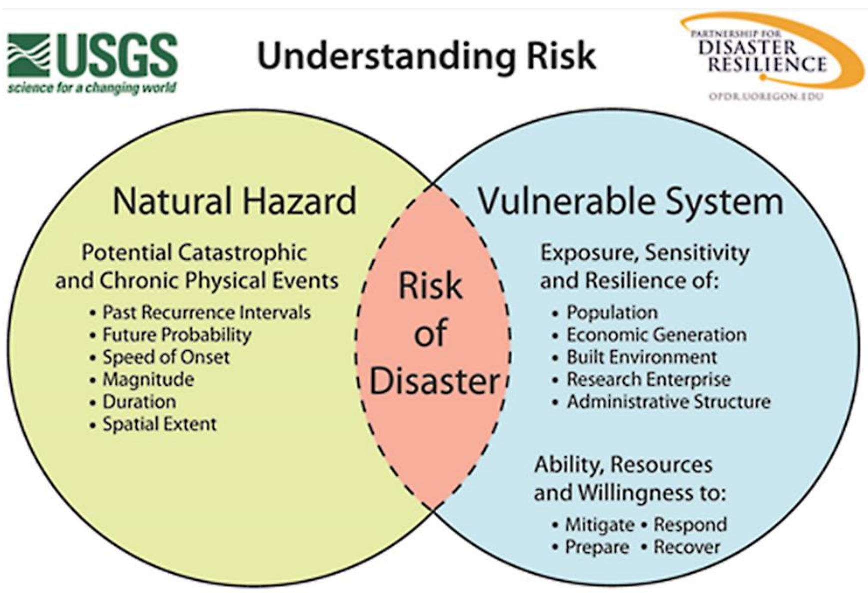
2.1 Introduction

Requirement 44 CFR §201.4(c)(2), [The plan must include] risk assessments that provide the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments.

The purpose of the Oregon NHMP Risk Assessment is to identify and characterize Oregon's natural hazards, determine which jurisdictions are most vulnerable to each hazard, and estimate potential losses to vulnerable structures and infrastructure and to state facilities from those hazards.

It is impossible to predict exactly when natural hazards will occur or the extent to which they will affect communities within the state. However, with careful planning and collaboration, it is possible to minimize losses that can result from natural hazards. The identification of actions that reduce the state's sensitivity and increase its resilience assist in reducing overall risk — the area of overlap in **Figure 2-1**. The Oregon NHMP Risk Assessment informs the State's mitigation strategy, found in **Chapter 3**.

Figure 2-1. Understanding Risk



Source: Wood (2007)

Assessing the state's level of risk involves three components: characterizing natural hazards, assessing vulnerabilities, and analyzing risk. Characterizing natural hazards involves determining hazards' causes and characteristics, documenting historic impacts, and identifying future probabilities of hazards occurring throughout the state. Section 2.2, State Risk Assessment has a chapter for each hazard (2.2.X).

Each hazard chapter has a section entitled "2.2.X.1 Analysis and Characterization" wherein the hazard is characterized. Sections "2.2.X.2 Probability" assess the probability of hazard occurrence.

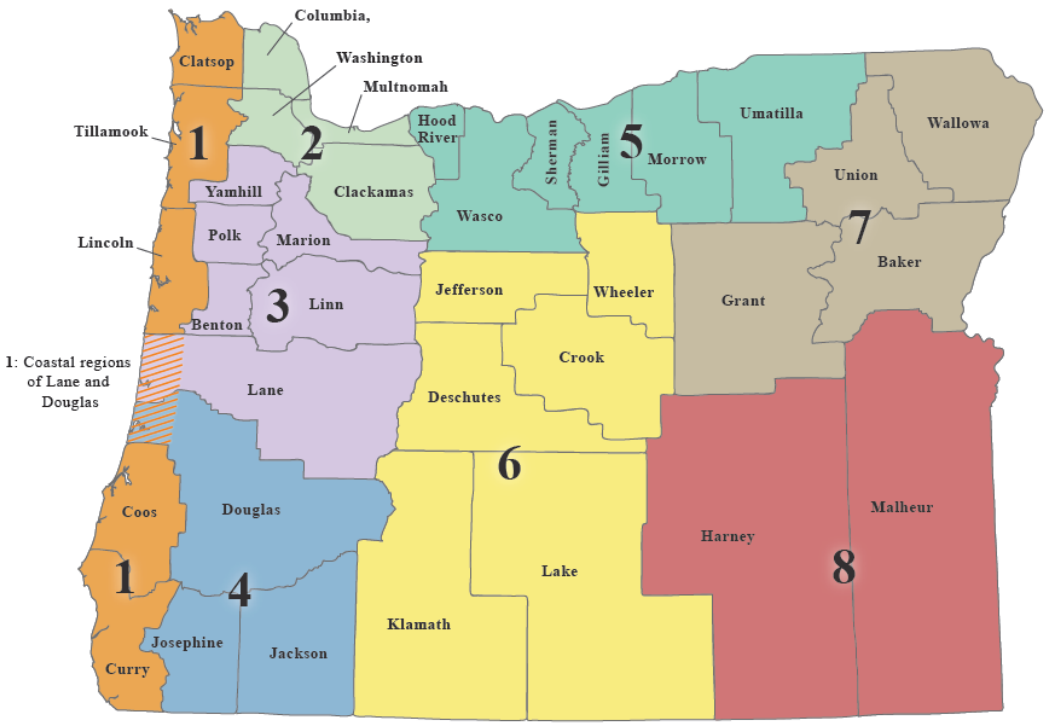
A vulnerability assessment combines information from the hazard characterization with an inventory of the existing (or planned) property and population exposed to a hazard and attempts to predict how different types of property and population groups will be affected by each hazard. Vulnerability is determined by a community's exposure, sensitivity, and resilience to natural hazards as well as by its ability to mitigate, prepare for, respond to, and recover from a disaster. Sections 2.2.X.3 Vulnerability identify assess the state's vulnerabilities to each hazard. For this update, the vulnerability assessment includes not only a summary of the potential loss estimate for state-owned and –leased facilities, critical facilities, but also local critical facilities, historic resources, archaeological resources, and social vulnerability.

A risk analysis involves estimating damages, injuries, and costs likely to be incurred in a geographic area over a period of time. Risk has two measurable components: (a) the magnitude of the harm that may result, defined through vulnerability assessments; and (b) the likelihood or probability of the harm occurring, defined in the hazard characterization. For this update, the State developed a risk assessment methodology and applied it as a pilot to seven of the eleven hazards. These seven were chosen because data was available for the assessment. Probability and some elements of vulnerability were ranked and combined to deliver a risk score for each county for each hazard and for all seven hazards combined. Afterward, the more qualitatively assessed four remaining hazards were incorporated into the pilot and the results compared. A detailed description of the pilot is in Section 2.1.2, **2020 Risk Assessment Methodology** with a brief assessment of risk.

This Plan also analyzes risk at the regional level. Regional risk assessments begin with a description of the region's physical geography, assets, and vulnerabilities in the Regional Profile section. The Profile is followed by a characterization of each hazard and identification of the vulnerabilities and potential impacts of each hazard, and finally a brief assessment of risk. Regions are defined in the Oregon NHMP Natural Hazards Regions map (**Figure 2-2**):

- **Region 1 – Coast:** Clatsop, Tillamook, Lincoln, coastal Lane, coastal Douglas, Coos, and Curry Counties;
- **Region 2 – Northern Willamette Valley/Portland Metro:** Colombia, Clackamas, Multnomah, and Washington Counties;
- **Region 3 – Mid/Southern Willamette Valley:** Benton, Lane, Linn, Marion, Polk, and Yamhill Counties;
- **Region 4 – Southwest:** Douglas (non-coastal), Jackson, and Josephine Counties;
- **Region 5 – Mid-Columbia:** Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties;
- **Region 6 – Central:** Crook, Deschutes, Jefferson, Klamath, Lake, and Wheeler Counties;
- **Region 7 – Northeast:** Baker, Grant, Wallowa, and Union Counties; and
- **Region 8 – Southeast:** Harney and Malheur Counties.

Figure 2-2. Oregon NHMP Natural Hazards Regions



2.1.1 Overview

2.1.1.1 Hazard Characterization and Analysis

Requirement: 44 CFR §201.4(c)(2)(i): The risk assessment shall include… (i) An overview of the type and location of all natural hazards that can affect the State…

Oregon Hazards

The State of Oregon is subject to 11 primary natural hazards. **Table 2-1** lists each hazard and describes in general terms where the hazard is located. Section **2.2, State Risk Assessment** describes each hazard in greater detail in subsections 2.2.X.1. The probability of occurrence and the influence of climate change are presented in subsections 2.2.X.2. The state's vulnerability to each hazard is discussed in subsections 2.2.X.3, and a brief assessment of risk will be found in subsections 2.2.X.4. In this update, dust storms are not addressed and Extreme Heat is addressed for the first time.

Table 2-1. Oregon Hazard Overview

Hazards	Generalized Locations
Coastal Hazards	Oregon coast
Droughts	generally east of the Cascades, with localized risks statewide
Earthquakes	
Cascadia Subduction	primarily western Oregon
Other active earthquake faults	localized risks statewide
Extreme Heat	southwest, mid-Columbia, northeast and southeast Oregon
Floods	localized risks statewide
Landslides	localized risks statewide
Tsunamis	Oregon coast*
Volcanoes	central Oregon, Cascade Range and southeast Oregon, High Lava Plains
Wildfires	primarily southwest, central and northeast Oregon, with localized risks statewide
Windstorms	localized risks statewide
Winter Storms	localized risks statewide

*Maps and GIS files showing potential tsunami inundation for five levels of local Cascadia scenarios and two maximum-considered distant tsunami scenarios are available as DOGAMI Open-File Report O-13-19 (Priest, et al., 2013).

Source: Oregon NHMP lead state agency(ies) for each hazard

Requirement: 44 CFR §201.4(c)(2)(ii): The risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described... based on estimates provided in … the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

For each of the 11 hazards addressed in this Plan, a state agency has been identified as the lead over that hazard (**Table 2-2**). All hazards have at least one lead and most have a support hazard expert who compiled and analyzed hazard data for this state risk assessment. In some instances both experts are from the same agency. For other hazards two agencies worked together to perform the analysis. Due to the wide range of data available for each hazard, the method used to assess risk varies from hazard to hazard. For example, there is a wealth of data available to assess risk to earthquakes, but data on windstorms is difficult to locate. In response, the State relies on hazard lead and support experts to determine the best method, or combination of methods, to identify probability, vulnerability and potential impacts for this Plan. In general, each hazard is assessed by using a combination of exposure, historical, and scenario analyses. Hazards for which more data exist — coastal hazards, earthquake, flood, landslide, tsunami, wildfire and, to a lesser degree, volcanic events (primarily related to Mount Hood) — have undergone a more robust analysis.

Table 2-2. Oregon NHMP Hazard Lead Agencies

Hazard	Lead Agency	Support Agency
Coastal Hazards	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Droughts	Oregon Water Resources Department	Oregon Climate Change Research Institute
Earthquakes	Department of Geology and Mineral Industries	Oregon Office of Emergency Management
Extreme Heat	Oregon Climate Change Research Institute	Oregon Health Authority
Floods ▫ Dam Safety	Department of Geology and Mineral Industries Oregon Water Resources Department Dam Safety Program	Department of Land Conservation and Development
Landslides	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Tsunamis	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Volcanoes	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Wildfires	Oregon Department of Forestry	Oregon Department of Forestry
Windstorms	Oregon Public Utility Commission	Oregon Climate Change Resource Institute
Winter Storms	Oregon Department of Land Conservation and Development	Oregon Climate Change Research Institute

Source: DLCD

Disaster Declarations

Since 1955 (the year the United States began formally tracking natural disasters), Oregon has received 34 major disaster declarations, two emergency declarations, and 49 fire management assistance declarations. **Table 2-2** lists each of the major disaster declarations, the hazard that the disaster is attributed to, and the counties impacted. Since 1955, Clackamas, Clatsop, Columbia, Coos, Curry, Douglas, Lane, Lincoln, Linn, Tillamook, and Yamhill Counties have each been impacted by 10 or more federally declared non-fire related disasters. Of the 34 major disasters to impact Oregon, the vast majority have resulted from storm events. Notably, flooding impacts from those events are reported in over two thirds of the major disaster declarations.

The reported federal disaster declarations (including fire management assistance declarations) document that storm events, floods, and wildfires have been the primary chronic hazards with major disaster impacts in Oregon over the last half century. The data also show a trend geographically of a greater number of major federal disaster declarations in the northwest corner of the state. Anecdotally, this pattern plays out for non-federally declared hazard events in the state as well. The following subsections summarize type, location, history, and probability information for each of the hazard types listed above.

Table 2-3. Presidential Major Disaster Declarations Since 1955

Disaster	Incident Period	Disaster Type	Baker	Benton	**Clackamas**	**Clatsop**	**Columbia**	**Coos**	Crook	**Curry**	Deschutes	**Douglas**	Gilliam	Grant	Harney	Hood River	Jackson	Jefferson	Josephine	Klamath	Lake	**Lane**	**Lincoln**	**Linn**	Malheur	Marion	Morrow	Multnomah	Polk	Sherman	Siletz IR*	**Tillamook**	Umatilla	Union	Wallowa	Warm Springs IR*	Wasco	Washington	Wheeler	**Yamhill**
DR-4519	Feb. 5-9, 2020	severe storms, flooding, landslides, and mudslides																															x	x	x					
DR-4452	Apr. 6-21, 2019	severe storms, flooding, landslides, and mudslides								x		x		x										x									x						x	
DR-4432	Feb. 23-26, 2019	severe winter storms, flooding, landslides, and mudslides						x		x		x						x				x																		
DR-4328	Jan. 7-10, 2017	severe winter storms, flooding, landslides, and mudslides					x				x					x			x																					
DR-4296	Dec. 14-17, 2016	severe winter storm and flooding																	x			x																		
DR-4258	Dec. 6-23, 2015	severe winter storms, straight-line winds, flooding, landslides, and mudslides			x	x	x	x		x		x										x	x	x				x	x			x						x		x
DR-4169	Feb. 6–14, 2014	severe winter storm		x																		x	x	x																
DR-4055	Jan. 17–21, 2013	severe winter storm / flooding / landslides / mudslides		x			x	x		x		x				x						x	x	x		x			x			x								
DR-1964	Mar. 11, 2011	tsunami						x		x													x																	
DR-1956	Jan. 13–21, 2011	winter storms / flooding / mudslides/ landslides / debris flows			x	x			x			x											x									x								
DR-1824	Dec. 13, 2007– Jan. 26, 2008	winter storms / flooding			x	x	x																				x		x	X		x						x		x
DR-1733	Dec. 1–17, 2007	storms / flooding / landslides / mudslides																												X		x						x		x
DR-1683	Dec. 14–15, 2006	winter storms / flooding		x		x	x																x							x	x	x					x		x	x
DR-1672	Nov. 5–8, 2006	storms / flooding / landslides / mudslides				x										x							x									x								
DR-1632	Dec. 18, 2005– Jan. 21, 2006	storms / flooding / landslides / mudslides		x	x	x	x	x	x	x		x	x				x	x	x				x	x						x	x	x				x			x	x
DR-1510	Dec. 26, 2003– Jan. 14, 2004	winter storms	x	x	x	x	x		x		x	x	x	x	x	x		x			x	x	x	x	x	x	x	x	x	x		x	x	x	x		x		x	x
DR-1405	Feb. 7-8, 2002	winter storm						x		x		x										x		x																
DR-1221	May 28–June 3, 1998	flooding							x																															
DR-1160	Dec. 25, 1996– Jan. 6, 1997	winter storm / flooding						x				x					x		x	x	x	x													x					
DR-1107	Dec. 10–12, 1995	storms / high winds		x		x	x					x										x	x	x								x						x		x
DR-1099	Feb. 4–21, 1996	storms / flooding		x	x	x	x	x			x	x	x			x		x	x			x	x	x		x	x	x	x	x		x	x	x	x		x	x		x
DR-1061	July 8–9, 1995	flash flooding																																			x			
DR-1036	May 1–Oct. 31, 1994	El Niño effects				x	x	x		x		x										x	x									x								
DR-1004	Sep. 20, 1993	earthquakes																		x																				
DR-985	Mar. 25, 1993	earthquake			x																					x												x		x
DR-853	Jan. 6-9, 1990	storms / flooding				x																										x								
DR-413	Jan. 25, 1974	storms / flooding / snow melt		x	x		x	x		x		x	x			x	x		x			x	x			x			x			x			x		x	x		x
DR-319	Jan. 21, 1972	storms / flooding			x	x		x				x										x	x	x				x				x						x		
DR-301	Feb. 13, 1971	storms / flooding				x																										x								
DR-184	Dec. 24, 1964	heavy rains / flooding	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	x

Disaster	Incident Period	Disaster Type	Baker	Benton	**Clackamas**	**Clatsop**	**Columbia**	**Coos**	Crook	**Curry**	Deschutes	**Douglas**	Gilliam	Grant	Harney	Hood River	Jackson	Jefferson	Josephine	Klamath	Lake	**Lane**	**Lincoln**	**Linn**	Malheur	Marion	Morrow	Multnomah	Polk	Sherman	Siletz IR*	**Tillamook**	Umatilla	Union	Wallowa	Warm Springs IR*	Wasco	Washington	Wheeler	**Yamhill**
Total number of disasters by county / IR* post 1964			2	9	**10**	**14**	**12**	**12**	5	**10**	4	**15**	5	3	2	7	4	5	7	3	3	**14**	**15**	**11**	2	6	4	5	7	4	2	**17**	5	4	6	1	6	9	5	**11**
DR-144	Feb. 25, 1963	flooding	**No individual county impact data available**																																					
DR-136	Oct. 16, 1962	storms																																						
DR-69	Mar. 1, 1957	flooding																																						
DR-60	July 20, 1956	storm / flooding																																						
DR-49	Dec. 29, 1955	flooding																																						

*IR = Indian Reservation

Bold "x" = A county that has been impacted by 10 or more federally declared non-fire related disasters

Source: Oregon Office of Emergency Management (2013)

Vulnerability Assessments

Requirement: 44 CFR §201.4(c)(2)(ii): The risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described... based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

The vulnerability assessment provides an overview and analysis of the state's vulnerabilities to each of Oregon's 11 hazards addressed in this Plan. Both local and state risk assessments are referenced to identify vulnerabilities, most vulnerable jurisdictions, and potential impacts from each hazard.

Requirement: 44 CFR §201.4(c)(2)(ii): The risk assessment shall include… (ii)…State owned or operated critical facilities located in the identified hazard areas shall also be addressed.

Requirement: 44 CFR §201.4(c)(2)(iii): The risk assessment shall include… (iii) An overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

State Vulnerability Assessment

The exposure analysis and estimate of potential losses to state-owned/leased facilities and critical/essential facilities and local critical facilities located within hazard zones performed by the Department of Geology and Mineral Industries (DOGAMI) for the 2015 Oregon NHMP was updated by DOGAMI in 2020. Loss data are not available in local plans. Therefore, this Plan only includes the most recent estimates provided by DOGAMI.

An overview of seismic lifeline vulnerabilities was a new addition to the 2015 Oregon NHMP and is carried forward to the 2020 Oregon NHMP because it is still being implemented. It includes a summary of the Oregon Department of Transportation's (ODOT's) 2012 Oregon Seismic Lifeline Report (OSLR) findings, including identification of system vulnerabilities, loss estimates and recommended next steps. Both the facilities and lifeline report findings are further discussed and updated in the **Regional Risk Assessments**.

For the 2020 update, DOGAMI analyzed exposure of historic resources to coastal erosion, earthquake, flood, landslide, tsunami, volcano, and wildfire hazards for each county. OPRD analyzed exposure of archaeological resources to coastal erosion, earthquake, flood, and landslide for each county. Technical issues prevented analysis with respect to tsunami, volcano, and wildfire at this time.

In addition, social vulnerability was included in the state vulnerability assessment for the first time in the 2020 update. The Centers for Disease Control and Prevention (CDC) publishes a social vulnerability index which is updated every two years. This index was used in the 2020 Risk Assessment Methodology. Details are in Section **2.1.3**.

Local Vulnerability Assessments

Requirement: 44 CFR §201.4(c)(2)(ii): The risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described... based on estimates provided in local risk assessments …. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

The OEM Hazard Analysis Methodology was first developed by FEMA in 1983 and has been gradually refined by OEM over the years. There are two key components to this methodology: vulnerability and probability. Vulnerability examines both typical and maximum credible events, and probability reflects how physical changes in the jurisdiction and scientific research modify the historical record for each hazard.

This analysis is conducted by county or city emergency program managers, usually with the assistance of a team of local public safety officials. The assessment team initially identifies which hazards are relevant in that community. Then, the team scores each hazard in four categories: history, probability, vulnerability, and maximum threat. Following is the definition and ranking method for each category:

- History = the record of previous occurrences:
  - Low 0–1 event past 100 years,
  - Moderate 2–3 events past 100 years, and
  - High 4+ events past 100 years.
- Probability = the likelihood of future occurrence within a specified period of time:
  - Low one incident likely within 75–100 years,
  - Moderate one incident likely within 35–75 years, and
  - High one incident likely within 10–35 years.

- Vulnerability = the percentage of population and property likely to be affected under an "average" occurrence of the hazard:
  - Low < 1% affected,
  - Moderate 1–10% affected, and
  - High > 10% affected.

- Maximum Threat = the highest percentage of population and property that could be impacted under a worst-case scenario:
  - Low < 5% affected,
  - Moderate 5–25% affected, and
  - High > 25% affected.

Each county in Oregon performs its hazard analysis in conjunction with NHMP updates. As part of this analysis, each county develops risk scores for natural hazards that affect its communities. These scores range from 24 (low) to 240 (high), and reflect risk for each particular hazard, as determined by a team process facilitated by the Emergency Manager. This method provides local jurisdictions with a sense of hazard priorities, or relative risk. It does not predict the occurrence of a particular hazard in a community, but it does "quantify" the risk of one hazard compared with another. By doing this analysis, local planning can first be focused where the risk is greatest. This analysis is also intended to provide comparison of the same hazard across various local jurisdictions.

Among other things, the hazard analysis can:

- Help establish priorities for planning, capability development, and hazard mitigation;
- Serve as a tool in the identification of hazard mitigation measures;
- Be one tool in conducting a hazard-based needs analysis;
- Serve to educate the public and public officials about hazards and vulnerabilities; and
- Help communities make objective judgments about acceptable risk.

Although this methodology is consistent statewide, the reported raw scores for each county are based on partially subjective rankings for each hazard. Because the rankings are used to describe the “relative risk” of a hazard within a county, and because each county conducted the analysis with a different team of people working with slightly different assumptions, comparing scores between counties must be treated with caution.

For the purposes of the Oregon NHMP, the Local Vulnerability Assessment focuses only on county vulnerability rankings (H, M, L) taken from LNHMP Hazard Analysis scores. These rankings provide the state an understanding of local hazard concerns and priorities. **Table 2-4** presents the local vulnerability rankings for each of Oregon’s 11 hazards by county. In the **Regional Risk Assessments**, county vulnerability rankings are presented alongside state vulnerability rankings.

For the 2020 update, DOGAMI analyzed exposure of historic resources to coastal erosion, earthquake, flood, landslide, tsunami, volcano, and wildfire hazards for each county. OPRD analyzed exposure of archaeological resources to coastal erosion, earthquake, flood, and landslide for each county. Technical issues prevented analysis with respect to tsunami, volcano, and wildfire at this time.

In addition, social vulnerability was included in the vulnerability assessment for the first time in the 2020 update. The Center for Disease Control and Prevention (CDC) publishes a social vulnerability index which is updated every two years. This index was used in the 2020 Risk Assessment Methodology. Details are in Section **2.1.3**.

Table 2-4. Local Vulnerability Rankings by County

County	Most Recent HVA	Coastal Erosion	Tsunami	Drought	Earthquake	Volcanic	Landslide	Wildfire	Flood	Wind Storm	Winter Storm
Baker	2020 (draft)			H	H	L	L	H	M	M	H
Benton	2015			L	H	L	L	M	M	M	M
Clackamas	2018			L	H	M	L	M	M	L	M
Clatsop	2015	—	—	N/A	H	M	M	M	M	H	—
Columbia	2020 (draft)			L	H	M	—	M	H	—	H
Coos	2016	H	M	H	M	—	H	M	H	H	L
Crook	2017				H	H	L	M	H	M	M
Curry	2015	H	M		H	H	L	H	H	H	
Deschutes	2015			L	H	H	L	H	L	M	H
Douglas - central	2017			L	H		L	H	M	M	M
Douglas - coastal	2017	—	H	L	H		M	M	H	H	L
Gilliam	2018			M	M	M		M	M	M	H
Grant	2019			H	M	H	L	H	H	L	H
Harney	2017			H	L	L	L	H	M	L	H
Hood River	2018			M	M	M	M	M	L	M	H
Jackson	2017			M	H	L	L	M	M	M	M
Jefferson	2013			H	L	H	L	H	M	L	H
Josephine	2017			H	H	L	L	H	M	M	H
Klamath	2017			H	H	M	L	H	M		M
Lake	2020			H	H	H	L	H	H	H	H
Lane - central	2015			L	M	L	M	M	M	H	H
Lane - coastal			—		—		—	—	—	—	—
Lincoln	2020		H	M	H	L	H	L	M	H	M
Linn	2017			L	H	M		M	M	M	H
Malheur	2018			H	L	L	L	M	M	M	H
Marion	2016			H	H	L	H	M	H	L	H
Morrow	2016				M	L	L	M	M	M	H
Multnomah	2016				H	M	M	H	H	M	M
Polk	2016				M	M	L	M	M	H	H
Sherman	2018			H	L	L	L	H	M	M	H
Tillamook	2016		M		H	L	M	M	H	H	H
Umatilla	2012			—	M			M	M	H	H
Union	2013			M	H	L	L	H	H	H	H
Wallowa	2013			M	L	L	L	M	M	M	M
Wasco	2019			H	M	H	L	M	M	H	H
Washington	2015			M	H	H	L	M	M	H	H
Wheeler	2018			H	H	H	M	H	H	M	H
Yamhill	2019			M	H	L	L	L	H	M	H

Note: "-" indicates that the hazard was evaluated in 2015, but not in the latest local HVA

Source: Most recent local Hazard Vulnerability Analyses, dates listed above in the table.

Local and State Vulnerability Assessment Comparison

Vulnerability rankings guide local and state mitigation goals and actions that inform mitigation priorities at the local and state scale. Prior to 2015 past iterations of the Oregon NHMP stated local and state vulnerability rankings separately. No comparison or analysis of similarities and differences among the rankings of risk assessment methods was conducted. Starting with the 2015 plan, the state placed local and state vulnerability rankings side-by-side to identify if and where similarities and differences occur.

As stated earlier in this Plan, in most cases, local governments use the OEM Hazard Analysis to assess risk. The OEM Hazard Analysis Methodology ranks vulnerability to each hazard based on the estimated percentage of population and property likely to be affected. The ranking of vulnerability is based on best data retrieved from the local level — often including objective data, studies, Hazus, etc. as well as local knowledge — and is therefore somewhat subjective. This methodology identifies which hazards are priorities at the local level.

For the State Risk Assessment, in 2015, the hazard leads determined vulnerability based on some combination of research, literature and agency knowledge forming the factual basis for each hazard risk assessment accompanied by some level of subjectivity. In 2020 the pilot risk assessment methodology was used to determine vulnerability. That determination was based on a narrow set of data – state-owned and leased buildings, state critical facilities, local critical facilities, and a social vulnerability index. **Table 2-5** shows a side-by-side comparison of local and state vulnerability rankings.

Table 2-5. Local and State Vulnerability Ranking by County

Symbols in this table are defined as:

Local
H = High Vulnerability
M = Moderate Vulnerability
L = Low Vulnerability

State
VH = Very High Vulnerability
H = High Vulnerability
M = Moderate Vulnerability
L = Low Vulnerability
VL = Very Low Vulnerability

County	Coastal Erosion/ Coastal Hazards		Tsunami		Drought		Earthquake		Volcanic		Landslide		Wildfire		Flood		Wind Storm		Winter Storm		Extreme Heat	
	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State
Baker					H	M	H	L	L	VL	L	VL	H	L	M	VL	M	H	H	H		M
Benton					L	L	H	L	L	L	L	L	M	VL	M	L	M	M	M	M		M
Clackamas					L	VL	H	VL	M	L	L	H	M	VL	M	VL	L	L	M	M		L
Clatsop	—	L	—	VH	N/A	L	H	H	M	VL	M	L	M	VL	M	L	H	H	—	H		M
Columbia					L	VL	H	VL	M	VL	—	H	M	VL	H	VL	—	H	H	H		L
Coos	H	M	M	VH	H	H	M	VH		M	H	H	M	M	H	H	H	H	L	H		H
Crook						M	H	M	H	L	L	M	M	H	H	M	M	M	M	M		M
Curry	H	VL	M	L	M	L	M	H	H	VL	H	L	H	VL	H	VL	H	H	L	—		M
Deschutes					L	H	H	VL	H	M	L	VL	H	L	L	VL	M	L	H	H		L
Douglas - central					L	H	H	H		M	L	H	H	H	M	H	M	M	M	M		H
Douglas - coastal	—	M	H	H	L	H	H	VH		M	M	H	M	M	H	H	H	M	L			
Gilliam					M	VL	M	VL	M	VL		VL	M	VL	M	VL	M	L	H	H		L
Grant					H	M	M	VL	H	VL	L	VL	H	M	H	M	L	H	H	H		L
Harney					H	H	L	L	L	L	L	L	H	M	M	H	L	L	H	M		M
Hood River					M	M	M	VH	M	VH	M	M	M	H	L	L	M	H	H	H		M
Jackson					M	H	H	H	L	M	L	H	M	M	M	VH	M	H	M	H		M
Jefferson					H	VH	L	H	H	VH	L	H	H	VH	M	VH	L	—	H	H		H
Josephine					H	H	H	H	L	M	L	M	H	M	M	H	M	H	H	H		M
Klamath					H	VH	H	VH	M	H	L	H	H	VH	M	H		—	M	M		H
Lake					H	H	H	VH	H	H	L	M	H	H	H	M	H	M	H	H		H
Lane - central					L	M	M	L	L	H	M	M	M	M	M	M	H	M	H	H		H
Lane - coastal	—	L	—	VH		M	—	VH		L	—	H	—	M	—	M	—	H	—	L		
Lincoln	L	M	H	M	M	M	H	VH	L	L	H	VH	L	L	M	L	H	H	M	—		M
Linn					L	H	H	VH	M	H		M	M	H	M	M	M	M	H	H		H
Malheur					H	VH	L	H	L	M	L	H	M	VH	M	H	M	M	H	M		M
Marion					H	VH	H	VH	L	VH	H	H	M	VH	H	H	L	H	H	H	M	H
Morrow					H	VH	M	VH	L	H	L	H	M	VH	M	VH	M	M	H	H		H
Multnomah							H	M	M	L	M	H	H	L	H	VH	M	H	M	H		M
Polk					M	M	M	M	M		L	L	M	M	M	M	H	H		—		H
Sherman					H	VL	L	VL	L	VL	L	VL	H	L	M	L	M	M	M			L
Tillamook	H	L	M	L		L	H	M	L	VL	M	H	M	VL	H	L	H	H	H	H		M
Umatilla					—	VH	M	VH		H		H	M	H	M	H	H	H	H	H		M
Union					M	L	H	M	L	VL	L	L	H	M	H	VL	H	H	H	H		M
Wallowa					M	L	L	L	L	VL	L	VL	M	L	M	L	M	M	M	M		M

County	Coastal Erosion/ Coastal Hazards		Tsunami		Drought		Earthquake		Volcanic		Landslide		Wildfire		Flood		Wind Storm		Winter Storm		Extreme Heat	
	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State	Local	State
Wasco					H	VH	M	H	H	H	L	VH	M	VH	M	H	H	H	H	H		M
Washington					M	VL	H	L	H	VL	L	H	M	VL	M	VL	H	H	H	H		L
Wheeler					H	L	H	VL	H	VL	M	L	H	H	H	VL	M	M	H	H		L
Yamhill					M	H	H	VH	L	M	L	M	L	M	H	H	M	M	H	H		H

Sources: Hazard lead agencies, local Hazard Vulnerability Analyses, dates listed in Table 2-4

This comparison indicates similarities and differences between local and state vulnerability rankings. For some counties, local and state assessments agree on the level of vulnerability to a hazard. In other instances, local and state rankings are not in sync. For example, in several instances a county did not score itself for a hazard (indicating it is not at risk to that hazard), or scored itself “L” (as having low vulnerability) to a hazard, while the state ranked that county as having “H” (high) vulnerability to that hazard.

It would be instructive to compare the hazard leads’ vulnerability scores from 2015 with the scores resulting from the 2020 risk assessment and both with the local vulnerability rankings to see which, if any, are more in sync and investigate why. The results of such a comparison could lead to more accurate assessments both by local practitioners and by improving the 2020 risk assessment methodology. All three perspectives – local practitioners, state hazard experts, and objective data – are necessary for reaching the best assessment of vulnerability.

Local vulnerability assessments are based in part on local knowledge and experience. While this perspective may be skewed by the last hazard event suffered, it also contextualizes the assessment with a depth of knowledge and experience with the community that is valuable to the assessment. Local practitioners with such understanding can identify errors in data, assumptions, or interpretation that may be made by outside experts. They know the places that the population cares about protecting, for example iconic establishments or heritage sites. The local perspective is also helpful on the human side of vulnerability assessment. People know their neighbors and the organizations in the community that serve those in need. They are invaluable in identifying the potential and actual human costs of hazard events.

While the state may provide data and analysis, the local risk assessors can use that data and analysis to derive a deeper understanding of the vulnerabilities of their community, use that knowledge to improve the local risk assessment, and then to more effectively mitigate. Local risk assessments therefore can add depth and granularity to the state risk assessment. As the state strives to incorporate local risk assessments into the state risk assessment (Section **3.6**), this deeper local understanding of local vulnerability and risk, based in part on state data and analysis and in part on local knowledge and experience, will help the state focus its limited resources in communities that need them most and in the ways those communities need them most. This partnership or linkage between state and local mitigation planning promises to be beneficial to both local and state government and most importantly, to the citizens of Oregon.

2.1.2 2020 Risk Assessment Methodology

2.1.2.1 Previous Risk Assessments

During the 2012 Oregon NHMP update process the State realized that no standardized statewide risk assessment methodology is being used across all hazards — each state hazard lead uses a different method to assess risk. This is due in part to the fact that "many state agencies do not have the tools and/or resources to conduct a full risk assessment. Likewise, most agencies do not maintain existing statewide risk assessment data" as identified in Task 5 of the Mid-Planning Alterations to the 2012 work plan. In response, the State allocated remaining federal funds from DR-1733 to support initial stages of the development of a standardized risk assessment model.

Beginning in March 2013, Oregon's Interagency Hazard Mitigation Team (IHMT) established a Risk Assessment Sub-Committee (RAS-C) that worked in partnership with faculty and staff from the University of Oregon's Department of Geography InfoGraphics Lab and Oregon Partnership for Disaster Resilience (OPDR) to develop a new risk assessment model concept. When fully developed and implemented, the model was to provide a standardized way to assess vulnerability to natural hazards in Oregon at the state level thereby allowing the State to better identify where to strategically target mitigation resources. This initiative was facilitated by the Department of Land Conservation and Development (DLCD).

The RAS-C convened a total of five times from March to August to develop a risk assessment methodology that (a) meets federal requirements, (b) draws from the strengths of existing methods, and (c) addresses Oregon's unique priorities. The committee took a four-pronged approach to developing a new risk assessment model. Phase One involved review of natural hazard risk assessment methodologies found in academic literature and in other state Natural Hazards Mitigation Plans. In Phase Two, the UO team developed a proposed risk assessment model concept drawing from the strongest elements of the literature review and other research. While this phase focused heavily on adapting Susan Cutter's Social Vulnerability Index (SoVI), a key driver was the development of a framework tailored toward Oregon that could address key shortcomings identified in the SoVI and other models. In addition, the model incorporated state priorities identified by the RAS-C. Phase Three involved testing the feasibility of the proposed model. Finally, in Phase Four, the UO team developed a timeline, work plan and budget in an effort to identify the resources needed to fully develop the risk assessment model and interface. The proposed 3-year budget was roughly $600,000, which included UO staff and resources.

2.1.2.2 2020 Risk Assessment Procedure

DLCD and partners have tried three times to procure funding for development of the risk assessment concept model; however, the project was not funded and the risk assessment model was never developed. During the 2020 Oregon NHMP update, DLCD sought to adopt a methodology that advanced the goal of employing a standardized risk assessment that could be used across all hazards statewide to inform hazard mitigation prioritization. DLCD surveyed risk assessment methodologies used in other SNHMPs, assessed its capacity to implement various techniques, and incorporated best practices into the 2020 Risk Assessment (2020 RA).

The 2020 RA methodology is driven by the understanding that risk is a function of probability and vulnerability (Wood N. , 2011). **Table 2-2** shows the different state agencies that have been identified as leads over the eleven hazards included in the Plan. Of the eleven, seven are included in the 2020 RA: coastal hazards, earthquakes, floods, landslides, tsunamis, volcanic hazards, and wildfires. Two of the seven—Tsunami and Coastal Hazards—only affect counties in Region 1. The assessment is comprised of the following probability and vulnerability components:

Probability

- Probability of a hazard event

Vulnerability

- Exposure of state-owned and –leased properties to natural hazards
- Exposure of state-owned and –leased critical facilities to natural hazards
- Exposure of local critical facilities to natural hazards
- Social vulnerability index

Relative probability is determined by subject-matter experts who assigned each county a probability score for each hazard. Scores are determined on a 1–5 scale, with 1 being the least probable and 5 being the most. The factors considered to determine probability are hazard-dependent and can be viewed in each hazard chapter of the **State Risk Assessment**.

The 1-5 scale is also used to assign vulnerability scores—both physical and social. Physical, or built-environment vulnerability, is determined using a geographic information system to analyze by hazard the exposure of State-owned and –leased facilities (critical and non-critical) and local critical facilities. Social vulnerability is derived from an index created by the U.S. Center for Disease Control and Prevention (CDC). The physical vulnerability components are combined and rescaled to calculate a 1-5 overall physical vulnerability score. This value is then combined with the social vulnerability score to determine overall vulnerability.

The probability and vulnerability scores are then summed and rescaled to calculate a cumulative 1-5 risk score. Finally, each county was assigned a descriptive ranking for each hazard and for all hazards combined using the Jenks Natural Breaks Classification method; the classification method is shown in **Table 2-6**. The remaining four hazards—drought, extreme heat, windstorms, and winter storms—are not included in the 2020 RA due to insufficient data.

Table 2-6. Risk Score Classification: Natural Breaks and Risk Scores

Natural Breaks & Risk Scores			
Low Cutoff	**High Cutoff**	**Description**	**Abbreviated Description**
0.00	2.10	Very Low	VL
2.11	2.30	Low	L
2.31	2.80	Moderate	M
2.81	3.20	High	H
3.21	5.00	Very High	VL

2.1.2.3 Risk Assessment Progress and Limitations

The 2020 RA takes certain steps toward the goal of standardizing the risk assessment. For example, the methodology enables the comparison of risk across multiple hazards and at different geographic scales—county, region, and state. Moreover, the results are easily mapped, providing useful visualizations of each jurisdiction's relative risk to 7 different natural hazards. Additionally, through incorporating the CDC's SoVI, the 2020 RA makes progress toward identifying those communities that historically have been least able to prepare, respond, and recover after a natural hazard event.

Although the new methodology represents a step forward, the 2020 RA falls short in many areas needed to capture more accurately the nuances in probability, as well as social and physical vulnerability. Moreover, an ideal risk assessment would not be a static model but a living and modifiable tool that would enable hazard mitigation planners across jurisdictions to adjust inputs to assess more accurately risk in their area. The remaining discussion illustrates the limitations of specific components of the 2020 RA and then discusses generally how the assessment could be improved to better model risk and plan for hazard mitigation in the state.

The limitations of the social vulnerability index developed by the CDC are discussed at greater length in Section **2.1.3, Social Vulnerability**; however, a few bear repeating here.

First, the SoVI relies on data from the American Community Survey (ACS). While the ACS is a tremendous resource and frequently provides the best available data on a wide variety of social and economic topics across multiple U.S. geographies, the ACS is a statistical survey and therefore subject to sampling and non-sampling error. In some instances this means that estimates cannot be relied upon—especially when considering geographies that are sparsely populated.

Data currency of the SoVI is another limitation. When the 2020 RA was developed, the most recent version of the CDC index featured data from the ACS 2012–2016 (5-year). The ACS 2014–2018 (5-year) was not released until April 2020, after much of the analysis for the 2020 RA was already been completed.

Finally, the 2020 RA fails to incorporate the total number of people exposed to each hazard, which should be considered along with each population's relative vulnerability. Moreover, although it is widely understood that socially vulnerable communities are not evenly distributed across space, the 2020 RA assumes as much by providing a single SoVI score for each county. Future iterations of the assessment should strive to more accurately model where socially vulnerable communities are concentrated; this effort should also include a spatiotemporal dimension to account for how population distribution is dependent on the time of day.

As mentioned above, the probability score in the 2020 RA is assigned by subject matter experts using different factors depending on the hazard. Although this flexibility enables subject matter experts to use their best judgement and the most appropriate data for each hazard, it also potentially skews the results toward one hazard over another. For example, some experts strictly considered the likelihood of occurrence in their assessment while others discuss aspects of vulnerability in their probability narrative — indicating that the components of the 2020 RA are not as distinct as initially intended. Future iterations of the assessment should present clearer guidelines for determining probability to further standardize the assessment and more accurately depict the relative risk of each hazard.

The methodology for the 2020 RA is straightforward, transparent, and illustrates risk at a macro level; however, the static nature the assessment implies additional limitations. For example, modeling risk at the county-level misses important geographic differences within each county. The ability to model at a more granular level would benefit both physical and social vulnerability. Additionally, the 2020 RA does not allow for weighting or easy modification of the assessment components. Ultimately, these characteristics make it challenging to consider different scenarios at different scales. For example, the current assessment cannot be used to easily model hazard events at different magnitudes; nor is it possible to consider how implementing a mitigation action might influence risk in a particular area.

Finally, the 2020 RA limits the definition of risk to people and property. Among other considerations, a more expansive definition might include how hazards impact the environment.

2.1.2.4 2020 Risk Assessment Components

As described above, the 2020 RA calculates risk using probability and vulnerability components. The following tables show by hazard how each county scored on the various components—revealing which are most influential in determining risk. Again, the components of the 2020 RA are the probability of a hazard event, the physical vulnerability of state-owned and –leased buildings and critical facilities, physical vulnerability of local critical facilities, and social vulnerability. The tables also show—in the far-right-hand columns—how the various components are combined and rescaled to arrive at a county-level risk score for each hazard. The maps following each table visually depict the results from the column labeled “Risk” under the heading “Risk (Prob. + Physical + Social).”

Table 2-7. Coastal Hazards, 2020 Risk Assessment

Coastal Risk Components											
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 1	Clatsop	3.50	2.00	1.00	2.00	1.67	2.00	1.83	L	2.39	M
	Coos	1.75	1.00	1.00	1.00	1.00	4.00	2.50	M	2.25	L
	Curry	2.25	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.75	VL
	Douglas Coastal	1.50	1.00	1.00	1.00	1.00	4.00	2.50	M	2.17	L
	Lane Coastal	1.75	2.00	1.00	1.00	1.33	3.00	2.17	L	2.03	VL
	Lincoln	3.00	4.00	1.00	1.00	2.00	3.00	2.50	M	2.67	M
	Tillamook	4.25	3.00	1.00	2.00	2.00	2.00	2.00	L	2.75	M

*Coastal hazard probability includes probability scores from four coastal hazards: coastal erosion, coastal flooding, coastal landslides, and coastal sand inundation.

Source: DLCD, 2020

Figure 2-3. Coastal Hazards Risk by Region

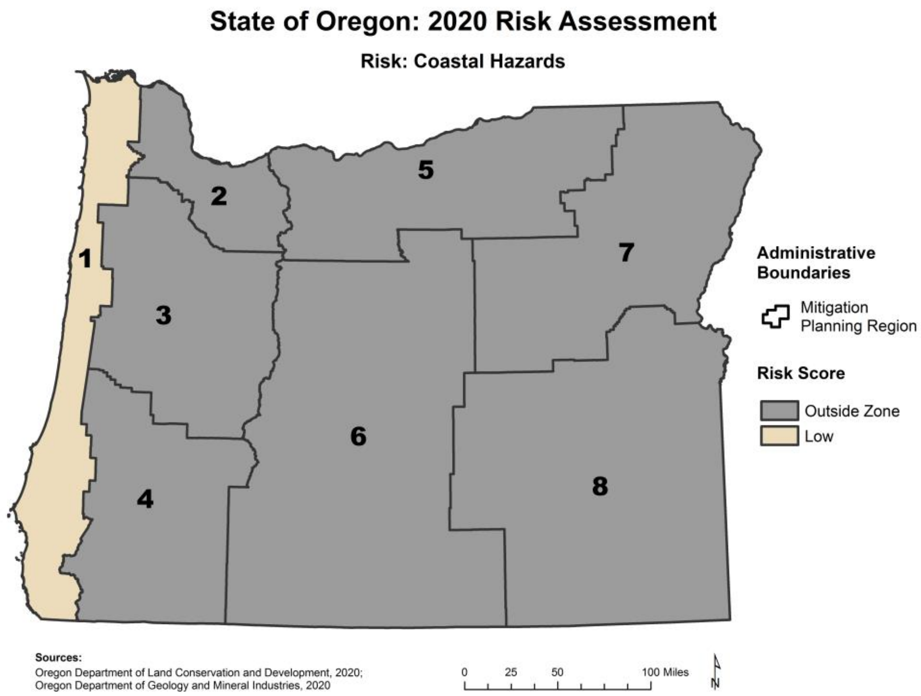


Figure 2-4. Coastal Hazards Risk by County

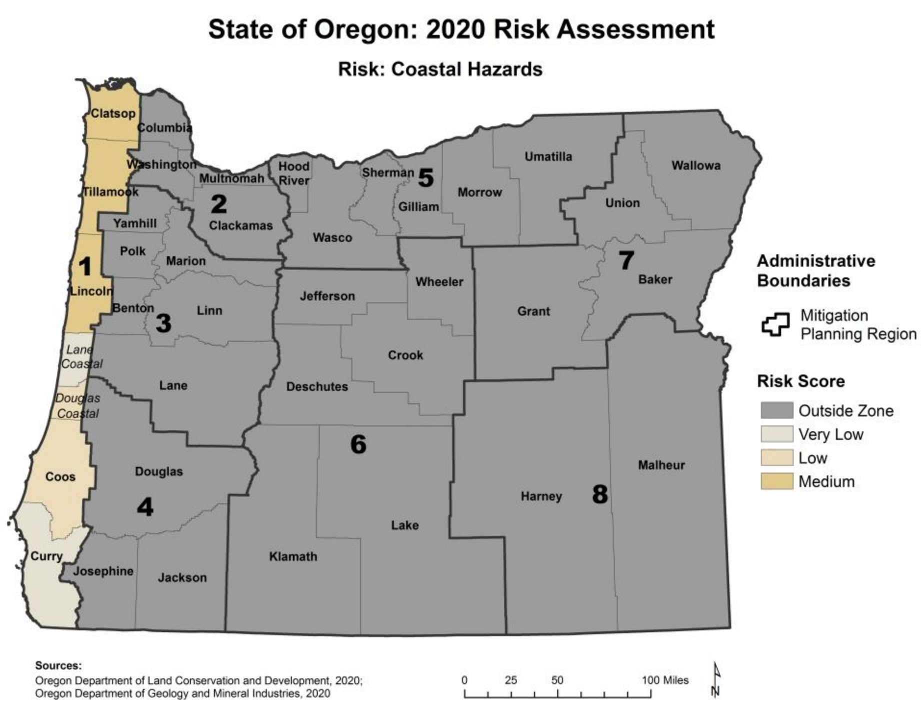


Table 2-8. Earthquake Hazard, 2020 Risk Assessment

Earthquake Risk Components												
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 1	Clatsop	5.00	4.00	4.00	5.00	4.33	2.00	3.17	H	3.78	VH
	Coos	5.00	5.00	5.00	5.00	5.00	4.00	4.50	VH	4.67	VH
	Curry	5.00	4.00	5.00	4.00	4.33	2.00	3.17	H	3.78	VH
	Douglas Coastal	4.00	4.00	4.00	5.00	4.33	4.00	4.17	VH	4.11	VH
	Lane Coastal	4.00	4.00	5.00	4.00	4.33	3.00	3.67	VH	3.78	VH
	Lincoln	4.00	3.00	4.00	4.00	3.67	3.00	3.33	VH	3.56	VH
	Tillamook	4.00	3.00	3.00	4.00	3.33	2.00	2.67	M	3.11	H
Region 2	Clackamas	4.00	2.00	1.00	2.00	1.67	1.00	1.33	VL	2.22	L
	Columbia	5.00	2.00	2.00	2.00	2.00	1.00	1.50	VL	2.67	M
	Multnomah	5.00	2.00	2.00	2.00	2.00	3.00	2.50	M	3.33	VH
	Washington	5.00	2.00	2.00	3.00	2.33	1.00	1.67	L	2.78	M
Region 3	Benton	4.00	2.00	2.00	2.00	2.00	2.00	2.00	L	2.67	M
	Lane	5.00	1.00	1.00	1.00	1.00	3.00	2.00	L	3.00	H
	Linn	4.00	2.00	3.00	3.00	2.67	4.00	3.33	VH	3.56	VH
	Marion	4.00	3.00	3.00	3.00	3.00	5.00	4.00	VH	4.00	VH
	Polk	4.00	1.00	1.00	3.00	1.67	3.00	2.33	M	2.89	H
	Yamhill	4.00	3.00	3.00	2.00	2.67	4.00	3.33	VH	3.56	VH
Region 4	Douglas	4.00	2.00	2.00	2.00	2.00	4.00	3.00	H	3.33	VH
	Jackson	4.00	2.00	2.00	2.00	2.00	4.00	3.00	H	3.33	VH
	Josephine	5.00	2.00	1.00	2.00	1.67	4.00	2.83	H	3.56	VH

Source: DLCD, 2020

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Table 2 7. (*continued*) Earthquake Hazard, 2020 Risk Assessment

Earthquake Risk Components											
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 5	Gilliam	2.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.33	VL
	Hood River	5.00	5.00	5.00	4.00	4.67	3.00	3.83	VH	4.22	VH
	Morrow	2.00	2.00	1.00	2.00	1.67	5.00	3.33	VH	2.89	H
	Sherman	2.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.33	VL
	Umatilla	2.00	2.00	2.00	2.00	2.00	5.00	3.50	VH	3.00	H
	Wasco	3.00	1.00	1.00	2.00	1.33	5.00	3.17	H	3.11	H
Region 6	Crook	2.00	3.00	1.00	2.00	2.00	3.00	2.50	M	2.33	M
	Deschutes	3.00	2.00	2.00	1.00	1.67	1.00	1.33	VL	1.89	VL
	Jefferson	3.00	1.00	1.00	1.00	1.00	5.00	3.00	H	3.00	H
	Klamath	4.00	2.00	2.00	1.00	1.67	5.00	3.33	VH	3.56	VH
	Lake	3.00	3.00	4.00	3.00	3.33	4.00	3.67	VH	3.44	VH
	Wheeler	3.00	1.00	1.00	2.00	1.33	1.00	1.17	VL	1.78	VL
Region 7	Baker	3.00	2.00	3.00	2.00	2.33	2.00	2.17	L	2.44	M
	Grant	3.00	2.00	1.00	2.00	1.67	1.00	1.33	VL	1.89	VL
	Union	2.00	2.00	3.00	2.00	2.33	2.00	2.17	L	2.11	L
	Wallowa	2.00	3.00	4.00	2.00	3.00	2.00	2.50	M	2.33	M
Region 8	Harney	3.00	1.00	1.00	1.00	1.00	3.00	2.00	L	2.33	M
	Malheur	2.00	1.00	1.00	2.00	1.33	5.00	3.17	H	2.78	M

Source: DLCD, 2020

Figure 2-5. Earthquake Hazard Risk by Region

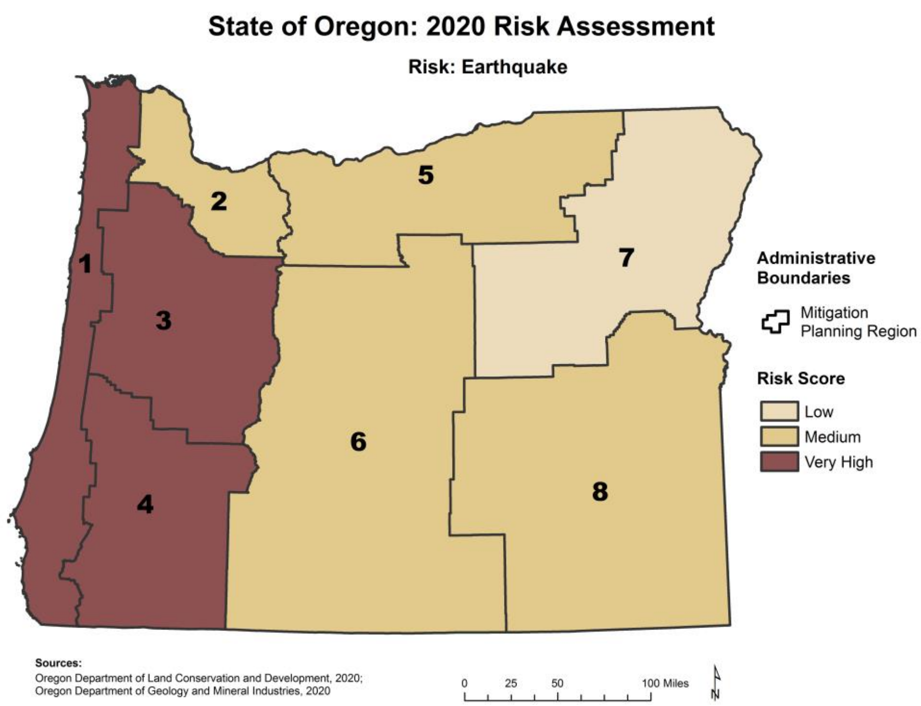

Figure 2-6. Earthquake Hazard Risk by County

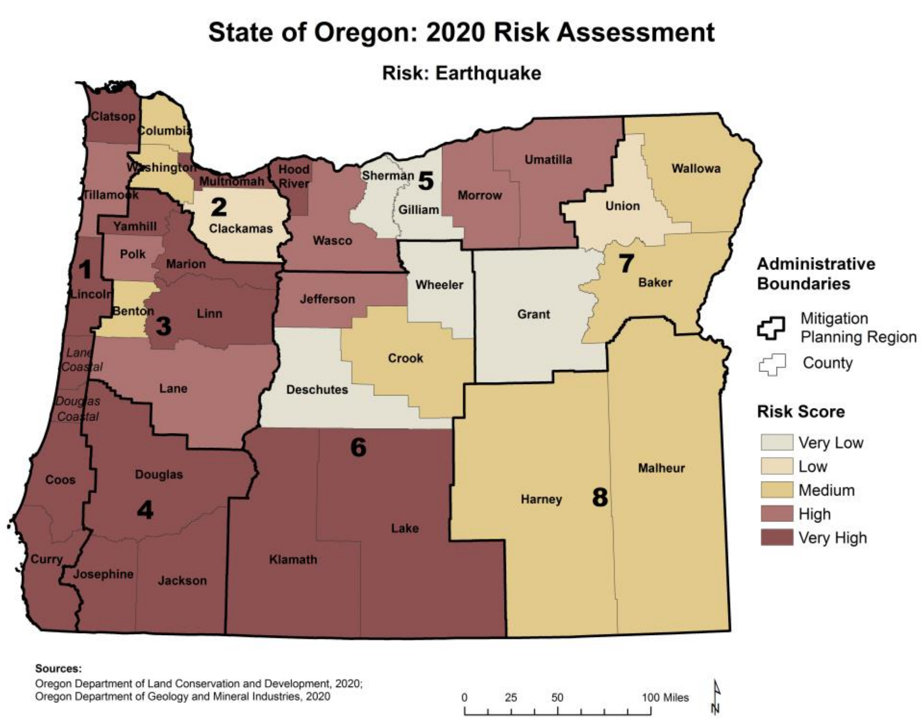

Table 2-9. Flood Hazard, 2020 Risk Assessment

Flood Risk Components												
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 1	Clatsop	5.00	1.00	1.00	3.00	1.67	2.00	1.83	L	2.89	H
	Coos	5.00	1.00	1.00	3.00	1.67	4.00	2.83	H	3.56	VH
	Curry	5.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	2.67	M
	Douglas Coastal	5.00	2.00	1.00	2.00	1.67	4.00	2.83	H	3.56	VH
	Lane Coastal	5.00	3.00	1.00	2.00	2.00	3.00	2.50	M	3.33	VH
	Lincoln	5.00	2.00	1.00	1.00	1.33	3.00	2.17	L	3.11	H
	Tillamook	5.00	1.00	1.00	3.00	1.67	2.00	1.83	L	2.89	H
Region 2	Clackamas	5.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	2.33	M
	Columbia	5.00	2.00	1.00	3.00	2.00	1.00	1.50	VL	2.67	M
	Multnomah	5.00	4.00	5.00	3.00	4.00	3.00	3.50	V	4.00	VH
	Washington	4.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	2.00	VL
Region 3	Benton	5.00	1.00	1.00	4.00	2.00	2.00	2.00	L	3.00	H
	Lane	5.00	2.00	2.00	3.00	2.33	3.00	2.67	M	3.44	VH
	Linn	5.00	2.00	1.00	2.00	1.67	4.00	2.83	H	3.56	VH
	Marion	4.00	3.00	3.00	3.00	3.00	5.00	4.00	VH	4.00	VH
	Polk	4.00	2.00	1.00	2.00	1.67	3.00	2.33	M	2.89	H
	Yamhill	4.00	1.00	1.00	2.00	1.33	4.00	2.67	M	3.11	H
Region 4	Douglas	5.00	1.00	2.00	3.00	2.00	4.00	3.00	H	3.67	VH
	Jackson	4.00	3.00	3.00	2.00	2.67	4.00	3.33	VH	3.56	VH
	Josephine	5.00	2.00	1.00	2.00	1.67	4.00	2.83	H	3.56	VH

Source: DLCD, 2020

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Table 2 8. (*continued*) Flood Hazard, 2020 Risk Assessment

Flood Risk Components											
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 5	Gilliam	4.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	2.00	VL
	Hood River	4.00	1.00	1.00	1.00	1.00	3.00	2.00	L	2.67	M
	Morrow	4.00	2.00	1.00	3.00	2.00	5.00	3.50	VH	3.67	VH
	Sherman	4.00	4.00	1.00	4.00	3.00	1.00	2.00	L	2.67	M
	Umatilla	4.00	1.00	1.00	1.00	1.00	5.00	3.00	H	3.33	VH
	Wasco	4.00	1.00	1.00	1.00	1.00	5.00	3.00	H	3.33	VH
Region 6	Crook	2.00	1.00	1.00	5.00	2.33	3.00	2.67	M	2.44	M
	Deschutes	2.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.33	VL
	Jefferson	2.00	1.00	1.00	4.00	2.00	5.00	3.50	VH	3.00	H
	Klamath	2.00	1.00	1.00	1.00	1.00	5.00	3.00	H	2.67	M
	Lake	2.00	1.00	1.00	2.00	1.33	4.00	2.67	M	2.44	M
	Wheeler	4.00	1.00	1.00	4.00	2.00	1.00	1.50	VL	2.33	M
Region 7	Baker	3.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	2.00	VL
	Grant	4.00	5.00	4.00	4.00	4.33	1.00	2.67	M	3.11	H
	Union	2.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.67	VL
	Wallowa	4.00	2.00	1.00	1.00	1.33	2.00	1.67	L	2.44	M
Region 8	Harney	3.00	3.00	3.00	4.00	3.33	3.00	3.17	H	3.11	H
	Malheur	3.00	1.00	1.00	2.00	1.33	5.00	3.17	H	3.11	H

Source: DLCD, 2020

Figure 2-7. Flood Hazard Risk by Region

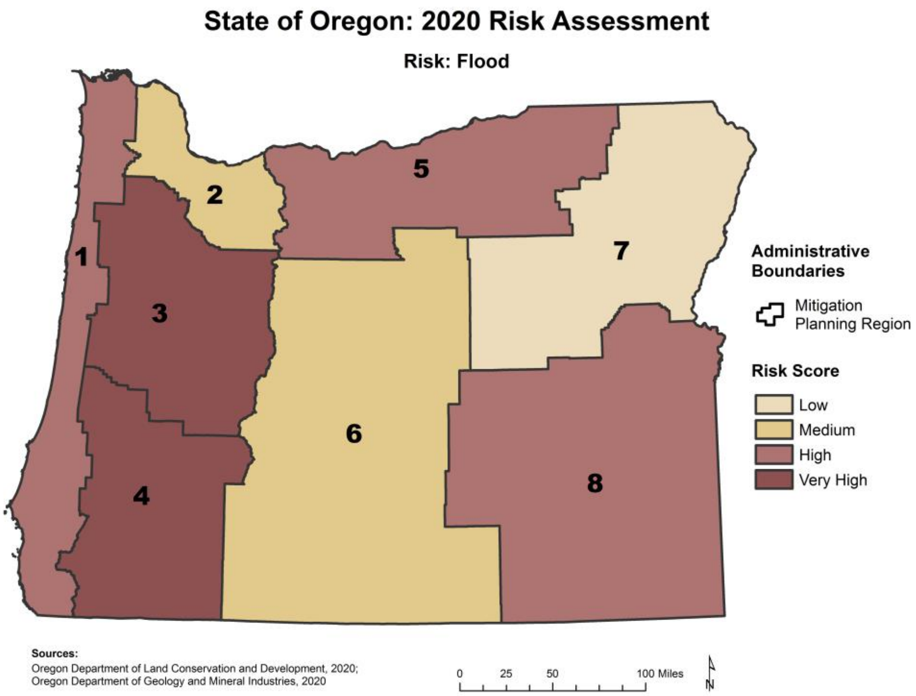


Figure 2-8. Flood Hazards Risk by County

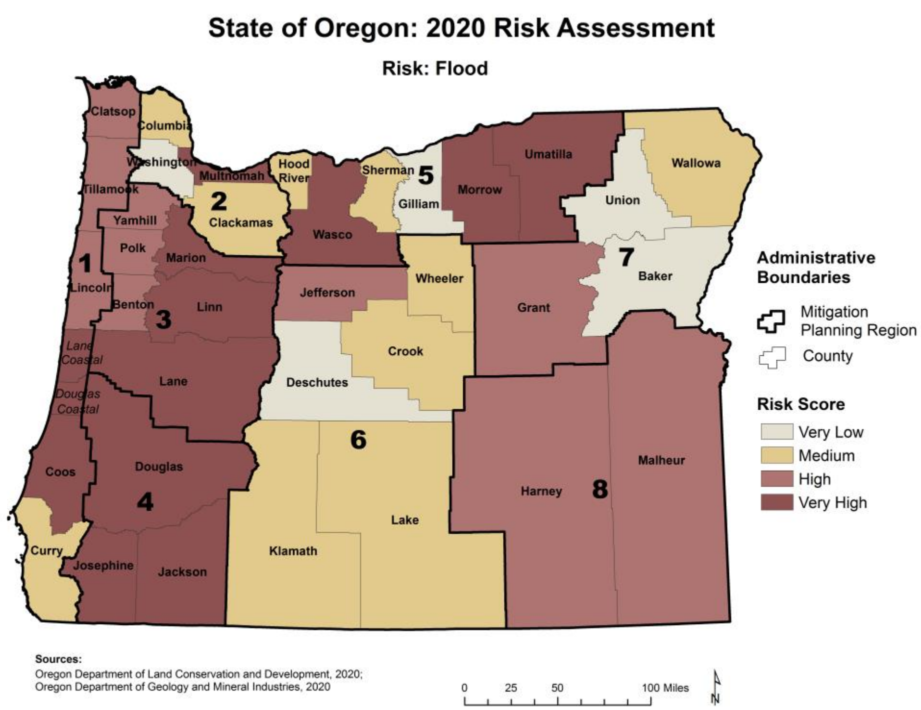


Table 2-10. Landslide Hazard, 2020 Risk Assessment

Landslide Risk Components											
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 1	Clatsop	5.00	2.00	1.00	4.00	2.33	2.00	2.17	L	3.11	H
	Coos	5.00	1.00	1.00	4.00	2.00	4.00	3.00	H	3.67	VH
	Curry	5.00	4.00	1.00	2.00	2.33	2.00	2.17	L	3.11	H
	Douglas Coastal	5.00	2.00	2.00	3.00	2.33	4.00	3.17	H	3.78	VH
	Lane Coastal	5.00	3.00	1.00	4.00	2.67	3.00	2.83	H	3.56	VH
	Lincoln	5.00	4.00	5.00	4.00	4.33	3.00	3.67	VH	4.11	VH
	Tillamook	5.00	3.00	4.00	4.00	3.67	2.00	2.83	H	3.56	VH
Region 2	Clackamas	4.00	1.00	1.00	2.00	1.33	1.00	1.17	VL	2.11	L
	Columbia	5.00	5.00	1.00	3.00	3.00	1.00	2.00	L	3.00	H
	Multnomah	4.00	1.00	1.00	2.00	1.33	3.00	2.17	L	2.78	M
	Washington	4.00	1.00	1.00	2.00	1.33	1.00	1.17	VL	2.11	L
Region 3	Benton	4.00	1.00	2.00	2.00	1.67	2.00	1.83	L	2.56	M
	Lane	5.00	2.00	3.00	1.00	2.00	3.00	2.50	M	3.33	VH
	Linn	4.00	2.00	1.00	1.00	1.33	4.00	2.67	M	3.11	H
	Marion	4.00	1.00	1.00	1.00	1.00	5.00	3.00	H	3.33	VH
	Polk	4.00	1.00	1.00	2.00	1.33	3.00	2.17	L	2.78	M
	Yamhill	5.00	1.00	1.00	2.00	1.33	4.00	2.67	M	3.44	VH
Region 4	Douglas	5.00	2.00	2.00	3.00	2.33	4.00	3.17	H	3.78	VH
	Jackson	5.00	1.00	2.00	3.00	2.00	4.00	3.00	H	3.67	VH
	Josephine	5.00	1.00	2.00	1.00	1.33	4.00	2.67	M	3.44	VH

Source: DLCD, 2020

(Table continued on next page)

Table 2 9. (*continued*) Landslide Hazard, 2020 Risk Assessment

Landslide Risk Components													
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 5	Gilliam	4.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	2.00	L
	Hood River	5.00	3.00	1.00	3.00	2.33	3.00	2.67	M	3.44	VH
	Morrow	2.00	1.00	1.00	2.00	1.33	5.00	3.17	H	2.78	H
	Sherman	3.00	3.00	1.00	1.00	1.67	1.00	1.33	VL	1.89	L
	Umatilla	3.00	1.00	1.00	2.00	1.33	5.00	3.17	H	3.11	VH
	Wasco	4.00	2.00	1.00	4.00	2.33	5.00	3.67	VH	3.78	VH
Region 6	Crook	3.00	4.00	1.00	1.00	2.00	3.00	2.50	M	2.67	H
	Deschutes	2.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.33	L
	Jefferson	4.00	1.00	1.00	2.00	1.33	5.00	3.17	H	3.44	VH
	Klamath	2.00	1.00	1.00	1.00	1.00	5.00	3.00	H	2.67	H
	Lake	2.00	1.00	2.00	1.00	1.33	4.00	2.67	M	2.44	H
	Wheeler	5.00	2.00	2.00	5.00	3.00	1.00	2.00	L	3.00	VH
Region 7	Baker	4.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	2.33	H
	Grant	4.00	1.00	1.00	3.00	1.67	1.00	1.33	VL	2.22	M
	Union	4.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	2.33	H
	Wallowa	5.00	1.00	1.00	4.00	2.00	2.00	2.00	L	3.00	VH
Region 8	Harney	2.00	1.00	1.00	1.00	1.00	3.00	2.00	L	2.00	L
	Malheur	2.00	1.00	1.00	2.00	1.33	5.00	3.17	H	2.78	H

Source: DLCD, 2020

Figure 2-9. Landslide Hazard Risk by Region

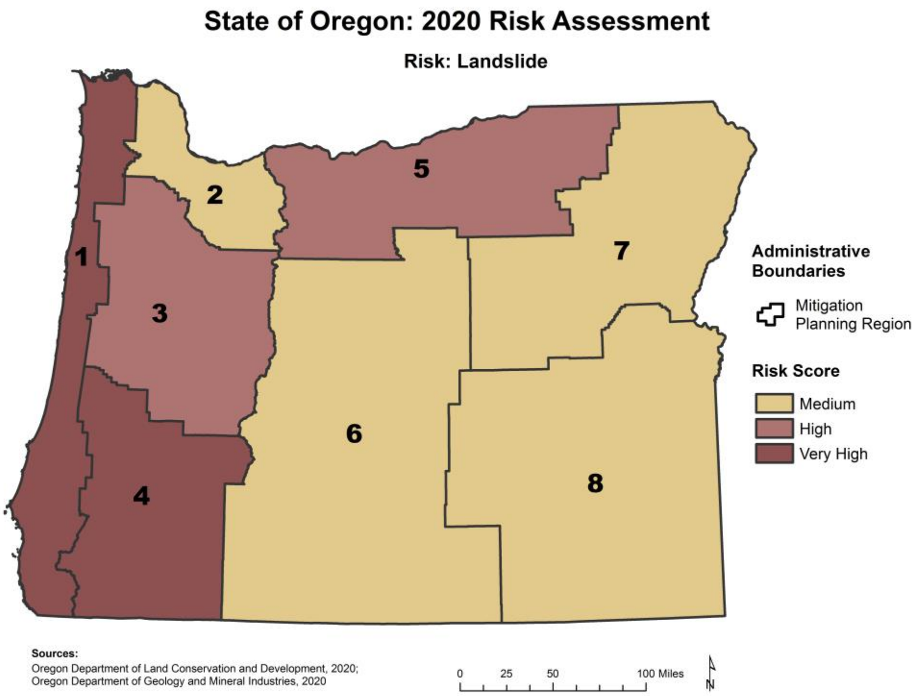


Figure 2-10. Landslide Hazards Risk by County

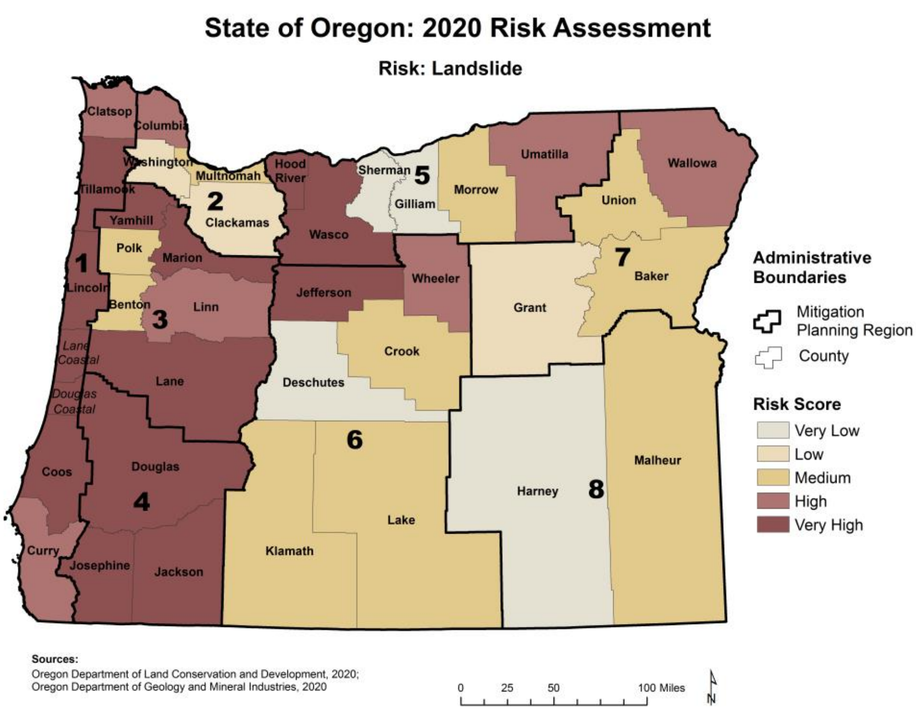


Table 2-11. Tsunami Hazard, 2020 Risk Assessment

Tsunami Risk Components												
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 1	Clatsop	4.00	5.00	4.00	5.00	4.67	2.00	3.33	VH	3.56	VH
	Coos	5.00	4.00	5.00	3.00	4.00	4.00	4.00	VH	4.33	VH
	Curry	5.00	2.00	1.00	1.00	1.33	2.00	1.67	L	2.78	M
	Douglas Coastal	4.00	2.00	1.00	3.00	2.00	4.00	3.00	H	3.33	VH
	Lane Coastal	4.00	4.00	3.00	4.00	3.67	3.00	3.33	VH	3.56	VH
	Lincoln	4.00	3.00	2.00	2.00	2.33	3.00	2.67	M	3.11	H
	Tillamook	4.00	1.00	1.00	4.00	2.00	2.00	2.00	L	2.67	M

Source: DLCD, 2020

Figure 2-11. Tsunami Hazard Risk by Region

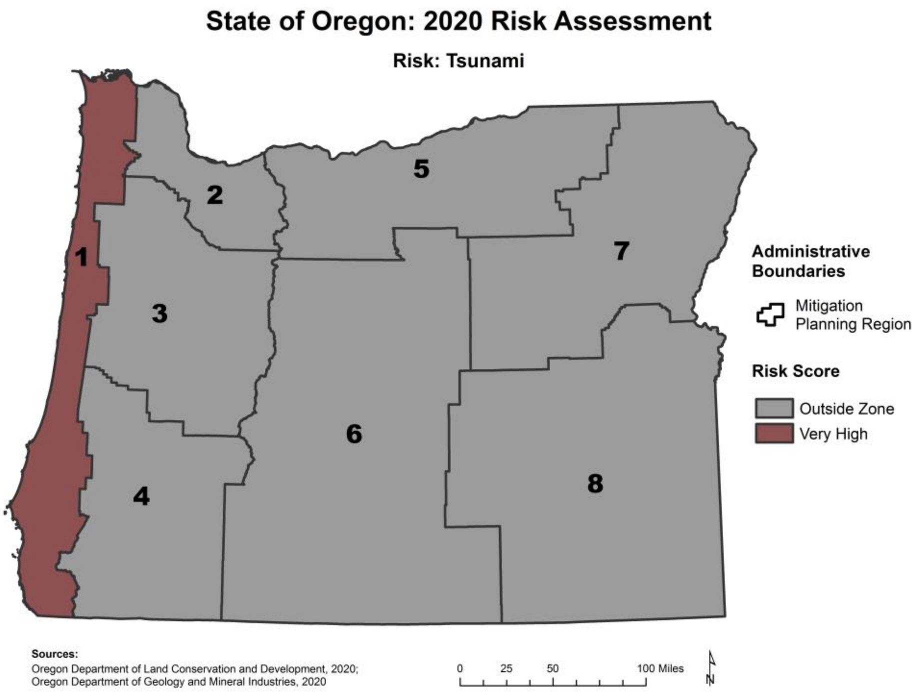


Figure 2-12. Tsunami Hazards Risk by County

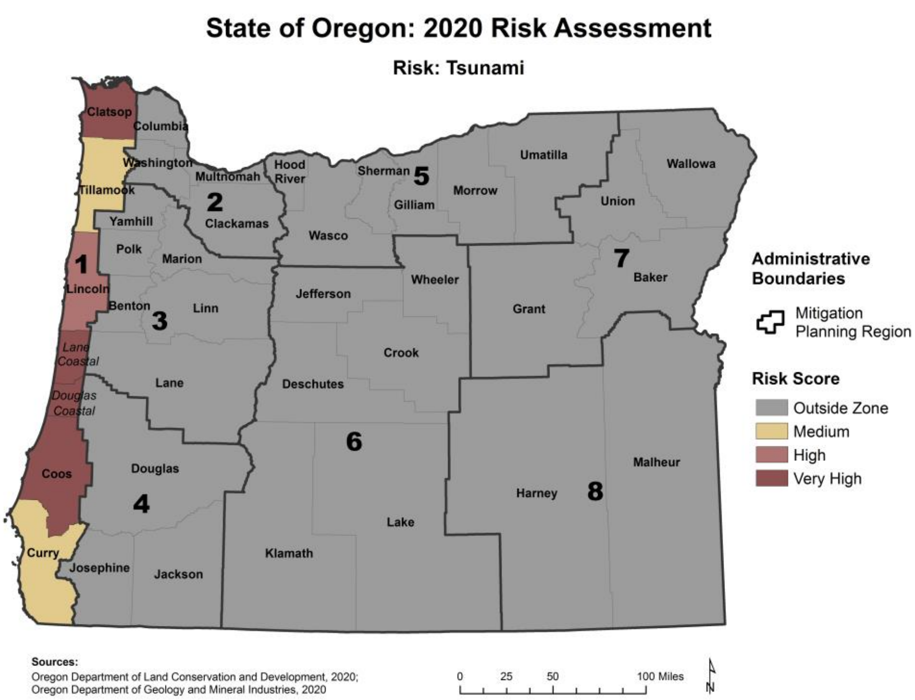


Table 2-12. Volcanic Hazard, 2020 Risk Assessment

Volcanic Risk Components												
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 1	Clatsop	1.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.33	VL
	Coos	1.00	1.00	1.00	1.00	1.00	4.00	2.50	M	2.00	VL
	Curry	1.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.33	VL
	Douglas Coastal	1.00	1.00	1.00	1.00	1.00	4.00	2.50	M	2.00	VL
	Lane Coastal	1.00	1.00	1.00	1.00	1.00	3.00	2.00	L	1.67	VL
	Lincoln	1.00	1.00	1.00	1.00	1.00	3.00	2.00	L	1.67	VL
	Tillamook	1.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.33	VL
Region 2	Clackamas	3.00	3.00	4.00	2.00	3.00	1.00	2.00	L	2.33	M
	Columbia	1.50	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.17	VL
	Multnomah	3.00	1.00	1.00	1.00	1.00	3.00	2.00	L	2.33	M
	Washington	1.50	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.17	VL
Region 3	Benton	1.50	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.50	VL
	Lane	3.00	5.00	3.00	2.00	3.33	3.00	3.17	H	3.11	H
	Linn	3.00	1.00	1.00	4.00	2.00	4.00	3.00	H	3.00	H
	Marion	3.00	1.00	2.00	3.00	2.00	5.00	3.50	VH	3.33	VH
	Polk	1.50	1.00	1.00	1.00	1.00	3.00	2.00	L	1.83	VL
	Yamhill	1.50	1.00	1.00	1.00	1.00	4.00	2.50	M	2.17	L
Region 4	Douglas	3.00	1.00	1.00	1.00	1.00	4.00	2.50	M	2.67	M
	Jackson	3.00	1.00	1.00	1.00	1.00	4.00	2.50	M	2.67	M
	Josephine	1.50	1.00	1.00	1.00	1.00	4.00	2.50	M	2.17	L

Source: DLCD, 2020

(Table continued on next page)

Table 2 11. (*continued*) Volcanic Hazard, 2020 Risk Assessment

Volcanic Risk Components												
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 5	Gilliam	2.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.33	VL
	Hood River	3.00	5.00	1.00	5.00	3.67	3.00	3.33	VH	3.22	VH
	Morrow	2.00	1.00	1.00	1.00	1.00	5.00	3.00	H	2.67	M
	Sherman	2.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.33	VL
	Umatilla	2.00	1.00	1.00	1.00	1.00	5.00	3.00	H	2.67	M
	Wasco	3.00	2.00	1.00	1.00	1.33	5.00	3.17	H	3.11	H
Region 6	Crook	1.50	1.00	1.00	1.00	1.00	3.00	2.00	L	1.83	VL
	Deschutes	3.00	4.00	4.00	5.00	4.33	1.00	2.67	M	2.78	M
	Jefferson	3.00	2.00	1.00	3.00	2.00	5.00	3.50	VH	3.33	VH
	Klamath	3.00	1.00	1.00	1.00	1.00	5.00	3.00	H	3.00	H
	Lake	1.50	1.00	1.00	1.00	1.00	4.00	2.50	M	2.17	L
	Wheeler	1.50	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.17	VL
Region 7	Baker	1.50	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.50	VL
	Grant	2.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.33	VL
	Union	1.50	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.50	VL
	Wallowa	1.50	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.50	VL
Region 8	Harney	1.50	1.00	1.00	1.00	1.00	3.00	2.00	L	1.83	VL
	Malheur	1.50	1.00	1.00	1.00	1.00	5.00	3.00	H	2.50	M

Source: DLCD, 2020

Figure 2-13. Volcanic Hazard Risk by Region

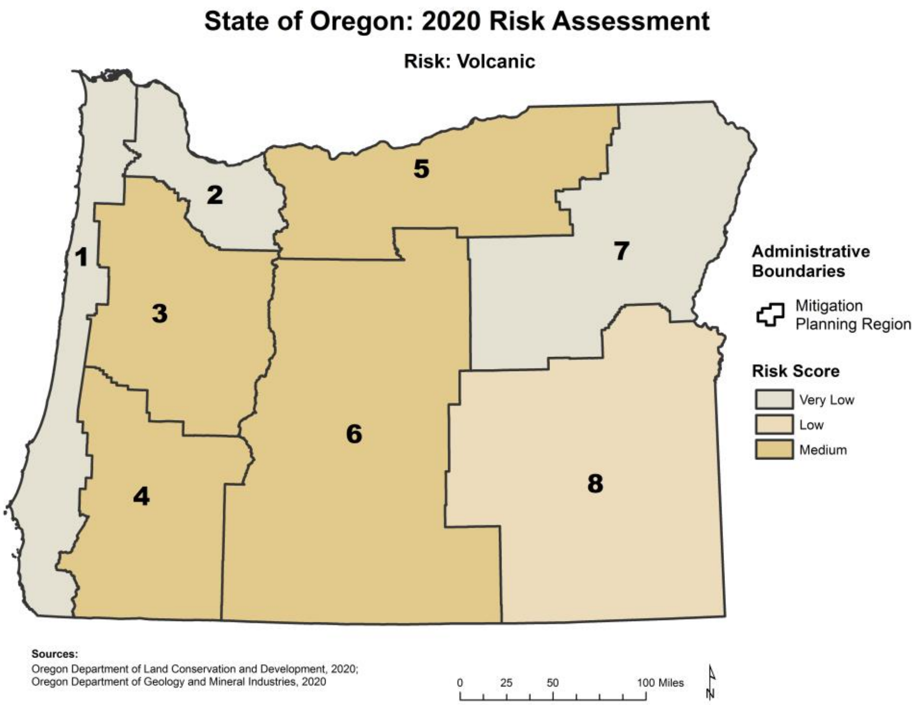


Figure 2-14. Volcanic Hazard Risk by County

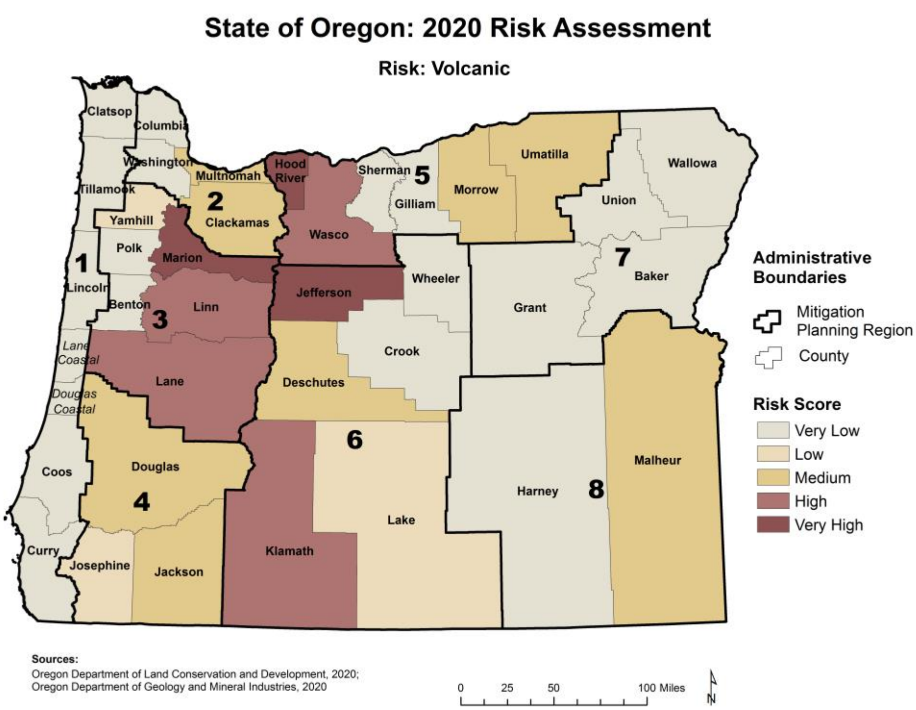


Table 2-13. Wildfire Hazard, 2020 Risk Assessment

Wildfire Risk Components												
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 1	Clatsop	2.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.67	VL
	Coos	2.00	1.00	1.00	1.00	1.00	4.00	2.50	M	2.33	M
	Curry	1.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.33	VL
	Douglas Coastal	3.00	1.00	1.00	1.00	1.00	4.00	2.50	M	2.67	M
	Lane Coastal	2.00	2.00	2.00	2.00	2.00	3.00	2.50	M	2.33	M
	Lincoln	1.00	1.00	1.00	1.00	1.00	3.00	2.00	L	1.67	VL
	Tillamook	2.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.67	VL
Region 2	Clackamas	2.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.33	VL
	Columbia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.00	VL
	Multnomah	2.00	1.00	1.00	1.00	1.00	3.00	2.00	L	2.00	VL
	Washington	1.00	1.00	1.00	1.00	1.00	1.00	1.00	VL	1.00	VL
Region 3	Benton	2.00	1.00	1.00	1.00	1.00	2.00	1.50	VL	1.67	VL
	Lane	3.00	1.00	1.00	1.00	1.00	3.00	2.00	L	2.33	M
	Linn	2.00	1.00	1.00	1.00	1.00	4.00	2.50	M	2.33	M
	Marion	2.00	1.00	1.00	1.00	1.00	5.00	3.00	H	2.67	M
	Polk	1.00	1.00	1.00	1.00	1.00	3.00	2.00	L	1.67	VL
	Yamhill	2.00	1.00	1.00	1.00	1.00	4.00	2.50	M	2.33	M
Region 4	Douglas	5.00	2.00	1.00	2.00	1.67	4.00	2.83	H	3.56	VH
	Jackson	5.00	2.00	1.00	1.00	1.33	4.00	2.67	M	3.44	VH
	Josephine	4.00	1.00	1.00	2.00	1.33	4.00	2.67	M	3.11	H

Source: DLCD, 2020

(Table continued on next page)

Table 2 12. (*continued*) Wildfire Hazard, 2020 Risk Assessment

Wildfire Risk Components											
		Probability*	Physical Vulnerability				Social Vulnerability	Vulnerability (Social + Physical)		Risk (Prob. + Physical + Social)	
Region	County		State Buildings	State Critical Facilities	Local Critical Facilities	Total Combined & Rescaled		Total Combined & Rescaled	Vulnerability	Total Combined & Rescaled	Risk
Region 5	Gilliam	3.00	1.00	1.00	2.00	1.33	1.00	1.17	VL	1.78	VL
	Hood River	3.00	2.00	3.00	3.00	2.67	3.00	2.83	H	2.89	H
	Morrow	4.00	2.00	3.00	3.00	2.67	5.00	3.83	VH	3.89	VH
	Sherman	3.00	3.00	2.00	4.00	3.00	1.00	2.00	L	2.33	M
	Umatilla	4.00	1.00	1.00	1.00	1.00	5.00	3.00	H	3.33	VH
	Wasco	5.00	3.00	2.00	2.00	2.33	5.00	3.67	VH	4.11	VH
Region 6	Crook	4.00	4.00	4.00	2.00	3.33	3.00	3.17	H	3.44	VH
	Deschutes	4.00	3.00	3.00	3.00	3.00	1.00	2.00	L	2.67	M
	Jefferson	5.00	5.00	5.00	1.00	3.67	5.00	4.33	VH	4.56	VH
	Klamath	3.00	2.00	1.00	2.00	1.67	5.00	3.33	VH	3.22	VH
	Lake	3.00	2.00	1.00	3.00	2.00	4.00	3.00	H	3.00	H
	Wheeler	4.00	5.00	5.00	5.00	5.00	1.00	3.00	H	3.33	VH
Region 7	Baker	5.00	2.00	1.00	2.00	1.67	2.00	1.83	L	2.89	H
	Grant	5.00	4.00	4.00	3.00	3.67	1.00	2.33	M	3.22	VH
	Union	5.00	2.00	2.00	1.00	1.67	2.00	1.83	L	2.89	H
	Wallowa	3.00	4.00	2.00	2.00	2.67	2.00	2.33	M	2.56	M
Region 8	Harney	4.00	2.00	2.00	3.00	2.33	3.00	2.67	M	3.11	H
	Malheur	4.00	4.00	4.00	2.00	3.33	5.00	4.17	VH	4.11	VH

Source: DLCD, 2020

Figure 2-15. Wildfire Hazard Risk by Region

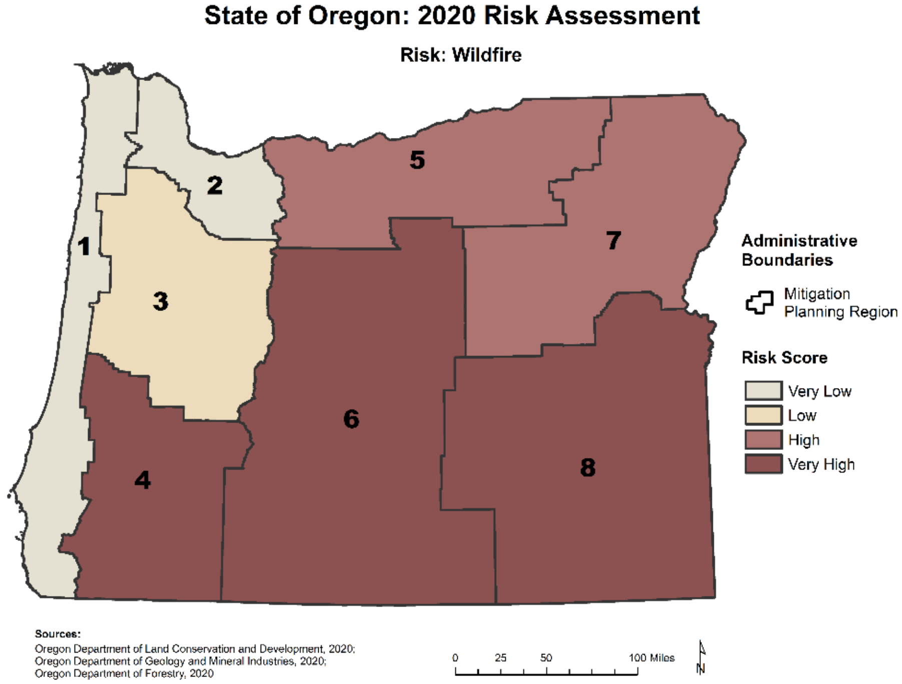
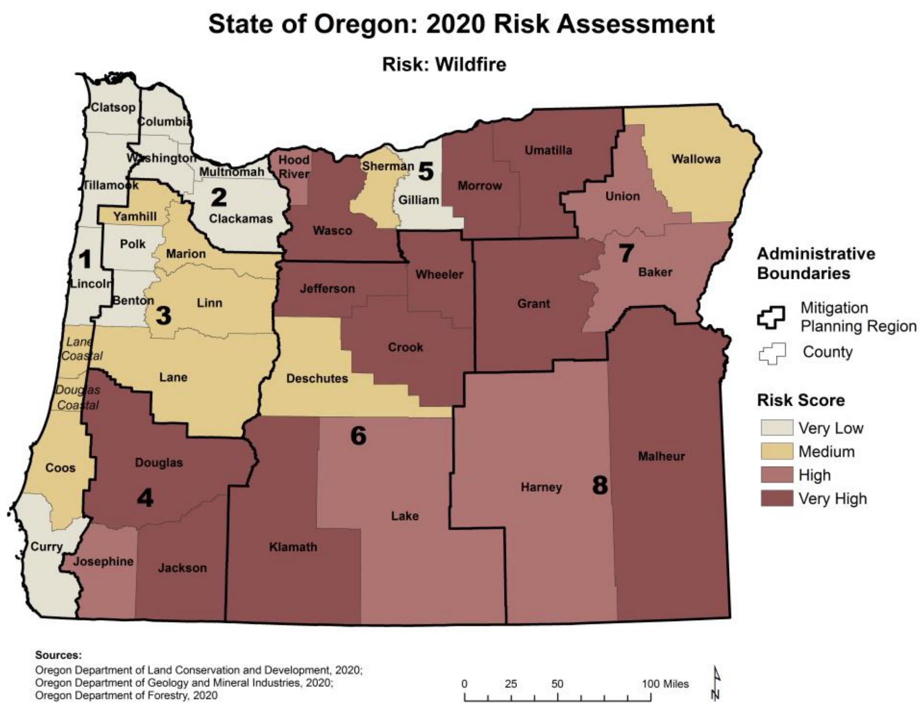


Figure 2-16. Wildfire Hazard Risk by County



2.1.2.5 2020 Risk Assessment Findings

While the component tables offer a detailed look at what is driving risk to individual hazards, **Table 2-14**, **Seven Hazards Combined, 2020 Risk Assessment** shows which counties are most at risk when all seven hazards are considered together.

According to the 2020 RA, seven counties are at very high risk when all seven hazards are considered together: Coos County, Marion County, Douglas County, Jackson County, Hood River County, Wasco County, and Jefferson County. These results are presented in the column labeled “Risk” under the heading “All Hazards (7),” and are mapped in **Figure 2-18**, **Seven Hazards Combined Risk by County**. In addition to each Oregon County, a combined risk score is also calculated for each hazard planning region. Of the eight, Region 4 is the only region that is at very high risk when the seven hazards are considered collectively. This result is mapped in **Figure 2-17**, **Seven Hazards Combined Risk by Region**.

Between the seven hazards, earthquakes pose a very high risk to the greatest number of counties—sixteen in total. Landslides pose a very high risk to fourteen counties, and flooding possess a very high risk to thirteen counties.

Ten counties, or county-equivalents, are at very high risk to three or more hazards. Seven overlap with the counties that are at very high risk when all seven hazards are considered together. Lane Coastal, Douglas Coastal, and Josephine County are the three additional counties.

Table 2-14. Seven Hazards Combined, 2020 Risk Assessment

	Coastal Hazards		Earthquake		Flood		Landslide		Tsunami		Volcanic		Wildfire		All Hazards (7)	
	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk
Oregon	2.29	L	2.99	H	2.92	H	2.94	H	3.33	VH	2.09	VL	2.62	M		
Region 1	2.29	L	3.83	VH	3.14	H	3.56	VH	3.33	VH	1.62	VL	1.95	VL	2.82	H
Clatsop	2.39	M	3.78	VH	2.89	H	3.11	H	3.56	VH	1.33	VL	1.67	VL	2.67	M
Coos	2.25	L	4.67	VH	3.56	VH	3.67	VH	4.33	VH	2.00	VL	2.33	M	3.26	VH
Curry	1.75	VL	3.78	VH	2.67	M	3.11	H	2.78	M	1.33	VL	1.33	VL	2.39	M
Douglas Coastal	2.17	L	4.11	VH	3.56	VH	3.78	VH	3.33	VH	2.00	VL	2.67	M	3.09	H
Lane Coastal	2.03	VL	3.78	VH	3.33	VH	3.56	VH	3.56	VH	1.67	VL	2.33	M	2.89	H
Lincoln	2.67	M	3.56	VH	3.11	H	4.11	VH	3.11	H	1.67	VL	1.67	VL	2.84	H
Tillamook	2.75	M	3.11	H	2.89	H	3.56	VH	2.67	M	1.33	VL	1.67	VL	2.57	M
Region 2	—	—	2.75	M	2.75	M	2.50	M	—	—	1.75	VL	1.33	VL	2.22	L
Clackamas	—	—	2.22	L	2.33	M	2.11	L	—	—	2.33	M	1.33	VL	2.07	VL
Columbia	—	—	2.67	M	2.67	M	3.00	H	—	—	1.17	VL	1.00	VL	2.10	VL
Multnomah	—	—	3.33	VH	4.00	VH	2.78	M	—	—	2.33	M	2.00	VL	2.89	H
Washington	—	—	2.78	M	2.00	VL	2.11	L	—	—	1.17	VL	1.00	VL	1.81	VL
Region 3	—	—	3.28	VH	3.33	VH	3.09	H	—	—	2.49	M	2.17	L	2.87	H
Benton	—	—	2.67	M	3.00	H	2.56	M	—	—	1.50	VL	1.67	VL	2.28	L
Lane	—	—	3.00	H	3.44	VH	3.33	VH	—	—	3.11	H	2.33	M	3.04	H
Linn	—	—	3.56	VH	3.56	VH	3.11	H	—	—	3.00	H	2.33	M	3.11	H
Marion	—	—	4.00	VH	4.00	VH	3.33	VH	—	—	3.33	VH	2.67	M	3.47	VH
Polk	—	—	2.89	H	2.89	H	2.78	M	—	—	1.83	VL	1.67	VL	2.41	M
Yamhill	—	—	3.56	VH	3.11	H	3.44	VH	—	—	2.17	L	2.33	M	2.92	H
Region 4	—	—	3.41	VH	3.59	VH	3.63	VH	—	—	2.50	M	3.37	VH	3.30	VH
Douglas	—	—	3.33	VH	3.67	VH	3.78	VH	—	—	2.67	M	3.56	VH	3.40	VH
Jackson	—	—	3.33	VH	3.56	VH	3.67	VH	—	—	2.67	M	3.44	VH	3.33	VH
Josephine	—	—	3.56	VH	3.56	VH	3.44	VH	—	—	2.17	L	3.11	H	3.17	H

Source: DLCD, 2020

(Table continued on next page)

Table 2 13. (*continued*) Seven Hazards Combined, 2020 Risk Assessment

	Coastal Hazards		Earthquake		Flood		Landslide		Tsunami		Volcanic		Wildfire		All Hazards (7)	
	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk
Oregon	2.29	L	2.99	H	2.92	H	2.94	H	3.33	VH	2.09	VL	2.62	M		
Region 5	—	—	2.65	M	2.94	H	2.83	H	—	—	2.39	M	3.06	H	2.77	M
Gilliam	—	—	1.33	VL	2.00	VL	2.00	VL	—	—	1.33	VL	1.78	VL	1.69	VL
Hood River	—	—	4.22	VH	2.67	M	3.44	VH	—	—	3.22	VH	2.89	H	3.29	VH
Morrow	—	—	2.89	H	3.67	VH	2.78	M	—	—	2.67	M	3.89	VH	3.18	H
Sherman	—	—	1.33	VL	2.67	M	1.89	VL	—	—	1.33	VL	2.33	M	1.91	VL
Umatilla	—	—	3.00	H	3.33	VH	3.11	H	—	—	2.67	M	3.33	VH	3.09	H
Wasco	—	—	3.11	H	3.33	VH	3.78	VH	—	—	3.11	H	4.11	VH	3.49	VH
Region 6	—	—	2.67	M	2.37	M	2.59	M	—	—	2.38	M	3.37	VH	2.68	M
Crook	—	—	2.33	M	2.44	M	2.67	M	—	—	1.83	VL	3.44	VH	2.54	M
Deschutes	—	—	1.89	VL	1.33	VL	1.33	VL	—	—	2.78	M	2.67	M	2.00	VL
Jefferson	—	—	3.00	H	3.00	H	3.44	VH	—	—	3.33	VH	4.56	VH	3.47	VH
Klamath	—	—	3.56	VH	2.67	M	2.67	M	—	—	3.00	H	3.22	VH	3.02	H
Lake	—	—	3.44	VH	2.44	M	2.44	M	—	—	2.17	L	3.00	H	2.70	M
Wheeler	—	—	1.78	VL	2.33	M	3.00	H	—	—	1.17	VL	3.33	VH	2.32	M
Region 7	—	—	2.19	L	2.31	L	2.47	M	—	—	1.46	VL	2.89	H	2.26	L
Baker	—	—	2.44	M	2.00	VL	2.33	M	—	—	1.50	VL	2.89	H	2.23	L
Grant	—	—	1.89	VL	3.11	H	2.22	L	—	—	1.33	VL	3.22	VH	2.36	M
Union	—	—	2.11	L	1.67	VL	2.33	M	—	—	1.50	VL	2.89	H	2.10	VL
Wallowa	—	—	2.33	M	2.44	M	3.00	H	—	—	1.50	VL	2.56	M	2.37	M
Region 8	—	—	2.56	M	3.11	H	2.39	M	—	—	2.17	L	3.61	VH	2.77	M
Harney	—	—	2.33	M	3.11	H	2.00	VL	—	—	1.83	VL	3.11	H	2.48	M
Malheur	—	—	2.78	M	3.11	H	2.78	M	—	—	2.50	M	4.11	VH	3.06	H

Figure 2-17. Seven Hazards Combined Risk by Region

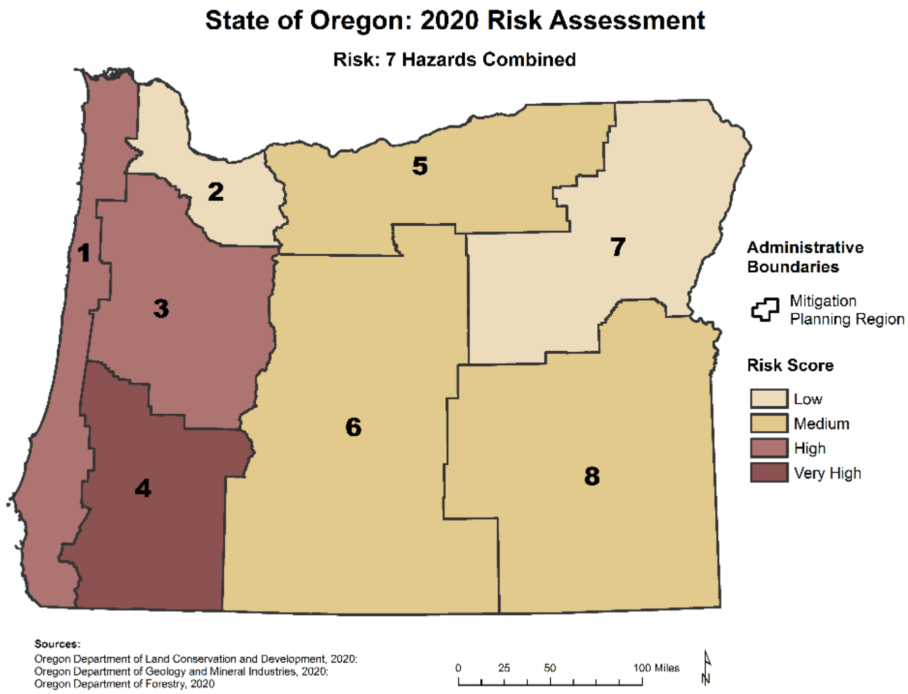
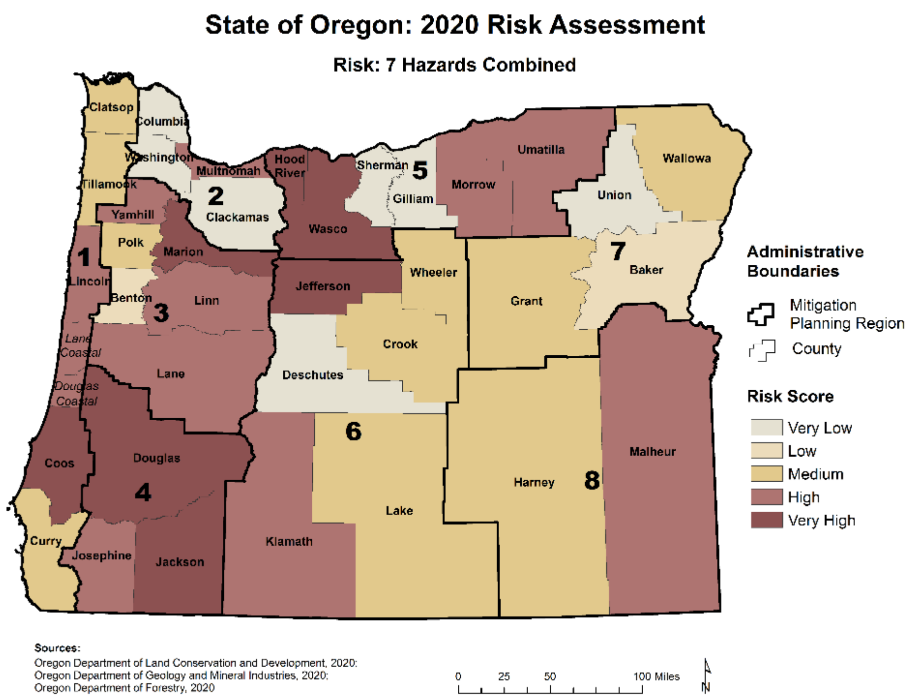


Figure 2-18. Seven Hazards Combined Risk by County



2.1.2.6 Considering All Eleven Hazards

As mentioned previously, not all of the hazards covered in the Plan are included in the 2020 Risk Assessment. Four hazards - drought, extreme heat, windstorms, and winter storms - are excluded due to insufficient data. Although not included in the official assessment, relying on available data and their expertise, subject-matter experts assigned each hazard a qualitative risk score on the Very Low to Very High (1-5) scale. DLCD used that score to calculate a combined risk score for all eleven hazards using the same methodology employed in the 2020 RA. Based on its combined score, each region and county was assigned a descriptive ranking using the Jenks Natural Breaks Classification method. The results are presented in **Table 2-15**, **Eleven Hazards Combined, 2020 Risk Assessment** in the "Risk Score" and "Risk" columns under the "All Hazards (11)" banner.

Incorporating the four additional hazards does not drastically change the results of the 2020 RA. Seven counties are at very high risk when all eleven hazards are considered together—two are different from the seven-hazard assessment and five remain the same. Hood River and Coos Counties are replaced by Morrow and Linn Counties.

Between the eleven hazards, earthquakes, landslides, and flooding continue to pose a very high risk to the greatest number of counties. Of the four additional hazards examined, winter storms possess a very high risk to the greatest number of counties—four in total.

Thirteen counties, or county-equivalents, are at very high risk to three or more hazards: Coos County, Douglas Costal, Lane Coastal, Marion County, Douglas County, Jackson County, Josephine County, Hood River County, Morrow County, Umatilla County, Wasco County, Jefferson County, and Klamath County.

Table 2-15. Eleven Hazards Combined, 2020 Risk Assessment

	Coastal Hazards		Earthquake		Flood		Landslide		Tsunami		Volcanic		Wildfire		All Hazards (7)		Drought	Extreme Heat	Wind-storm	Winter Storm	All Hazards (11)	
	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk	Risk	Risk	Risk	Risk Score	Risk
Oregon	2.29	L	2.99	H	2.92	H	2.94	H	3.33	VH	2.09	VL	2.62	M			M	M	M	M	3.18	M
Region 1	2.29	L	3.83	VH	3.14	H	3.56	VH	3.33	VH	1.62	VL	1.95	VL	2.82	H	M	L	H	M	3.18	M
Clatsop	2.39	M	3.78	VH	2.89	H	3.11	H	3.56	VH	1.33	VL	1.67	VL	2.67	M	L	L	H	H	3.18	M
Coos	2.25	L	4.67	VH	3.56	VH	3.67	VH	4.33	VH	2.00	VL	2.33	M	3.26	VH	M	M	VH	M	3.64	H
Curry	1.75	VL	3.78	VH	2.67	M	3.11	H	2.78	M	1.33	VL	1.33	VL	2.39	M	M	L	H	M	2.73	L
Douglas Coastal	2.17	L	4.11	VH	3.56	VH	3.78	VH	3.33	VH	2.00	VL	2.67	M	3.09	H	H	—	H	M	3.36	M
Lane Coastal	2.03	VL	3.78	VH	3.33	VH	3.56	VH	3.56	VH	1.67	VL	2.33	M	2.89	H	M	—	H	M	3.18	M
Lincoln	2.67	M	3.56	VH	3.11	H	4.11	VH	3.11	H	1.67	VL	1.67	VL	2.84	H	M	L	H	H	3.27	M
Tillamook	2.75	M	3.11	H	2.89	H	3.56	VH	2.67	M	1.33	VL	1.67	VL	2.57	M	L	L	H	H	3.00	M
Region 2	—	—	2.75	M	2.75	M	2.50	M	—	—	1.75	VL	1.33	VL	2.22	L	VL	L	L	L	2.00	VL
Clackamas	—	—	2.22	L	2.33	M	2.11	L	—	—	2.33	M	1.33	VL	2.07	VL	VL	L	L	L	2.00	VL
Columbia	—	—	2.67	M	2.67	M	3.00	H	—	—	1.17	VL	1.00	VL	2.10	VL	VL	L	L	L	2.11	VL
Multnomah	—	—	3.33	VH	4.00	VH	2.78	M	—	—	2.33	M	2.00	VL	2.89	H	L	M	M	M	3.11	M
Washington	—	—	2.78	M	2.00	VL	2.11	L	—	—	1.17	VL	1.00	VL	1.81	VL	VL	L	L	L	1.67	VL
Region 3	—	—	3.28	VH	3.33	VH	3.09	H	—	—	2.49	M	2.17	L	2.87	H	M	H	H	H	3.78	H
Benton	—	—	2.67	M	3.00	H	2.56	M	—	—	1.50	VL	1.67	VL	2.28	L	L	M	M	M	2.56	L
Lane	—	—	3.00	H	3.44	VH	3.33	VH	—	—	3.11	H	2.33	M	3.04	H	M	M	M	M	3.67	H
Linn	—	—	3.56	VH	3.56	VH	3.11	H	—	—	3.00	H	2.33	M	3.11	H	H	H	H	H	4.11	VH
Marion	—	—	4.00	VH	4.00	VH	3.33	VH	—	—	3.33	VH	2.67	M	3.47	VH	H	M	H	VH	4.33	VH
Polk	—	—	2.89	H	2.89	H	2.78	M	—	—	1.83	VL	1.67	VL	2.41	M	M	M	M	M	2.78	L
Yamhill	—	—	3.56	VH	3.11	H	3.44	VH	—	—	2.17	L	2.33	M	2.92	H	M	H	H	H	3.78	H
Region 4	—	—	3.41	VH	3.59	VH	3.63	VH	—	—	2.50	M	3.37	VH	3.30	VH	H	H	M	M	4.11	VH
Douglas	—	—	3.33	VH	3.67	VH	3.78	VH	—	—	2.67	M	3.56	VH	3.40	VH	H	H	M	M	4.11	VH
Jackson	—	—	3.33	VH	3.56	VH	3.67	VH	—	—	2.67	M	3.44	VH	3.33	VH	H	H	M	M	4.11	VH
Josephine	—	—	3.56	VH	3.56	VH	3.44	VH	—	—	2.17	L	3.11	H	3.17	H	H	H	M	H	4.00	H

Source: DLCD, 2020

(Table continued on next page)

Table 2 14. (*continued*) Eleven Hazards Combined, 2020 Risk Assessment

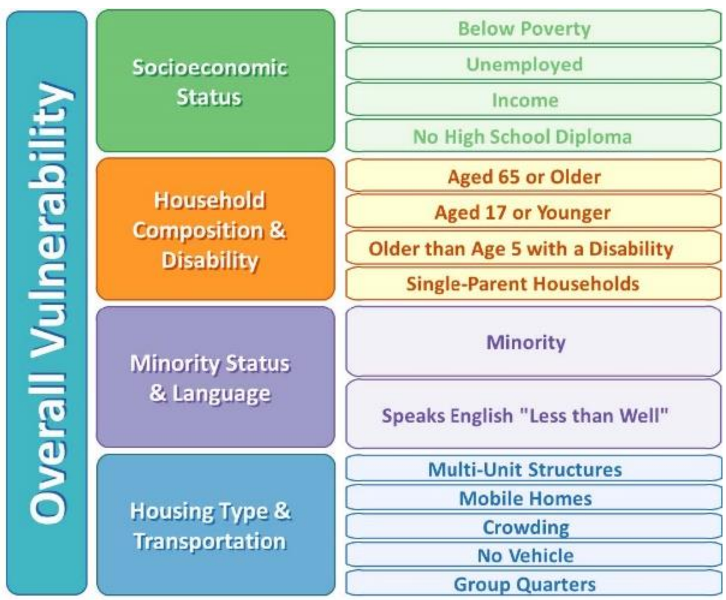
	Coastal Hazards		Earthquake		Flood		Landslide		Tsunami		Volcanic		Wildfire		All Hazards (7)		Drought	Extreme Heat	Wind-storm	Winter Storm	All Hazards (11)	
	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk Score	Risk	Risk	Risk	Risk	Risk	Risk Score	Risk
Oregon	2.29	L	2.99	H	2.92	H	2.94	H	3.33	VH	2.09	VL	2.62	M			M	M	M	M	3.18	M
Region 5	—	—	2.65	M	2.94	H	2.83	H	—	—	2.39	M	3.06	H	2.77	M	M	M	M	VH	3.56	H
Gilliam	—	—	1.33	VL	2.00	VL	2.00	VL	—	—	1.33	VL	1.78	VL	1.69	VL	L	L	M	H	1.78	VL
Hood River	—	—	4.22	VH	2.67	M	3.44	VH	—	—	3.22	VH	2.89	H	3.29	VH	M	M	M	H	3.89	H
Morrow	—	—	2.89	H	3.67	VH	2.78	M	—	—	2.67	M	3.89	VH	3.18	H	VH	H	VH	VH	4.33	VH
Sherman	—	—	1.33	VL	2.67	M	1.89	VL	—	—	1.33	VL	2.33	M	1.91	VL	L	L	M	H	2.22	VL
Umatilla	—	—	3.00	H	3.33	VH	3.11	H	—	—	2.67	M	3.33	VH	3.09	H	H	M	L	VH	3.89	H
Wasco	—	—	3.11	H	3.33	VH	3.78	VH	—	—	3.11	H	4.11	VH	3.49	VH	H	M	H	VH	4.33	VH
Region 6	—	—	2.67	M	2.37	M	2.59	M	—	—	2.38	M	3.37	VH	2.68	M	H	M	L	M	3.22	M
Crook	—	—	2.33	M	2.44	M	2.67	M	—	—	1.83	VL	3.44	VH	2.54	M	H	M	VL	L	2.78	L
Deschutes	—	—	1.89	VL	1.33	VL	1.33	VL	—	—	2.78	M	2.67	M	2.00	VL	H	L	VL	L	2.00	VL
Jefferson	—	—	3.00	H	3.00	H	3.44	VH	—	—	3.33	VH	4.56	VH	3.47	VH	H	H	M	H	4.22	VH
Klamath	—	—	3.56	VH	2.67	M	2.67	M	—	—	3.00	H	3.22	VH	3.02	H	VH	H	M	H	4.00	H
Lake	—	—	3.44	VH	2.44	M	2.44	M	—	—	2.17	L	3.00	H	2.70	M	H	H	L	H	3.44	M
Wheeler	—	—	1.78	VL	2.33	M	3.00	H	—	—	1.17	VL	3.33	VH	2.32	M	M	L	M	H	2.89	L
Region 7	—	—	2.19	L	2.31	L	2.47	M	—	—	1.46	VL	2.89	H	2.26	L	H	M	M	M	2.78	L
Baker	—	—	2.44	M	2.00	VL	2.33	M	—	—	1.50	VL	2.89	H	2.23	L	H	M	L	M	2.67	L
Grant	—	—	1.89	VL	3.11	H	2.22	L	—	—	1.33	VL	3.22	VH	2.36	M	H	L	L	M	2.67	L
Union	—	—	2.11	L	1.67	VL	2.33	M	—	—	1.50	VL	2.89	H	2.10	VL	M	M	M	M	2.56	L
Wallowa	—	—	2.33	M	2.44	M	3.00	H	—	—	1.50	VL	2.56	M	2.37	M	M	M	M	M	2.89	L
Region 8	—	—	2.56	M	3.11	H	2.39	M	—	—	2.17	L	3.61	VH	2.77	M	VH	H	L	L	3.33	M
Harney	—	—	2.33	M	3.11	H	2.00	VL	—	—	1.83	VL	3.11	H	2.48	M	H	H	VL	VL	2.56	L
Malheur	—	—	2.78	M	3.11	H	2.78	M	—	—	2.50	M	4.11	VH	3.06	H	VH	H	L	L	3.44	M

2.1.3 Social Vulnerability

Social vulnerability describes the socioeconomic factors that affect individual and community resilience (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). While there is no single set of vulnerability criteria, researchers have identified a core set of traits commonly associated with higher vulnerability. The 2020 Risk Assessment leverages a social vulnerability index created by the U.S. Center for Disease Control and Prevention (CDC) and expands on select vulnerability variables in each regional profile.

In collaboration with public health experts in the public and private sectors, the Geospatial Research, Analysis & Services Program (GRASP) at the CDC developed a Social Vulnerability Index (**Figure 2-19**). The index is comprised of fifteen social factors, with the underlying data derived from the U.S. Census Bureau's American Community Survey (ACS). The 2020 Risk Assessment uses data aggregated at the county level but the index is also available for census tracts.

Figure 2-19. CDC Social Vulnerability Themes and Components



Source Centers for Disease Control and Prevention / Agency for Toxic Substances and Disease Registry / Geospatial Research, Analysis, and Services Program (2016)

The fifteen variables are grouped into four broad "themes" and then combined to create an overall vulnerability score which is then used to calculate a percentile rank, with a higher value indicating greater vulnerability (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). For the 2020 Risk Assessment, counties were further divided into quintiles based on their percentile rank using the equal interval classification method. These vulnerability categories were then factored into the risk assessment along with physical exposure—to state-owned and -leased buildings and state and local critical facilities—and the probability of hazard occurrence.

While the CDC tool aggregates various socioeconomic characteristics to create a composite measure of vulnerability, each regional community profile examines select risk factors to identify trends and dynamics between and within natural hazard mitigation planning regions. Some of the variables examined in the profiles are the same as or similar to those included in the CDC tool. However, it should be noted that although the CDC index and regional profiles both use estimates from the five-year ACS, the periods are different (2012-2016 versus 2013-2017, respectively). Other characteristics presented in the regional community profiles have been included in previous iterations of this Plan and remain relevant drivers of vulnerability. **Table 2-16** illustrates which variables are included in the CDC index that are also presented in the regional community profiles and those that are covered in one but not the other.

Table 2-16. Comparing Social Vulnerability Variables: CDC Index and Oregon NHMP Regional Community Profiles

CDC Social Vulnerability Index Variable ACS 2012-2016		2020 NHMP Regional Community Profile Variable ACS 2013-2017	
Variable	**Table/Source**	**Variable**	**Table/Source**
Persons below poverty estimate	B17001	Persons below poverty estimate	S1701
Civilian (age 16+) unemployed estimate	DP03	Civilian (age 16+) unemployment rates	Oregon Employment Department, 2019
Per capita income estimate	B19301		
Persons (age 25+) with no high school diploma estimate	B06009	Persons (age 25+) with no high school diploma estimate and other educational attainment estimates	DP02
Persons aged 65 and older estimate	S1501	Persons aged 65 and older estimate	DP05
Persons aged 17 and younger estimate	B09001	Persons aged 17 and younger estimate	DP05
Civilian noninstitutionalized population with a disability estimate	DP02	Civilian noninstitutionalized population with a disability and disability by vulnerable age groups estimates	DP02
Single-parent household with children under 18 estimate	DP02	Single-parent household with children under 18 estimate	DP02
Minority (all persons except white non-Hispanic) estimate	B01001H		
Persons (age 5+) who speak English "less than well" estimate	B16005	Persons (age 5+) who speak English "less than very well" estimate	DP02
Housing in Structure with 10 or more units estimate	DP04		
Mobile homes estimate	DP04	Units in Structure estimates (includes multi-family, single-family, and mobile homes)	B25024
At household level (occupied housing units), more people than rooms estimate	DP04		
Household with no vehicle estimate	DP04		
Persons in institutionalized group quarters estimate	B26001		
		Annual tourism estimates	(Dean Runyan Associates, 2019)
		Homeless population estimate	Point-in-Time Count, 2019
		Sex Ratio estimate	S0101

CDC Social Vulnerability Index Variable ACS 2012-2016	2020 NHMP Regional Community Profile Variable ACS 2013-2017	
	Median household income and median household income distribution estimates	DP03
	Housing tenure estimates (owner-occupied housing units, renter-occupied housing units)	DP04
	Persons under 18 years below poverty line estimate	S1701
	Household type estimates (family, non-family, householder living alone)	DP02
	Family household with children estimate	DP02

Source: Source Centers for Disease Control and Prevention / Agency for Toxic Substances and Disease Registry / Geospatial Research, Analysis, and Services Program (2016); DLCD, 2020

2.1.4 Introduction to Climate Change

The climate is an important factor influencing certain natural hazards. Industrialization has given rise to increasing amounts of greenhouse gas emissions worldwide, which is causing the Earth's climate to warm (IPCC, 2013). Climate change is already affecting Oregon communities and resources (Dalton, Dello, Hawkins, Mote, & Rupp, 2017); (May, et al., 2018); (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019). In itself, climate change is not a distinct natural hazard, but it is expected to amplify the risk of certain natural hazards. Climate change is anticipated to increase the frequency and/or magnitude of some natural hazards in Oregon, such as extreme heat events, droughts, wildfires, floods, landslides, and coastal erosion and flooding. This section presents an overview of climate change in Oregon as it pertains to climate-related natural hazards.

Oregon's climate is broadly characterized by mild, wet winters and warm, dry summers. East of the Cascade Range, winters tend to be colder, summers hotter, and annual precipitation less than west of the Cascades due to farther proximity to the moderating effects of the Pacific Ocean and the rain shadow created by the Cascade Range. Oregon's climate is also characterized by large variability from year to year, and that variability is largely dominated by the interaction between the atmosphere and ocean in the tropical Pacific Ocean that is responsible for El Niño and La Niña events. Human activities are changing the climate, particularly temperature, beyond natural variability.

Already, Oregon's average temperature has increased by nearly 2°F since the beginning of the 20th century. Not only that, but hot days are getting hotter and more frequent and cold days less frequent. In the same timeframe, Cascade Mountain snowpacks have declined due to warmer winters causing precipitation to fall more as rain and less as snow, and higher temperatures have caused earlier spring snowmelt and spring peak stream flows resulting in lower summer stream flows in many rivers. In Oregon's forested areas, large areas have been impacted by disturbances that include wildfire in recent years, and climate change is a major factor contributing to forest dryness that facilitates fire. On the coast, sea level rise and increasing deep-water wave heights in recent decades are likely to have increased the frequency of coastal flooding and erosion. Closer to home for some Oregonians, a three-fold increase in heat-related illness has been documented in Oregon with each 10°F rise in daily maximum temperature (Dello & Mote (2010); Dalton, et al. (2013), (2017); May, et al. (2018); Mote, et al. (2019).

2.1.4.1 Oregon Responses to Climate Change

The human influence on the climate is clear (IPCC, 2013). Global greenhouse gas emissions will determine the amount of warming both globally and here in Oregon. On that basis, Oregon and other states and local communities have undertaken measures to reduce greenhouse gas emissions as a way to slow the warming trend. Even if greenhouse gas emissions were drastically reduced globally, we cannot avoid some additional warming over the coming century due to the climate system's considerable inertia. Climate changes happening today are largely a result of emissions that occurred up to several decades to almost a century ago. As such, states and local communities are planning and beginning to implement measures to adapt to future climate conditions that cannot be avoided. In many cases, planning for climate change — or adaptation planning — quickly comes down to improved planning for natural hazards, since many of the anticipated effects of climate change will be experienced in the form of natural hazard events. That said, planning to adapt to climate change and planning to mitigate natural hazards are not entirely the same thing, although there is considerable overlap.

In 2010, the State of Oregon produced the Oregon Climate Adaptation Framework, which identifies 11 climate-related risks for which the state must plan. The Framework is in the process of being updated as of this writing (2020). Six of those 11 climate risks — drought, extreme heat, coastal erosion, fire, flood, and landslides — are directly identified in the 2020 Oregon NHMP. Extreme heat is a new hazard considered in the 2020 Oregon NHMP that was not included in the 2015 Oregon NHMP. In addition, two other hazards in the 2020 Oregon NHMP — windstorms and winter storms — have an underlying climate component.

Oregon and the Pacific Northwest have a wealth of climate impacts research from the last several decades. In 2007 the Oregon Legislature created the Oregon Climate Change Research Institute (OCCRI) under HB 3543. Much of the material in this "Introduction to Climate Change" is drawn from OCCRI's Oregon Climate Assessment Reports (OCAR) from 2010–2019, with emphasis on the two most recent assessments: OCAR3 (Dalton, Dello, Hawkins, Mote, & Rupp, 2017) and OCAR4 (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019), which includes the Northwest chapter of the Fourth National Climate Assessment (May, et al., 2018). This section also relies on a summary report from the "Oregon Climate Change Effects, Likelihood, and Consequences Workshop" held in August 2019 that brought together subject matter experts from the State's regional public universities along with Oregon state agency staff to discuss the likelihood, confidence, and consequences of a range of climate change effects in Oregon. All of OCCRI's reports can be found at http://www.occri.net/publications-and-reports/.

This section is not meant to be a comprehensive assessment of climate change and impacts in Oregon or an all-encompassing overview of each hazard. Rather, it presents future projections of temperature and precipitation, and describes some of the effects of such future conditions based on the frequency and magnitude of natural hazards in Oregon.

2.1.4.2 Past and Future Climate in Oregon

Historical

The impacts of climate change in Oregon are largely driven by changes in temperature and precipitation. Temperatures in Oregon increased nearly 2°F since the beginning of the 20th century. Nearly every year in the 21st century (2000–2019) has been warmer than the 20th century average, excepting 2011. Looking at it another way, only 9 years during 20th century have been above the 21st century average (NOAA, 2020). Over the last 30 years (1990–2019), temperatures in Oregon have been above the 1970–1999 average in all but three years (1993, 2008, 2011) (**Figure 2-20**). Annual precipitation amounts since the beginning of the 20th century have varied considerably from year to year without a significant trend beyond the normal range of natural variability (**Figure 2-20**). However, warmer temperatures have caused precipitation to fall more often as rain instead of snow contributing to a 37% reduction in the amount of water stored in the Oregon's mountain snowpack during 1955–2016 (Mote, Lettenmaier, Xiao, & Engel, 2018).

Future Climate

Projections of future climate changes come from simulations using global climate models (GCMs), which are sophisticated computer models of the Earth's atmosphere, water, and land and how these components interact over time and space on a gridded sphere according to the fundamental laws of physics. GCMs are some of the most sophisticated tools scientists use for understanding the climate system. Research centers around the world run computerized GCMs as part of the Coupled Model Intercomparison Project (CMIP), providing scientists and decision makers with many simulations of future global climate to use to assess the range of future climate projections for the globe. For the fifth and latest available phase of CMIP, called CMIP5, simulations of the 21st century climate are driven by what are called "representative concentration pathways" (RCPs). RCPs represent the total amount of extra energy (in watts per square meter) entering the climate system due primarily to increasing greenhouse gas emissions throughout the 21st century and beyond. There are several RCPs, each with a different set of assumptions regarding global greenhouse gas emissions. The higher global emissions are, the greater the expected increase in global temperature.

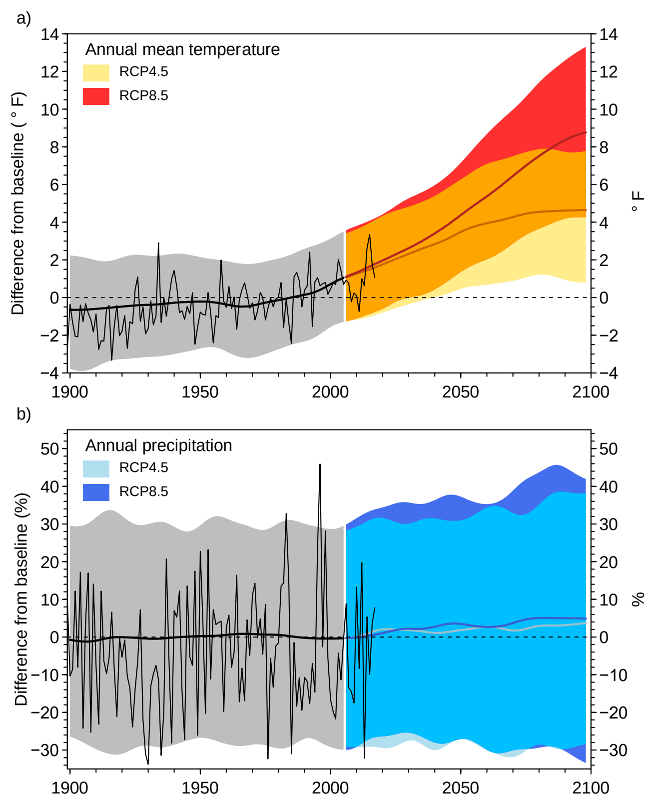
The temperature and precipitation projections summarized for Oregon in this section use data from the grid cells covering Oregon in multiple GCMs driven by two RCPs. The lower emissions scenario, RCP 4.5, represents a moderate effort to reduce global greenhouse gas emissions which peak near mid-21st century then decline. The higher emissions scenario, RCP 8.5, represents a business-as-usual continuation of emissions throughout the 21st century.

Annual

Figure 2-20 shows Oregon's observed mean annual temperatures and total annual precipitation from 1900 to 2017, simulated historical mean annual temperatures and precipitation for 1900 to 2005, and simulated future mean annual temperatures and precipitation for 2006 to 2099 under the two different RCPs. Note that the observed temperatures and precipitation generally fall within the range of simulated historical values which gives confidence in the future simulations. Note also that the projected temperature trends under different RCPs generally track closely until about 2030 or so, and then dramatically diverge after 2050. There are not substantial differences between the RCPs for projected precipitation changes.

Every climate model shows an increase in temperature for Oregon, with the magnitude of the increase depending on the rate or magnitude of global greenhouse gas emissions. Larger temperature increases are projected under the higher emissions scenario (RCP 8.5) than under the lower emissions scenario (RCP 4.5). There is no plausible scenario in which Oregon cools in the 21st century. CMIP5 global climate models project an increase by mid-21st century (2040–2069) in annual temperatures in Oregon of 1.8°F to 6.9°F over the recent past (1970–1999) (**Table 2-17**). The lower projection is possible only if greenhouse gas emissions are significantly reduced (**Figure 2-20**, RCP 4.5 scenario). Both scenarios show a similar amount of warming through about 2040, meaning that temperatures beyond 2040 depend on global greenhouse emissions occurring now (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). Climate models are split on whether annual precipitation in Oregon will increase or decrease.

Figure 2-20. Observed, Simulated, and Projected Changes in Oregon's Mean Annual (a) Temperature and (b) Precipitation from the Baseline (1970–1999) for RCP 4.5 and RCP 8.5 Scenarios



Note: Thin black lines are observed values (1900-2017) from the National Centers for Environmental Information. The thicker solid lines depict the mean values of simulations from 35 climate models for the 1900-2005 period based on observed climate forcings (black line) and the 2006-2099 period for the two future scenarios (orange and red lines in the top panel, blue and grey in the bottom panel). The shading depicts the range in annual temperatures from all models. The mean and range have been smoothed to emphasize long-term (greater than year-to-year) variability.

Source: Mote, et al. (2019)

Seasonal

Projections of annual temperature and precipitation provide a foundation of general expectations of climate change, but some of the most relevant climate projections for planning purposes, and the most crucial to some of the hazards addressed in this Plan, are projected changes in seasonal temperature and precipitation and projected changes in extreme temperature and precipitation events. **Table 2-17** and **Table 2-18** summarize projections in Oregon's annual and seasonal temperature and precipitation, respectively, based on analyses of CMIP5 data.

Table 2-17 contains the mean and range of projected changes in Oregon's mean annual temperatures from historical (1970–1999) to mid-21st century (2040–2069), using both RCP 4.5 and RCP 8.5 scenarios. Projected changes are shown annually and for each season. Of particular note in **Table 2-17** is that both scenarios (for RCP 4.5 and RCP 8.5) show projected increases in average temperature for the year and for every season. All models are in agreement that each season will be warmer in the future, and that the largest amount of warming will occur in the summer. Increased summer temperatures will increase the risk of wildfires, drought, and heat waves as well as increase health-threats from poor air quality conditions. Increased average winter temperatures will result in less snowpack in Oregon, which also contributes to increase risk of "snow droughts"—years with normal precipitation, but lack of sufficient accumulated snowpack due to warm temperatures.

Table 2-17. Projected Future Changes in Oregon's Mean Annual and Seasonal Temperatures from Late 20th Century (1970–1999) to Mid-21st Century (2040–2069) under RCP 4.5 and RCP 8.5 Scenarios

Time Period	**Annual**		**Winter (Dec, Jan, Feb)**		**Spring (Mar, Apr, May)**		**Summer (Jun, Jul, Aug)**		**Fall (Sep, Oct, Nov)**	
Representative concentration pathway scenario	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Mean change	3.6°F	5.0°F	3.3°F	4.5°F	3.1°F	4.1°F	4.5°F	6.3°F	3.7°F	5.2°F
Range	1.8–5.4°F	2.9–6.9°F	1.6–5.1°F	2.4–6.5°F	1.4–5.0°F	2.0–5.9°F	2.2–6.8°F	3.6–8.9°F	1.5–5.4°F	2.6–7.0°F

Note: The mean change is averaged across 35 global climate models and the range is the 5th to 95th percentile range representing model responses across the 35 global climate models excluding the smallest 5% and largest 5% of changes.
Source: Dalton, et al. (2017)

Table 2-18 contains a summary of projected mean percent change and range of changes for total precipitation in Oregon from historical (1970–1999) to mid-21st century (2040–2069), under both RCP 4.5 and RCP 8.5 scenarios. Projected changes are shown annually and for each season. Note in the "Annual" column in Table 2-4 that precipitation amounts are projected to remain within the range of current natural variability. However, Table 2-4 also shows that there is some indication from climate models that summers will be drier in the future. Such warmer and drier summers projected for Oregon would increase the risk of wildfire and drought hazards.

Table 2-18. Projected Future Relative Changes in Oregon's Total Annual and Seasonal Precipitation from Late 20th Century (1970–1999) to Mid-21st Century (2040–2069) under RCP 4.5 and RCP 8.5 Scenarios

	Annual		Winter (Dec, Jan, Feb)		Spring (Mar, Apr, May)		Summer (Jun, Jul, Aug)		Fall (Sep, Oct, Nov)	
Representative concentration pathway scenario	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Mean change	1.9%	2.7%	4.9%	7.9%	1.9%	2.7%	-6.3%	-8.7%	0.5%	-0.8%
Range	-4.9–9.0%	-6.0–11.4%	-6.4–16.5%	-4.7–24.3%	-8.9–12.1%	-7.2–17.4%	-28.5–16.1%	-33.1–22.5%	-17.0–14.4%	-17.1–14.9%

Note: The mean change is averaged across 35 global climate models and the range is the 5th to 95th percentile range representing model responses across the 35 global climate models excluding the smallest 5% and largest 5% of changes.

Source: Dalton, et al. (2017)

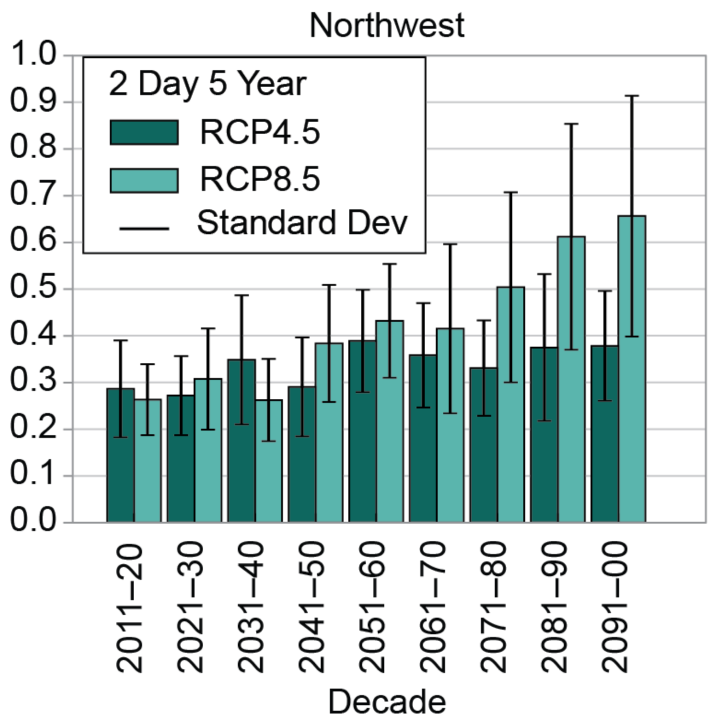
Extremes

Natural hazards are often an expression of extreme conditions — windstorms, rain storms, floods, droughts, heat waves, and so on. Extreme precipitation is perhaps the most common and widespread natural hazard in Oregon. Many people may associate extreme rainfall events almost exclusively with western Oregon, but in fact extreme precipitation events occur across the entire state. Extreme precipitation events west of the Cascades are generally associated with atmospheric rivers—long, narrow swaths of warm, moist air that carry large amounts of water vapor from the tropics to mid-latitudes—whereas closed low pressure systems often lead to isolated precipitation extremes east of the Cascade Range (Parker & Abatzoglou, 2016).

Observed trends in the frequency of extreme precipitation events across Oregon have depended on the location, time frame, and metric considered, but overall the frequency has not changed substantially. As the atmosphere warms, it is able to hold more water vapor that is available for precipitation. As a result, the frequency and intensity of extreme precipitation events are expected to increase in the future (Dalton, Dello, Hawkins, Mote, & Rupp, 2017), including atmospheric river events (Kossin, et al., 2017). In addition, regional climate modeling results suggest a weakened rain shadow effect in winter projecting relatively larger increases in precipitation east of the Cascades and smaller increases west of the Cascades in terms of both seasonal precipitation totals and precipitation extremes (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019).

There are multiple ways to define extreme precipitation events. One way is the 2-day, 5-year return interval event—that is, the magnitude of cumulative precipitation over two days with a 20% probability of occurring in any given year. The frequency of such events is projected to increase over the 21st century (**Figure 2-21**). For example, by the 2050s under RCP 8.5, the frequency is expected to double, becoming a 2.5-year return interval event. This translates to a couple more events of the type per year by mid-21st century. The frequency of extreme precipitation events increases more under RCP 8.5 than RCP 4.5 because warming is greater for RCP 8.5 allowing the atmosphere to hold more water vapor available for precipitation.

Figure 2-21. Projected Extreme Precipitation Event Frequency for the 2-day duration and 5-year return interval event for the Northwest under RCP 4.5 and RCP 8.5 Scenarios



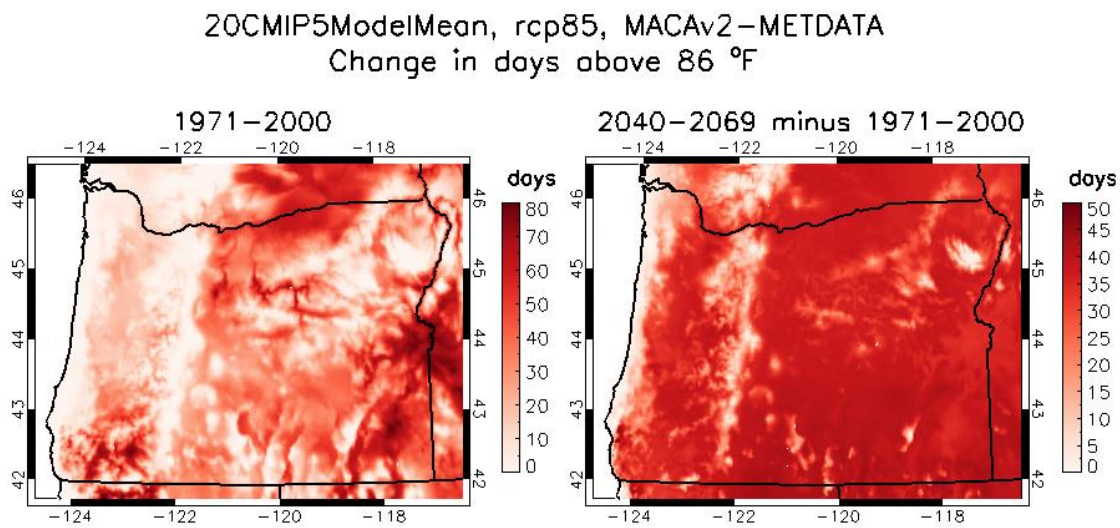
Calculated for 2006–2100 but decadal anomalies begin in 2011. Error bars are ±1 standard deviation; standard deviation is calculated from the 14 or 16 model values that represent the aggregated average over the regions, over the decades, and over the ensemble members of each model. The average frequency for the historical reference period is 0.2 by definition and the values in this graph should be interpreted with respect to a comparison with this historical average value.

Source: Easterling, et al. (2017)

For the first time, extreme heat is included as a hazard in the 2020 Oregon NHMP. This is due to the recognition that as the climate continues to warm, extreme heat events will be an emerging hazard with implications for public health as well as infrastructure. Extreme heat events are expected to increase in frequency, duration, and intensity in Oregon due to continued warming temperatures. In fact, the hottest days in summer are projected to warm more than the change in mean temperature over the Pacific Northwest (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). Extreme heat events occur from time to time as a result of natural variability, but human-caused climate change is already contributing to the severity of such events (Vose, Easterling, Kunkel, LeGrande, & Wehner, 2017).

There are several ways to measure extreme heat. One is to measure the change in magnitude of the warmest day of the year; another is to count the number of days with temperatures above a certain threshold. By the middle of the 21st century (2036–2065), the temperature of the warmest day of the year is projected to increase by about 6°F averaged over the Northwest relative to the period 1976–2005 (Vose, Easterling, Kunkel, LeGrande, & Wehner, 2017). The number of days with temperatures greater than 86°F—"hot days"—are expected to increase across Oregon (**Figure 2-22**). In the baseline period (1970–1999), the hottest parts of the state—lower elevation portions of eastern Oregon, as well as the Rogue River valley—experience at least 30 hot days per year. By mid-21st century under the higher scenario (RCP 8.5), most locations in Oregon except the mountains and the coast will experience at least an additional 30 hot days per year, in many places doubling the frequency of such days (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019).

Figure 2-22. Average Number of Hot Days Per Year for 1971–2000 (left) and Projected Change by 2040–2069 under RCP 8.5 (right).



Note: Hot days are defined as days with daily high temperature >86°F (30°C). Results were averaged over 20 climate models (right). Data comes from the Northwest Climate Toolbox, climatetoolbox.org.

Source: Mote, et al. (2019)

Effect of Oregon's Future Climate Conditions on Natural Hazards

In 2010, Oregon achieved a significant milestone in the release of two reports for two important initiatives that developed in parallel; both reports addressed climate change across the state. OCCRI released the Oregon Climate Assessment Report (Dello & Mote, 2010), the first ever comprehensive scientific assessment of climate change in Oregon. At the same time, the state released the Oregon Climate Change Adaptation Framework, representing the efforts of over a dozen state agencies and institutes, including OCCRI, to begin to establish a rigorous framework for addressing the effects of climate change across the state.

Since the 2010 Oregon Climate Assessment Report, OCCRI has produced three updated assessment reports in 2013, 2017, and 2019 (http://www.occri.net/publications-and-reports/). The latter two—the Third Oregon Climate Assessment Report (Dalton, Dello, Hawkins, Mote, & Rupp, 2017) and the Fourth Oregon Climate Assessment Report (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019), which includes the Northwest chapter of the Fourth National Climate Assessment (May, et al., 2018) —are relied upon to update the climate change information in the 2015 Oregon NHMP.

The Framework is concurrently being updated (2020) along with the 2020 Oregon NHMP. Development of Oregon's 2010 Climate Change Adaptation Framework was significant in that the state began to address the need to plan for the effects of future climate conditions. Furthermore, Oregon's 2010 Framework was the first state-level adaptation strategy based on climate risks as opposed to affected sectors. Oregon's 2010 Framework lays out 11 climate risks that are of concern to the state. The risks provide a consistent basis for agencies and communities to review plans and decisions to identify measures to reduce those risks. Many of the risks in the 2010 Oregon Framework are natural hazards.

Following is a summary of the principal effects of changing climate conditions on the natural hazards addressed in the 2020 Oregon NHMP. Hazards are discussed together where the climate changes and drivers are essentially the same. How each hazard (or group of hazards) affects each of the eight Oregon NHMP Natural Hazard Regions is then summarized.

Relationship Between Adaptation Framework Risks and Hazards in the Oregon NHMP

Table 2-19. Relationship Between Adaptation Framework Risks and Hazards in the Oregon NHMP

	Oregon NHMP Hazards							
Adaptation Framework climate risks	Coastal Erosion	Droughts	Heat Wave*	Wildfire	Floods/ CMZ	Landslides	Wind-storms	Winter Storms
Increased temperatures	x	X	X	X				
Changes in hydrology		X			X	X		
Increased wildfires		x		X	x	x		
Increase in ocean temperatures and changes in ocean chemistry	X				x			X
Increased drought		X		X				
Increased coastal erosion	X					x		
Changes in habitat								
Increase in invasive species and pests		x		X				
Loss of wetland ecosystems and services		X			X			
Increased frequency of extreme precipitation events and flooding					X	X		x
Increased landslides						X		

*Heat waves or extreme heat is now identified as a natural hazard for the first time in the 2020 Oregon natural hazards mitigation plan.

What is contained in Table 2-6: The leftmost column contains the climate risks in the 2010 Oregon Climate Change Adaptation Framework. Column headings show natural hazards identified in the 2020 Oregon Natural Hazards Mitigation Plan (NHMP).

How to read this table: Cells with an x or X show which climate risks will affect the frequency, intensity, magnitude, or duration of which natural hazards. A big X shows a primary relationship between the risk and the hazard. A small x shows a secondary relationship. The green cells in the body of the table show where a 2010 Adaptation Framework risk and a natural hazard in the 2020 Oregon NHMP are essentially the same thing.

Note that the first two risks — increased temperatures and changes in hydrology — are the primary climate drivers for natural hazards. The other climate risks represent known environmental or ecosystem responses to one or both of the primary drivers. Note also that a clear link has not been established between climate change and the frequency or intensity of windstorms.

Coastal Erosion and Coastal Flooding

Regions affected: 1

Oregon's ocean shoreline is constantly subject to the dynamic and powerful forces of the Pacific Ocean, and it changes at timescales that vary from days to decades. Variable and changing ocean conditions continuously reshape the ocean shoreline, particularly where the shore is composed primarily of sand. Sand levels on Oregon's beaches generally experience an annual cycle of erosion through winters and rebuilding in summer months. Over any extended time period, sandy beaches and shores will build out and retreat several times, due in part to the effects of winds, storms, tides, currents, and waves. These cycles can occur over decades. In the annual cycle, beach profiles do not always recover to the heights and extent of previous years. In recent years, sand levels have remained fairly low at many locations on the Oregon coast.

The shape of Oregon's ocean shoreline is a function in part of ocean water levels and wave heights. Ocean water levels are also a primary factor in the frequency of flooding around the fringes of Oregon's estuaries. In other words, erosion of the ocean shore is directly affected by sea levels and wave heights. Flooding on the estuarine fringe is affected by ocean water levels — including tides and storm surges — in addition to freshwater inflow from the estuarine watershed. Other factors influence coastal erosion, but sea levels and wave heights are the primary climate-related drivers that influence rates of coastal erosion.

Recent studies make it clear that global ocean water levels are rising. Global mean sea levels are very likely to rise 0.3–0.6 feet (9–18 cm) by 2030, 0.5–1.2 feet (15–38 cm) by 2050, and 1.0–4.3 feet (30–130 cm) by 2100. However, faster-than-expected Antarctic ice sheet melt under higher emissions scenarios could result in a global mean sea level rise exceeding 8 feet (2.4 m) by 2100. Regardless of pathway, oceans will continue rising even after 2100 (Sweet, Horton, Kopp, LeGrande, & Romanou, 2017a). In Oregon (as elsewhere) the rates of relative sea level rise—those experienced along Oregon's coastlines—are not the same as rates of change in global mean sea levels, because of a number of factors related to ocean conditions and vertical movement of the land. Oregon's western edge is uplifting, so the rates of relative sea level rise in Oregon are not as high as rates seen in other West Coast locations. But even after factoring in local conditions, sea levels along most of Oregon's coast are rising. For locations in which sea level is not currently rising, the projected rate of future sea level rise is expected to outpace the current rate of vertical land movement in the 21st century. For more information on coastal erosion and sea level rise, see the **Coastal Hazards** section.

Recent research also indicates that significant wave heights off Oregon's shorelines are increasing. Increasing significant wave heights may be a factor in the observed increase of coastal flooding events in Oregon. During El Niño events, sea levels can rise up to about 1.5 feet (0.5 meters) higher over extended periods (seasons). Attributing increasing wave heights to climate change may not be possible until the second half of the 21st century because natural variability is quite large and future projections of average and extreme wave heights along the West Coast are mixed (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

It is *very likely* (>90%) that the Oregon coast will experience an increase in coastal erosion and flooding hazards due to climate change induced sea level rise (*high confidence*) and possible changes to wave dynamics (*medium confidence*).

The executive summary of the 2010 Oregon Climate Adaptation Framework provides a summary of various challenges associated with "increased coastal erosion and risk of inundation from increasing wave heights and storm surges":

Increased wave heights, storm surges, and sea levels can lead to loss of natural buffering functions of beaches, tidal wetlands, and dunes. Accelerating shoreline erosion has been documented and is resulting in increased applications for shore protective structures. Shoreline alterations typically reduce the ability of beaches, tidal wetlands, and dunes to adjust to new conditions.

Increasing sea levels, wave heights, and storm surges will increase coastal erosion and likely increase damage to private property and infrastructure situated on coastal shorelands. Coastal erosion and the common response to reduce shoreland erosion can lead to long-term loss of natural buffering functions of beaches and dunes. Applications for shoreline alteration permits to protect property and infrastructure are increasing, but in the long term they reduce the ability of shore systems to adjust to new conditions.

Extreme Heat

Regions affected: 1-8

All eight regions in the 2020 Oregon NHMP are projected to experience an increase in the frequency and severity of very warm temperatures, relative to the local climate. Inland areas at lower elevations, which climatologically see the greatest number of very hot temperature days, will see an even greater number of very hot days in the coming decades. Very hot days, measured in an absolute sense, will continue to be rare in coastal and high elevation regions.

Extreme heat events occur from time to time as a result of natural variability, but human-caused climate change is already contributing to the severity of such events (Vose, Easterling, Kunkel, LeGrande, & Wehner, 2017). Recent extremely hot summers (2015, 2017, 2018) in highly populated parts of western Oregon have been unprecedented and have brought increased interest in the effect of global warming on local summer temperatures. In Oregon's biggest city, Portland, summer extreme heat in terms of annual total days over 90°F has steadily increased in frequency and severity despite large year-to-year variability. The record number of days over 90°F in Portland was set in 2018. Today, Portland sees about nine more days above 90°F than in 1940. This trend will continue, though the rate of change may increase, along with continued year-to-year variability. The hot summers of 2015, 2017, and 2018 serve as wake-up calls for what is to come, as they are good examples of what is projected to be relatively common by the mid-21st century.

Extreme heat events will to continue to increase in frequency and severity under continued climate warming. The number of days with temperatures greater than 86°F (30°C)—"hot days"—are expected to increase across Oregon (**Figure 2-22**). In the baseline period (1970–

1999), the hottest parts of the state—lower elevation portions of eastern Oregon, as well as the Rogue River valley—experience at least 30 hot days per year. By mid-21st century under the higher scenario (RCP 8.5), most locations in Oregon except the mountains and the coast will experience at least an additional 30 hot days per year, in many places doubling the frequency of such days (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019). Closer to home for some Oregonians, a three-fold increase in heat-related illness has been documented in Oregon with each 10°F rise in daily maximum temperature.

Extreme heat events can bring a wide array of impacts from increased morbidity and mortality from heat-related illness to disrupted transportation and infrastructure damaged by extreme heat. Heat waves will result in increased deaths and illness among vulnerable human populations. The elderly, infants, chronically ill, low-income communities, and outdoor workers are the main groups threatened by heat waves (Ebi, et al., 2018). Extreme heat events can disrupt transportation by delaying rail and air transportation when safe operating guidelines are exceeded, damaging rail tracks that may bend or roadway joints that may buckle under extreme heat (Jacobs, et al., 2018). In addition, heat waves can increase the demands on electric power for cooling, increasing the risk of cascading failures within the electric power network (Clarke, et al., 2018).

Droughts and Wildfires

Regions affected: 1-8

All eight regions in the 2020 Oregon NHMP are potentially affected by increasingly common droughts and wildfires. Moreover, areas that have historically been both hotter and drier than the statewide average — southwest Oregon counties and central and eastern Oregon — are at somewhat higher risk of increased drought and wildfire than the state overall. Droughts and wildfires are addressed as separate hazards in this Plan. However, the underlying climate mechanism is similar for both. These hazards all occur in conjunction with warmer and drier conditions.

Virtually all climate models project warmer, drier summers for Oregon, with mean projected increases in summer temperatures of 4.5 to 6.3°F and a decline in mean summer precipitation amounts of 6.3 to 8.7% by mid-21st century relative to late-20th century depending on emissions scenario (**Table 2-17**, **Table 2-18**). These summer conditions will be coupled with projected decreases in mountain snowpack due to warmer winter temperatures. Models project a mean increase in winter temperatures of 3.3 to 4.5°F by mid-21st century relative to late-20th century depending on emissions scenario (**Table 2-17**). This combination of factors exacerbates the likelihood of drought, which in turn can dry out vegetation often leading to an increase in the incidence and likelihood of wildfires. Vegetation dryness is expected to increase across most of Oregon—with the most pronounced increases in southern Oregon, the eastern Cascade Range, and parts of the Blue Mountains—resulting in increased wildfire frequency and area burned across the state, even in areas west of the Cascade Range where wildfire has historically been infrequent (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

It is likely (>66%) to *very likely* (>90%) that Oregon will experience an increase in the frequency of one or more types of drought. An increase in drought frequency caused by increasing temperature is more likely than an increase in drought frequency caused by an increase in periods of low precipitation, and the confidence of this assessment is higher for temperature driven drought (*high confidence*) than for precipitation driven drought (*medium confidence*).

It is likely (>66%) that Oregon will experience an increase in wildfire frequency and intensity (*high confidence*). The greatest increased risk will be in the western and southern portions of the region, and more so at lower elevation wildlands than higher elevation wildlands.

The executive summary of Oregon's 2010 Climate Change Adaptation Framework provides a summary of challenges associated with "increased incidence of drought" and "increase in wildfire frequency and intensity," as follows.

Wildfire

Increased temperatures, the potential for reduced precipitation in summer months, and accumulation of fuels in forests due to insect and disease damage present high risk for catastrophic fires, particularly in forests east of the crest of the Cascade Range. An increase in frequency and intensity of wildfire will damage larger areas, and likely cause greater ecosystem and habitat damage. Larger and more frequent wildfires will increase human health risks due to exposure to smoke.

Increased risk of wildfire will result in increased potential for economic damage at the urban-wildland interface. Wildfires destroy property, infrastructure, commercial timber, recreational opportunities, and ecosystem services. Some buildings and infrastructure subject to increased fire risk may not be adequately insured against losses due to fire. Increased fire danger will increase the cost to prevent, prepare for, and respond to wildfires.

Droughts

Longer and drier growing seasons and droughts will result in increased demand on ground water resources and increased consumption of water for irrigation, which will have potential consequences for natural systems. Droughts affect wetlands, stream systems, and aquatic habitats. Droughts will result in drier forests and increase likelihood of wildfire.

Droughts will cause significant economic damage to the agriculture industry through reduced yields and quality of some crops. Droughts can increase irrigation-related water consumption, and thus increase irrigation costs. Drought conditions can also have a significant effect on the supply of drinking water.

Winter Storms, Floods, and Landslides

Regions affected: 1–4

Flooding and landslides are projected to occur more frequently throughout western Oregon, in Oregon NHMP Regions 1 through 4. While winter storms affect all areas of the state, there is no current research available indicating any change in the incidence of winter storms due to changing climate conditions.

The projected increases in extreme precipitation is expected to result in a greater risk of flooding in certain basins. Changes in flood risk are strongly associated with the dominant form of precipitation in a basin, with mixed rain-snow basins in Washington and Oregon already seeing increases in flood risk. Generally, western Oregon basins are projected to experience increased flood risk in future decades. Increased flood risk involves both an increased incidence of flooding of a certain magnitude and an increase in the magnitude of floods of a certain return interval. In other areas of the state, flood risk may decrease in some basins and increase in others. Some of Oregon's largest floods occur when warm heavy rain from atmospheric rivers falls on snowpack leading to rapid snowmelt, resulting in rain-on-snow flooding events (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). The frequency and intensity—amount of transported moisture—of atmospheric river events is projected to increase along the West Coast in response to rising atmospheric temperatures (Kossin, et al., 2017). This larger moisture transport of atmospheric rivers would lead to greater likelihoods of flooding along the West Coast (Konrad & Dettinger, 2017).

It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). It is *very likely* that Oregon will experience an increase in the frequency of extreme river flows (*high confidence*). It is *more likely than not* (>50%) that these extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (*low confidence*), although this depends on local conditions (site-dependent river channel and floodplain hydraulics).

In Oregon, landslides are strongly correlated with rainfall when the soil becomes saturated, so increased rainfall — particularly in extreme events — will likely trigger increased incidence of landslides. Landslide risk can also be amplified in areas with recent wildfire, particularly if followed by heavy rain. With climate change expected to increase the frequency of both wildfires and heavy rains, it follows that landslide risk also increases with climate change (Kopp, et al., 2017). However, landslide risk depends on a variety of site-specific factors unrelated to climate.

The executive summary of Oregon's 2010 Climate Change Adaptation Framework provides a summary of challenges associated with both flooding and landslides:

Floods

Extreme precipitation events have the potential to cause localized flooding due partly to inadequate capacity of storm drain systems. Extreme events can damage or cause failure of dam spillways. Increased incidence and magnitude of flood events will increase damage to property and infrastructure and will increase the vulnerability of areas that already experience repeated flooding. Areas thought to be outside the floodplain may begin to experience flooding. Many of these areas have improvements that are not built to floodplain management standards and are not insured against flood damage, therefore being more vulnerable to flood events. Finally, increased flooding will increase flood-related transportation system disruptions, thereby affecting the distribution of water, food, and essential services.

Landslides

Increased landslides will cause increased damage to property and infrastructure and will disrupt transportation and the distribution of water, food, and essential services. Widespread damaging landslides that accompany intense rainstorms (such as "Pineapple Express" winter storms) and related floods occur during most winters. Particularly high consequence events occur about every decade; recent examples include those in February 1996, November 2006, and December 2007.

Windstorms

Regions affected: Unknown

There is little research on changing wind in the Pacific Northwest as a result of climate change.

2.1.4.3 Evolving Climate Science and the Oregon NHMP

Oregon is committed to planning and understanding how climate change will impact its citizens and natural resources. Climate change will exacerbate certain natural hazards such as drought, wildfire, and extreme heat in the State of Oregon. Climate change planning is not only for the future; it is occurring and affecting Oregon now.

Oregon sits at the forefront of climate change research in the United States. In 2007, the Oregon State Legislature established the Oregon Climate Change Research Institute (OCCRI) at Oregon State University. Since its establishment, OCCRI has provided extensive support to Oregon State agencies, conducted novel climate change research, delivered numerous community outreach and education activities, produced multiple regional, state, and local climate assessment reports, and led two large federal climate change centers: the Pacific Northwest Climate Impacts Research Consortium (2010–2021), funded through the National Oceanic and Atmospheric Administration, and the Northwest Climate Science Center (2010–2017), funded through the Department of Interior. Both centers specifically focus on how climate change impacts the Pacific Northwest, with an interest in natural hazards. The NHMP will once again draw from the latest research at OCCRI and region partners for the 2025 plan.

The 2020 NHMP relied on climate change information based on the current state-of-the-art global climate model outputs from the Coupled Model Intercomparison Project phase 5 (CMIP5). CMIP5 outputs supported the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which was released in 2013, as well as the Fourth National Climate Assessment, which was released in 2017–2018. The legislation that created OCCRI requires an assessment of the state of the science as it impacts Oregon. The 2020 NHMP drew heavily from the two most recent reports: the Third and Fourth Oregon Climate Assessment Reports (Dalton, Dello, Hawkins, Mote, & Rupp, 2017) (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019).

From 2013 to 2020, a new round of global climate model outputs—CMIP phase 6—was developed from which new climate information and knowledge will continue to be developed in the coming years. The sixth assessment report of the IPCC is planned to be released in 2021. The Fifth National Climate Assessment is scheduled to be released in 2022. The climate change information for the 2025 update will be based on these reports and future OCCRI Oregon climate assessment reports.

Climate science is rapidly evolving, and it is impossible to predict where the state of the science will be in 5 years. Many of the foundational findings have remained the same throughout generations of climate assessments, yet new understanding of certain aspects of the climate is evolving, such as attribution of extreme climate events to human-caused climate change, compounding climate extremes, and regional or local climate impacts.

Oregon commits to addressing climate change in each climate-related hazard, statewide and by OEM hazard mitigation region, in the 2025 plan to the extent that the science can support inclusion into each section. We addressed the uncertainty of the state of the science, and maintain that we will only draw from peer-reviewed literature to support the plan. The U.S. National Climate Assessment is now undergoing a sustained assessment, or continued examination of climate change impacts as they affect the United States. OCCRI is involved in the sustained assessment, and we will draw from this work in the 2025 plan. With some confidence, OCCRI will be able to improve information about climate change impacts to extreme heat, drought, flood, wildfire, and coastal hazards in the 2025 report.

2.1.5 State-Owned/Leased Facilities, State Critical Facilities, and Local Critical Facilities Potential Loss Assessment

Requirement: 44 CFR §201.4(c)(2)(ii): The risk assessment shall include… (ii) State owned or operated critical facilities located in the identified hazard areas shall also be addressed.

Requirement: 44 CFR §201.4(c)(2)(iii): The risk assessment shall include… (iii) An overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

According to the Oregon Department of Administrative Services (DAS), the State of Oregon owns or leases buildings having a total value of nearly $7.3 billion in 2019. Because of this investment it is important the State assess the vulnerability of these structures to Oregon's natural hazards. Data to support this analysis were available for the following hazards: coastal erosion, earthquake, flood, landslide, tsunami, volcano, and wildfire. The Oregon Department of Geology and Mineral Industries (DOGAMI) assembled the best-available statewide natural hazard data and assessed which state-owned/leased buildings are exposed to each hazard. While this study primarily focused on state assets, DOGAMI also assessed the vulnerability of local critical facilities to natural hazards throughout the state.

The data for this analysis was furnished by DAS. As a part of the quality control review, DOGAMI removed nearly 400 building points from the original 2019 DAS dataset to build the dataset used in the vulnerability assessment. Many of the buildings were removed based on attributes in the GIS data that indicated that the points represented non-structures (e.g., property grounds). The final data set contained 5,350 state facilities.

Notably, the DAS building data does not identify "critical/essential" facilities. Within the state facilities dataset DOGAMI created a subcategory of critical facilities. DOGAMI and the Department of Land Conservation and Development (DLCD) defined critical facilities as buildings that function as airports, communications, emergency operations, fire stations, hospitals or health clinics, military facilities, police stations, schools, detention centers, or miscellaneous facilities (e.g., ODOT Maintenance Facility) that would be needed during or immediately after a natural disaster. DOGAMI identified 1,674 state critical facilities. **Figure 2-23** shows the distribution and dollar value (potential loss) of these 5,350 state-owned/leased facilities, including critical facilities, within Oregon NHMP Natural Hazard Regions.

Local critical facilities are a building, or a group of buildings, that either are publicly or privately owned airports, communications, emergency operations, fire stations, hospitals or clinics, military facilities, police stations, schools, detention centers, or miscellaneous facilities, as defined by DOGAMI and DLCD. The dataset that DOGAMI developed and used in the vulnerability assessment had 8,757 buildings with a total value of $26 billion. Local critical facilities are shown in **Figure 2-24** and are included in regional maps.

These facilities were carried forward from the database developed for the 2015 State NHMP. The 2015 data of local critical facilities were verified or modified, and additions or deletions were completed as necessary.

2.1.5.1 Assessment Methods

DOGAMI used two primary methods for assessing vulnerability to hazards: Hazus damage estimates for earthquakes and exposure analysis for floods, coastal erosion, volcanic hazards, tsunamis, wildfires, and landslides.

Hazus is a software package developed by FEMA that "provides nationally applicable, standardized methodologies for estimating potential wind, flood, and earthquake losses on a regional basis… The multi-hazard Hazus is intended for use by local, state, and regional officials and consultants to assist mitigation planning and emergency response and recovery preparedness. For some hazards, Hazus can also be used to prepare real-time estimates of damages during or following a disaster" (FEMA, 2012, pp. 1-1). The results of the Hazus damage analysis are provided as a *loss estimation* (i.e., the building damage in dollars) and as a *loss ratio* (loss estimation divided by the total value of the building, represented as a percentage). DOGAMI aggregated and reported losses at a county level.

Exposure analysis was used to characterize risk for floods, coastal erosion, volcanic hazards, tsunamis, wildfires, and landslides. This is a simple method to determine which facilities lie within a natural hazard area and which do not. It is an alternative for natural hazards for which Hazus damage functions or high-quality, statewide hazard mapping is not available, and therefore, loss estimation is not possible or recommended. DOGAMI categorized most hazards with simple classification schemes (most commonly "High," "Moderate," "Low," or "Other"). For each hazard, the attribute "Other" was used to describe very low hazard areas, unmapped and/or unstudied areas, or zero hazard zones (further defined for individual hazards). Exposure analysis results are communicated in terms of the number of facilities exposed, the value exposed (i.e., total facility value in dollars), and a county-level percentage of value exposed (i.e., the total value exposed value divided by the total value of all facilities in the county).

For the 2020 Risk Assessment, DOGAMI used the percentage of building value exposed or a loss ratio to a given hazard to calculate a vulnerability score for each county in each category of potential loss for each hazard faced by a county. Scores for coastal hazards and tsunamis were only calculated for counties in Region 1. The percentage of exposure or loss for each county for each hazard was statistically distributed into five categories (Very Low, Low, Moderate, High, or Very High) using the Jenks Natural Breaks method. DOGAMI applied this method to the results for all state facilities, state critical facilities, and local critical facilities. The vulnerability scores derived from this method were used along with other parameters (e.g., social vulnerability index) to calculate an overall vulnerability score for each county for each hazard and an overall risk score for each county for all hazards combined.

2.1.5.2 Hazard Data Limitations

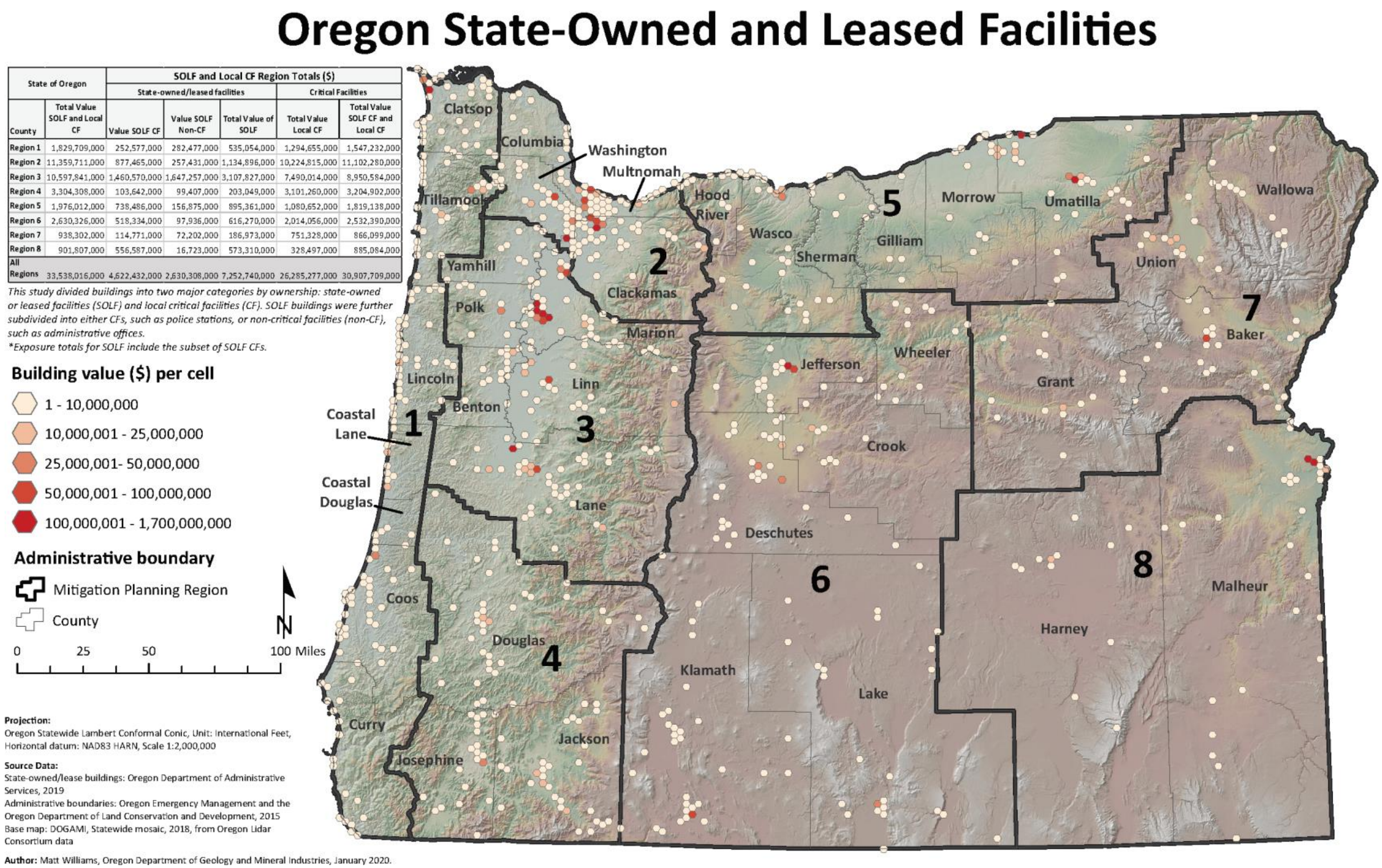
This assessment evaluates each hazard individually; there are no comprehensive or multi-hazard assessments. In order to prioritize facilities most vulnerable facilities to natural hazards, DOGAMI categorized most hazards with simple classification schemes (most commonly "High," "Moderate," "Low," or "Other"). For each hazard "Other" is used to describe very low hazard areas, unmapped and/or unstudied areas, or zero hazard zones (further defined for individual hazards).

Statewide natural hazard data are generalized in several ways and provide a gross view of their distribution and magnitude across the state. They are often combined or derived from other data sources that themselves can have widely different quality, accuracy, attribution, or currency. Future investigations or actual hazard events may substantially modify our understanding of where and when natural hazards might occur.

It is worth noting that building-specific information can make an enormous difference when evaluating the actual damaging effects of natural hazards. For example, a modern seismically reinforced building may receive far less or no earthquake damage relative to older un-reinforced buildings next door. The Hazus damage assessment is highly dependent on the quality of the facility attributes and as some assumptions had to be made due to lack of specificity in the data, some error is inevitable. In addition, Hazus is a model, not reality, which is an important factor when considering the loss ratio of an individual building. The results of the Hazus model are only useful when aggregated across large numbers of facilities and it does not provide a site-specific analysis. Because of this model limitation, we chose to aggregate at a county level and the loss estimates for individual buildings are likely inaccurate. Exposure analysis does not attempt to account for building- or site-specific characteristics.

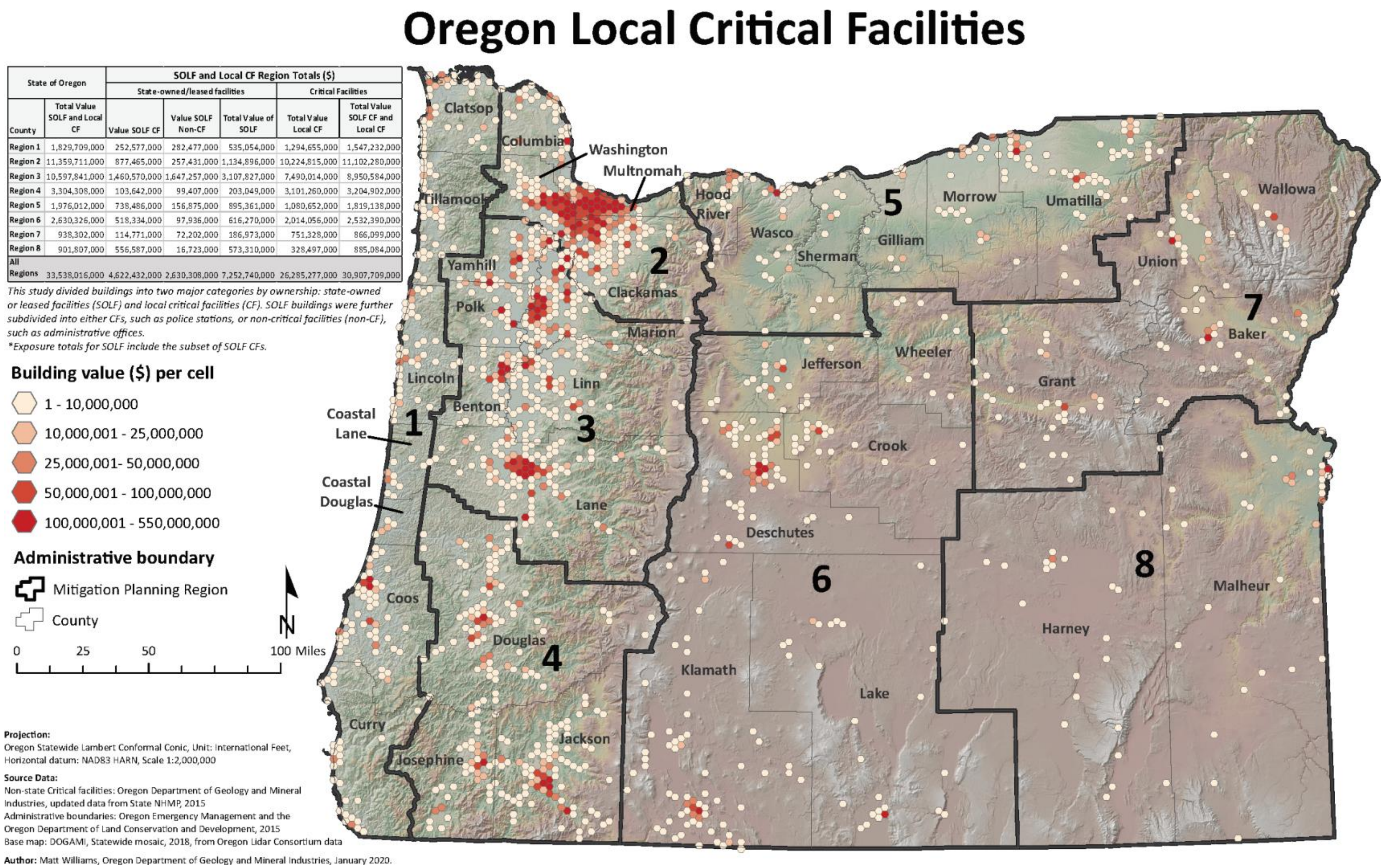
The limitations of the vulnerability scoring were related to the sample of size of the results for some hazards. This issue was most prevalent with the coastal hazards because there were only seven counties (i.e., sample size of seven) to statistically distribute into five categories. Therefore, the reliability of the vulnerability scores for tsunami and coastal erosion is greatly reduced. The vulnerability scoring for state critical facilities exposed to volcanic hazards was limited to four counties, so data were distributed into four categories instead of five. In this case, the Very High category was dropped from the possible vulnerability scores.

Figure 2-23. Statewide Distribution of State-Owned/Leased Facilities and State Critical Facilities



Source: DOGAMI

Figure 2-24. Statewide Distribution of Local Critical Facilities



State of Oregon		SOLF and Local CF Region Totals ($)				
		State-owned/leased facilities			Critical Facilities	
County	Total Value SOLF and Local CF	Value SOLF CF	Value SOLF Non-CF	Total Value of SOLF	Total Value Local CF	Total Value SOLF CF and Local CF
Region 1	1,829,709,000	252,577,000	282,477,000	535,054,000	1,294,655,000	1,547,232,000
Region 2	11,359,711,000	877,465,000	257,431,000	1,134,896,000	10,224,815,000	11,102,280,000
Region 3	10,597,841,000	1,460,570,000	1,647,257,000	3,107,827,000	7,490,014,000	8,950,584,000
Region 4	3,304,308,000	103,642,000	99,407,000	203,049,000	3,101,260,000	3,204,902,000
Region 5	1,976,012,000	738,486,000	156,875,000	895,361,000	1,080,652,000	1,819,138,000
Region 6	2,630,326,000	518,334,000	97,936,000	616,270,000	2,014,056,000	2,532,390,000
Region 7	938,302,000	114,771,000	72,202,000	186,973,000	751,328,000	866,099,000
Region 8	901,807,000	556,587,000	16,723,000	573,310,000	328,497,000	885,084,000
All Regions	33,538,016,000	4,622,432,000	2,630,308,000	7,252,740,000	26,285,277,000	30,907,709,000

Source: DOGAMI

2.1.5.3 Facilities within Hazard Areas

The spatial distribution of the facilities within hazard zones is not easily viewed on a statewide map. Therefore, maps depicting hazard zones and facilities within those zones have only been created at the regional scale. Those maps can be found in the **Regional Risk Assessments**.

Coastal Erosion

DOGAMI used the results from several of their coastal erosion studies to develop a coastal erosion hazard zone for this analysis. However, these data do not cover the entire Oregon coastline: coastal erosion hazard zones have not been created for Lane, Douglas, and Coos Counties, and only partial data coverage exists for Curry County. To address these data gaps, DOGAMI excluded those portions of the coast from the analysis, using a 0.5-km buffer of the coastline to delineate an “other” value. In areas where mapping exists, the hazard is mapped as Active, High, Moderate, or Low Hazard Zones which, for the purposes of this analysis, were simplified to “High” (encompassing Active and High), “Moderate,” and “Other” (encompassing Low hazards and unmapped areas). The “Low” hazard zones incorporate hypothetical landslide block failures assumed to fail in the event of a M9 Cascadia earthquake and were placed under “Other” due to their very low probability. All other areas of the state received a “None” attribute.

Coastal Erosion Hazard Facility Summary

Of the 5,350 state facilities evaluated, 34 were located within a High or Moderate coastal erosion zone and represented a value of approximately $11.5 million. No critical state facilities were identified to be within a coastal erosion hazard zone. An analysis of local critical facilities shows that 22 buildings with a total value of $7.5 million are vulnerable to coastal erosion.

Earthquake

The state facilities and local critical facilities vulnerability assessment used a combination of datasets that represent key geologic factors that contribute to earthquake hazard damage. This assessment utilized the FEMA developed software of Hazus-MH to estimate the amount of damage that may occur during a CSZ event and a 2,500-year probabilistic scenario. The damage estimates from the CSZ were very low east of the Cascade Mountains, so the loss estimates we reported from this event were limited to the western regions (1–4) (Madin & Burns, 2013). DOGAMI assessed the four eastern regions (5–8) with the USGS 2500-year probabilistic scenario (Petersen, et al., 2014).

Results from both earthquake analyses were reported in terms of loss estimation (i.e., the building damage in dollars) and loss ratio which is the loss estimation divided by the total value of the building, represented as a percent. The results were also summarized by extensive or complete damage probabilities, which is synonymous with yellow-tagged or red-tagged buildings.

Earthquake Hazard Facility Summary

Of 5,350 state facilities evaluated, 838 building were flagged as completely or extensively damaged following a CSZ event (Regions 1–4) or a 2,500-year probabilistic scenario (Regions 5–8) totaling over $1.3 billion of damages to property. Among the 1,647 critical state facilities, 360 were flagged as completely or extensively damaged. DOGAMI determined that out of the 8,757 local critical facilities, 1,880 buildings were flagged as completely or extensively damaged following a CSZ event (Regions 1–4) or a 2,500-year probabilistic scenario (Regions 5–8) totaling over $4.3 billion of damages to property.

Flood

DOGAMI used a combination of Federal Emergency Management Agency (FEMA) effective and preliminary flood zone data, state digitized flood zone data, and FEMA Q3 data to develop a statewide flood hazard zone for this analysis. DOGAMI indicated a flood hazard if a building fell within floodways, 100-year floodplains, or 500-year floodplains. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. In particular, rural or sparsely populated areas tend to have poorly mapped or nonexistent flood hazard data. For these reasons, buildings were simply classified as “Hazard Zone” or “Other.” “Hazard Zone” indicates a building falls within one of the floodway, 100-year, or 500-year flood hazard zones. “Other” indicates there is insufficient information to determine whether a flood hazard exists for a given site. Buildings with “Other” designations could conceivably face relatively high flood hazards or no flood hazard at all.

Flood Hazard Facility Summary

Of the 5,350 state facilities evaluated, 632 were located within a flood hazard zone and had an estimated total value of over $900 million. Of these, 165 were identified as critical state facilities. DOGAMI also found that 683 local critical facilities were exposed to flood hazard, with a total value of $1.6 billion.

Landslides and Debris Flow

The state facilities and local critical facilities vulnerability assessment used the statewide landslide susceptibility map (Burns, Mickelson, & Madin, 2016) in this report to identify the general level of susceptibility to landslide hazards, primarily shallow and deep landslides. Burns and others (2016) used SLIDO inventory data along with maps of generalized geology and slope to create a landslide susceptibility overview map of Oregon that shows zones of relative susceptibility: Very High, High, Moderate, and Low. SLIDO data directly define the Very High landslide susceptibility zone, while SLIDO data coupled with statistical results from generalized geology and slope maps define the other relative susceptibility zones (Burns, Mickelson, & Madin, 2016). This susceptibility map was used to determine which state facilities are vulnerable to the landslide hazard. The statewide landslide susceptibility model was originally published with susceptibility values of 1 through 4. Since landslide susceptibility is also an input into Hazus-MH, it was necessary to translate the results into a Hazus compliant scale of 1–10. The landslide susceptibility categories were changed in this way: Low (1 = 1), Moderate (2 = 4), High (3 = 7) and Very High (4 = 10).

Landslide Hazard Facility Summary

Of the 5,350 state facilities evaluated, 1,379 (amounting to nearly $835 million) were located within Very High and High landslide hazard areas; this included 277 critical state facilities. DOGAMI determined that out of the 8,757 local critical facilities, 472 were in Very High or High hazard zones with a total value over $640 million.

Tsunami

DOGAMI used published tsunami inundation model results (Priest, et al., 2013) for the entire coast to determine the tsunami hazard zone for this analysis. The coast-wide inundation models divide tsunami scenarios by whether an earthquake source is local or distant. The distant source tsunami scenarios were not used in this report. The local tsunami scenarios used in this report for exposure analysis were CSZ "t-shirt" sizes of Small (Sm), Medium (M), Large (L), Extra Large (XL), and Extra-Extra Large (XXL).

The recurrence interval associated with each local source tsunami scenario is as follows (Priest, et al., 2013):

- XXL 1,200 years
- XL 1,050–1,200 years
- L 650–800 years
- M 425–525 years
- SM 300 years

For the purposes of the NHMP building exposure analysis, all these zones are described as "High," with the remainder of the state receiving an "Other" designation to encompass very-low probability events or no tsunami hazard

Tsunami Hazard Facility Summary

Of the 5,350 state facilities evaluated, 523 were located within the tsunami hazard zone and had an estimated total value of $248 million. Of the 523 state facilities exposed to tsunami hazard, 131 were identified as critical state facilities. DOGAMI determined that out of the 8,757 local critical facilities, 281 were in High hazard zones with a total value over $350 million.

Volcanic Hazards

DOGAMI used data from the U.S. Geological Survey (USGS) and DOGAMI's Mount Hood lahar mapping to develop the statewide volcanic hazard layer for this analysis. USGS maintains hazard zone data for five volcanic areas in the Cascade Mountains of Oregon: Mount Hood, Crater Lake, Newberry Crater, Mount Jefferson, and the Three Sisters. This assessment scores each facility based on whether it is located within a proximal hazard zone (translating to "High") or distal hazard zone (translating to "Moderate" or "Low"). The maximum credible lahar scenario for each volcano was classified as "Low" because it has a very low probability of occurring, while the others were placed into a "Moderate" category. DOGAMI added its own lahar data for Mount Hood which resulted in a slight expansion of "Low" hazard areas for the maximum credible lahar scenario. Any facility located within these hazard zones is considered vulnerable to volcanic hazards. Outside these hazard zones, the volcanic hazard is undetermined and categorized as "Other" rather than "None" due to the possibility of widespread volcanic effects, such as ash fall or acid rain.

Volcanic Hazard Facility Summary

Of the 5,350 state facilities evaluated, 125 were located within a volcanic hazard area and represented an approximate value of $355 million. Of those, 100 were located in the Moderate or High hazard zones. 19 critical facilities fall in a High or Moderate hazard zone, while the remaining 3 critical facilities fall into Low volcanic hazard zone. DOGAMI determined that out of the 8,757 local critical facilities, 110 were in Moderate or High hazard zones with a total value of $244 million.

Wildfire

The Oregon Department of Forestry (ODF) participated in a statewide fire hazard and risk assessment in 2018 as part of the Pacific Northwest Quantitative Wildfire Risk Assessment for Oregon and Washington (Pyrologix LLC, 2018). Following ODF guidance, DOGAMI evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in “High,” “Moderate,” and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are also represented here as “Low.” For more detailed information regarding this dataset, refer to the Pacific Northwest Quantitative Wildfire Risk Assessment or contact an ODF representative.

Wildfire Hazard Facility Summary

Of the 5,530 state facilities evaluated, 1,111 were within the High or Moderate wildfire hazard zone and total about $950 million in value. Among critical state facilities, 365 were within the High or Moderate wildfire hazard zone. DOGAMI determined that out of the 8,757 local critical facilities, 955 were in High or Moderate hazard zones with a total value over $775 million.

2.1.6 Seismic Transportation Lifeline Vulnerabilities

Requirement: 44 CFR §201.4(c)(2)(iii): The risk assessment shall include… (iii) …The State shall estimate the potential dollar losses to … infrastructure…located in the identified hazard areas.

The Oregon Department of Transportation has been engaged for several decades in data collection on highway and bridge conditions (Oregon Seismic Lifelines Identification Project, May 2012; https://www.oregon.gov/ODOT/Planning/Documents/Seismic-Lifelines-Evaluation-Vulnerability-Synthese-Identification.pdf), development of options for mitigation against damage to roadways and bridges that may be caused by seismic events (Oregon Seismic Options Report, May 2013; ftp://ftp.odot.state.or.us/bridge/bridge_website_chittirat/Oregon_Highways_Seismic_Options_Report_3_2013.pdf) and in 2014 completed a prioritization of these options in the Oregon Highways Seismic Plus Report (https://www.oregon.gov/ODOT/Bridge/Docs_Seismic/Seismic-Plus-Report_2014.pdf) published in October 2014.

The Governor's Task Force on Resilience Plan Implementation (ORTF) recommendations on implementation of the Oregon Resilience Plan (ORP) issued in September 2014 brought forward the most critical recommendations of the ORP to be implemented in the 2015-17 biennium. With respect to transportation infrastructure resilience, the ORTF recommended that additional revenue be identified to complete the most critical backbone routes identified in ODOT's Seismic Options Report within a decade, and the complete program by 2060. The funding source should be ongoing and "pay-as-you-go," rather than financed through bonding, to provide resources for all phases over the course of several decades (Governor's Task Force on Resilience Plan Implementation, 2014).

The 2013 Oregon Seismic Options Report presented the seismic bridge retrofit as a standalone program. The program cost and implementation approach were simplified in 2014 by focusing only on seismic retrofit work on bridges and mitigation of unstable slopes along proposed lifeline routes. The ODOT Bridge Section evaluated a variety of options for blending the seismic mitigation effort with other bridge structural needs. ODOT looked for opportunities for cost effective approaches. The following classifications formed the framework for this prioritization process.

- Many bridges along Oregon state highways are in relatively good condition, with many years of remaining service life absent a major seismic event, and could benefit from a standalone retrofit project.
- Some bridges are not good candidates for seismic retrofit due to structural and other condition issues. Most of these bridges were built in the 1950s and 1960s, and many were built over poor soils which can amplify the seismic forces the bridge must endure during a seismic event.
- Other bridges will need to be replaced within the next several decades, and it makes no sense to retrofit a bridge only to replace it within a decade; for these structures, replacement will be more cost-effective in the long term than retrofit.
- Still other bridges will need significant rehabilitation work, and there would be significant cost benefits to combining retrofit and repair projects.

The 2014 Seismic Plus Report provides ODOT's last statewide seismic vulnerability assessment for state bridges and unstable slopes along the state's seismic lifeline routes. It also provides a mitigation plan for strengthening Oregon's lifeline corridors and making them seismically resilient in case of a major Cascadia seismic event. Since the publication of this report, a few state bridges have either been replaced or seismically retrofitted. Updates to the program are reflected in the annual Bridge Condition Report (ODOT Bridge Condition Report).

Phase I of the Oregon Highways Seismic Plus Report received funding through HB 2017 passed in 2017 during the 79th Oregon Legislative Assembly that has allowed scoping for seismic work on I-5 near Eugene for the 2021-2024 State Transportation Improvement Program (STIP). The initial amount is $10 million/year with increases expected over time as the gas tax revenue increases. Phase I also includes portions of I-84 that are planned for to be retrofitted moving from east to west. **Figure 2-25** below illustrates the Phases 1–5 of the Seismic Plus Report.

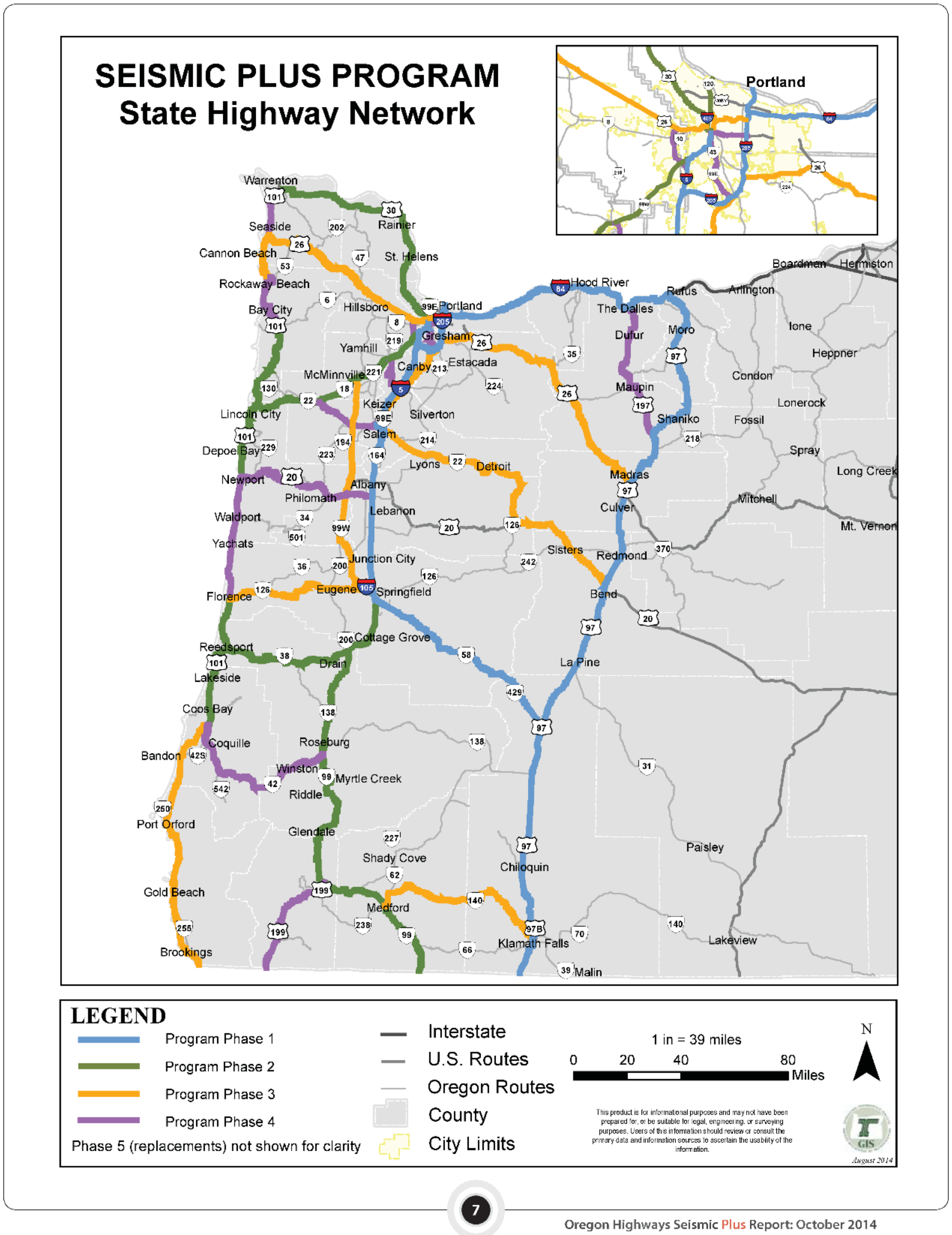
The 2021-2024 STIP funding includes $31M to address ODOT bridge seismic needs.

Since the allocation of funding in 2017, four bridges along the Phase I route have been replaced mainly due to their age and condition. ODOT's first priority for seismic retrofitting are state bridges carrying the Phase 1 highway segments. Construction is underway on the northern half of US-97 (I-84 to OR-58), while the southern half of US-97 and OR-58 is under design. Also, several bridges carrying I-205, including the Abernethy bridge, will be either replaced or widened and retrofitted as an additional benefit to a modernization project between Stafford Road and OR-213 (https://www.i205corridor.org/).

The Southern Oregon Seismic Bridge Retrofit project is currently being designed. The project includes portions of Phase 2 and Phase 3 addressing key lifeline routes to and from the Rogue Valley. The construction phase is funded.

ODOT worked in cooperation with a variety of stakeholders and decision makers over several decades to find solutions to this statewide problem. The most challenging decision is to determine when to begin these investments and how to generate the necessary revenue. As part of the statewide effort to make the Oregon highway system seismically resilient, ODOT's responsibility has become clear: retrofit all seismically vulnerable bridges and address unstable slopes on key lifeline routes in a strategic and systematic program to allow for rescue and recovery following a major earthquake.

Figure 2-25. ODOT Seismic Plus Programs State Highway Network Program Phases



The Oregon Highway Seismic Plus Program is based on the work of the Oregon Seismic Lifeline Routes identification project, which is described below.

In 2012 the Oregon Department of Transportation (ODOT) conducted the Oregon Seismic Lifeline Routes (OSLR) identification project. The purpose of the OSLR project was twofold:

- Support emergency response and recovery efforts by identifying the best connecting highways between service providers, incident areas and essential supply lines to allow emergency service providers to do their jobs with minimum disruption; and
- Support community and regional economic recovery after a disaster event.

The focus of the OSLR project is on state highway right of way, with the assumption that other transportation modes and facilities are part of an integrated lifelines system. The Oregon Seismic Resilience Plan furthers the discussion of the roles of the different modes and facilities in the aftermath of a CSZ event.

The OSLR project study recommended a specific list of highways and bridges that comprise the seismic lifeline network; and established a three-tiered system of seismic lifelines to help prioritize investment in seismic retrofits on state-owned highways and bridges.

A Cascadia Subduction Zone event has the potential to simultaneously affect all of western Oregon, potentially crippling the statewide transportation network.

This project was conducted by the ODOT Transportation Development Division (TDD) from September 2011 through April 2012, in coordination and consultation with Bridge, Maintenance, Geotechnical, and other impacted divisions within the agency, as well as with other state agencies including the Oregon Department of Geological and Mineral Industries (DOGAMI) and the Public Utility Commission (PUC) through a Project Management Team (PMT) and Steering Committee (SC). The full report (https://www.oregon.gov/ODOT/Planning/Documents/Seismic-Lifelines-Evaluation-Vulnerability-Synthese-Identification.pdf) is located in **9.1.16**, Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification.

2.1.6.1 Methodology

The OSLR project management team used the following five-step process to conduct the OSLR analysis.

Step 1: Identify Study Corridors

State highways west of US-97 were selected as study corridors that met one or more of the following characteristics (**Table 2-20**):

- Likely ability to promote safety and survival through connections to major population centers with survival resources;
- Current use as a strategic freight and commerce route; and
- Connection to one or more of the following key destinations of statewide significance:
  - I-84 east of Biggs Junction,
  - US-20 east of Bend,
  - The California border on I-5,
  - The California border on US-97,
  - A crossing of the Columbia River into southwest Washington,
  - A port on the Columbia or Willamette River,
  - A port on the coast,
  - Portland International Airport, and
  - Redmond Municipal Airport.

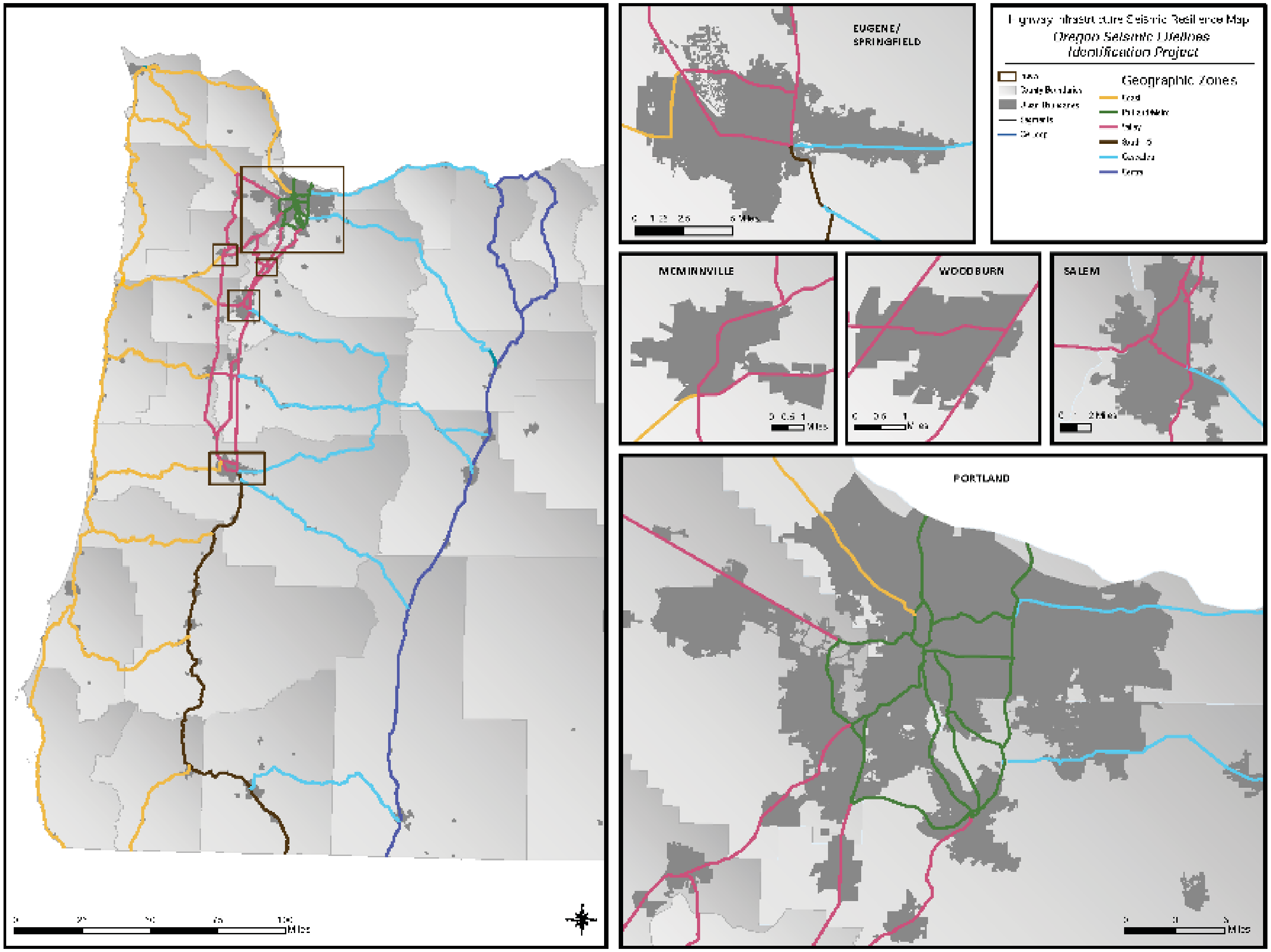
The study corridors were grouped geographically into the following six distinct zones within the western half of the state (**Figure 2-26**):

- Coast (US-101 and connections to US-101 from the I-5 corridor),
- Portland Metro (highways within the Portland Metro region),
- Valley (circulation between the Portland metro area and other major population centers in the Willamette Valley),
- South I-5 (the section of I-5 south of Eugene-Springfield),
- Cascades (highways crossing the Cascades Mountains),
- Central (the US-97/US-197 corridor from Washington to California), and
- Central (the US-97/US-197 corridor from Washington to California).

Step 2: Develop Evaluation Framework

The PMT established an evaluation framework that consists of the following four main elements: goals, objectives, criteria, and parameters (**Table 2-20**).

Figure 2-26. Oregon Seismic Lifeline Routes (OSLR) Geographic Zones



Source: ODOT

Table 2-20. Oregon Seismic Lifeline Routes (OSLR) Evaluation Framework

Goals	Objectives	Criteria
Support survivability and emergency response efforts immediately following the event *(immediate and short-term needs)*	1A. Retain routes necessary to bring emergency responders to emergency locations	bridge seismic resilience roadway seismic resilience dam safety roadway width route provides critical non-redundant access to major area access to fire stations access to hospitals access to ports and airports access to population centers access to ODOT maintenance facilities ability to control use of the highway
	1B. Retain routes necessary to (a) transport injured people from the damaged area to hospitals and other critical care facilities and (b) transport emergency response personnel (police, firefighters, and medical responders), equipment and materials to damaged areas	route provides critical non-redundant access to a major area bridge seismic resilience dam safety roadway seismic resilience access to hospitals access to emergency response staging areas
Provide transportation facilities critical to life support for an interim period following the event *(midterm needs)*	2A. Retain the routes critical to bring life support resources (food, water, sanitation, communications, energy, and personnel) to the emergency location	access to ports and airports bridge seismic resilience after short term repair dam safety roadway seismic resilience access to critical utility components access to ODOT maintenance facilities Freight access
	2B. Retain regional routes to hospitals	access to hospitals
	2C. Retain evacuation routes out of the affected region	access to Central Oregon access to ports and airports Importance of route to freight movement
Support statewide economic recovery *(long-term needs)*	3A. Retain designated critical freight corridors	Freight access bridge seismic resilience after short-term repair roadway seismic resilience after short-term repair route provides critical non-redundant access to a major area access to ports and airports access to railroads
	3B. Support statewide mobility for connections outside the affected region	access to Central Oregon access to ports and airports access to railroads
	3C. Retain transportation facilities that allow travel between large metro areas	route provides critical non-redundant access to a major area connection to centers of commerce

Source: ODOT

The criteria in the evaluation framework fell into three categories:

1. **Connections:** criteria relating to proximity to key resources and geographic areas likely to be essential after a seismic event,
2. **Capacity:** measure the characteristics of the roadway itself, and
3. **Resilience:** assess the likely capability that a corridor will function in the aftermath of a major seismic event, with or without a short term repair.

Criteria within each category are listed in **Table 2-21**.

Table 2-21. Oregon Seismic Lifeline Routes (OSLR) Criteria by Group

Connections	Capacity	Resilience
Access to fire stations	width of roadway	bridge seismic resilience
Access to hospitals	ability to control use of highway	roadway seismic resilience
Access to ports and airports	freight access	bridge seismic resilience after short-term repair
Access to railroads		roadway seismic resilience after short-term repair
Access to ODOT maintenance facilities		
Access to population centers		
Access to emergency response staging areas		
Access to critical utilities		
Access to central Oregon		

Source: ODOT

<u>Step 3: Analyze Selected Highways</u>

Each of the criteria were weighted and ranked (high, moderate, low performance) for each study segment.

<u>Step 4: Solicit Feedback from Steering Committee</u>

The OSLR project team used the results of the evaluation to identify a three-tiered seismic lifeline system — Tier 1 being the highest priority roadway segment, Tier 2 being the next highest, and Tier 3 being the third highest priority grouping to functions as follows:

- Tier 1: A system that provides access to and through the study area from Central Oregon, Washington, and California, and provides access to each region within the study area;
- Tier 2: Additional roadway segments that extend the reach of the Tier 1 system throughout seismically vulnerable areas of the state and that provide lifeline route redundancy in the Portland Metro Area and Willamette Valley; and
- Tier 3: Roadway segments that, together with Tier 1 and Tier 2, provide an interconnected network (with redundant paths) to serve all of the study area.

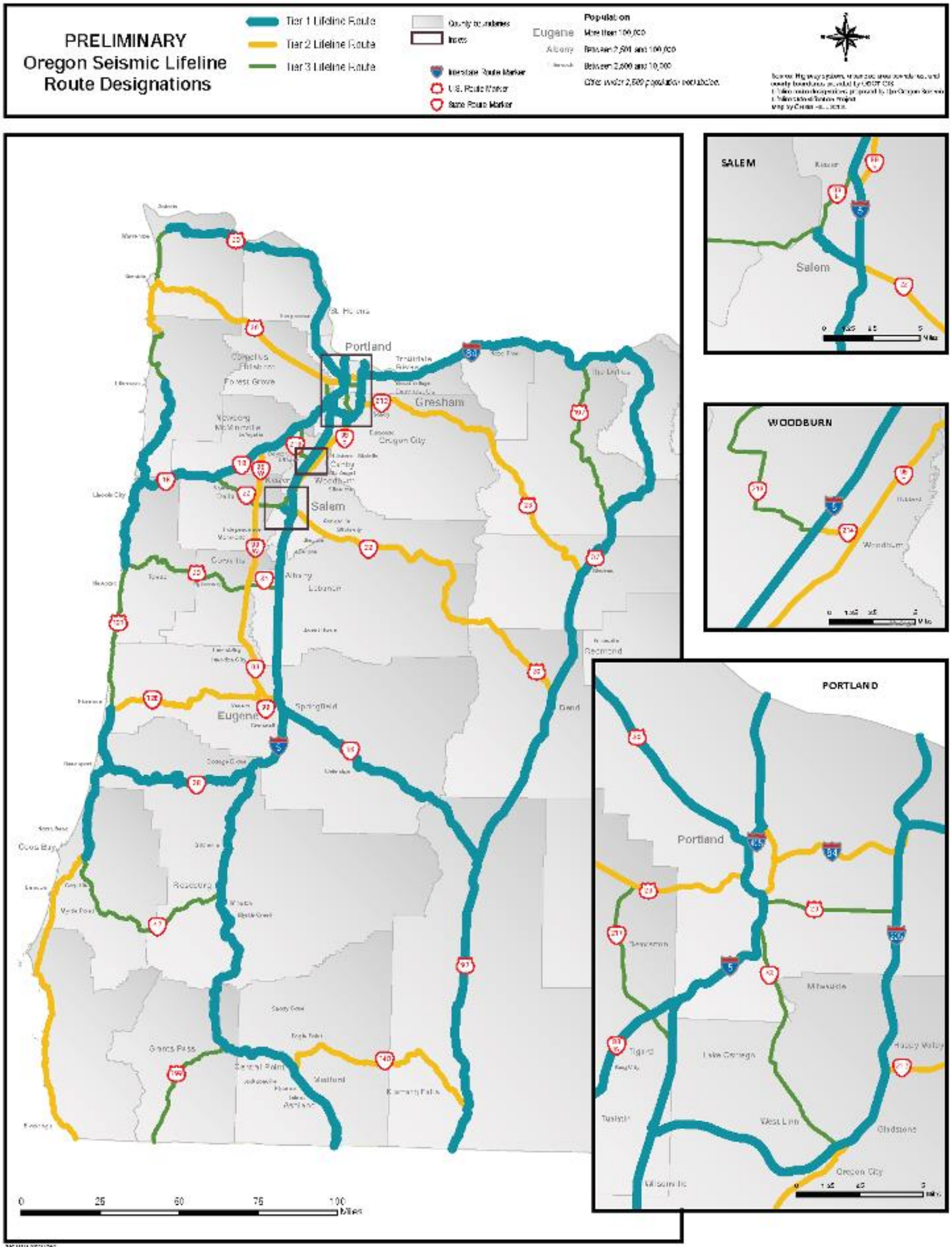
Step 5: Propose a System of Lifeline Routes

The proposed Tier 1 lifeline network shown provides roadway access to within about 50 miles of all locations in western Oregon. Total roadway miles for each tier are as follows:

- Tier 1: 1,146 miles,
- Tier 2: 705 miles, and
- Tier 3: 422 miles.

This provides a total of 2,273 miles of designated lifeline route. Study routes not identified as seismic lifelines total 298 miles. **Figure 2-27** shows the proposed seismic lifeline routes with tier designations.

Figure 2-27. Preliminary Oregon Seismic Lifeline Routes (OSLR), by Tier



Source: ODOT

2.1.6.2 Seismic Hazards Affecting Lifeline Routes

The following seismic hazards have the potential to affect the seismic vulnerability of structures (such as bridges, retaining walls, culverts, and tunnels) and roadway grades along the lifeline routes during a CSZ event:

Ground shaking. Ground shaking is a function of the distance to the earthquake epicenter, the magnitude of the earthquake, regional bedrock properties, and the stiffness of the site-specific soils. It includes the potential for ground amplification because of soft soil deposits. The effects of ground shaking, including the intensity, frequency content, and duration of the shaking, can physically damage structures (such as bridges, culverts, retaining walls, and tunnels), as well as trigger other seismic hazards (such as liquefaction and landslides).

Coseismic deformation. During a subduction zone earthquake, the tectonic plates undergo elastic deformation on a regional scale, resulting in the potential for several meters of permanent uplift or subsidence that could occur along the entire rupture zone, as expected along the entire Oregon Coast for the CSZ magnitude 9.0 event. Coseismic subsidence can affect tsunami wave heights and runup. If the ground subsides during the seismic event, the effective tsunami wave and associated runup are increased by the amount of subsidence. In addition, coseismic deformation can reduce ground elevations along low-elevation roadway grades to the extent that the elevations end up below design sea level following coseismic subsidence.

Liquefaction. Soil liquefaction is a phenomenon by which loose, saturated, and sandy/silty soils undergo almost a complete loss of strength and stiffness because of seismic shaking. Its occurrence along highway corridors is likely most significant at bridge sites (which are often near bodies of water) or along roadways that are adjacent to bodies of water (such as estuaries, rivers, and lakes). Liquefaction may cause failure of retaining walls from excessive earth pressure, movement of abutments and slopes caused by lateral spreading (liquefaction-induced slope instability), and loss of bearing or pile capacity for bridge abutments and pile caps.

Landslides. Landslide hazards are most likely to occur at locations of steeply sloping ground within the Coast Range and Cascade Mountains, or near alluvial channels. Landslides located above a roadway may lead to the blockage of a road from debris buildup. Landslides located below a roadway may cause undermining and loss of road grade. Landslides can occur at locations with recognized slope instabilities, but they can also occur in areas without a historic record of landslide activity.

However, the thoroughness of current mapping of faults for the State of Oregon is uncertain and very few of the observed earthquakes in Oregon are associated with mapped crustal faults. It is anticipated that, given the heavy vegetative cover for a lot of Oregon and the short period of time for which records have been kept, not all active faults have been identified.

Tsunamis. Tsunamis may affect lifeline routes near and adjacent to the coastline. The resulting water forces can damage structures within the tsunami run-up zone and can also cause debris buildup or inundation and the washing away of roadway grades.

2.1.6.3 State Vulnerability

Given the current conditions of the state highway system, the western half of Oregon will be profoundly impacted by a CSZ that will fragment major highways by damaging and destroying bridges, triggering landslides that obstruct and/or undermine roadways, other geological hazards such as soil liquefaction and the potential for tsunami that could overwhelm low-lying transportation facilities.

Significant loss of life is likely in tsunami prone areas. Additional loss of life from untreated injuries and disease due to a fragmented response network could also be significant. Loss of life due to structural collapse could be widespread, exacerbating by the duration of ground shaking and the size of the event at the coast, in the Coast Range, along the Lower Columbia, in the Metro area and in the central valleys.

The long-term economic impacts would be profound. Many residential, commercial, and industrial buildings would collapse or suffer significant damage. Supply lines for reconstruction materials would be disrupted and the transportation system capacity to move goods is likely to be usurped for a period of weeks for response/survival supplies and materials and personnel needed to re-establish essential services. The ability of employees and customers to get to businesses could be disrupted for weeks if not longer. Smaller and locally based businesses cannot typically survive long periods of closure.

A program to immediately (within the next few years) retrofit all seismic lifeline routes in western Oregon to current design standards is not possible with current budget limitations. Even if the State were able to embark on a program of rapid seismic strengthening of the entire highway system, let alone other regional and private transportation assets, it would be prudent to begin where the most benefit is accomplished in the least time for the least cost. That is a key premise of the development of the OSLR project and the Seismic Options Report that was, in part, based upon it.

2.1.6.4 Statewide Loss Estimates

The OSLR project included consideration of the costs of retrofitting bridges and other highway facilities to support the tiering decisions and a preliminary work for revenue requests for implementation. Cost estimates were made for construction projects to mitigate or correct vulnerabilities on the recommended Seismic Lifelines system. Details can be found in Appendix A of the Seismic Plus Report (Appendix **9.1.13**).

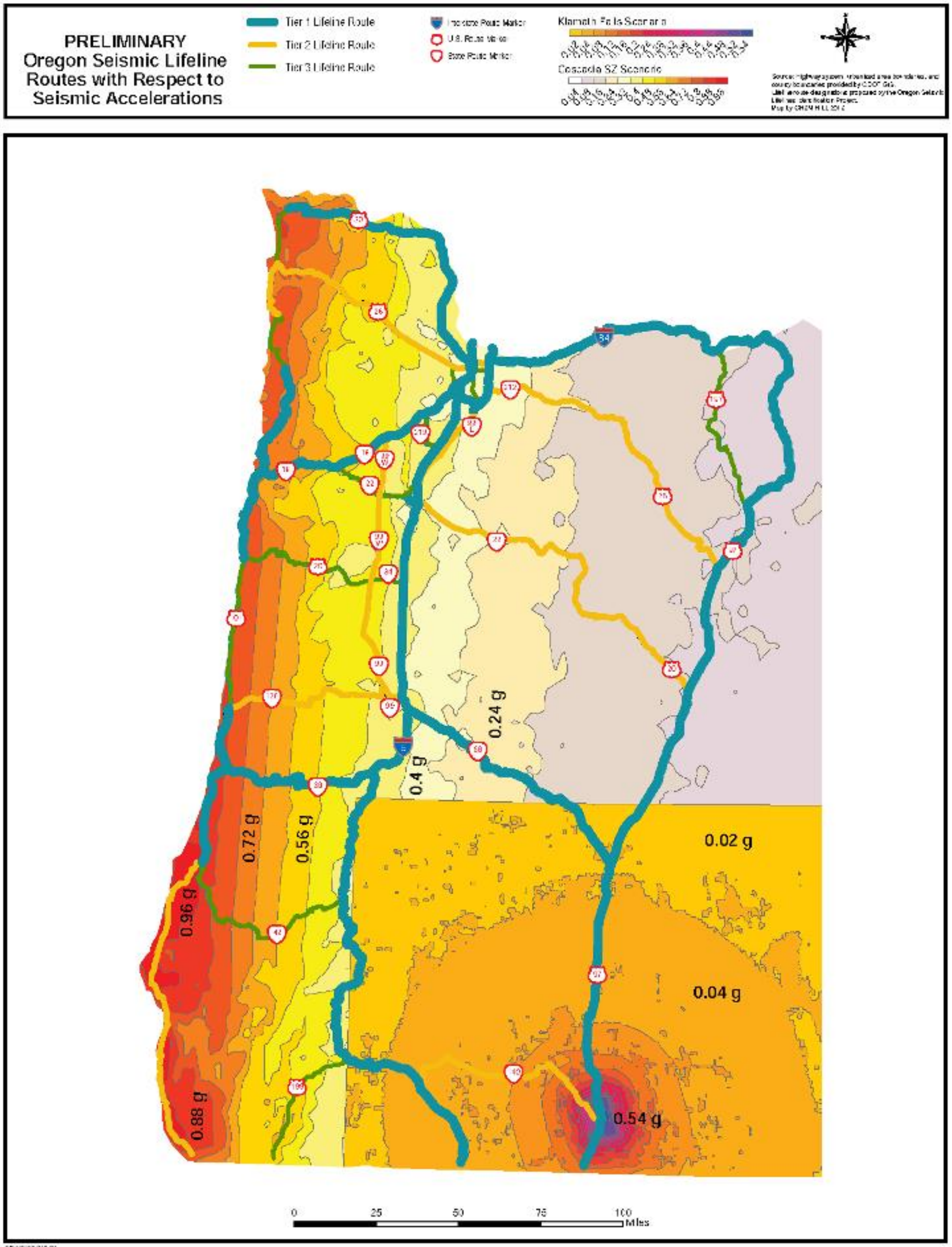
Appendices G and H of that report (Appendix **9.1.13**) address both a scenario wherein a major earthquake occurs and a scenario wherein a major earthquake does not occur**.** This analysis was done to answer a slightly different question: what is the value of making the recommended improvements to the identified lifeline routes?

> *"Significant economic losses in production activity can be avoided by preparing for a major earthquake ahead of time. With no preparation ahead of time, Oregon could lose up to $355 billion in gross state product in the 8 to 10 year period after the event. Proactive investment in bridge strengthening and landslide mitigation reduces this loss between 10% and 24% over the course of the eight years simulated for this analysis."*
>
> *By keeping bridges that would otherwise decay and restrict the movement of freight open to heavy trucks, the proposed program will have significant benefits to Oregon's economy even if we avoid a major earthquake. ODOT's analysis (see Appendix H) indicates the investments in bridge replacements and rehabilitation made over the initial two decades of the Seismic Plus Program will avoid the loss of 70,000 jobs by 2035, compared to the significant deterioration in bridge conditions that will occur with the current levels of investment in bridges. This benefit occurs regardless of whether Oregon suffers a major earthquake and is on top of the significant economic losses avoided by the Seismic Plus Program in the event of an earthquake."*

It is important to note that the losses considered in the economic analysis only considered impacts directly related to transportation system failures. It did not account for impacts outside of the transportation economic impacts such as the collapse of industrial or commercial buildings or basic service failures. Even so, the benefit to cost ratio of making needed improvements to the Seismic Lifelines system is 46:1.

Figure 2-28 shows seismic vulnerability of proposed lifeline routes relative to projected ground shaking from a CSZ event. These lifelines, including bridges on these roadways, are the most significant vulnerabilities of the state highway system.

Figure 2-28. Preliminary Seismic Lifeline Routes and Seismic Acceleration



Source: OSLR, ODOT

Bridges: Bridges are the most significant vulnerabilities of the state highway system. They are primarily vulnerable to the following seismic hazards:

- Ground shaking, which can result in structural damage of the bridge elements;
- Liquefaction, which can result in movement or failure of the abutments and/or the bridge piers;
- Tsunamis that can scour or result in large loads on bridge piers and abutments and, if high enough, can damage the bridge superstructure; and
- Landslides that can undermine a bridge.

Road grade vulnerabilities: Roadway grades are vulnerable to the following seismic hazards:

- Ground shaking, which can result in structural damage of roadway elements, including culverts, retaining walls, and abutments;
- Liquefaction, which can result in movement or failure of the slopes and ground under and adjacent to the roadway;
- Landslides, which can result in failure of the slope above the roadway (which may lead to the blockage of a road from debris buildup) and/or failure of the slope below the roadway (which may result in loss or complete failure of road grade). Landslides may be known, new, or ancient slides reactivated by ground shaking. Landslide potential is most prominent in the Coast Range and Cascade Mountains.
- Tsunamis, which can scour or deposit debris on the roadways making them inaccessible; and
- Coseismic deformation, which can result in the roadway grade being below design sea level.

Tunnels: Tunnels generally perform well in seismic events; however, some amount of rock fall and structural damage is likely, particularly at portals. The length of tunnels along each segment was tabulated.

Dams: Dams can pose significant risk to roadways because of releases of large volumes of water that can wash out roadway grades and scour out bridge foundations. This sudden release of water could be due to a dam failure, intentional rapid drawdown in response to structural damage, or overtopping due to a landslide into the upstream pool. Furthermore, rapid drawdown of water levels can also cause slope failures upstream of the dam along the edge of the reservoir. The dams identified in this study are those that have a potential to pose a risk to a state highway. Only one segment was noted to be at risk per dam, in spite of the fact that a dam failure may cause damage on multiple downstream segments. In general, segments farther downstream are at lower risk due to attenuation of the flood wave and the fact that further downstream waterways and crossings generally have a larger capacity.

2.1.6.5 Data

The main sources of data used to analyze the seismic vulnerability of each highway segment include:

- ODOT GIS database;
- DOGAMI references;
- U.S. Geological Survey (USGS) seismic hazard references;
- Risks from Earthquake Damage to Roadway Systems (REDARS2) data;
- DOGAMI and the Federal Emergency Management Agency evaluations of the potential impacts of a major seismic event in Oregon;
- Local knowledge of CH2M HILL staff who have lived and worked in these regions;
- Interviews with key maintenance and technical staff at ODOT;
- Interviews of technical and field staff at DOGAMI; and
- Public mapping databases, including aerial photographs, digital terrain models (DTMs), and transportation GIS databases.

During the last 15 years ODOT Bridge Section has compiled statewide hazard and vulnerability data including data on bridge seismic vulnerabilities and existing landslides, while other state and federal agencies have compiled geographic and other data defining seismic risks including predicted tsunami inundation zones. That work was the foundation of the OSLR study. Most of the earlier studies have been either comprehensive (statewide) but imprecise, or precise but not comprehensive.

Some statewide information used in the OSLR analysis (for example, the landslide data) was compiled from various sources and is based on varied data-gathering technologies and data-evaluation methods. Therefore, the data are highly variable and are not precise or consistent as a whole. Some older statewide or region-wide data were used in this project in place of more recent site-specific information to provide a platform to make relative comparisons (rather than absolute measures) of seismic risks along various candidate lifeline routes.

2.1.6.6 Anticipated Next Steps

Funds provided by the HB 2017 are mainly allocated for the seismic work on Phase 1 highway segments. With the current budget for bridge seismic retrofitting, it may take even more than the originally planned (20–30 years) to strengthening all the roadway in Phase 1. The 2014 Seismic Plus Report shows similar mitigation costs for other phases, but those figures will look much different 20-30 years from now. It is not clear how long the HB 2017 will authorize funds to support ODOT’s seismic program, but even if it were to be indefinite, inflation 20–30 years from now will diminish the buying power of these funds (Albert Nako, Elizabeth Hunt, and Bret Hartman, personal communications, May 2020).

During the 2021–2024 STIP cycle is the first time any of the seismic program work has been field scoped providing updated costs. The scoping results were much higher than the planning level estimates previously calculated due to:

- More detailed level estimates that capture site specific costs associated with staging and foundation work; and
- A recent trend of increasing construction costs noted for all work types across the Agency (Oregon Department of Transportation, 2019).

Based on the estimated costs, it would take decades to complete Phase 1 of the Seismic Plus Program at which time many of the bridges that were initially retrofitted would be reaching the end of their service life. Without additional funds it is unlikely that all five phases could be completed as planned. Most of the bridges would be replaced because of their age and conditions before they would be considered for seismic retrofit. Also, to address seismic resiliency bridges still in relatively good condition would need to be replaced (Oregon Department of Transportation, 2019).

Discussions are continuing around options to maximize the value of the HB 2107 seismic funding. The first priority will be on retrofitting major river crossings. The major I-5 river crossings between Eugene and Portland include the Boone Bridge, which will be evaluated as directed by the 2019 Legislature, and the Santiam River Bridge. To address the seismic resiliency of the Southbound Santiam River Bridge, the plan is to include retrofit work as part of the 2021–2024 STIP (Oregon Department of Transportation, 2019).

The second priority will be around evaluating alternate lifeline routes by addressing the portion of I-5 north of Eugene similar to the Southern Oregon Triage project. The process of identifying a route south of Eugene, involved a triage strategy that included the use of local roads and bridges to provide a lifeline following a Cascadia seismic event (Oregon Department of Transportation, 2019).

HB 2017 seismic funding available after the Southbound Santiam River Bridge retrofit is funded will be used to address bridges identified for work as part of an updated strategy (Oregon Department of Transportation, 2019).

During the 2021-2024 STIP scoping process, ODOT realized this need to re-evaluate the current approach. Since publication of the 2019 Bridge Condition Report, ODOT has developed a Seismic Implementation Plan that currently is in draft form and anticipated for Oregon Transportation Commission approval sometime in the later part of 2020. The Implementation Plan will provide guidance for maximizing seismic resiliency with the current budget by considering detour routes for the most expensive state bridges and/or adopting triage approaches for certain highway segments (Albert Nako, Elizabeth Hunt, and Bret Hartman, personal communications, May 2020).

HB 2017 provided funding for an additional seismic project entitled the Southern Oregon Triage strategy. The strategy focuses on mitigating seismic impacts along Interstate 5 south of Eugene, and OR 140, which are key lifeline routes to and from the Rogue Valley. Most of the seismic impacts on the routes are expected to be addressed through quick repairs or temporary detours. The funding will be used to address those bridges and potentially unstable slopes that are more problematic or where a feasible detour does not exist (Oregon Department of Transportation, 2019).

Right of way funding is available for Coastal Maintenance Stations at central coast and Coos Bay; an additional facility at Astoria is being considered but is not currently funded. Each station will be supplied with seismic response kits. The purpose of the kits is to stockpile key materials and supplies that can be used to assist local communities in the early days following a seismic event. The kits will include culvert pipes of various sizes; construction materials; solar power generators and trailer mounted solar light panels; diesel and unleaded fuel storage tanks; survival supplies (water, field rations, first aid supplies); power tools; batteries; portable boats; flat railroad cars; and satellite phones and Ham radios (Oregon Department of Transportation, 2019) (personal communications with ODOT staff, May 2020).

The Bridge Seismic Standards Engineer and other ODOT leadership, is working collaboratively with Oregon counties to develop planning reports documenting county routes and priorities for seismic resiliency. ODOT provides bridge data and technical support and the counties provide information about their network. While the information is useful for county planning, a comparison can be made to the state seismic bridge priorities to determine possible state highway detour routes that may be more cost effective to seismically retrofit or replace. Eventually the planning reports may provide an opportunity for seismic resiliency funding from either state or federal funds (Oregon Department of Transportation, 2019).

2.1.7 Cultural Resources

2.1.7.1 Overview

Every day, in countless ways, Oregonians experience their cultural heritage. They drive roads following routes first created by pioneers or Native Americans. They buy food from century-old farms. They shop at businesses in historic commercial areas. They visit parks created years ago by Oregonians with visions of healthy communities.

Oregonians attend schools and work in buildings built by and named for historic people, whose fortitude and dreams created the businesses and communities they live in. An Oregonian's engineering or medical discovery decades ago may have been the breakthrough that enabled today's medical treatment.

An Oregonian's dress, food, language, material goods and music are the tangible remnants of heritages transmitted to them from previous generations of Oregonians and from those new to Oregon. This means heritage is found in the closet, the workplace, the auditorium, the historic barn and elsewhere. In short, Oregon heritage is everywhere.

Our diverse Oregon cultural heritage attracts visitors to Oregon, who in turn help our economy. Eighty-three percent of the leisure tourists responding to a Mandala Research study in 2012 said they are cultural and heritage tourists for whom heritage activities and places were important to their decision to vacation in Oregon. Cultural and heritage activities are especially popular with "well-rounded, active" tourists. These active tourists are the most common variety of tourist in Oregon and they spend on average 39% more on their visits than the average tourist.

Oregon recognizes the importance of protecting and preserving the natural, cultural, and historic resources found throughout the state. Additionally, the economic impact that these resources have on local, regional, and statewide tourism is documented and significant. The important connection to our history and our future economic growth is tied to the deliberate efforts to preserve these resources. Oregon's recognized experts — Oregon Parks and Recreation Department, the State Historic Preservation Office, and the Oregon Heritage Commission — are essential partners in the identification, protection, and preservation of Natural, Cultural, and Historical Resources (NCHR) on mitigation projects. Through agency partnership, and at all levels of government, we share responsibility to develop plans of action that ensure these important resources are preserved for future generations to connect with, experience, and enjoy.

2.1.7.2 Existing Efforts

The State's success in preserving Oregon's resources through intentional planning and mitigation efforts through collaborative partnerships and creative approaches is an ongoing process. This work is accomplished by working with local, tribal, state, and national partners to increase the awareness of Natural, Cultural, and Historical Resources (NCHRs) and identifying opportunities to protect them through existing site specific plans and actions. OEM is committed to requiring local jurisdictions to follow all applicable laws, rules, and regulations related to resource protection in mitigation projects administered by the State Hazard Mitigation Officer.

An example of this commitment through action is the availability of NCHR-related information on OPRD's website and encouragement of consideration of NCHRs in disaster planning. This information is designed to assist emergency managers, organizations, and agencies charged with protecting and preserving collections, sites, and artifacts in making informed decisions related to NCHR. OPRD intends to promote awareness, Best Management Practices, and dialog within the emergency management community and the professionals that maintain these important resources.

OEM curates and manages a GIS system called RAPTOR (Real-Time Assessment and Planning Tool for Oregon). This used by emergency managers before, during, and after disasters in staying informed of developing situations and maintaining an awareness of issues or resources at risk. NCHR information in RAPTOR ensures an awareness of resources at risk and allows for consideration in the development of mitigation, response, and recovery actions that can help protect them. NCHRs are included in the RAPTOR training being delivered to emergency managers to ensure they are aware of existing data sets that can assist them in their decision making process.

For the 2020 Risk Assessment, OPRD provided a spreadsheet of historic structures and their attributes that DOGAMI developed into a GIS layer and analyzed against the seven hazards included in the 2020 Risk Assessment pilot. The resulting report indicated the number of historic resources in each hazard area in each county and statewide. This information was used to inform the vulnerability analyses in the state and regional risk assessments. The next steps would be to rank the resources according to type and significance, map them, and develop strategies for better protecting them from the hazards to which they are vulnerable.

In addition, for the 2020 Risk Assessment, OPRD conducted just such a GIS analysis for archaeological resources against four of the seven hazards: coastal erosion, earthquakes, floods, and landslides. Technical difficulties prevented analysis at this time against tsunamis, volcanic hazards, and wildfires. The resulting report indicated the number of archaeological resources:

- In each county;
- Listed on the National Register of Historic Places;
- Eligible for listing;
- Ineligible for listing; and
- Eligibility not yet evaluated.

This information was used to inform the vulnerability analyses in the state and regional risk assessments. Next steps would be to overcome the current technical difficulties and produce the same results for the remaining three hazards; map the resources; and develop strategies for protecting them from the hazards to which they are vulnerable. These steps will have to be carefully planned and executed to comply with laws and rules about access to sensitive archaeological data.

2.1.7.3 Future Strategic Opportunities

There is a recognized need for additional staff at OEM and some of that need is for attention to natural, cultural, and historic resources in mitigation and recovery projects. Additional staff could provide assistance in the development of onsite, tailored project proposals that include consideration of NCHRs. Specific guidance on project application development considering NCHR presence, known risk potential, and mitigation opportunities throughout the development of any local project proposal would result in more consistent compliance with FEMA's Environmental Planning and Historic Preservation Program (EHP) requirements as well as in elevating the importance of the consideration and inclusion of NCHRs in the mitigation and recovery program at all levels of government. This would enable OEM to develop an implementation strategy including formal planning processes, mitigation project standard operating procedures, and mechanisms that ensure NCHRs are considered in comprehensive mitigation planning efforts.

As part of a future risk assessment process, methods to determine potential collection losses in monetary value as well as methods to assess potential tourism loss as a result of collection damage or destruction could be identified and implemented. This would be followed by possible mitigation strategies to protect cultural and historical resources. Additionally, some strategies are offered as ways to provide technical assistance to local governments and nonprofit organizations to ensure cultural and historic resources of local significance are included in risk assessment and mitigation strategies.

1. Possible actions to assess risk to cultural and historic resources of statewide significance in a future <u>risk assessment:</u>
    a. Actions related to assessing exposure of cultural and historic resources of statewide significance to potential damage from natural disaster events —
        - Continue to update historical resource surveys to maintain an accurate inventory of resources at both the state and local levels.
        - Survey and re-survey historic repositories and ensure resource catalog information is current.
        - Continue to develop a GIS inventory of resources that has current, verified information which can then be used in concert with hazard specific GIS information to identify resources at risk and the level of hazard potential exposure to which they are subject.
        - Prioritize combining resource data layers and known hazard data layers to identify resources at risk and prioritize mitigation efforts to protect and preserve them.
        - Continue to provide emergency preparedness training to museums, libraries, and archivists to assist them in understanding the risks to their collections and steps they can take to minimize damage.
        - Work toward compatibility of historic site databases so they can be integrated into a single mapping system.
        - Create and promote local incentives to inventory, designate, and rehabilitate historic properties.
    b. Actions related to assessing potential damage to cultural and historic resources of statewide significance and resulting dollar losses from natural disaster events —
        - Survey existing federal, state, and local jurisdictions' potential damage assessment tools for natural, historical, and cultural resources. Identify models or modify models that are feasible for use in Oregon.
        - Survey existing federal, state, and local methodologies currently in use for valuation of resources. Identify multiple methods that are peer group or nationally accepted forms of valuation.

  - Develop and deliver training to emergency managers and resource curators on valuation methods. Encourage emergency managers and resource curators to estimate potential losses in both collection damage/loss as well as economic impacts due to a loss of tourism and visitors.
  - Encourage emergency managers to include these estimated potential losses in their planning and prioritization of mitigation projects to ensure resource protection and preservation.
  - Identify existing data sets and develop assessment tools to estimate the economic loss potential to the state economy from impacts to historic buildings, organizations, and businesses located in historic buildings, and tourism.

2. Possible actions to include cultural and historic resources of statewide significance in a future mitigation strategy —
   a. Actions related to identifying how to protect cultural and historic resources of statewide significance from potential damage from natural disaster events —
      - As natural, cultural, and historic resource data sets are updated and become available in GIS data layers, this information can continue to be combined with existing natural hazard information to assess existing risk potential and possible mitigation opportunities.
      - Provide training to state and local decision makers on the availability of these data sets and how the information can be used to identify resources at risk.
      - Provide guidance on methods of assessment for the potential economic impacts as a result of resource damage or loss.
      - Continue to add resource inventories into GIS layers for access to the information in RAPTOR by emergency managers for planning, response, recovery, and mitigation activities.
   b. Actions related to providing funding or technical assistance to local governments for including cultural and historic resources of local significance in local NHMP risk assessments and mitigation strategies —
      - Provide technical assistance to local governments related to the identification, risk assessment, valuation, and mitigation options and opportunities to ensure resource protection and preservation.
      - Update resource inventory databases and work toward the consolidation of this information into a single location that can be used by emergency managers for awareness and consideration in local NHMPs.
      - Work toward developing and providing resource identification and preservation training opportunities targeting emergency managers, historic site owners, and collection curators to promote collaborative planning efforts.
      - Assess national, state, and local programs to identify best management practices related to emergency management and resource protection efforts. Include the results of this work in training courses delivered to emergency managers, historic site owners, and collection curators.

- Identify opportunities to include volunteers and collection curators in the mitigation, notification, response, and recovery phases of disaster management to ensure resource protection.
- Continue to assist local representatives in resource identification and recordation.
- Compile “Connecting to Collections” disaster plans and engage organizations in sharing them with emergency managers for inclusion in local NHMPs. Use the collection to promote the development of additional plans through awareness and technical assistance.

2.1.7.4 Summary

OEM will continue to incorporate natural, cultural, and historical resource consideration and compliance in all mitigation and recovery projects. As additional information related to these resources becomes more accessible through the use of current and new technology, decision makers at all levels will have the opportunity to make more informed decisions that ensure protection and preservation. These resources are important for the historical significance as well as the economic impacts to the community of Oregon. With additional staff, OEM and OPRD could increase the level of consideration and prioritization of NCHRs in mitigation work and pre-disaster planning, fostering more consistent consideration of NCHRs in mitigation and recovery projects and planning while protecting and promoting Oregon’s historical treasures.

2.2 State Risk Assessment

Requirement: 44 CFR §201.4(c)(2)(i): The risk assessment shall include… (i) An overview of the type and location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate;

The spatial distribution of the facilities within hazard zones is not easily viewed on a statewide map. Therefore, maps depicting hazard zones and facilities within those zones have only been created at the regional scale. Those maps can be found in section **2.3**, **Regional Risk Assessments**.

2.2.1 Coastal Hazards

Figure 2-29. Erosion at The Capes Condominiums, Oceanside, Oregon

Notes: The Capes, a multi-million dollar condominium complex constructed on an old Holocene dune field adjacent to Oceanside. Due to erosion of the sand at the toe of the bluff during the 1997-98 El Niño winter, the bluff face began to fail threatening several of the homes built nearest the bluff edge.

Source: DOGAMI

The Pacific Northwest (PNW) coast of Oregon is without doubt one of the most dynamic coastal landscapes in North America, evident by its long sandy beaches, sheer coastal cliffs, dramatic headlands and vistas, and ultimately the power of the Pacific Ocean that serves to erode and change the shape of the coast. It is these qualities along with its various natural resources that have drawn people to live along its narrow shores. However, coastal communities are increasingly under threat from a variety of natural hazards that all come together along the coastal strip. These include wave-induced coastal erosion (both short and long term), wave runup and overtopping (wave-induced flood hazards), inundation of homes by wind-blown sand, coastal landslides, earthquakes, and potentially catastrophic tsunamis generated by the Cascadia Subduction Zone (CSZ). Over time, these hazards are gradually being compounded, in part due to the degree of development that has evolved along the Oregon coast in recent decades. A particular concern is that the local geology and geomorphology of the region have restricted development to low-lying areas, chiefly along dunes, barrier spits, or along coastal bluffs present along the open coast that are subject to varying rates of erosion, and to low-lying areas adjacent to the numerous estuaries that make up the coast. All of these sites are highly susceptible to increased impacts as erosion processes and flood hazards intensify, driven by rising sea level and increased storminess.

Figure 2-30. A) Emergency Riprap Being Placed in Front of a Home at Gleneden Beach, Following a Recent Bluff Failure (February 2013). B) Homes Being Inundated with Excess Sand during a Strong Wind Event in November 2001

Source: DOGAMI

Beaches and coastal bluffs are some of the most dynamic landforms, responding to a myriad of variables. Both landforms are constantly changing (at varying time scales) as they respond to changes in the ocean processes (waves, nearshore currents, and tides) that affect the beach and toe of the bluff as well as those sub-aerial processes (rainfall, sun, wind) that directly affect coastal bluffs. There are many dangers inherent in living on the coast. While coastal bluffs gradually erode over the long-term, they can also respond very rapidly, at times sliding away (in a matter of minutes to a few hours) so that homes and sections of highways are damaged or destroyed (**Figure 2-30A**). Beaches are especially dynamic features, as sand is constantly shifted about. This is especially noticeable in major storms, with the shoreline retreating rapidly, periodically destroying homes built too close to the sea. At other times, large quantities of sand migrate back onto beaches, burying homes built atop coastal dunes (**Figure 2-30B**). There is no location on the Oregon coast that is immune to coastal hazards.

Without question, the most important natural variables that influence changes to the shape and width of the beach and ultimately its stability are the beach sand budget (balance of sand entering and leaving the system) and the processes (waves, currents, tides, and wind) that drive the changes.

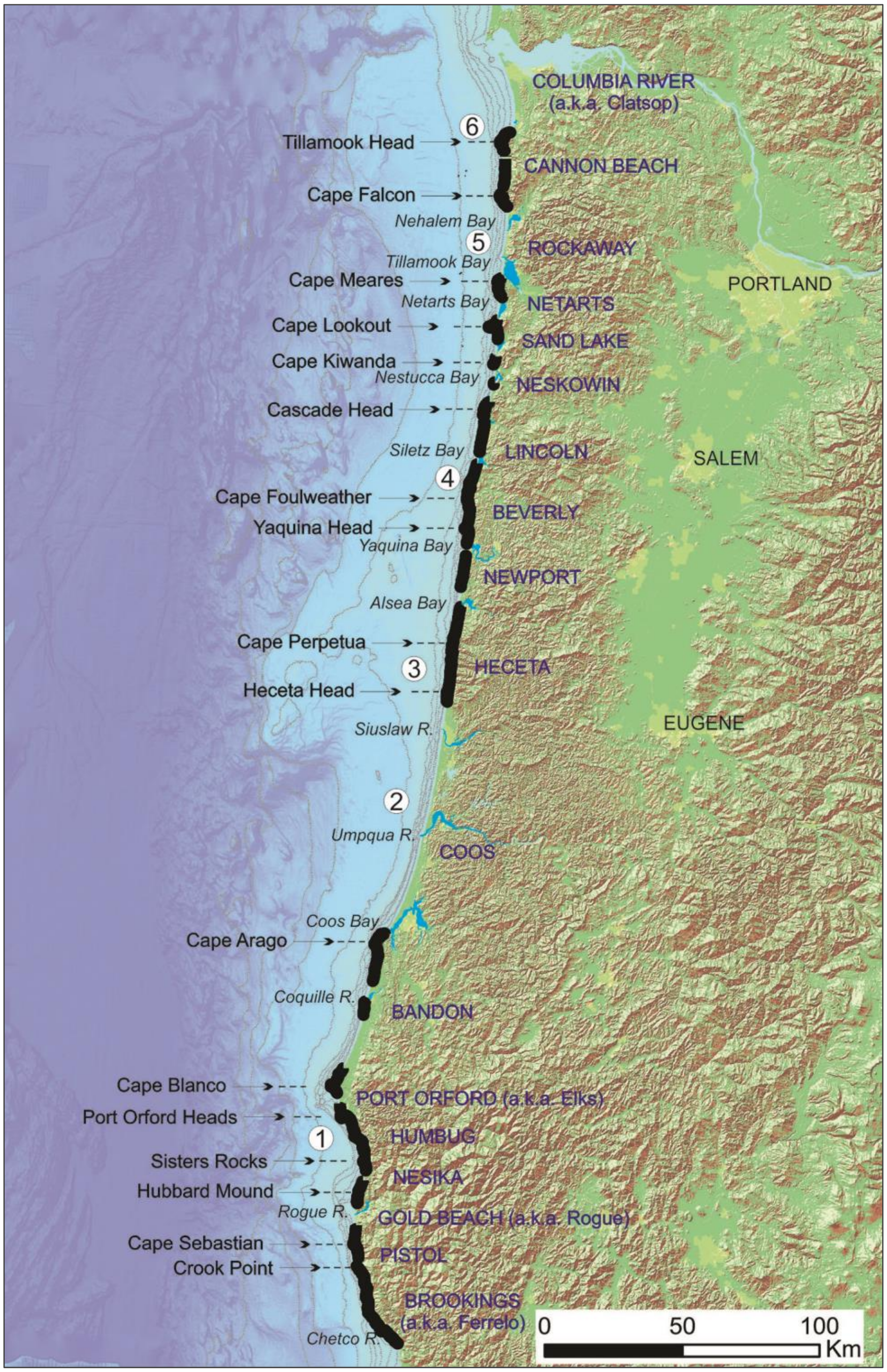
Human influences associated with jetty construction, dredging practices, coastal engineering, and the introduction of non-native dune grasses have all affected the shape and configuration of the beach, including the volume of sand on a number of Oregon’s beaches, ultimately influencing the stability or instability of these beaches.

2.2.1.1 Analysis and Characterization

Geology and Geomorphology

The Oregon coast is 366 miles long from the Columbia River to the California border. The present coastline is the result of geologic processes that include a rise in sea level as Ice Age glaciers melted. The coastal geomorphology of this landscape reflects a myriad of geomorphic features (**Figure 2-31**) that range from plunging cliffs (in Regions 1, 4, and 5), rocky shorelines and shore platforms (Regions 1, 3, 5, and 6), wide and narrow sandy beaches backed by both dunes (Regions 2, 5, and 6) and cliffs (Regions 3 and 4), gravel and cobble beaches backed by cliffs (Regions 1, 5, and 6), barrier spits (Regions 2, 4, and 5), and estuaries (Regions 1–6). Cliffed or bluff-backed shorelines make up the bulk of the coast accounting for 58% of the coastline, the remainder being dune-backed. Geomorphically, the coast can be broken up into a series of "pocket beach" littoral cells (**Figure 2-31**) that reflect resistant headlands (chiefly basalt) interspersed with short to long stretches of beaches backed by both less resistant cliffs and dunes (e.g., Lincoln and Tillamook Counties [Regions 3 and 5 in **Figure 2-31**; also see **Figure 2-32**]). The headlands effectively prevent the exchange of sand between adjacent littoral cells. Some beaches form barrier spits, creating estuaries or bays behind them (e.g., Netarts, Nestucca, and Siletz spits). About 75.6% of the coastline consists of beaches composed of sand or gravel backed by either dunes or bluffs, while the remaining 24.4% of the coast is composed of a mixture of rocky cliffs (including headlands) and shores. Of the 18 littoral cells on the Oregon coast, the largest is the Coos cell, which extends from Cape Arago in the south to Heceta Head in the north, some 62.6 miles long.

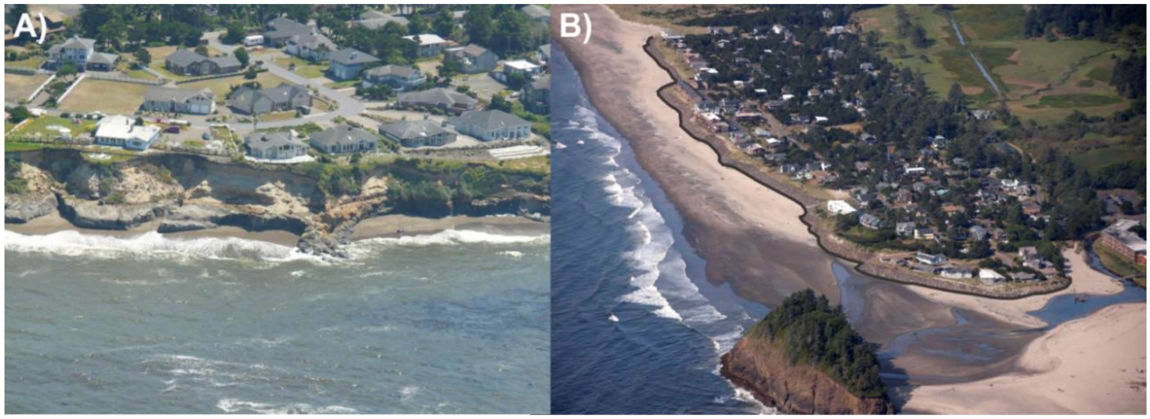
Figure 2-31.Oregon's Coastal Geomorphology and Littoral Cells



Note: Bold black lines denote the locations of cliffs and rocky shores. Faint grey lines denote faulting. Numbers indicate regional coastal geomorphic features: plunging cliffs (1, 4, and 5); rocky shorelines and shore platforms (1, 3, 5, and 6); wide and narrow sandy beaches backed by dunes (2, 5, and 6) and cliffs (3 and 4); gravel and cobble beaches backed by cliffs (1, 5, and 6); barrier spits (2 and 5); and estuaries (1–6).

Source: DOGAMI

Figure 2-32.(A) Houses Line the Cliff at Fogarty Creek in Lincoln County. (B) Extensive Erosion along the Dune-Backed Beaches in Neskowin Have Resulted in the Construction of Massive Riprap



Note the proximity of the eroding cliff edge to homes.

Source: L. Stimely, DOGAMI

Interspersed among the littoral cells are 21 estuaries that range in size from small, such as the Winchuck estuary (0.5 km2) adjacent to the Oregon/California border, to large, such as the Columbia River (380 km2), which separates the states of Oregon and Washington. The estuaries are all ecologically important to many fish and wildlife species and in many cases are the sites of important recreational and commercial enterprise. In general, Oregon estuaries can be divided into two broad groups based on physiographic differences between estuaries located on the north and south coast. On the northern Oregon coast, the prevalence of pocket beach littoral cells and weaker rock formations in the coast range has resulted in more rapid erosion of the region's rock formations. This produces ample material at the coast, and coupled with alongshore sediment transport, has aided the formation of barrier spits across drowned river valleys and hence estuaries. In contrast, sediment loads on the southern Oregon coast are comparatively lower due to there being more resistant rock formations. Furthermore, the region is generally much steeper, which essentially limits the landward extent of the tide in drowned rivers and, hence, ultimately the size of the estuaries.

Unlike much of the U.S. coast, population pressure on the Oregon coast is relatively low and is largely confined to small coastal towns separated by large tracts of coast with little to no development. The bulk of these developments are concentrated on the central to northern Oregon coast in Lincoln, Tillamook, and Clatsop Counties. On the cliffed shores of the central Oregon coast, between Newport and Lincoln City, homes are perched precariously close to the edge of the cliffs (**Figure 2-32A**). In some areas the erosion has become acute, requiring various forms of coastal engineering (commonly riprap) to mitigate the problem **(Figure 2-32B**), and in a few cases the landward removal of the homes. In other areas, critical infrastructure such as US-101 tracks close to the coast, and in a few areas, erosion of the cliffs has resulted in expensive remediation (e.g., adjacent to Nesika Beach in Curry County). Although the processes driving coastal erosion on bluff-backed shores are entirely a function of the delicate balance between the assailing forces (waves, tides, and currents) and properties of the rock (rock type, bedding, strength, etc.), increasing development pressure, weak land-use regulations, a lack of quantitative information, and ignorance of the physical processes have contributed to the need for remediation in many coastal areas.

Elsewhere, significant development is typically located along the most seaward dune (foredune) system (**Figure 2-32B**), as developers seek to capitalize on ocean views and proximity to the beach. However, major storms, especially in the late 1990s have resulted in extensive erosion, with many communities (e.g., Neskowin and Rockaway Beach in Tillamook County) having to resort to major coastal engineering in order to safeguard individual properties. The magnitude and extent of these erosion events have now left entire communities entirely dependent on the integrity of the structures.

Sand Budget

The beach sand budget is the rate at which sand is brought into the coastal system versus the rate at which sand leaves the system. A negative balance means that more sand is leaving than is arriving and results in erosion of that segment of shoreline. A positive balance means that more sand is arriving than is leaving, enabling that segment of shoreline to gain sand and accrete and potentially advance seaward. Along the Oregon coast, potential sources of sand include rivers, bluffs, dunes, and the inner shelf. Potential sand sinks include bays (estuaries), dunes, dredging around the mouths of estuaries, and mining of sand.

Attention is often focused on the effects of beach and dune erosion. Yet, there are segments of Oregon's coast where periodically the concern is excess sand build-up, as has occurred in places like Pacific City, Manzanita, Bayshore Spit, Nedonna, and Cannon Beach.

Classifying Coastal Hazards

Natural hazards that affect coastal regions can be divided into two general classes, *chronic* and *catastrophic*.

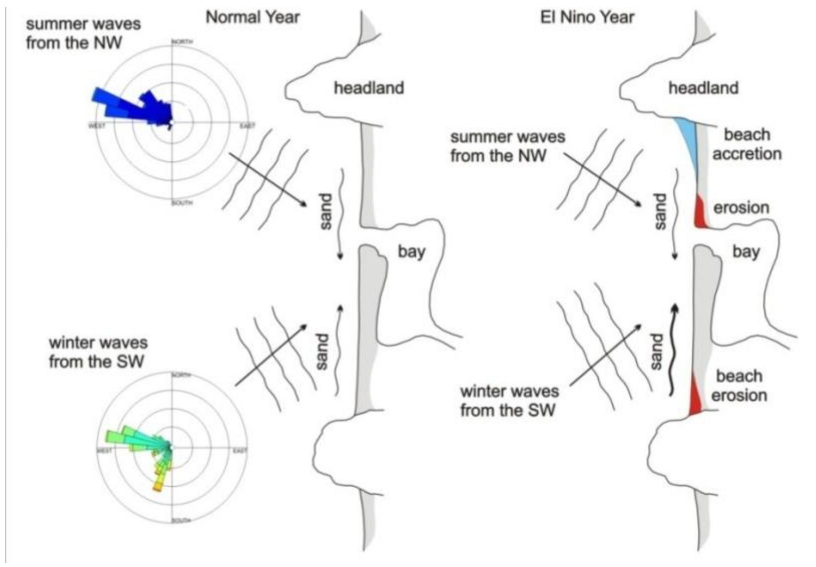
Chronic hazards such as beach, dune, and bluff erosion; landslides; slumps; and flooding of low-lying lands during major storms usually cause gradual and cumulative damage. However, storms that produce large winter waves, heavy rainfall, and/or high winds may result in very rapid erosion or other damage that can affect properties and infrastructure over a matter of hours. The regional, oceanic, and climatic environments that result in intense winter storms determine the severity of chronic hazards along the Oregon coast. Chronic hazards are typically local in nature, and threats to human life and property that arise from them are generally less severe than those associated with catastrophic hazards. However, the wide distribution and frequent occurrence of chronic hazards makes them a more immediate concern.

Catastrophic hazards are regional in scale and scope. Cascadia Subduction Zone earthquakes, and the ground shaking, subsidence, landsliding, liquefaction, and tsunamis that accompany them are catastrophic hazards. Tsunamis generated from distant earthquakes can also cause substantial damage in some coastal areas. The processes associated with earthquakes, tsunamis, floods, and landslides are discussed later in this chapter.

Causes of Coastal Hazards

Chronic coastal hazards include periodic high rates of beach and dune erosion, sand inundation, "hotspot erosion" due to the occurrence of El Niños and from rip current embayments, intermittent coastal flooding as a result of El Niños, storm surges and high ocean waves, and the enduring recession of coastal bluffs due to long-term changes in mean sea level, variations in the magnitude and frequency of storm systems, and climate change. Other important hazards include mass wasting of sea cliffs such as slumping and landslides, which may be due to wave attack and geologic instability.

Figure 2-33.Patterns of Sediment Transport During "Normal" and El Nino Years



Source: Komar (1986)

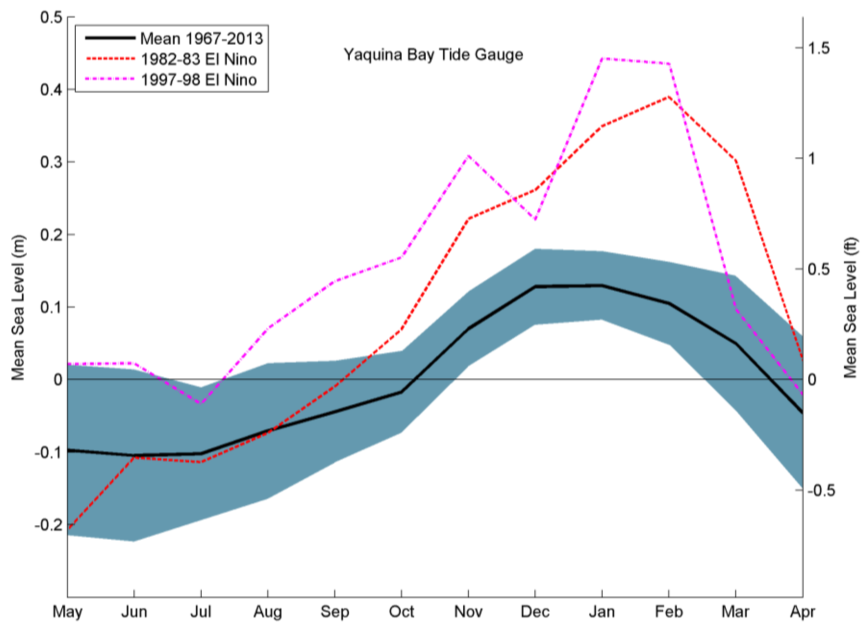
Most of these hazards are the product of the annual barrage of rain, wind, and waves that batter the Oregon coast, causing ever-increasing property damage and losses. A number of these hazards may be further exacerbated by climate cycles such as the El Niño Southern Oscillation, or longer-term climate cycles associated with the Pacific Decadal Oscillation. Other hazards, such as subduction zone earthquakes and resulting tsunamis, can have catastrophic impacts on coastal communities' residents and infrastructure, and in many areas these impacts will persist for many decades following the event due to adjustments in the coastal morphodynamics following subsidence or uplift of the coast. All of these processes can interact in complex ways, increasing the risk from natural hazards in coastal areas.

Waves

Along dune- and bluff-backed shorelines, waves are the major factor affecting the shape and composition of beaches. Waves transport sand onshore (toward the beach), offshore (seaward to form nearshore bars etc.), and along the beach (longshore transport). Short-term beach and shoreline variability (i.e., storm related changes) is directly dependent on the size of the waves that break along the coast, along with high ocean water levels, and cell circulation patterns associated with rip currents. In contrast, long-term shoreline change is dependent on the balance of the beach sediment budget, changes in sea level over time, and patterns of storminess.

The Oregon coast is exposed to one of the most extreme ocean wave climates in the world, due to its long fetches and the strength of the extratropical storms that develop and track across the North Pacific. These storms exhibit a pronounced seasonal cycle producing the highest waves (mean = 12.8 ft) in the winter, with winter storms commonly generating deep-water wave heights greater than 33 ft, with the largest storms in the region having generated waves in the range of 45 to 50 ft. In contrast, summer months are dominated by considerably smaller waves (mean = 5.3 ft), enabling beaches to rebuild and gain sand eroded by the preceding winter. When large waves are superimposed on high tides, they can reach much higher elevations at the back of the beach, contributing to significantly higher rates of coastal erosion and flood hazards. It is the combined effect of these processes that leads to the erosion of coastal dunes and bluffs, causing them to retreat landward.

Figure 2-34.Average Monthly Tides for the Yaquina Bay Tide Gage Expressed as an Average for the Period 1967–2013, and as Monthly Averages for the 1982-83 and 1997-98 El Niños



Note: Shaded region= ±1 standard deviation providing a measure of normal ranges.
Source: Jonathan Allan, DOGAMI

Winds and waves tend to arrive from the southwest during the winter and from the northwest during the summer. Net sand transport tends to be offshore and to the north in winter and onshore and to the south during the summer (**Figure 2-33**). El Niño events can exaggerate the characteristic seasonal pattern of erosion and accretion and may result in an additional 60–80 feet of "hotspot" dune erosion along the southern ends of Oregon's littoral cells, particularly those beaches that are backed by dunes, and on the north side of estuary inlets, rivers and creeks.

Ocean Water Levels

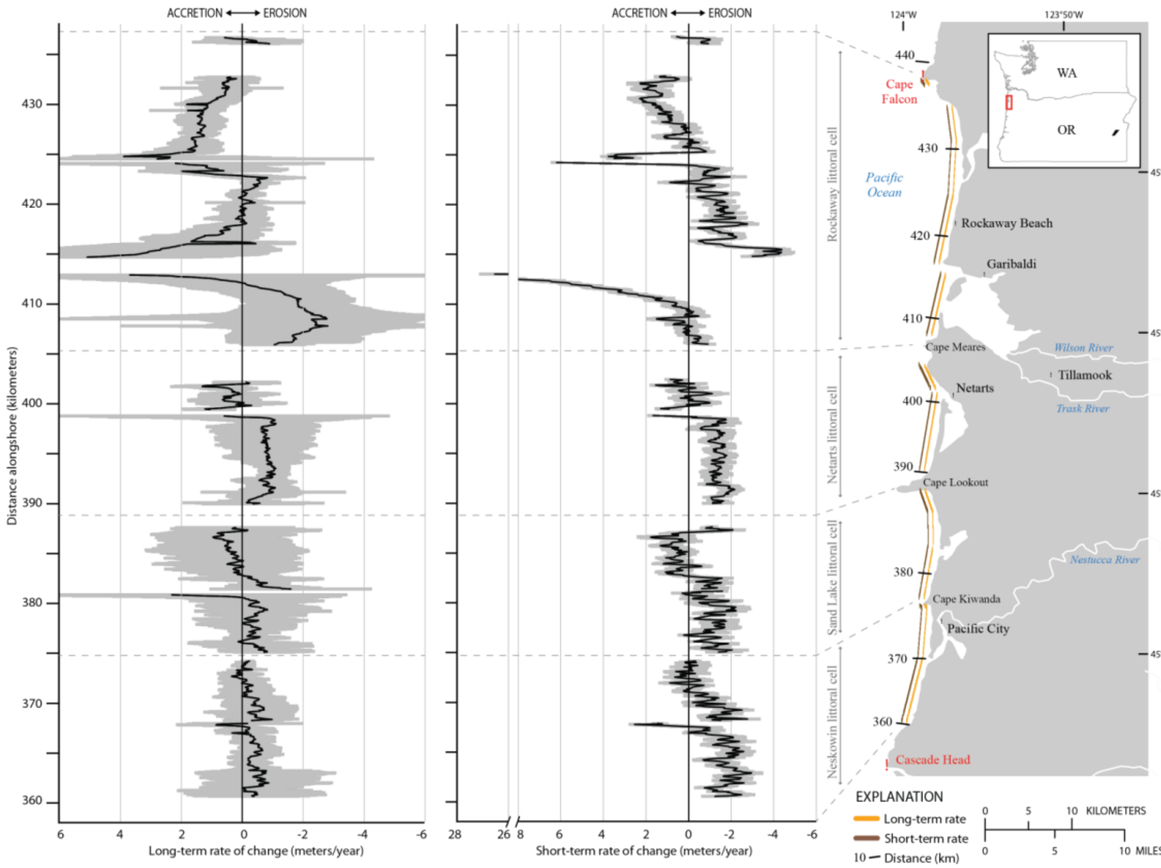
The elevation of the sea is controlled in part by the astronomical tide. High ocean water levels at the shoreline may be the product of combinations of high tides, storm surges, strong onshore-directed winds, El Niños, and wave runup. As can be seen in **Figure 2-34**, the Oregon coast experiences a seasonal cycle in its measured tides, with the tides tending to be highest in the winter and lowest in the summer. This seasonal variation is entirely a function of ocean upwelling during the summer months, which brings cold dense water to the surface; due to the Coriolis effect and ocean currents, this water is directed landward where it piles up along the coast depressing sea level. In the winter this process breaks down resulting in a warming of the ocean, which raises the mean sea level. The typical seasonal variability in water levels is about 0.8 ft, increasing to as much as 2 ft during an El Niño (**Figure 2-34**), essentially raising the mean shoreline elevation, enabling waves to break closer to dunes or along the base of coastal bluffs.

Shoreline Changes

Dune-backed beaches respond very quickly to storm wave erosion, sometimes receding tens of feet during a single storm and hundreds of feet in a single winter season. Beach monitoring studies undertaken by DOGAMI staff (http://nvs.nanoos.org/BeachMapping) have documented storm induced erosion of 30–60 ft from single storm events, while seasonal changes may reach as much as 90–130 ft on the dissipative, flat, sandy beaches of Oregon, and as much as 190 ft on the more reflective, steeper beaches of the south coast (e.g., adjacent to Garrison Lake, Port Orford). Furthermore, during the past 15 years a number of sites on the northern Oregon coast (e.g., Neskowin, Netarts Spit, and Rockaway Beach) have experienced considerable erosion and shoreline retreat. For example, erosion of the beach in Neskowin has resulted in the foredune having receded landward by as much as 150 ft since 1997. South of Twin Rocks near Rockaway, the dune has eroded about 140 ft over the same time period. Continued monitoring of these study sites is now beginning to yield enough data from which trends (erosion or accretion rates) may be extrapolated. These latter datasets are accessible via the web (http://nvs.nanoos.org/BeachMapping).

Recently, studies undertaken by the USGS provide additional insights into the spatial extent of erosion patterns on the Oregon coast. **Figure 2-35** provides analyses of both long-term (about 1900s to 2002) and short-term (about 1960s/80s to 2002) shoreline change patterns along the Tillamook County coast, confirming measured data reported by DOGAMI. As can be seen from the figure, long-term erosion rates (albeit low rates) dominate the bulk of Tillamook County (i.e., Bayocean Spit, Netarts, Sand Lake, and Neskowin littoral cells), while accretion prevailed in the north along Rockaway Beach and on Nehalem Spit. The significant rates of accretion identified adjacent to the mouth of Tillamook Bay are entirely due to construction of the Tillamook jetties, with the north jetty completed in 1917 and the south jetty in 1974. Short-term shoreline change patterns indicate that erosion has continued to dominate the bulk of the shoreline responses observed along the Tillamook County coast. Erosion is especially acute in the Neskowin, Sand Lake and Netarts littoral cells, and especially along Rockaway Beach. In many of these areas, the degree of erosion remains so significant, that were we to experience a major storm(s) in the ensuing winters, the risk of considerable damage to property and infrastructure in these areas would likely be high.

Figure 2-35.Long- and Short-Term Shoreline Change Rates for the Tillamook County Region



Source: http://envision.bioe.orst.edu/StudyAreas/Tillamook/ruggiero_talk_PelicanPub_02102014.pdf

Source: Ruggiero, et al. (2013)

The processes of wave attack significantly affect shorelines characterized by indentations, known as inlets. Waves interact with ocean tides and river forces to control patterns of inlet migration. This is especially the case during El Niños. During an El Niño, large storm waves tend to arrive out of the south, which causes the mouth of the estuary to migrate to the north, where it may abut against the shoreline, allowing large winter waves to break much closer to the shore. This can result in significant "hotspot" erosion north of the estuary mouth. Recent examples of the importance of inlet dynamics during an El Niño are Alsea Spit near Waldport (**Figure 2-36**), Netarts Spit near Oceanside, and at Hunter Creek on the southern Oregon coast at Gold Beach.

Figure 2-36. Alsea Bay Spit Erosion as a Result of the 1982-83 El Niño (left), and State of the Beach in 2009 (right)

Note: Yellow/black line delineates a riprap structure constructed to protect the properties from further erosion. Orange line defines the maximum extent of dune erosion due to wave attack as a result of the 1982-83 event. Note the northward migration of the estuary mouth compared to its position in 2009.

Source: DOGAMI

Floods

Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FISs) are also often used in characterizing and identifying flood-prone areas. FEMA conducted many FISs in the late 1970s and early 1980s. Included were "VE" zones, areas subject to wave action and ocean flooding during a "100-year" event that encompass the area extending from the surf zone to the inland limit of wave runup, and/or wave overtopping and inundation, and/or the location of the primary frontal dune or any other area subject to high-velocity wave action from coastal storms. Areas identified as VE zones are subject to more development standards than other flood zones. Between 2009 and 2014, DOGAMI worked with FEMA to remap FEMA coastal flood zones established for Oregon's coastal communities, utilizing improved topographic information, revised information on extreme storm waves and ocean water levels, and a revised methodology for calculating erosion, wave runup and overtopping.

Landslides

Simple surface sloughing is the dominant process along bluff-backed shorelines. Other shorelines are backed by steep slopes, where deep-seated landslides and slumping are the dominant processes (**Figure 2-37**). The geologic composition of the bluff is a primary control on slope stability.

Headlands, generally composed of basalt, are more resistant to erosion and do not readily give way. In contrast, soft bluff-forming sandstone and mudstone are highly susceptible to slope movement. Prolonged winter rains saturate these porous bluff materials, increasing the likelihood of landslides.

The geometry and structure of bluff materials also affect slope stability by defining lines of weakness and controlling surface and subsurface drainage. As waves remove sediment from the toe of the bluff, the bluffs become increasingly vulnerable to slope failure due to increased exposure to wave attack. The extent to which the beach fronting the bluff acts as a buffer is thus important in this regard. Thus a reduction in the sand beach volume in front of a bluff increases its susceptibility to wave erosion along its toe, which can eventually contribute to the failure of the bluff.

A recent example of such a process occurred at Gleneden Beach in Lincoln County in November 2006 (**Figure 2-37**), when a large rip current embayment (an area of the beach that exhibits more erosion and beach narrowing due to removal of sand by rip currents) formed in front of a portion of the bluff, allowing waves to directly attack the base of the bluff. In a matter of two days, the bluff eroded back by up to 30 ft, undermining the foundations of two homes, and almost resulting in their destruction.

Figure 2-37. Bluff Failure Due to Toe Erosion by Ocean Waves

Note: The top of the bluff eroded landward by about 30 ft over a 48-hour period in November 2006.

Photo source: OPDR

Similar processes occurred nearby during the 1972-73 winter, which led to one home having to be pulled off its foundation. Both examples provide a stark reminder of the danger of building too close to the beach and that these types of changes do occur relatively frequently

Landslide risk is especially high on the southern Oregon coast in Curry County, where multiple slide failures are presently affecting Highway 101. One of the largest recent events occurred on March 3, 2019 at Hooskanaden Creek, affecting travel on Highway 101. Movement in the central part of the landslide near Highway 101 varied from 45 to 130 ft. Significant active landsliding is also evident on the central Oregon coast in the Beverly Beach littoral cell, located immediately north of Yaquina Head. Within this eight-mile stretch of highway, there are four active landslide blocks that require frequent remediation of the highway.

Figure 2-38. Landslide Movement Affecting U.S. Highway 101 at Hooskanaden Creek on March 3, 2019. Inset Photo Shows the Overall Scale of the Landslide and Its Proximity to the Coast

Photo source: Michael Olsen, 2020

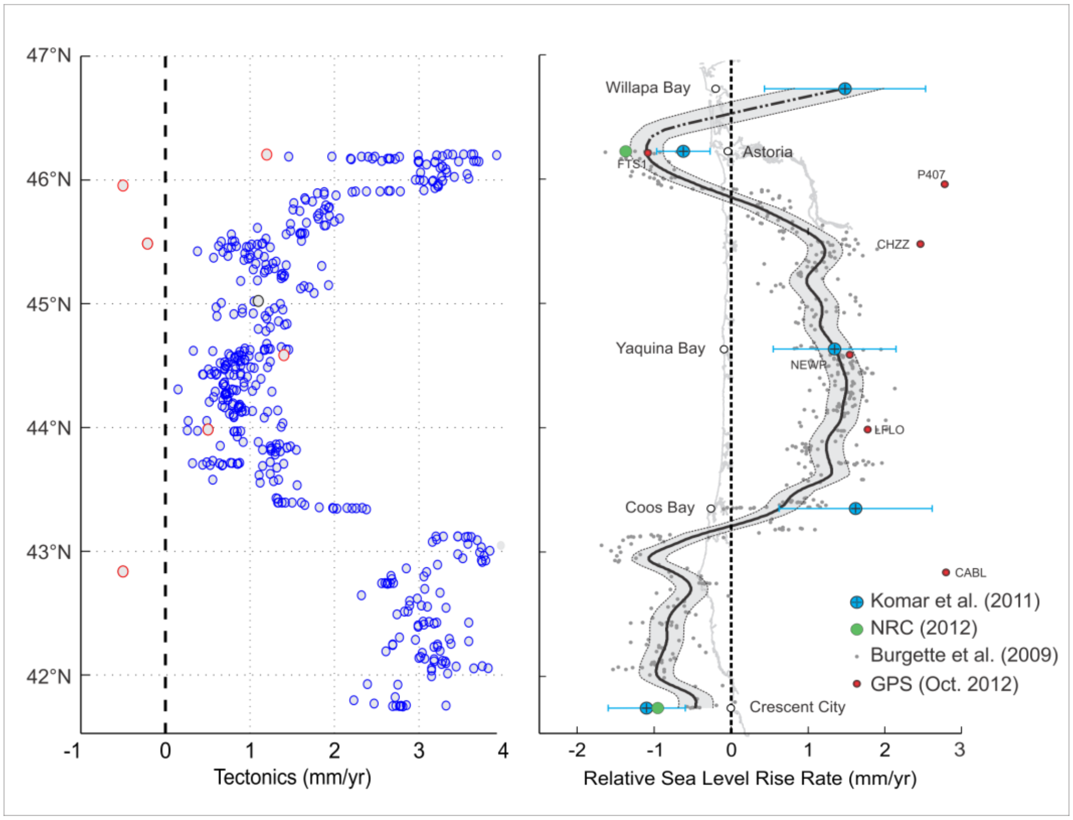
Climate Change and Sea Level Rise

An understanding of the trends and variations in sea level on the Oregon coast provides important insights as to the spatial patterns of erosion and flood hazards. In general, tectonic uplift is occurring at a much faster rate (about 2–4 mm/year) on the south coast (south of about Coos Bay), while the uplift rates on the central to northern Oregon coast are much lower, averaging about 1 mm/year (**Figure 2-39**, left). When combined with regional patterns of sea level change (**Figure 2-39**, right), it is apparent that the southern Oregon coast is essentially an emergent coast, with the coast rising at a much faster rate when compared with sea level. In contrast, the central to northern Oregon coast is a submergent coast due to the fact that sea level is rising faster than the land. Not surprisingly, it is the north coast that exhibits the most pervasive erosion and flood hazards when compared with the south coast.

In 2012, the National Research Council (2012) completed a major synthesis of the relative risks of sea level rise on the U.S. West Coast. The consensus from that report is that sea level has risen globally by on average 1.7 mm/year, while rates derived from satellite altimetry indicate an increase in the rate of sea level rise to 3.2 mm/year since 1993 (National Research Council, 2012). Combining our knowledge of glacial isostatic rebound (the rate at which the earth responds to the removal of ice from the last glaciations), regional tectonics, and future temperature patterns, the committee concluded that sea level on the Oregon coast would increase by approximately 2.1 ft by 2100.

Global measurements of sea level change continue to be quantified through satellite altimetry, with the most recent (February 2020) measurements indicating a net increase of 3.39 mm/year since 1993 (Copernicus Marine and Environment Monitoring Service (CMEMS), Aviso Satellite Altimetry Data website, Mean Sea Level Rise page, https://www.aviso.altimetry.fr/en/data/products/ocean-indicators-products/mean-sea-level.html). Regional projections of future sea level rise scenarios have also been updated for the United States, based on revised global projections of sea level change undertaken using global climate change modeling (Sweet and others, 2017). These revised data reflect the most up-to-date scientific information, including recent observational and modeling literature that examine the potential for rapid ice melt in Greenland and Antarctica. Based on these latest analyses, a physically plausible global sea level rise in the range of 6 ft to 8.9 ft is now more likely. Sweet and others (2017) define six global sea level rise scenarios, termed: Low, Intermediate-low, Intermediate, Intermediate-high, High and Extreme, which correspond to global sea level increases of 1 ft, 1.6 ft, 3.3 ft, 4.9 ft, 6.6 ft, and 8.2 ft respectively. These data can then be used to calculate regional estimates of sea level rise, after accounting for tectonic changes, glacial isostatic rebound, and shifts in ocean circulation patterns. For the Pacific Northwest, Sweet and others (2007) indicate that the regional sea level rise is projected to be less than the global average falling mainly under the Low-to-Intermediate scenarios (e.g., 0.3–3.3 ft).

Figure 2-39. Coast Variations in Rates of Tectonic Uplift, and Relative Sea Level Trends for the Oregon Coast



Source: Komar & Allan (2010); website: http://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level/

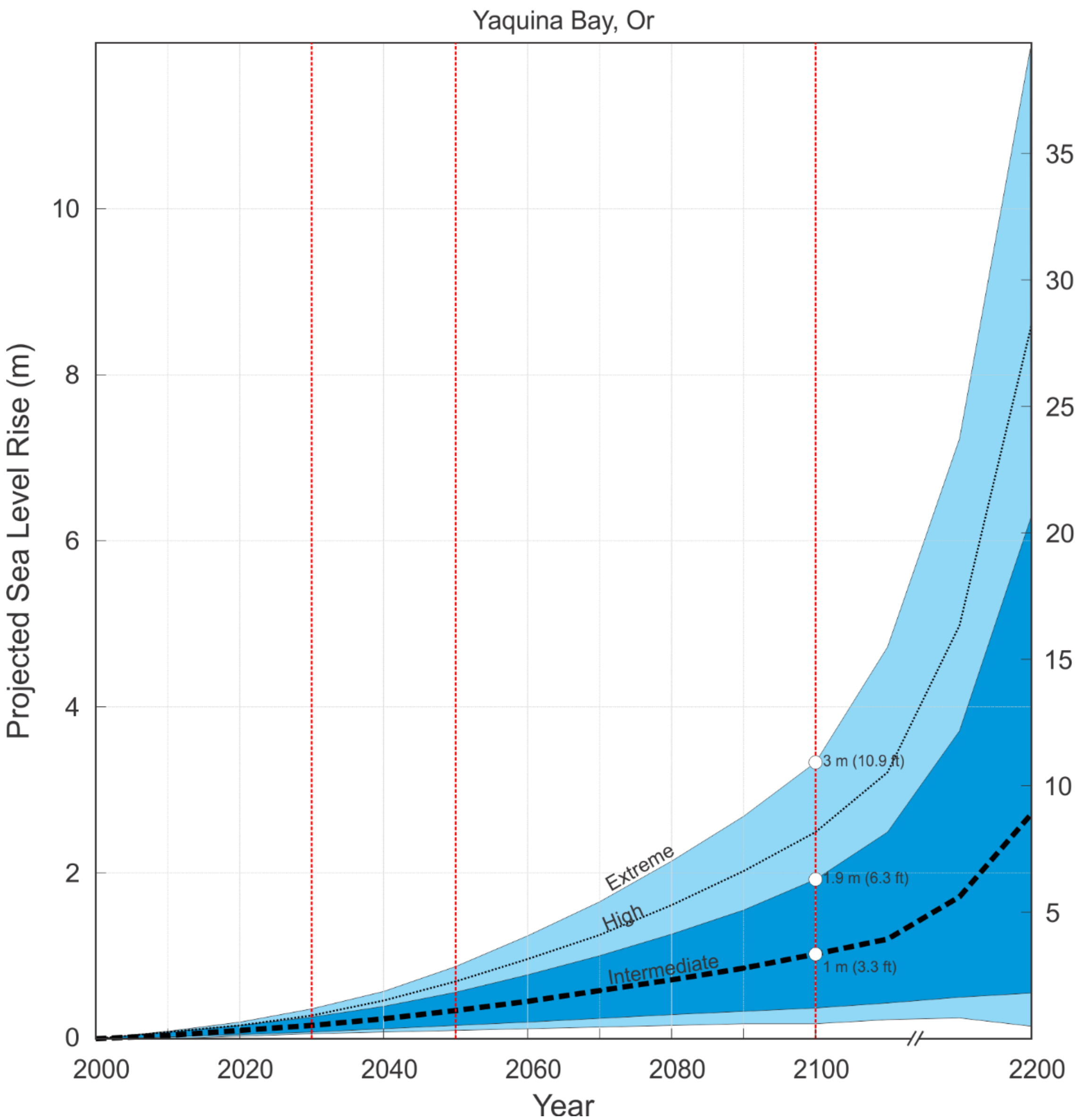
Table 2-22. Projected Sea Level Rise for the Central Oregon Coast

By Year 2030		By Year 2050		By Year 2100	
Projection	**Range**	**Projection**	**Range**	**Projection**	**Range**
0.5 ft	0.2–1.2 ft	1.1 ft	0.3–2.9 ft	3.4 ft	0.6–10.9 ft

Table 2-22 presents the revised Sweet and others (2017a) projected sea level rise findings for the Central Oregon coast. The largest increase in regional sea level is estimated to be 10.9 ft by 2100 (**Figure 2-40**) while the intermediate projection reflects an increase of about 3.4 ft by 2100. As noted previously, the extreme 10.9 ft projection reflects the now plausible scenario of a catastrophic failure of the Greenland and Antarctic ice sheets. Under this latter scenario, projected sea levels in 2200 could well exceed 30 ft along the Oregon coast.

Of importance, these projections assume that sea level is uniform year round. However, as noted previously, sea level on the Oregon coast exhibits a pronounced seasonal cycle of about 0.8 ft between summer and winter, increasing to as much as 2 ft in response to the development of a strong El Niño. Thus, when combined with projected future increases in regional sea level, it becomes apparent that the potential increase in mean sea level could be substantially greater depending on the time of year. For example, by 2100, sea level during an El Niño winter could be as much as 13 ft under the most extreme scenario, raising the mean shoreline position by that amount, which will have shifted upward and landward as beaches respond to the change in mean water levels. Based on these projections, it can be expected that areas presently classified as emergent (e.g., the southern Oregon coast), will become submergent over time as the rate of sea level rise surpasses tectonic uplift. Furthermore, erosion and flood hazards on the northern Oregon coast will almost certainly accelerate, increasing the risk to property.

Figure 2-40. Projected Future Changes in Regional Sea Levels on the Oregon Coast



Source: Created by Jonathan Allan, DOGAMI, with integrated sea level rise projections from Sweet and others (2017).

Human Activities

Human activities affect the stability of all types of shoreline. Large-scale human activities such as jetty construction and maintenance dredging have a long-term effect on large geographic areas. This is particularly true along dune-backed and inlet-affected shorelines such as the Columbia River and Rockaway littoral cells (**Figure 2-31**). The planting of European beach grass (*Ammophila arenaria*) since the early 1900s and, more recently, American beach grass (*Ammophila breviligulata*) has locked up sand in the form of high dunes. Such a process can contribute to a net loss in the beach sand budget and may help drive coastal erosion.

Residential and commercial development can affect shoreline stability over shorter time periods and smaller geographic areas. Activities such as grading and excavation, surface and subsurface drainage alterations, vegetation removal, and vegetative as well as structural shoreline stabilization can all affect shoreline stability.

While site-specific coastal engineering efforts such as the construction of riprap revetments is less likely to cause direct adverse impacts to the beach, the cumulative effect of constructing many of these structures along a particular shore (e.g., as has occurred along the communities of Gleneden Beach, Siletz Spit, Lincoln City, Neskowin, Pacific City, and Rockaway) will almost certainly decrease the volume of sediment being supplied to the beach system, potentially affecting the beach sediment budget and hence the stability of beaches within those littoral cells.

Heavy recreational use in the form of pedestrian and vehicular traffic can affect shoreline stability over shorter time frames and smaller spaces. Because these activities may result in the loss of fragile vegetative cover, they are a particular concern along dune-backed shorelines. Graffiti carving along bluff-backed shorelines is another byproduct of recreational use that can damage fragile shoreline stability.

Historic Coastal Hazard Events

Table 2-23 lists historic coastal erosion and flood hazard events in Oregon.

Table 2-23. Historic Coastal Hazard Events in Oregon

Date	Location	Description
Jan. 1914	Newport	damage (Nicolai Hotel)
1931	Rockaway	coastal damage from December storm
Oct–Dec. 1934	Waldport and Rockaway	flooding (Waldport) coastal damage (Rockaway Beach)
Dec. 1935	Cannon Beach and Rockaway Beach	coastal damage
Jan. 1939	coastwide	severe gale; damage: coastwide severe flooding (Seaside, and Ecola Creek near Cannon Beach): • multiple spit breaches (southern portion of Netarts Spit) • storm damage (along the shore of Lincoln City and at D River) • flooding (Waldport) • extensive damage (Sunset Bay Park) • storm surge overtopped foredune (Garrison Lake plus Elk River lowland)
Dec. 1940	Waldport	flooding
1948	Newport	wave damage (Yaquina Arts Center)
Jan. 1953	Rockaway	70-ft dune retreat; one home removed
Apr. 1958	Sunset Bay State Park Newport	flooding (Sunset Bay); wave damage (Yaquina Arts Center in Newport)
Jan.–Feb. 1960	Sunset Bay State Park	flooding
1964	Cannon Beach	storm damage
Dec. 1967	Netarts Spit Lincoln City Newport Waldport	damage: coastwide State constructed wood bulkhead to protect foredune along 600 ft section (Cape Lookout State Park campground) flooding and logs (Lincoln City) wave damage (Yaquina Arts Center, Newport) flooding (Waldport) Storm damage (Beachside State Park washed up driftwood (Bandon south jetty parking lot)
1971–73	Siletz Spit	high tide line eroded landward by 300 ft Feb. 1973; one home completely destroyed; spit almost breached logs through Sea Gypsy Motel (Nov. 1973)
1982–83	Alsea Spit	northward migration of Alsea Bay mouth; severe erosion
1997–98	Lincoln and Tillamook Counties	El Niño winter (second strongest on record); erosion: considerable
1999	coastwide	five storms between January and March; coastal erosion: extensive, including: • significant erosion (Neskowin, Netarts Spit, Oceanside, Rockaway beach); • overtopping and flooding (Cape Meares) • significant erosion along barrier beach (Garrison Lake); overtopping 27-ft high barrier
Dec. 2007	Tillamook and Clatsop Counties	wind storm
Dec. 7-11 2015	Tillamook and Clatsop Counties	coastal and riverine flooding in response to several days of heavy rain. large storm waves exceeding 30 ft on Dec 11th resulted in coastal erosion issues in several communities.

Date	Location	Description
Feb. 2018	Curry County	major coastal landslide at Hooskanaden, located in southern Curry County
2019-2020	Siletz Spit	significant erosion over the 2019-20 winter resulted in several homes impacted and the need for emergency permits for coastal engineering.

Sources: Allan & Priest (2001); Allan & Komar (2002); Allan, et al. (2003), (2006); Allan & Hart (2007), (2008); Allan, et al. (2009), (2012); Allan & Stimely (2013); Komar (1986) (1987); Komar & Rea (1976); Komar & McKinney (1977), (1997); Komar & Allan (2010); Peterson, et al. (1990); Priest (1999); Revell, et al. (2002); Schlicker, et al. (1973); Stembridge (1975); and Terich and Komar (1974)

2.2.1.2 Probability

The erosion of the Oregon coast is exceedingly complex, reflecting processes operating over both short and long time scales, and over large spatial scales. However, the most significant erosion effects are largely controlled by high-magnitude (relatively infrequent) events that occur over the winter (the months of October to March), when wave heights and ocean water levels tend to be at their highest. Conversely, problems with sand build-up is a function of a readily available sand supply and its subsequent redistribution by wave (specifically nearshore currents) and wind processes. These latter processes may be periodically enhanced under strong El Niño conditions, resulting in both enhanced beach and dune erosion, and the subsequent redistribution of those eroded sediments to downdrift locations where the sediments accumulate in dunes. The best examples of this process occurring presently on the Oregon coast include the Neskowin littoral cell in Tillamook County; Alsea Spit in central Lincoln County; and at Cannon Beach in Clatsop County.

Waves

Previous analyses of extreme waves for the Oregon coast estimated the "100-year" storm wave to be around 33 feet. In response to a series of large wave events that occurred during the latter half of the 1990s, the wave climate was subsequently re-examined and an updated projection of the 100-year storm wave height was determined, which is now estimated to reach approximately 47–52 feet (**Table 2-24**), depending on which buoy is used. These estimates are of considerable importance to the design of coastal engineering structures and in terms of defining future coastal erosion hazard zones.

Table 2-24. Projection of Extreme Wave Heights for Various Recurrence Intervals

Recurrence Interval (years)	Extreme Wave Heights (feet)	
	NDBC buoy #46002 (Oregon)	NDBC buoy #46005 (Washington)
10	42.5	41.7
25	46.2	44.0
50	48.8	
75	50.1	45.7
100	51.2	47.1

Note: Each wave height is expected to occur on average once during the recurrence interval. NDBC is National Data Buoy Center

Source: Jonathan Allan, DOGAMI

Sand Inundation

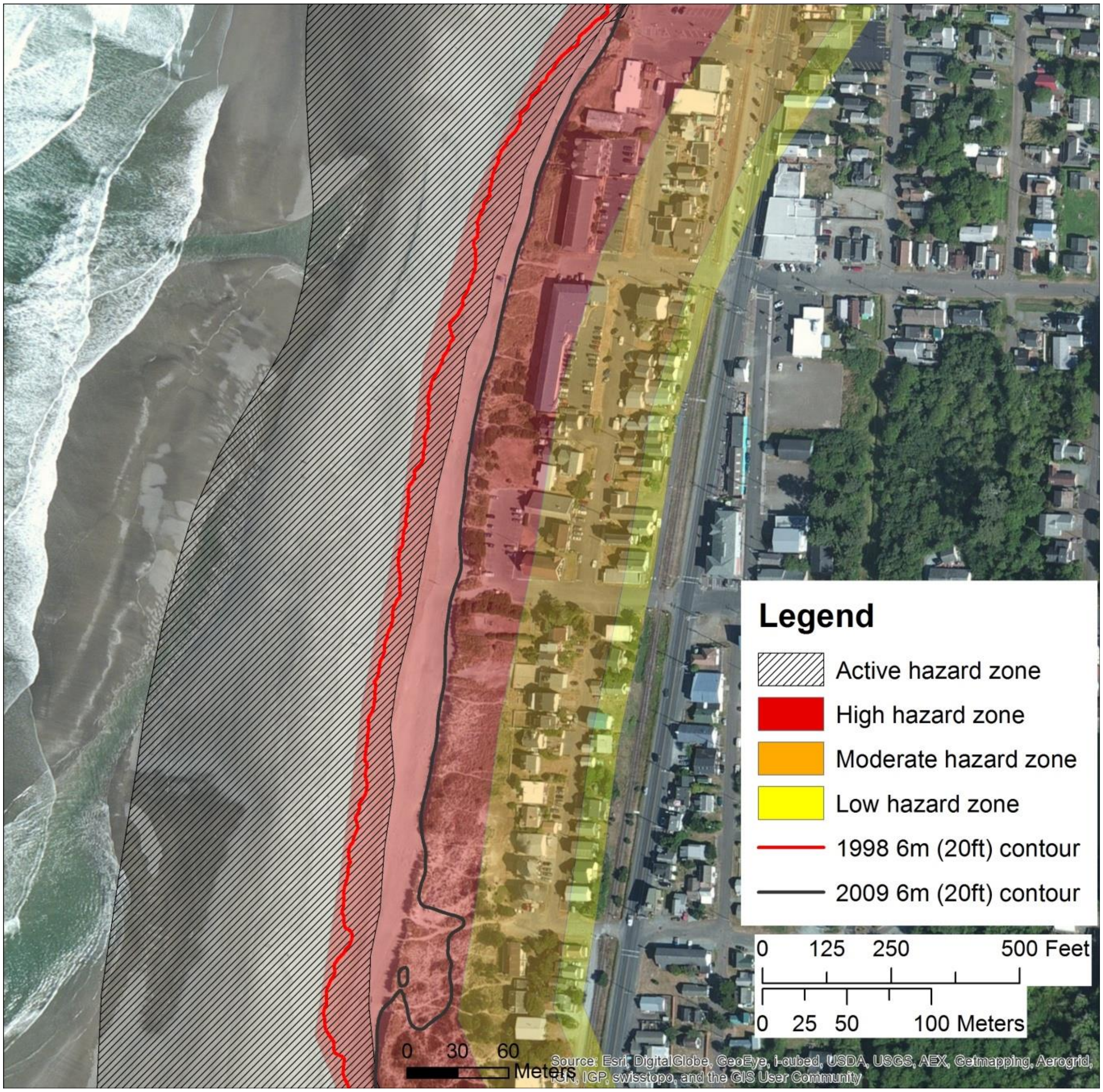
As noted previously, beaches are especially dynamic features, as sand is constantly shifted about. This is especially noticeable in major storms, with the shoreline retreating rapidly, periodically destroying homes built too close to the sea. At other times, large quantities of sand migrate back onto beaches, burying homes built atop coastal dunes (**Figure 2-30B**). The probability of such events taking place has not been adequately studied. However, given existing dune grading activities in several communities, the repeat build-up of sand occurs annually, which may be enhanced during strong El Niño events.

The best examples of sand inundation include the communities of Pacific City located at the north end of the Neskowin littoral cell and along Alsea Spit. In both examples, homes have been built on the seaward foredune, in areas prone to large sand movements. Repeat GPS measurements of the changes taking place in such areas indicate that the annual accumulation of sand among the homes can range from as little as 2 ft to well over 3 ft per year, requiring periodic (in some cases annual) remediation that includes foredune grading to push the sand back out onto the beach. This process will inevitably continue as long as there is a ready supply of sand, a prevailing wave and wind climate that drives sand northward, and the absence of vegetation in the dunes. Thus, while sand grading is used to relocate sand back onto the beach, dune grass planting is a second essential step needed to stabilize the dune. Once grasses have become established, the foredune can be expected to stabilize and begin to slowly advance seaward. The latter process may be aided by careful dune management approaches (e.g., grading) that maintains a well vegetated dune, while encouraging the seaward advance of the dune.

Another notable coastal area presently dealing with sand build-up is a small area north of Ecola Creek in Cannon Beach ((Allan, O’Brien, & Gabel, 2018)). Analyses by Allan and others indicated that about 294,000 yards have accumulated north of Ecola Creek since 1997, necessitating periodic grading of the evolving dune.

Sand aggradation is also significant in the vicinity of Seaside, where it aggrades up against the Seaside promenade, requiring annual grading.

Figure 2-41. Example Map Product Showing Erosion Hazard Zones Developed for Rockaway Beach in Tillamook County



Note: The erosion that has taken place since 1998 (red line) up through 2009 (black line).
Photo source: DOGAMI

Coastal Erosion Hazard Zones

For the purposes of providing erosion hazard information for the Oregon coast, DOGAMI has completed coastal erosion hazard maps for Lincoln, Tillamook, and Clatsop Counties, as well in the Nesika Beach area in Curry County. Maps were completed for these areas mainly because these areas contain the largest concentration of people living along the coastal strip, and in the case of Nesika Beach in response to a specific request by the Department of Land Conservation and Development agency. In all cases, the maps depict erosion hazard zones that fall into four categories (**Figure 2-41**):

- **Active Hazard Zone (AHZ):** For dune-backed shorelines, the AHZ encompasses the active beach to the top of the first vegetated foredune, and includes those areas subject to large morphological changes adjacent to the mouths of the bays due to inlet migration. On bluff-backed shorelines the AHZ includes actively eroding coastal bluff escarpments and active or potentially active coastal landslides.
- **High Hazard Zones (HHZ):** This scenario is based on a large storm wave event (wave heights about 47.6 ft high) occurring over the cycle of an above average high tide, coincident with a 3.3 ft storm surge. The wave heights associated with this scenario have an expected recurrence interval of 50-60 years or a 2% chance in any given year.
- **Moderate Hazard Zones (MHZ):** This scenario is based on an extremely severe storm event (waves about 52.5 ft high) and may or may not encompass a long-term rise in sea level (depends on the coastal region). As with the HHZ, the wave event occurs over the cycle of an above average high tide, coincident with a 5.6 ft storm surge. The wave heights associated with this scenario have an expected recurrence interval of 100 years or a 1% chance in any given year.
- **Low Hazard Zones (LHZ):** This scenario is analogous to the MHZ scenario described previously, with the addition of a 3.3 ft coseismic subsidence of the coast.

In July 2014, DOGAMI completed new updated maps for the dune-backed beaches in Tillamook County using a probabilistic approach to map the erosion hazard zones. The revised modeling used three total water level scenarios (10%, 2%, and 1% events) produced by the combined effect of extreme wave runup (R) plus the tidal elevation (T), and erosion due to sea level rise (low/mean/maximum estimates) at 2030, 2050, and 2100. In total 81 scenarios of coastal erosion were modeled; an additional two scenarios were also modeled that considered the effects of a Cascadia subduction zone earthquake, and the effects of a single (1%) storm, where the storm's duration was taken into account. The completed study ultimately recommended five hazard zones for consideration.

Coastal Flooding

Between 2009 and 2014, DOGAMI completed coastal flood modeling for all seven coastal counties on behalf of the Federal Emergency Management Agency (e.g., Allan, et al. (2012), (2015a), (2015b), (2015c), (2015d), (2017)). These analyses included assessments of the 1% annual probability, or 100-year, extreme storm wave event and the associated calculated wave setup, runup, and total water level (i.e., the wave runup superimposed on the tidal level) to help guide the determination of Special Flood Hazard Areas (SFHAs). The most significant were regions subject to high coastal flood risk (Zone VE), characterized with base flood elevations (BFEs) that are used to guide building practices. Additional modeling of the 0.2%, or 500-year, event was also undertaken. These analyses represent the best available information to date on the risk of coastal flooding. However, as the effects of climate change begin to accelerate and drive regional and global mean sea level increases, existing areas already prone to flooding (e.g., parts of the northern Oregon coast) will almost certainly become worse, while other areas presently not affected are likely to begin to see an increasing incidence for erosion and propensity for flooding.

Landslides

Landslides are prevalent along the Oregon coast, in areas characterized with steeper slopes, weaker geology, and higher annual precipitation. Of the seven coastal counties, two (Lane and Douglas Counties) have a negligible landslide hazard, while the remaining five counties experience frequent coastal landsliding. Although we do not know exactly where and when landslides will occur, they are more likely to happen in the areas where previous landslides have occurred. Furthermore, they are much more prevalent during heavy rainfall events, and in steep bluff areas subject to wave toe erosion and undercutting. Due to the coastal terrain and proximity to the Cascadia subduction zone, it is certain that the Oregon coast will be severely impacted with many thousands of landslides following a future great earthquake.

Probability of Coastal Hazards in Each Coastal County

To determine the probability of a particular coastal hazard (coastal erosion, flooding, coastal landslide, and—new in 2020—sand inundation) occurring on the Oregon coast, the overall exposure level associated with each hazard and for each county was first defined. This is needed to appreciate that although certain hazards have a very high probability of occurring everywhere along the Oregon coast, the degree of development varies considerably from county to county (and community to community), which directly impinges on a site’s exposure.

While one can extrapolate a probability for storm events (e.g., 100-year storm), in the context of the NHMP this is not hugely helpful. This is because in some cases smaller, more frequent events (e.g., 10-year storms) may result in cumulative erosion that could well exceed a single 100-year storm. Of importance also is the fact that nowhere has a particular exceedance event been formally defined (e.g., is the concern about the 10-year, 50-year or 100-year storm?), guided by some planning horizon.

For landslides, each county was evaluated based on whether the local terrain and geology is conducive to landsliding, and whether there were known instances of historical coastal landslides. Thus, counties that had little to no terrain capable of landsliding (e.g., coastal Lane County) were given a low rank, compared with those counties where previous landslides have occurred (e.g., Lincoln County).

Finally, since some hazards have never been defined from a probabilistic standpoint, we decided to focus our attention on a more qualitative classification scheme. In all cases, the approach used here was guided by local knowledge of the Oregon coast, various technical studies (e.g., FEMA flood modeling, ongoing beach monitoring) and recent research (sea level rise and extreme storms).

Table 2-25. Probability Classification Scheme for Coastal Hazards

Classification	Probability of Outcome	Probability of Outcome with High Uncertainty
Extremely likely	> 99%	> 99%
Very likely	80–90%	≥ 80%
Likely	60–80%	≥ 60%
About as likely as not	40–60%	40–60%
Unlikely	15–40%	< 40%
Very unlikely	1–15%	< 15%
Extremely unlikely	< 1%	< 1%

Source: J. Allan, DOGAMI, 2020

Table 2-26. Probability and Exposure Rankings of Coastal Sand Inundation and Coastal Erosion

		Coastal Sand Inundation		Coastal Erosion	
		Probability	Exposure	Probability	Exposure
Region 1	Clatsop	Likely	Mod High	Extremely likely	High
	Coos	Unlikely	Low	Extremely likely	High
	Curry	Very unlikely	Low	Extremely likely	Moderately Low
	Douglas Coastal	Likely	Low	Extremely likely	Low
	Lane Coastal	Likely	Low	Extremely likely	Moderately Low
	Lincoln	Very unlikely	Low	Extremely likely	Very High
	Tillamook	Extremely likely	High	Extremely likely	Very High

Table 2-27. Probability and Exposure Rankings of Coastal Flooding and Coastal Landslides

		Coastal Flooding		Coastal Landslides	
		Probability	Exposure	Probability	Exposure
Region 1	Clatsop	Likely	Moderately Low	Extremely likely	Moderate
	Coos	Unlikely	Low	Unlikely	Low
	Curry	Unlikely	Low	Extremely likely	Moderate
	Douglas Coastal	Unlikely	Low	Extremely unlikely	Low
	Lane Coastal	Unlikely	Low	Very unlikely	Low
	Lincoln	Unlikely	Low	Extremely likely	High
	Tillamook	Very likely	Moderate	Very likely	Moderate

The final probability ranking, 1 to 5 (1 = low probability/low exposure to 5 = high probability/high exposure), was thus based on the combined probability classification and the degree of exposure of coastal erosion, coastal flooding, coastal landslides, and coastal sand inundation) and ranked accordingly. For example, although the Douglas County coastline is extremely likely to experience erosion in any given year, since there is virtually no development on the open coast, the exposure is considered to be low. Conversely, beaches and dunes in Tillamook County are undergoing active erosion, while the exposure is very high due to the fact there is significant development adjacent to the coast.

Table 2-28. Final Probability Ranking of Coastal Hazards

		Coastal Sand Inundation	Coastal Erosion	Coastal Flooding	Coastal Landslides	Combined Probability
Region 1	Clatsop	3	4	3	4	3.50 = VH
	Coos	1	4	1	1	1.75 = VL
	Curry	1	3	1	4	2.25 = L
	Douglas Coastal	2	2	1	1	1.50 = VL
	Lane Coastal	2	3	1	1	1.75 = VL
	Lincoln	1	5	1	5	3.00 = H
	Tillamook	4	5	4	4	4.25 = VH

Source: J. Allan, DOGAMI, 2020

Climate Change

Recent research indicates that sea levels along Oregon's coast are rising as are wave heights off the Oregon coast. Increasing significant wave heights may be a factor in the observed increase of coastal flooding events in Oregon. During El Niño events, sea levels can rise up to about 1.5 feet (0.5 meters) higher over extended periods (seasons). It is very likely (>90%) that the Oregon coast will experience an increase in coastal erosion and flooding hazards due to climate change induced sea level rise (high confidence) and possible changes to wave dynamics (medium confidence).

2.2.1.3 Vulnerability

Chronic hazards are clearly evident along Oregon's shores, including beach, dune, and bluff erosion, landslides, slumps, gradual weathering of sea cliffs, and flooding of low-lying coastal lands during major storms. The damage caused by chronic hazards is usually gradual and cumulative. The regional, oceanic, and climatic environments that result in intense winter storms determine the severity of chronic hazards along the coast. These hazards threaten property and, in extreme events, human life.

For the 2020 vulnerability assessment, DOGAMI used the hazard mapping from several DOGAMI coastal erosion studies performed between 2001 and 2014. The coastal erosion hazard is mapped as Active, High, Moderate, or Low Hazard Zones which, for the purposes of the 2020 NHMP, were simplified to High (encompassing Active and High), Moderate, and Other (encompassing Low hazards and unmapped areas). The Low hazard zones incorporate hypothetical landslide block failures assumed to fail in the event of a M9 Cascadia earthquake and were placed under "Other" due to their very low probability. However, this data does not cover the entire Oregon coastline: coastal erosion hazard zones have not been created for Lane, Douglas, and Coos Counties, and only partial data coverage exists for Curry County. To address these data gaps, DOGAMI excluded those portions of the coast from the analysis, and instead used a 0.5-km buffer of the coastline to delineate an "Other" zone.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from coastal hazards to state buildings and critical facilities as well as to local critical facilities statewide. About $11.5M in value of state buildings and state critical facilities are located in coastal erosion hazard areas, and the majority of that value (86%) is located in Lincoln and Tillamook Counties. None is located in Coos, Coastal Douglas, or Coastal Lane Counties. About $285K of value in local critical facilities is located in coastal erosion areas in Clatsop and Tillamook Counties; none in the other coastal counties.

The total value of state-owned and leased buildings and critical facilities in Region 1 is approximately $535,054,000 representing the maximum potential for loss of state assets due to coastal hazards. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, only one minor loss of just over $700 to a state facility was recorded in Region 1 since the beginning of 2015. It was not due to a coastal hazard.

DAS's records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Historic Resources

Of the 3,121 historic resources located in Oregon's coastal counties, none are located in coastal erosion high hazard areas. Only one, in Tillamook County, is located in a moderate coastal erosion hazard area, and 54 are located in low or other coastal erosion hazard areas. Of the 54 in low or other coastal erosion hazard areas, 33 are located in Clatsop county and ten in Tillamook County.

Archaeological Resources

Of the 369 archaeological resources in Oregon's coastal counties, 119 are located in an area of high coastal erosion hazards. Of those, 30 are listed on the National Register of Historic places and 2 are eligible for listing. Eighty-seven have not been evaluated as to their eligibility for listing. The 32 listed and eligible archaeological resources in high coastal erosion hazard areas are located in Clatsop, Lincoln, and Tillamook Counties. Twenty-one other listed and eligible archaeological resources are located in moderate coastal erosion hazard areas in the same three counties. Sixty-seven listed and eligible archaeological resources are located in areas of low or other coastal erosion hazard areas in throughout the coastal counties. The coastal portions of Lane and Douglas Counties were not included in this assessment.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

For the 2020 vulnerability assessment, DLCD combined this index with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Coos County, the coastal portion of Douglas County, and Lincoln County are more vulnerable than the other coastal counties, but still are only moderately vulnerable.

Most Vulnerable Jurisdictions

The Department of Geology and Mineral Industries is the agency with primary oversight of the coastal erosion hazard. Based on agency staff review of the 2020 vulnerability assessment available hazard data, knowledge derived from field experience, discussions with scientists, scientific publications, agency reports, and thesis dissertations, DOGAMI ranks Tillamook, Lincoln, Clatsop, and Curry Counties one through four respectively as the counties most vulnerable to coastal erosion in the state.

Coastal hazards in Coos, Lane, and Douglas Counties are considered to be generally negligible. This is because the bulk of these coastlines have little population base and hence are largely unmodified. In Coos County, coastal hazards can be found in a few discrete communities such as adjacent to the Coquille River south jetty in Bandon and along Lighthouse Beach near Cape Arago. Similarly, coastal hazards in Lane County are confined almost entirely to the Heceta Beach community and adjacent to the Siuslaw River mouth, particularly adjacent to the lower estuary mouth where development lines coastal bluffs that are gradually being eroded by riverine processes.

The most vulnerable counties and communities on the Oregon coast include:

Tillamook County (ranked #1):

- Neskowin (erosion and flooding)
- Pacific City (erosion (1970s); replaced by recent sand inundation),
- Tierra del Mar (erosion and flooding)
- Cape Meares (flooding and landsliding)
- Twin Rocks (erosion and flooding)

- Rockaway Beach (erosion and flooding)
- Nehalem (flooding during extreme high tides)

Lincoln County (ranked #2):

- Yachats to Alsea Spit (erosion)
- Waldport (erosion and flooding)
- Alsea Spit (erosion [1982/83 and 1997/98 El Niños]; replaced by recent sand inundation)
- Seal Rock (erosion and landsliding)
- Ona Beach to Southbeach (erosion and landsliding)
- Newport (landsliding)
- Beverly Beach (erosion and landsliding)
- Gleneden Beach to Siletz Spit (erosion, landsliding, and flooding)
- Lincoln City (erosion and landsliding)

Clatsop County (ranked #3):

- Falcon Cove (erosion and landsliding)
- Arch Cape (erosion and flooding)
- Tolovana to Cannon Beach (erosion and flooding)
- Cannon Beach (erosion; sand inundation north of Ecola Creek)
- Ecola State Park (landsliding)
- Seaside (flooding)

Curry County (ranked #4):

- Multiple coastal sections affecting Highway 101 (landsliding and erosion)
- Gold Beach, Hunter Creek (erosion)
- Nesika Beach (erosion and landsliding)
- Port Orford (flooding at Garrison Lake)

Coos County (ranked #5):

- North Coos Spit (erosion)
- Lighthouse Beach (bluff erosion)
- Bandon (erosion and flooding, particularly adjacent to the Coquille River south jetty)

Lane County (ranked #6):

- Heceta Beach (erosion and flooding; erosion especially significant in the north at the mouth of Sutton Creek).

Douglas County (ranked #7)

- Coastal hazards in Douglas County are considered to be negligible.

2.2.1.4 Risk

In the 2020 update DOGAMI and DLCD developed a new risk ranking system that combines the probability of the hazard (based on the new approach described above) with the limited vulnerability assessment to arrive at a composite risk score referred to as the 2020 Risk Score.

According to the 2020 risk assessment, the counties at greatest risk from coastal hazards are Clatsop, Lincoln, and Tillamook Counties. This is consistent with DOGAMI's independent assessment.

2.2.2 Droughts

Despite its rainy reputation, the state of Oregon is often confronted with continuing challenges associated with drought and water scarcity. Precipitation in Oregon follows a distinct spatial and temporal pattern; it tends to fall mostly in the cool season (October–March). The Cascade Mountains block rain-producing weather patterns, creating a very arid and dry environment east of these mountains. Moist air masses originating from the Pacific Ocean cool and condense when they encounter the mountain range, depositing precipitation primarily on the inland valleys and coastal areas.

Oregon's water-related challenges are greater than just the temporal and spatial distribution of precipitation in Oregon. A rapidly growing population in the American West has placed a greater demand on this renewable, yet finite resource. The two terms, drought and water scarcity, are not necessarily synonymous; distinctly, water scarcity implies that demand is exceeding the supply. The combined effects of drought and water scarcity are far-reaching and merit special consideration.

Drought is typically measured in terms of water availability in a defined geographic area. It is common to express drought with a numerical index that ranks severity. Most federal agencies use the Palmer Method which incorporates precipitation, runoff, evaporation, and soil moisture. However, the Palmer Method does not incorporate snowpack as a variable. Therefore, it is does not provide a very accurate indication of drought conditions in Oregon and the Pacific Northwest, although it can be very useful because of its a long-term historical record of wet and dry conditions.

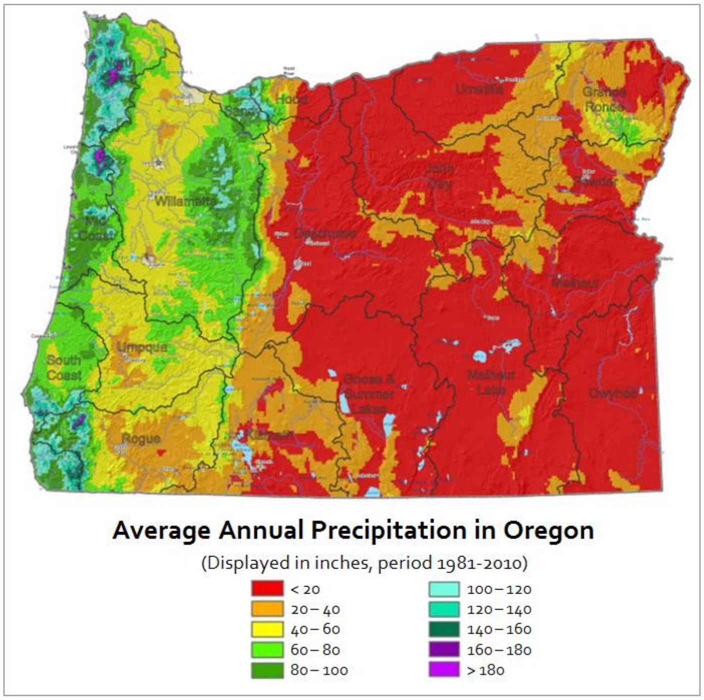
With climate change, snow droughts—the type of drought in which snowpack is low, but precipitation is near normal—are expected to occur more often. The 2015 drought in Oregon was a "snow drought" and serves as a good example of what future climate projections indicate may become commonplace by mid 21st century (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). Going forward, drought indices that can account for a changing climate, such as the Standard Precipitation-Evapotranspiration Index (SPEI), may provide a more accurate estimate of future drought risks.

Oregon's Emergency Operations Plan includes a Drought Annex for the purposes of coordinating state and federal agency response to drought emergencies caused by water shortages and to provide emergency water supplies for human consumption under conditions of inadequate supply. The Annex outlines several steps and lists major responsibilities of various federal, state, and local jurisdictions. It also includes a description of federal drought assistance programs and guidelines for water curtailment planning and program development.

2.2.2.1 Analysis and Characterization

Defining drought can be difficult given the issue of both water supply and demand. Redmond (2002) puts forth a simple definition that encapsulates both supply and demand, "drought is insufficient water to meet needs." Oregon's Legislative Assembly describes drought as a potential state emergency when a lack of water resources threatens the availability of essential services and jeopardizes the peace, health, safety, and welfare of the people of Oregon (Oregon Revised Statute §539.710).

Figure 2-42. Oregon Average Annual Precipitation, 1981–2010



Sources: PRISM Climate Group, Oregon State University (http://www.prism.oregonstate.edu/); map by Oregon Water Resources Department

Droughts can be characterized by the dominant impact caused by increased demand or decreased supply. In the early 1980s, researchers with the National Drought Mitigation Center and the National Center for Atmospheric Research located more than 150 published definitions of drought. There clearly was a need to categorize the hazard by "type of drought.” The following definitions are a response to that need. However, drought cannot always be neatly characterized by the following definitions, and sometimes all four definitions can be used to describe a specific instance of drought.

Meteorological or climatological droughts usually are defined in terms of the departure from a normal precipitation pattern and the duration of the event. Drought is a slow-onset phenomenon that usually takes at least three months to develop and may last for several seasons or years.

Agricultural droughts link the various characteristics of meteorological drought to agricultural impacts. The focus is on precipitation shortages and soil-water deficits. Agricultural drought is largely the result of a deficit of soil moisture. A plant’s demand for water is dependent on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil.

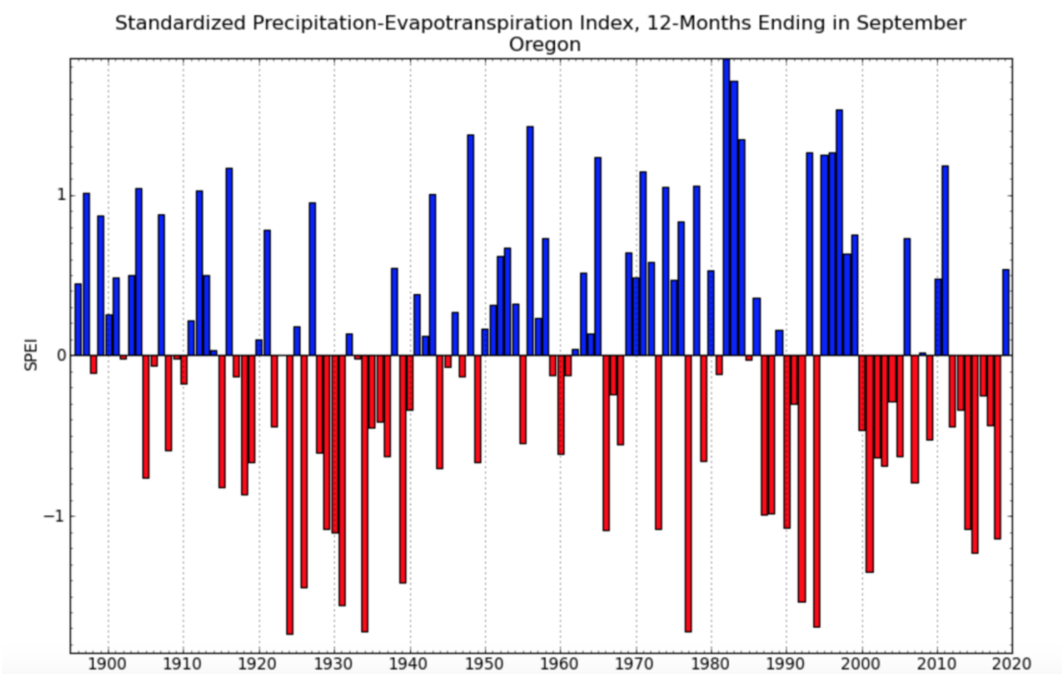
Hydrological droughts refer to deficiencies in surface water and sub-surface water supplies. It is reflected in the level of streamflow, lakes, reservoirs, and groundwater. Hydrological measurements are not the earliest indicators of drought. When precipitation is reduced or deficient over an extended period of time, the shortage will be reflected in declining surface and sub-surface water levels.

Socioeconomic droughts occur when physical water shortage begins to affect people, individually and collectively. Most socioeconomic definitions of drought associate it with supply, demand, and economic good. One could argue that a physical water shortage with no socio-economic impacts is a policy success

History of Droughts in Oregon

Oregon records, dating back to the late 1800s, associate drought with a departure from expected precipitation. Droughts in the Pacific Northwest can persist for a few years, but rarely prolong for a decade. The Dust Bowl era (1930s) had many years with below average precipitation, which caused problems for agriculture, but every year in that decade was not considered to be a drought year. However, three water years in the 1930s fall in the top eight lowest statewide Standard Precipitation-Evapotranspiration Index (SPEI) values on record (1895–2019). While droughts are often referred to as happening in a calendar year, it is more appropriate to define them by water year. The water year begins at the start of the cool, rainy season on October 1 and continues through September 30 of the following year. For example, Water Year 2014 started on October 1, 2013.

Figure 2-43. Water Year Standard Precipitation-Evapotranspiration Index (SPEI) for Oregon



Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/, with the following selections: Oregon, SPEI, 1895–2019, September, 12-month

Table 2-29. Water Years with the Lowest SPEI Values, Averaged Statewide, on Record (1895–2019) for the State of Oregon

Rank	Water Year	SPEI Value
1	1924	−1.73
2	1934	−1.72
3	1977	−1.72
4	1994	−1.69
5	1931	−1.56
6	1992	−1.53
7	1926	−1.44
8	1939	−1.41
9	2001	−1.35
10	2015	−1.23
11	2018	−1.14

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/, with the following selections: Oregon, SPEI, 1895–2019, September, 12-month

Low stream flows prevailed in western Oregon during the period from 1976-81, but the worst year, by far, was 1976-77, the single driest year of the century. The Portland Airport received only 7.19 inches of precipitation between October 1976 and February 1977, only 31% of the average 23.16 inches for that period. This drought also impacted California and other parts of the West Coast. It is often acknowledged as one of the most significant droughts in Oregon's history and fittingly shows up as the third lowest SPEI value statewide.

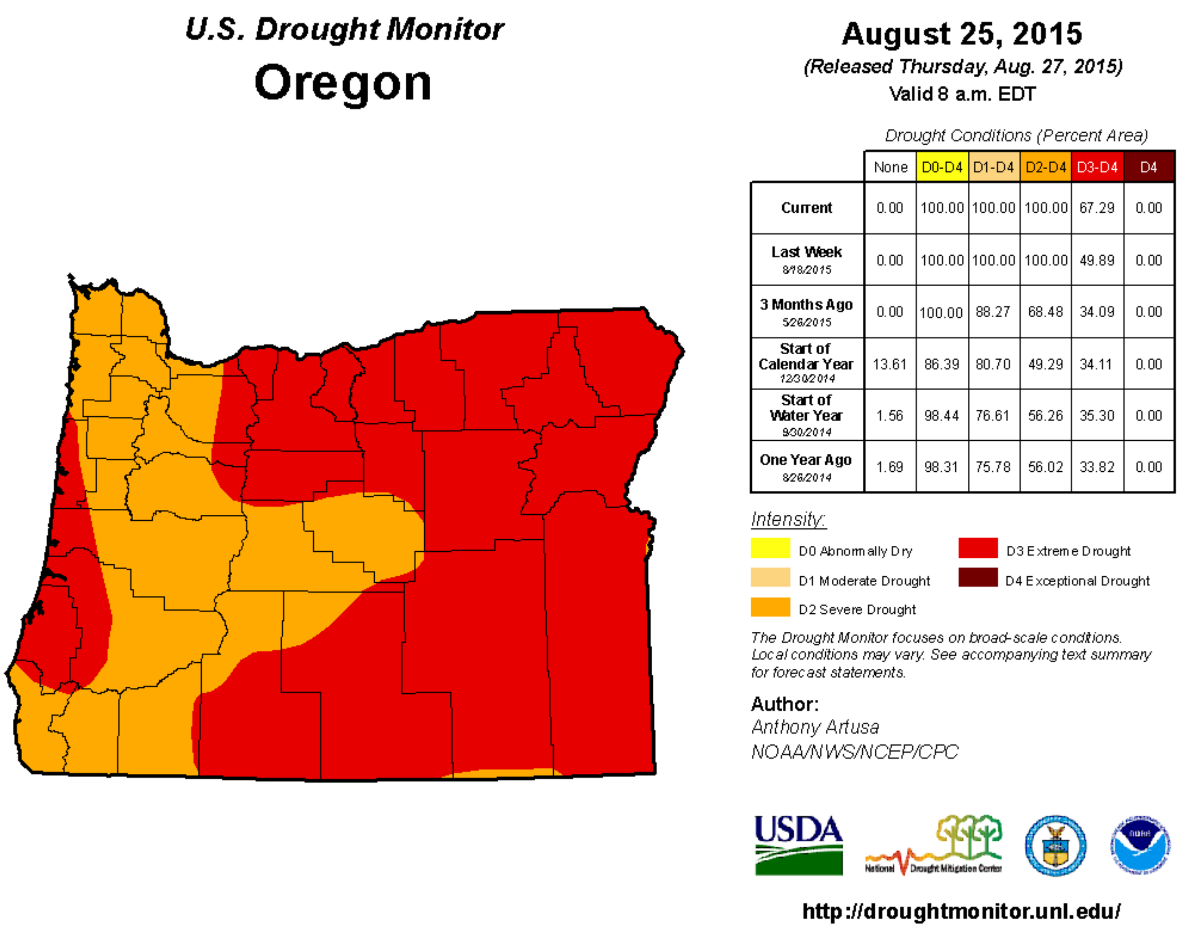
The 1992 drought was not as severe as the 1976-77 drought; however, it did occur toward the end of several years of drier than normal conditions in the late 1980s and early 1990s, making it the peak year for drought conditions. The Governor declared a drought emergency for all Oregon counties (Executive Order 92-21). Forests throughout the state suffered from a lack of moisture. Fires were common and insect pests, which attacked the trees, flourished.

In 2001 and 2002, Oregon experienced drought conditions, affecting six out of eight regions. During the 2005 drought, the Governor issued declarations for 13 counties, all east of the Cascades, and the USDA issued three drought declarations, overlapping two of the Governor's. State declarations were made for Baker, Wallowa, Wheeler, Crook, Deschutes, Klamath, Lake, Hood River, Wasco, Sherman, Gilliam, Morrow, and Umatilla Counties. Federal declarations were made in Coos, Klamath, and Umatilla Counties. Federal drought declarations, similar to declarations by Oregon's governor, provide emergency relief and response actions by various agencies. The U.S. Department of Agriculture, for example, can provide accessibility to emergency loans for crop losses. Since 2001, the Governor has declared a drought in 14 out of 20 years (2001–2020), in at least one Oregon county. Most of these declarations have involved one or more counties in Regions 5-8.

In 2015, Oregon had its warmest year on record. Winter precipitation amounts that year were near normal, but winter temperatures that were 5–6°F above average caused the precipitation that did fall to fall as rain instead of snow, reducing mountain snowpack accumulation. This resulted in record low snowpack across the state, earning official drought declarations for 25 of Oregon's 36 counties (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). At the peak of the drought which began in 2014, all of Oregon was in severe or extreme drought, according to the U.S.

Drought Monitor (Figure 2-44). Recent research has indicated that human-caused climate change exacerbated the 2015 drought in Oregon (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). The 2015 drought in Oregon was a "snow drought" and serves as a good example of what future climate projections indicate may become commonplace by mid 21st century (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Figure 2-44. August 25, 2015 U.S. Drought Monitor Report for Oregon



Source: U.S. Drought Monitor (http://droughtmonitor.unl.edu/)

Impacts

Droughts are not just a summer-time phenomenon; winter droughts can have a profound impact on the state's agricultural sector, particularly east of the Cascade Mountains.

Even though drought may not be declared as often in Western Oregon as in counties east of the Cascades, when drought conditions do develop in the Willamette Valley, the impacts are widespread and severe when both winter snow and spring/summer rain are low. Reasons for broad and significant impact include:

- Higher population density and growing population in the Willamette Valley;
- Dependence on surface water supplies for many municipalities, agriculture and industries from large flood control reservoirs in the Willamette river system;
- Agriculture is a major industry becoming increasingly dependent on irrigation;
- Increased frequency of toxic algal blooms in the Willamette system reservoirs, resulting in restrictions on use of water from reservoirs for drinking (i.e., for human and animals). Affected waters may not be safe for agricultural irrigation, and other uses; necessitating purchasing and transporting water from alternative sources;
- Since drought is typically accompanied by earlier onset of snowmelt (e.g., during flood control or early storage season), little or no snowmelt runoff is stored until later;
- Earlier start to growing season, before the start of the irrigation season, means that crops may not be irrigated until the irrigation season begins;
- Insufficient number of farm workers available because the growing season began before the workers were scheduled to arrive; and
- Responsibilities to recovering anadromous fish.

These are relatively recent and developing concerns, in particular on livestock and some other agricultural operations, and therefore there is no single comprehensive source or other sources for information to assess economic impacts. Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms.

Below-average snowfall in Oregon’s higher elevations has a far-reaching effect on the entire state, especially in terms of hydroelectric power generation, irrigation, recreation, and industrial uses. In March of 2014, Mount Ashland Ski Resort in southern Oregon announced that it would be unable to open due to the lack of snow. The following year the Ski Resort had to make snow in order to open. The lack of snow has affected other regions of the state as well. In the Klamath Basin, the Natural Resources Conservation Service reports that the mountains are generally snow-free below 5,000 feet. The Taylor Butte SNOTEL site at elevation 5,030 feet was snow-free on March 1, 2014, a first for the site since it was installed in 1979. Five long-term snow measurement sites in the Klamath basin set new record lows for March 1 snowpack. In fact, 81% of measurement sites west of 115°W (near the eastern border of Nevada) set record low April 1 snowpack in 2015, a quarter of which recorded no snow for the first time ((Mote, et al., 2016)).

There also are environmental consequences. A prolonged drought in Oregon’s forests promotes an increase of insect pests, which in turn, damage trees already weakened by a lack of water. In the Willamette Valley, for example, there has been an unusual pattern of tree mortality involving Douglas fir, grand fir, and western red cedar. Water stress brought on by drought and other factors is the central cause in these mortality events (Oregon Department of Forestry, 2008).

A moisture-deficient forest constitutes a significant fire hazard (see the **Wildfire** section of this Plan). The 2015 wildfire season was one of the most severe in the Pacific Northwest. In addition, drought and water scarcity add another dimension of stress to imperiled species. The following information addresses the impact of a severe or prolonged drought on the population, infrastructure, facilities, economy, and environment of Oregon:

Population: Droughts can affect all segments of Oregon's population, particularly those employed in water-dependent activities (e.g., agriculture, hydroelectric generation, recreation, etc.). For example, in 2015 farmers in eastern Oregon's Treasure Valley received a third of their normal irrigation water (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). Also, domestic water-users may be subject to stringent conservation measures (e.g., rationing) during times of drought and could see increases in electricity consumption and associated costs.

Infrastructure: Infrastructure such as highways, bridges, energy and water conveyance systems, etc., is typically unaffected by drought. However drought can cause structural damage. An example would include be areas of severe soil shrinkage. In these uncommon situations, soil shrinkage would affect the foundation upon which the infrastructure was built. In addition, water-borne transportation systems (e.g., ferries, barges, etc.) could be impacted by periods of low water.

Critical/essential facilities: Facilities affected by drought conditions include communications facilities, hospitals, and correctional facilities that are subject to power failures. Storage systems for potable water, sewage treatment facilities, water storage for firefighting, and hydroelectric generating plants also are vulnerable. Low water also means reduced hydroelectric production especially as the habitat benefits of water compete with other beneficial uses.

State-owned or -operated facilities: A variety of state-owned or -operated facilities could be affected by a prolonged drought. The most obvious include schools, universities, office buildings, health-care facilities, etc. Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms. There is no single comprehensive source or other sources for information to assess economic impacts to the state or state-owned facilities. Power outages are always a concern. Maintenance activities (e.g., grounds, parks, etc.) may be curtailed during periods of drought. The Oregon Parks and Recreation Department operates several campground and day-use facilities that could be impacted by a drought. For example, in 2015 visitation at Detroit Lake decreased 26% due to low water levels and unusable boat ramps (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Economy: Drought has an impact on a variety of economic sectors. These include water-dependent activities and economic activities requiring significant amounts of hydroelectric power. The agricultural sector is especially vulnerable as are some recreation-based economies (e.g., boating, fishing, water or snow skiing). Whole communities can be affected. This was particularly evident during the 2001 water year when many Oregon counties sought relief through state and federal drought assistance programs.

Water Year 2001 was the third driest water year in Oregon's climate history; the drought was one of the most economically significant in the state's history. The community of Detroit, in Marion County, suffered economic hardships when lake levels became too low to support recreational summer activities. The drought directly affected over 200,000 irrigated acres in the Klamath River Basin. Farmers were among the first to be affected, followed by local agricultural support industries (e.g., pesticides, fertilizer, farm equipment, etc.), as well as Native American Tribes which depend on local fisheries.

The 2015 drought during the state's warmest year on record also saw major economic impacts, straining summer recreational activities such as skiing, boating, fishing, and hunting, as well as the local economies that depend on visitors. Detroit Lake, for example, saw a 26 percent decline in visitors due to low water levels and inaccessible boat ramps. Winter recreational activities also felt the impact of a record-low snowpack. Mt. Ashland ski resort was not able to open during the 2014-15 ski season.

Limited water supply and high temperatures damaged crops and reduced yields, and ranchers in multiple counties struggled with dry pastures and limited water for livestock. Heat-stressed cattle were fed supplemental rations to help provide necessary nutrients. Some ranchers shipped cattle to feedlots earlier than normal or weaned calves early, due to a lack of feed and water. There is no single comprehensive source or other sources for information to assess economic impacts of drought impacts on agriculture, particularly west of the Cascades.

The 2015 fire season for the Pacific Northwest was notable for its severity and cost. The Oregon Department of Forestry estimates that large-fire costs for state agencies amounted to $94.4 million, more than $70 million in additional expenses compared to the 10-year average of $22.3 million.

Documenting drought conditions, especially its impacts on people and the environment, is an important component of understanding and preparing for future droughts. Using drought emergency relief funds, the state of Washington completed an economic assessment that quantifies the impacts of the 2015 drought on the state's farmers and ranchers, an effort that had not previously been done at the statewide level.

Oregon does not have the resources to conduct a thorough analysis of drought's impact to various sectors. Today, most impact-related data are collected anecdotally. The state should invest in ways to track and quantify the effects of drought and assist the most vulnerable jurisdictions.

Environment: Oregon has several fish species listed as threatened or endangered under the Endangered Species Act (ESA). Some of these species have habitat requirements that are jeopardized by the needs or desires of humans. For example, in times of scarcity, the amount of water needed to maintain habitat for fish species may conflict with the needs of consumptive uses of water. The state of Oregon is committed to implementation of the ESA and the viability of a productive economic base. There are no easy solutions, only continuous work to resolve difficult drought situations.

There were several significant fish die-offs in 2015. Most noteworthy in the Willamette, Clackamas, John Day, and Deschutes Rivers and some hatcheries, where high water temperatures amplified the effects of naturally occurring parasites. Half of Oregon's hatcheries were affected by drought conditions in 2015. The Department of Fish and Wildlife implemented a daily fishing curtailment regulation in nearly every stream in Oregon in 2015. This was the first time that a statewide curtailment was implemented.

Historic Drought Events

Table 2-30. Historic Droughts and Dry Periods in Oregon

Date	Location	Description
1928-41	statewide	prolonged drier than normal conditions that caused major problems for agriculture; the three Tillamook burns, in the normally wet coastal range, the first in 1933, were the most significant impacts of this very dry period
1976-77	western Oregon	the 1977 drought was one of the most significant on record in western Oregon
1985–94	statewide	generally dry period, capped by statewide droughts in 1992 and 1994; 10 consecutive years of dry conditions caused problems throughout the state, such as fires and insect outbreaks
2001-02	affected all regions except Regions 2, 3	the second most intense drought in Oregon’s history; 18 counties with state drought declaration (2001); 23 counties state-declared drought (2002); some of the 2001 and 2002 drought declarations were in effect through June or December 2003
2003	Regions 5–8	Governor-declared drought issued in seven counties: Sherman, Wheeler, Crook, Baker, Wallowa, Malheur, and Harney
2004	Regions 5–8	Governor-declared drought issued in four counties: Morrow, Klamath, Baker, and Malheur
2005	Regions 5–7	affected area: 13 of Oregon’s 36 counties
2007	Regions 6–8	Governor-declared drought emergency in Lake, Grant, Baker, Union, Malheur, and Harney Counties
2008	Region 5	Governor-declared drought emergency in Sherman and Gilliam Counties
2010	Region 6	Governor-declared drought emergency for Klamath County and contiguous counties
2012	Region 6	Governor-declared drought emergency for the Lost River Basin, located in Klamath County and Lake County
2013	Regions 5–8	Governor-declared drought in Gilliam, Morrow, Klamath, Baker, and Malheur Counties
2014	Regions 4, 6–8	Governor-declared drought in 10 counties: Klamath, Lake, Malheur, Harney, Jackson, Josephine, Crook, Wheeler, Grant, and Baker; Oregon experienced its third driest Nov.–Jan. period since 1895
2015	statewide	Governor-declared drought in 25 counties, with federal declarations in all counties. Oregon experienced its warmest year on record (1895–2019) resulting in record low snowpack across the state. All of Oregon was in severe or extreme drought at the peak of the drought in August, according to the U.S. Drought Monitor.
2018	Regions 4-8, 1	Governor-declared drought in 11 counties
2020	Region 1, 6	Governor-declared drought in Klamath and Curry Counties as of April 28, 2020.

Sources: Taylor and Hatton (1999); Governor-declared drought declarations obtained from the Oregon State Archives division

2.2.2.2 Probability

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It is a temporary condition and differs from aridity because the latter is restricted to low rainfall regions and is a permanent feature of climate. It is rare for drought not to occur somewhere in North America each year. Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change, and the absence of historic information.

Climate Variability

The variability of Oregon's climate often can be attributed to long-term oscillations in the equatorial Pacific Ocean: El Niño and La Niña. Simply stated, these systems involve the movement of abnormally warm or cool water into the eastern Pacific, dramatically affecting the weather in the Pacific Northwest. El Niño tends to bring warm and dry winters; the inverse is true with La Niña. However, there have been wet years during an El Niño event, dry years in a La Niña, and both types of water years in neutral conditions. In other words, El Niño and La Niña do not explain all of the variability in every given winter. Also, climate change is reducing the robustness of the low-elevation snowpack, which will likely influence the frequency of drought conditions and associated impacts on Oregon communities.

Drought – The Nebulous Natural Hazard

- Drought is often associated with water scarcity, which usually is perceived as a "human-caused" hazard, rather than a "natural" hazard.
- Drought is frequently an "incremental" hazard, the onset and end are often difficult to determine. Also, its effects may accumulate slowly over a considerable period of time and may linger for years after the termination of the event.
- Quantifying impacts and provisions for disaster relief is a less clear task than it is for other natural hazards.
- The lack of a precise and universally accepted definition adds to the confusion about whether or not a drought actually exists.
- Droughts are often defined by growing seasons, the water year, and livestock impacts.

An El Niño system moves heat, both in terms of water temperature and in atmospheric convection. The heat is transported toward North America, increasing the likelihood of mild temperatures and dry conditions in Oregon. Its effects are most pronounced from December through March.

La Niña conditions are more or less opposite of those created by El Niño. It involves the movement of abnormally cool water into the eastern Pacific. This event increases the likelihood of cooler than normal temperatures in Oregon and increased precipitation. It also is most pronounced from December to March.

Predicting Droughts in Oregon

Predicting weather patterns is difficult at best; however, the 1997-98 El Niño event marked the first time in history that climate scientists were able to predict abnormal flooding and drought months in advance for various locations around the United States (http://www.nationalgeographic.com/elnino/mainpage2.html). The methodology consists of monitoring water temperatures, air temperatures, and relative humidity plus measuring sea-surface elevations. Once an El Niño or La Niña pattern is established, climatologists can project regional climatic behavior. Although the scientific community is optimistic about its recent forecasting achievements, not all droughts are associated with El Niño or La Niña events.

Climate Change

Climate models project warmer, drier summers for Oregon, with mean projected increases in summer temperatures of 4.5 to 6.3°F and a decline in mean summer precipitation amounts of 6.3 to 8.7% by mid-21st century relative to late-20th century depending on emissions scenario (**Table 2-17**, **Table 2-18**). These summer conditions will be coupled with projected decreases in mountain snowpack due to warmer winter temperatures. Models project a mean increase in winter temperatures of 3.3 to 4.5°F by mid-21st century relative to late-20th century depending on emissions scenario (**Table 2-17**). This combination of factors increases the likelihood that Oregon will experience increased frequency of one or more types of drought under future climate change. In addition, Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

It is *very likely* (>90%) that drought frequency due to low spring snowpack—"snow droughts"—will increase in the future because of the direct link between temperature and snow accumulation and melt. The 2015 snow drought provides a glimpse into the future. It is also *very likely* (>90%) that drought frequency due to high spring and summer evaporative demand will increase in the future. It is likely (>66%) that drought frequency due to low summer runoff will increase. It is *more likely than not* (>50%) that drought frequency due to low summer precipitation and due to low summer soil moisture in the upper soil layer will increase. Snow drought is very likely to increase in mid-to-low elevation mountainous regions of the Cascades (Regions 2–4, 6) and eastern Oregon (Region 7). Droughts due to lower summer precipitation, soil moisture, and runoff are more likely to increase in western Oregon (Regions 1-4) than in eastern Oregon (particularly Regions 6 and 8) due to projected spatial patterns in precipitation change.

2.2.2.3 Vulnerability

There is a tendency to associate drought conditions with the arid sections of the state, principally east of the Cascade Mountains. However, this perception is not entirely accurate. During the winter of 2002-03, during 2015 and as recent as 2020, Coos and Curry Counties on the southwestern coast experienced drought conditions.

When a drought occurs, it may affect all regions of the state. However, most of Oregon's urban areas usually fare much better during a drought than rural, less populated regions of the state.

By encouraging or invoking water conservation measures during a drought, a public municipal water system can reduce residential and industrial demand for water.

Rural areas are much more dependent on water for irrigation for agricultural production. Landowners in rural or less-populated areas are often reliant on individual, privately owned wells as a drinking water source. Generally speaking, counties east of the Cascades and in the southern portions of the state are more prone to drought-related impacts.

Most Vulnerable Jurisdictions

The Oregon Water Resources Department (OWRD) is the state agency with primary oversight of drought conditions and mitigation activities. Based on the frequency of drought declarations issued by the Governor issued since 1992, Klamath and Baker Counties are the most vulnerable to drought. Klamath County has been under a Governor-declared drought on 14 occasions since 1992, while Baker County has received 11 declarations during this same time period. Lake, Malheur, Sherman, Gilliam, and Morrow Counties are vulnerable as well.

These communities were identified as most vulnerable based on only one indicator: the frequency of drought declarations. A broader, more detailed assessment that considers other factors, such as past economic or environmental drought-related impacts for each community, would help the state better prioritize its mitigation and response-related activities.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau’s American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur. The high social vulnerability of Klamath, Malheur, and Morrow Counties compounds their high vulnerability to drought.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. None of these losses was due to drought.

DAS’s records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

2.2.2.4 Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The probability of drought is difficult to predict because of the multitude of variables that contribute to it and the lack of historic data. Projected increases in temperature coupled with decreases in precipitation make it likely that Oregon will experience more frequent droughts, especially "snow droughts." Droughts occur throughout the state, winter and summer, and create a wide variety of impacts, particularly in rural areas. While the communities most vulnerable to drought are all located east of the Cascades, drought occurs and its impacts are felt statewide. We do not have the data to make a quantitative assessment of risk from drought; however, there has been a drought event in fourteen of the last twenty years. Qualitatively, the risk of drought in Oregon is at least moderate to high, and likely to become very high in future years.

2.2.3 Earthquakes

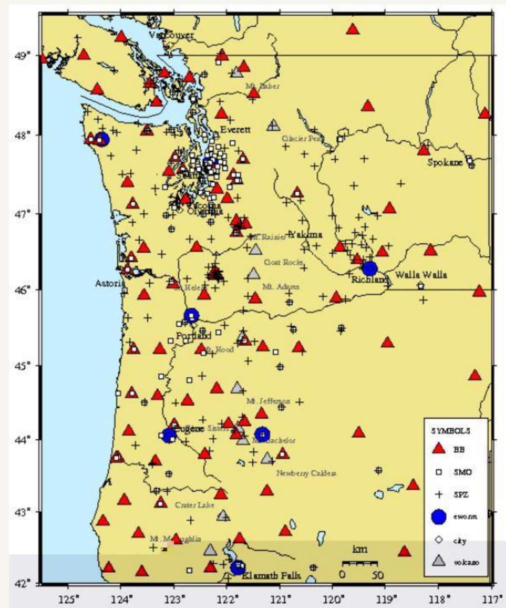
Oregon has experienced few damaging earthquakes during its recorded history, leading to complacency and lack of attention to earthquake-resistant design and construction. Since the mid-1980s, an increasing body of geologic and seismologic research has changed the scientific understanding of earthquake hazards in Oregon, and in recent years several large and destructive earthquakes around the world have heightened public awareness. Recognized hazards range from moderate sized crustal earthquakes in eastern Oregon to massive subduction zone megathrust events off the Oregon coast. All have the potential for significant damage as long as most of Oregon's buildings and infrastructure have inadequate seismic resistance. The scale of structural retrofit and replacement needed to make Oregon earthquake safe is huge, and beyond our capacity to implement in anything less than decades. To manage the human and economic impact of the next damaging earthquake will require thoughtful and comprehensive emergency response planning, based on realistic loss estimates driven by accurate and detailed geologic and seismologic, structural and cultural information. To minimize the human and economic impact of the next damaging earthquake will require a sustained program of public education, forward-thinking research, and structural replacement and retrofit, based on cost-effective earthquake resistant design and a combination of public funding and private sector incentives

2.2.3.1 Analysis and Characterization

Earthquake Sources

Earthquakes are a highly variable natural phenomenon. The vast majority occur when two masses of rock in the earth's crust abruptly move past each other along a large crack or fracture called a fault. The energy released as the two parts slide along the fault produces waves of shaking that we perceive as an earthquake. Faults typically build up stress over decades to millennia in response to large-scale movement of the earth's tectonic plates. Even the most active faults only produce damaging earthquakes at intervals of a century or more, and for many the intervals are much longer. As a result, it is very difficult to forecast the likelihood of an earthquake on a particular fault because we rarely have a long enough record to determine a statistically meaningful return period (average time between earthquakes).

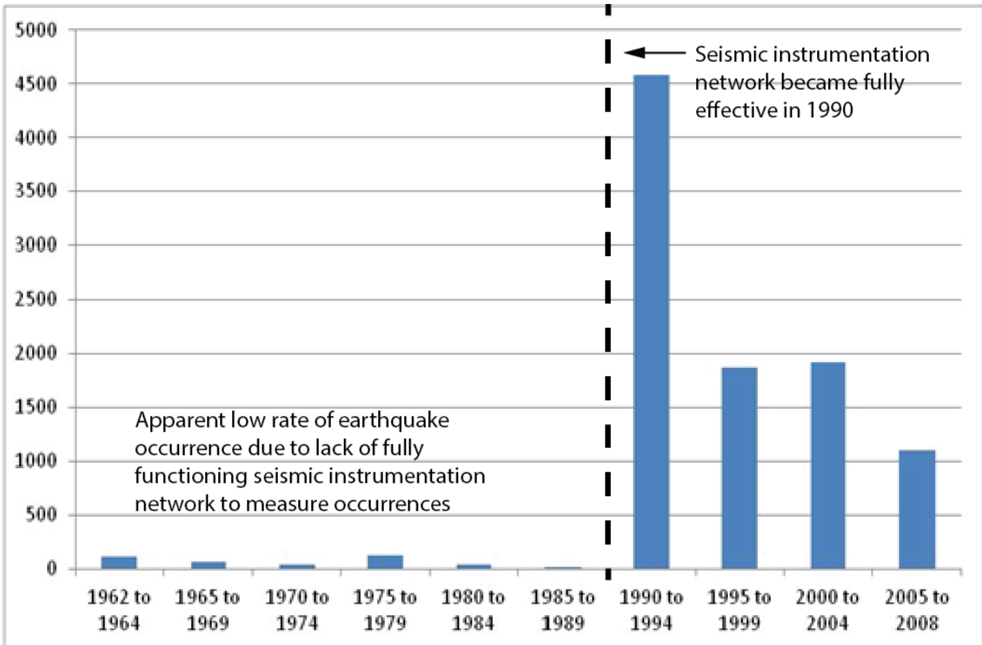
Figure 2-45. Earthquake Monitoring Stations in the Pacific Northwest



Note: The earthquake monitoring network system is operated out of the University of Washington by the Pacific Northwest Seismic Network.

Source: Pacific Northwest Seismic Network (http://www.pnsn.org/)

Figure 2-46. Annual Rate of Earthquake Occurrence in Oregon, in 5-Year Increments



Note: Seismic instruments began operation in 1970, but the network only became fully effective in 1990. Spike in earthquake numbers in the early 1990s is due to aftershocks from the 1993 Scotts Mills and Klamath Falls earthquakes.

Source: unknown

The history of earthquakes in a region comes from three types of information. Instrumental data comes from networks of seismic recording instruments (seismographs) that are widely deployed in the Pacific Northwest.

Seismic networks can detect very small earthquakes, locate them to within a few miles, and determine their magnitude accurately. Seismographs have only existed for about a century, and in Oregon, the instrumental record is really only complete and modern from about 1990 on. Historical felt location data comes from verbal and written reports of earthquake effects. The felt record extends back to the mid-1800s for Oregon, but only locates moderate to large earthquakes, and those only with an accuracy of tens or even hundreds of miles.

Paleoseismic data use geologic records of earthquake effects to determine the approximate size and timing of earthquakes that happened in prehistoric times. The paleoseismic record can extend back for thousands or tens of thousands of years, but provides only approximate information about the size, time, and place of past large earthquakes.

Figure 2-47. Deep Sea Sediment Cores that Record Past Megathrust Earthquakes off the Oregon Coast

Note: Red T's mark the top of each layer

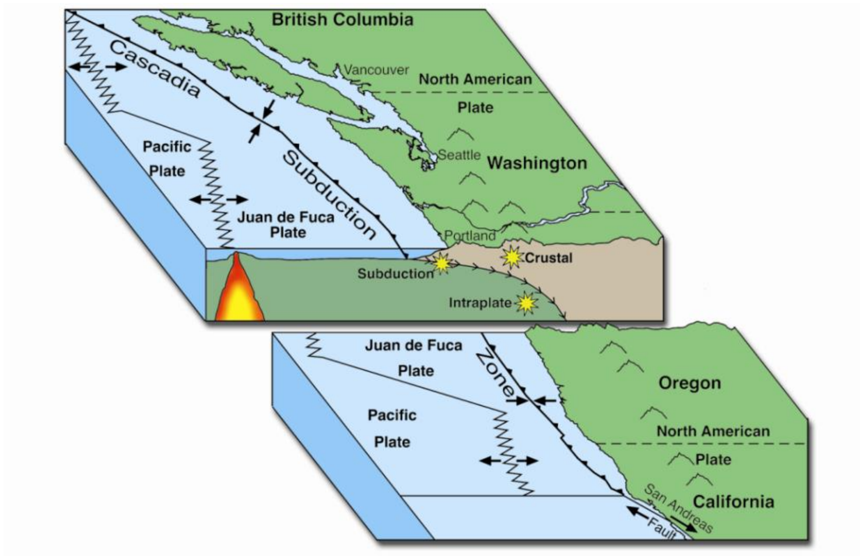
Source: Goldfinger, et al. (2012)

In Oregon, the combined earthquake history derived from these three sources clearly outlines two major types of earthquake hazard and two less significant sources. By far the greatest is the hazard posed by infrequent **megathrust earthquakes** on the Cascadia Subduction Zone. The second major hazard comes from smaller **crustal earthquakes** on faults in or near populated areas, which includes all of Oregon's damaging historic earthquakes. Intraplate earthquakes, which have been historically damaging in the Puget Sound area, are possible in Oregon but no damaging prehistoric or historic events are known. Finally, earthquakes associated with Oregon's many young volcanoes may produce damaging shaking in communities close to the volcano.

The Cascadia Subduction Zone is the boundary between two of the earth's crustal plates. These continent-sized plates are in constant slow motion, and the boundaries between plates are the site of most earthquake activity around the globe. At the Cascadia Subduction Zone, the Juan De Fuca plate, located offshore of Oregon and Washington, slides to the northeast and under the North American plate, which extends from the Oregon coast clear to the middle of the Atlantic Ocean. The Juan de Fuca plate slides beneath the continent (subducts) at about 1.5 inches per year, a speed which has been directly measured using high-accuracy GPS. The fault that separates the plates extends from Cape Mendocino in Northern California to Vancouver Island in British Columbia, and slopes down to the east from the sea floor. The fault is usually locked, so that rather than sliding slowly and continuously, the 1.5 inches per year of subduction motion builds tremendous stress along the fault. This stress is periodically released in a megathrust earthquake, which can have a magnitude anywhere from 8.3 to 9.3.

Figure 2-48 is a schematic three-dimensional diagram with the generalized locations of the three types of earthquake sources found in Oregon: subduction zone, crustal, and intraplate.

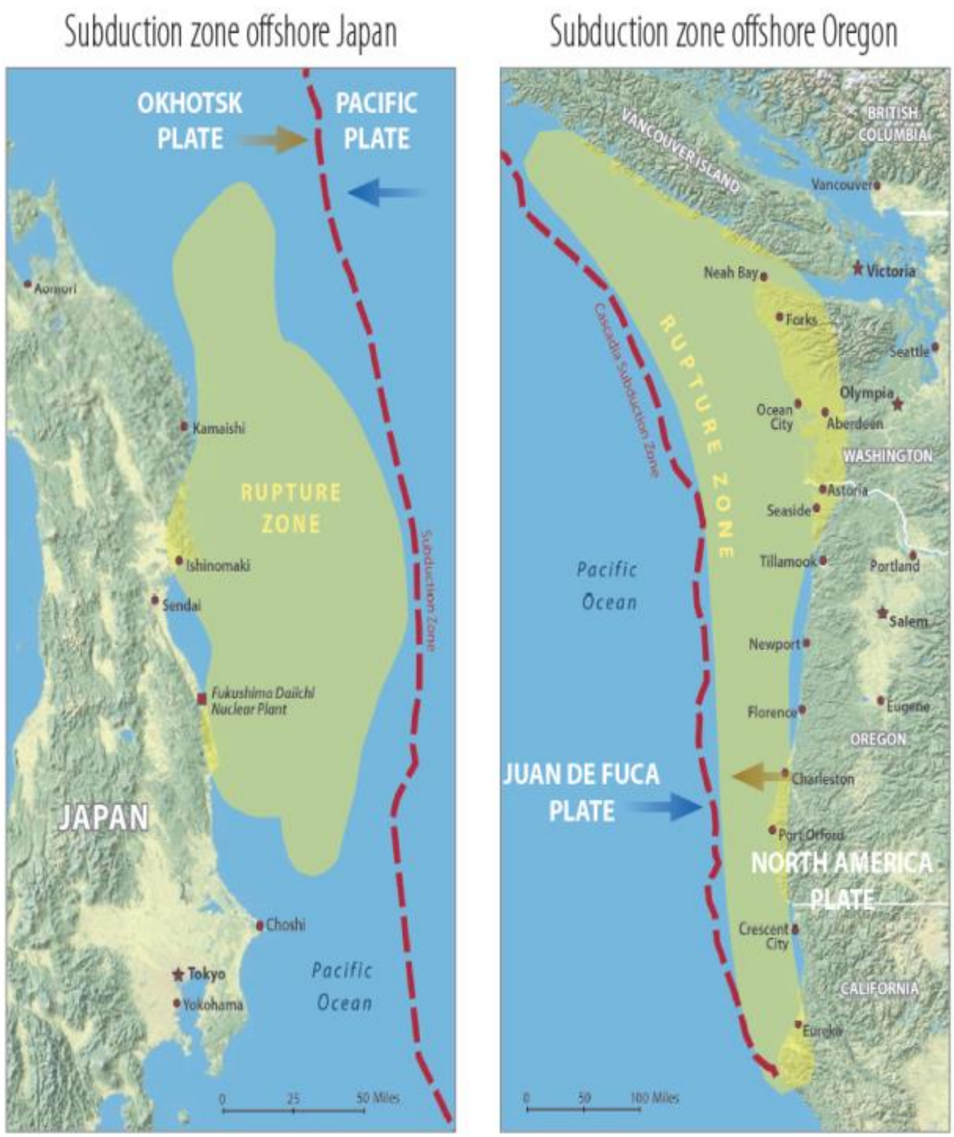
Figure 2-48. General Source Areas for Subduction Zone, Crustal Earthquakes, and Intraplate Earthquakes



Source: DOGAMI

The Cascadia Subduction Zone closely mirrors the subduction zone in northern Japan that produced the 2011 Tohoku earthquake (**Figure 2-49**). This magnitude 9 megathrust event and its associated tsunami captured the world's attention with unforgettable images of destruction on a massive scale. Oregon should regard this as a window into our future, as this is the very type of earthquake that our best science tells us is likely on the Cascadia Subduction Zone. Particular attention must be paid to the incredibly destructive tsunami that accompanied the Tohoku earthquake, and we must plan for a similar tsunami in Oregon. (See the **Tsunami** section of this Plan for more information about tsunamis in Oregon.)

Figure 2-49. Comparison of the Northern Japan Subduction Zone in and the Cascadia Subduction Zone



Note: Yellow patches are the measured earthquake rupture zone in Japan, modeled earthquake rupture zone in Oregon.

Source: DOGAMI

2011 Tohoku Earthquake Numbers

- about 16,000 dead
- 92% of deaths due to tsunami (drowning)
- Fatality rate within the tsunami inundation zone about 16%
- about 4,000 missing (as of 10/12/2011)
- about 6,000 injuries
- Population within 40 km of coastline about 3,000,000
- about 300,000 homes destroyed
- about 600,000 homes damaged

Crustal earthquakes occur for the most part on shore on much smaller faults located in the North American plate. These are the more familiar "California-style" earthquakes with magnitudes in the 5 to 7 range. Although much smaller than the megathrust earthquakes, crustal earthquakes may occur much closer to population centers, and are capable of producing severe shaking and damage in localized areas. For many parts of eastern Oregon, crustal faults dominate the hazard, and they may also have a significant impact in the Portland region and Willamette Valley.

Intraplate earthquakes are a third type that is common in the Puget Sound, where they represent most of the historical record of damaging events. In Oregon, these earthquakes occur at much lower rates, and none have ever been close to a damaging magnitude. They contribute little to the aggregate hazard in most of Oregon.

Earthquake Effects

Earthquake damage is largely controlled by the strength of shaking at a given site. The strength of shaking at any point is a complex function of many factors, but magnitude of the earthquake (which defines the amount of energy released) and distance from the epicenter or fault rupture, are the most important. The ripples in a pond that form around a dropped pebble spread out and get smaller as they move away from the source. Earthquake shaking behaves in the same way: you can experience the same strength of shaking 10 miles from a magnitude 6 earthquake as you would feel 100 miles from a magnitude 9 earthquake.

Two measurement scales are used to describe the magnitude and intensity of earthquakes. To measure the magnitude, the "moment magnitude" (M_w, or M) scale uses the Arabic numbering scale. It provides clues to the physical size of an earthquake (NOAA-OAR-CPO-2014-2003692) and is more accurate than the previously used Richter scale for larger earthquakes. The second scale, the "modified Mercalli," measures the shaking intensity and is based on felt observations and is therefore more subjective than the mathematically derived moment magnitude. It uses Roman numerals to indicate the severity of shaking. It is important to understand the relationship between the intensity of shaking the amount of damage expected from a given earthquake scenario.

Table 2-31 gives an abbreviated description of the 12 levels of Modified Mercalli intensity.

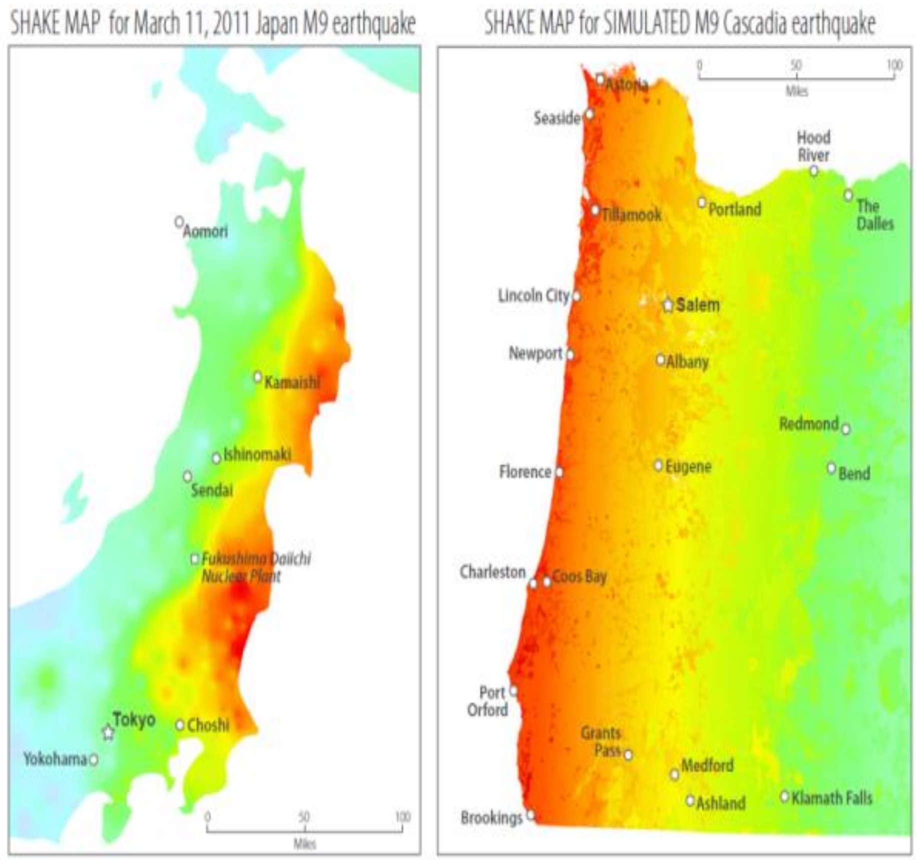
Table 2-31. Levels of Modified Mercalli Intensity

Level	Intensity
I	not felt except by a very few under especially favorable conditions
II	felt only by a few persons at rest, especially on upper floors of buildings
III	felt quite noticeably by persons indoors, especially on upper floors of buildings; many people do not recognize it as an earthquake; standing motor cars may rock slightly; vibrations similar to the passing of a truck; duration estimated
IV	felt indoors by many, outdoors by few during the day; at night, some awakened; dishes, windows, doors disturbed; walls make cracking sound; sensation like heavy truck striking building; standing motor cars rocked noticeably
V	felt by nearly everyone; many awakened; some dishes, windows broken; unstable objects overturned; pendulum clocks may stop
VI	felt by all, many frightened; some heavy furniture moved; a few instances of fallen plaster; damage slight
VII	damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken
VIII	damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse; damage great in poorly built structures; fall of chimneys, factory stacks, columns, monuments, walls; heavy furniture overturned
IX	damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; damage great in substantial buildings, with partial collapse; buildings shifted off foundations
X	some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; rails bent
XI	few, if any (masonry) structures remain standing; bridges destroyed; rails bent greatly
XII	damage total; lines of sight and level are distorted; objects thrown into the air

Sources: http://earthquake.usgs.gov/learn/topics/mercalli.php, abridged from *The Severity of an Earthquake* (http://pubs.usgs.gov/gip/earthq4/severitygip.html); U.S. Geological Survey General Interest Publication 1989-288-913

Future megathrust earthquakes on the Cascadia Subduction Zone (CSZ) will occur off the coast, and the strength of shaking will decrease inland. Oregon coastal communities will experience severe shaking, but the Portland area and Willamette Valley communities are far enough inland that they will feel much less shaking. Because of the size of the megathrust fault, the shaking will impact all of Oregon west of the Cascades, and will still be felt to the east of the Cascades, and will extend to northern California and British Columbia. The other unique characteristic of megathrust earthquakes is that the strong shaking will last for several minutes, in contrast to a large crustal earthquake, which might shake for only 30 seconds. The long duration of shaking contributes greatly to damage, as structures go through repeated cycles of shaking. **Figure 2-50** shows a side-by-side comparison of ShakeMaps for (a) the 2011 M9 earthquake in Japan, and (b) a simulated M9 CSZ event in Oregon.

Figure 2-50. Comparison of Measured Shaking from Tohoku Earthquake and Simulated Shaking from M9 Cascadia Megathrust Earthquake

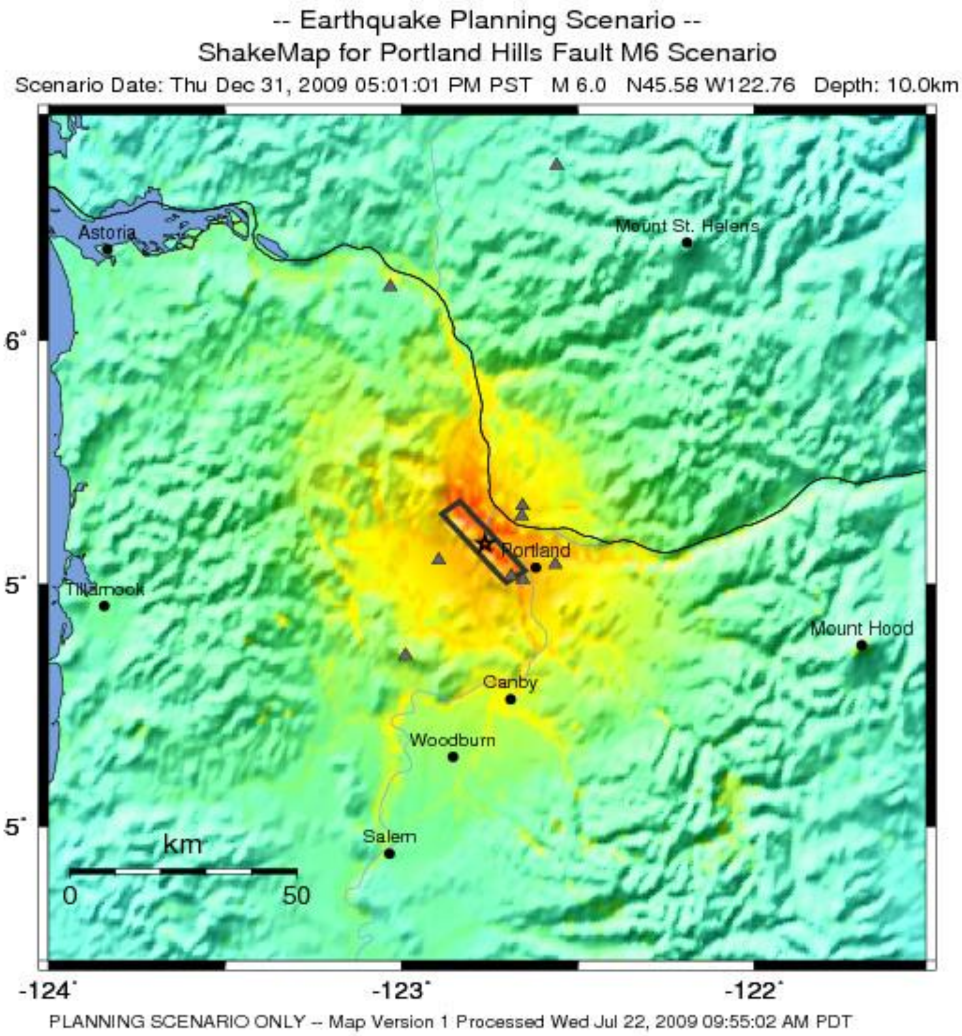


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Source: DOGAMI, *Cascadia* Winter 2012 (http://www.oregongeology.org/pubs/cascadia/CascadiaWinter2012.pdf)

Future crustal earthquakes will occur along one of many Oregon fault lines; the shaking will be strongest near the epicenter, and will decrease fairly quickly as you move away. So a magnitude 6 earthquake in Klamath Falls may cause significant damage near the epicenter, but will be only weakly felt in Medford or Eugene. **Figure 2-51** shows a M6 crustal fault ShakeMap scenario along the Portland Hills fault.

Figure 2-51. Simulated Shaking from M6.0 Crustal Earthquake on the Portland Hills Fault

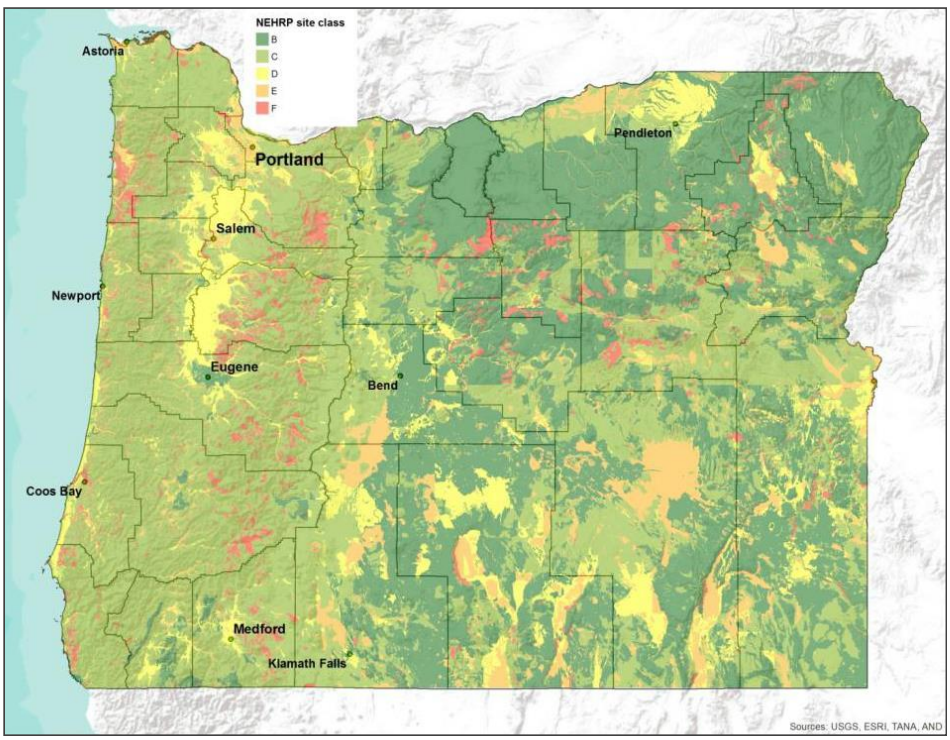


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Source: U.S. Geological Survey

The other important factor in controlling earthquake damage is the contribution of local geology. Soft soils can strongly amplify shaking (**Figure 2-52**), loose saturated sand or silt can liquefy, causing dramatic damage, and new landslides can occur on steep slopes while existing landslide deposits may start to move again. These effects can occur regardless of earthquake source, and the geologic factors that cause them can be identified in advance by geologic and geotechnical studies. Liquefaction- and earthquake-induced landslides are both more likely to occur during the several minutes of shaking produced by a megathrust earthquake, and these effects are expected to be widespread during the next event (**Figure 2-53**, **Figure 2-54**, and **Figure 2-55**). In 2013, DOGAMI published a suite of statewide earthquake hazard maps with GIS files in Open-File Report O-13-06, *Ground motion, ground deformation, tsunami inundation, coseismic subsidence, and damage potential maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone earthquakes* (Madin & Burns, 2013); http://www.oregongeology.org/pubs/ofr/p-O-13-06.htm). DOGAMI is currently updating those maps with more detailed geologic information using funds from Oregon DAS-GEO. The updates will be published in 2021

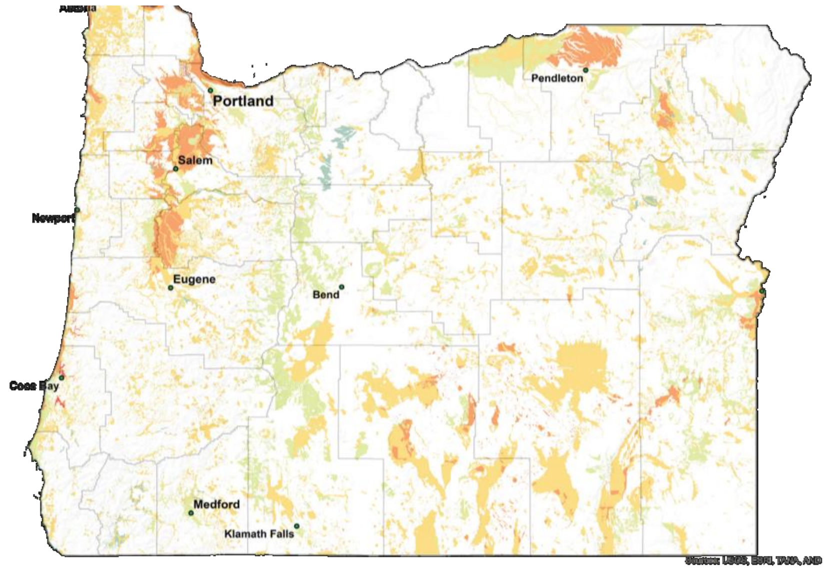
Figure 2-52. Soils Map Showing Where Soils Can Amplify Earthquake Ground Shaking



Note: This NEHRP soils map shows areas where soils can amplify the earthquake ground shaking. NEHRP site class F soils (dark orange on map) are prone to produce the greatest amplification.

Source: Madin & Burns (2013)

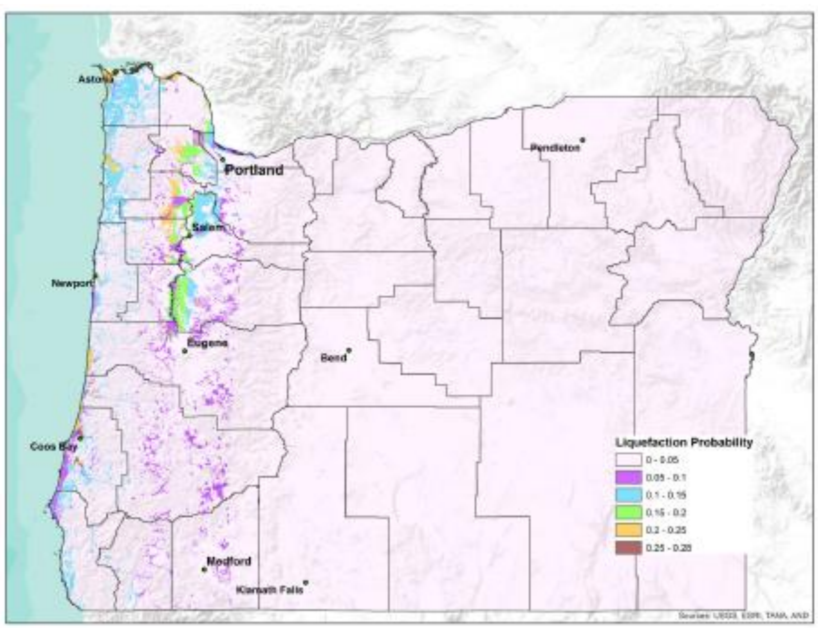
Figure 2-53. Liquefaction Susceptibility Map



Note: This liquefaction susceptibility map shows areas where soils can liquefy due to the earthquake ground shaking. Areas in red are most prone to liquefy.

Source: Madin & Burns (2013)

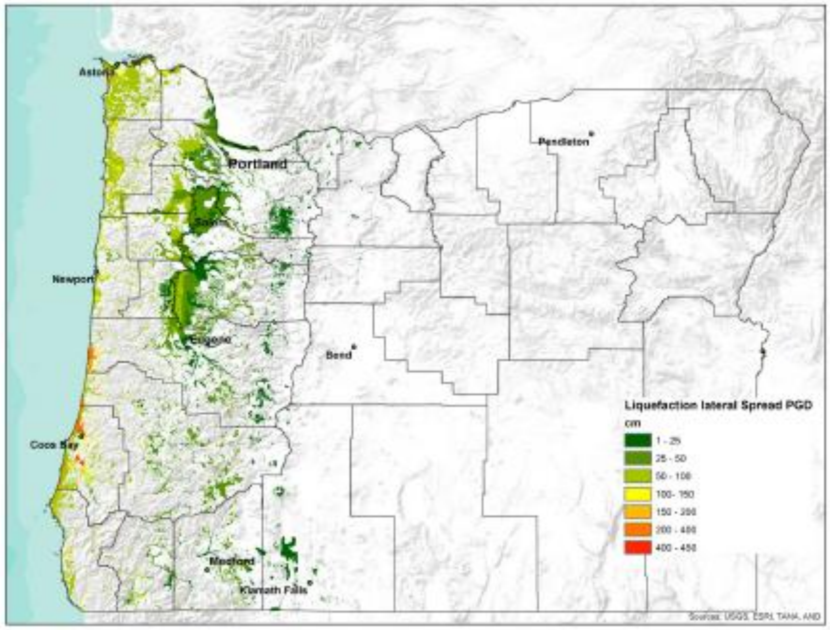
Figure 2-54. Liquefaction Probability Map



Note: This liquefaction probability map shows the probability of soil liquefaction due to a magnitude 9 Cascadia earthquake. Areas in dark red have the highest probability.

Source: Madin & Burns (2013)

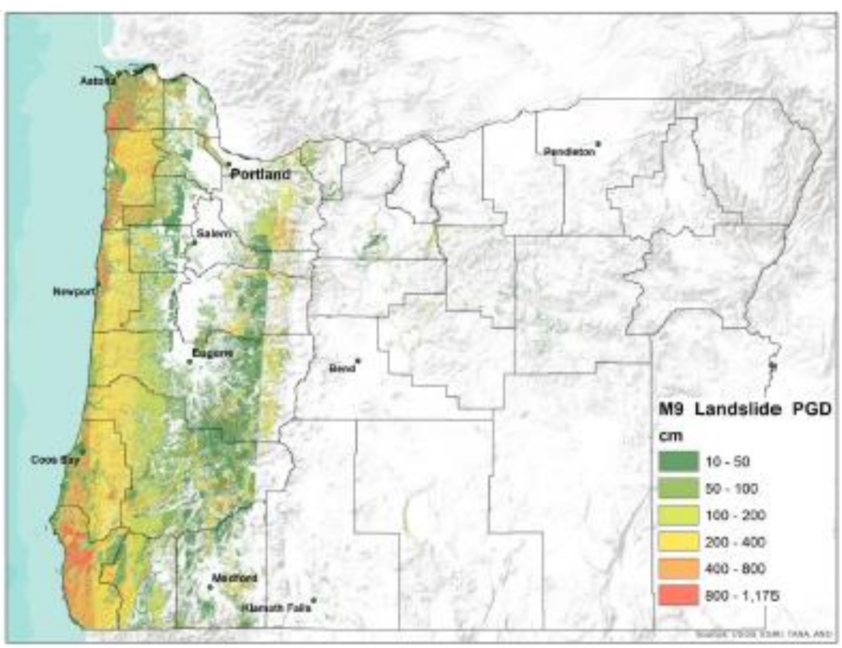
Figure 2-55. Lateral Spreading Map



Note: This lateral spreading map shows areas of lateral spreading hazard due to a magnitude 9 Cascadia earthquake. Areas in red have the highest displacement.

Source: Madin & Burns (2013)

Figure 2-56. Expected Displacement Map



Note: This landslide hazard map shows areas and amount of expected displacement due to a magnitude 9 Cascadia earthquake. Areas in red have the highest displacement.

Source: Madin & Burns (2013)

Historic Earthquake Events

Table 2-32 lists historic earthquakes in Oregon from both CSZ events and combined crustal events.

Table 2-32. Historic Earthquakes in Oregon

Date	Location	Description
1873[1]	Del Norte County, Calif.	felt in Portland; localized chimney damage as far north as Port Orford, Oregon
1877[1]	Portland, Oregon	intensity VII; chimney damage
1892[1]	Portland, Oregon	intensity VI; affected area: 26,000 square kilometers; buildings swayed, people terrified and rushed into the street; felt in Astoria and Salem
1893[1]	Umatilla, Oregon	intensity VI-VII; damage to buildings in Umatilla
1896[1]	McMinnville, Oregon	intensity VI; three shocks in succession in McMinnville; main shock felt at Portland and Salem
1906[1]	Paisley, Oregon	intensity V; three additional shocks followed within 1.5 hours
1913[1]	Seven Devil's Mountains of western Idaho	intensity V; broke windows and dishes
1915[1]	Portland, Oregon	intensity V; three shocks reported; rattled dishes, rocked chairs, and caused fright at Portland
1923[1]	southern Oregon	intensity V; plaster fell at Alturas, California; tremor felt at Lakeview, Oregon
Apr. 8, 1927[1]	eastern Baker County,	maximum intensity V (Halfway and Richland); center: eastern Baker County; felt widely over eastern Oregon
July 15 – Nov. 1936[1]	Milton-Freewater, Oregon	intensity VII; magnitude 5.75; center: near the State line between Milton-Freewater, Oregon, and Walla Walla, Washington; affected area: 272,000 sq km in the two states and Idaho; ground cracking observed 6.5 km west of Freewater; marked changes in flow of well water chimneys damaged, plaster broken and walls cracked in Freewater and Umapine; total damage: $100,000; numerous aftershocks up to Nov. 17 (more than 20 moderate shocks during the night and stronger ones (V) on July 18 and Aug. 4 and 27)
Dec. 29, 1941[1]	Portland, Oregon	intensity VI; affected area: 13,000 sq km (Portland); felt at Hillsboro, Sherwood, Yamhill, and into Washington (Vancouver and Woodland); windows broken
Apr. 13, 1941[1]	Olympia, Wash.	magnitude 7.0; at Olympia, Washington, and a broad area around the capital city; fatalities: 8; damage: $25 million; affected area: 388,000 sq km; damage: widespread (Oregon); injuries: several (Astoria and Portland); maximum intensity: VIII (Clatskanie and Rainier); chimneys twisted and fell; damage to brick and masonry
Dec. 15, 1953[1]	Portland, Oregon	intensity: VI; minor damage (Portland area); affected area: 7,700 sq km; one cracked chimney and slight damage to fireplace tile; plaster cracking (Portland and Roy, Oregon, and Vancouver, Washington)
Nov. 16, 1957[1]	Salem, Oregon	intensity VI; affected area: 11,600 sq km (northwestern Oregon); frightened all in the city and cracked plaster (West Salem)
Aug. 18, 1961[1]	Albany/Lebanon, Oregon	intensity VI; magnitude 4.5; affected area: 18,000 sq km; felt region extended into Cowlitz County, Wash; damage: minor (Albany and Lebanon, south of the 1957 center); felt in both cities; two house chimneys toppled, and plaster cracked
Nov. 6, 1961[1]	Portland, Oregon	intensity VI; affected area: 23,000 sq km (northwestern Oregon and southwestern Washington); principle damage: plaster cracking; part of a chimney fell, and windows and lights broke

Date	Location	Description
May 26 – June 11, 1968[1]	Oregon/Calif. border	intensity: VI; magnitude: 4.7; affected area: 18,000 sq km (in the two states); series of earthquakes near the Oregon-California border; chimneys fell or cracked, and part of an old rock cellar wall fell; ground fissures in Bidwell Creek Canyon, near Fort Bidwell, California
1993[2]	Scott's Mills, Oregon	5.7 M_w; largest earthquake since 1981; felt from Puget Sound to Roseburg, Oregon[4]
1993[3]	Klamath Falls, Oregon	5.9 M_w and 6.0 M_w[3]; affected area: 130,000 sq km (southwestern Oregon and northern California); losses: concentrated in downtown area; intensity VII in downtown Klamath Falls and immediate vicinity and to the Oregon Institute of Technology, but surrounding experienced intensity VI[5]; fatalities: 2
2001[2]	Nisqually, Wash.	felt as far south as central Oregon
Jan. 4, 2015	NW Nevada	M4.1, 1.5 km deep
Jan. 22, 2015	NW Nevada	M4.5, 1.5 km deep
May 8, 2015	Pacific Ocean, west of Coos Bay, Oregon	M4.4, 10 km deep
Jul. 4, 2015	east of Springfield, Oregon	M4.0, 8 km deep
Jul. – Dec. 2015	NW Nevada	M4.0-4.7, 1.3-1.5 km deep; cluster of earthquakes
Nov. 29, 2019	Port Orford, Oregon	M4.5, 16.7 km deep
Feb. 8, 2020	Pacific Ocean west of Coos Bay, Oregon	M4.7, 10 km deep

Sources:

(1) USGS. Oregon Earthquake History. Retrieved October 28, 2013, http://earthquake.usgs.gov/earthquakes/states/oregon/history.php

(2) USGS. Earthquake Archive. Retrieved October 28, 2013, http://earthquake.usgs.gov/earthquakes/search/

(3) Sherrod (1993)

(4) Thomas, et al. (1996)

(5) Dewey (1993)

(6) Bott & Wong (1993)

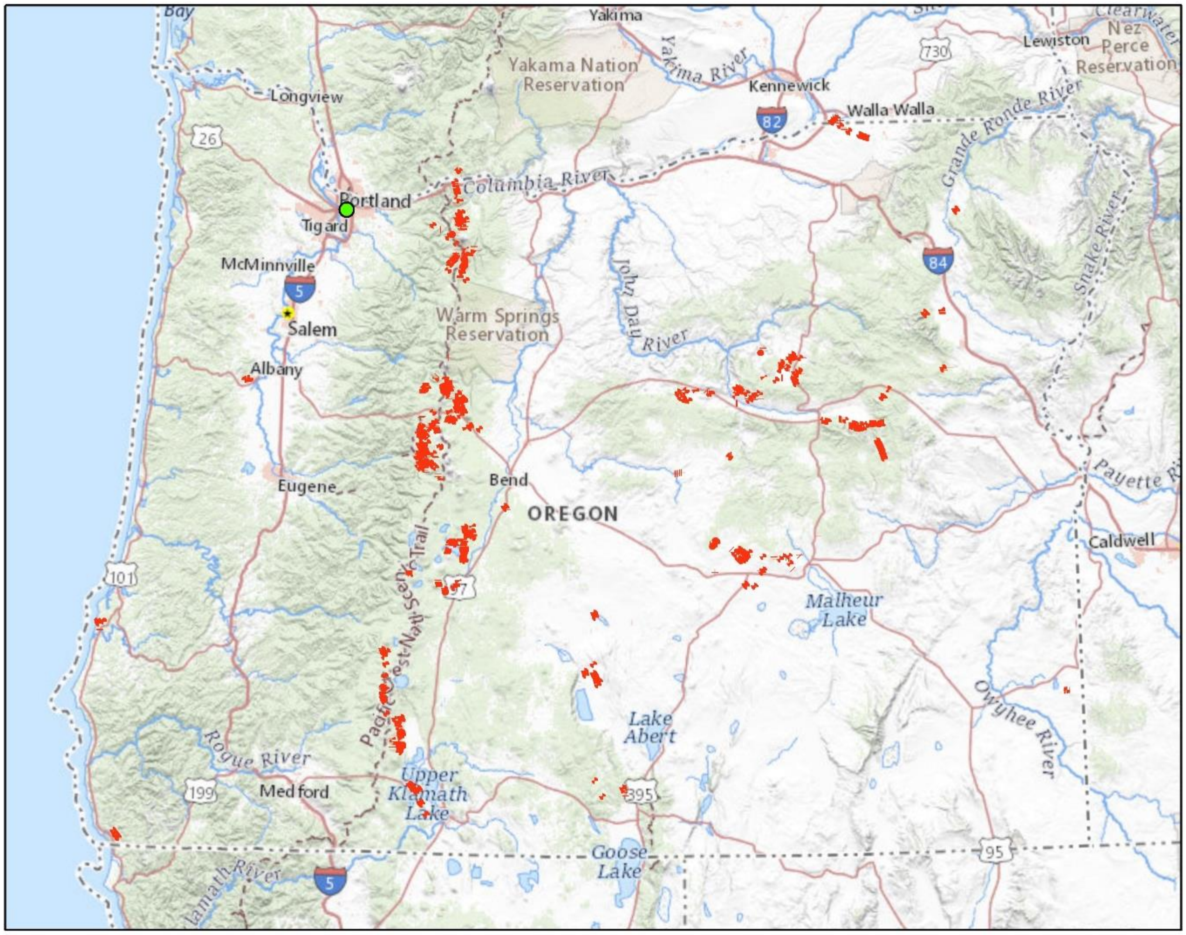
(7) Pacific Northwest Seismic Network, Retrieved May 22, 2020, https://pnsn.org/events?custom_search=true

2.2.3.2 Probability

The probability of damaging earthquakes varies widely across the state. In coastal and western Oregon, the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well-understood recurrence history. For eastern Oregon, the hazard is dominated by numerous crustal faults and background seismicity, with poorly understood probability that varies from region to region.

Over the last decade, DOGAMI has been acquiring and analyzing large swaths of high-resolution lidar topographic data throughout Oregon. In Eastern Oregon and the Cascades, this has led to the identification of dozens of previously unknown, active young fault segments. **Figure 2-57** shows these newly discovered faults; very few have been investigated, none in detail.

Figure 2-57. Surface Faulting Identified with Lidar Data



Note: Red lines show surface rupturing faults that have been identified by inspection of lidar topographic data collected by the Oregon Lidar Consortium. Most of these faults should be considered active, though few have been studied in the field and none in detail.

Source: Ian Madin, DOGAMI, Esri basemap

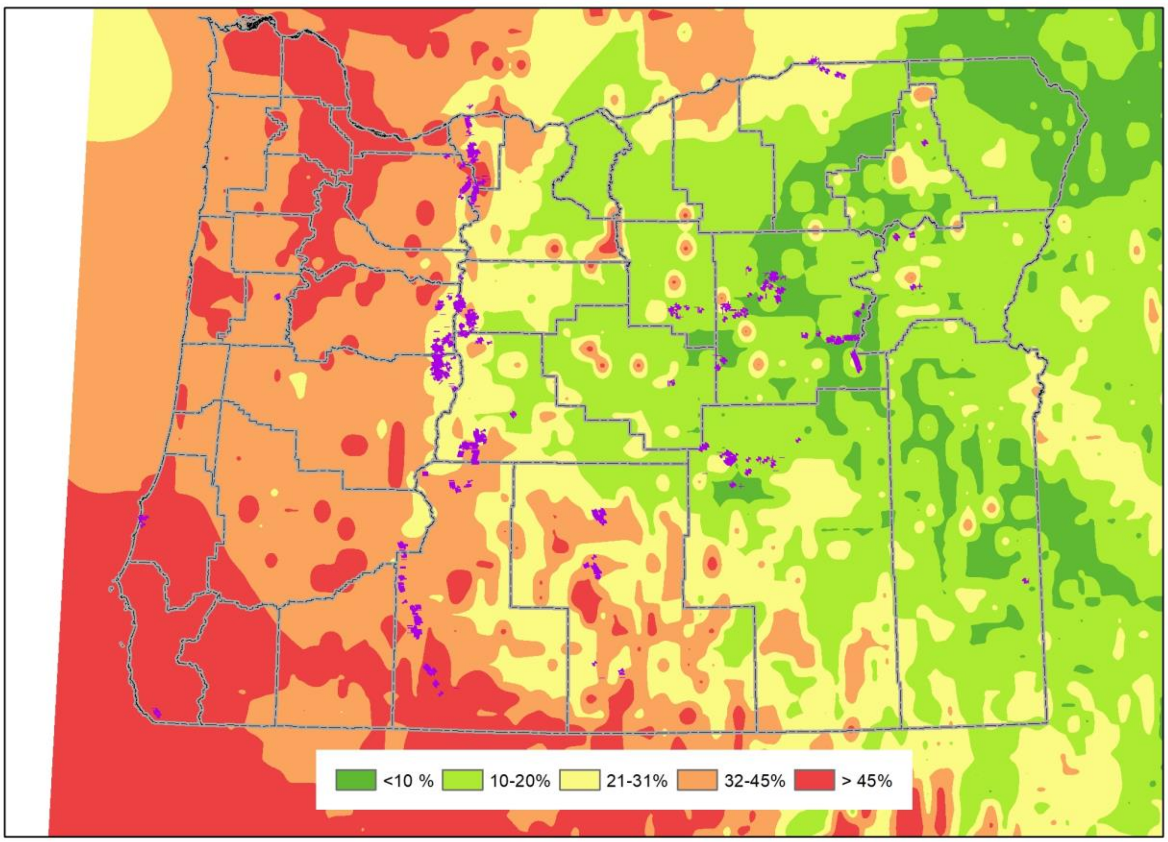
In this update (2020), new information was available to provide a more quantitative assessment of the counties in Oregon with the greatest earthquake hazard probability. USGS has published a 2018 update of its National Seismic Hazard Maps. They now include a map of the probability of experiencing damaging shaking, based on all known earthquake sources, history, and local soil conditions. The results of this map for Oregon are shown in **Figure 2-58**. The newly identified active young fault segments shown in Figure 2-30 are also shown in **Figure 2-58**.

Figure 2-58 shows the probabilistic hazard for the entire state. This map shows the likelihood of shaking strong enough to cause damage in the next 100 years. The threshold for damage is set at Modified Mercalli Intensity VI, the level at which structural damage begins to occur, and the map uses the most recent (2018) USGS National Seismic Hazard Map probabilistic bedrock shaking combined with a topography-based model of amplification due to soft soils. This map incorporates all that is known about the probabilities of earthquake on the Cascadia Subduction

Zone, and all Oregon faults for which published slip rate information is available. It does not include the recently discovered faults shown in **Figure 2-57**.

For Oregon west of the crest of the Cascades, the Cascadia subduction zone is responsible for most of the hazard, as shown in **Figure 2-58**. The paleoseismic record includes 18 magnitude 8.8–9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7 to 12%. An additional 10–20 smaller, magnitude 8.3–8.5, earthquakes affected only the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37–43%.

Figure 2-58. Probability of experiencing shaking of Modified Mercalli Intensity VI or greater during the next 100 years

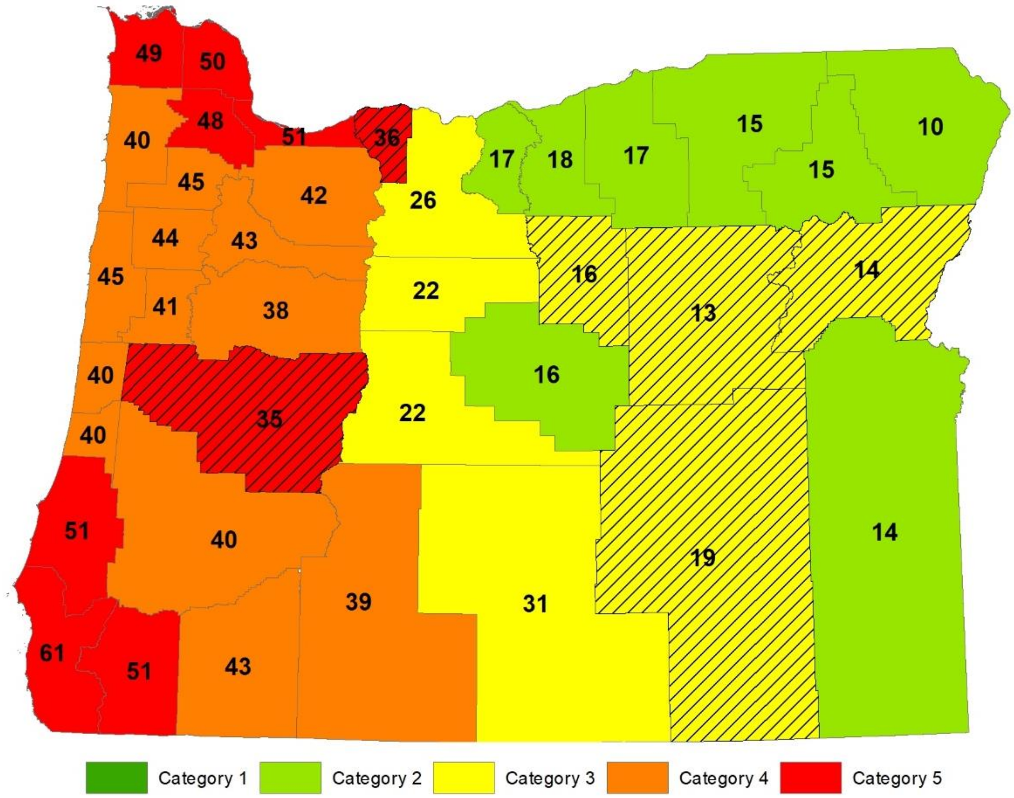


Note: Purple lines are faults that have been recently discovered with lidar data that are not included in the USGS hazard map models.

Source: USGS

Using these two new sources of information, DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered lidar faults. If a county had newly discovered faults that were within 10–12 miles of a community, the category defined by the average probability of damaging shaking was increased one step. The results of this ranking are shown in **Figure 2-59**.

Figure 2-59. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults (Figure 2-57 and Figure 2-58)



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.

Source: DOGAMI

To rank the earthquake probability for each of the counties using the 2020 risk assessment methodology, DOGAMI used the data for the map in **Figure 2-58** and interpolated a raster for the State of Oregon using 30-meter cells. DOGAMI then calculated the mean value of that probability for each of the counties in Oregon and used those values to rank them from 1 (least probability) to 5 (greatest probability).

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

Where one of the newly discovered faults mapped in **Figure 2-57** is within 10–20 miles of a community, the probability level was increased by one category. The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way.

Table 2-33. Probability of Earthquake by County using the 2020 Risk Assessment Methodology

Region	County	Probability	Category # 1 - 5
Region 1	Clatsop	49	5
	Coos	51	5
	Curry	61	5
	Douglas Coastal	40	4
	Lane Coastal	40	4
	Lincoln	45	4
	Tillamook	40	4
Region 2	Clackamas	42	4
	Columbia	50	5
	Multnomah	51	5
	Washington	48	5
Region 3	Benton	41	4
	Lane	35	5
	Linn	38	4
	Marion	43	4
	Polk	44	4
	Yamhill	45	4
Region 4	Douglas	40	4
	Jackson	43	4
	Josephine	51	5
Region 5	Gilliam	18	2
	Hood River	36	5
	Morrow	17	2
	Sherman	17	2
	Umatilla	15	2
	Wasco	26	3
Region 6	Crook	16	2
	Deschutes	22	3
	Jefferson	22	3
	Klamath	39	4
	Lake	31	3
	Wheeler	16	3
Region 7	Baker	14	3
	Grant	13	3
	Union	15	2
	Wallowa	10	2
Region 8	Harney	19	3
	Malheur	14	2

2.2.3.3 Vulnerability

Oregon has a long history of earthquakes (and tsunamis, which often accompany major off-shore seismic events) because of the state's proximity to the Cascadia Subduction Zone (CSZ) just off the Pacific Coast, and also from crustal faults that run under or near populated areas. Oregon is vulnerable to damage because of its topography and geology; many of its local soil profiles are prone to liquefaction during the shaking that would occur during a Cascadia event. Depending on the size of the fault rupture, areas receiving major damage from a magnitude 8.0–9.0 earthquake would include most of the counties in western Oregon; the heavily populated metropolitan areas of Portland, Salem, and Eugene would certainly experience major damage.

A major Cascadia earthquake (>M_W 8.5) or a local crustal earthquake (>M_W 5.0) would be devastating to the Portland Metro area. The Northern Willamette Valley/Portland Metro Region is the most densely populated region with a total population of almost 1.5 million people. A major earthquake would likely do extensive damage to many of the region's 1382 bridges and overpasses as few bridges have been retrofitted to withstand this type of event. In addition, many structures are located on soils likely to experience liquefaction from the shaking that would occur. Most of the state's major critical infrastructure such as energy sector lifelines, transportation hubs, and medical facilities is particularly vulnerable to damage from liquefaction and long periods of shaking. The Northern Willamette Valley/Portland Metro Region also has 49 dams that could be affected by a major earthquake.

Depending on the size of the fault rupture, this magnitude of earthquake would likely cause extensive damage to structures and infrastructure in the Mid/Southern Willamette Valley Region as well. The city of Salem, Oregon's state capital, is only 46 miles south of Portland. To gain a perspective of the potential damage from a major earthquake, 169 of the state's facilities are located in or near Salem. To replace these state facilities would cost over $850 million dollars. Marion County, where Salem is located, has over 20 dams and 400 bridges that could also be affected.

The long-term effects from a major earthquake would be felt for years. Major damage would likely occur to most of western Oregon's public and private buildings, its vast road network, to its rail lines and power transmission lines, and to the state's most important employment centers.

A major earthquake that occurs in the southern, central, or eastern areas of Oregon would be catastrophic to that region. It may also be catastrophic to the state economically if key facilities and infrastructure (i.e., highways, bridges, rail lines, power transmission lines, and dams) are damaged to the degree that links with the Portland Metro region and the rest of the state could not quickly be repaired. However, the length of time for the state to recover from such a disaster occurring in an area away from the Portland Metro area should be much shorter than if the same event occurred near Portland.

In the late 1990s, DOGAMI developed two earthquake loss models for Oregon: (a) a magnitude 8.5 Cascadia Subduction Zone (CSZ), and (b) a 500-yr probabilistic ground motion model, which combines CSZ, intraplate and crustal events. Both models are based on Hazus, a computer program developed by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event is based on a potential 8.5 earthquake generated off the Oregon coast. The 500-yr model incorporates earthquake ground motions with 10% chance of exceedance in the next 50 years, which was used by the building code. It does not look at a single earthquake (as in the CSZ model) but encompasses many faults.

Neither model takes into account damage and losses from unreinforced masonry buildings or tsunamis. Due to the limitations of Hazus with respect to modeling damage from unreinforced masonry buildings and tsunamis at that time, DOGAMI estimated fatalities outside of the Hazus model. DOGAMI developed lower bound estimates on the order of 5,000 fatalities.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning and policy purposes. Despite the model limitations, valuable estimates of damage, functionality and relationships between county estimates are made available for each region within Oregon. Results for each State of Oregon Natural Hazard Region are found in the **Regional Risk Assessments** section.

In 2000, DOGAMI co-organized an important conference convening scientists to discuss the Cascadia fault. At this Geological Society of America Penrose conference, which was held in Seaside, Oregon, there was scientific consensus that the most recent Cascadia earthquake occurred in 1700, that it was a magnitude 9 earthquake, and the Cascadia fault would produce future magnitude 9 earthquakes and damaging tsunamis (DOGAMI Special Paper 33, https://www.oregongeology.org/pubs/sp/SP-33.pdf)

Also in 2000, the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) developed a report called "Oregon at Risk" which addressed the many cross-cutting effects that earthquakes have on our communities, including the basic services provided by infrastructure. Five objectives were outlined: (a) earthquake awareness and education, (b) earthquake risk information, (c) earthquake safety of buildings and lifelines, (d) geoscience and technical information, and (e) emergency pre-disaster planning, response, and recovery. The report is available on the following the Oregon Office of Emergency Management webpage: https://www.oregon.gov/oem/Documents/Oregon_at_Risk_2000.pdf

In 2007, DOGAMI (Lewis, 2007) completed a rapid visual screening (RVS) of educational and emergency facilities in communities across Oregon, as directed by the Oregon Legislature in Senate Bill 2 (2005). RVS is a technique developed by the Federal Emergency Management Agency (FEMA), known as FEMA 154, to identify, inventory, and rank buildings that are potentially vulnerable to seismic events. DOGAMI surveyed a total of 3,349 buildings, giving each a “low,” “moderate,” “high,” or “very high” potential of collapse in the event of an earthquake. It is important to note that these rankings represent a probability of collapse based on limited observed and analytical data and are therefore *approximate* rankings (Lewis, 2007). The RVS study can help prioritize which buildings require additional studies and which do not. To fully assess a building’s potential of collapse, a more detailed engineering study completed by a qualified professional is required. Details of this study for each State of Oregon Natural Hazard Region can be found in the **Regional Risk Assessments** section.

In 2012 the USGS published Professional Paper 1661-F, *Turbidite Event History — Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone* (Goldfinger, et al., 2012), which provides the most comprehensive catalog of prehistoric Cascadia Subduction earthquakes to date, including a 10,000 year chronology (**Table 2-34**) of as many as 40 subduction earthquakes ranging from about M8.1 to about M9.3. This study forms the basis for efforts to evaluate the consequences and likelihood of future Cascadia earthquakes, and has been particularly useful in DOGAMI's program to map tsunami inundation zones along the Oregon coast.

Table 2-34. Turbidite Event History Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone

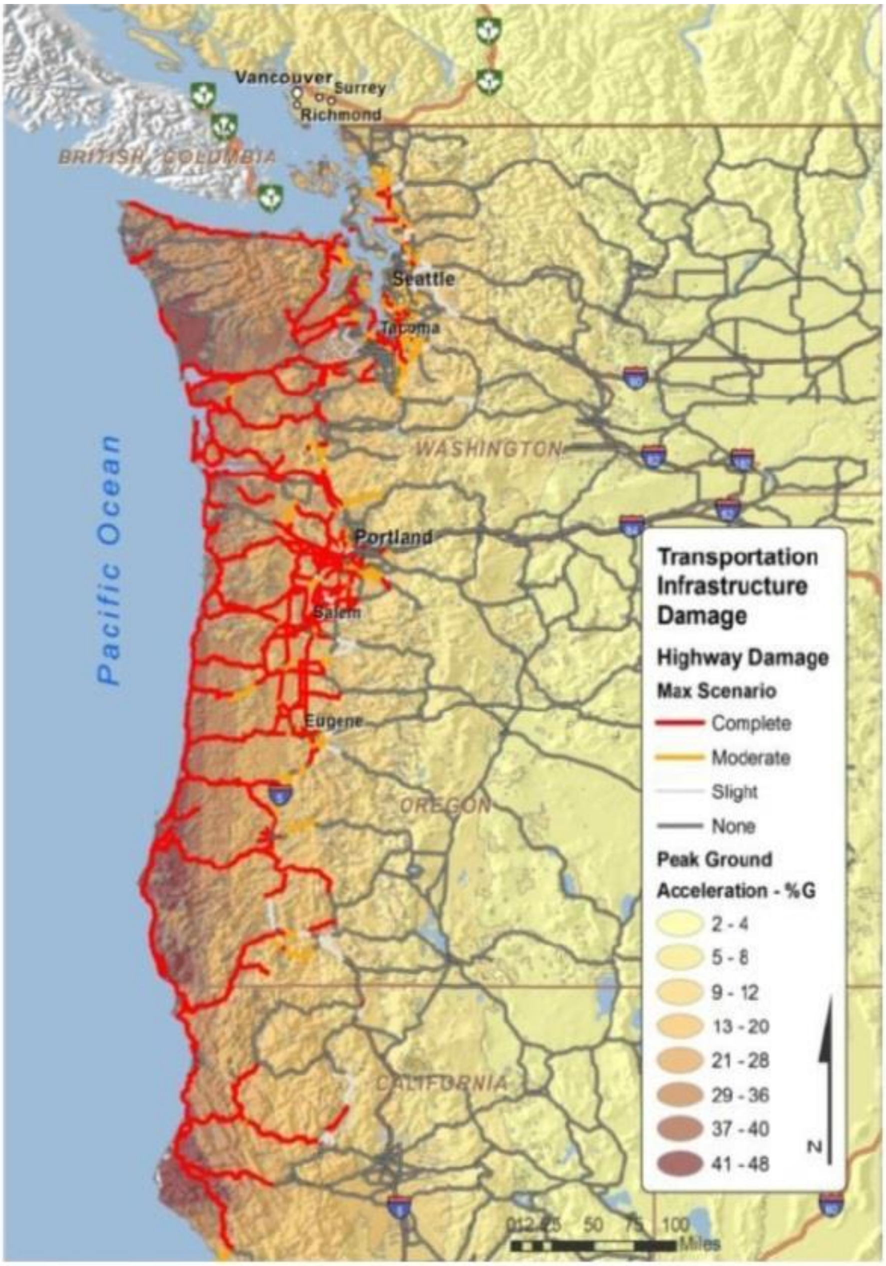
Turbidite number	Mean age	Northern margin following interval, in years	Northern margin slip from following time, in meters	Southern margin interval, in years	Southern margin slip from time, in meters	Average northern and southern slip, in meters	Segment name	Rupture length, in kilometers	Rupture width, in kilometers	Mw	Seismic moment
1	250					16.0	A	1,000	83	9.00	398.4E+27
2	482	232	8.9	232	8.3	8.4	A	1,000	55	8.70	138.3E+27
2a	550			57	2.1	2.1	D	222	40	8.19	23.8E+27
3	798	305	11.2	248	8.9	10.0	A	1,000	83	8.87	250.2E+27
3a	1,077			279	10.0	10.0	C	444	50	8.34	40.1E+27
4	1,243	446	16.3	167	6.0	11.2	A	1,000	83	8.90	277.9E+27
4a	1,429			186	6.7	6.7	C	444	50	8.25	29.9E+27
5	1,554	311	11.4	125	4.5	7.9	A	1,000	83	8.80	197.4E+27
5a	1,820			266	9.6	9.6	C	444	50	8.41	51.9E+27
5b	2,036			216	7.8	7.8	B	660	60	8.66	122.5E+27
5c	2,323			286	10.3	10.3	C	444	50	8.41	51.1E+27
6	2,536	982	35.9	213	7.7	21.8	A	1,000	83	9.09	542.7E+27
6a	2,730			194	7.0	7.0	D	222	40	8.24	28.7E+27
7	3,028	492	18.0	298	10.7	14.4	A	1,000	83	8.97	358.2E+27
7a	3,157			129	4.6	4.6	D	222	40	8.23	27.5E+27
8	3,443	415	15.2	286	10.3	12.7	A	1,000	83	8.94	317.2E+27
8a	3,599			442	5.6	0.0	B	660	60	8.67	124.4E+27
8b	3,890			447	10.5	10.5	D	222	40	8.15	21.0E+27
9	4,108	665	24.4	218	7.9	16.1	A	1,000	83	9.01	401.1E+27
9a	4,438			548	11.9	0.0	B	660	60	8.35	41.4E+27
9b	4,535			426	3.5	3.5	D	222	40	8.17	22.5E+27
10	4,770	661	24.2	235	8.5	16.3	A	1,000	83	9.01	406.6E+27
10a	5,062			292	10.5	10.5	C	444	50	8.39	47.6E+27
10b	5,260			198	7.1	7.1	B	660	60	8.43	55.7E+27
10c	5,390			130	4.7	4.7	C	444	50	8.55	82.7E+27
10d	5,735			344	12.4	12.4	C	444	50	7.90	9.0E+27
10f	5,772			37	1.3	1.3	C	444	50	8.37	44.8E+27
11	5,959	1189	43.5	187	6.7	25.1	A	1,000	83	9.13	625.5E+27
12	6,466	508	18.6	508	18.3	18.4	A	1,000	55	8.93	304.0E+27
12a	6,903			437	15.7	15.7	D	222	40	8.22	26.7E+27
13	7,182	715	26.2	278	10.0	18.1	A	1,000	83	9.04	450.7E+27
14*	7,625	443	16.2	443	16.0	16.1	A	1,000	83	9.01	400.7E+27
14a	7,943			318	11.4	11.4	D	222	40	8.17	22.1E+27
15	8,173	548	20.1	230	8.3	14.2	A	1,000	83	8.97	353.0E+27
15a	8,459			286	10.3	10.3	D	222	40	8.36	42.9E+27
16	8,906	733	26.8	447	16.1	21.4	A	1,000	83	9.09	534.1E+27
16a	9,074			169	6.1	6.1	D	222	40	7.54	2.6E+27
17	9,101	195	7.2	27	1.0	4.1	A	1,000	55	8.49	67.0E+27
17a	9,218	117	4.3	117	4.2	4.2	A	1,000	55	8.50	70.1E+27
18	9,795	577	21.1	577	20.8	20.9	A	1,000	83	9.08	521.2E+27

Source: Goldfinger, et al. (2012)

In 2013, DOGAMI published Open-File Report O-13-09, *Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub* (Wang, Bartlett, & Miles, 2013). This report highlights the concentration of critical energy facilities in the Portland Harbor area of the lower Willamette River, and the seismic risk posed by a combination of liquefiable soils and the age and poor condition of many facilities in the area. The report also points out how dependent Oregon is on this concentration of facilities for virtually all petroleum products used in the State, and the potential impacts on post-earthquake recovery if these facilities are damaged.

Also in 2013, the Cascadia Region Earthquake Workgroup (CREW) issued a Cascadia magnitude 9 scenario, which provided a narrative on the expected effects throughout the region including northern California, Oregon, Washington, and British Columbia (www.crew.org). Some of the CREW scenario was obtained from the 2011 Federal Emergency Management Agency (FEMA) regional planning scenario for the Pacific Northwest (Draft Analytical Baseline Study for the Cascadia Earthquake and Tsunami, September 12, 2011) based on a magnitude 9 megathrust earthquake. Using the most current version of Hazus, FEMA's disaster loss modeling software, they have prepared the most comprehensive and realistic Cascadia scenario to date). In addition to Hazus analysis, FEMA evaluated likely tsunami effects for several Oregon coastal communities. Data like this provides a critical tool for planning emergency response and for designing a resiliency plan, as it highlights areas of infrastructure damage that affect the entire system. State and local government agencies have been working with FEMA to provide local knowledge to inform the scenario, and the final document and associated databases should be adopted as the basis for planning. In general the scenario results predict severe damage in coastal areas, particularly in tsunami inundation zones with widespread but moderate damage along the I-5 corridor (**Figure 2-60**). For more information about tsunamis in Oregon, see the **Tsunami** section. For more information about seismic lifeline vulnerability see Section **2.1.6**, **Seismic Transportation Lifeline Vulnerabilities** section.

Figure 2-60. Draft Hazus Results from the 2011 FEMA Analytical Baseline Study for the Cascadia Earthquake and Tsunami



Source: FEMA

The Oregon Seismic Safety Policy Advisory Commission (OSSPAC) developed a report in 2013 entitled "The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami." The report (Appendix **9.2.3**), which was commissioned by a legislative resolution, estimated the impacts of an M9.0 Cascadia subduction earthquake on the State's population, buildings, and infrastructure with a focus on seven sectors:

- Businesses,
- Coastal communities,
- Energy,
- Transportation,
- Communication,
- Critical buildings, and
- Water and wastewater.

For each of these sectors the Plan sets a desired level of performance (time to recover a given level of service) and estimates performance under current conditions in each of four earthquake impact zones:

- **Tsunami**, where damage will be complete and saving lives through evacuation is the main focus;
- **Coastal**, where damage will be severe and the focus will be on managing a displaced population with little functioning infrastructure;
- **Valley**, where moderate damage will be widespread, and the focus will be on restoring services quickly to re-start the economy; and
- **Eastern**, where damage will be light and the focus will be on staging recovery efforts for the rest of the state.

For the first three zones, times for restoration of services (**Table 2-35**) are typically several months, and in some cases several years, a clearly unacceptable level of performance, and far short of the general performance goal of two weeks to restore most services to functional, if not original conditions. These results are particularly sobering in the face of the report's finding that where services are not restored within 2 to 4 weeks, businesses will either fail or leave.

The report includes extensive recommendations for actions that if implemented over the next 50 years, should greatly improve the performance of Oregon's buildings and infrastructure in the next great earthquake. These include:

- Undertaking comprehensive assessments of key structures and systems,
- Launching a sustained program of investment in retrofit of Oregon's public buildings,
- Creating a package of incentives to help Oregon's private sector improve its resilience, and
- Updating public policies to streamline recovery and to increase public preparedness

Upon consideration of the Plan, the 2013 Oregon Legislature passed Senate Bill 33 establishing an Oregon Resilience Task Force to facilitate a comprehensive and robust plan to implement the Oregon Resilience Plan. The Task Force will report to the Oregon Legislature during the 2015 session.

The report and an executive summary are available at:

- https://www.oregon.gov/oem/Documents/2014_ORTF_cover_letter.pdf and
- https://www.oregon.gov/oem/Documents/2014_ORTF_report.pdf.

Table 2-35. Estimated Times for Restoration Services Post CSZ and Tsunami Event

Critical Service	Zone	Estimated Time to Restore Service
Electricity	Valley	1 to 3 months
Electricity	Coast	3 to 6 months
Police and fire stations	Valley	2 to 4 months
Drinking water and sewer	Valley	1 month to 1 year
Drinking water and sewer	Coast	1 to 3 years
Top-priority highways (partial restoration)	Valley	6 to 12 months
Healthcare facilities	Valley	18 months
Healthcare facilities	Coast	3 years

Source: Oregon Resilience Plan, OSSPAC (2013)

Most Vulnerable Jurisdictions

Although it is relatively straightforward to rank counties based on earthquake hazards, it is much more complicated to rank them based on vulnerability. The severity of the expected hazard varies widely among Oregon counties, as does the amount of exposed population, buildings and infrastructure, and the fragility of those structures. Damage and loss estimates made using FEMA's Hazus software take all of these factors into account, and as a result can provide consistent information to compare community vulnerability. Although DOGAMI has developed Hazus loss estimates in recent years for many Oregon communities, the only statewide Hazus data that allows comparison of county vulnerability are from a study published in 1999. That study looked at two earthquake scenarios: (a) a magnitude 8.5 earthquake on the Cascadia Subduction Zone (CSZ), and (b) a probabilistic shaking based on the shaking expected to have a 10% chance of occurring in the next 50 years (500-year model).

The CSZ event is based on a potential magnitude 8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from the event. The 500-Year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults, each with a 10% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single "average" earthquake during this time. Neither model takes unreinforced masonry buildings into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models do provide some approximate estimates of damage.

Table 2-36 lists all counties in the state in the order of projected losses and damages (highest to lowest) based on the two models mentioned above. See DOGAMI Special Paper 29 (Wang &

Clark, 1999); http://www.oregongeology.org/pubs/sp/SP-29.pdf) for more information on these earthquake loss models.

Table 2-36. Projected Loss and Damage Rankings by County from Two Earthquake Loss Models

Counties listed from highest to lowest based on projected losses and damages due to a *Cascadia Subduction Zone (CSZ) earthquake*	
1. Multnomah	19. Klamath
2. Lane	20. Deschutes
3. Coos	21. Hood River
4. Washington	22. Jefferson
5. Marion	23. Grant
6. Benton	24. Gilliam
7. Lincoln	25. Harney
8. Josephine	26. Lake
9. Clatsop	27. Umatilla
10. Jackson	28. Baker
11. Linn	29. Crook
12. Curry	30. Malheur
13. Clackamas	31. Morrow
14. Douglas	32. Sherman
15. Yamhill	33. Union
16. Polk	34. Wallowa
17. Tillamook	35. Wasco
18. Columbia	36. Wheeler

Counties listed from highest to lowest based on projected losses and damages due to *combined crustal events using a 500-year model*	
1. Multnomah	19. Columbia
3. Lane	21. Umatilla
3. Lane	21. Umatilla
4. Marion	22. Hood River
5. Clackamas	23. Malheur
6. Coos	24. Lake
7. Jackson	25. Wasco
8. Benton	26. Jefferson
9. Linn	27. Baker
10. Klamath	28. Morrow
11. Josephine	29. Union
12. Lincoln	30. Wallowa
13. Clatsop	31. Crook
14. Yamhill	32. Grant
15. Douglas	33. Harney
16. Polk	34. Sherman
17. Curry	35. Wheeler
18. Tillamook	36. Gilliam

Source: Wang & Clark (1999)

It should be emphasized that the original 1999 DOGAMI study did not include tsunami-related losses. In the future, an updated Hazus study should include the current population and infrastructure as well as losses from a tsunami. If tsunami losses are included, rankings might shift.

It is also important to note that total losses will generally be a function of the population of the county. It may be a better approach to look at the loss ratio, or the cost of damage expressed as a percentage of total value. A county with a small population and a large loss ratio might still have smaller total losses than a populous county with a very low loss ratio.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a Magnitude 9 Cascadia Subduction Zone (CSZ) event and a 2,500-year probabilistic scenario. The damage estimates from the CSZ were very low east of the Cascade Mountains, so the loss estimates reported from this event are limited to the western regions (1–4) (Madin & Burns, 2013). DOGAMI assessed the four eastern regions (5–8) with the USGS 2,500-year probabilistic scenario (Petersen, et al., 2014). The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High). The vulnerability scores derived were used along with each county's social vulnerability score to calculate an overall vulnerability score for each county in Oregon.

Of 5,350 state facilities evaluated, 838 building were flagged as extensively or completely damaged following a CSZ event (Regions 1–4) or a 2,500-year probabilistic scenario (Regions 5–8) totaling over $1.3 billion in potential damage to property. Among the 1,647 critical state facilities, 360 were flagged as extensively or completely damaged.

Of 8,757 local critical facilities evaluated, 1,880 buildings were flagged as completely or extensively damaged following a CSZ event (Regions 1–4) or a 2500-year probabilistic scenario (Regions 5–8) totaling over $4.3 billion in potential damage to property.

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to earthquakes. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. None of these losses was due to an earthquake.

DAS's records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Historic Resources

Of the 58,872 historic resources statewide, 31,928 are in an area of high or very high exposure to ground shaking amplification, over 30% of them in Multnomah County. Many fewer, 2,594 are in an area of high or very high liquefaction potential, almost 58% of them in Linn County.

Archaeological Resources

Of the 43,659 archaeological resources located in earthquake hazard areas statewide, 964 are in areas of high earthquake hazards. Of those, 28 are listed on the National Register of Historic Places and 41 are eligible for listing. Fifty have been determined not eligible, and 845 have not been evaluated. By far, the majority of archaeological resources in earthquake hazard areas (33,643) are located in areas of low earthquake hazards.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

For the 2020 vulnerability assessment, DLCD combined this index with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Coos, Lincoln, the coastal portions of Douglas and Lane, Linn, Marion, Yamhill, Hood River, Morrow, Umatilla, Klamath and Lake Counties are the most vulnerable to impacts from earthquake hazards.

Seismic Lifelines

Please refer to Section **2.1.6**, **Seismic Transportation Lifeline Vulnerabilities** for a discussion of potential seismic impacts to the state transportation system, its vulnerabilities and potential loss estimates.

2.2.3.4 Risk

In the 2020 update DOGAMI and DLCD developed a new risk ranking system that combines the probability of the hazard (based on the new approach described above) with the limited vulnerability assessment to arrive at a composite risk score referred to as the 2020 Risk Score. Those results are presented in **Table 2-37**, and clearly differ from the 1999 loss-based ranking in **Table 2-36**. For a variety of reasons, the 1999 loss-based rankings and the 2020 loss-based rankings are not comparable.

According to the 2020 risk assessment, the counties at greatest risk from earthquake hazards are Clatsop, Coos, Curry, the coastal portions of Douglas and Lane, Lincoln, Multnomah, Linn, Marion, Yamhill, Douglas, Jackson, Josephine, Hood River, Klamath, and Lake Counties.

Table 2-37. 2020 Risk Assessment Methodology County Earthquake Risk Scores

Region	County	Earthquake Risk	Region	County	Earthquake Risk
Region 1	Clatsop	VH	**Region 5**	Gilliam	VL
	Coos	VH		Hood River	VH
	Curry	VH		Morrow	H
	Douglas Coastal	VH		Sherman	VL
	Lane Coastal	VH		Umatilla	H
	Lincoln	VH		Wasco	H
	Tillamook	H	**Region 6**	Crook	M
Region 2	Clackamas	L		Deschutes	VL
	Columbia	M		Jefferson	H
	Multnomah	VH		Klamath	VH
	Washington	M		Lake	VH
Region 3	Benton	M		Wheeler	VL
	Lane	M	**Region 7**	Baker	M
	Linn	VH		Grant	VL
	Marion	VH		Union	L
	Polk	H		Wallowa	M
	Yamhill	VH	**Region 8**	Harney	M
Region 4	Douglas	VH		Malheur	M
	Jackson	VH			
	Josephine	VH			

Source: DOGAMI, DLCD (2020)

2.2.4 Extreme Heat

Extreme heat is associated with more fatalities than any other severe weather event in the United States. For the first time, extreme heat is included as a hazard in the 2020 Oregon NHMP. This is due to the recognition that as the climate continues to warm, extreme heat events will be an emerging hazard with implications for public health as well as infrastructure. Extreme heat events are expected to increase in frequency, duration, and intensity in Oregon due to continued warming temperatures. In fact, the hottest days in summer are projected to warm more than the change in mean temperature over the Pacific Northwest (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). Extreme heat events occur from time to time as a result of natural variability, but human-caused climate change is already contributing to the severity of such events (Vose, Easterling, Kunkel, LeGrande, & Wehner, 2017).

2.2.4.1 Analysis and Characterization

Extreme heat events occur from time to time as a result of natural variability. Synoptic conditions that drive extreme heat events in the Pacific Northwest include, upper-level ridges—or large areas of high atmospheric pressure—and strong offshore flow. There are several ways to measure extreme heat. One common way is to count the number of days with temperatures above a certain threshold, such as days with temperatures above 90°F. Areas that climatologically see the greatest number of very hot temperature days include inland areas at lower elevations in eastern Oregon, as well as parts of southern Oregon, particularly the Rogue River Valley. Human-caused climate change is already contributing to the severity of such events (Vose, Easterling, Kunkel, LeGrande, & Wehner, 2017).

Recent extremely hot summers (2015, 2017, and 2018) in highly populated parts of western Oregon have been unprecedented and have brought increased interest in the effect of global warming on local summer temperatures. In Oregon’s biggest city, Portland, summer extreme heat in terms of annual total days over 90°F has steadily increased in frequency and severity despite large year-to-year variability. The record number of days over 90°F in Portland was set in 2018. Today, Portland sees about nine more days above 90°F than in 1940. This trend will continue, though the rate of change may increase, along with continued year-to-year variability. The hot summers of 2015, 2017, and 2018 serve as wake-up calls for what is to come, as they are good examples of what is projected to be relatively common by the mid-21st century.

The National Weather Service issues heat warnings when the heat index exceeds given local thresholds. The heat index is a measure of how hot it feels combining both temperature and relative humidity. As relative humidity increases, a given temperature can feel even hotter. **Figure 2-61** displays NOAA’s National Weather Service rubric for temperature and relative humidity according to the danger of heat-related illnesses.

Figure 2-61. NOAA National Weather Service Heat Index

NOAA's National Weather Service

Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

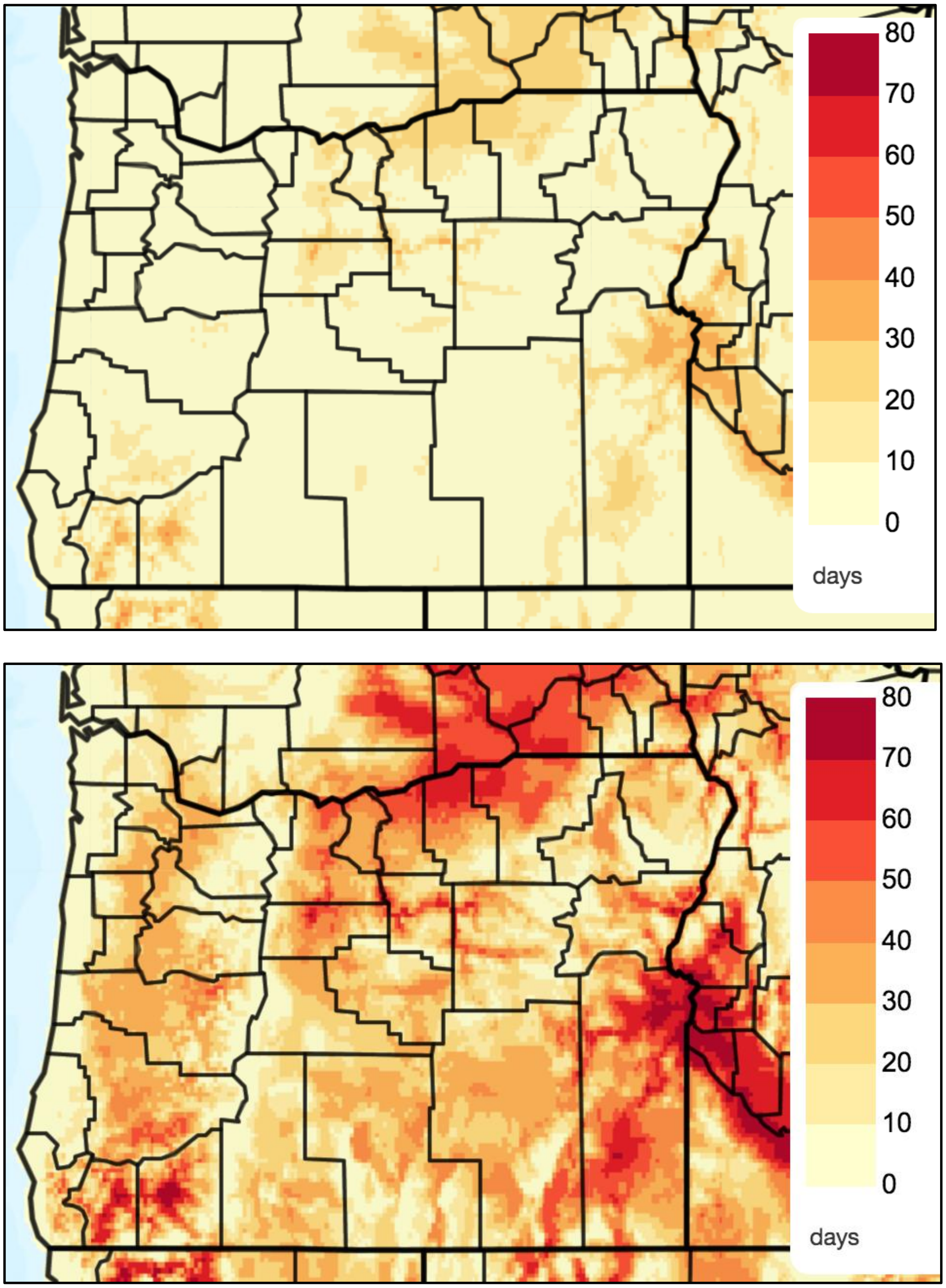
Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: https://www.weather.gov/phi/heat

There have historically been few places in Oregon that experience substantial number of days with heat index greater than 90°F. Under future climate change, however, nearly the entire state could see substantial increases in such extreme heat days (Figure 2-62).

Figure 2-62. Frequency of Days April–October with Heat Index ≥ 90°F in Historic (1971–2000, top) and Future (2040–2069, bottom) Periods under RCP 8.5



Note: Displayed is the multi-model mean derived from 18 downscaled CMIP5 climate models.

Source: Northwest Climate Toolbox, https://climatetoolbox.org/tool/climate-mapper

Historic Extreme Heat Events

Table 2-38. Historic Heat and Excessive Heat Events in Oregon

Date	Location	Notes
July 26–28, 1998	Region 2	A three-day heat wave brought record high temperatures to western Oregon. The high temperature of 99 degrees at Portland International Airport on the 26th eclipsed the previous record for that date of 98 set in 1988, and the high of 101 on the 28th broke the previous daily record of 99 set in 1973. In Eugene, the high of 102 on the 26th broke the previous daily record of 101 set in 1988, and the 105 degrees on the 27th tied the record high for the month of July. There was one reported death from heat-related illness.
July 10–14, 2002	Region 5–7	A record breaking heat wave shattered many daily record high temperatures across the state, with a few locations breaking all-time records.
June 24–26, 2006	Region 1–3, 5	A broad upper ridge of unusually high height coupled with a thermally induced surface trough of low pressure lingered over the Pacific Northwest for several days. This pattern resulted in persistent offshore flow, and therefore many days of record-smashing high temperatures. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row.
July 20-24, 2006	Region 1–3, 5, 7	An unusually strong ridge of high pressure brought several days of record breaking hot and humid weather to NW Oregon. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row. Many daily maximums were between 10 and 20 degrees above normal. A few sites reported record high minimum temperatures during this very humid event; a couple broke all-time record high minimums as well. 4500 homes lost power during this event. In north central and eastern Oregon, daily maximum temperatures between 100 and 113 degrees were observed at lower elevations, with temperatures 90 to 100 degrees at elevations up to 4000 feet. Several people were treated for heat related illness.
June 28–30, 2008	Region 2, 3, 5, 7	An upper level ridge and thermal trough across the Pacific Northwest produced temperatures above 100 degrees for two consecutive days breaking records in many locations. Two people died of heat-related illness.
August 15–17, 2008	Region 5–7	Excessive Heat Event: An upper level ridge and dry air brought excessive heat into eastern Oregon. Many locations experienced multiple days of at least 100 degree temperatures.
July 25–26, 2010	Region 5, 7	Excessive Heat Event: Temperatures topped 100 degrees for two successive days in Hermiston, Pendleton, 5 miles northeast of Pendleton, Ione, Echo, Arlington, and Umatilla.
August 1, 2011	Region 5	A dry weak westerly flow aloft under a broad upper level high pressure system combined with a surface thermal trough to bring several days of temperatures in the 90s.
July 1, 2014	Region 3	An upper level ridge combined with a surface thermal trough and low level offshore winds resulted in a hot day across Northwest Oregon where inland temperatures peaked in the upper 90s inland and the upper 80s along the coast.
June 7–9, 2015	Region 2	An unseasonably strong upper level ridge of high pressure resulted in hot temperatures early in June where high temperatures were in the low to mid 90s, which were around 20 degrees higher than the seasonal normals. The low temperatures were also unseasonably warm. The hospital visits for heat related illness for Northwest Oregon increased by 50 during this period.

Date	Location	Notes
June 26–28, 2015	Region 2, 3	Excessive Heat Event: A strong upper level ridge of high pressure resulted in hot temperatures across Northwest Oregon. Afternoon temperatures peaked in the low 90s to the low 100s, which are around 20 degrees warmer than the seasonal normals. Monsoonal moisture and onshore winds resulted in fairly high humidities (40 to 50% in the afternoons) making the temperatures feel 2 to 5 degrees warmer than they were. The mid-level moisture also added to an increase of thunderstorms around the region. Clouds from these thunderstorms limited overnight radiation cooling. Nighttime temperatures were in the mid 60s to low 70s, which are 10 to 15 degrees warmer than the seasonal normals. There were several new daily records set for the warmest low temperatures. The Multnomah County had 10 emergency room visits for heat related illnesses. There were two reported drownings, including one at nighttime.
July 1–5, 2015	Region 2, 3	A strong upper ridge over the region resulted in hot weather for the Willamette Valley where temperatures peaked 10 to 15 degrees Fahrenheit above the seasonal normal. High Temperatures were in the mid 90s to low 100s. The low temperatures were also unseasonably warm.
July 28–30, 2015	Region 2, 3	Excessive Heat Event: A strong upper level ridge resulted in excessively warm temperatures where the high temperatures were 15 to 20 degrees Fahrenheit above the seasonal normal. High temperatures were in the upper 90s to around 105 for the Willamette Valley. The daily maximum temperature of 105 degrees at Eugene broke the previous record of 99 last set in 2003. Emergency Preparedness officials opened cooling shelters. Several people were treated for heat related illnesses at medical centers. Local newspapers reported 3 separate incidents where children were left in hot cars in the Eugene area.
August 18–19, 2015	Region 2	Excessive Heat Event: Strong high pressure at the surface and aloft over the area resulted in excessively hot temperatures across northwest Oregon. Warming aloft combined with offshore winds and a thermal trough west of the Cascades contributed to the heat. Temperatures peaked in the mid to upper 90s which is 10 to 15 degrees above the seasonal normal in most areas. Daily high temperatures broke several records at area airports.
June 2–5, 2016	Region 3	Excessive Heat Event: Unseasonably strong ridge of high pressure resulted in a period of early-season hot temperatures across Northwest Oregon. Temperatures of 95 to 100 in early June lead to people seeking relief at local rivers. Three drownings were reported.
August 11–14, 2016	Region 2	Ridge of high pressure lead to hot temperatures across Northwest Oregon. Temperatures in the upper 80s to mid 90s lead to people seeking relief at local rivers. Two river drownings were reported in the Greater Portland Metro area during this heat event.
August 25-26, 2016	Region 1, 2	Ridge of high pressure and offshore winds brought temperatures along the North Oregon Coast up into the mid 80s to mid 90s on August 25. Inland, temperatures on August 25-26 reached the upper 90s. Temperatures in the mid 80s to mid 90s lead to people seeking relief at local rivers, lakes, and beaches. One swimmer drowned. News reported 8 runners were taken to the hospital with heat-related injuries during the Hood-to-Coast relay through Portland.
May 22-23, 2017	Region 2	Ridge of high pressure brought a couple days of warm weather. Temperatures climbed up into the upper 80s to low 90s in many locations across the area. Early season heat led people to seek relief in local rivers and lakes. While air temperatures were warm, river and lake temperatures were still cold, leading to two drownings across the area.

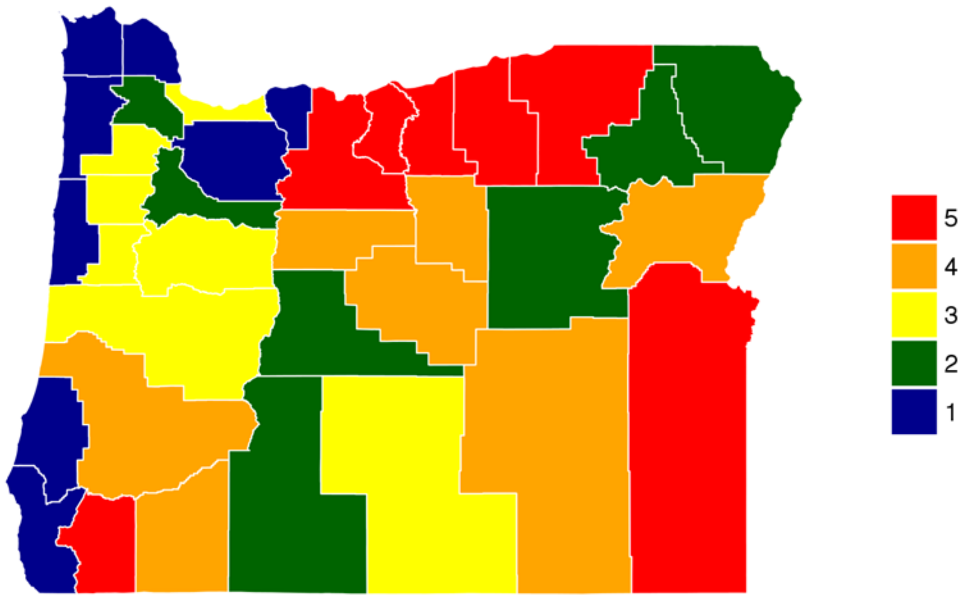
Date	Location	Notes
August 1–4, 2017	Region 2–4, 6	Excessive Heat Event: Strong high pressure brought record breaking heat to many parts of southwest, south central, and northwest Oregon. Region 2–3: The record-breaking heat led people to seek relief at local rivers. Two people drowned while swimming. Region 4: Reported high temperatures during this interval ranged from 98 to 112 degrees (Jackson), 95 to 110 degrees (Douglas), 87 to 109 degrees (Josephine, eastern Curry). Region 6: Reported high temperatures during this interval ranged from 82 to 102 degrees.
July 12–17, 2018	Region 2, 3, 4	Region 2–3: High pressure over the region led to a stretch of hot day July 12 through July 17th. Hot temperatures led people to cool off in local rivers. There were two drownings recorded on July 16 and July 18. Temperatures on July 16th near the Sandy River in Troutdale got up to 98 degrees Region 4: Strong high pressure coupled with very dry air brought very hot temperatures to the area during this interval. High temperatures ranged from 89 to 105 degrees (Jackson) and from 91 to 104 degrees (Josephine, eastern Curry).
June 11–12, 2019	Region 4 and eastern Curry County	Strong high pressure and a very dry air mass made for hot conditions over southwest Oregon during this interval. Reported high temperatures ranged from 95 to 101 degrees (Jackson), 89 to 101 degrees (Douglas), 88 to 105 degrees (Josephine, eastern Curry).
August 27-28, 2019	Region 4 and eastern Curry County	Excessive Heat Event: High pressure aloft forced a thermal trough near the coast to move inland, bringing hot and dry conditions to the inland west side valleys in southwest Oregon. Reported high temperatures in this zone ranged from 99 to 106 degrees on 08/27 and from 92 to 95 degrees on 08/28. Low temperatures on the morning of 08/28 ranged from 50 to 67 degrees.

Source: https://www.ncdc.noaa.gov/stormevents

2.2.4.2 Probability

The relative probability of experiencing extreme heat events was determined by dividing the counties into quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning “very low.” The probability of extreme heat events is highest in southern Oregon (Region 4), Columbia Plateau (Region 5), parts of central Oregon (Region 6), and Snake River Plain in eastern Oregon (Region 8). It is lowest on the coast (Region 1) and high elevations in Regions 2, 3, 7. **Figure 2-63** shows the relative probability rankings of each county in Oregon.

Figure 2-63. Relative Probability of Extreme Heat



Note: 5 = "Very High"; 4 = "High"; 3 = "Moderate"; 2 = "Low"; 1 = "Very Low"

Source: Oregon Climate Change Research Institute

Climate Change

In the future, extreme heat events are expected to increase in frequency, duration, and intensity due to warming temperatures in all eight regions in the 2020 Oregon NHMP. It is extremely likely (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon (very high confidence). Increases in extreme heat events are likely to be greater for eastern Oregon (Region 5–8) than for western Oregon (Region 1–4) (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). Inland areas at lower elevations, which climatologically see the greatest number of very hot temperature days, will see an even greater number of very hot days in the coming decades. Most locations in Oregon except the mountains and the coast will experience at least an additional 30 hot days per year, in many places doubling the frequency of such days (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019). Very hot days, measured in an absolute sense, will continue to be rare in coastal and high elevation regions.

2.2.4.3 Vulnerability

Extreme heat is associated with more fatalities than any other severe weather event in the United States. Extreme heat events occur from time to time as a result of natural climatic variability, but are expected to increase in frequency, duration, and intensity in Oregon due to continued warming temperatures.

This section covers impacts of extreme heat and which groups of people are most vulnerable as well as a simple vulnerability assessment to identify the relative vulnerability across the state in terms of sensitivity and adaptive capacity.

Vulnerable Populations and Impacts

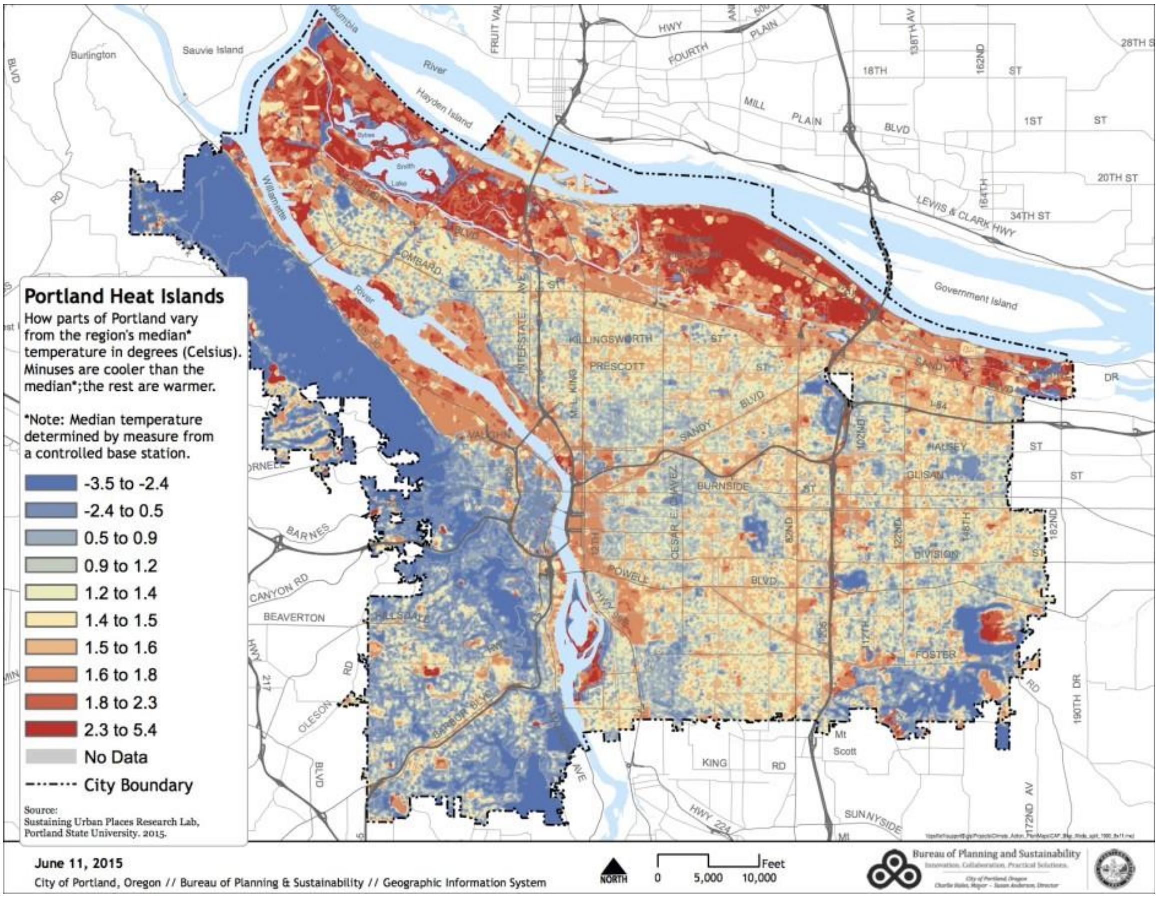
Extreme heat events can bring a wide array of impacts from increased morbidity and mortality from heat-related illness to disrupted transportation and infrastructure damaged by extreme heat.

Heat exposure can lead to heat rashes, heat cramps, heat exhaustion, and heat stroke. The adverse effects are not limited to the direct physiological consequences. Indirect impacts include the exacerbation of existing renal, cardiovascular, and respiratory conditions. Mental health can also be affected by extreme heat (https://www.ncbi.nlm.nih.gov/pubmed/30007545). There is evidence that extreme heat is associated with higher levels of aggression, violence, and suicidal behavior. Heat-related impacts on health may be immediate or delayed. Even small increases in average summer temperatures can lead to increases in heat-related deaths, especially among those with underlying medical conditions. A three-fold increase in heat-related illness has been documented in Oregon with each 10°F rise in daily maximum temperature (Dalton, Mote, & Snover, 2013).

Heat waves will result in increased deaths and illness among vulnerable human populations. Older adults, children, infants, people with existing medical conditions or disabilities, low-income communities, and outdoor workers are among the groups most threatened by heat waves (Ebi, et al., 2018). People who work outside (including construction workers, farmworkers, foresters, and fishers), as well as outdoor athletes face higher exposures to extreme heat. People who live in social isolation, including linguistic isolation or those living alone with few social relationships are also at higher risk. Social determinants, including race and ethnicity, income and educational attainment are correlated to numerous health outcomes, including heat-related illness.

Extreme heat in urban areas poses risk to human health and safety, especially for those living and working in urban heat islands. People living outdoors or in the upper floors of multi-family housing units may be particularly vulnerable. In cities, non-white populations are more likely to live in urban heat islands neighborhoods with impervious surfaces and low tree coverage, and areas with limited access to green space. Urban areas also may face increased energy and water demand and increased risk of disruption to civic and economic activity. A study of Portland, OR residents found that sociodemographic factors such as income, race, age, and English-speaking ability are associated with higher risk of adverse heat effects (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5923682/). **Figure 2-64** shows Portland's urban heat islands, locations that see hotter temperatures during heat events.

Figure 2-64. Portland, Oregon's Urban Heat Islands, the Parts of the City That See Hotter Temperatures in Heat Waves



Source: Shandas, V. and J. Voelkel, Sustaining Urban Places Research (SURP) Lab, Portland State University, 2016.

People working and living in less urban areas are also at risk. For example, farmworkers must often work outdoors (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4199019/) and are therefore more exposed to heat for greater periods of time. Approximately 30% of those interviewed in Oregon reported two or more heat related illness symptoms during their work. These symptoms, and associated hospitalizations, will naturally increase with higher temperatures if adequate protections are not provided. People living in areas like the Oregon coast or mountains might not be acclimated to extreme heat events and may lack critical infrastructure or protective equipment, for example air conditioning.

In addition to human health impacts, extreme heat events can disrupt transportation by delaying rail and air transportation when safe operating guidelines are exceeded, damaging rail tracks that may bend or roadway joints that may buckle under extreme heat (Jacobs, et al., 2018). Heat waves can increase the demands on electric power for cooling, increasing the risk of cascading failures within the electric power network (Clarke, et al., 2018). In addition, prolonged warm temperatures and severe heat are associated with tree mortality and forest conditions favorable to wildfire and wildfire spread, making it more difficult to fight ongoing wildfires.

Oregon Health Authority's and Oregon OSHA's Extreme Heat Planning and Response

Heat-related deaths and illness are preventable, yet many Oregonians are not familiar with the risks or what they can do to protect themselves. The Oregon Health Authority and some local health departments have produced risk communication materials to educate the public on symptoms, warning signs and recommended actions by vulnerable group, including fact sheets in multiple languages. Depending on a person's housing, access to transportation, and other factors these behavioral changes may be more difficult.

The Oregon Health Authority (OHA) has the capacity to track heat related illnesses in the state with a 24-hour lag. When heat waves occur, the agency, through its Electronic Surveillance System for the Early Notification System of Community-Based Epidemics (ESSENCE), generally observes an increase in heat-related emergency department visits (https://www.oregon.gov/oha/PH/DISEASESCONDITIONS/COMMUNICABLEDISEASE/PREPAREDNESS SURVEILLANCEEPIDEMIOLOGY/ESSENCE/Documents/HazardReports/ESSENCE_Hazards.pdf). While ESSENCE provides valuable data to inform scope and outreach, it could be improved by increasing reporting by health care clinics and increasing public health capacity to monitor and analyze the received data. Hospitalization data are also available, albeit with a much longer lag than ESSENCE. During 2013-2017, there were 219 hospitalizations for heat-related illness in Oregon, mostly in those 35 years and older (https://ephtracking.cdc.gov/DataExplorer/#/).

Oregon has some capacity for shelter from heat, but these cooling centers are limited in number and geographical distribution. Improvements in the built environment, including the expansion of tree canopies, shaded parks, fountains, and wading pools can provide public access to cooling. There is a need to engage more healthcare providers and coordinated care organizations (CCOs) who may be able to help prevent heat-related illness and death among vulnerable groups through targeted education and delivery of health-related services to Oregon Health Plan members (http://www.oregon.gov/oha/HPA/HP/docs/OHA%208440%20CCOHousing-Survey-Report.pdf).

A Crisis and Emergency Risk Communications (CERC) toolkit has been developed by OHA, translated into multiple languages, and promoted for use by local public health authorities. This toolkit provides critical information about the signs of heat illness, frequently asked questions, evidence-based social media messages, talking points and press releases. OHA's Public Health Duty Officer is routinely notified by National Weather Service (NWS) staff of impending extreme weather, including heat waves, and participates in NWS weather briefings.

OHA has identified the need for a more detailed vulnerability assessment. There also may be opportunity to strengthen early warning systems using meteorological and health data to issue targeted warnings to people in Oregon. OHA and local public health authorities can often provide community partners with technical assistance to develop heat response plans. These can include developing thresholds for certain actions and a tiered approach, such as when sporting events should take extra protective measures and when the events should be canceled. Creating clear plans for responding to extreme heat can help community partners make the right call at the right time. Based on data analysis that showed a high number of heat-related hospitalizations related to outdoor athletic events, the Multnomah County Health Department piloted a project with the City of Portland to include extreme heat guidelines for large outdoor event organizers within the City's permitting process.

Oregon OSHA's Local Emphasis Program (LEP) is designed to educate employers and outdoor workers about the effects and prevention of exposure to extreme heat, and to encourage employers to maintain a safe and healthy workplace. The Program focuses on existing general rules; it provides guidelines but no adopted standards. This affords some protection from heat exposure for outdoor workers, but not necessarily sufficient or adequate protection. As long as outdoor workers continue to suffer heat stress, more can be done to protect them.

In 2020, Governor Kate Brown issued Executive Order 20-04 that included several directives to State Agencies to address climate change impacts, including a specific directive to Oregon Health Authority to work with the Oregon Occupational Safety and Health (OSHA) to propose new standards for protecting outdoor workers from extreme heat.

Vulnerability Assessment

Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat. For the purposes of this plan, one measure of sensitivity and one measure of adaptive capacity were selected and combined to assess vulnerability by county in Oregon.

Sensitivity

Sensitivity is the degree to which people or communities are negatively affected by extreme heat exposures. Certain populations are more sensitive than others. Older adults, infants and children, pregnant women, people with preexisting diseases and those who take certain medications that affect thermoregulation or block nerve impulses are some of the populations with higher sensitivity.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html. The CDC used 15 metrics of social vulnerability including metrics related to socioeconomic status, household composition and disability, minority status and language, and housing and transportation. The CDC's overall vulnerability scores are normalized from 0 to 1, such that a score of 1 is the greatest vulnerability. Overall vulnerability scores were obtained for each county in Oregon and sorted by quintiles and given rankings shown in **Table 2-39**. A ranking of 1 means "very low" sensitivity and a ranking of 5 means "very high" sensitivity. For example, Josephine County's overall vulnerability score from the CDC Social Vulnerability Index is 0.669, which falls in the 0.6–0.8 range and was given a sensitivity rank of 4 meaning "high" sensitivity. Sensitivity rankings for all counties are shown in column 1 of **Table 2-39**.

Table 2-39. Sensitivity Rankings

Quantile Range	Sensitivity	Rank	Vulnerability
0.0–0.2	Very Low	1	Very Low
0.2–0.4	Low	2	Low
0.4–0.6	Moderate	3	Moderate
0.6–0.8	High	4	High
0.8–1.0	Very High	5	Very High

Adaptive Capacity

Adaptive capacity is the ability of communities, institutions, or people to adjust to potential hazards, to take advantage of opportunities, or to respond to consequences in ways that reduce harmful exposures (i.e., the ability to prepare for, respond to, and cope with heat events). Health outcomes are strongly influenced by adaptive capacity factors, including those related to the natural and built environments, government regulations and response. Examples of factors that influence a person's adaptive capacity to extreme heat include access to air conditioning and the ability to afford to run it, housing quality, access to information in one's first language, access to cooling centers or other built environment features like parks or natural areas, access to transportation, access to health care, and strong social networks.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are houseless.

The Northwest Energy Efficiency Alliance (NEEA, 2019) assessed the penetration of cooling systems in Oregon in 2016–2017. According the NEEA's analysis, about 68% of single-family homes and manufactured homes in Oregon have cooling systems, and about one quarter of multifamily residences have cooling systems. **Table 2-40** breaks down air-conditioning penetration of single-family and manufactured homes by cooling zones.

Table 2-40. Percentage of Homes with Cooling Equipment

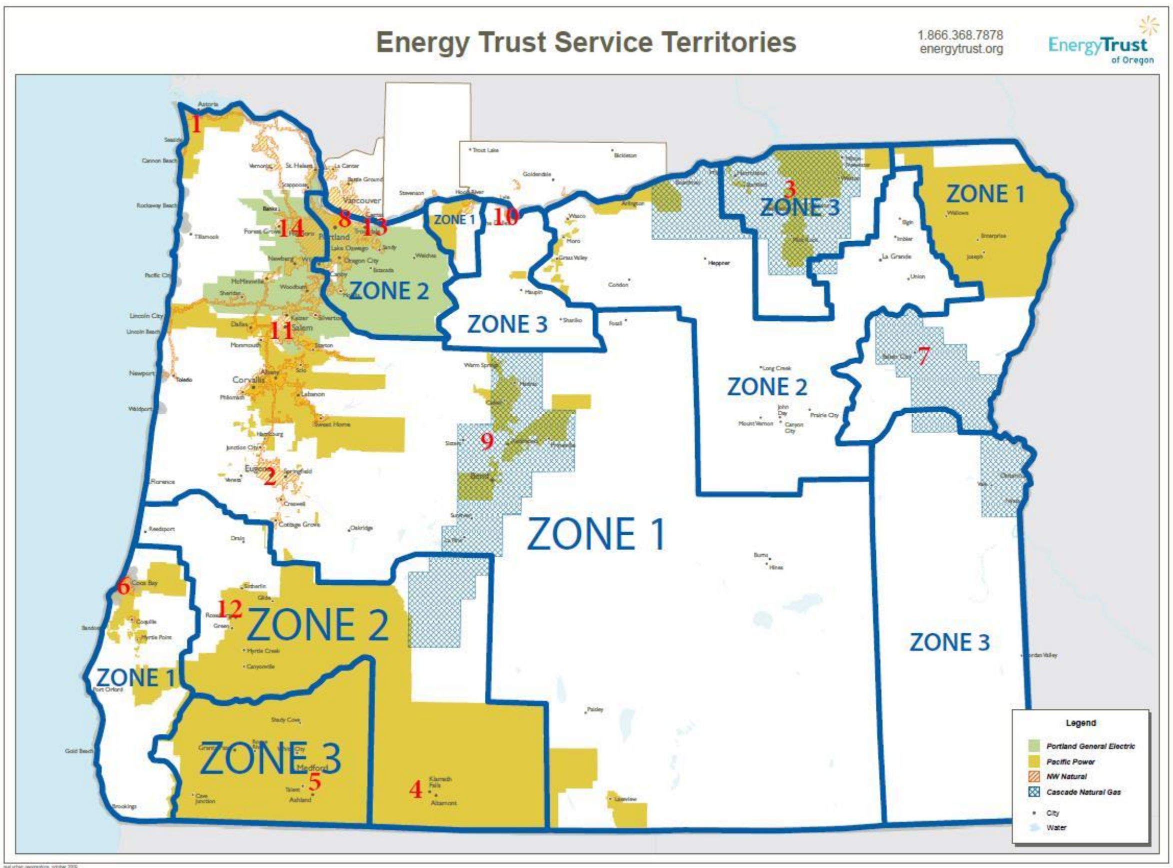
	Single Family Homes	Manufactured Homes
Cooling Zone 1 (All of Regions 1 and 3 plus Columbia, Washington, Hood River, Jefferson, Wheeler, Crook, Deschutes, Lake, Wallowa, Baker, Harney Counties)	57.7%	59.5%
Cooling Zone 2 (Multnomah, Clackamas, Douglas, Sherman, Gilliam, Morrow, Klamath, Union, Grant Counties)	55.4%	66.8%
Cooling Zone 3 (Josephine, Jackson, Malheur, Wasco, and Umatilla Counties)	90.7%	76.9%
All Cooling Zones (Oregon)	67.9%	67.7%

Source: https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf, p. 41

The Northwest Power and Conservation Council (http://www.nwcouncil.org) defines cooling zones in terms of annual cooling degree-days, derived by subtracting 65 degrees from the daily average temperature. Days with average temperatures at or below 65 degrees are not cooling-degree days. Cooling Zone 1 is defined as having fewer than 300 cooling degree-days annually; Cooling Zone 2 is defined as having 300 to 600 cooling degree-days annually; and Cooling Zone 3 is defined as having more than 600 cooling degree-days annually. **Figure 2-65** and **Table 2-40** display Cooling Zones for each Oregon county according to Energy Trust of Oregon (2017).

Air-conditioning penetration is highest (91%) in Cooling Zone 3, which includes Josephine, Jackson, Malheur, Wasco, and Umatilla counties—the places accustomed to extreme heat. Just more than half of single-family homes in Cooling Zones 1 (58%) and 2 (55%) have air-conditioning. Even though Cooling Zone 3 counties have high probabilities of extreme heat events occurring, those locations are also more accustomed and prepared for extreme heat. Other areas of Oregon can experience extreme heat—and can expect to experience extreme heat with greater frequency under climate change—yet about half of homes in Cooling Zones 1 and 2 don't have cooling systems in place, making those counties more vulnerable in terms of adaptive capacity to extreme heat events than counties in Cooling Zone 3.

Figure 2-65. Cooling Zones



Note: Red numerals indicate weather station numbers.

Source: Energy Trust of Oregon, https://www.energytrust.org/wp-content/uploads/2018/06/AC-Research_PhaseII_9MAR2018_Final.pdf

Rankings for this adaptive capacity measure were determined by quintiles of percent of single-family homes with cooling systems. For example, cooling zones with 0 to 20% of single-family homes with air-conditioning were assigned a score of 5 meaning that adaptive capacity is very low (meaning higher vulnerability). Cooling zones 1 and 2 had between 40% and 60% of single-family homes with air-conditioning and counties in those zones ranked at a 3 for "moderate" adaptive capacity. Cooling zone 3 had between 80% and 100% of single-family homes with air-conditioning and counties in that zone ranked at a 1 for "very high" adaptive capacity (meaning lower vulnerability). Adaptive capacity rankings for each county are shown in column 2 in **Table 2-41**.

Table 2-41. Adaptive Capacity Rankings

Quantile Range	Adaptive Capacity	Rank	Vulnerability
0.0–0.2	Very Low	5	Very High
0.2–0.4	Low	4	High
0.4–0.6	Moderate	3	Moderate
0.6–0.8	High	2	Low
0.8–1.0	Very High	1	Very Low

Methodology and Results

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1-2 earned a ranking of 1 (very low); scores of 3-4 earned a ranking of 2 (low); scores of 5-6 earned a ranking of 3 (moderate); scores of 7-8 earned a ranking of 4 (high); and scores of 9-10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region rounded to the nearest whole number **Table 2-42** displays the vulnerability rankings as well as rankings for sensitivity and adaptive capacity for each county and NHMP region.

Relative vulnerability is low in Region 2, high in Region 3, and moderate throughout the rest of the state. It is notable that while the vulnerability scores are moderate for Regions 5, 6 and 8 and high for Region 3, they are the only regions that have counties with very high sensitivity: Marion County (Region 3); Morrow, Umatilla, and Wasco Counties (Region 5); Jefferson and Klamath Counties (Region 6); and Malheur County (Region 8). Adaptive capacity is ranked 1 (very low vulnerability) in five counties and moderate in the rest; no counties rank 4 or 5 (very high vulnerability) for adaptive capacity. The high and very high sensitivity scores are tempered by very low and moderate adaptive capacity scores, resulting in primarily moderate vulnerability scores.

According to this method of assessing vulnerability, Region 3 is the most vulnerable overall to extreme heat, and Coos, Linn, Marion, Yamhill, Douglas, Morrow, Jefferson, Klamath, and Lake Counties are the counties most vulnerable to extreme heat statewide.

Table 2-42. Relative Vulnerability Rankings for Oregon Counties and Regions

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 1	**3**	**3**	**3**
Clatsop	2	3	3
Coos	4	3	4
Curry	2	3	3
Lincoln	3	3	3
Tillamook	2	3	3
Region 2	**2**	**3**	**2**
Clackamas	1	3	2
Columbia	1	3	2
Multnomah	3	3	3
Washington	1	3	2
Region 3	**4**	**3**	**4**
Benton	2	3	3
Lane	3	3	3
Linn	4	3	4
Marion	5	3	4
Polk	3	3	3
Yamhill	4	3	4
Region 4	**4**	**2**	**3**
Douglas	4	3	4
Jackson	4	1	3
Josephine	4	1	3
Region 5	**3**	**2**	**3**
Gilliam	1	3	2
Hood River	3	3	3
Morrow	5	3	4
Sherman	1	3	2
Umatilla	5	1	3
Wasco	5	1	3
Region 6	**3**	**3**	**3**
Crook	3	3	3
Deschutes	1	3	2
Jefferson	5	3	4
Klamath	5	3	4
Lake	4	3	4
Wheeler	1	3	2
Region 7	**2**	**3**	**3**
Baker	2	3	3
Grant	1	3	2
Union	2	3	3
Wallowa	2	3	3
Region 8	**4**	**2**	**3**
Harney	3	3	3
Malheur	5	1	3

Source: Oregon Climate Change Research Institute

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

This is the first time the Oregon NHMP has addressed extreme heat. The state has not collected or developed statewide data on the potential dollar loss to state assets from extreme heat. This may be developed through a vulnerability assessment proposed for implementation of the draft, updated Climate Change Adaptation Framework.

ODOT has determined that of its assets, roadways are most vulnerable to damage from extreme heat. Impacts include rutting and cracking; pavement preservation, rehabilitation, and reconstruction are the most cost-effective mitigation measures.

In January 2020, ODOT published a brochure, *Adapting Oregon's Transportation Infrastructure to Extreme Weather and Climate Change Most Vulnerable Jurisdictions*, which states:

The Oregon Department of Transportation (ODOT) is planning for and assessing projected climate impacts on the state's transportation infrastructure and operations. A series of resilience pilot studies have increased our understanding of climate risks, impacts, and potential solutions...Later this year ODOT will begin work on a Statewide Climate Change Vulnerability Assessment to create a roadmap for the actions and investments necessary to adapt to a changing climate and keep the transportation system functional. This assessment will consider extreme weather hazards, current asset conditions, and future climate projections and will inform future priority investments to enhance the resiliency of the transportation system.

ODOT estimates that an additional $25M/year could be targeted to pavement preservation from in parts of central and eastern Oregon. This amount is considered a proxy for the potential dollar loss to roadways from extreme heat.

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. None of these losses was due to extreme heat.

DAS's records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

2.2.4.4 Risk

With respect to extreme heat, risk is defined as the combination of the likelihood of occurrence of extreme heat events (probability) and vulnerability to extreme heat (which includes sensitivity and adaptive capacity).

The relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability (**Figure 2-63** and **Table 2-43**, column 2) and vulnerability (**Table 2-43**, column 3). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1-2 earned a ranking of 1; scores of 3-4 earned a ranking of 2; scores of 5-6 earned a ranking of 3; scores of 7-8 earned a ranking of 4; and scores of 9-10 earned a ranking of 5. Rankings for NHMP regions are averages of the counties within a region rounded to the nearest whole number. **Table 2-43** displays the relative risk rankings as well as the rankings for relative probability and relative vulnerability for each county and NHMP region.

Region 4, Region 5, and Region 8 face the greatest risk from extreme heat. Morrow County alone (Region 5) is at very high risk. The counties at high risk are: Linn, Yamhill, Douglas, Jackson, Josephine, Gilliam, Sherman, Umatilla, Wasco, Crook, Jefferson, Lake, Baker, Harney, and Malheur.

Table 2-43. Risk Rankings for Oregon Counties and Regions

County	Probability	Vulnerability	Risk
Region 1	**1**	**3**	**2**
Clatsop	1	3	2
Coos	1	4	3
Curry	1	3	2
Lincoln	1	3	2
Tillamook	1	3	2
Region 2	**2**	**2**	**2**
Clackamas	1	2	2
Columbia	1	2	2
Multnomah	3	3	3
Washington	2	2	2
Region 3	**3**	**4**	**3**
Benton	3	3	3
Lane	3	3	3
Linn	3	4	4
Marion	2	4	3
Polk	3	3	3
Yamhill	3	4	4
Region 4	**4**	**3**	**4**
Douglas	4	4	4
Jackson	4	3	4
Josephine	5	3	4
Region 5	**4**	**3**	**4**
Gilliam	5	2	4
Hood River	1	3	2
Morrow	5	4	5
Sherman	5	2	4
Umatilla	5	3	4
Wasco	5	3	4
Region 6	**3**	**3**	**3**
Crook	4	3	4
Deschutes	2	2	2
Jefferson	4	4	4
Klamath	2	4	3
Lake	3	4	4
Wheeler	4	2	3
Region 7	**3**	**3**	**3**
Baker	4	3	4
Grant	2	2	2
Union	2	3	3
Wallowa	2	3	3
Region 8	**5**	**3**	**4**
Harney	4	3	4
Malheur	5	3	4

Source: Oregon Climate Change Research Institute

2.2.5 Floods

Floods are a common and widespread natural hazard in Oregon; the state has an extensive history of flooding. Flooding typically results from large-scale weather systems that generate prolonged rainfall or rain-on-snow events that result in large amounts of runoff. Other sources of flooding include flash floods associated with locally intense thunderstorms, channel migration, ice or debris jams, and, much less frequently, dam failures.

The National Flood Insurance Program (NFIP) identifies 252 communities in Oregon as flood-prone including locations in all 36 counties, 213 cities, and three Tribal Nations. Every county and all but one of these flood-prone cities participates in the NFIP, allowing residents to purchase NFIP flood insurance. Nine additional cities for which FEMA has not mapped Special Flood Hazard Areas also belong to the NFIP, indicating that they believe a flood hazard exists within their jurisdiction and that their residents should have access to NFIP flood insurance.

2.2.5.1 Analysis and Characterization

History of Flooding in Oregon

Oregon has an extensive history of flooding. **Table 2-44** summarizes major floods within the state. Oregon's deadliest recorded flood occurred in Heppner in 1903 when a June 14th storm dropped 1.5 inches of rain within a twenty-minute period. The storm was centered in the headwaters area of Willow Creek above Heppner in Northeastern Oregon. Within minutes, a five-foot wall of water and debris poured through Heppner with enough velocity to rip homes off foundations. These floodwaters claimed 247 lives.

Another late spring flood in 1948 is best remembered for destroying the entire city of Vanport (now Delta Park). Record flow levels on the Columbia River caused the structural failure of a dike. Much of Vanport was destroyed in minutes and was never rebuilt. Nineteen thousand people lost their homes and eighteen people lost their lives.

Many of Oregon's floods of records occurred in December 1964 and January 1965 during the "Christmas Flood." Damage from these floods totaled over $157 million dollars and twenty Oregonians lost their lives. From December 20 through 24, 1964, the most severe rainstorm to occur in Central Oregon and one of the most severe west of the Cascades left many areas with two thirds their normal annual rainfall in five days. The ensuing floods destroyed hundreds of homes and businesses, forced the evacuation of thousands of people, destroyed at least 30 bridges, and washed out hundreds of miles of roads and highways.

A similar flood event occurred in February 1996. Following an extended period of unseasonably cold weather and heavy snowfall in the Pacific Northwest, warming temperatures and rain began thawing the snowpack and frozen rivers throughout Oregon. On February 6, a strong subtropical jet stream or "Pineapple Express" reached Oregon. This warm, humid air mass brought record rainfall amounts, quickly melting the snowpack. At least twenty-five rivers reached flood stage. Many reached flood levels comparable to those reached in the 1964 flood. Twenty-seven of Oregon's 36 counties were eventually covered by a Presidential major disaster declaration due to this event. Statewide, damages totaled over $280 million.

A series of powerful wind and rain storms caused extensive flooding in northwestern in December of 2007. Three people were killed as a result of these storms. The City of Vernonia was hard hit with over 200 buildings substantially damaged and subsequently elevated or bought-out by FEMA.

Types of Flooding

Riverine: Riverine flooding is the most common flood hazard in Oregon. It is caused by the passage of a larger quantity of water than can be contained within the normal stream channel. The increased stream flow is usually caused by heavy rainfall over a period of several days. Examples of riverine events are the flooding in December 2007, February 1996, and December 1964 to January 1965. The most severe flooding conditions occur, however, when heavy rainfall is augmented by rapid snowmelt. These rain-on-snow events occur on mountain slopes within the low elevation snow zones of the Pacific Northwest. These events make more water available for runoff than does precipitation alone by melting the snowpack and by adding a small amount of condensate to the snowpack (Van Heeswijk, Kimball, & Marks, 1996). If the ground is frozen, stream flow can be increased even more by the inability of the soil to absorb additional runoff. Rain falling on snow also is a major cause of mid-winter avalanches, which tend to coincide with flood events. Significant rain-on-snow events occur in years that are colder and wetter than normal because snow accumulates at lower elevations, and then is melted off during subsequent rain events (Ferguson, 2000). Rain-on-snow events, including those that occurred in 1894, 1948, 1964, 1977, and 1996 (**Table 2-45**), are associated with some of the State's most damaging floods.

Flash floods: Flash flooding is caused by extremely intense rainfall over a short period of time, commonly within a single drainage. Flash floods usually occur in the summer during the thunderstorm season. The two key contributors to flash flooding are rainfall intensity and duration. Topography, soil conditions, and ground cover also impact flooding. Flash floods, because of their intensity, often pick up large loads of sediment and other solid materials. In these situations, a flash flood may arrive as a fast moving wall of debris, mud, and water.

Occasionally, floating debris or ice accumulates at a natural or man-made obstruction and restrict the flow of water. Water held back by the ice jam or debris dam can cause flooding upstream. Subsequent flash flooding can occur downstream if the obstruction suddenly releases. Areas subject to flash floods are not as obvious as a typical riverine floodplain. However, flash floods may be associated with recognizable locations such as canyons or arroyos. There is also always some potential for flash floods associated with dam failure.

The most notorious flash flood in Oregon was the June 14, 1903, event in Heppner summarized previously. More recent flash floods have occurred in Wallowa Co. (July 2002) and the City of Rufus (August 2003).

Alluvial fan flooding: 44 CFR Part 59.1 defines alluvial fan flooding as flooding occurring on the surface of an alluvial fan. Alluvial fans are fan-shaped deposits of water-transported material (alluvium) that typically form at the base of steep topographic features where there is a marked break in slope. FEMA notes that alluvial fans can make attractive, but dangerous, development sites. Attractive because they provide commanding views and good drainage, but dangerous because flood flows can happen quickly over unpredictable flow paths, at high velocity, and carry large amounts of debris (Federal Emergency Management Agency [FEMA], 1989). The potential for this type of flooding in Oregon is unstudied and past events (if any) have been poorly documented.

Coastal floods: Coastal areas have additional flood hazards. Winds generated by tropical storms or intense offshore low-pressure systems can drive ocean water inland and cause significant flooding. The height of storm surge is dependent on the wind velocity, water depth and the length of open water (the fetch) over which the wind is flowing. Storm surges are also affected by the shape of the coastline and by the height of tides.

Coastal flooding also may result from tsunamis. A tsunami is a series of traveling ocean waves generated by an earthquake or landslide that occurs below or on the ocean floor. Oregon's seven coastal counties and many coastal cities are susceptible to flood damage associated with tsunamis. Both "distant" tsunamis generated from seismic events in the Pacific basin and "near shore" tsunamis generated from activity associated with the Cascadia Subduction Zone can impact Oregon's coast. For more information, see the Tsunami chapter of this Plan.

Shallow area flooding: Some areas are characterized by FEMA as being subject to shallow flooding. These are areas that are predicted to be inundated by the 100-year flood with flood depths of one to three feet. Flooding events are expected to be low velocity events characterized by "sheet flows" of water.

Urban flooding: As land is converted from fields or woodlands to roads, roofs, and parking lots, it loses its ability to absorb rainfall. This transition from pervious surfaces to impervious surfaces results in more and faster runoff of water. During periods of urban flooding, streets can become swift moving rivers, and basements can fill with water. Storm drains may back up with yard waste, causing additional nuisance flooding.

Playa flooding: Playa flooding results from greater than normal runoff into a closed basin. Closed basin systems are those areas that have one or more rivers emptying into one or more lakes that have no outlet. In these situations, water can only leave the system through evaporation. Thus, if annual precipitation in the basin increases significantly, evaporation is not enough to reduce water levels. Lake levels rise and inundate the surrounding properties.

The best-known example of playa basin flooding in Oregon occurs at Malheur and Harney lakes in Harney County. In higher than average precipitation years, the lakes flood adjacent ranches and public roads. Malheur and Harney lakes flooded during the years 1979 to 1986, and then gradually receded. During the wetter years of 1997 to 1999, these lakes again flooded. By 2005, following a number of dry years, they had receded significantly. In spring 2011, as a result of a heavy snowpack and persistent rainfall, Harney Lake's water level increased significantly with flooding observed in low-lying areas.

Ice jams: Ice jams happen in colder regions of the State during winter and early spring while rivers are frozen. Sudden warming at higher altitudes melts snow resulting in increased runoff which breaks the ice from reaches of frozen river below. On the way downstream, the floating ice can "jam" in a narrow reach of the drainage or against a road crossing which then dams melting water. As the ice weakens, water breaches the dam releasing a torrent of water.

Dam failure: Dam failures and accidents, though rare, can result in extreme flooding downstream of the dam. Catastrophic dam failures have occurred in other parts of the country and around the world. The South Fork Dam failure (1889 Johnstown flood) resulted in over 2000 fatalities in western Pennsylvania. The Saint Francis Dam in southern California failed in 1928 with a loss of an estimated 600 people. Oregon's dam safety statutes (ORS 540.350 through 400) came into effect shortly after the Saint Francis disaster. Many historical dam failures were triggered by flood events, others by poor dam construction, and some have been triggered by earthquakes.

Channel Migration in Association with Flooding

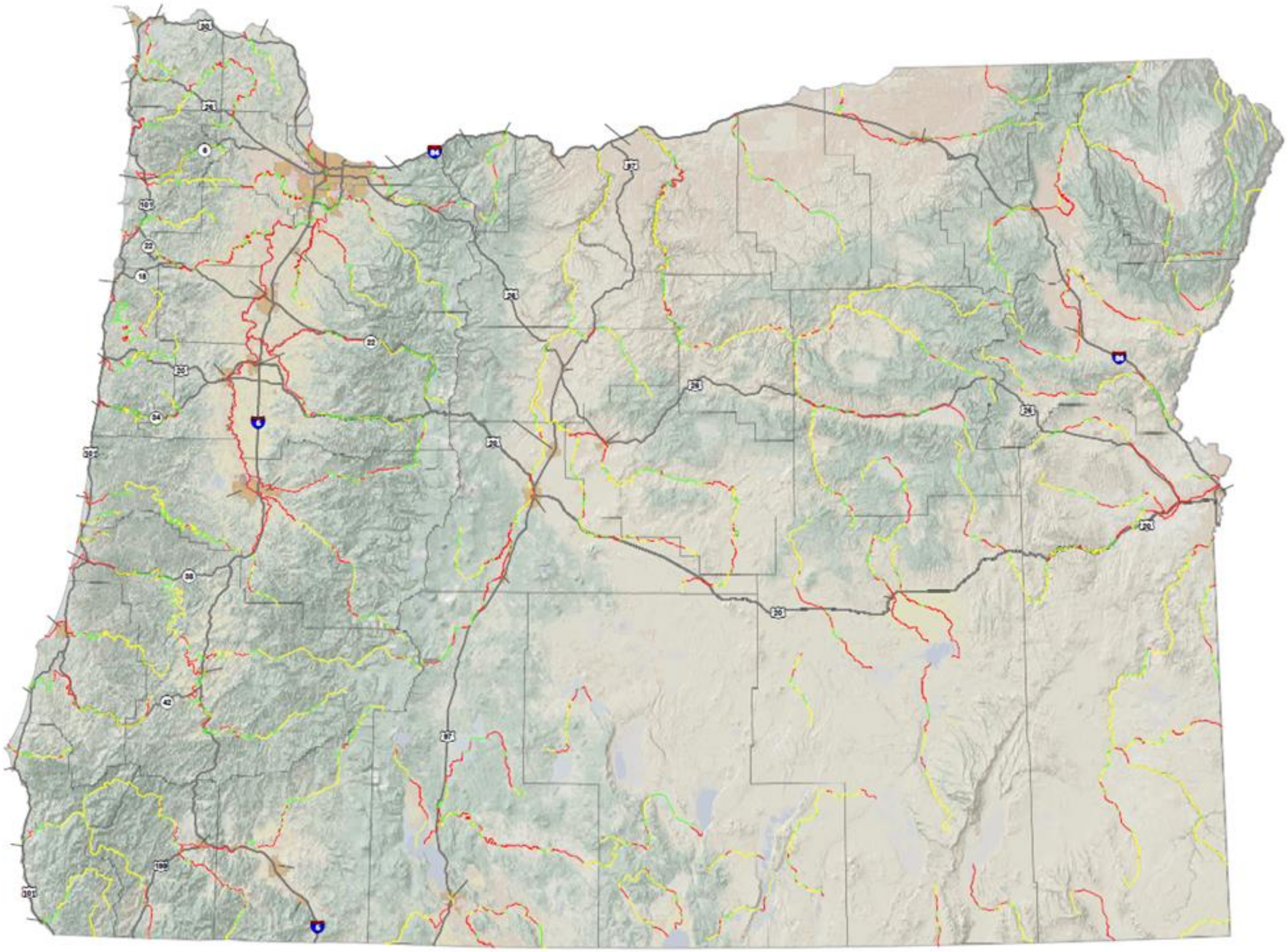
Channel migration is the process by which streams move laterally over time. It is typically a gradual phenomenon that takes place over many years due to natural processes of erosion and deposition. In some cases, usually associated with flood events, significant channel migration can happen rapidly. In high flood flow events stream channels can "avulse" and shift to occupy a completely new channel.

Areas most susceptible to channel migration are transitional zones where steep channels flow from foothills into broad, flat floodplains. The most common physiographic characteristics of a landscape prone to channel migration include moderate channel steepness, moderate to low channel confinement (i.e., valley broadness), and erodible geology.

Channel migration can and has created hazardous conditions within Oregon's developed riparian areas. Rapid migration can undercut structure foundations and damage infrastructure. The upper Sandy River in eastern Clackamas County is an example of where channel migration and development intersect. A recent January 2011 flood resulted in temporary avulsion that washed out section of Lolo Pass Road and also bank erosion that damaged and destroyed several homes.

Channel migration is not a standard consideration of the NFIP and has not been mapped systematically in Oregon. DOGAMI has recently completed a statewide channel migration screening for major rivers in Oregon (Roberts & Anthony, 2017). This study classified nearly 7,000 river miles into high, medium, and low potential susceptibility to channel migration based on river and valley characteristics. DOGAMI selected and is currently mapping detailed channel migration zones in four counties in Oregon based on the results of the 2017 screening. The screening will continue to be used to prioritize future detailed channel migration zone mapping as funding becomes available.

Figure 2-66. Channel migration screening overview map of Oregon showing major rivers with low (yellow), moderate (green), and high (red) susceptibility.



Source: Roberts & Anthony (2017)

The El Niño Southern Oscillation (ENSO) Cycle

- El Niño and La Niña are opposite phases of what is known as the El Niño-Southern Oscillation (ENSO) cycle. The ENSO cycle is a scientific term that describes the fluctuations in temperature between the ocean and atmosphere in the east-central Equatorial Pacific.
- La Niña is sometimes referred to as the cold phase of ENSO and El Niño as the warm phase of ENSO. These deviations from normal surface temperatures can have large-scale impacts not only on ocean processes, but also on global weather and climate.
- El Niño and La Niña episodes typically last nine to 12 months, but some prolonged events may last for years. They often begin to form between June and August, reach peak strength between December and April, and then decay between May and July of the following year.
- While their periodicity can be quite irregular, El Niño and La Niña events occur about every 3 to 5 years. Typically, El Niño occurs more frequently than La Niña.

Source: NOAA, What are El Niño and La Niña?, http://oceanservice.noaa.gov/facts/ninonina.html

El Niño and La Niña Events in Oregon and Relationship to Flooding

One of the most prominent aspects of Oregon's weather and climate is its variability. This variability ranges over many time and space scales, from small-scale phenomena such as wind gusts and localized thunderstorms, to larger-scale features like fronts and storms, to even more prolonged features such as droughts and periods of flooding. Fluctuations occur on multi-seasonal, multi-year, multi-decade and even multi-century time scales. Examples of these longer time-scale fluctuations include an abnormally hot and dry summer, an abnormally cold and snowy winter, a consecutive series of abnormally mild or exceptionally severe winters, and even a mild winter followed by a severe winter. Human inputs into our geophysical environment are also imposing cumulative impacts with measurable changes to global climate, sea-level and even localized weather. These human inputs along with the normal climate cycles may be working together in unpredictable ways and lead to future climate scenarios that do not resemble past, historic cycles. Under a warming climate, while it is still uncertain exactly how ENSO variability may change, recent research is more confident that the relationships between ENSO and its impacts around the globe will be stronger.

The terms El Niño and La Niña represent opposite extremes of the ENSO cycle in an otherwise continuum of global climate events, with "average" conditions generally prevailing between those extremes. In the past three decades there have been several El Niños, with the 1982 to 1983 and 1997 to 1998 events having been the strongest on record, while the period between 1990 and 1995 was characterized by persistent El Niño conditions, the longest on record (Trenberth, 1999).

Table 2-44. Recent ENSO Events in Oregon

El Niño Events	La Niña Events
1982-1983	1988-1989
1994-1995	1995-1996
1997-1998	1999-2000
2002-2003	
2004-2005	
2006-2007	2007-2009
2009-2010	2010-2012
2014-2016	2016
	2017-2018
2018-2019	La Niña Events

Source: NOAA, Multivariate ENSO Index (MEI) http://www.esrl.noaa.gov/psd/enso/mei/ and https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

In general, the longer time-scale phenomena are associated with changes in oceanic and atmospheric circulation that encompass areas far larger than a particular affected region. At times, these persistent features occur simultaneously over vast, and seemingly unrelated, parts of the hemisphere, or even the globe, resulting in abnormal weather, temperature, and rainfall patterns throughout the world. During the past several decades, scientists have discovered that important aspects of this interannual variability in global weather patterns are linked to a global-scale, naturally occurring phenomenon known as the El Niño Southern Oscillation (ENSO) cycle. A measure of this cycle is the Southern Oscillation Index (SOI), which is "calculated from the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin, Australia."

Historical El Niño and La Niña events in Oregon

The earliest systematic study of ENSO in the Northwest was by Redmond and Koch (1991). The results were sufficiently strong that the authors suggested a cause-effect relationship between the SOI and Oregon weather. They determined that the Southern Oscillation Index (SOI) can be used as a predictor for weather, especially for winter weather. Greatest correlations between SOI and winter weather patterns occur with about a four-month time lag with summer average SOI correlating well with weather in the Northwest during the following winter. SOI values less than zero represent El Niño conditions, near zero values are average, and positive values represent La Niña conditions.

In Oregon El Niño impacts associated with these climate features generally include warmer winter temperatures and reduced precipitation with drought conditions in extreme events.

What Oregonians should especially plan for and monitor, however, is La Niña. Severe flooding during the winters of 1995-96, 1998-99, and 2007-08 are attributable largely to the combination of heavy snows and warm, intense tropical rain. During La Niña events, heavy rain arrives in Oregon from the western tropical Pacific, where ocean temperatures are well above normal, causing greater evaporation, more extensive clouds, and a greater push of clouds across the Pacific toward Oregon. During February 1996, for example, severe flooding — the worst in the state since 1964 — killed several people and caused widespread property damage. Nearly every river in Oregon reached or exceeded flood stage, some setting all-time records. Debris flows and landslides were also numerous. (Note that debris flow events are typically associated with periods of heavy rainfall or rapid snowmelt on steeply sloping ground. The term "mudslide" is often used interchangeably but is poorly defined as a natural hazard. FEMA uses the terms "mudslide" and "mudflow" in the context of the National Flood Insurance Program, e.g., 44 CFR 59.1 and 206.2(a)(17).)

Historic Flood Events

Table 2-45 lists historic damaging floods in Oregon.

Table 2-45. Historic Damaging Floods in Oregon

Date	Location	Notes
Sep. 1861	Klamath, Willamette, and Umpqua	Klamath, Douglas, Lane, Linn, Benton, Marion, Polk, Yamhill, Clackamas, Multnomah Counties
June 1880	Columbia	Clatsop, Columbia, Multnomah, Hood River, Sherman, Gilliam, Morrow
Jan. 1881	Willamette Basin	Lane, Linn, Benton, Marion, Polk, Yamhill, Clackamas, Multnomah Counties
Dec. 1882	Umatilla	Umatilla County
June 1884	John Day	Grant, Wheeler, Wasco, Sherman Gilliam
May-June 1894	Columbia River Basin	Clatsop, Columbia, Multnomah, Hood River, Sherman, Gilliam, Morrow; rain on snowpack; highest flood stage ever recorded at Vancouver, Washington (33.6 ft)
June 1903	Willow Creek	flash flood in Heppner; 247 people killed
Apr. 1904	Silvies and Klamath	Harney, Klamath Counties
Feb. 1907	western Oregon and John Day	Grant, Wheeler, Wasco, Sherman, Gilliam
Nov. 1909	Deschutes, Willamette, Santiam, Umpqua, Coquille, and Rogue	Deschutes, Jefferson, Wasco, Linn, Douglas, Coos, Curry, Josephine, Jackson
Mar. 1910	Powder and Malheur	Baker, Malheur, Harney
June 1913	Columbia	Clatsop, Columbia, Multnomah, Hood River, Sherman, Gilliam, Morrow
Jan. 1923	Clackamas, Santiam, Sandy, Deschutes, Hood, and McKenzie	Clackamas, Linn, Multnomah, Deschutes, Jefferson, Wasco, Hood River, Lane Counties; record flood levels
Feb. 1925	Malheur	Malheur, Harney
Feb. 1927	Klamath, Willamette, Umpqua, Rogue, and Illinois	major flooding
May 1928	Columbia	Clatsop, Columbia, Multnomah, Hood River, Sherman, Gilliam, Morrow
Mar. 1931	Umatilla, Sandy, Clackamas, and Santiam	Umatilla, Clackamas, Multnomah, Linn
Mar. 1932	Malheur, Grande Ronde, John Day, and Umpqua	Malheur, Harney, Union, Wallowa, Grant, Wheeler, Wasco, Sherman, Gilliam, Douglas
Jan. 1933	Coquille	Coos County
Nov.–Dec. 1942	Willamette Basin	Lane, Linn, Benton, Clackamas, Multnomah; 10 deaths; $34 million damage
Dec. 1945	Coquille, Santiam, Rogue, and McKenzie	Coos, Linn, Jackson, Josephine, Curry and Lane Counties; 9 deaths and homes destroyed in Eugene area
Dec. 1946	Willamette, Clackamas, Luckiamute, and Santiam	
May - June 1948	Columbia River	Multnomah County, Wasco County; rain on snow; destruction of the City of Vanport
Mar. 1952	Malheur, Grand Ronde, and John Day	Malheur, Harney, Union, Wallowa, Grant, Wheeler, Wasco, Sherman, Gilliam counties; highest flood stages on these rivers in 40 years
Dec. 1955	Rogue, Umpqua, Coquille	DR-49. Jackson, Josephine, Curry, Douglas, Coos Counties; 11 deaths; major property damage

Date	Location	Notes
July 1956	central Oregon	DR-60. City of Mount Vernon, Grant County and City of Mitchell, Wheeler County; flash floods
Feb. 1957	SE Oregon	DR-69. $ Malheur, Baker, Wallowa Counties; 3.2 million in flood damages
Dec. 1961	Willamette Basin	Lane, Linn, Benton, Clackamas, Multnomah; $3.8 million in flood damages
Dec. 1964–Jan. 1965	Pacific Northwest	DR-184. All 36 counties; rain on snow; record flood on many rivers
Dec. 1967	central Oregon coast	Clatsop, Tillamook, Lincoln Counties; storm surge
Feb 1971	north coast	DR-301. Clatsop and Tillamook counties
Jan. 1972	western Oregon	DR-319. Clackamas, Clatsop, Coos, Douglas, Lane, Lincoln, Linn, Multnomah, Tillamook, Washington counties; record flows on coastal rivers
Jan. 1974	western Oregon	DR-413. Benton, Clackamas, Columbia, Coos, Curry, Douglas, Gilliam, Hood River, Jackson, Josephine, Lane, Lincoln, Marion, Polk, Tillamook, Wallowa, Wasco, Washington, Yamhill counties; $65 million in damages
Nov. –Dec. 1977	western Oregon	Multnomah, Clackamas counties; rain-on-snow event; $16.5 million in damages
1979 to present	Harney County	cyclical playa flooding on Harney and Malheur lakes
Dec. 1981	Umpqua and Coquille	Douglas and Coos Counties
Jan. 1982	Tillamook County	
Feb. 1982	Malheur and Owyhee Basins	Malheur and Harney Counties
Jan. 1990	Clatsop and Tillamook Counties	DR-853
July 1995	Fifteenmile Creek	DR-1061. Flash flood in Wasco County.
Feb. 1996	nearly statewide	DR-1099. Benton, Clackamas, Clatsop, Columbia, Coos, Deschutes, Douglas, Gilliam, Hood River, Jefferson, Josephine, Lane, Lincoln, Linn, Marion, Morrow, Multnomah, Polk, Sherman, Tillamook, Umatilla, Union, Wallowa, Wasco, Washington, Yamhill counties; damages totaling over $280 million
Nov. 1996	SW Oregon	DR-1149. Flooding, landslides, and debris flows; eight deaths in Douglas, Coos, and Lane Counties
Jan. 1997	SW and NE Oregon	DR-1160. Coos, Jackson, Josephine, Baker, Grant, Wallowa, Gilliam, Morrow, Umatilla, Wheeler, and Lake Counties
May–June 1998	Crook County and Prineville	DR-1221. Ochoco River
Dec. 1998	Lincoln and Tillamook Counties	
Nov. 1999	Coastal rivers in Lincoln and Tillamook Counties	heavy rainfall and high tides
Jan. 2000	Curry, Douglas, and Josephine Counties	A Flood Warning was issued for the South fork of the Coquille River from Myrtle Point to Coquille City, North and South Forks of the Coquille River. Brookings recorded 4.72 inches of rain, a record for the date. Two Small Stream Flood Advisories were issued, the first for Elk Creek, the second for Deer Creek. A Flood Warning was issued for the lower Rogue River from Agness to Gold Beach.
Feb. 2000	Coos County	A Flood Warning was issued for the South Fork of the Coquille River at Myrtle Point
July 2000	Deschutes County	A slow moving thunderstorm with heavy rain flooded the Becky Johnson Community Center and Health Clinic Campus.

Date	Location	Notes
Sept. 2000	Clackamas County	Heavy rain, estimated at 3 inches in places, plus glacial melt associated with abnormally warm temperatures, acted together to trigger floods and rock and mud slides on the western slopes of Mount Hood.
Apr. 2001	Wheeler	A slow moving thunderstorm produced an estimated 1 inch of rain over mountainous terrain in southeastern Wheeler County.
June 2001	Grant County	The Oregon Dept. of Transportation reported flash flooding on State Highway 26
July 2001	Douglas, Deschutes, and Lake Counties	A Flash Flood Warning was issued for East Central Douglas county. The Boulder Creek area was of special concern. A heavy slow moving thunderstorm dumped one inch of rain in one hour over Sunriver. Lakeview Police reported rock and/or mudslides on State Highway 140 at mileposts 22, 23.2, and 25.1. They also reported 0.25-inch hail up to an inch deep and 2 feet of water in spots on the same highway.
June 2002	Baker and Malheur Counties	Slow-moving thunderstorms dropped very heavy rainfall over the Rye Valley area near the Baker-Malheur County line.
July 2002	Wallowa County	flash flood above Wallowa Lake damaged Boy Scout Camp facility
August 2003	City of Rufus, Sherman County	flash flood (Gerking Canyon)
Dec. 2005–Jan. 2006	western and central Oregon,	
Nov. 2006	Clatsop, Hood River, Lincoln, and Tillamook Counties	DR-1672. Heavy precipitation and wind resulted in flooding, landslides, and mudslides (DR-1672)
Feb. 2007	western and central Oregon, and the Confederated Tribes of the Siletz Indians	DR-1683. Benton, Clatsop, Columbia, Lincoln, Polk, Tillamook, Wasco, Wheeler, Yamhill counties; severe winter storm and flooding
Dec. 2007	Northwestern Oregon, Southern Coast	DR-1733. Clatsop, Columbia, Polk, Tillamook, Washington, Yamhill counties; heavy precipitation and wind resulted in flooding, landslides, mudslides, and tree blow down
Dec. 2008	Tillamook County	Flooding caused by convergence of heavy precipitation and high tides
Jan. 2009	Tillamook and Washington Counties	severe winter storm/snow event which included snow, high winds, freezing rain, ice, blizzard conditions, mudslides, and landslide (flooding, post DR-1824)
Jan. 2011	Clackamas, Clatsop, Crook, Douglas, Lincoln, and Tillamook Counties	DR-1956. Severe winter storm, flooding, mudslides, landslides, and debris flows
Apr. 2011	Harney County	widespread basin flooding; Oregon DOT closed and breached U.S. 20 at milepost 132.6 on April 8, 2011, for flood relief; the breach was done at the request of Harney County Emergency Operations Center to avoid damage to nearby residences; larger culverts were later installed
May – June 2011	Union and Grant Counties	melting heavy snowpack caused riverine and playa flooding
June 2011	Heppner	persistent showers with heavy rainfall of 1 to 2 inches produced flooding on Willow and Hinton Creeks; flash flooding on Hinton and Willow Creeks damaged roads, bridges, and the Morrow County Fairgrounds; the Heppner elementary school was evacuated as a precaution
Jan. 2012	Columbia, Hood River, Tillamook, Polk, Marion, Yamhill, Lincoln, Benton, Linn, Lane, Douglas, Coos, and Curry Counties	heavy rain and wind; ice (DR-4055); flooding in the Willamette Valley; 130 homes and seven businesses were damaged in the City of Turner; 21 streets were closed in the City of Salem; the state Motor Pool lost 150 vehicles and thousands of gallons of fuel; Thomas Creek in the City of Scio overtopped, damaging several buildings

Date	Location	Notes
Nov. 2012	Curry, Josephine, and Lane Counties	heavy precipitation; the Curry Coastal Pilot reported over 2 million dollars in infrastructure damage in Brookings and another 2 million in Curry County due to recent heavy rains; sinkholes and overflowing sewage facilities were also reported; according to KVAL news, Eugene Public Works has opened its emergency command center to deal with numerous flooding incidents, including two flooded intersections
Sep. 2013	Multnomah and Tillamook Counties	heavy rain resulted in flooding of the Wilson River near Tillamook as well as urban flooding in the Portland Metro area; KPTV-KPDX Broadcasting reported that heavy rain resulted in flooding and damage to the Legacy Good Samaritan Medical Center and several businesses in Northwest Portland; besides damage to the hospital’s emergency and operating room, some elective surgeries were cancelled
Feb. 2014	Lane, Coos, Marion, and Tillamook Counties	A series of fronts resulted in a prolonged period of rain for Northwest Oregon, and minor flooding of several of the area's rivers from February 12th through February 17th. Heavy rains caused the Coquille River at Coquille to flood. The flood was categorized as a moderate flood. The Nehalem River near Foss in Tillamook County exceeded flood stage on February 18th, 2014.
Feb. 2014	Douglas County	In Jackson County heavy rains caused a brief flood on Little Butte Creek at Eagle Point.
March 2014	Tillamook County	Heavy rain resulted in the Nehalem River to flood near Foss. The river reached flood stage around 2 pm March 6, and crested at 14.8 feet at 8 pm
March 2014	Union, Umatilla, and Grant Counties	Heavy rain fell across much of the northern Blue Mountains and Wallowa County throughout the first week of March. March 9th received very heavy rain with snow levels around 6000 ft. This allowed for a significant increase in runoff, which led to a quick rise in rivers for the period
August 2014	Clackamas County	Heavy rain caused the Sandy River to rapidly rise. A footbridge near Ramona Falls broke loose sending a man into the turbulent waters. The man drowned in the river.
Dec. 2014	Tillamook, Lincoln, Lane, Polk Clackamas, Benton, Coos, and Douglas Counties	A slow moving front produced heavy rain over Northwest Oregon which resulted in the flooding of eight rivers. The rain also caused a couple of land/rock slides that both blocked two highways. Heavy rain brought flooding to several rivers in southwest Oregon.
Feb. 2015	Curry, Coos, Douglas, Josephine, and Jackson Counties	Heavy rains caused flooding on the Rogue River at Agness and along the Coquille River at Coquille.
Nov. 2015	Tillamook County	A very moist frontal system produced heavy rain across the region resulting in flooding. Rain rates of 0.3 to 0.5 inch per hour were observed for several hours at many locations. The 5-day rainfall total ending in the morning on November 17th for Lees Camp, OR was 14.60 inches.

Date	Location	Notes
Dec. 2015	Tillamook, Lincoln, Washington, Clackamas, Multnomah, Lane, Yamhill, Clatsop, Columbia, Hood River, Polk, Coos, Douglas, Jackson, and Curry Counties	DR-4258. A moist Pacific front produced heavy rainfall across Northwest Oregon which resulted in river flooding, urban flooding, small stream flooding, landslides, and a few sink holes. After a wet week (December 5 through Dec 11), several rivers were near bank full ahead of another front on December 12th. Flooding from the Nehalem River and Rock Creek in Vernonia resulted in evacuation of homes and the implementation of the Vernonia Emergency Command Center. Heavy rain resulted in a landslide that closed OR-47 at mile marker 8. More than $15 million dollars in property damage reported in these counties combined.
Jan. 2016	Jackson, Josephine, Curry, and Coos Counties	Heavy rain brought flooding to some areas of southwest Oregon. Minor flooding on the Rogue at Agness and moderate flooding on the Coquille River at Coquille.
March 2016	Coos County	Heavy rains brought flooding to the Coquille River at Coquille
May 2016	Baker County	A strong thunderstorm dumped up to a quarter of an inch of rain over a 15-minute period over terrain scorched by wildfire in August of 2015 causing flash flooding and debris flows.
Oct. 2016	Tillamook County, Northern Oregon Coast	The combination of heavy rain, large swell, and high tides brought minor tidal overflow flooding during high tides to the North Oregon Coast.
Nov. 2016	Columbia, Tillamook, Lincoln, Benton, Washington, Polk, and Yamhill Counties	A moist Pacific front moving slowly across the area produced heavy rainfall, resulting in flooding of several rivers across Northwest Oregon and at least two landslides.
Dec. 2016	Josephine, Jackson, Douglas, Lane, Coos, and Curry Counties	DR-4296. Heavy rain brought some areal flooding to parts of southwest Oregon.
Jan. 2017	Columbia, Deschutes, Hood River, Josephine, Coos, and Curry Counties	An extended period of heavy rain combined with snowmelt to cause flooding of the Coquille River the South Fork of the Coquille River and, the Rogue River flooded at Agness flooded twice that month.
Feb. 2017	Marion, Polk, Yamhill, Washington, Columbia, Benton, Tillamook, Lane, Coos, Curry, Klamath, Wheeler and Malheur Counties	High river flows combined with high tide to flood some areas near the southern Oregon coast. Heavy rain combined with snow melt caused flooding along the Coquille River and the Rogue River twice this month in southwest Oregon. Heavy rain combined with snow melt caused flooding along the Sprague River in south central Oregon. Flows on the John Day river reached flood levels downstream of Monument due to the breaking up of an ice jam.
March 2017	Malheur, Harney, Wallowa, Umatilla, and Wheeler Counties	An extended period of snow melt, combined with a period of heavy rain, caused an extended period of flooding along portions of the John Day River, the Umatilla, and the Silvies Rivers. Flooding occurred on the Snake River near Ontario.
May 2017	Multnomah County and Wallowa County	Heavy rain from a strong thunderstorm in addition to a log jam caused the rapid rise of Oneonta Creek in the Oneonta Gorge. Two hikers were injured in the flash flood. In Wallowa County the Imnaha River at Imnaha had minor flooding early on May 6th, due to snow melt.
June 2017	Umatilla County	In Pendleton, heavy rain caused several small debris flows along Airport Road and several intersections were flooding with water about 5 to 6 inches deep. Rainfall amounts include 1.54 inches of rain at the NWS office at the Pendleton Airport, with 0.88 inch falling in 30 minutes.
Sept. 2017	Baker County	Thunderstorms producing heavy rain over the 2016 Rail Fire burned area on the Wallowa-Whitman National Forest resulted in flash flooding and debris flows.

Date	Location	Notes
Oct. 2017	Tillamook, Benton, and Clackamas Counties	A very potent atmospheric river brought strong winds to the north Oregon Coast and Coast Range on October 21st. What followed was a tremendous amount of rain for some locations along the north Oregon Coast and in the Coast Range, with Lees Camp receiving upwards of 9 inches of rain. All this heavy rain brought the earliest significant Wilson River Flood on record, as well as flooding on several other rivers around the area.
Jan. 2018	Lincoln and Clatsop Counties	A strong stationary low pressure system off the British Columbia coast brought impressively high seas into the Oregon Coast. Wave heights up to 37 feet were recorded at buoys off the coast, with top one-tenth wave heights up to 45 feet. Damaging surf caused severe beach erosion, damaged a couple buildings right along the beach, injured one person, and killed one person.
Feb. 2018	Umatilla County	Two to three inches of rain fell along the west slopes of the Blue Mountains from February 1st through 4th. The increased runoff caused high water levels and minor flooding along the Umatilla and Walla Walla Rivers.
May 2018	Grant and Wallowa Counties	Heavy rain from slow-moving thunderstorms caused rockslides and water on roadways within an area that includes Mount Vernon, John Day and Canyon City
June 2018	Lane County and Baker County	In Lane County an upper-level trough moved across the area from the southwest, generating strong thunderstorms which produced locally heavy rainfall, lightning, hail, and gusty winds. Thunderstorms with heavy rainfall developed over Southwest Baker County on June 20th, leading to flash flooding and debris flow on the Rail and Cornet-Windy Ridge fires' burn scar areas.
Oct. 2018	Morrow County	Moist upslope flow into the Blue Mountains produced heavy rain with rainfall rates of up to one inch per hour and storm total accumulations between one and three inches. Localized flooding was reported near the town of Heppner where water inside a residence forced an evacuation.
Dec. 2018	Tillamook County	A strong low pressure system over the Gulf of Alaska brought a strong cold front through. This generated strong winds across northwest Oregon, and also brought heavy rain which caused flooding on the Tillamook river. Large seas also caused damage in spots along beaches.
Jan. 2019	Coos and Curry Counties	A weekend of very heavy rain led to rivers rising across southern Oregon. The Rogue River at Agness exceeded flood stage and the Coquille River at Coquille flooded as well.
Feb. 2019	Columbia, Washington and Multnomah Counties	Back-to-back low pressure systems dropping south along the coast of British Columbia and Washington brought cold air south into NW Oregon as well as plenty of moisture. There was flooding along Fox Creek in Rainier and 40 county roads in Washington County. In Multnomah County, Northwest Rocky Point Road between U.S. 30 and Skyline Boulevard was closed because of a large crack in the road caused by heavy rains and snowmelt.
Feb. 2019	Douglas, Jefferson, Lane, Coos, and Curry Counties	DR-4432. Very heavy rain along with the melting of recent snowfall caused flooding at several locations in southern Oregon in late February. Deer Creek at Roseburg, South Fork of the Coquille at Myrtle Point, North Fork of the Coquille at Myrtle Point, the Coquille River at Coquille and the Rogue River at Agness all exceeded flood stage.

Date	Location	Notes
April 2019	Lane, Benton, Marion, Clackamas and Linn Counties	DR-4452. Linn County declared. A particularly strong atmospheric river took aim for the south Willamette Valley, sitting over areas south of Salem for two days, producing anywhere from 2.5 to 5 inches of rain over a 48 hour period. Some areas in the Cascades and Cascade Foothills saw 5 to 7 inches of rain over that 48 hour period. Heavy rain combined with snow melt from all the snow from a few weeks prior in this same area caused flooding along most of our rivers in this area as well as along the main-stem Willamette River up to around Oregon City.
April 2019	Douglas, Coos and Curry Counties	DR-4452. Douglas and Curry Counties declared. Two days of very heavy rainfall (compared to April normals) combined with snowmelt led to areal flooding in southwest and south central Oregon.
April 2019	Union, Grant, Umatilla, Wallowa and Wheeler Counties	DR-4452. Grant, Umatilla, and Wheeler Counties declared. Snow water equivalents near 200% of normal in the Blue Mountains coupled with warm temperatures and near record rainfall totals for April produced significant river flooding across eastern Oregon.
April 2019	Wheeler County	Total rainfall of 1.67 inches was recorded just east of Mitchell. This heavy rain over a short period of time triggered a flash flood through Huddleston Heights and Nelson Street, and off of High Street and Rosenbaum with mud and debris blocking roads in and around the town of Mitchell.
July 2019	Deschutes County	Slow moving thunderstorms produced localized flooding and minor mud flows around the Tumalo area during the evening of July 1st.
Aug. 2019	Crook and Wasco Counties	A powerful upper storm system combined with modest low- and mid-level moisture to yield scattered, strong to severe storms and flash flooding. Storms developed first across the higher terrain of central Oregon nearer the Cascades and adjacent Ochoco mountains. Storms then built northward with hail and damaging winds along the way.

Source: NOAA Storm Event Database, (http://www.ncdc.noaa.gov/stormevents/), January 2020; Planning for Natural Hazards: Flood TRG (Technical Resource Guide), July 2000, DLCD, Community Planning Workshop

2.2.5.2 Probability

Flood risk or probability is generally expressed by frequency of occurrence. Since 1960 at least one damaging flood has occurred somewhere in Oregon in 42 of 52 years reported by NOAA (NOAA Storm Events Database, https://www.ncdc.noaa.gov/stormevents/). Probability of flooding is measured as the average recurrence interval of a flood of a given size and place. It is stated as the percent chance that a flood of a certain magnitude or greater will occur at a particular location in any given year.

FEMA's NFIP extends regulation to an area covered by the "base flood," a flood that has a 1% chance of occurring in any year. Flood Insurance Rate Maps depict the inundation area of the 1% annual flood. It is important to recognize, however, that floods occur more frequently near the flooding source. Information regarding the probability of flooding at a given location in the regulated flood zones is provided by Flood Insurance Studies (FIS) for large watersheds. FEMA does not provide information about floods emanating from small watersheds (less than one square mile), or for floods caused by local drainage issues. Probabilities for these types of flood are, as a result, difficult to obtain.

The majority of flood studies in Oregon were conducted in the late 1970s and early 1980s. These studies represent flood risk at a point in time and don't reflect changing conditions in the watershed. Many of Oregon's metropolitan areas have significantly developed during the past twenty years resulting in increased impervious surface which causes higher velocities and increased volume of water. While FEMA's Map Modernization Program did result in updated FIRMs for 14 counties, many of these maps were produced using models from old flood insurance studies. Whether or by how much these old models underestimate current flood potential is unknown.

In 2009 FEMA transitioned from Map Modernization, intended to provide FIRMs in a digital format, to a Risk Mapping, Assessment, and Planning Program (Risk MAP), intended to direct FEMA's investment in new flood models and to provide communities with flood risk management products and services beyond the traditional FIRM. FEMA has initiated Risk MAP watershed-based projects in Clackamas, Clatsop, Curry, Douglas, Harney, Hood River, Jackson, Klamath, Lane, Lincoln, Malheur, and Marion Counties. Not all of these projects will result in new FIRMs. Rather, as part of the Risk MAP program, FEMA will evaluate the need to revised FIRMs based on national metrics. In any case, communities in the studied watersheds are expected to receive non-regulatory mapping products to assist them with floodplain risk management. Mapping projects in Tillamook and Washington Counties, which have yet to receive modernized FIRMs, will be completed under Risk MAP. Effective FIRM dates are presented in each Regional Risk Assessment.

Despite shortcomings of NFIP Flood Insurance Rate Maps, most Oregon communities exclusively rely on them to characterize the risk of flooding. Some jurisdictions use their own flood hazard maps derived from aerial photos of past flood events in conjunction with FEMA FIRMs to better reflect their communities' flood risks. Others have implemented a higher regulatory standard to address changing conditions; for example Metro's balanced cut and fill requirements, and Tillamook County's and the City of Vernonia's requirement that new homes and substantial improvements to existing homes be elevated at least three feet above base flood elevation (BFE).

Base Flood Elevation (BFE)

Base Flood Elevation is the projected depth of floodwater at the peak of a base flood, generally measured as feet above sea level.

Source: DLCD

Channel migration associated with flooding also can be identified with respect to a probability of migration over a period of 100 years. Historic aerial photos are catalogued to calculate past rates of migration which are then projected out to define a channel migration zone. Avulsion (i.e., channel shifting) zones, which are a component of the larger channel migration zone, are an exception to the migration rate approach. Areas of likely avulsion are identified by professional judgment of a fluvial geomorphologist, using high-resolution topographic data, aerial photos, and field observation.

Identification of channel migration susceptibility at the regional level is described in terms of low, moderate, and high relative probabilities. Probability is determined by assessing physiographic parameters of channel gradient, confinement, and pattern.

Probability of Flooding in Each Oregon County

County-level flood probability rankings and statistics were determined by DLCD and DOGAMI using historical flood information. The first step was to compile a list of all recorded floods in Oregon across 146 years of available data, also used to update **Table 2-45**, **Historic Damaging Floods in Oregon**. Data for this list had two sources: DLCD's Technical Resource Guide, Chapter 4, Section 2, Table 1: Historic Flooding in Oregon (Andre, et al., 2001; https://oregonexplorer.info/data_files/OE_topic/hazards/documents/04_flood.pdf), which was used to record events that occurred prior to 2000, and the NOAA Storm Event Database (https://www.ncdc.noaa.gov/stormevents/), which captured events from 2000 to the present. Next the list was organized by counties impacted and by decade and the flood frequency was used to calculate the average time between recorded events, or recurrence interval, for each county in Oregon. Probability rankings were assigned according to the recurrence interval, and for the purposes of the 2020 Risk Assessment calculations, the rankings were assigned a value from 1 to 5 indicating least to greatest probability.

Table 2-46. Classifying Flood Probability

Recurrence Interval (Years)	Probability Rank	Probability Value
≤ 10	Very High	5
11–15	High	4
16–20	Moderate	3
21–50	Low	2
> 50	Very Low	1

The methods used to assign county-level flood probability rankings and statistics have several limitations. First, the data are not based on a consistent metric or minimum magnitude defining a flood. Further, the data do not reflect the duration, watershed location, or magnitude of flood events. DLCD's Technical Resource Guide, Chapter 4, Section 2, Table 1: Historic Flooding in Oregon (Andre, et al., 2001) typically records at most 12 events in a single region in a decade. In comparison, the NOAA Storm Event Database records as many as 45 storm-driven flooding events in one region within a decade. By compiling data from two different sources, neither of which has a consistent or quantitative metric for defining a flood, has resulted in a list that is inconsistent and likely incomplete. As a result, the recurrence intervals and probability rankings potentially underestimate the chance of flooding across Oregon.

Table 2-47. Probability of Flooding by County for the 2020 Risk Assessment Methodology

Region	County	Recurrence Interval (Years)	Probability Rank	Probability Value
Region 1	Clatsop	9	Very High	5
	Coos	5	Very High	5
	Curry	8	Very High	5
	Douglas Coastal	ND	ND	5*
	Lane Coastal	ND	ND	5*
	Lincoln	9	Very High	5
	Tillamook	5	Very High	5
Region 2	Clackamas	7	Very High	5

Region	County	Recurrence Interval (Years)	Probability Rank	Probability Value
	Columbia	10	Very High	5
	Multnomah	7	Very High	5
	Washington	15	High	4
Region 3	Benton	10	Very High	5
	Lane	7	Very High	5
	Linn	9	Very High	5
	Marion	15	High	4
	Polk	11	High	4
	Yamhill	12	High	4
Region 4	Douglas	6	Very High	5
	Jackson	12	High	4
	Josephine	10	Very High	5
Region 5	Gilliam	11	High	4
	Hood River	13	High	4
	Morrow	15	High	4
	Sherman	12	High	4
	Umatilla	15	High	4
	Wasco	11	High	4
Region 6	Crook	29	Low	2
	Deschutes	21	Low	2
	Jefferson	25	Low	2
	Klamath	37	Low	2
	Lake	49	Low	2
	Wheeler	11	High	4
Region 7	Baker	18	Moderate	3
	Grant	13	High	4
	Union	21	Low	2
	Wallowa	12	High	4
Region 8	Harney	16	Moderate	3
	Malheur	16	Moderate	3

*Note: The events impacting Coastal Lane and Coastal Douglas Counties could not be separated from the full county data and were given No Data (ND) rankings. For the purposes of the 2020 Risk Assessment calculations, the coastal portions of Douglas and Lane Counties were assigned a probability value consistent with the other coastal counties.

Source: DOGAMI and DLCD

Climate Change

Riverine flood risk is strongly associated with the dominant form of precipitation in a basin, with mixed rain-snow basins in Oregon already seeing increases in flood risk. Generally, western Oregon basins are projected to experience increased precipitation, including extreme precipitation, which is likely to result in increased extreme river flows in future decades. It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (high confidence). It is very likely that Oregon will experience an increase in the frequency of extreme river flows (high confidence). Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. However, when considering rain-on-snow events, which cause some of the biggest floods in Oregon, there are some contradictory results as to how the changes in rain-on-snow events will affect flood magnitudes in different areas of the state and at different elevations. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics).

2.2.5.3 Vulnerability

Damage and loss of life occur when flood waters come into contact with the built environment or where people congregate. Flood can have secondary effects of causing stream bank erosion and channel migration, or precipitating landslides.

Every Oregon County has suffered flood losses at one time or another. Some counties and cities are more susceptible to both flood events and damages. There are several ways to consider vulnerability. We have assessed vulnerability using data from FEMA's National Flood Insurance Program in conjunction with population and building inventory data. We have also considered vulnerability with respect to state assets and local critical facilities, historic and archaeological resources, and social vulnerability.

Table 2-48 and Table 2-49 consider vulnerability based on the total number of NFIP flood insurance claims paid since the beginning of the NFIP in 1978. These tables identify the ten counties and ten cities respectively that have had the greatest number of NFIP flood insurance claims. The number of NFIP flood insurance claims is an indicator of the number of times residents in these communities have experienced flood damages.

Table 2-48. Top 10 Oregon Counties Vulnerable to Flooding as Measured by the Total Number of Paid NFIP Claims since 1978

Rank	County	Total # Claims	Total $ Paid Claims	Population	Claims Per Capita (%)	# Policies	# Structures in SFHA*	# Repetitive Loss Structures
1	Clackamas	491	$10,534,298	419,425	0.12%	1,138	2819	122
2	Tillamook	485	$5,844,442	26,395	1.84%	1,185	3308	212
3	Lane	379	$3,459,653	375,120	0.10%	2,003	1,2743	86
4	Lincoln	347	$4,548,493	48,210	0.72%	1,034	2988	152
5	Washington	258	$3,264,048	606,280	0.04%	694	2469	99
6	Jackson	154	$1,350,228	219,200	0.07%	462	4460	17
7	Douglas	150	$928,739	111,735	0.13%	902	5769	12
8	Columbia	138	$5,786,992	51,900	0.27%	294	2732	29
9	Marion	98	$1,138,585	344,035	0.03%	272	5185	28
10	Clatsop	91	$1,576,647	39,200	0.23%	438	2921	16

Sources: PSU Population Research Center, Certified Population Estimates July 1, 2018, https://www.pdx.edu/population-research/sites/g/files/znldhr3261/files/2020-05/Certified%20Population%20Estimates_%2012_15_2019_1.pdf; FEMA Community Information System (CIS) database, 2020; Building Inventory, DOGAMI, 2020

*SFHA = Special Flood Hazard Area, the area with a 1% chance of flooding each year

Table 2-49. Top 10 Oregon Cities Vulnerable to Flooding as Measured by the Total Number of Paid NFIP Claims since 1978

Rank	City	Total # Claims	Total $ Paid Claims	Population	Claims Per Capita (%)	# Policies	# Structures in SFHA*	# Repetitive Loss Structures
1	Portland	239	$3,011,279	648,740	0.04%	1,943	2,646	52
2	Vernonia	232	$13,737,080	2,065	11.23%	163	367	77
3	Salem	202	$3,466,592	165,265	0.12%	868	2,144	46
4	Tillamook	202	$8,229,287	4,920	4.11%	104	310	161
5	Lincoln City	75	$1,314,220	8,730	0.86%	727	515	26
6	Lake Oswego	66	$3,589,841	38,215	0.17%	273	255	2
7	Milwaukie	66	$2,678,586	20,525	0.32%	47	67	27
8	Rockaway Beach	64	$816,233	1,350	4.74%	318	488	8
9	Coos Bay	58	$1,356,523	16,680	0.35%	101	466	14
10	Sheridan	58	$753,616	6,190	0.94%	306	1,058	8

Sources: https://www.pdx.edu/population-research/sites/g/files/znldhr3261/files/2020-05/Certified%20Population%20Estimates_%2012_15_2019_1.pdf; FEMA Community Information System (CIS) database, 2020; Building Inventory, DOGAMI, 2020

*SFHA = Special Flood Hazard Area, the area with a 1% chance of flooding each year

Table 2-50 and Table 2-51 consider vulnerability based on total NFIP flood insurance claim value in dollars since the start of the NFIP in 1978. These tables identify the ten counties and ten cities respectively where the greatest cumulative claim amounts have been paid. This amount is an indicator of the extent of flood damage a community has experienced.

Table 2-50. Top 10 Oregon Counties Vulnerable to Flooding as Measured by Total Dollar ($) Amount Paid on NFIP Claims since 1978

Rank	County	Total # Claims	Total $ Paid Claims	Population	Claims Per Capita ($)	# Structures in SFHA*	# Repetitive Loss Structures
1	Clackamas	491	$10,534,298	419,425	$25	2,819	122
2	Tillamook	485	$5,844,442	26,395	$221	3,308	212
3	Columbia	138	$5,786,992	51,900	$112	2,732	29
4	Lincoln	347	$4,548,493	48,210	$94	2,988	152
5	Lane	379	$3,459,653	375,120	$9	12,743	86
6	Washington	258	$3,264,048	606,280	$5	2,469	99
7	Clatsop	91	$1,576,647	39,200	$40	2,921	16
8	Jackson	154	$1,350,228	219,200	$6	4,460	17
9	Marion	98	$1,138,585	344,035	$3	5,185	28
10	Multnomah	83	$1,076,634	813,300	$1	3,515	3

Sources: PSU Population Research Center, Certified Population Estimates July 1, 2018, https://www.pdx.edu/population-research/sites/g/files/znldhr3261/files/2020-05/Certified%20Population%20Estimates_%2012_15_2019_1.pdf; FEMA Community Information System (CIS) database, 2020; Building Inventory, DOGAMI, 2020

*SFHA = Special Flood Hazard Area, the area with a 1% chance of flooding each year

Table 2-51. Top 10 Oregon Cities Vulnerable to Flooding as Measured by Total Dollar ($) Amount Paid on NFIP Claims since 1978

Rank	City	Total # Claims	Total $ Paid Claims	Population	Claims Per Capita ($)	# Structures in SFHA*	# Repetitive Loss Structures
1	Vernonia	232	$13,737,080	2,065	$6,652.34	367	77
2	Tillamook	202	$8,229,287	4,920	$1,672.62	310	161
3	Lake Oswego	66	$3,589,841	38,215	$93.94	255	2
4	Salem	202	$3,466,592	165,265	$20.98	2144	46
5	Portland	239	$3,011,279	648,740	$4.64	2646	52
6	Milwaukie	66	$2,678,586	20,525	$130.50	67	27
7	West Linn	51	$1,805,959	25,830	$69.92	131	2
8	Oregon City	25	$1,467,599	34,860	$42.10	137	5
9	Tualatin	50	$1,390,379	27,055	$51.39	212	10
10	Coos Bay	58	$1,356,523	16,680	$81.33	466	14

Sources: PSU Population Research Center, Certified Population Estimates July 1, 2018, https://www.pdx.edu/population-research/sites/g/files/znldhr3261/files/2020-05/Certified%20Population%20Estimates_%2012_15_2019_1.pdf; FEMA Community Information System (CIS) database, 2020; Building Inventory, DOGAMI, 2020

*SFHA = Special Flood Hazard Area, the area with a 1% chance of flooding each year

2.2.5.4 Repetitive Losses

Recently FEMA has migrated its repetitive loss (RL) and severe repetitive loss (SRL) property and claims information from BureauNet to a new database, PIVOT, and tightened its policy on sharing this information. To obtain access to PIVOT, state and local governments must now have an intergovernmental agreement (IGA) with FEMA in place. For a state with an IGA to share information from PIVOT with a local government, the local government must also have an IGA with FEMA in place. Currently, the State of Oregon is engaged in negotiating the required IGA with FEMA and the draft IGA is with FEMA for review. Therefore, the State of Oregon is unable to access PIVOT and accurately update or report on RL and SRL properties at this time. The information herein is the most current and accurate the State of Oregon is able to obtain and share at this time. After the IGA is executed, the State of Oregon will update this information.

Table 2-52. Top 10 Oregon Communities with the Greatest Number of Repetitive Losses

Rank	Community	County	# Repetitive Losses
1	Tillamook County	Tillamook County	212
2	City of Tillamook	Tillamook County	161
3	Lincoln County	Lincoln County	152
4	Clackamas County	Clackamas County	122
5	Washington County	Washington County	99
6	Lane County	Lane County	86
7	City of Vernonia	Columbia County	77
8	City of Portland	Washington, Clackamas, and Multnomah Counties	52
9	City of Salem	Polk County and Marion County	46
10	Columbia County	Columbia County	29

Source: FEMA Community Information System (CIS) database, 2020

FEMA's Community Information Systems (CIS) database identifies a total of 268 buildings in Oregon that qualify as RL properties. The NFIP defines an RL property as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period since 1978. At least two of the claims must be more than 10 days apart but within 10 years of each other. Or, (a) the property has incurred flood-related damage on two occasions, in which the cost of the repair, on the average, equaled or exceeded 25% of the market value of the structure at the time of each such flood event, and (b) at the time of the second incidence of flood-related damage, the contract for flood insurance contained increased cost of compliance coverage.

In Oregon, RL properties represent about 1% of all insured properties, and account for about 14% of all claims paid (21% of the dollar amount paid). RL properties in Oregon have suffered on average less than 3 losses each. Most (80%) of Oregon's repetitive loss properties were built in floodplains before FEMA FIRMs became available (FEMA NFIP BureauNet, http://bsa.nfipstat.fema.gov/, accessed 7/11/2014). The majority of Oregon's 268 repetitive loss buildings appear to be residential structures, but the State has yet to verify all of the repetitive loss buildings. Building type will be assigned to each RL property as part of the annual review described below.

Beyond identifying vulnerable buildings, the RL list normally provided by FEMA but currently unavailable to the State of Oregon has value for hazard mitigation planning because the locations of these buildings may indicate areas of persistent flood or drainage problems.

FEMA reports RL counts in the double digits for unincorporated Clackamas (38), Lane (13), Lincoln (20), Tillamook (23), and Washington (22) (FEMA NFIP Community Information System (CIS), accessed 6/16/2020). The following cities show RL buildings in the double digits: City of Tillamook (13), City of Portland (19), City of Milwaukie (17), City of Vernonia (12), and City of

Salem (31) (FEMA NFIP Community Information System, accessed 6/16/2020). Together these counties and cities account for over half of Oregon's repetitive losses. The State should focus on conducting future flood mitigation planning and project development in these communities. Any mitigation of repetitive loss buildings along the coast also should address exposure to tsunami hazards.

Severe Repetitive Losses

Severe repetitive loss (SRL) properties are a subset of RL properties. SRL properties:

1. Are covered under a contract for flood insurance made available under the NFIP; and
2. Have incurred flood related damage:
    - For which four or more separate claims payments have been made under flood insurance coverage with the amount of each such claim exceeding $5,000, and with the cumulative amount of such claims payments exceeding $20,000; or
    - For which at least two separate claims payments have been made under such coverage, with the cumulative amount of such claims exceeding the market value of the insured structure.

Oregon is fortunate to have fewer than a dozen (11) SRL properties. Four of the SRL buildings are located in a county identified as most vulnerable to flood damages.

RL and SRL Mitigation Strategy

The State's strategy for selecting properties for flood hazard mitigation projects is four-fold. Priority projects are (a) are geographically balanced; (b) in communities with a FEMA-approved local hazard mitigation plan; (c) on buildings that have sustained substantial damages or repetitive losses, (d) located in jurisdictions capable of managing Federal grants. Buy-outs are the preferred mitigation action in areas affected by tsunami and in floodways.

The state will work with local jurisdictions that take it upon themselves to sign an information sharing agreement with FEMA and request repetitive loss data for their communities. When requested or during Community Assistance Visit (CAV) or Community Assistance Contact (CAC) processes the state will work with local communities that have obtained their repetitive loss data from FEMA to establish a priority ranking for properties that would benefit most from hazard mitigation by means of acquisition, relocation, elevation, or demolition. The state will conduct verification of the FEMA repetitive loss data in these situations (assuming the state has access to the PIVOT database where that data is held at that time). Verification of properties is needed because the State has found that FEMA's RL list contains many address and geolocation errors, and in some cases the building has already been mitigated. The state will maintain and review the verified list of repetitive loss properties once established as a basis for selecting and funding hazard mitigation projects.

DLCD will work with communities to determine whether potential mitigation projects are cost-effective, environmentally sound, and technically feasible. Cost-effectiveness of mitigation must be proven for RL properties and unfortunately the dollar losses suffered by many properties in Oregon may not allow mitigation to be funded using the Federal mitigation grant programs. Even FEMA's Greatest-Savings-to-the-Fund (GSTF) calculation may not provide sufficient benefits to mitigate many properties.

OEM will then work with these communities to turn qualified potential projects into sub-grant applications. In addition to this routine work, Notice of Funding Availability letters will be sent directly to jurisdictions with validated RL and SRL properties whenever funding opportunities become available. The State will continue to encourage owners of SRL properties to participate in FEMA mitigation programs.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a “High” flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated “Other.” Sites with “Other” designations could conceivably face relatively high flood hazards or no flood hazard at all.

Of the 5,350 state facilities evaluated, 632 were located within a flood hazard zone and had an estimated total value of over $900M. Of these, 165 were identified as state critical facilities. In addition, 683 local critical facilities were exposed to flood hazard, with a total value of $1.6B.

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to floods. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. Four of those losses were due to flooding, but it is not possible to discern from the records whether the flooding was caused by a flood hazard event or a smaller storm or physical malfunction like a broken pipe. Net claims totaled close to $30,000 with one of the four claims at over $22,000.

DAS’s records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS’s insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update’s reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Historic Resources

Of the 58,872 historic resources statewide, 4,538 are located in areas of high flood hazard, with the greatest concentration (52%) in Region 3 and 62% of those in Lane County. The next greatest concentration is in Region 2, with 869 historic resources in areas of high flood hazard. Forty-five percent of those resources are located in Multnomah County; 41% in Clackamas County.

Archaeological Resources

Three thousand seven hundred ninety-two (3,792) archaeological resources are located in areas of high flood hazard statewide, with the greatest concentrations in Region 6 (27%) and Region 3 (23%). Statewide, 112 (3%) are listed on the National Register of Historic Places and 254 (7%) are eligible for listing.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

Most Vulnerable Jurisdictions

DLCD supplemented the countywide assessment of vulnerability by looking at cities that received the most NFIP claims by dollar amount and count. Several of the 10 cities with the highest number and dollar amount of NFIP paid claims are within the three most vulnerable counties (Clackamas, Columbia, and Tillamook).

2.2.5.5 Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Coos County and the coastal portions of Douglas and Lane Counties (Region 1); Multnomah County (Region 2); Lane, Linn, and Marion Counties (Region 3); Douglas, Jackson, and Josephine Counties (Region 4); and Morrow, Umatilla, and Wasco Counties (Region 5) face the greatest risk statewide from the impacts of flood events.

2.2.5.6 Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in

2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD has the following authorities:

- Review designs for dams proposed to store water and wastewater prior to construction, as OWRD approval is required prior to dam construction after design safety is demonstrated, and again prior to filling the reservoir;
- Review and condition plans for removal of dams rated high or significant hazard
- Maintain design, construction and inspection information in its files (many electronic);
- Conduct dam breach inundation analysis for hazard rating (consequence of failure);
- Inspect dams with a frequency based mostly on hazard but which can also consider the condition of dams;
- Evaluate the general condition of dams;
- Take regulatory action on dams that are unsafe, potentially unsafe, or need maintenance action;
- Require an Emergency Action Plan (EAP) for high hazard dams, providing a template for owners to develop these plans;
- Respond to unusual conditions and potential emergencies;
- Take certain actions on dams in an actual emergency; and
- Coordinate with federal agencies on emergency inspection and response.

OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

The OWRD has been striving to inspect the over 900 dams under its jurisdiction are schedule, with recommendations sent to dam owners. At times, urgent dam safety notices are needed, and for uncooperative dam owners may lead to an administrative hearing and formal order. The program meets the minimum FEMA standard for Emergency Action Plans and sometimes exceeds FEMA guidance for dam safety inspections on schedule and for condition classification.

Analysis and Characterization

As of December 2019, there were 945 state-regulated dams and another 252 federally regulated dams that met Oregon's statutory size threshold (at least 10 feet high and storing at least 3 million gallons) for regulation by OWRD. The largest dams are under federal ownership or regulation. An additional 12,000 or so dams that fall below that threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to the dam owner's property and waters below the dam to community destruction with mass fatalities. The 1889 Johnston Flood in Pennsylvania was caused by a dam failure and resulted in over 2000 lives lost. Oregon's first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Historic Significant Dam Failures

Oregon has records of at least 55 dam failures in the State. Many of these failures had very little or no impacts on people, structures or properties. The 21 dams with more serious to tragic effects are listed in **Table 2-53**.

Table 2-53. Historic Significant Dam Failures

Year	Location	Description
1896	Goodrich dam west of Baker City in Baker Co.	Flood wave killed entire family of 7
1917	Killamacue dam west of Haines in Baker Co.	Property damaged
1920	Bonneyview dam east of Prineville in Crook Co.	Property damaged
1925	Bully Creek dam west of Vale in Malheur Co.	Multiple homes badly damaged, loss of livestock
1927	Cottonwood creek dam northwest of Lakeview in Lake Co.	Property damaged
1937	Spaulding Vaughn dam in Baker Co.	Property damaged
1941	Willow Creek (Malheur) dam west of Vale in Malheur Co.	Near catastrophic failure with more than 100 persons at risk, extreme flooding prevented
1949	Kern Brothers dam south of Burns in Harney Co.	Property damaged
1951	N. Indian Creek dam in northern Malheur Co.	Property damaged
1952	Rock Creek dam east of Burns in Harney Co.	Property damaged
1956	Goodrich dam west of Baker City in Baker Co.	Property damaged in the second failure of a dam at this site
1956	Sams Valley dam east of Gold Hill in Jackson Co.	Landslide related to reservoir filling threatened homes
1958	Vaughn Reservoir in rural Malheur Co.	Property damaged
1959	Currant Creek dam east of Antelope in Wasco Co.	Property damaged
1961	Woodrat Knob dam near Lake Creek in Jackson Co.	Major landslide on dam with persons evacuated, flooding prevented
1978	Kern Brothers dam south of Burns in Harney Co.	Property damaged including failure of Krumbo dam, second failure at this dam site
1982	Mann creek dam near Sweet Home in Linn Co.	Washed out multiple forest roads
1983	Star Mountain dam near Riverside in Malheur Co.	Washed out railroad and roads, damaged homes
1996	Powers Log Pond in Powers in south Coos Co.	Damaged road and limited damage to dwellings
2005	Simplot Lagoon south of Hermiston in Umatilla Co.	Washed out State Highway, major irrigation ditch and made 1 home unrepairable
2016	Heater Reservoir near Sublimity in Marion Co.	Flooded area occupied by Christmas tree packers, flooded paved road

Source: Oregon Water Resources Department Dam Safety Program records, accessed 2020

Dam Hazard Ratings

Oregon's new dam safety laws were developed considering the joint Association of State Dam Safety Officials and FEMA's Model State Dam Safety Program. Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

OWRD conducts hazard rating reviews as its limited resources permit. Correction of hazard ratings is a Program priority, and therefore hazard ratings can and do change. Ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts. Since 2013, OWRD has formally reviewed the hazard ratings of over 25 state-regulated dams, resulting in the ratings of about 16 being elevated to high hazard status. Federal agencies conduct similar analyses to determine hazard ratings of federally regulated dams.

Table 2-54. Summary: High Hazard and Significant Hazard Dams in Oregon

Region / County	Hazard Ratings		
	State		Federal
	High	Significant	High
Region 1	12	5	0
Clatsop	4	1	0
Coos	2	4	0
Curry	1	0	0
Lincoln	5	0	0
Tillamook	0	0	0
Region 2	10	34	10
Clackamas	2	13	7
Columbia	0	2	0
Multnomah	6	4	2
Washington	2	15	1
Region 3	9	38	19
Benton	1	1	0
Lane	1	5	13
Linn	1	0	6
Marion	2	13	0
Polk	2	8	0
Region 4	20	27	13
Douglas	9	10	5
Jackson	9	16	8
Josephine	2	1	0

Region / County	Hazard Ratings		
	State		Federal
	High	Significant	High
Region 5	7	6	10
Gilliam	0	0	0
Hood River	0	2	1
Morrow	0	2	1
Sherman	0	0	1
Umatilla	0	2	4
Wasco	7	0	3
Region 6	8	17	11
Crook	3	7	2
Deschutes	1	2	2
Jefferson	0	3	4
Klamath	1	0	3
Lake	3	5	0
Wheeler	0	0	0
Region 7	5	11	7
Baker	0	8	5
Grant	0	0	1
Union	4	3	0
Wallowa	1	0	1
Region 8	5	13	5
Harney	0	10	0
Malheur	5	3	5

Source: Oregon Water Resources Department, 2019

Table 2-55 shows all "High Hazard" and "Significant Hazard" dams in Oregon, the County in which they are located, and the regulatory government level. Since hazard ratings are always subject to change, this table is current as of December 1, 2019. The Oregon Water Resources Department regulates dams shown as "State." "Federal" dam regulators/owners of high hazard rated dams include the US Army Corps of Engineers, USDI Bureaus of Reclamation and Land Management, USDA Forest Service, and Federal Energy Regulatory Commission.

Table 2-55. High Hazard and Significant Hazard Dams in Oregon, by County

	Name	County	Rating	Regulator
1	Brownlee Dam	Baker	High	Federal
2	Mason Dam	Baker	High	Federal
3	Oxbow Hydro Dam	Baker	High	Federal
4	Thief Valley Reservoir	Baker	High	Federal
5	Unity Reservoir	Baker	High	Federal
6	Bull Run Dam 2 (Lower)	Clackamas	High	Federal
7	Faraday Diversion Dam	Clackamas	High	Federal
8	Faraday Forebay	Clackamas	High	Federal
9	North Fork Dam (Clackamas)	Clackamas	High	Federal
10	River Mill Dam	Clackamas	High	Federal
11	Timothy Lake	Clackamas	High	Federal
12	Willamette Falls	Clackamas	High	Federal
13	Ochoco Reservoir	Crook	High	Federal
14	Prineville Reservoir (Bowman)	Crook	High	Federal
15	Crane Prairie	Deschutes	High	Federal
16	Wickiup Reservoir (USBR)	Deschutes	High	Federal
17	Creekside Dam #1	Douglas	High	Federal
18	Creekside IWR	Douglas	High	Federal
19	Galesville Reservoir	Douglas	High	Federal
20	Lemolo Lake Dam	Douglas	High	Federal
21	Soda Springs Dam	Douglas	High	Federal
22	Olive Lake	Grant	High	Federal
23	Clear Branch Creek Dam	Hood River	High	Federal
24	Agate Dam	Jackson	High	Federal
25	Applegate Lake	Jackson	High	Federal
26	Emigrant	Jackson	High	Federal
27	Fish Lake (Jackson-USBR)	Jackson	High	Federal
28	Howard Prairie	Jackson	High	Federal
29	Hyatt Reservoir	Jackson	High	Federal
30	Lost Creek Reservoir (COE)	Jackson	High	Federal
31	Reeder Gulch Reservoir	Jackson	High	Federal

	Name	County	Rating	Regulator
32	Haystack Equalizing Pond	Jefferson	High	Federal
33	Pelton Dam	Jefferson	High	Federal
34	Pelton Regulating Dam	Jefferson	High	Federal
35	Round Butte Dam	Jefferson	High	Federal
36	Gerber Reservoir	Klamath	High	Federal
37	JC Boyle Dam	Klamath	High	Federal
38	Upper Klamath Lake	Klamath	High	Federal
39	Blue River Dam	Lane	High	Federal
40	Cottage Grove	Lane	High	Federal
41	Cougar Reservoir	Lane	High	Federal
42	Dexter	Lane	High	Federal
43	Dorena	Lane	High	Federal
44	Fall Creek Reservoir	Lane	High	Federal
45	Fern Ridge	Lane	High	Federal
46	Hills Creek Reservoir	Lane	High	Federal
47	Hult Log Storage Pond	Lane	High	Federal
48	Leaburg Dam	Lane	High	Federal
49	Lookout	Lane	High	Federal
50	Walterville Power Intake	Lane	High	Federal
51	Walterville Pumped S. Pond	Lane	High	Federal
52	Big Cliff Dam	Linn	High	Federal
53	Detroit Reservoir	Linn	High	Federal
54	Foster Reservoir	Linn	High	Federal
55	Green Peter Reservoir	Linn	High	Federal
56	Smith River	Linn	High	Federal
57	Trail Bridge Reg. Reservoir	Linn	High	Federal
58	Agency Valley Dam	Malheur	High	Federal
59	Bully Creek Dam	Malheur	High	Federal
60	Owyhee	Malheur	High	Federal
61	Rock Creek (Malheur)	Malheur	High	Federal
62	Warm Springs Reservoir (USBR)	Malheur	High	Federal

	Name	County	Rating	Regulator
63	Willow Creek (Morrow)	Morrow	High	Federal
64	Bonneville Dam	Multnomah	High	Federal
65	Bull Run Dam 1 (Upper)	Multnomah	High	Federal
66	John Day Dam	Sherman	High	Federal
67	Cold Springs Reservoir (USBR)	Umatilla	High	Federal
68	Indian Lake Dam	Umatilla	High	Federal
69	Mckay Reservoir (USBR)	Umatilla	High	Federal
70	Mcnary Dam	Umatilla	High	Federal
71	Hells Canyon Dam	Wallowa	High	Federal
72	Happy Canyon	Wasco	High	Federal
73	The Dalles Dam	Wasco	High	Federal
74	Wasco Dam	Wasco	High	Federal
75	Scoggins	Washington	High	Federal
76	North Fork	Benton	High	State
77	Buche (Clackamas)	Clackamas	High	State
78	Mompano	Clackamas	High	State
79	Bear Creek	Clatsop	High	State
80	Middle	Clatsop	High	State
81	Seaside City	Clatsop	High	State
82	Wickiup Lake (Astoria)	Clatsop	High	State
83	Pony Creek - Lower	Coos	High	State
84	Pony Creek - Upper	Coos	High	State
85	Barnes Butte	Crook	High	State
86	Joe Fisher	Crook	High	State
87	Johnson Creek (Crook)	Crook	High	State
88	Ferry Creek	Curry	High	State
89	North Canal Diversion	Deschutes	High	State
90	Bear Creek 3	Douglas	High	State
91	Berry Creek	Douglas	High	State
92	Cooper Creek (Sutherlin)	Douglas	High	State
93	Hayhurst Road	Douglas	High	State
94	Paris	Douglas	High	State
95	Plat I	Douglas	High	State
96	Updegrave	Douglas	High	State
97	Wageman	Douglas	High	State
98	Winchester	Douglas	High	State
99	Duggan	Jackson	High	State
100	Lake Creek	Jackson	High	State
101	Osborne Creek	Jackson	High	State

	Name	County	Rating	Regulator
102	Sams Valley	Jackson	High	State
103	Wade	Jackson	High	State
104	Walch Dam	Jackson	High	State
105	Willow Creek	Jackson	High	State
106	Woodrat Knob	Jackson	High	State
107	Yankee	Jackson	High	State
108	Mcmullen Creek	Josephine	High	State
109	Strong	Josephine	High	State
110	Crescent Lake	Klamath	High	State
111	Bullard Creek F.R.S. (Lake)	Lake	High	State
112	Cottonwood	Lake	High	State
113	Drews	Lake	High	State
114	Santa Clara	Lane	High	State
115	Big Creek #1 (Lower)	Lincoln	High	State
116	Big Creek #2 (Upper)	Lincoln	High	State
117	Mill Creek	Lincoln	High	State
118	Olalla	Lincoln	High	State
119	Spring Lake	Lincoln	High	State
120	Foster Log Pond	Linn	High	State
121	Antelope	Malheur	High	State
122	Crowley	Malheur	High	State
123	Lonesome Lake	Malheur	High	State
124	Pole Creek	Malheur	High	State
125	Willow Creek 3 (Malheur)	Malheur	High	State
126	Franzen	Marion	High	State
127	Silver Creek	Marion	High	State
128	Portland #1 (Mt. Tabor)	Multnomah	High	State
129	Portland #3 (Washington Park)	Multnomah	High	State
130	Portland #4 (Washington Park)	Multnomah	High	State
131	Portland #5 (Mt. Tabor)	Multnomah	High	State
132	Portland #6 (Mt. Tabor)	Multnomah	High	State
133	Van Raden	Multnomah	High	State
134	Croft	Polk	High	State
135	Mercer	Polk	High	State
136	Jubilee Lake	Union	High	State
137	Morgan Lake	Union	High	State
138	Pilcher Creek	Union	High	State
139	Wolf Creek	Union	High	State
140	Wallowa Lake	Wallowa	High	State

	Name	County	Rating	Regulator
141	Crow Creek	Wasco	High	State
142	Currant Creek	Wasco	High	State
143	Pine Hollow	Wasco	High	State
144	Rock Creek (Wasco)	Wasco	High	State
145	Younglife Waste A (Lower)	Wasco	High	State
146	Younglife Waste B (Middle)	Wasco	High	State
147	Younglife Waste C (Upper)	Wasco	High	State
148	Barney	Washington	High	State
149	Kay Lake	Washington	High	State
150	Baker, Er	Yamhill	High	State
151	Mcguire	Yamhill	High	State
152	Balm Creek Reservoir	Baker	Significant	State
153	Camp Creek Reservoir (Baker)	Baker	Significant	State
154	Clear Creek Reservoir-West Fork	Baker	Significant	State
155	Goodrich Reservoir	Baker	Significant	State
156	Killamacue Reservoir	Baker	Significant	State
157	Love Reservoir (Baker)	Baker	Significant	State
158	Salmon Creek Reservoir	Baker	Significant	State
159	Whited Reservoir (Baker)	Baker	Significant	State
160	Thompson (Benton)	Benton	Significant	State
161	Beyer Reservoir	Clackamas	Significant	State
162	Cedar Grove Lake	Clackamas	Significant	State
163	Day Reservoir	Clackamas	Significant	State
164	Deardorff, Betty Jane	Clackamas	Significant	State
165	Drescher Reservoir	Clackamas	Significant	State
166	Haberlach Dam	Clackamas	Significant	State
167	Oswego Lake Dam	Clackamas	Significant	State
168	Rogers - Joseph Reservoir	Clackamas	Significant	State
169	Rose Reservoir	Clackamas	Significant	State
170	Sandy Farms No. 1-A	Clackamas	Significant	State
171	Teasel Creek	Clackamas	Significant	State
172	Veterans Reservoir	Clackamas	Significant	State
173	Zielinski Farm Reservoir	Clackamas	Significant	State
174	Fishhawk Lake	Clatsop	Significant	State
175	Rainier City Reservoir	Columbia	Significant	State
176	Salmonberry Reservoir	Columbia	Significant	State
177	Jackson Farms Dam	Coos	Significant	State
178	Powers Log Pond	Coos	Significant	State

	Name	County	Rating	Regulator
179	Rink Creek Reservoir	Coos	Significant	State
180	Windhurst	Coos	Significant	State
181	Bear Creek (Crook)	Crook	Significant	State
182	Bonnie View Dam	Crook	Significant	State
183	Dick Dam	Crook	Significant	State
184	Mainline 1	Crook	Significant	State
185	Mainline 2	Crook	Significant	State
186	Mainline 3	Crook	Significant	State
187	Wampler-Werth	Crook	Significant	State
188	Bend Hydro (Mirrorpond)	Deschutes	Significant	State
189	Mckenzie Canyon Dam	Deschutes	Significant	State
190	Canyonville Reservoir	Douglas	Significant	State
191	Dillard Lumber Co Dike	Douglas	Significant	State
192	Dixonville Log Pond	Douglas	Significant	State
193	Dollar Mill Pond	Douglas	Significant	State
194	Drain Plywood Log Pond	Douglas	Significant	State
195	Drain Sewage Lagoon	Douglas	Significant	State
196	Gardiner	Douglas	Significant	State
197	Kinnan, Frank Reservoir	Douglas	Significant	State
198	Sun Studs Log Pond	Douglas	Significant	State
199	Sutherlin Log Pond	Douglas	Significant	State
200	Beede North	Harney	Significant	State
201	Beede South	Harney	Significant	State
202	Chickahominy Reservoir	Harney	Significant	State
203	Corcoran	Harney	Significant	State
204	Cottonwood (Drewsey)	Harney	Significant	State
205	Griffin Creek Dam	Harney	Significant	State
206	Hunter Reservoir (Harney)	Harney	Significant	State
207	Moon Reservoir	Harney	Significant	State
208	South Fork Reservoir	Harney	Significant	State
209	Stinking Water Creek	Harney	Significant	State
210	Green Point-Lower (No. 1)	Hood River	Significant	State
211	Green Point-Upper (No. 2)	Hood River	Significant	State
212	Bounds Reservoir	Jackson	Significant	State
213	Bradshaw	Jackson	Significant	State
214	Bradshaw 2	Jackson	Significant	State
215	Frog Pond #1	Jackson	Significant	State
216	Gardener Reservoir	Jackson	Significant	State
217	Hammel No. 2	Jackson	Significant	State

	Name	County	Rating	Regulator
218	Harrison	Jackson	Significant	State
219	Hoover Pond 1	Jackson	Significant	State
220	Hoover Pond 2	Jackson	Significant	State
221	Hoover Pond 3	Jackson	Significant	State
222	Lester James #1	Jackson	Significant	State
223	Lester James Reservoir 2	Jackson	Significant	State
224	Lester James Reservoir 3	Jackson	Significant	State
225	Mccormick Reservoir	Jackson	Significant	State
226	Skou Reservoir	Jackson	Significant	State
227	Woolfolk Reservoir	Jackson	Significant	State
228	Brewer Reservoir (Jefferson)	Jefferson	Significant	State
229	Fuston Ranch Dam	Jefferson	Significant	State
230	Gillworth Reservoir	Jefferson	Significant	State
231	Sowell Dam	Josephine	Significant	State
232	Cottonwood Meadows	Lake	Significant	State
233	Micke	Lake	Significant	State
234	Muddy Creek Reservoir	Lake	Significant	State
235	Thompson Valley Diversion (Slid)	Lake	Significant	State
236	Thompson Valley Reservoir	Lake	Significant	State
237	Farnam Creek Reservoir	Lane	Significant	State
238	Forcia And Larsen Log Pond	Lane	Significant	State
239	Ford Farms Reservoir	Lane	Significant	State
240	Schwartz Reservoir	Lane	Significant	State
241	Vaughn Log Pond	Lane	Significant	State
242	Love Reservoir (Malheur)	Malheur	Significant	State
243	Parsnip Creek Diversion	Malheur	Significant	State
244	Star Mountain Reservoir	Malheur	Significant	State
245	Barnes Bros. Reservoir	Marion	Significant	State
246	Berger Lake	Marion	Significant	State
247	Fredericks Pond	Marion	Significant	State
248	Funrue	Marion	Significant	State
249	Heater Dam	Marion	Significant	State
250	Heater Reservoir #2	Marion	Significant	State
251	Koinenia Lake Dam	Marion	Significant	State
252	Lorence Lake	Marion	Significant	State
253	Neil Creek Reservoir	Marion	Significant	State
254	Peterson, Floyd	Marion	Significant	State
255	Pettit Reservoir	Marion	Significant	State

	Name	County	Rating	Regulator
256	Spring Lake Estates	Marion	Significant	State
257	Waldo Lake	Marion	Significant	State
258	Carty Reservoir	Morrow	Significant	State
259	Sand Dunes Wastewater Lagoon Dam	Morrow	Significant	State
260	Binford Dam	Multnomah	Significant	State
261	Mt. Hood Community College Dam	Multnomah	Significant	State
262	Peyralans Reservoir	Multnomah	Significant	State
263	Sester, William H. Reservoir 1	Multnomah	Significant	State
264	Deraeve Reservoir #1 (Lower)	Polk	Significant	State
265	Eola Hills Reservoir	Polk	Significant	State
266	Fern Creek	Polk	Significant	State
267	Kennel Reservoir	Polk	Significant	State
268	Koning "E" Reservoir	Polk	Significant	State
269	Mt. Springs Ranch Dam	Polk	Significant	State
270	Olson Reservoir (Mark)	Polk	Significant	State
271	Shaffer Reservoir	Polk	Significant	State
272	Meacham Lake Dam	Umatilla	Significant	State
273	Simplot Waste Lagoon #1	Umatilla	Significant	State
274	Elgin Mill Trmt. Lagoon #2	Union	Significant	State
275	Jimmy Creek Reservoir	Union	Significant	State
276	Little Park Dam	Union	Significant	State
277	Burkhalter #2	Washington	Significant	State
278	Cook Reservoir (Wash)	Washington	Significant	State
279	Dierickx	Washington	Significant	State
280	Dober Reservoir	Washington	Significant	State
281	Ettinger Pond	Washington	Significant	State
282	Hoefer-Pierson Reservoir	Washington	Significant	State
283	Jesse Enlargement	Washington	Significant	State
284	Lind Reservoir	Washington	Significant	State
285	Maple Headquarters Reservoir	Washington	Significant	State
286	Paul Chobin Dam	Washington	Significant	State
287	Pierson-Upper	Washington	Significant	State
288	Tualatin Park	Washington	Significant	State
289	Unger-Bill Dam	Washington	Significant	State
290	Walters, Glenn #1 - Large	Washington	Significant	State
291	Walters, Glenn #5	Washington	Significant	State
292	Amity Hills Dam	Yamhill	Significant	State

	Name	County	Rating	Regulator
293	Haskins Creek Dam	Yamhill	Significant	State
294	Hickory Hill Farm	Yamhill	Significant	State
295	Jensen (Yamhill Farm)	Yamhill	Significant	State
296	Katz Farm	Yamhill	Significant	State
297	Kuehne Dam	Yamhill	Significant	State
298	Muhs Quarry Dam	Yamhill	Significant	State
299	Olson Flashboard Dam	Yamhill	Significant	State
300	Panther Creek Reservoir	Yamhill	Significant	State
301	Walker (Bryan Creek)	Yamhill	Significant	State
302	Yamhill Vista Dam #5	Yamhill	Significant	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam. OWRD will be conducting such risk assessments on 16 of the state-regulated high hazard dams in poor or unsatisfactory condition (**Table 2-56**) over the next several years.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally regulated. A dam's condition is considered public information for state-regulated dams, but the conditions of federally regulated dams are generally not subject to disclosure. Therefore, the condition of federally regulated high hazard dams is summarized (**Table 2-57**). State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Fifty-six of the seventy-six state-regulated high hazard dams are in satisfactory or fair condition; 20 are in poor or unsatisfactory condition.

Table 2-56. Summary: Condition of Oregon's State- and Federally regulated High Hazard Dams

	High Hazard Dams		
Condition	**State**	**Federal**	**Total**
Satisfactory	30	15	45
Fair	25	27	52
Poor	13	22	35
Unsatisfactory	7	3	10
Not Rated	1	8	9
Total	76	75	151

Source: Oregon Water Resources Department, 2019

Table 2-57. Summary: Condition of Oregon's State-Regulated High Hazard Dams by County

	Condition of State-Regulated High Hazard Dams					
Region/County	**Satisfactory**	**Fair**	**Poor**	**Unsatisfactory**	**Not Rated**	**Total**
Region 1	**2**	**5**	**2**	**3**	**0**	**12**
Clatsop	0	3	1	0	0	4
Coos	1	0	1	0	0	2
Curry	0	0	0	1	0	1
Lincoln	1	2	0	2	0	5
Tillamook	0	0	0	0	0	0
Region 2	**8**	**2**	**0**	**0**	**0**	**10**
Clackamas	1	1	0	0	0	2
Columbia	0	0	0	0	0	0
Multnomah	5	1	0	0	0	6
Washington	2	0	0	0	0	2
Region 3	**5**	**4**	**0**	**0**	**0**	**9**
Benton	1	0	0	0	0	1
Lane	1	0	0	0	0	1
Linn	0	1	0	0	0	1
Marion	1	1	0	0	0	2
Polk	1	1	0	0	0	2
Yamhill	1	1	0	0	0	2
Region 4	**4**	**9**	**5**	**2**	**0**	**20**
Douglas	3	4	2	0	0	9
Jackson	1	4	3	1	0	9
Josephine	0	1	0	1	0	2
Region 5	**4**	**3**	**0**	**0**	**0**	**7**
Gilliam	0	0	0	0	0	0
Hood River	0	0	0	0	0	0
Morrow	0	0	0	0	0	0
Sherman	0	0	0	0	0	0
Umatilla	0	0	0	0	0	0
Wasco	4	3	0	0	0	7
Region 6	**4**	**3**	**1**	**0**	**0**	**8**
Crook	1	1	1	0	0	3
Deschutes	0	1	0	0	0	1
Jefferson	0	0	0	0	0	0
Klamath	1	0	0	0	0	1
Lake	2	1	0	0	0	3
Wheeler	0	0	0	0	0	0
Region 7	**2**	**0**	**3**	**0**	**0**	**5**
Baker	0	0	0	0	0	0
Grant	0	0	0	0	0	0
Union	2	0	2	0	0	4
Wallowa	0	0	1	0	0	1
Region 8	**1**	**0**	**2**	**2**	**0**	**5**
Harney	0	0	0	0	0	0
Malheur	1	0	2	2	0	5
TOTAL	**30**	**26**	**13**	**7**	**0**	**76**

Source: Oregon Water Resources Department, 2019

Table 2-58. Condition of State-Regulated High Hazard Dams in Oregon

Region	County	Dam Name	Condition
Region 1	Clatsop	Middle	Fair
	Clatsop	Seaside City	Fair
	Clatsop	Wickiup Lake (Astoria)	Fair
	Clatsop	Bear Creek	Poor
	Coos	Pony Creek - Upper	Satisfactory
	Coos	Pony Creek - Lower	Poor
	Curry	Ferry Creek	Unsatisfactory
	Lincoln	Spring Lake	Satisfactory
	Lincoln	Mill Creek	Fair
	Lincoln	Olalla	Fair
	Lincoln	Big Creek #1 (Lower)	Unsatisfactory
	Lincoln	Big Creek #2 (Upper)	Unsatisfactory
Region 2	Clackamas	Mompano	Satisfactory
	Clackamas	Buche (Clackamas)	Fair
	Multnomah	Portland #1 (Mt. Tabor)	Satisfactory
	Multnomah	Portland #3 (Washington Park)	Satisfactory
	Multnomah	Portland #4 (Washington Park)	Satisfactory
	Multnomah	Portland #5 (Mt. Tabor)	Satisfactory
	Multnomah	Portland #6 (Mt. Tabor)	Satisfactory
	Multnomah	Van Raden	Fair
	Washington	Barney	Satisfactory
	Washington	Kay Lake	Satisfactory
Region 3	Benton	North Fork	Satisfactory
	Lane	Santa Clara	Satisfactory
	Linn	Foster Log Pond	Fair
	Marion	Franzen	Satisfactory
	Marion	Silver Creek	Fair
	Polk	Croft	Satisfactory
	Polk	Mercer	Fair
	Yamhill	Mcguire	Satisfactory
	Yamhill	Baker, Er	Fair
Region 4	Douglas	Berry Creek	Satisfactory
	Douglas	Plat I	Satisfactory
	Douglas	Updegrave	Satisfactory
	Douglas	Bear Creek 3	Fair
	Douglas	Hayhurst Road	Fair
	Douglas	Paris	Fair
	Douglas	Wageman	Poor
	Douglas	Winchester	Poor
	Douglas	Cooper Creek (Sutherlin)	Fair
	Jackson	Willow Creek	Satisfactory
	Jackson	Lake Creek	Fair
	Jackson	Sams Valley	Fair
	Jackson	Wade	Fair
	Jackson	Yankee	Fair

Region	County	Dam Name	Condition
	Jackson	Duggan	Poor
	Jackson	Osborne Creek	Poor
	Jackson	Walch Dam	Poor
	Jackson	Woodrat Knob	Unsatisfactory
	Josephine	Strong	Fair
	Josephine	Mcmullen Creek	Unsatisfactory
Region 5	Wasco	Pine Hollow	Satisfactory
	Wasco	Younglife Waste A (Lower)	Satisfactory
	Wasco	Younglife Waste B (Middle)	Satisfactory
	Wasco	Younglife Waste C (Upper)	Satisfactory
	Wasco	Crow Creek	Fair
	Wasco	Currant Creek	Fair
	Wasco	Rock Creek (Wasco)	Fair
Region 6	Crook	Joe Fisher	Satisfactory
	Crook	Johnson Creek (Crook)	Fair
	Crook	Barnes Butte	Poor
	Deschutes	North Canal Diversion	Fair
	Klamath	Crescent Lake	Satisfactory
	Lake	Bullard Creek F.R.S. (Lake)	Satisfactory
	Lake	Cottonwood	Satisfactory
	Lake	Drews	Fair
Region 7	Union	Pilcher Creek	Satisfactory
	Union	Wolf Creek	Satisfactory
	Union	Jubilee Lake	Poor
	Union	Morgan Lake	Poor
	Wallowa	Wallowa Lake	Poor
Region 8	Malheur	Antelope	Satisfactory
	Malheur	Lonesome Lake	Poor
	Malheur	Pole Creek	Poor
	Malheur	Crowley	Unsatisfactory
	Malheur	Willow Creek 3 (Malheur)	Unsatisfactory

Source: Oregon Water Resources Department, 2019

State-Regulated High Hazard Dams Not Meeting Safety Standards

There are 20 state-regulated high hazard dams in Oregon that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). These dams and the population at risk, based on a screen using the screening tool DSS-WISE, are shown in **Table 2-59** and **Figure 2-67**. As the dam safety program conducts analysis over time, the number of dams in less than satisfactory condition may change. Currently dams that are in poor or unsatisfactory condition are in need of rehabilitation or other action to bring them into a fully safe condition. As of December 2019, these are the Oregon dams that are not yet demonstrably unsafe, but that do pose unacceptable risk. When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

OWRD is working to complete a comprehensive risk of failure assessment protocol. This will include clear written documentation of methods consistent with FEMA guidelines for dam safety risk management. The program will develop dam-specific risk of failure for each of the following hazards with analysis specific to Oregon conditions if applicable to the identified or likely vulnerabilities at the dam:

A. Overtopping in flood exceeding spillway capacity
B. Spillway blockage or erosion
C. General internal erosion
D. Internal erosion conduit
E. Seismic deformation - Cascadia subduction zone
F. Landslide into dam or reservoir

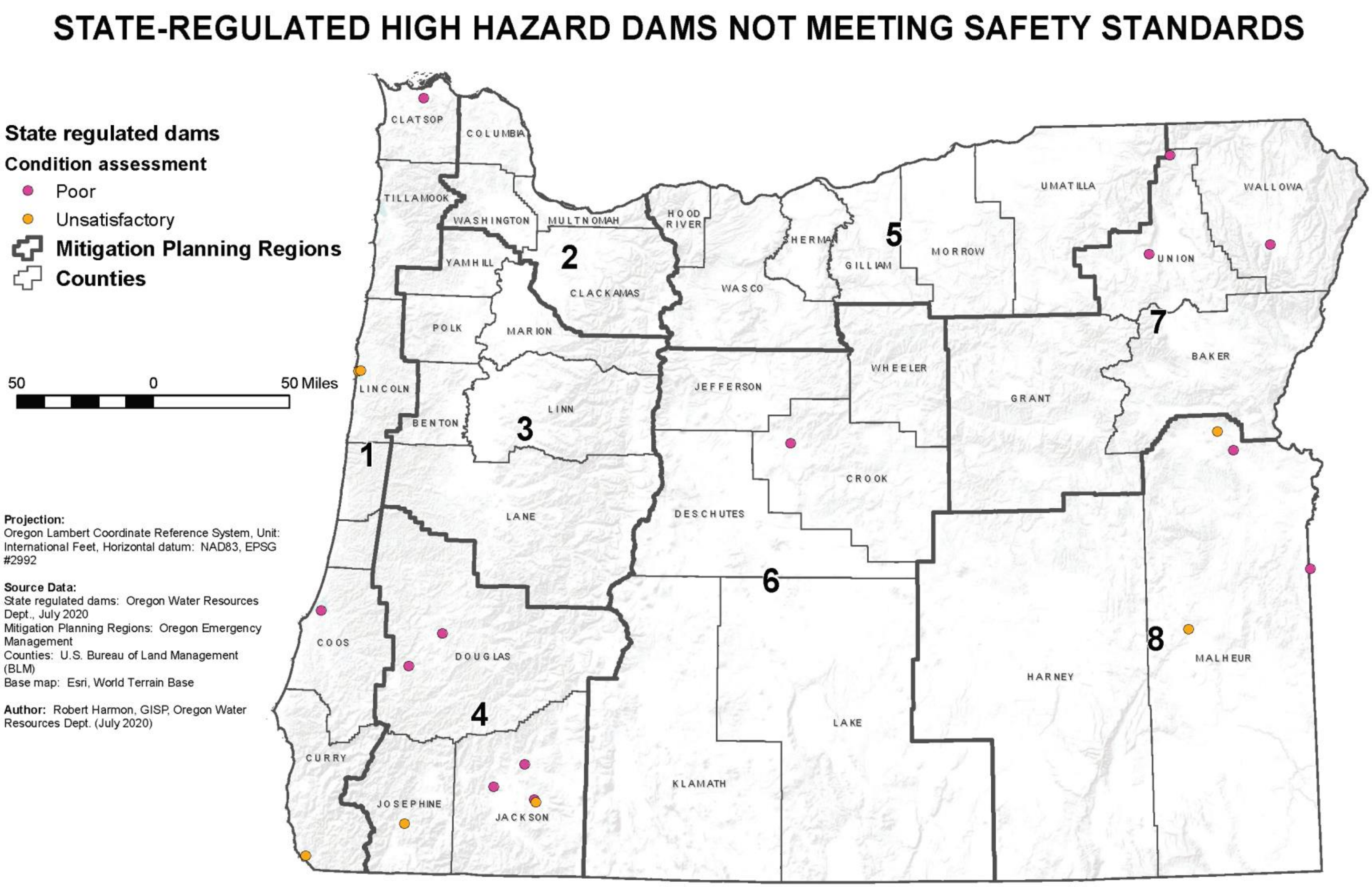
Table 2-59. State-Regulated High Hazard Dams Not Meeting Safety Standards

Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Bear Creek (Astoria)	OR00449	POOR	20	57	Clatsop
Pony Creek Lower	OR00070	POOR	687	408	Coos
Barnes Butte Reservoir	OR00284	POOR	1,787	1,648	Crook
Ferry Creek	OR00437	UNSAT	84	25	Curry
Wageman	OR00496	POOR	6	12	Douglas
Winchester		POOR	Small	Small	Douglas
Duggan Dam	OR00475	POOR	6	11	Jackson
Osborne Creek Dam	OR00401	POOR	227	500	Jackson
Walch Dam		POOR	Small	Small	Jackson
Woodrat Knob	OR00357	UNSAT	123	229	Jackson
McMullen Creek	OR00513	UNSAT	85	243	Josephine
Big Creek Reservoir #1 (Lower)	OR00225	UNSAT	16	35	Lincoln
Big Creek Reservoir #2 (Upper)	OR00473	UNSAT	26	52	Lincoln
Crowley Reservoir	OR00132	UNSAT	3	3	Malheur
Lonesome Lake		POOR	Small	Small	Malheur
Pole Creek	OR00239	POOR	37	103	Malheur
Willow Creek 3 (Malheur)	OR00390	UNSAT	3,426	3,518	Malheur
Jubilee Lake		POOR	Small	Small	Union
Morgan Lake Dam	OR00653	POOR	11,128	6,362	Union
Wallowa Lake (Top of Dam)	OR00465	POOR	1,131	1,334	Wallowa

Note: "PAR" is number of "Persons At Risk" in the dam failure inundation zone based on a conservative estimate using DSS-WISE dam breach estimator. It includes all persons that normally could be in the inundation area. Actual impacts depend on the velocity and depth of water and will be determined as part of Oregon's HHPD grant tasks.

Source: DSS-Wise output

Figure 2-67. State-Regulated High Hazard Dams Not Meeting Safety Standards



Without an engineering risk analysis, the condition of a dam is the best indicator OWRD has of the failure potential of most of the high hazard dams it regulates. Much of Oregon's dam infrastructure is aging, and many dams were designed prior to the current understanding of earthquake hazard, especially the risk associated with the expected Magnitude 9 Cascadia Subduction Zone earthquake.

The federal government owns or regulates the largest dams. For homeland security reasons, we do not know and therefore cannot discuss the condition of those dams or their likelihood of failure. Many state-regulated dams are privately owned, others are owned by local governments and a few by the State. The state classifies dams as high, significant, or low hazard. The condition of each high hazard dam is rated. About 12,000 dams are smaller than the state statutory threshold for regulation so their conditions are unknown.

As of December 2019, almost 75% of the state-regulated high hazard dams in Oregon were in satisfactory or fair condition, meaning that they should probably perform acceptably in rare hydrologic and/or seismic events. The other approximately 25% need remedial action and of those, roughly half need action prior to those extreme events (which will occur, but when is unknown). Those needing remediation as quickly as feasible are located in Curry, Lincoln, Jackson, Josephine, and Malheur Counties. The recurrence interval of events that could trigger failure is a necessary factor in determining the probability and risk of failure at these specific dams.

Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

Table 2-59, State-Regulated High Hazard Dams Not Meeting Safety Standards, indicates the number of people currently anticipated to be impacted by potential failure of the state-regulated high hazard dams in poor or unsatisfactory condition. OWRD plans to do more analysis to determine the number and value of structures that may be impacted as well.

The dam safety program will evaluate more specific impacts to hospitals, major roads and other critical infrastructure during its risk evaluation of dams. The dam safety program does not have specific expertise on environmental effects of dam breach events, but it is likely failure of a large dam will also have serious environmental effects. Failure of the dams undergoing risk analysis could cause extensive local damage to property and infrastructure, but would not have large statewide economic effects. The dams with the greatest potential large scale (statewide or greater) effects from dam failure are under the jurisdiction of the Federal government and not eligible for the HHPD work. Information from this risk analysis will be included in the next update of the 2025 Oregon NHMP.

Most Vulnerable Jurisdictions

Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), the counties with high hazard dams in poor or unsatisfactory condition are considered most vulnerable: Clatsop, Coos, Crook, Curry, Douglas, Jackson, Josephine, Lincoln, Malheur, Union, and Wallowa. Of those, by far the greatest number of people in potentially dangerous locations if a dam were to fail are in Union County.

As with high hazard dams, whether counties with significant hazard dams are actually "most vulnerable jurisdictions" depends on the conditions of those dams. Since the dams' conditions have not yet been rated, we cannot determine the counties' vulnerability with respect to significant hazard dams. The counties with the most state-regulated significant hazard dams are: Jackson (16), Washington (15), Clackamas and Marion (13 each) followed by Yamhill (11), Douglas and Harney (10 each).

Risk

The term "risk" is defined somewhat differently with respect to dam safety than it is for natural hazards mitigation. FEMA's (2015) "Federal Guidelines for Dam Safety Risk Management," (FEMA P-1025, January 2015) provides this brief overview:

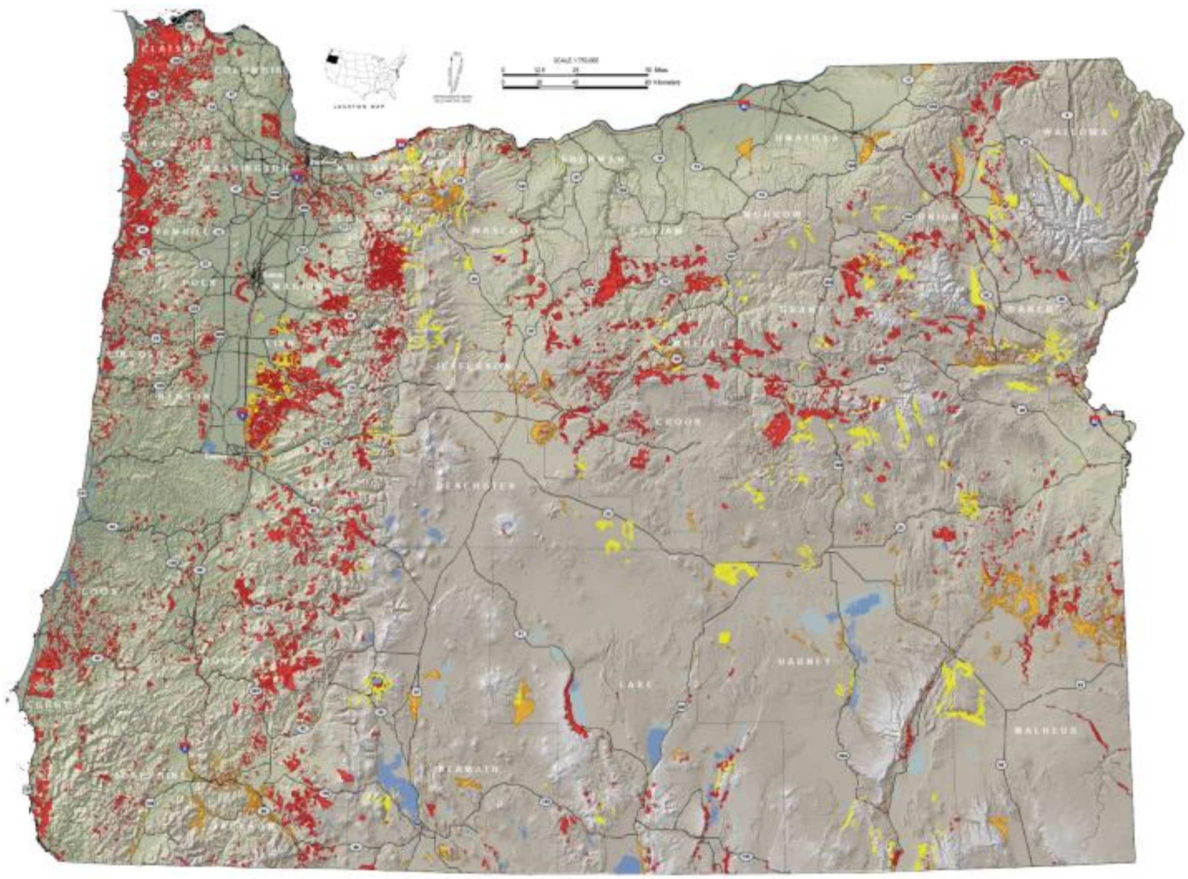
> *The term risk, when used in the context of dam safety, is comprised of three parts: (1) the likelihood of occurrence of a load (e.g., flood, earthquake, etc.), (2) the likelihood of an adverse structural response (e.g., dam failure [Failure characterized by the sudden rapid and uncontrolled release of impounded water or liquid-borne solids], damaging spillway discharge, etc.), and (3) the magnitude of the consequences resulting from that adverse event (e.g., life loss, economic damages, environmental damages, etc.). Typically, the direct consequences of dam failure are estimated. Indirect consequences could also result, in which failure of the dam results in loss or failure of key facilities, which can ultimately lead to additional economic consequences or loss of life. If indirect consequences can be identified and estimated, they can be incorporated into the risk estimates.*

With FEMA and State funding, OWRD will be completing risk assessments for 16 of the state-regulated high hazard dams in poor or unsatisfactory condition over the next several years. For now, the potential for damage to the dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

2.2.6 Landslides

Landslides can be found throughout the state of Oregon, as seen in the current statewide landslide inventory database, SLIDO-2, in **Figure 2-68** and **Table 2-60** (Burns, Mickelson, & Saint-Pierre, 2011a). While these are not derived from the most up-to-date data, they are still valid indicators of the geographic distribution of landslides throughout the state. Systematic statewide landslide mapping has not been performed; however in general the areas of the state with more relief and steeper slopes, such as the Coast Range Mountains and the Cascade Mountains, tend to have more landslides. In general counties in Oregon have hundreds to thousands of existing landslides as shown in **Table 2-60** derived from the SLIDO-2 database.

Figure 2-68. Statewide Landslide Inventory



Mapped Landslide Deposits

- Landslide
- Fan
- Talus-Colluvium

Note: Clackamas County has many more landslides than most other counties, which is partially because new very detailed lidar based mapping was completed in the NW portion of this county.

Source: Burns, et al. (2011a)

Table 2-60. Number of Identified Landslides within or Touching Each County in Oregon

County	Number of Identified Landslides	County	Number of Identified Landslides
Baker	499	Lake	204
Benton	885	Lane	1,353
Clackamas	3,013	Lincoln	773
Clatsop	774	Linn	1528
Columbia	212	Malheur	737
Coos	1,524	Marion	622
Crook	397	Morrow	56
Curry	384	Multnomah	1,330
Deschutes	83	Polk	52
Douglas	1,526	Sherman	18
Gilliam	35	Tillamook	1,332
Grant	477	Umatilla	151
Harney	435	Union	483
Hood River	178	Wallowa	62
Jackson	809	Wasco	237
Jefferson	274	Washington	538
Josephine	380	Wheeler	413
Klamath	582	Yamhill	187

Source: Burns, et al. (2011a)

DOGAMI found that in order to truly understand the landslide hazard in Oregon, lidar (light detection and ranging) topographic data must be collected and used during the mapping of existing landslides and modeling of future susceptibility. In fact, DOGAMI estimates that SLIDO-2 captures between 0% and 25% of the existing landslides in Oregon. This variance in landslide detail can be seen when examining the small NW portion of Clackamas County which has been recently mapped.

One of the most common and devastating geologic hazards in Oregon is landslides. Average annual repair costs for landslides in Oregon exceed $10 million and individual severe winter storm losses can exceed $100 million (Wang, Summers, & Hofmeister, 2002). As population growth continues to expand and development into landslide susceptible terrain occurs, greater losses are likely to result.

Landslides in Oregon are typically triggered by periods of heavy rainfall and/or rapid snowmelt. Earthquakes, volcanoes, and human activities also trigger landslides.

Three main factors influence an area's susceptibility to landslides: geometry of the slope, geologic material, and water. Certain geologic formations are more susceptible to landslides than others. In general, locations with steep slopes are most susceptible to landslides, and the landslides occurring on steep slopes tend to move more rapidly and therefore may pose life safety risks.

2.2.6.1 Analysis and Characterization

The term “landslide” encompasses a wide range of geologic processes and a variety of nomenclatures that can lend itself to confusion. The general term landslide refers to a range of mass movement including rock falls, debris flows, earth slides, and other mass movements. One very important thing to understand is the fact that all landslides have different frequencies of movements, triggering conditions, and very different resulting hazards.

All landslides can be classified into one the following six types of movements: (a) slides, (b) flows, (c) spreads, (c) topples, (d) falls, and (f) complex (**Figure 2-69**). Most slope failures are complex combinations of these distinct types, but the generalized groupings provide a useful means for framing discussion of the type of hazard associated with the landslide, the landslide characteristics, identification methods, and potential mitigation alternatives.

El Niño Southern Oscillation and Effects on Landslides

The strongest impacts of intra-seasonal variability on the U.S. occur during the winter months over the western U.S. During the winter this region receives the bulk of its annual precipitation. Storms in this region can last for several days or more and are often accompanied by persistent atmospheric circulation features. Of particular concern are the extreme precipitation events which are linked to flooding and landslide. There is strong evidence for a linkage between weather and climate in this region from studies that have related the El Niño-Southern Oscillation (ENSO) to regional precipitation variability. From these studies it is known that extreme precipitation events can occur at all phases of the El Niño-Southern Oscillation (ENSO) cycle, but the largest fraction of these events occur during La Niña episodes and during ENSO-neutral winters. During La Niña episodes much of the Pacific Northwest experiences increased storminess, increased precipitation and more overall days with measurable precipitation. The risk of flooding and rain-induced landslides (and debris flows) in this region can be related to La Niña episodes.

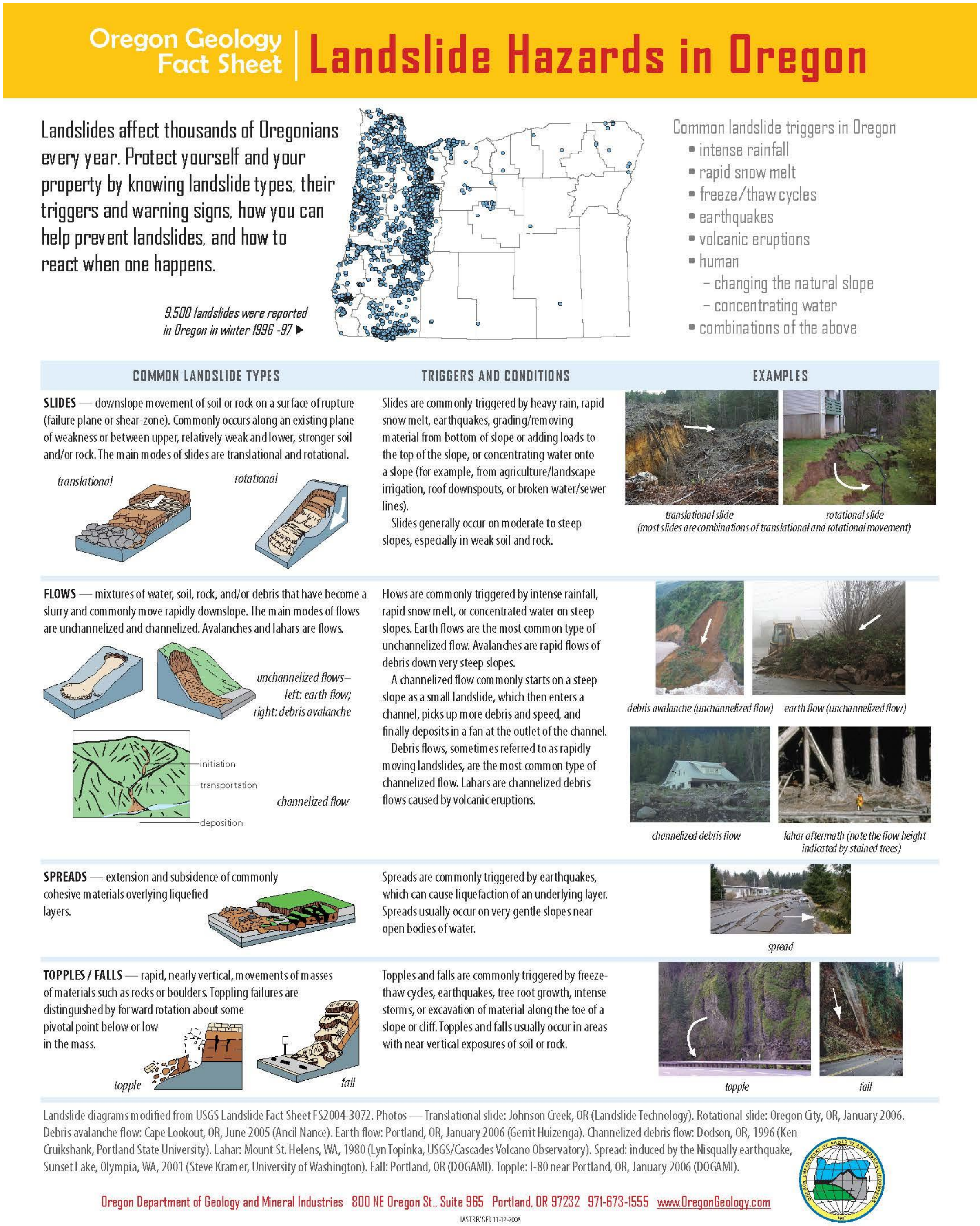
Source: NOAA/Climate Prediction Center, http://www.cpc.noaa.gov/products/intraseasonal/intraseasonal_faq.html#usimpactsSource: NOAA/Climate Prediction Center, http://www.cpc.noaa.gov/products/intraseasonal/intraseasonal_faq.html#usimpacts

These types of movements can be combined with other aspects of the landslide such as type of material, rate of movement, depth of failure, and water content for a better understanding of the type of landslide.

One potentially life-threatening type of landslide is the channelized debris flow or “rapidly moving landslide,” which initiates upslope, moves into and down a steep channel (or drainage) and deposits material, usually at the mouth of the channel. Debris flows are also commonly initiated by other types of landslides that occur on slopes near a channel. They can also initiate within the channel in areas of accelerated erosion during heavy rainfall or snowmelt. Rapidly moving landslides have caused most of the recent landslide related injuries and deaths in Oregon. Debris flows or rapidly moving landslides following storms caused eight deaths in Oregon in 1996, a La Niña year.

Areas that have failed in the past often remain in a weakened state, and many of these areas tend to fail repeatedly over time. This commonly leads to distinctive geomorphology that can be used to identify landslide areas, although over time the geomorphic expression may become subtle, making the landslide difficult to identify. Other types of landslides tend to occur in the same locations and produce distinctive geomorphology, such as channelized debris flows, which form a fan at the mouth of the channel after repeated events. This is also true for the talus slopes, which form after repeated rock fall has taken place in an area.

Figure 2-69. Common Types of Landslides in Oregon



Source: DOGAMI, Landslide Hazards in Oregon fact sheet (http://www.oregongeology.org/pubs/fs/landslide-factsheet.pdf)

Previously impacted areas are particularly important to identify, as they may pose a substantial hazard for future instability and help identify areas that are susceptible to future events. Large, slow moving landslides frequently cause significant property damage, but are far less likely to result in serious injuries. The 1998 Kelso, Washington, the 1997 Tillamook County, and the 2005 Oregon City slides are examples.

The velocity of landslides varies from imperceptible to over 35 miles per hour. Some volcanic induced landslides have been known to travel between 50 to 150 miles per hour. On less steep slopes, landslides tend to move slowly and cause damage gradually. Debris flows typically start on steep hillsides as shallow landslides, enter a channel, then liquefy and accelerate. Canyon bottoms, stream channels, and outlets of canyons can be particularly hazardous. Landslides can move long distances, sometimes as much as several miles. The Dodson debris flows in 1996 started high on Columbia River Gorge cliffs and traveled down steep canyons to form debris fans in the Dodson-Warrendale area.

Landslide recurrence interval is highly variable. Some large landslides move continuously at very slow rates. Others move periodically during wet periods. Very steeply sloped areas can have relatively high landslide recurrence intervals (10 to 500 years on an initiation site basis).

Because debris flows can be initiated at many sites over a watershed, in some cases recurrence intervals can be less than 10 years. Slope alterations can greatly affect recurrence intervals for all types of landslides, and also cause landslides in areas otherwise not susceptible. Most slopes in Western Oregon steeper than 30 degrees (about 60%) have a risk of rapidly moving landslide activity regardless of geologic unit. Areas directly below these slopes in the paths of potential landslides are at risk as well.

Based on the Oregon Department of Forestry Storm Impacts Study, the highest debris flow hazard occurs in western Lane County, western Douglas County, and Coos County. The combination of steep slopes and geologic formation (sedimentary rock units) contributes to the increased hazard. The debris flow hazard is also high in much of the Coast Range and Cascade Mountains and in the Columbia River Gorge.

Deep landslides are generally defined as having a failure plane within the regional bedrock unit (generally greater than 15 feet deep), whereas the failure plane of shallow landslides is commonly between the thin soil mantle and the top of the bedrock. Deep landslide hazard is high in parts of the Coast Range. Deep landslides are fairly common in pyroclastic rock units of the Western Cascade Mountains, and in fine-grained sedimentary rock units of the Coast Range. Deep landslides also occur in semi-consolidated sedimentary rocks at or near the Oregon coast particularly around Newport, Lincoln County, and Tillamook County, and in the Troutdale Formation around the Portland area.

Infrequent very large landslides and debris flows may occur in any of the larger mountain ranges or in deep gorges throughout Oregon.

During 1996 and 1997, heavier than normal rains caused over 700 landslides within the Portland Metropolitan region, which totaled over $40 million for mitigation (Burns, Burns, James, & Hinkle, 1998). In the City of Portland, 17 homes were completely destroyed and 64 were badly damaged. There were no serious injuries associated with the landslides in Portland or in other urban areas within Oregon during the 1996 storms.

The Oregon Department of Forestry Storm Impacts Study estimated that tens of thousands of landslides occurred on steep slopes in the forests of Western Oregon during 1996. The Oregon Department of Geology and Mineral Industries Slope Failures in Oregon inventoried thousands of reports of landslides across the state resulting from the 1996-1997 storms. There are a significant number of locations in Oregon that are impacted frequently (every 10 to 100 years) by dangerous landslides. The number of injuries and deaths in the future will be directly related to vulnerability: the more people in these areas, the greater the risk of injury or death.

Historic Landslide Events

Oregon has declared 28 major disaster declarations from 1955 through 2012. Most of these are related to storm events causing flooding and landslides. One of the most significant of these disasters is the 1996 and 1997 storms, which caused thousands of landslides in Oregon.

Table 2-61. Historic Landslides in Oregon from SLIDO-2

Date	No. of Landslides	Comments
1931–1935	2	
1946–1950	1	
1951–1955	2	Presidential DR-49
1956–1960	1	Presidential DR-60, -69
1961–1965	14	Presidential DR-136, -144, -184
1966–1970	1	
1971–1975	11	Presidential DR-301, -319, -413
1976–1980	24	
1981–1985	9	
1986–1990	8	Presidential DR-853
1991–1995	42	Presidential DR-985, -1004, -1036, -1061
1996–2000	7,903	Presidential DR-1099, -1107, -1149, -1160, -1221
2001–2005	648	Presidential DR-1405, -1510
2006–2010	1,960	*Presidential DR-1632, -1672, -1683 -1733, -1824
2011-2015	384	*Presidential DR-1956, -1964, -4055, -4169
2016-2019	140	*Presidential DR-4258, -4296, -4328, -4432, -4452

Note: Presidential Disaster Declarations marked with an asterisk (*) were based in part on the impact of landslides.

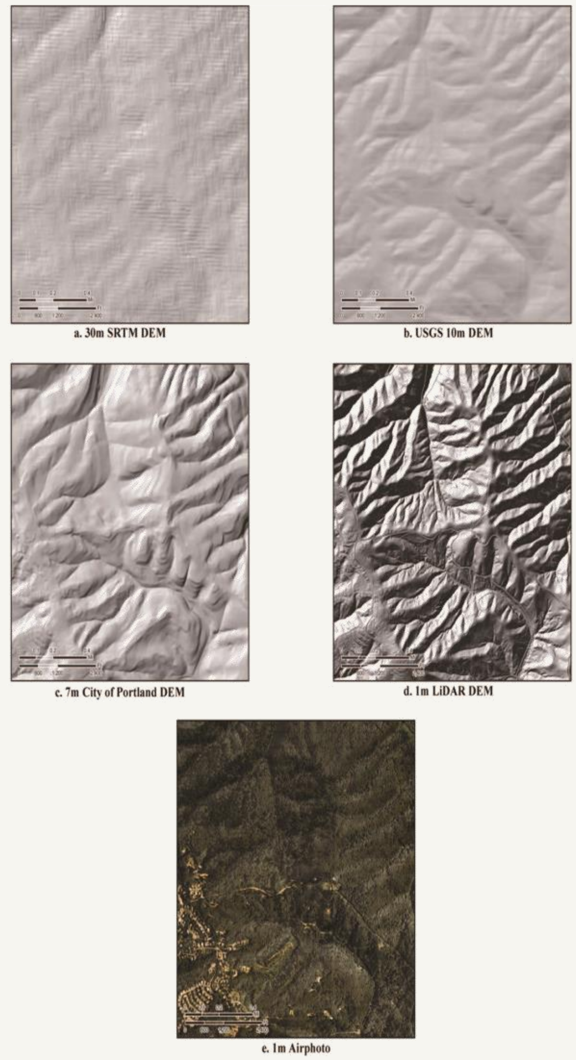
Source: Burns, et al. (2011a)

2.2.6.2 Probability

Landslides are found in every county in Oregon as shown in **Table 2-60**. There is a 100% probability of landslides occurring in Oregon in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events which are projected to increase in frequency under future climate change, or during a future earthquake.

In order to reduce losses from landslides, areas of landslide hazard must first be identified. The first step in landslide hazard identification is to create an inventory of past (historic and prehistoric) landslides. Once this inventory is created, it can be used to create susceptibility maps which display areas that are likely to have landslides in the future. Once the landslide hazards are identified on inventory and susceptibility maps, the risk can be quantified, mitigation projects prioritized and implemented.

Figure 2-70. Visual Comparison of Five Remote Sensing Data Sets



Note: The air photo is draped over a DEM so that it appears to have the 3-dimensional view provided by a stereo-pair

Source: Burns (2007)

In 2005, DOGAMI began a collaborative landslide research program with the U.S. Geological Survey (USGS) Landslide Hazards Program to identify and understand landslides in Oregon. In order to begin the extensive undertaking of mapping existing landslides throughout Oregon, a pilot project area was selected to compare remote sensing data/images for effectiveness. The remote sensing data sets compared included (Burns W. J., 2007) (**Figure 2-70**):

1. 30-m (98 ft) digital elevation model (DEM) from the Shuttle Radar Topography Mission;
2. 10-m (33 ft) DEM derived from USGS topographic quadrangles;
3. Photogrammetric and ground-based 1.5-m (5 ft) interval contour data;
4. Stereo aerial photographs from 1936 to 2000; and
5. Lidar imagery with an average of 1 data point per square meter (3.2 ft) and with a vertical accuracy of about 5 cm (6 in).

Two key findings of the pilot project were: (a) the use of the lidar data resulted in the identification of between 3 to 200 times the number of landslides identified using the other data sets, and (b) the ease and accuracy of mapping the spatial extent of the landslides identified from lidar data were greatly improved compared to other mapping methods.

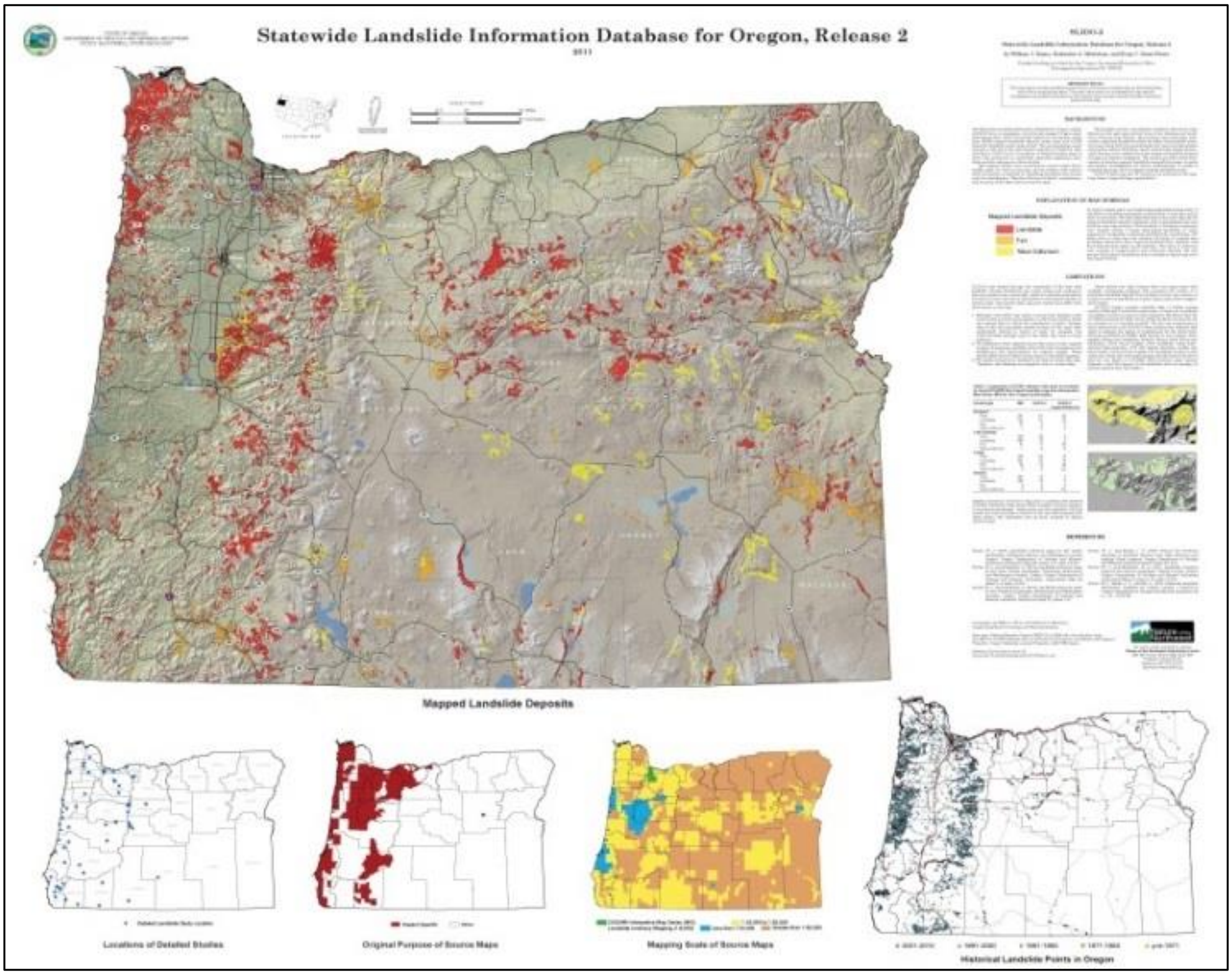
When examining the results of the comparison of remote sensing data, several debris flow fans at the mouths of channels or potential channelized debris flow deposits, were identified with serial stereo-pair aerial photos, which did not get identified on the lidar-derived DEMs. Dense development has taken place in Oregon in the last 40 years, which can mask landslide features, especially if major earthwork has taken place. In most of the populated areas of Oregon, if historic air photos are available, at least one review of (greater than 40 years old) photos should be performed (Burns W. J., 2007).

In order to develop accurate large-scale landslide inventory maps, DOGAMI recommends the following minimal requirements:

1. All previously identified landslides from geologic maps, previous landslide studies, and other local sources should be compiled.
2. The mapper should have experience identifying all types and ages of landslides within the area being studied.
3. Lidar data should be used to identify landslides and accurately locate the extents of previously mapped landslides (from step 1).
4. An orthophoto of similar age to the lidar data should be used to minimize the misidentification of man-made cuts and fills as landslides.
5. The mapper should use at least one set of historical stereo-pair aerial photography to locate landslides in the area being studied.
6. Non-spatial data should also be collected at the time of the mapping so that a comprehensive database can be formed. Non-spatial data should generally include confidence of interpretation, movement class, direction of movement, etc. and are described in detail in section 6.0 of this paper. A comprehensive check of spatial (map) and non-spatial data should be developed and implemented including technical review of mapped landslides and field checks where possible.

Step 1 was accomplished in 2008 with the publication of SLIDO-1. This publication has been updated and again published as SLIDO-2 (**Figure 2-71**).

Figure 2-71. Statewide Landslide Information Database for Oregon, Release 2

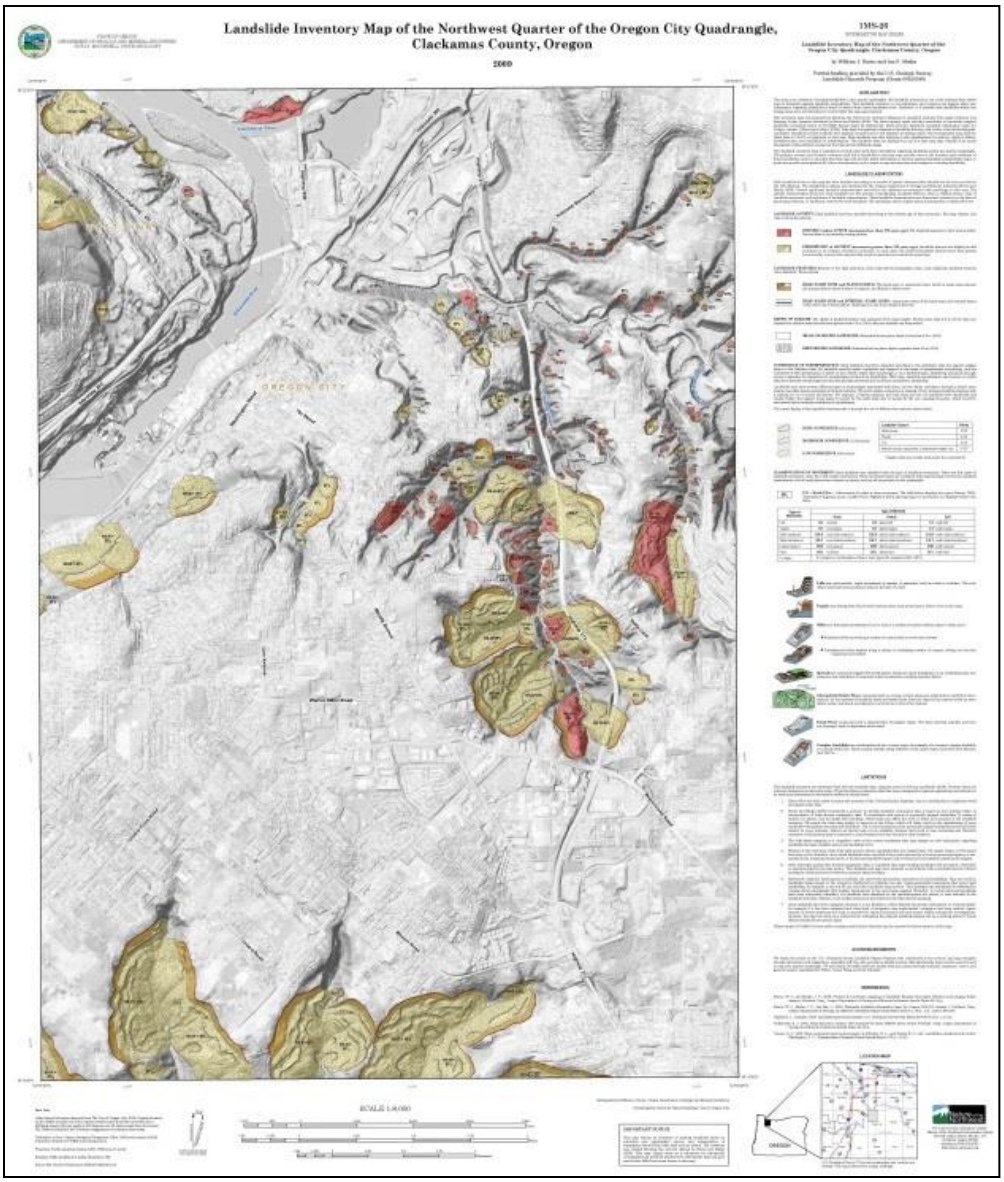


Note: The resulting SLIDO-2 geodatabase includes 22,542 landslide deposit polygons and landslide-related features from 313 published and unpublished studies, 10,636 historical landslide point locations (including all points from the 1996-97 events), and 72 locations of detailed studies on individual landslides, a significant increase over SLIDO-1.

Source: Burns, et al. (2011a)

A protocol was developed by DOGAMI so that we can produce consistent lidar-based landslide inventory maps at an accelerated rate without having to describe how the mapping was done every time a new area is mapped (Burns & Madin, 2009). The results of following this protocol in any particular area include a very detailed database and map of the landslide inventory (**Figure 2-72**).

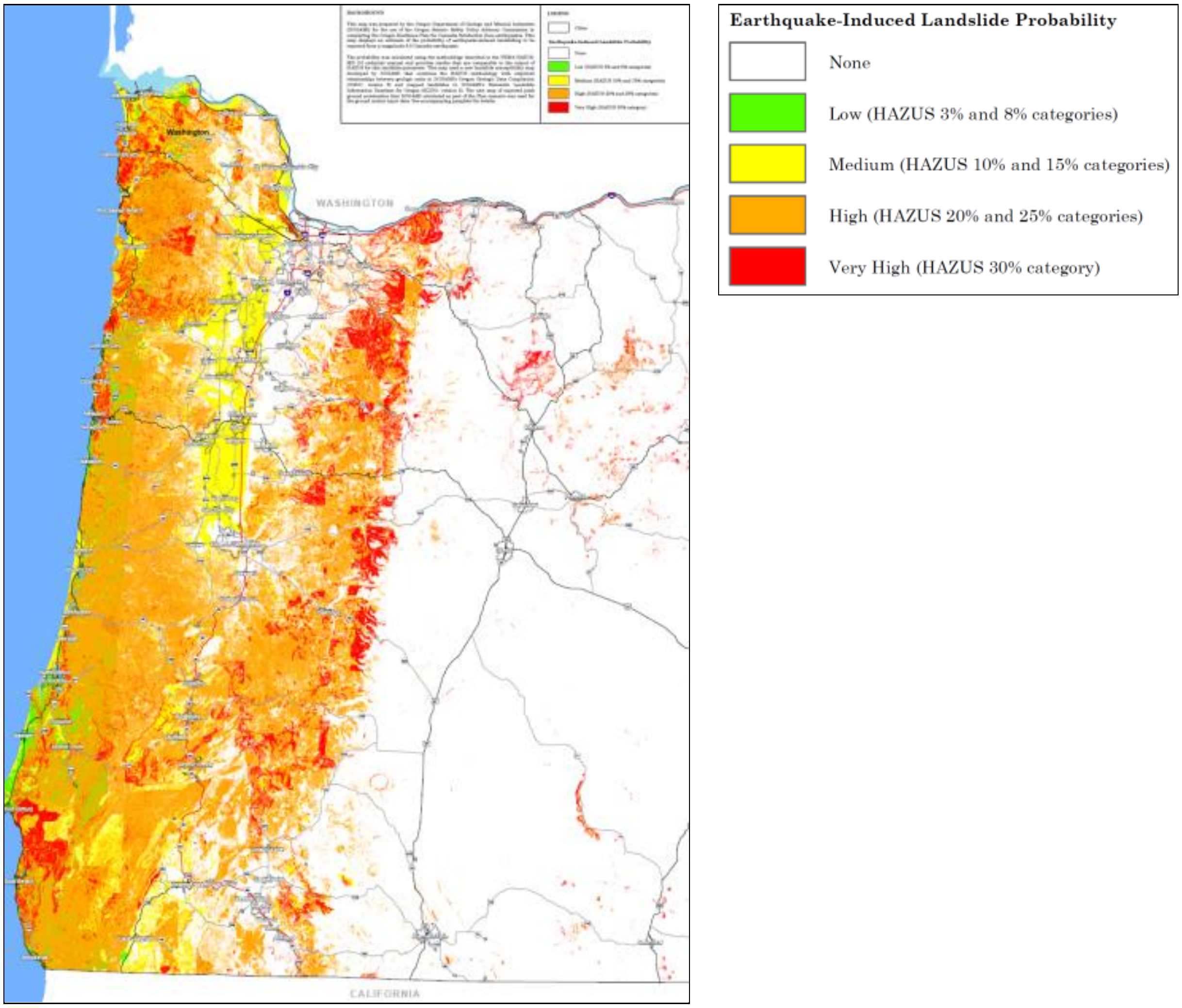
Figure 2-72. Example of a Lidar-Based Landslide Inventory (Oregon City, Oregon)



Source: Burns & Mickelson (2010)

With an accurate landslide inventory in hand, the next step in a complete landslide hazard mapping program is developing susceptibility maps for common types of landslides (see **Figure 2-73**). DOGAMI has completed a shallow landslide susceptibility protocol and is in progress of completing deep landslide and channelized debris flow susceptibility mapping protocols.

Figure 2-73. Example of an Earthquake-Induced Landslide Susceptibility Map



Source: Madin & Burns (2013)

Probability of Landslides in Each Oregon County

Climate, geology, and topography combine to make portions of Oregon landslide-prone. Precipitation, earthquakes, and human activity are the main triggers of landslides. The growing Oregon population has pushed development into landslide-prone areas, putting people and infrastructure at risk.

In order to produce the **Table 2-63,** Future Probability of Landslides in Each County in Oregon, we used the *Landslide Susceptibility Overview Map of Oregon* (2016). The landslide susceptibility overview map of Oregon uses three statewide data sets: 1) geologic map (Oregon Geologic Data Compilation, release 6), 2) landslide inventory (Statewide Landslide Information Layer for Oregon [SLIDO], release 3.2), and 3) slope map (lidar-derived data and U.S. Geological Survey national elevation data). We combined generalized geology and landslide inventory to determine landslide area per geologic unit area and to establish classes of low, moderate, and high landslide density. Then we calculated spatial statistics of the slope map to determine classes of low, moderate, and high slopes prone to landsliding within each geologic unit. Using a hazard matrix, we combined these two data sets, landslide density and slopes prone to landsliding, with the original landslide inventory to establish final landslide susceptibility overview map zones.

The statewide overview map zones classify Oregon into the following susceptibility zones: 37% low, 28% moderate, 30% high, and 5% very high (the very high zone by definition consists of mapped landslides). Most areas classified as moderate or higher landslide susceptibility are located in the Cascade Mountains, the Coast Range, and the Klamath Mountains and portions of central and northeastern Oregon.

Figure 2-74. How Data Sets Are Combined to Create Final Landslide Susceptibility Zones

Graphic display of how data sets are combined to create the final landslide susceptibility zones.		**Landslide Density** Combine: 1 Generalized Geologic Map + 2 Landslide Inventory			**Landslides** 2 Landslide Inventory
	Class	Low (less than 7%)	Moderate (between 7% and 17%)	High (greater than 17%)	Existing Landslides
Slope Prone to Landsliding Combine: 2 Landslide Inventory + 3 Slope Map	Low (less than 1 STD)	Low	Moderate	High	Very High
	Moderate (between the mean and 1 STD)	Moderate	Moderate	High	Very High
	High (equal to or greater than mean)	High	High	High	Very High

Source: Burns, et al. (2016)

We defined each susceptibility class as:

Low: Landsliding unlikely. Areas classified as Landslide Density = Low (less than 7%) and areas classified as Slopes Prone to Landsliding = Low. Note that landslide density and slopes prone to landsliding data were not considered in this category because existing slides are inherently prone to instability. Note also that the inventory quality of existing landslides varies highly across the state.

Moderate: Landsliding possible. Areas classified as Landslide Density = Low to Moderate (less than 17%) and areas classified as Slopes Prone to Landsliding = Moderate OR areas classified as Landslide Density = Moderate (7%-17%) and areas classified as Slopes Prone to Landsliding = Low.

High: Landsliding likely. Areas classified as Landslide Density = High (greater than 17%) and areas classified as Slopes Prone to Landsliding = Low and Moderate OR areas classified as Landslide Density = Low and Moderate (less than 17%) and areas classified as Slopes Prone to Landsliding = High.

Very High: Existing landslides. Landslide Density and Slopes Prone to Landsliding data were not considered in this category. Note: the quality of landslide inventory (existing landslides) mapping varies across the state.

The statewide results for the classes are:

- 37% low
- 28% moderate
- 30% high
- 5% very high (mapped landslides)

These previously developed hazard zones were related then used, along with experience-based judgment, to develop the probability table.

Table 2-62. Classifying Landslide Probability

Percent of County with High + V High	Probability	# 1–5
0–10	Unlikely	1
10–20	Possible	2
20–30	Likely	3
30–50	Very Likely	4
50+	Extremely Likely	5

Source: Burns, et al. (2016)

This relationship was then used to establish the final probability of landslide hazard per county table.

Table 2-63. Future Probability of Landslides in Each County in Oregon

Region/County		Landslide Probability	# 1–5
Region 1	Clatsop	Extremely Likely	5
	Coos	Extremely Likely	5
	Curry	Extremely Likely	5
	Douglas Coastal	Extremely Likely	5
	Lane Coastal	Extremely Likely	5
	Lincoln	Extremely Likely	5
	Tillamook	Extremely Likely	5
Region 2	Clackamas	Very Likely	4
	Columbia	Extremely Likely	5
	Multnomah	Very Likely	4
	Washington	Very Likely	4
Region 3	Benton	Very Likely	4
	Lane	Extremely Likely	5
	Linn	Very Likely	4
	Marion	Very Likely	4
	Polk	Very Likely	4
	Yamhill	Extremely Likely	5
Region 4	Douglas	Extremely Likely	5
	Jackson	Extremely Likely	5
	Josephine	Extremely Likely	5
Region 5	Gilliam	Very Likely	4
	Hood River	Extremely Likely	5
	Morrow	Possible	2
	Sherman	Likely	3
	Umatilla	Likely	3
	Wasco	Very Likely	4
Region 6	Crook	Likely	3
	Deschutes	Possible	2
	Jefferson	Very Likely	4
	Klamath	Possible	2
	Lake	Possible	2
	Wheeler	Extremely Likely	5
Region 7	Baker	Very Likely	4
	Grant	Very Likely	4
	Union	Very Likely	4
	Wallowa	Extremely Likely	5
Region 8	Harney	Possible	2
	Malheur	Possible	2

Source: Burns, et al. (2016)

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

2.2.6.3 Vulnerability

Landslides occur statewide in Oregon, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the coast and Coast Range Mountains and the Cascade Mountains have the most landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage to the state. Less commonly, landslides and debris flows in this area cause loss of life.

Most Vulnerable Jurisdictions

The Department of Geology and Mineral Industries is the agency with primary oversight of the landslide hazard. After agency staff review of available hazard data including SLIDO-4 and based on the 2020 vulnerability scores, DOGAMI lists Clatsop, Coos, Curry, Douglas Coastal, Lincoln, Tillamook, Lane Coastal, Clackamas, Columbia, Multnomah, Washington, Lane, Linn, Marion, Benton, Yamhill, Douglas, Jackson, Josephine, Hood River, Wasco, Jefferson, Wheeler and Wallowa Counties as having the highest hazard and risk to landslide in the state. Because of their importance to the state's economy, landslides occurring in Multnomah, Clackamas, and Washington Counties present the greatest vulnerability to impacts from this type of disaster. Landslides that close US-101 or any of the many highways connecting the I-5 corridor to the coast have a significant effect on commerce in the Oregon Coast Region.

In performing the 2020 vulnerability analysis, potential dollar losses from damage to state-owned and -leased buildings and state and local critical facilities exposed to landslide hazards were combined with the CDC's social vulnerability index. All elements were weighted equally.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities statewide. Over $777.5M in value of state buildings, state and local critical facilities is exposed to landslide hazards statewide.

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to landslides. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. None of these losses were due to landslides.

DAS's records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Historic Resources

Of the 58,872 historic buildings throughout the state, 58,835 are exposed to landslide hazards – only 37 are not. The vast majority of those exposed are in low landslide hazard areas. 3,751 are in high landslide hazard areas. See Appendix **9.1.12** for details.

Archaeological Resources

Of the 22,060 archaeological resources located in landslide hazard areas statewide, 12,943 are in areas of high earthquake hazards. Of those, 296 are listed on the National Register of Historic Places and 1,438 are eligible for listing. Five hundred seventy have been determined not eligible, and 10,639 have not been evaluated as to their eligibility for listing. See Appendix **9.1.13** for details.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

For the 2020 vulnerability assessment, DLCD combined this index with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Lincoln, and Wasco, Counties are the most vulnerable to impacts from landslide hazards.

Currently, there is no method to evaluate statewide vulnerability to landslides. The list of most vulnerable jurisdictions is primarily based on the 2020 vulnerability scores and are in alignment with the landslide susceptibility data in SLIDO-4. DOGAMI has performed landslide risk analysis of some individual communities in Oregon including Astoria, part of the US-30 transportation corridor, the Mount Hood region, parts of the Portland Metro area, and Silverton, Eugene-Springfield. The Mount Hood multi-hazard risk study provides details on the methods used to evaluate landslide and other hazard risk (Burns W. J., et al., 2011b).

2.2.6.4 Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

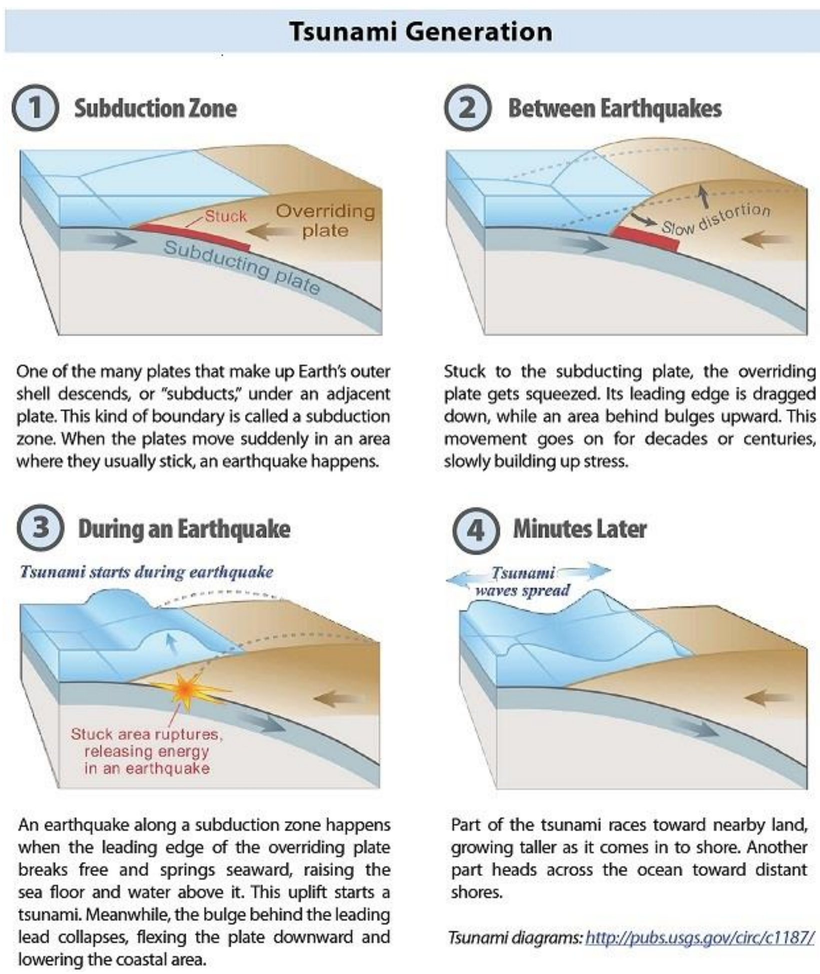
In the case of landslide hazards, the 2020 risk scores were generally greater than the vulnerability scores, elevated primarily due to very high probability of landslides occurring. According to the 2020 risk scores and DOGAMI's professional expertise, Regions 1, 2, 3, 4, 5, and 6 carry highest risk of landslides.

2.2.7 Tsunamis

Tsunamis are a low frequency natural hazard in Oregon and are restricted almost exclusively to coastal areas. Tsunamis are most often caused by the abrupt change in the seafloor accompanying an earthquake (**Figure 2-75**). The most common sources of the largest tsunamis are earthquakes that occur at subduction zones like the Cascadia Subduction Zone (CSZ), where an oceanic plate descends beneath a continental plate (**Figure 2-76**). Other important processes that may trigger a tsunami include underwater volcanic eruptions and landslides (includes landslides that start below the water surface and landslides that enter a deep body of water from above the water surface). Tsunamis can travel thousands of miles across ocean basins, so that a particular coastal area may be susceptible to two different types of tsunami hazard caused by:

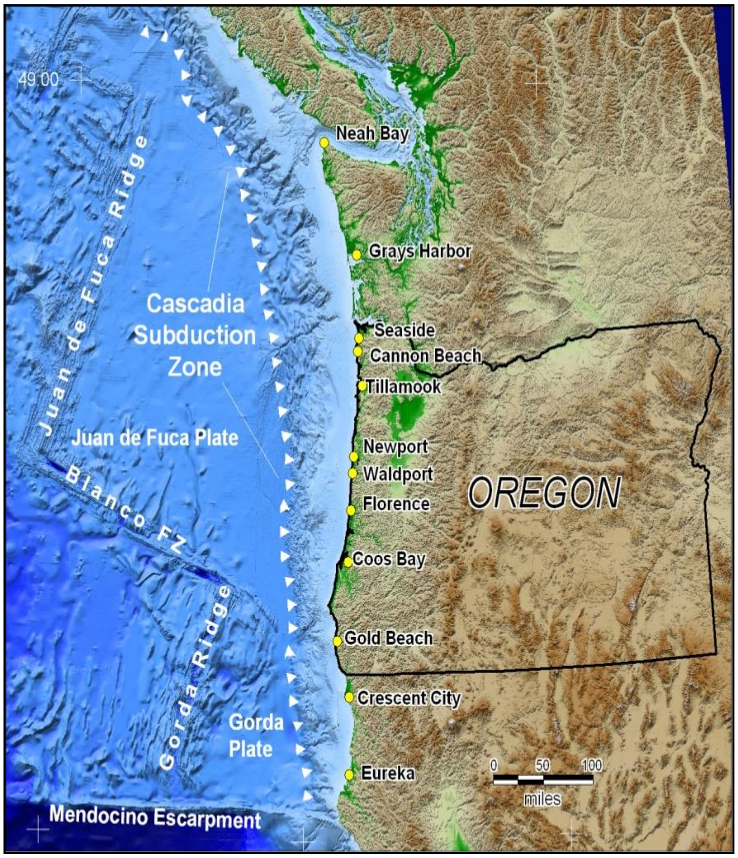
1. Distant sources across the ocean basin, and
2. Local sources that occur immediately adjacent to a coast.

Figure 2-75. Generation of a Tsunami by Subduction Zone Earthquakes



Source: DOGAMI, *Cascadia,* Winter 2012 (http://www.oregongeology.org/pubs/cascadia/CascadiaWinter2012.pdf)

Figure 2-76. Cascadia Subduction Zone (CSZ) Active Fault Map



Note: The fault, indicated by the triangles, is the contact where the Juan de Fuca Plate plunges beneath the North American continental plate.

Source: DOGAMI

Distant tsunamis that may threaten the Oregon Coast are usually generated by a subduction zone earthquake elsewhere in the Pacific and would take at least 4 hours to reach the Oregon coastline from the closest source, the subduction zone in the Gulf of Alaska. For example, the 1964 Alaska tsunami reached the Oregon Coast in four hours after the magnitude 9.2 earthquake that generated it. In contrast, a local tsunami generated by a CSZ earthquake, would take about 10-20 minutes to reach most of the coast.

Most locally generated tsunamis will be higher and travel farther inland (overland and up river) than distant tsunamis. By the time the tsunami wave hits the coastline, it may be traveling at 30 mph and have heights of 20 to about 100 feet, depending on the local coastal bathymetry (water depths), shape of the shore, and the amount of fault movement on the subduction zone. The tsunami wave will break up into a series of waves that will continue to strike the coast for a day or more, with the most destructive waves arriving in the first 4-5 hours after the local earthquake. As was seen in the 2004 Sumatra tsunami, the first wave to strike the coast is not always the most destructive. This was again the case during the 2011 Japan tsunami.

The coasts of Washington, Oregon, and northern California are particularly vulnerable to tsunamis from magnitude 9+ earthquakes that occur about every 500 years on the CSZ (**Figure 2-76**). Additionally, smaller tsunamis and earthquakes occur in the subduction zone south of Bandon on the southern Oregon coast. The recurrence for these smaller rupture events can be as low as about 230 years in Curry County.

The initial tsunami wave mimics the shape and size of the sea floor movement that causes it, but quickly evolves into a series of waves that travel away from the source of disturbance, reflect off of coastlines, and then return again and again over many hours. The tsunami is thus “trapped” owing to the processes of reflection and refraction. In the deep ocean, tsunami waves may be only a few feet high and can travel at wave speeds of 300–600 mph. As a tsunami approaches land where the water depth decreases, the forward speed of the wave will slow and the wave height increase dramatically. When the wave makes landfall, the water is mobilized into a surging mass that floods inland until it runs out of mass and energy. The wave then retreats, carrying all sorts of debris. Successive waves then batter the coast with this debris. Swimming through such turbulent debris-laden water is next to impossible.

Tsunamis are more destructive than the earthquake that caused them. Loss of lives from the tsunami can often be many times the loss from the earthquake ground shaking. This was highlighted by the December 26, 2004 tsunami, associated with a magnitude 9.3 earthquake, which occurred offshore from the Indonesian island of Sumatra. The tsunami impacted almost every country located around the Indian Ocean rim and claimed the lives of approximately 350,000 people. The greatest loss of life occurred along the coast of Sumatra, close to the earthquake epicenter. The event displaced some 2 to 3 million people and its economic impact continues to be felt to the present.

In addition, fires started by the preceding earthquake are often spread by the tsunami waves, if there is a gasoline or oil spill. As was seen in the Sumatra 2004 tsunami, flood inundation from a tsunami may be extensive, as tsunamis can travel up rivers and streams that lead to the ocean. Delineating the inland extent of flooding, or inundation, is the first step in preparing for tsunamis.

2.2.7.1 Analysis and Characterization

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on the Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the Cascadia Subduction Zone (CSZ) happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

On March 11, 2011, a magnitude (Mw) 9.0 earthquake struck off the east coast of Japan. This caused a massive tsunami that inundated much of the eastern coastline of Japan and reached the west coast of the U.S. many hours later. There was one death and millions of dollars of damage to ports and harbors in Oregon and California (Figure 2-77). In contrast, Japan suffered approximately 18,000 deaths as well as a nuclear catastrophe which will continue to be a hazard far into the future; destruction from the tsunami and earthquake resulted in about $250 billion in damages. Oregon received a Presidential Declaration of Disaster (DR-1964) which brought millions of dollars of financial aid to repair and mitigate future tsunami damage. Debris from tsunami-damaged buildings in Japan floated across the Pacific Ocean and began arriving on the Canadian and U.S. West Coast in December 2011 and continued to arrive several years after the event.

Figure 2-77. Tsunami Damage on the Chetco River, Oregon from the Tsunami Generated by an Earthquake Offshore Japan in 2011

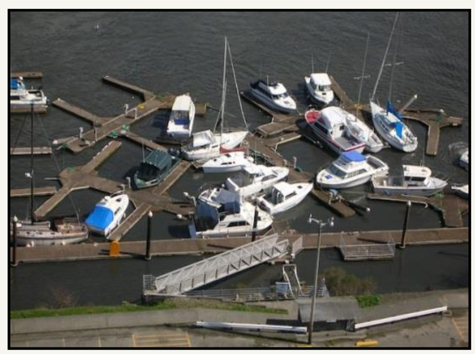


Photo source: U.S. Coast Guard

In March 1964, a tsunami struck southeastern Alaska following an earthquake beneath Prince William Sound and arrived along the Alaska coastline between 20 and 30 minutes after the quake, devastating villages. Damages were estimated to be over $100 million (1964 dollars). Approximately 120 people drowned. The tsunami spread across the Pacific Ocean and caused damage and fatalities in other coastal areas, including Oregon. The tsunami killed five people in Oregon and caused an estimated $750,000 to $1 million in damage. In Crescent City, California, there were 10 fatalities, while damage to property and infrastructure was estimated to range from $11 to 16 million.

Going still further back in time, there is scientific consensus that the Pacific Northwest experienced a subduction zone earthquake estimated at magnitude 9 on January 26, 1700. The earthquake generated a tsunami that caused death and damage as far away as Japan, where it was well-documented in the literature of the time. The earthquake and tsunami left behind geologic “footprints” in the form of (a) tsunami sand sheets in marshes, (b) layers of marsh vegetation covered by tide-borne mud when the coast abruptly subsided, and (c) submarine sand and silt slurries shaken off the continental shelf by the earthquake (turbidites). The widespread and large body of oral traditional history of the Thunderbird and Whale stories passed down by First Nations people depict both strong ground shaking and marine flooding that may have been inspired by this event. Although this earthquake undoubtedly produced tsunamis that reached on the order of 30–40 feet at the coast, geologic evidence from study of 10,000 years of turbidite deposits suggests that the 1700 earthquake was just an average event.

Some Cascadia earthquakes have been many times larger, so, while devastating, the earthquake and tsunami were far from the worst case.

In 2013 the Oregon Department of Geology and Mineral Industries (DOGAMI) completed an analysis of the full range of Cascadia tsunamis and earthquakes, separating the results into five size classes with “T-shirt” names, S, M, L, XL, and XXL. The XL or XXL events probably only happened once or twice in the last 10,000 years, but estimated tsunami heights were comparable to those of the 2011 Japan and 2004 Sumatra tsunamis, the largest known.

The tsunami wave tends to arrive at the coast as a fast moving surge of rising water. As the tsunami enters coastal bays and rivers, it may move as a high-velocity current or a breaking wave that travels up an estuary as a bore (wall of turbulent water like the waves at the coast after they break). This inland wave of water can often cause most or all of the damage, and the current may be just as destructive when it is retreating from the land as when it is advancing. For example, in Seaside the damage from the 1964 Alaskan tsunami occurred along the Necanicum River and Neawanna Creek, well inland from the coast. In addition, storm waves and wind waves may ride on top of the tsunami waves, further compounding the level of destruction.

During Cascadia earthquakes there is also the added effect of coastal subsidence, or the drop in elevation of the land relative to sea level, during the earthquake. This is due to the release of the accumulated strain that caused the western edge of the North American Plate to bend and bulge. The new earthquake models used for the local tsunami scenarios indicate that portions of the Oregon coast could drop by a several feet to approximately 15 feet.

Seven tsunami flooding (inundation) zones were mapped by DOGAMI between 2009 and 2013: five local Cascadia tsunami scenarios, S, M, L, XL, XXL, and two maximum-considered distant tsunami scenarios (the 1964 Alaska tsunami and a larger hypothetical maximum Alaska tsunami, AKmax). All 7 are depicted on DOGAMI tsunami inundation maps (TIMs, **Figure 2-78**) plus digital files for use in geographic information systems (GIS). The five local CSZ-sourced inundation scenarios involve greater and greater amounts of movement on the subduction zone fault, ranging from 30 feet (S scenario) to 144 feet (XXL scenario). The seven inundation lines are reduced to two for evacuation planning: AKmax inundation is the distant tsunami evacuation zone, and XXL is the local tsunami evacuation zone (**Figure 2-78**). Brochures illustrating these zones and evacuation routes are available for all population centers, but both zones can also be viewed for any part of the coast using an interactive map portal and mobile phone apps at www.oregontsunami.org. The evacuation zones are critical for life safety planning and preparation. All seven scenarios were modeled on a mean higher high tide (MHHW) and include the effects of subsidence from the earthquake fault process (release of strain on the North American Plate).

Figure 2-78. Examples of DOGAMI Tsunami Inundation Maps (TIMs) and Tsunami Evacuation Maps for North Bend (Coos Bay Area)

The top map illustrates inundation for five "T-shirt" size CSZ scenarios (S, M, L, XL, and XXL); the middle map shows inundation from two maximum considered distant tsunamis from subduction zone earthquakes in the Gulf of Alaska, a hypothetical maximum (termed Alaska Maximum or AKmax in DOGAMI databases), and the largest historical event that struck the Oregon coast in 1964. Note the close similarity of Alaska Maximum to the Small CSZ inundation.

Source: DOGAMI, *Cascadia* Winter 2012 (http://www.oregongeology.org/pubs/cascadia/CascadiaWinter2012.pdf)

Historic Tsunami Events

Table 2-64. Historic Distant Tsunamis in Oregon

Date	Origin of Event	Affected Oregon Community	Damage	Remarks
Apr. 1868	Hawaii	Astoria		observed
Aug. 1868	N. Chile	Astoria		observed
Aug. 1872	Aleutian Islands	Astoria		observed
Nov. 1873	N. California	Port Orford		debris at high tide line
Apr. 1946	Aleutian Islands	Bandon		barely perceptible
Apr. 1946		Clatsop Spit		water 3.7 m above MLLW
Apr. 1946		Depoe Bay		bay drained; water returned as a wall
Apr. 1946		Seaside		wall of water swept up Necanicum River
Nov. 1952	Kamchatka	Astoria		observed
Nov. 1952		Bandon	log decks broke loose	
May 1960	S. Cent. Chile	Astoria		observed
May 1960		Seaside	bore on Necanicum River damaged boat docks	
May 1960		Gold Beach		observed
May 1960		Newport		observed for about 4 hours
May 1960		Netarts	some damage observed	
Mar. 1964	Gulf of Alaska	Cannon Beach	bridge and motel unit moved inland; $230,000 damage	
Mar. 1964		Coos Bay	$20,000 damage	
Mar. 1964		Depoe Bay	$5,000 damage; 4 children drowned at Beverly Beach	
Mar. 1964		Florence	$50,000 damage	
Mar. 1964		Gold Beach	$30,000 damage	
Mar. 1964		Seaside	1 fatality (heart attack); damage to city: $41,000; private: $235,000; four trailers, 10–12 houses, two bridges damaged	
May 1968	Japan	Newport		observed
Apr. 1992	N. California	Port Orford		observed
Oct. 1994	Japan	coast		tsunami warning issued, but no tsunami observed
Mar. 2011	Japan	coast	$6.7 million; extensive damage to the Port of Brookings	tsunami warning issued, observed ocean waves
Oct. 2012	Haida Gwaii, BC	coast		M 7.7 caused a tsunami with local runup of more than 7 meters and amplitudes up to 0.8 meter on tide gauges 4000 kilometers away in Hawaii. Source: NOAA

Date	Origin of Event	Affected Oregon Community	Damage	Remarks
Jan. 2018	Kodiak Is., AK	coast		minor tsunami impacts in AK, HI and US west coast; the largest tsunami amplitude was recorded at 25cm in Crescent City CA 4-5 hrs after the magnitude 7.9 earthquake

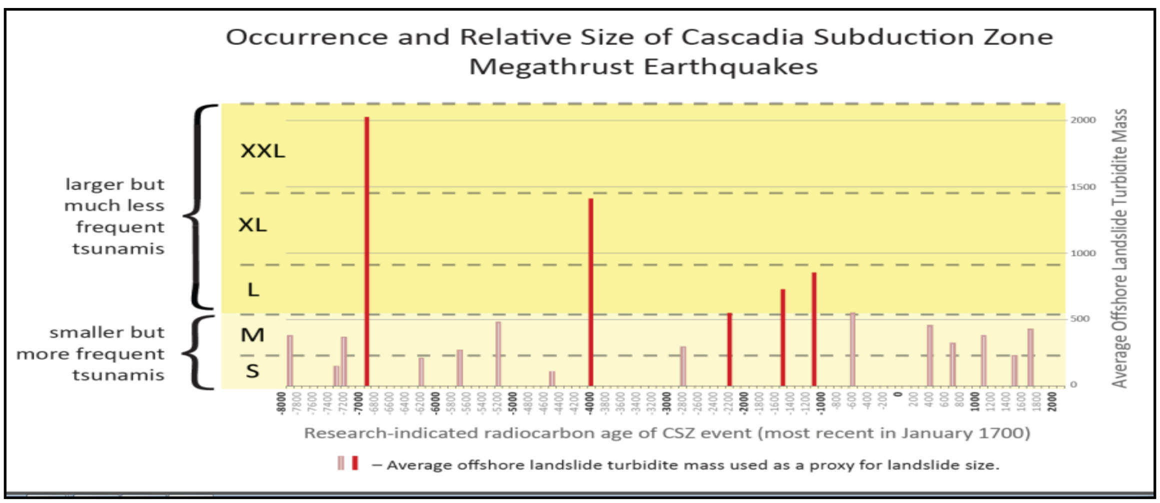
Sources: Lander, et al., (1993); FEMA, 2011, Federal Disaster Declaration; NOAA, https://www.ngdc.noaa.gov/hazel/view/hazards/tsunami/event-more-info/5673, downloaded on 4/15/20

In addition to the historical distant tsunamis of **Table 2-64**, the last CSZ tsunami struck at 9 PM on January 26, 1700. This may be considered a historic event, because the tsunami was recorded in historical port records in Japan. The date and time of occurrence here in Oregon were inferred by Japanese and USGS researchers from a tsunami and earthquake model.

2.2.7.2 Probability

While large (about magnitude 9) CSZ earthquakes and associated tsunamis have occurred on average every 500 years over the last 10,000 years, the time interval between events has been as short as a century and as long as 1,150 years. Smaller earthquakes on the southern part of the CSZ have occurred about as often as larger earthquakes, making CSZ events in southernmost Oregon about twice as likely as in northern Oregon. The size and frequency of the 19 large earthquakes on the CSZ are inferred from offshore turbidite deposits and are shown in **Figure 2-79**. All 19 of these large CSZ events were likely magnitude 8.7–9.2 earthquakes.

Figure 2-79. Occurrence and Relative Size of Cascadia Subduction Zone Megathrust Earthquakes



Source: DOGAMI *Cascadia*, Winter 2012 (http://www.oregongeology.org/pubs/cascadia/CascadiaWinter2012.pdf)

In April 2008 the USGS estimated that the probability of a magnitude 8-9 earthquake somewhere along the 750-mile-long Cascadia Subduction Zone was about 10% in the next 30 years. In 2012 USGS Professional Paper 1661-F (http://pubs.usgs.gov/pp/pp1661f/) showed that the southern part of the CSZ also ruptures in segments **Figure 2-80**, resulting in a greater probability of a rupture taking place in southern Oregon. Southern segment earthquakes and tsunamis will generally be smaller than full-margin events, and by the time they travel north along the coast are similar in size to distant tsunamis with the largest waves striking 2 hours or more after the earthquake (Priest, et al., 2014). New tsunami inundation maps from DOGAMI illustrate the range of inundation from all full-margin and significant segment ruptures on the CSZ. Most recently, Goldfinger, et al. (2017) completed revised estimates for the probability of a great earthquake taking place on the CSZ, estimated at 16–22% in the next 50 years, and approximately 43% for a southern Oregon partial rupture.

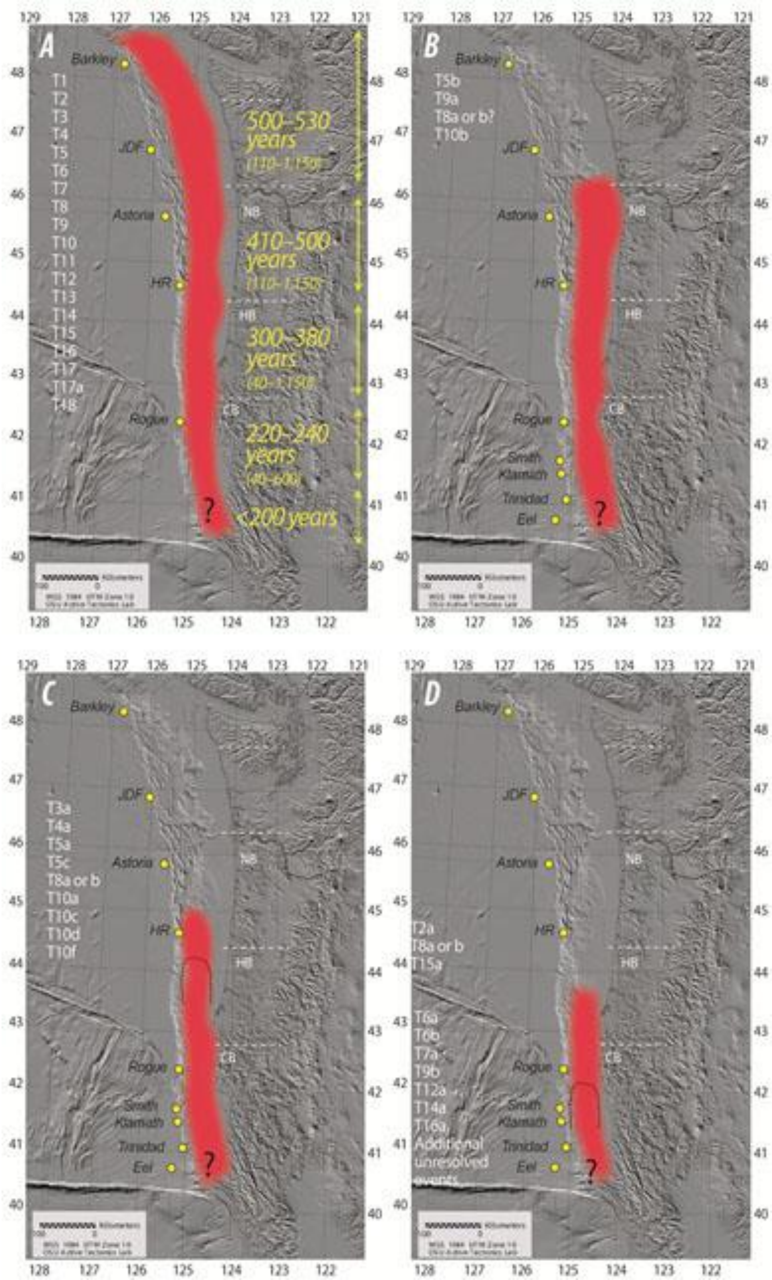


Figure 2-80. Hypothetical Rupture Patches of Cascadia Subduction Zone (CSZ) Earthquakes over Last 10,000 Years

White line with triangles marks the CSZ deformation front also visible as boundary between smooth to rough terrain. Numbers with "T" prefixes are offshore turbidite layers correlated with each rupture patch and arranged with youngest at the top. The white dashed lines are inferred segment boundaries of CSZ ruptures designated segments A (full-margin rupture), B (rupture north to Nehalem Bank [NB]), C (rupture north to Heceta Bank [HB]), and D (rupture north to Coquille Bank [CB]). Northern extents of segment D events break into two groups, one terminating south of the Rogue submarine canyon, indicated by dashed line. The second group extends north of Rogue but is not observed at Hydrate Ridge (HR). Although presumed to extend no further south than the southern terminus of the CSZ at Cape Mendocino, southern rupture limits are poorly known for all events indicated by query, limited by temporal coverage of turbidites and probable non-seismic turbidites in the early Holocene. Uncertainty in the northern extent of segments C and D are shown as the difference between the red patches and the black dashed lines. In the map of segment A, mean return in years of CSZ earthquakes is listed at each latitude and is calculated by dividing the number of turbidite layers into 10,000 years; minimum and maximum time intervals between turbidites at each latitude is given in parentheses. See Priest, et al. (2014) for estimates of height and arrival times of Segment C and D tsunamis.

Note: Red areas depict hypothetical rupture patches of Cascadia subduction zone (CSZ) earthquakes over the last 10,000 years inferred by Goldfinger, et al. (2012) from marine and onshore paleoseismic data plus geological and geophysical data

Source: Goldfinger, et al. (2012)

Probability of Coastal Hazards in Each Coastal County

Coastal paleoseismic records document the impacts of as many as 13 major subduction zone earthquakes and associated tsunamis over the past ~7,000 years, while recent studies of turbidite records within sediment cores collected in deep water at the heads of Cascadia submarine canyons provide evidence for at least 46 distinct tsunami events over the past approximately 10,200 years (Goldfinger, et al., 2017). The length of time between these events varies from as short as 100 years to as long as 1,200 years, with the average recurrence interval for major Cascadia earthquakes (magnitude >[Mw] 9) estimated to be about 530 years (Witter, et al., 2010); the last great (full-margin rupture) Cascadia earthquake took place on January 26, 1700. Given that the subduction zone is presently locked and the rate of convergence of the Juan de Fuca against the North American plates is about 1.5 inches per year, this suggests that approximately 12.1 m of strain has accumulated since the 1700 earthquake as it builds to the next rupture.

Recently, Goldfinger, et al. (2017) provided a revised assessment for the central to northern Oregon coast, which was found to have a mean recurrence time of about 340 years. Furthermore, they defined a conditional probability of the next Cascadia event taking place in the next 50 years of approximately 16 to 22%. Goldfinger, et al. (2012) indicated that the chance of a partial rupture occurring and impacting the southern Oregon coast is approximately 43% in the next 50 years. Using these data, we assign a higher probability risk of a Cascadia event occurring on the southern Oregon coast (i.e., Coos and Curry counties) compared with the remainder of the coast. The final probability was assigned a number from 1 to 5 for use in the 2020 risk assessment developed by DOGAMI and DLCD. This method combines the probability score with the vulnerability scores to arrive at the relative risk score.

Table 2-65. Probability and Exposure Rankings of Tsunami Hazards

		Probability	Exposure	Probability Score
Region 1	Clatsop	Likely	Very High	4 = H
	Coos	Very likely	Very High	5 = VH
	Curry	Very likely	Very High	5 = VH
	Douglas Coastal	Likely	Very High	4 = H
	Lane Coastal	Likely	Very High	4 = H
	Lincoln	Likely	Very High	4 = H
	Tillamook	Likely	Very High	4 = H

2.2.7.3 Vulnerability

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on the Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the Cascadia Subduction Zone (CSZ) happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

Because tsunamis in Oregon typically occur as a result of earthquakes, the unknown time and magnitude of such events adds to the difficulty in adequately preparing for such disasters. If a major earthquake occurs along the CSZ, a local tsunami could follow within 10 to 20 minutes.

Although tsunami evacuation routes have been posted all along the Oregon Coast, damage to bridges and roadways from an earthquake could make evacuation difficult even if a tsunami warning were given. In addition, if a major earthquake and tsunami occur during the "tourist season," causalities and fatalities from these disasters would be far greater than if the same events occurred during the winter months.

It is also important to consider where the impact of a tsunami would be the greatest. Owing to relatively large resident and visitor populations located at very low elevations, cities facing the Pacific Ocean on the northern Oregon Coast are more vulnerable to inundation and have the greater potential for loss of life than coastal cities in central and southern Oregon. USGS (Wood N. , 2007) estimated vulnerable populations using a tsunami inundation zone similar to the Medium CSZ event, which is the most likely event to occur. That study found that:

1. 22,201 residents and 10,201 households are in the zone, with the largest numbers in the northern coast;
2. the City of Seaside had the highest number of residents in the zone (4,790); and
3. 7,912 residents (36% of all residents in the zone) are in unincorporated communities, the balance in 26 incorporated communities.

Inventories that utilize 2010 census data and updated population modeling have been developed by DOGAMI (Bauer et al., 2020) in order to update the work of Wood (2007). Results indicate that for the L1 scenario, there are 32,630 people in the tsunami zone, comparable to results obtained by (Wood & Schmidtlein, 2011). For the XXL1 scenario, the number of people in the tsunami zone increases to approximately 56,500. Distant tsunamis, except for the most extreme events, will not affect significant numbers of residents, since they flood principally beaches and low-lying waterfront areas. Loss of life from distant tsunamis will also be far less than for local tsunamis, because there will be at least four hours to evacuate prior to wave arrival, compared with 10–20 minutes for a local Cascadia tsunami.

That said, visitors are more vulnerable than residents to both distant and locally generated tsunamis, because they are more likely to be at beaches and shoreline parks and are generally less aware of hazard response and preparedness. During the summer and holidays, visitors can greatly outnumber residents in the small coastal towns. In a pilot project of five coastal communities (Gearhart, Rockaway Beach, Lincoln City, Newport, and Port Orford), DOGAMI found that the visitor population may be about 2 to 5 times the local permanent population; differences here are entirely a function of the availability of the number of hotel/motels and holiday homes in each community. While intensive education and outreach programs led by DOGAMI and OEM have greatly increased awareness and preparedness, residents are much more likely to have received this education than visitors.

The Oregon Resilience Plan (ORP) uses the impact of a "Medium" or "M" CSZ earthquake and tsunami for planning purposes, because this was judged the most likely CSZ event (see DOGAMI Special Paper 43 (Witter, et al., 2011) for explanation). The ORP describes the "M" impact:

> *Following the Cascadia event, the coastal communities will be cut off from the rest of the state and from each other. The coastal area's transportation system, electrical power transmission and distribution grid, and natural gas service will be fragmented and offline, with long-term setbacks to water and wastewater services. Reliable communications will be similarly affected. Because so many of*

> *these connecting systems are single lines with little or no redundancy, any break or damage requiring repair or replacement will compromise the service capacity of the entire line.*
>
> *The loss of roads and bridges that run north and south will make travel up and down the coast and into the valley difficult, if not impossible, due to the lack of alternate routes in many areas. Reestablishing the roads and utility infrastructure will be a challenge, and the difficulties will be exacerbated in the tsunami inundation area by its more complete destruction. Even businesses outside of the tsunami inundation may not recover from the likely collapse of a tourist-based economy during the phased and complicated recovery and reconstruction period.*
>
> *Based on the resilience targets provided by the Transportation, Energy, Communications, and Water/Wastewater task groups, current timelines for the restoration of services up to 90-percent operational levels will take a minimum of one to three years, and often over three years in the earthquake-only zone. Restoration in the tsunami zone will take even longer than that... The most critical infrastructure is the road and highway system. Without functioning road systems, none of the infrastructure can be accessed to begin repairs.*
>
> *The tsunami will also create an enormous amount of debris that needs to be gathered, sorted, and managed. The recent experience of Japan, with a similar mountainous coastline, has shown that debris management competes with shelter and reconstruction needs for the same flat land that is often in the inundation zone.*

The ORP estimates that times for recovery of the coastal infrastructure for a Medium CSZ event will be: electricity and natural gas, 3–6 months; drinking water and sewer systems, 1–3 years; and Healthcare facilities, 3 years. The ORP gives no estimate for times to recover police and fire stations or the coastal transportation system, but times for the latter would no doubt be measured in years. Economic recovery would also be many years, since much of the coast is dependent on tourism that is directly dependent on the transportation system. According to the ORP:

> *Even if a business had sufficient capital to relocate, it is unlikely that the tourist industry will recover rapidly enough to support business start-up. Local authorities may need to keep tourists out of the inundation zones, for safety reasons, for months or years after a tsunami.*

Most Vulnerable Jurisdictions

For the 2020 vulnerability assessment, DOGAMI considered all Cascadia Subduction Zone (CSZ) tsunami hazard zones as high hazard areas.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from tsunami hazards to state buildings and critical facilities as well as to local critical facilities statewide. Over $248M in value of state buildings and state critical facilities are located in tsunami hazard areas, and 67% of that value is located in Clatsop County. More than $351K of value in local critical facilities is located in tsunami hazard areas. Again, most of that value, 49%, is located in Clatsop County.

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to tsunamis. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. None of these losses were due to tsunamis.

DAS's records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Historic Resources

Of the 3,121 historic resources located in Oregon's coastal counties, 794 are located in tsunami hazard areas. Seventy-three percent (582) are located in Clatsop County and 21% (170) in Coos County. None are located in the coastal portions of Douglas or Lane Counties.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

For the 2020 vulnerability assessment, DLCD combined this index with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Clatsop County, Coos County, and the coastal portion of Lane County are the most vulnerable to the CSZ tsunami hazard followed by the coastal portion of Douglas County.

The entire coastal region is highly vulnerable to tsunamis, but some areas are especially vulnerable owing to geographic and demographic factors. The Oregon Office of Emergency Management (OEM) is the agency with primary oversight of emergency response to the tsunami hazard. A 1990 revision of DOGAMI’s enabling statutes added geologic hazard mitigation to its responsibilities, but other state agencies such as OEM and local governments share this responsibility. Based on agency staff review of the available hazard data, OEM lists Clatsop and Tillamook Counties as having the greatest vulnerability to the tsunami hazard in the state. As previously mentioned, Seaside is the town most vulnerable to tsunamis on the coast, but Gearhart, Cannon Beach, Rockaway Beach, Pacific City, Neskowin, Salishan Spit, Cutler City in Lincoln City, South Beach in Newport, and downtown Waldport are all extremely difficult to evacuate owing to local geographic factors (marshes or lakes limiting evacuation, long distances to evacuation routes, and limited high ground for evacuees) and significant percentages of retirees with limited mobility.

Vulnerability of communities is based primarily on difficulty of evacuation in the 10-20 minutes between a CSZ earthquake and arrival of the tsunami. A community is considered highly vulnerable if the population is large with high ground located a long distance away accessible by only a few routes that could be compromised by earthquake damage.

2.2.7.4 Risk

In the 2020 update, DOGAMI and DLCD developed a new risk ranking system that combines the probability of the hazard with the limited vulnerability assessment to arrive at a composite risk score referred to as the 2020 Risk Score.

According to the 2020 risk assessment, the counties at greatest risk from the tsunami hazard are Clatsop County, Coos County, and the coastal portions of Douglas and Lane Counties.

2.2.8 Volcanoes

Volcanoes are potentially destructive natural phenomena, constructed as magma ascends and then erupts onto the earth's surface. Volcanic eruptions are typically focused around a single vent area, but vary widely in explosivity. Therefore volcanic hazards can have far reaching consequences. Volcanic hazards may occur during eruptive episodes or in the periods between eruptions.

Volcanic hazards may be divided into two categories based on the range of their impact from the eruptive center or active vent. *Proximal* hazards have an impact limited to a distance of about 30 miles or less from the active vent. *Distal* hazards have an impact far beyond the active vent. Proximal and distal hazards are individual to each volcano. In addition to the 30-mile threshold, proximal and distal zone boundaries are based on:

- Frequency and magnitude of past events at the volcano, as recorded by their deposits;
- Modeling that predicts the extent, depth, and travel time of future events; and
- Experience and judgment derived from observations and understanding of events at other volcanoes.

Eruptive events may include proximal hazards such as:

- Lava flows;
- Pyroclastic surges and flows (fast-moving combination of very hot ash, lava, and gases);
- Lahars (volcanic mudflows or debris flows);
- Debris avalanches (landslides);
- Release of volcanic gases; and
- Tephra fall (shower of ejected rock fragments and particles);

As well as distal hazards such as:

- Lahars;
- Eruption columns and clouds; and
- Ashfall.

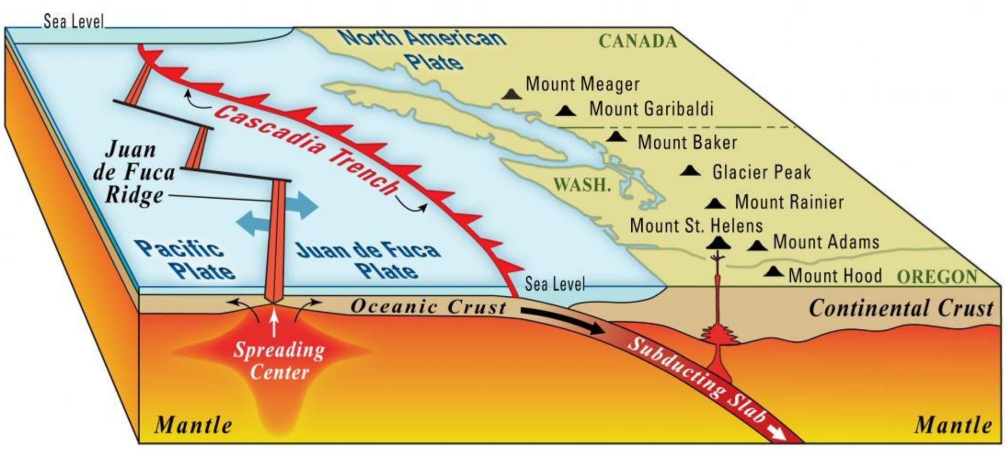
Eruptions may last from days to weeks or years, and have the potential to dramatically alter the landscape for decades. Unlike other geologic hazards (e.g., earthquakes, tsunamis), impending eruptions are often foreshadowed by a number of precursors including ground movements, earthquakes, and changes in heat output and volcanic gases. Scientists use these clues to recognize a restless volcano and to prepare for events that may follow. Hazards occurring between eruptive periods are typically related to earthquakes or natural erosion, which may trigger debris avalanches or debris flows on the flanks of the volcano. Such events often occur without warning.

Potentially hazardous volcanoes in Oregon are present along the crest of the Cascade Range and to a lesser extent in the High Lava Plains. The volcanoes within these regions provide some of Oregon's most spectacular scenery and popular recreational areas, yet the processes that led to their formation also present significant challenges and hazards to communities within the region. The catastrophic eruption of Washington's Mount St. Helens in 1980 and subsequent activity demonstrate both the power and detrimental consequences that Cascade-type volcanoes can have on the region. Lessons learned at Mount St. Helens led the U.S. Geological Survey (USGS) to establish the Cascades Volcano Observatory (CVO) in Vancouver, Washington. Scientists at CVO continually monitor volcanic activity within the Cascade Range, and in cooperation with the Oregon Department of Geology and Mineral Industries (DOGAMI), study the geology of volcanic terrains in Oregon (Ewart, Diefenbach, & Ramsey, 2018).

2.2.8.1 Analysis and Characterization

The volcanic Cascade Range extends southward from British Columbia into northern California. The volcanoes are a result of the complex interaction of tectonic plates along the Cascadia Subduction Zone (CSZ). Subduction is the process that results in the Juan de Fuca plate (oceanic crust) subducting, or sinking, underneath the North American plate (continental crust) on which we live (**Figure 2-81**). As the subducted plate descends, it heats up and begins to melt. This provides the reservoir of heat and molten rock needed to create the magma chambers that lie kilometers deep, beneath the Cascades.

Figure 2-81. Generalized Subduction Zone Setting



Source: Cascades Volcano Observatory Popular Graphics image gallery, http://volcanoes.usgs.gov/vsc/multimedia/cvo_popular_graphics_gallery.html

Stratovolcanoes like Mount Hood, also called composite volcanoes, are generally tall, steep, conical shaped features, built up through layering of volcanic debris, lava, and ash. Eruptions tend be explosive, for example, the violent 1980 eruption of Mount St. Helens, and they produce volcanic mudflows (lahars) that can travel far from the mountain. Future eruptions are likely to be similar and present a severe hazard to the surrounding area.

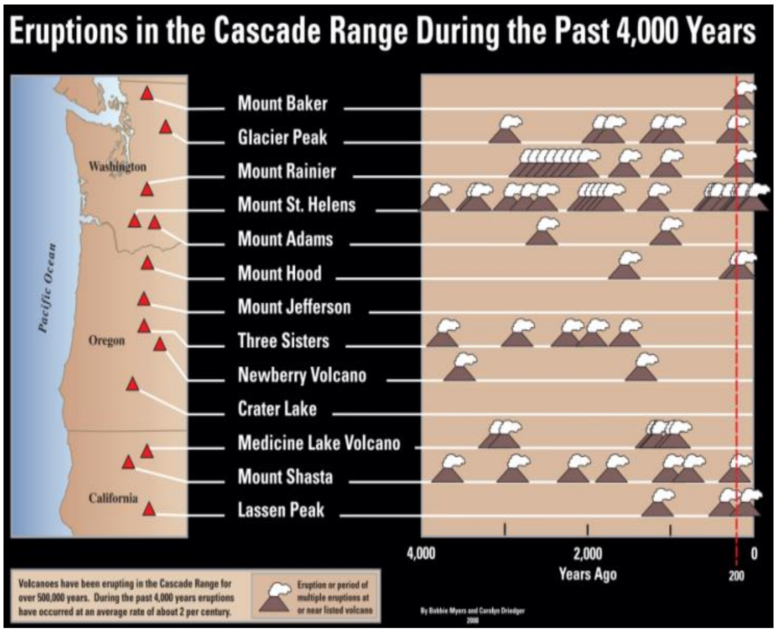
Volcanoes also pose other hazards because of their geology and resulting geomorphology. The relatively high elevation of volcanoes usually results in the meteorological effect called *orographic lifting*, which causes high precipitation and snow on the mountains that can result in flooding. The geologic material tends to be relatively weak and, when

Orographic lifting
The lifting of an air current caused by its passage up and over a mountain.
Source: Glossary of Geology, 4th ed.

combined with the steep slopes, can cause frequent and hazardous landslides. Cascade Mountain Range volcanoes are also located near the active CSZ and nearby potentially active crustal faults, which contribute to moderate seismic hazard in the area.

The volcanoes of the Cascade Range have a long history of eruption and intermittent quiescence. Note that in **Figure 2-82**, each volcano has a different frequency of eruption. Not all Cascade volcanoes have been active in the recent past. This is typical of a volcanic range and is one of the reasons forecasting eruptions can be difficult.

Figure 2-82. Eruptions in the Cascade Range During the Past 4,000 Years



Source: Myers and Driedger (2008)

Several smaller volcanoes, including Diamond Craters and Jordan Craters, in the High Lava Plains of southeast Oregon have experienced eruptions in the last 6,000 years. Generally nonexplosive eruptions at these sites have built complexes of lava flow fields and cinder cones. Unlike the far-reaching effects that may be generated by large, potentially explosive stratovolcanoes in the Cascade Range, hazards associated with future eruptions in sparsely populated southeast Oregon are most likely limited to localized lava flows.

Eruptive Hazards

Each eruption is a unique combination of hazards. Not all hazards will be present in all eruptions, and the degree of damage will vary. It is important to know that during an active period for a volcano many individual eruptions may occur and each eruption can vary in intensity and length. For example, while Mount St. Helens is best known for its catastrophic May 1980 eruption, periodic eruptions of steam and ash and the growth of a central lava dome have continued to pose a hazard since that time.

Proximal Hazards

Lava Flows

Lava flows are streams of molten rock that erupt relatively non-explosively from a volcano and move downslope. Hazards associated with lava flow events include ashfalls near vents; extensive damage or total destruction of objects in the lava flow path(s) by burning, crushing, or burial; and disruption of local stream drainages. Lava flows are generally not life threatening because people can usually outwalk or outrun them. The Parkdale Lava Flow, located along the north flank of Mount Hood, erupted from a small vent about 7,600 years ago (**Figure 2-83**).

Figure 2-83. Oblique Air-View of the Parkdale Lava Flow

Note: The flow erupted around 7,600 years ago from a small vent located about 6 miles south of Parkdale, Oregon.
Image source: Bill Burns, DOGAMI

Pyroclastic Flows and Surges

Pyroclastic flows are avalanches of rock and gas at temperatures of 600 to 1,500 ˚F. They typically sweep down the flanks of volcanoes at speeds of up to 150 miles per hour. Pyroclastic surges are a more dilute mixture of gas and rock. They can move even more rapidly than a pyroclastic flow and are more mobile. Both generally follow valleys, but surges especially may have enough momentum to overtop hills or ridges. Because of their high speed, pyroclastic flows and surges are difficult or impossible to escape. If it is expected that they will occur, evacuation orders should be issued as soon as possible for the hazardous areas. Objects and structures in the path of a pyroclastic flow are generally destroyed or swept away by the impact of debris or by accompanying hurricane-force winds. Wood and other combustible materials are commonly burned. People and animals may also be burned or killed by inhaling hot ash and gases. The deposit that results from pyroclastic flows is composed of a combination of ash, pumice, and rock fragments. These deposits may accumulate to hundreds of feet thick and can harden to a resistant rock called tuff. Pyroclastic flows and surges are considered a proximal hazard, but in some instances may extend tens or even hundreds of miles from the volcanic vent.

Lahars

Cascade Range volcanoes and the floodplains that drain them contain abundant evidence for past lahar events. Lahars or volcanic debris flows are water-saturated mixtures of soil and rock fragments originating from a volcano. These sediment gravity flows can travel very long distances (over 62 miles) and travel as fast as 50 miles per hour in steep channels close to a volcano; further downstream, where they reach gently sloping valley floors, speeds generally slow to 10 to 20 miles per hour. The largest of these flows are known to transport boulders exceeding 30 ft in diameter. Lahars are often associated with eruptions, but they can also be generated by rapid erosion of loose rock during heavy rains or by sudden outbursts of glacial water. Highly erodible, unconsolidated lahar deposits may be easily remobilized by normal rainfall, snowmelt, and streams for years after their deposition.

Hazards associated with lahars include direct impact and burial by the advancing flow (**Figure 2-84**), burial of valuable infrastructure or agricultural land, and secondary flooding due to temporary damming and breakouts along tributary streams. Because of their relatively high viscosity, lahars can move, or even carry away, vehicles and other large objects such as bridges. Municipalities, industries, and individuals who take their water from streams affected by lahars may have water quality and/or quantity issues. Wildlife could be adversely affected by changes in streams, including the deposition of debris in streambeds and floodplains. For example, salmonids trying to spawn could find it impossible to swim upstream. Long-term drainage pattern alteration and increased sedimentation rates downstream may persist for decades following such an event.

Figure 2-84. Trees Buried in Volcanic Sediment, Sandy River, Oregon

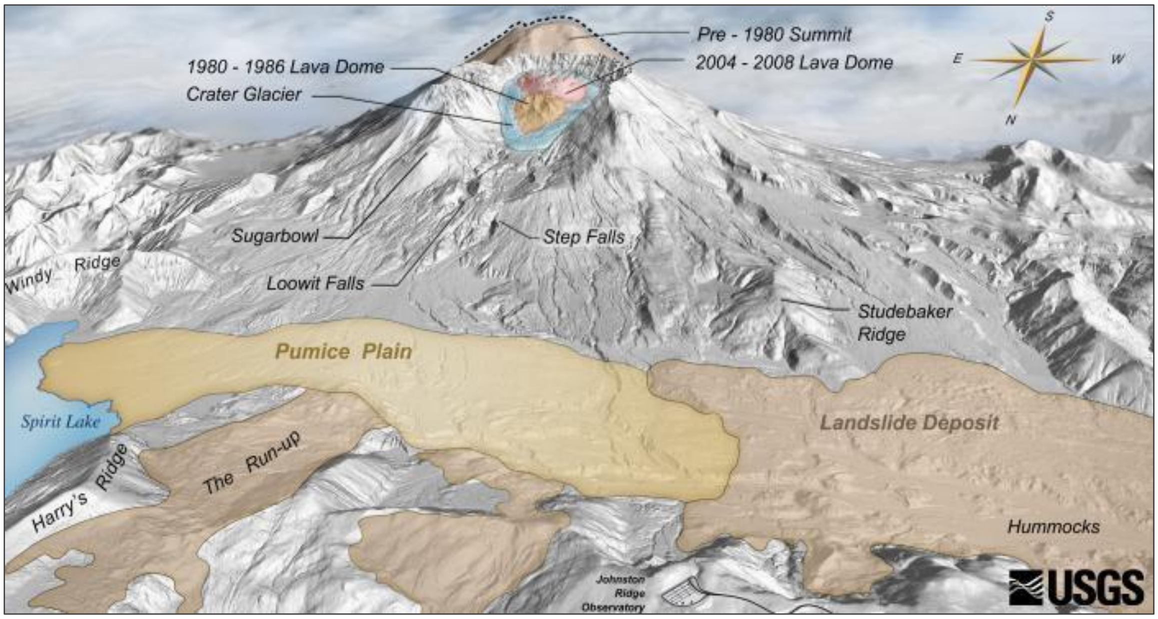
Note: Trunks of forest trees, initially growing on a terrace above the Sandy River (Oregon) at Oxbow Regional Park, were buried by rapid deposition of sediment following a dome-building eruption at Mount Hood in 1781. Erosion during a flood about a week before the photo was taken exposed this "ghost forest."

Photo source: T.C. Pierson, U.S. Geological Survey, 1/15/2009

Landslides

Because the stratovolcanoes that form the Cascade Mountains are composed of layers of weak fragmented rock and lava, they are prone to landslides. Landslides range in size from small to massive summit or flank failures like the one in May 1980 at Mount St Helens (**Figure 2-85**). They may be triggered by volcanic activity or during times of excessive rainfall or snowmelt. Speeds of movement range from slow creep to more catastrophic failure. If enough water is incorporated into the material, the failure will become a lahar.

Figure 2-85. Mount St. Helens



Source: USGS, Geology and history summary for Mount St. Helens, http://volcanoes.usgs.gov/volcanoes/st_helens/st_helens_geo_hist_101.html

Volcanic Gases

Magma contains dissolved gases that provide the driving force causing most volcanic eruptions. As magma rises towards the surface and pressure decreases, gases are released from the liquid portion of the magma (melt). These gases continue to travel upward and are eventually released into the atmosphere, both during and between eruptions. The majority of the gas emitted at volcanoes is water vapor (steam), derived from recent precipitation and groundwater. However, toxic gases including carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen halides, and fluorine may also be released. Depending on their concentrations, toxic gases can have both short-term effects and long-term effects on human and animal lives, property, agriculture, and the natural environment. Some examples of gas hazards:

- Carbon dioxide is heavier than air and can be trapped in low areas in concentrations that are deadly to people and animals;
- Sulfur dioxide, Hydrogen sulfide, and Fluorine are respiratory poisons;
- Sulfur Dioxide reacts with atmospheric water to create acid rain, causing corrosion and harming vegetation; and
- Fluorine can be absorbed onto volcanic ash particles that later fall to the ground, poisoning livestock grazing on ash-coated grass and also contaminating domestic water supplies.

Tephra

Tephra includes both solid and molten rock fragments, ranging in size from fine ash dust to larger "volcanic bombs" up to 3 feet in diameter. The largest rock fragments and volcanic bombs usually fall back to the ground within 2 miles of the vent. Tephra deposits pose significant risks to lives, structures, and property in the proximity of volcanic vents. Fine tephra is extremely slippery, hampering driving and walking, and can damage the lungs of small infants, the elderly, and those with respiratory problems. Fist-sized and larger bombs, flying as airborne projectiles, can cause significant injury or death. Tephra is disorienting by reducing visibility. If tephra accumulates in sufficient thickness it may collapse roofs, may topple or short-circuit electric transformers and power lines and clog other infrastructure such as water and sewage treatment facilities. Tephra clouds also commonly generate lightning that can interfere with electrical and communication systems and start fires.

Distal Hazards

Lahars

Lahars are both proximal and distal volcanic hazards. Please see the discussion of lahars in the *Proximal Hazards* section (above).

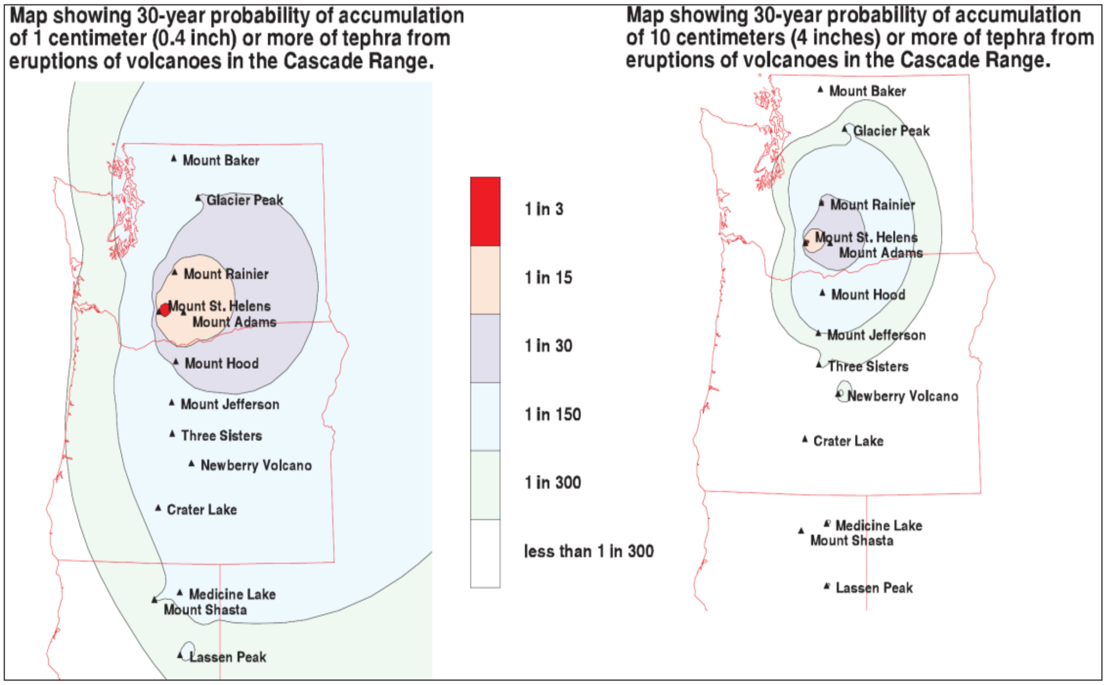
Eruption Columns And Clouds

Eruption columns and clouds occur during explosive volcanic eruptions as small fragments of volcanic glass, minerals, and rock, less than about 0.1 inch across, rise high into the air. Depending on the power of the eruption, columns can grow rapidly and reach more than 12 miles above a volcano, forming an eruption cloud. Large eruption clouds can extend hundreds of miles downwind, resulting in falling ash over enormous areas; the wind carries the smallest ash particles the farthest.

Ashfall

Dust-sized ash particles are the by-products of many volcanic eruptions. Ash, when blown into the air, can travel large distances causing significant problems for distal hazard zones. During ash-dominated eruptions, deposition is largely controlled by the prevailing wind direction. The predominant wind pattern over the Cascade Range is from the west to the east. Previous eruptions documented in the geologic record indicate most ashfall drifting to and settling in areas to the east of the Cascade volcanoes. The probable geographic extent of volcanic ashfall from select volcanic eruptions in the Pacific Northwest is shown in **Figure 2-86**.

Figure 2-86. Probable Geographic Extent of Volcanic Ashfall from Select Volcanic Eruptions in the Pacific Northwest



Source: Scott, et al. (1997a)

Within a few miles of the vent, the main ashfall hazards to man-made structures and humans include high temperatures, being buried, and being hit by falling fragments. Within 10–12 miles, hot ashfall may set fire to forests and flammable structures.

Structural damage can also result from the weight of ash, especially if it is wet. Four inches of wet ash may cause buildings to collapse. Accumulations of a half inch of ash can impede the movement of most vehicles, disrupt transportation, communication, and utility systems, and cause problems for human and animal respiratory systems. It is extremely dangerous for aircraft, particularly jet planes, as volcanic ash accelerates wear to critical engine components, can coat exposed electrical components, and erodes exposed structure. Ashfall may severely decrease visibility, or even cause darkness, which can further disrupt transportation and other systems. Recent work by the Volcano Hazards Group of the U.S. Geological Survey has attempted to rank the relative hazard of volcanoes in North America. According to this study, Oregon has four Very High Threat Volcanoes: Crater Lake, Mount Hood, Newberry Volcano, and South Sister (Ewert, et al., 2005).

Ashfall can severely degrade air quality and trigger health problems. In areas with considerable ashfall, people with breathing problems might need additional services from doctors or emergency rooms. In severe events an air quality warning could be issued, informing people with breathing problems to remain inside

Ashfall can create serious traffic problems as well as road damage. Vehicles moving over even a thin coating of ash can cause clouds of ash to swell. This results in visibility problems for other drivers, and may force road closures. Extremely wet ash creates slippery and hazardous road conditions. Ash filling roadside ditches and culverts can prevent proper drainage and cause shoulder erosion and road damage. Blocked drainages can also trigger debris flows if the blockage causes water to pool on or above susceptible slopes. Removal of ash is extremely difficult as traditional methods, such as snow removal equipment, stir up ash and cause it to continually resettle on the roadway.

Non-Eruptive Hazards

Earthquakes

Earthquake effects are a significant threat along the Cascade Mountains and come from three main sources: the CSZ, crustal faults, and volcanic activity. The CSZ is generally over 150 miles away, but it produces earthquakes as a large as M9.0 every 240 to 500 years. Crustal earthquakes occur in the North American plate at relatively shallow depths of approximately 6 to12 miles below the surface. However, some can rupture through the surface. The distance from a potentially active fault is critical to the evaluation of the earthquake shaking hazard. Volcanic earthquakes are usually small and frequent, but they can be as large as or larger than the M4.5 earthquake on Mount Hood in 2002. During 2002, a swarm of earthquakes ranging from M3.2 to M4.5 occurred on the southeast flank of Mount Hood. The damaging effects of all three kinds of earthquakes can be enhanced by amplification of shaking in soft soils, liquefaction, or induced landslides.

Flooding and Channel Migration

The relatively high elevation of volcanoes usually results in the meteorological effect called orographic lifting, which causes high precipitation and snow on the mountains. The result can be very high levels of rainfall and/or rapid snowmelt that can result in flooding.

Floods cause damage to assets through inundation of water and by erosion and deposition of soil and/or large objects. Defining the hazard associated with inundation by flooding is done by calculating the area that is likely to be flooded during different levels of flooding. Larger floods are less frequent than smaller floods, so flood levels may be defined by their return period. The longer the return period, the deeper the flood waters, and hence the larger the area that is inundated. Some common return periods used in flood hazard mapping include 10-year, 25-year, 100-year, and 500-year floods. Most flooding on Cascade Range volcanoes occurs when heavy, warm rain during large winter or spring storms falls on accumulations of low-elevation snow. Channel migration hazards can occur slowly, for example, by continuous erosion along a cutbank meander and deposition onto a point bar during high flows, or very rapidly during storm events through avulsion or rapid abandonment of the current river channel for a new one. Such rapid migration can not only destroy structures but even remove the land beneath structures.

For more information on flooding and channel migration zones see the **Flood** section.

Landslides

The general term *landslide* refers to a range of geologic events including rock falls, debris flows, earth slides, and other mass movements. Most landslides that occur on volcanoes are large deep-seated landslide complexes or debris flows. Deep-seated landslides have failure surfaces usually tens of feet below the surface and can cover large areas from acres to square miles. These types of landslides tend to move relatively slowly, but they can lurch forward if shaken by an earthquake or if disturbed by removal of material from the toe, by addition of material to the head, or by addition of water into the slide mass. Debris flows tend to initiate in the upper portion of a drainage, picking up water, sediment, and speed as they come down the drainage. As they reach the mouth of the confined or steep portion of the drainage, they tend to spread out and deposit the majority of the material, generally creating a fan. Debris flows are also commonly initiated by other types of landslides that occur on slopes near a channel. They can also initiate within the channel in areas of accelerated erosion during heavy rainfall or snowmelt.

Characterization of Individual Volcanoes

The history of volcanic activity in the Cascade Range is contained in its geologic record. The ages, eruptive history, and hazards associated with each volcano vary considerably. Cascade volcanoes may be characterized by intermittent periods of activity, followed by longer periods of relative quiescence. The incompleteness of eruptive records, even at relatively well-studied volcanoes, makes prediction of probability and recurrence intervals of future eruptions difficult to determine. **Table 2-66** lists Cascade Volcanoes in southwest Washington and Oregon that can affect Oregon communities. The discussion that follows further details those volcanic centers from **Table 2-66** for which the U.S. Geological Survey has developed hazard assessments and ranked as having a high to very high threat potential. Threat potential is described as very high, high, moderate, low, or very low based upon eruption history, distance to population centers, and potential impacts to aviation (Ewert, et al., 2005). From north to south these high-threat volcanoes are: Mount St. Helens (Wolfe & Pierson, 1995), Mount Adams (Scott, Iverson, Vallance, & Hildreth, 1995), Mount Hood (Scott, et al., 1997), (Burns W. J., et al., 2011b); Mount Jefferson (Walder, Gardner, Conrey, Fisher, & Schilling, 1999), the Three Sisters Region (Scott, Iverson, Schilling, & Fisher, 2001), Newberry Volcano (Sherrod, Mastin, Scott, & Schilling, 1997), and Crater Lake (Bacon, Mastin, Scott, & Nathenson, 1997). Digital hazard data for some of these volcanoes have been produced by Schilling (1996); Schilling, et al. (1997), Schilling, et al. (2008a), (2008b), (2008c). For a detailed inventory of each volcano's history and hazards, please refer to the appropriate report referenced above or **Table 2-66**. Further information can also be obtained from the U.S. Geological Survey Cascade Volcano Observatory at http://volcanoes.usgs.gov/observatories/cvo/.

Table 2-66. Prominent Volcanoes in the Cascade Range of Oregon and Southwest Washington

Volcano Name	Elevation	Volcano Type	Most Recent Eruptions	USGS Threat Potential	Nearby Towns	Remarks/Hazard Study
Mount St. Helens (Washington)	8,363 ft	strato-volcano	1980–1986; 2004–2008	high to very high	Portland, Castle Rock (Washington), Olympia (Washington), Vancouver (Washington), Yakima (Washington)	major explosive eruption and debris avalanche in 1980; widespread ashfall; (Wolfe & Pierson, 1995)
Mount Adams (Washington)	12,277 ft	strato-volcano	about 520,000 to 1,000 YBP	high to very high	Portland, Hood River, Vancouver (Washington), Yakima (Washington)	numerous eruptions in last 15,000 year; major debris avalanches effecting White Salmon River at 6,000 and 300 YBP; (Scott, Iverson, Vallance, & Hildreth, 1995)
Mount Hood	11,240 ft	strato-volcano	1760–1865	high to very high	Portland, Sandy, Welches, Brightwood, Parkdale, Hood River	pyroclastic flows in the Upper White River drainage; lahars in Old Maid Flat; lava dome at Crater Rock; steam explosions; Scott (1997a); Schilling, et al. (2008a)
Mount Jefferson	10,495 ft	strato-volcano	280,000 to 15,000 YBP	low to very low	Idanha, Detroit, Warm Springs, Madras, Lake Billy Chinook	potentially active and capable of large explosive eruptions; recent history of lava domes, small shields, and lava aprons; Walder, et al. (1999); Schilling, et al. (2007)
Mount Washington	7,796 ft	mafic volcano		low to very low		no hazard study
North Sister	10,085 ft	mafic volcano	300,000 to 120,000 YBP	high to very high	Sisters, Bend, Redmond, Sunriver, La Pine, Blue River, McKenzie Bridge, Vida, Springfield	deep glacial erosion; ashfall, pyroclastic flows, lava flows and domes, and lahars; Scott, et al. (2001); Schilling, et al. (2008c)
Middle Sister	10,047 ft	strato-volcano	about 40,000 to 14,000 YBP	high to very high	Sisters, Bend, Redmond, Sunriver, La Pine, Blue River, McKenzie Bridge, Vida, Springfield	potentially active, capable of large explosive eruptions, ashfall, pyroclastic flows, lava flows and domes, and lahars; Scott (2001); Schilling, et al. (2008c)

Volcano Name	Elevation	Volcano Type	Most Recent Eruptions	USGS Threat Potential	Nearby Towns	Remarks/Hazard Study
South Sister	10,358 ft	strato-volcano	about 50,000 to 2,000 YBP	high to very high	Sisters, Bend, Redmond, Sunriver, La Pine, Blue River, McKenzie Bridge, Vida, Springfield	potentially active, capable of large explosive eruptions, ashfall, pyroclastic flows, lava flows and domes, and lahar; most silicic of the cones in the Three Sisters complex; phase of uplift started in 1997 within a broad area about 6 km west of South Sister; Scott (2001); Schilling, et al. (2008c)
Broken Top	9,152 ft	strato-volcano	300,000–100,000 YBP	low to very low	Bend, Sunriver, La Pine	deep glacial erosion; lava flows, pyroclastic flows, ashfall; no hazard study
Mount Bachelor	9,068 ft	mafic volcano	about 18,000 to 7,700 YBP	moderate	Bend, Sunriver, La Pine	lava flows and near vent cinder and ashfall; no hazard study
Newberry Volcano	7,986 ft	shield volcano/ caldera	about 400,000 to 1,300 YBP	high to very high	Bend, Sunriver, La Pine	potentially active and capable of large explosive eruptions; lava flows and near vent cinder and ashfalls; present-day hot springs; (Sherrod, Mastin, Scott, & Schilling, 1997); Schilling, et al. (2008b)
Mount Thielsen	9,187 ft	shield volcano	> 250,000	low to very low	Chemult	Deep glacial erosion; Lava flows, pyroclastic eruptions; no hazard study.
Crater Lake Caldera (Mount Mazama)	8,159 ft	caldera	about 420,000 to 7,700 YBP	high to very high	Grants Pass, Roseburg, Chemult, La Pine, Fort Klamath, Chiloquin, Klamath Falls	lava flows, pyroclastic flows, ashfall; source of the widespread Mazama ash; Bacon, et al. (1997)
Mount McLaughlin	9,496 ft	strato-volcano	>80,000 YBP	low to very low	Medford, Grants Pass, Klamath Falls	lava flows, pyroclastic flows; no hazard study

Note: YBP is years before present.

Sources: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/;
Wolfe and Pierson (1995); Scott, et al. (1995), (1997a), (2001); Sherrod, et al. (1997); Bacon, et al. (1997); Walder, et al. (1999)

Mount St. Helens (Washington)

The May 18, 1980, eruption of Mount St. Helens is the best-known example of volcanism to most Oregonians. That eruption included a debris avalanche, as part of the volcanic edifice collapsed (**Figure 2-85**). This caused a lateral blast of rock, ash, and gas that devastated areas to the north of the volcano. Lahars rushed down the Toutle and Cowlitz River valleys, reaching the Columbia River and halting shipping for some time. All other river valleys on the volcano experienced smaller lahars. Pyroclastic flows devastated an area up to five miles north of the volcano. Ashfall deposits affected people as far away as Montana, and ash circled the earth in the upper atmosphere for over a year.

Except for the debris avalanche and lateral blast, the events of this eruptive period are typical of a Mount St. Helens eruption and can be expected to occur again (**Table 2-66**). The primary hazards that will affect Oregonians are ashfall and lahars that affect the Columbia River. Since the major eruptive activity in the early 1980s, Mount St. Helens has experienced two episodes of dome building activity. The latest activity lasted from 2004 until 2008. Another eruption from Mount St. Helens is very likely in the near future.

Mount Adams (Washington)

Mount Adams, located 35 miles north of Hood River, Oregon, is the largest active volcano in Washington State and among the largest in the Cascade Range (**Table 2-66**). The volcano was active from about 520,000 to about 1,000 years ago. Eruptions from Mount Adams within the last 500,000 years have mainly consisted of effusive lava flows; highly explosive events are rare in the geologic record of Mount Adams. Eruptions have also occurred from 10 vents in the vicinity of Mount Adams since the last period of glaciation about 15,000 years ago. Approximately 6,000 and 300 years ago, debris avalanches from the southwest face of Mount Adams generated clay-rich lahars that traveled down the White Salmon River. The summit of Mount Adams contains a large section of unstable altered rock that can spawn future debris avalanches and lahars.

Potential hazards from Mount Adams include lava flows near the central vent area and lahars that could reach and disrupt the Columbia River channel. Such lahars may have little or no advanced warning.

Mount Hood

The last major eruption of Mount Hood occurred in approximately 1781 (232 years ago) (**Table 2-66** and **Table 2-67**). The Sandy River that drains the volcano's northwest side was originally named the Quicksand River by Lewis and Clark, who traversed the area only a couple of years after an eruption. Lahars had filled the river channel with debris, much of which has now been scoured away. There were two other minor periods of eruptions during the last 500 years, the last in the mid-1800s. Typically, these involved lava flows near the summit, pyroclastic flows, and lahars but little ashfall. From its recent eruptive history, the volcano is most likely to erupt from the south side, but planning should be done assuming eruptions could be centered anywhere on the mountain. A large eruption could generate pyroclastic flows and lahars that could inundate the entire length of the Sandy and White River valleys. An eruption from the north flank could affect the Hood River Valley.

Due to its proximity to the Portland Metro area, major east-west highways, the Bull Run Reservoir (which supplies water to a majority of Portland area residents), and ski and summer recreation areas, Mount Hood poses the greatest potential volcanic hazard to Oregonians. In addition, a large volume of debris and sediment in lahars could affect shipping lanes in the Columbia River and operation of Bonneville and The Dalles dams.

In recent years, numerous debris flows caused by winter storms have flowed down river drainages. OR-35 is periodically closed for repair work after these events damaged the bridge over the White River. If a volcanic event occurred, the same drainages would be affected.

Table 2-67. Notable Geologic Events near Mount Hood

Date or Age	Event	Deposits
A.D. 1859, 1865, 1907?	minor explosive eruptions of Mount Hood	scattered pumice
late 19th century	late neoglacial advance	prominent, sharp-crested moraines
late 18th century	Old Maid eruptive period	lava dome, pyroclastic-flow and lahar deposits, tephra
about 500 years ago	debris flows in Zigzag River	debris-flow deposits
1,000 years ago	debris flows in upper Sandy River	debris-flow deposits
1,500 years ago	Timberline eruptive period	lava dome, pyroclastic-flow and lahar deposits, tephra
7,700 years ago	eruptions from vent near Parkdale; Mount Mazama ashfall	Basaltic andesite of Parkdale lava flow; about 5 cm of Mazama ash
11,000 to 20,000 years ago	waning phases of Evans Creek glaciation	moraines
13,000 to 20,000 years ago	Polallie eruptive period	lava domes, pyroclastic-flow and lahar deposits, tephra
20,000 to 25,000 years ago	maximum of Evans Creek glaciation	belts of moraines in most valleys
20,000 to 30,000 years ago	Mount Hood dome eruptions	lava domes, pyroclastic-flow and lahar deposits
30,000(?) to 50,000(?) years ago	Mount Hood lava-flow eruptions	andesite lava flows of Cathedral Ridge and Tamanawas Falls

Source: Bill Burns, DOGAMI, modified from Scott, et al. (1997b)

Mount Jefferson

Mount Jefferson is located in a relatively unpopulated part of the Cascade Range. The last eruptive episode at Mount Jefferson was about 15,000 years ago. Research at stratovolcanoes around the world indicates that Mount Jefferson should be regarded as dormant, not extinct.

The steep slopes of the volcano provide the setting for possible debris flows and lahars, even without an eruption. These would be confined to valleys, generally within 10 miles of the volcano.

A major eruption, however unlikely in the short term, could generate pyroclastic flows and lahars that would travel up to a few dozen miles down river valleys. Two reservoirs could be affected by pyroclastic flows from a major eruption: Detroit Lake and Lake Billy Chinook. An explosive eruption could spew ash for hundreds of miles in the downwind direction.

Many smaller volcanoes are located between Mount Jefferson and Mount Hood to the north and Three Sisters to the south. Eruptions from any of these would be primarily erupt *cinders* and ash to form cinder cones.

Three Sisters Region

North Sister has probably been inactive for at least 100,000 years (**Table 2-66**). Middle Sister last erupted between 25,000 and 15,000 years ago. South Sister had a very small ongoing uplift, which began in 1996 and became undetectable by 2003. The uplift was about one inch a year and likely indicated movement of a small amount of magma. At this writing, there is no indication that the uplift will ever develop into a volcanic eruption. However, that possibility cannot be ruled out. Hence, the Cascade Volcano Observatory has increased their monitoring of the area over the past several years.

Future eruptions at South Sister (and possibly Middle Sister) are likely to include lava flows, pyroclastic flows, and lahars. The possibility exists for lahars to travel many miles down valley floors, if an eruption melts a large amount of snow and ice. Ashfall would likely be contained within 20 miles of the vent.

Newberry Volcano

Newberry Volcano, unlike the stratovolcanoes of the Cascade Range, is a shield volcano with broad, relatively gently sloping flanks composed of stacked basaltic lavas flows (**Table 2-66**). The volcano is about 400,000 years old and has had thousands of eruptions both from the central vent area and along its flanks. The present 4 by 5 mi wide caldera at Newberry Volcano's summit formed about 75,000 years ago by a major explosive eruption and collapse event. This was the most recent of at least three caldera-forming eruptions that lofted pumice and ash high into the air and spread pyroclastic flows across the volcano's surface. The most recent eruption was 1,300 years ago when the "Big Obsidian Flow," a glassy rhyolitic lava flow, erupted within the caldera. Future eruptions are likely to include lava flows, pyroclastic flows, lahars, and ashfall. Newberry Volcano has attracted interest for its geothermal potential. The heat under the volcano, with temperatures in some areas in excess of 509 ˚F, is evidence that it is only dormant.

Crater Lake Caldera

About 7,700 years ago, Mount Mazama erupted with great violence, leaving the caldera that Crater Lake now occupies (**Table 2-66**). Layers of ash produced from that eruption have been found in eight western states and three Canadian provinces. The countryside surrounding Crater Lake was covered by pyroclastic flows. Wizard Island is the result of much smaller eruptions since that cataclysm. The most recent eruption was about 5,000 years ago and occurred within the caldera. No eruptions have occurred outside the caldera since 10,000 years ago.

This potentially active volcanic center is contained within Crater Lake National Park. The western half of the caldera is considered the most likely site of future activity. Effects from volcanic activity (e.g., ashfall, lava flows) are likely to remain within the caldera. If an eruption occurs outside the caldera, pyroclastic flows and lahars could affect valleys up to a few dozen miles from the erupting vent. The probability of another caldera-forming eruption is very low, as is the probability of eruptions occurring outside the caldera.

Other Volcanic Areas of Oregon

On the scale of geologic time, volcanic eruptions may occur in other parts of Oregon. However, on a human time scale, the probability of an eruption outside the Cascades is so low as to be negligible.

Although the high, snow-topped mountains of the Cascades are Oregon's most visible volcanoes, other potential eruptive centers exist. These include smaller peaks, such as the Belknap shield volcano in central Oregon, which had a lava flow about 1,400 years ago. Several smaller volcanoes, including Diamond Craters and Jordan Craters, in the High Lava Plains of southeast Oregon have experienced recent eruptions in the last 7,000 years. Generally non-explosive eruptions at these sites have built complexes of lava flow fields and cinder cones. Hazards associated with future eruptions in sparsely populated southeast Oregon would most likely include lava flows covering many square miles; ash and volcanic gases derived from these eruptions may be regionally significant.

Historic Volcanic Events

Table 2-68. Historic Volcanic Events in Oregon over the Last 20,000 Years

Date	Location	Description
about 18,000 to 7,700 YBP	Mount Bachelor, central Cascades	cinder cones, lava flows
about 20,000 to 13,000 YBP	Polallie Eruptive episode, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
about 13,000 YBP	Lava Mountain, south-central Oregon	Lava Mountain field, lava flows
about 13,000 YBP	Devils Garden, south-central Oregon	Devils Garden field, lava flows
about 13,000 YBP	Four Craters, south-central Oregon	Four Craters field, lava flows
about 7,780 to 15,000 YBP	Cinnamon Butte, southern Cascades	basaltic scoria cone and lava flows
about 7,700 YBP	Crater Lake Caldera	formation of Crater Lake caldera, pyroclastic flows, widespread ashfall
about 7,700 YBP	Parkdale, north-central Oregon	eruption of Parkdale lava flow
<7,000 YBP	Diamond Craters, eastern Oregon	lava flows and tephra in Diamond Craters field
< 7,700 YBP; 5,300 to 5,600 YBP	Davis Lake, southern Cascades	lava flows and scoria cones in Davis Lake field
about 10,000 to <7,700 YBP	Cones south of Mount Jefferson; Forked Butte and South Cinder Peak	lava flows
about 4,000 to 3,000 YBP	Sand Mountain, central Cascades	lava flows and cinder cones in Sand Mountain field
< 3,200 YBP	Jordan Craters, eastern Oregon	lava flows and tephra in Jordan Craters field
about 3,000 to 1,500 YBP	Belknap Volcano, central Cascades	lava flows, tephra
about 2,000 YBP	South Sister Volcano	rhyolite lava flow
about 1,500 YBP	Timberline eruptive period, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
about 1,300 YBP	Newberry Volcano, central Oregon	eruption of Big Obsidian flow
about 1,300 YBP	Blue Lake Crater, central Cascades	Spatter cones and tephra
1760–1810	Crater Rock/Old Maid Flat on Mount Hood	pyroclastic flows in upper White River; lahars in Old Maid Flat; dome building at Crater Rock
1859/1865	Crater Rock on Mount Hood	steam explosions/tephra falls
1907 (?)	Crater Rock on Mount Hood	steam explosions
1980	Mount St. Helens (Washington)	debris avalanche, ashfall, flooding on Columbia River
1981–1986	Mount St. Helens (Washington)	lava dome growth, steam, lahars
1989–2001	Mount St. Helens (Washington)	hydrothermal explosions
2004–2008	Mount St. Helens (Washington)	lava dome growth, steam, ash

Note: YBP is years before present.

Sources: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/;
Wolfe and Pierson (1995); Sherrod, et al. (1997); Scott, et al. (1997a), (2001); Bacon, et al. (1997); Walder, et al. (1999)

2.2.8.2 Probability

Geologists can make general forecasts of long-term volcanic activity from careful characterization of past activity, but they cannot supply a timeline. Several U.S. Geological Survey open-file reports provide the odds of certain events taking place at particular volcanoes. However, the U.S. Geological Survey stresses that government officials and the public must realize the limitations in forecasting eruptions and be prepared for such uncertainty.

Short-range forecasts, on the order of months or weeks, are often possible. There are usually several signs of impending volcanic activity that may lead up to eruptions. The upward movement of magma into a volcano prior to an eruption generally causes a significant increase in small, localized earthquakes and an increase in emission of carbon dioxide and compounds of sulfur and chlorine that can be measured in volcanic springs and the atmosphere above the volcano. Changes in the depth or location of magma beneath a volcano often cause changes in elevation. These changes can be detected through ground instrumentation or remote sensing. This, in fact, was how the South Sister Bulge uplift was discovered).

The Cascades Volcanic Observatory (CVO) employs scientists from a range of disciplines to continually assess and monitor volcanic activity in the Cascade Ranges. If anomalous patterns are detected (for example, an increase in earthquakes), CVO staff coordinate the resources necessary to study the volcano.

Probability of Volcanic Hazard Events

One method of evaluating probability of volcanic hazard events in Oregon is to consider the proximity of a county to the Cascade Range volcanoes along with the probability of tephra accumulation over a 30-year period and apply professional expertise and judgment. **Table 2-69** presents available information.

Table 2-69. Proximity to Cascade Range Volcanoes and 30-Year Probability of Tephra Accumulation

		Proximity to Cascade Range Volcanoes	30-Year Probability of Tephra Accumulation	
Region	**County**	Cross, West, East	At least 1 cm	At least 10 cm
Region 1	Clatsop	West	1:300	NA
	Coos	West	1:300	NA
	Curry	West	1:300	NA
	Douglas Coastal	West	1:300	NA
	Lane Coastal	West	1:300	NA
	Lincoln	West	1:300	NA
	Tillamook	West	1:300	NA
Region 2	Clackamas	Cross	1:30	1:150
	Columbia	West	NA	NA
	Multnomah	Cross	1:30	1:150
	Washington	West	NA	NA
Region 3	Benton	West	NA	NA
	Lane	Cross	NA	NA
	Linn	Cross	NA	1:150
	Marion	Cross	NA	1:150
	Polk	West	NA	NA
	Yamhill	West	NA	NA
Region 4	Douglas	Cross	NA	NA
	Jackson	Cross	NA	NA
	Josephine	West	NA	NA
Region 5	Gilliam	East	1:30	1:150
	Hood River	Cross	1:30	1:150
	Morrow	East	1:30	1:150
	Sherman	East	1:30	1:150
	Umatilla	East	1:30	1:300
	Wasco	Cross	1:30	1:150
Region 6	Crook	East	NA	1:300
	Deschutes	Cross	NA	1:300
	Jefferson	Cross	NA	1:150
	Klamath	Cross	NA	NA
	Lake	East	1:150	NA
	Wheeler	East	1:30	1:150
Region 7	Baker	East	1:150	NA
	Grant	East	1:30	1:300
	Union	East	1:150	NA
	Wallowa	East	1:150	NA
Region 8	Harney	East	1:150	NA
	Malheur	East	1:150	NA

Note: NA = not available

Source: Scott, et al. (1997a). Web: http://vulcan.wr.usgs.gov/Volcanoes/Hood/Hazards/ OFR97-89/OFR97-89.pdf

DOGAMI executed the 2020 Risk Assessment methodology using the information in **Table 2-69**. Each county was assigned a number from 1 to 5 indicating very low to very high probability, respectively (**Table 2-70**). Counties that cross the Cascade Range were assigned moderate probability (3) for both proximal and distal events. Coastal counties far west of the Cascade Range were assigned very low probability (1) for both proximal and distal events. Other counties were assigned values based on their location relative to the Cascade Range, the probability of tephra accumulation over a 30-year period, and DOGAMI's professional expertise and judgment. Proximal and distal probabilities were weighted equally in deriving the overall probability.

Table 2-70. Probability of Volcanic Hazards

Region	County	Probability of Volcanic Hazards		
		Proximal	Distal	Overall
Region 1	Clatsop	1	1	1
	Coos	1	1	1
	Curry	1	1	1
	Douglas Coastal	1	1	1
	Lane Coastal	1	1	1
	Lincoln	1	1	1
	Tillamook	1	1	1
Region 2	Clackamas	3	3	3
	Columbia	2	1	1.5
	Multnomah	3	3	3
	Washington	2	1	1.5
Region 3	Benton	2	1	1.5
	Lane	3	3	3
	Linn	3	3	3
	Marion	3	3	3
	Polk	2	1	1.5
	Yamhill	2	1	1.5
Region 4	Douglas	3	3	3
	Jackson	3	3	3
	Josephine	2	1	1.5
Region 5	Gilliam	1	3	2
	Hood River	3	3	3
	Morrow	1	3	2
	Sherman	1	3	2
	Umatilla	1	3	2
	Wasco	3	3	3
Region 6	Crook	1	2	1.5
	Deschutes	3	3	3
	Jefferson	3	3	3
	Klamath	3	3	3
	Lake	1	2	1.5
	Wheeler	1	2	1.5
Region 7	Baker	1	2	1.5
	Grant	1	3	2
	Union	1	2	1.5
	Wallowa	1	2	1.5
Region 8	Harney	1	2	1.5
	Malheur	1	2	1.5

2.2.8.3 Vulnerability

Oregon's vulnerability to volcanic events varies statewide. The Cascade Mountains, which separate Western Oregon from Central Oregon, pose the greatest threat for volcanic activity. Oregon Natural Hazard Mitigation Planning Regions that include the Cascade Mountains are most vulnerable to the effects of a volcanic event. Within the State of Oregon, there are several volcanoes that may pose a threat of future eruption. These include Mount Hood, which most recently erupted about 200 years ago, Newberry Volcano with recent eruptions about 1300 years ago, and the Three Sisters and Mount Jefferson with eruptions about 15,000 years ago. Eruptions from volcanoes in Washington State, like the Mount St. Helens eruption in 1980, can also significantly impact Oregon.

Most Vulnerable Jurisdictions

The Oregon Department of Geology and Mineral Industries (DOGAMI) is the agency with primary oversight of the volcanic hazards. According to the 2020 Risk Scores and agency staff review of the available hazard data, DOGAMI lists Marion, Hood River, Jefferson, Lane, Linn, Wasco, and Klamath Counties as having the greatest vulnerability to volcanic hazards in the state. Deschutes County is most vulnerable in the Central Oregon Region because the region's most populous city, Bend, is located there and the greatest concentration of volcanoes, including Newberry Caldera, is located near the Deschutes County's population centers. Klamath and Jefferson Counties are also vulnerable within this region. Other regions are vulnerable to damage from volcanic eruptions as well. If Mount Hood were to erupt, the Northern Willamette Valley, Portland Metro Region, and the Mid-Columbia Region would all be impacted. Because of Mount Hood's proximity to Portland, the Columbia River, the I-84 freeway, and major dams on the Columbia River, the potential for a significant disaster exists.

In performing the 2020 vulnerability analysis, potential dollar losses from damage to state-owned and -leased buildings and state and local critical facilities exposed to volcanic hazards were combined with the CDC's social vulnerability index.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities statewide. Close to $306M in value of state buildings, state and local critical facilities is exposed to volcanic hazards statewide, all of it in Regions 2, 3, 5, and 6. The greatest amount of exposure is in Region 3, in Lane County. In addition, of the 58,872 historic buildings throughout the state, 693 are exposed to volcanic hazards: 140 in a high hazard area, 443 in a moderate hazard area, and 110 in a low hazard area. See Appendix **9.1.12** for details.

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to volcanic hazards. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. None of these losses was due to volcanic hazards.

DAS's records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

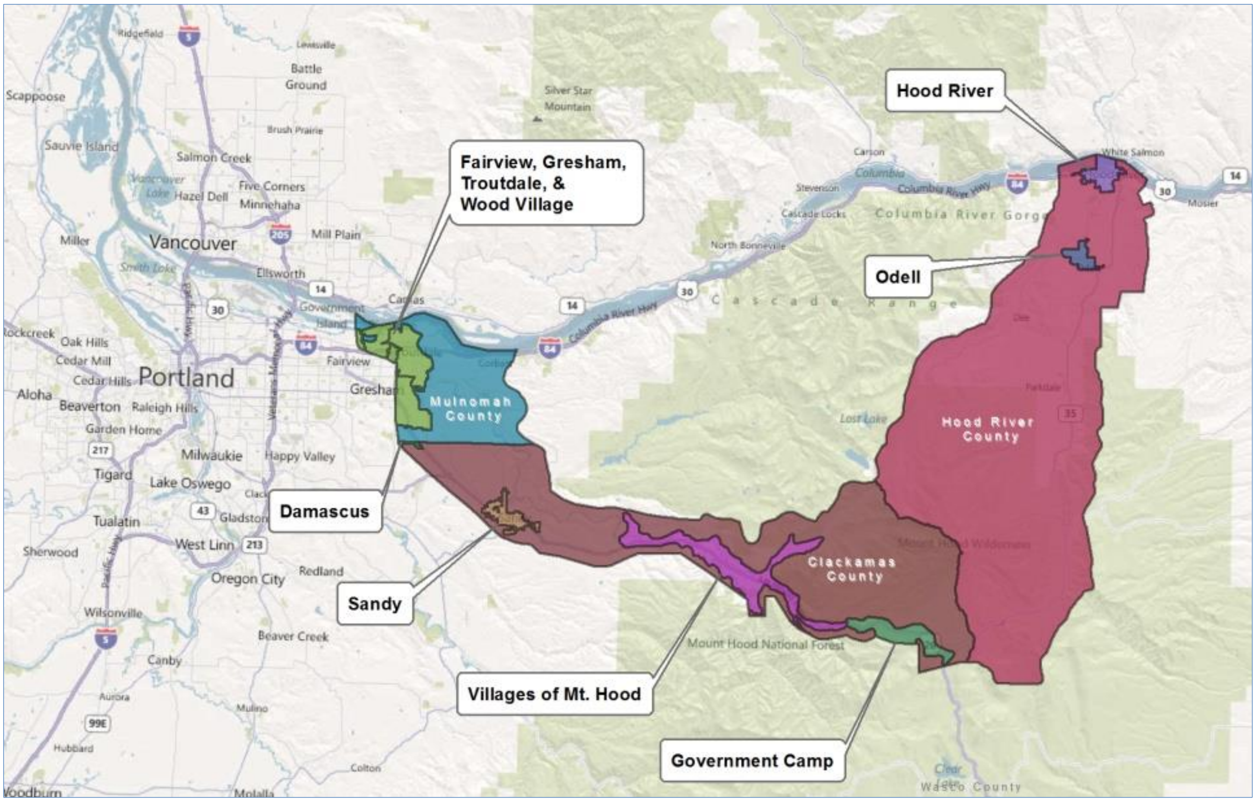
For the 2020 vulnerability assessment, DLCD combined this index with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Marion, Hood River, and Jefferson Counties are the most vulnerable to impacts from volcanic hazards.

Marion, Hood River, and Jefferson Counties scored very high for vulnerability to volcanic hazards. In each case, the very high score is attributable to a combination of a significant amount of potential damage to state and local buildings and critical facilities with significant social vulnerability. Lane, Linn, Morrow, Umatilla, Wasco, Klamath, and Harney Counties scored high (H). For the Eastern Oregon counties, social vulnerability was the driving factor. In Lane County, potential damage to state buildings was also a significant factor, as was potential damage to local critical facilities in Linn County.

2.2.8.4 Risk

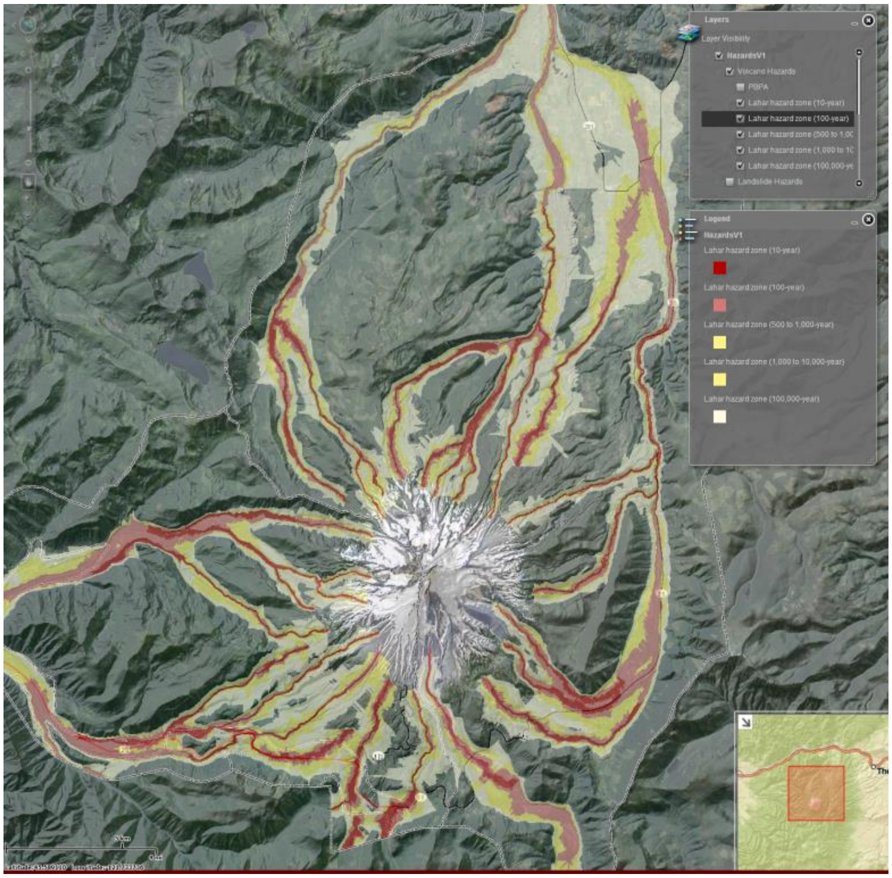
With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Little has been done to evaluate risk of volcanic hazards. One of the first studies to evaluate risk for the Mount Hood region was by Burns, et al. (2011b) (**Figure 2-87**, **Figure 2-88**, and **Table 2-71**). The main purpose of this study was to help communities on or near Mount Hood become more resilient to geologic hazards by providing accurate, detailed, and up-to-date information about the hazards and the community assets at risk. A second purpose was to explore hazard and risk analysis methodologies that would be applicable to other volcanic areas. The study examined volcano, landslide, flood, channel migration, and earthquake hazards on Mount Hood, along US-26 and the Sandy River Corridor, and along OR-35 and the Hood River Corridor (**Figure 2-87**). Two types of risk analysis were performed: (a) hazard and asset exposure, and (b) Hazus-MH (FEMA, 2005). **Figure 2-88** and **Table 2-71** are a summary of volcano and community asset exposure for the study area.

Figure 2-87. Mount Hood Risk Study Project Area



Source: Burns, et al. (2011b)

Figure 2-88. Interactive Web Map for Mount Hood Risk Study



Source: DOGAMI. Map generated at Hazards and Assets Viewer for Mount Hood website: http://www.oregongeology.org/MtHood/

This study also found approximately 5,000 people are located in the 500-year volcano hazard zones, which is a large amount of people to evacuate in an event. Although the report estimated 6% to 22% of the total study area community assets will be damaged or lost, this percentage is significantly more within some individual communities, especially The Villages at Mount Hood. Both risk methods resulted in ranges of percent damage and losses that appear reasonable. For example, we found 11% to 34% loss ratios for the volcano exposure method and 5% to 35% loss ratios for the Hazus-MH volcano analyses are all in the same approximate range of 10% to 35%. The report estimates the loss ratio for the 500-year volcano hazard to be approximately 18% for the study area from these ranges of percent loss from the various portions of the two risk analyses.

Table 2-71. Summary of Community Asset Exposure to Volcano Hazards for Mount Hood

Hazard	Population	Buildings		Generalized Land Use / Zoning Parcels		Critical Facilities	Primary Infrastructure—Roads (miles)
		Count	$ Value	Count	$ Value		
Proximal	2,129	1,604	$242 million	2,995	$208 million	8	287
Lahar, 10-year	163	120	$32 million	520	$19 million	0	22
Lahar, 100-year	473	531	$92 million	1,633	$71 million	0	91
Lahar, 500- to 10,000 year	3,843	3,731	$663 million	7,120	$402 million	7	271
Lahar, 100,000-year	14,635	9,897	$1,510 million	13,082	$1,364 million	21	525

Source: Burns, et al. (2011b)

The 2020 risk assessment methodology combined the probability of volcanic hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities as well as with an assessment of the social vulnerability of the local population.

In the case of volcanic hazards, the counties assessed as being at greatest risk – Marion, Hood River, and Jefferson (VH) followed by Lane, Linn, Wasco, and Klamath (H) – tracked closely with those assessed as most vulnerable.

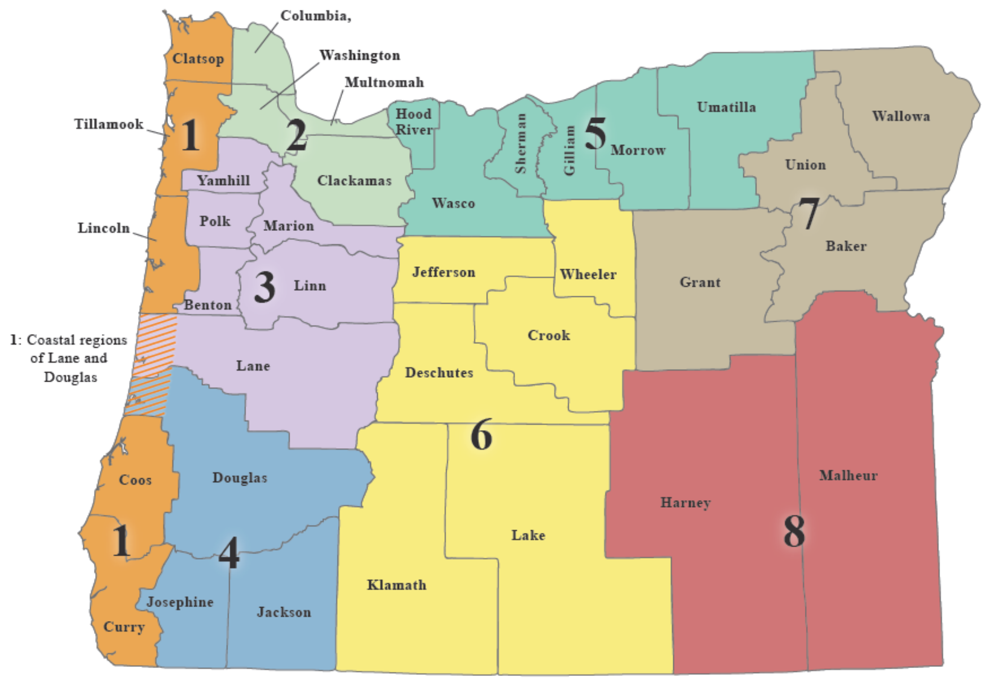
2.2.9 Wildfires

Wildfires are a common and widespread natural hazard in Oregon; the state has a long and extensive history of wildfire. A significant portion of Oregon's forestland is dominated by ecosystems dependent upon fire for their health and survival. In addition to being a common, chronic occurrence, wildfires frequently threaten communities. These communities are often referred to as the "wildland-urban interface" (WUI), the area where structures and other human development meet or intermingle with natural vegetative fuels.

Oregon has in excess of 41 million acres (more than 64,000 square miles) of forest and rangeland that is susceptible to damage from wildfire. In addition, significant agricultural areas of the Willamette Valley, north central, and northeastern Oregon grow crops such as wheat that are also susceptible to damage by wildfire.

The majority of wildfires take place between June and October, though fire season has been increasing in length since 1970 and is now, on average, 78 days longer than it used to be. This lengthening of the fire season is largely due to declining mountain snowpack and earlier spring snowmelt—a result of warming temperatures (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). These fires primarily occur in Oregon NHMP Natural Hazard Regions 4, 5, 6, and 7 (**Figure 2-89**); however, even areas classified as low or moderate are susceptible to wildfires if the right combination of fuels, weather, and ignition conditions exist. Historically, Oregon's largest wildfires have burned in the Coast Range (Regions 1 and 2) where the average rainfall is high, but heavy fuel loads created a low-frequency, high-intensity fire environment during the dry periods.

Figure 2-89. Oregon NHMP Natural Hazards Regions



> **El Niño Southern Oscillation and Wildfire Hazards**
>
> El Niño winters are often warmer and sometimes drier than average. Sometimes this leads to above average fire seasons.
>
> Unfortunately, El Niño is not a great predictor of above average fire seasons. Long-term drought is a much more accurate predictor.
>
> Source: Oregon Department of Forestry

According to OEM, extreme winds are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge. The Columbia River Gorge is the most significant east-west gap in the mountains between California and Canada. It serves as a funnel for east and west winds, where direction depends solely on the pressure gradient. Once set in motion, the winds can attain speeds of 80 mph. Wind is a primary factor in fire spread, and can significantly impede fire suppression efforts. This was exemplified in the Eagle Creek Fire of 2017 that burned almost 50,000 acres and lasted for about three months before being declared fully contained in the Columbia River Gorge area. This fire started with a firework lit by a 15-year-old boy on forestland.

Historically, 70% of the wildfires suppressed on lands protected by the Oregon Department of Forestry (ODF) result from human activity. The remaining 30% result from lightning. Typically, large wildfires result primarily from lightning in remote, inaccessible areas.

Large wildfires can have significant financial and social costs. Not only can they impact lives and property, they can also have negative short- and long-term economic and environmental consequences.

According to Oregon Forest Resources Institute which gathered information on the "Impacts of Oregon's 2017 Wildfire Season," large wildfires caused significant economic impacts from smoke alone. There were cancellations of cultural, social, and athletic events. Tourism and recreation were negatively impacted. People couldn't get to work because they were sick or roads were impassable. Over 665,000 acres of wildfire across the state in both forests and rangelands sent particulates and hazardous compounds into the air. The over 2,000 fires that caused this smoke problem diminished air quality for everyone, especially children, pregnant women and the elderly. Aftereffects of the fires included landslides, flooding, and reduced drinking water quality.

Life safety enhancement and cost savings may be realized by appropriate mitigation measures, starting with coordinated fire protection planning by local, state, tribes, federal agencies, the private sector, and community organizations. Additionally, and often overlooked, is the role that individual WUI property owners play in this coordinated effort.

Wildfire suppression costs escalate dramatically when agencies must adjust suppression tactics to protect structures. The cost of mobilizing personnel and equipment from across the state is significant. Non-fire agencies may also incur costs for providing or supporting evacuations, traffic control, security, public information, and other services during WUI fire incidents. These costs vary widely and have not been well documented.

The number of people living in Oregon's WUI areas is increasing. Where people have moved into these areas, the number of wildfires has escalated dramatically. Many people arriving from urban settings expect an urban level of fire protection. The reality is many WUI homes are located in portions of the state with limited capacity for structural protection and sometimes no fire protection whatsoever. Many Oregon communities (incorporated and unincorporated) are within or abut areas subject to serious wildfire hazards. In Oregon, there are 700,000-900,000 homes within the WUI, which has greatly complicated firefighting efforts and significantly increased the cost of fire suppression. While Oregon's Emergency Conflagration Act helps protect WUI communities that have depleted their local resources when threatened by an advancing wildfire, the escalating number of fires has led to the recognition that citizens in high fire risk communities need to provide mitigation and an appropriate level of local fire protection. Oregon's seller disclosure law requires a statement of whether or not property is classified as forestland-urban interface. Collaboration and coordination are ongoing among several agencies to promote educational efforts through programs like Firewise USA®, the Oregon Forestland-Urban Interface Fire Protection Act, and Fire Adapted Communities from the National Cohesive Wildfire Strategy.

Construction in vulnerable areas increases risk for certain populations. Oregon's Statewide Planning Goal 4 and Goal 7 play critical roles in guiding development in these areas. Measures to enhance life safety enhancement and save costs include Community Wildfire Protection Plans (CWPPs), coordinated fire protection planning, and coordination by local, state, tribal, federal agencies, the private sector, and community organizations. Many communities incorporate their CWPPs into their Natural Hazards Mitigation Plans (NHMPs).

Wildfire mitigation discussions are focused on reducing overabundant, dense forest fuels, particularly on public lands. The Healthy Forest Restoration Act aims to create fuel breaks by reducing overly dense vegetation and trees. It provides funding and guidance to reduce or eliminate hazardous fuels in National Forests, improve forest fire fighting, and research new methods to reduce the impact of invasive insects.

Oregon continues to make efforts in fuels management and forestry resilience and health in and near WUI areas. Sustaining the work over the years requires a substantial, ongoing capacity and financial commitment. Progress is often challenging because fuel mitigation methods vary and are often up to landowners to maintain. Recurring WUI fires continue to bring the issue into public focus, work as a catalyst to unite communities and stakeholders in a common set of objectives, and create collaborative approaches to mitigate fuels.

2.2.9.1 Analysis and Characterization

History of Wildfire

Wildfires have been a feature of the Oregon landscape for thousands of years. Prehistoric fires resulted from lightning events and in controlled forms of active management practices by Native Americans. The Blue Mountains in northeastern Oregon were named so by early immigrants because of the existence of a perpetual, blue-colored wildfire smoke haze that lingered over the region. Between 1840 and 1900, wildland fires burned at least two million acres of forestland in western Oregon. It is believed settlers caused many of these fires. Following the establishment of the U.S. Forest Service and Oregon Department of Forestry, in 1905 and 1911, respectively, an aggressive and coordinated system of fire prevention and suppression emerged. However, it took several decades before significant gains were made.

Major wildfires in 1933, 1939, 1945, and 1951 burned across more than 355,000 acres in the northern Coast Range and became known collectively as the "Tillamook Burn."

Better suppression and more effective fire prevention campaigns combined to reduce large wildfire occurrences following World War II. Suppression improvements included the establishment of organized and highly trained crews, which replaced the previous system of hiring firefighters on an as-needed basis. Additional improvement resulted from construction of an extensive system of forest roads, lookouts and guard stations, the use of aircraft for the detection of fires and the delivery of fire suppression retardant, the invention and modification of modern and efficient fire suppression equipment, and refinements in weather forecasting and fire reporting. Prevention benefited from war-era campaigns, which united prevention activities with patriotism, and birthed movements such as the Smokey Bear campaign and the Keep Oregon Green Association.

A pattern of frequent, large WUI fires emerged during the 1970s as people began flocking to more rural settings. Suburban growth increased and continued through the 1980s. This introduced substantially more structures into what had previously been wildland areas that historically depended on periodic fires to sustain a healthy forest ecosystem.

Project Wildfire

Project Wildfire is the result of a Deschutes County effort to create long-term wildfire mitigation strategies and provide for a disaster-resistant community. Project Wildfire is the community organization that facilitates, educates, disseminates and maximizes community efforts toward effective fire planning and mitigation.

Project Wildfire achieves its mission by:

- Developing long-term wildfire prevention and education strategies designed to reach an ever-changing community.
- Creating disaster 5 resistant communities through collaboration with community members and a network of specialized partners.
- Reducing the severity and amount of damage caused by wildfire in wildland urban interface (WUI) areas through hazardous fuels reduction programs.
- Reducing the impact of fuels reduction on the environment by recycling the woody biomass resulting from hazardous fuels reduction projects.

Source: Oregon Department of Forestry, Project Wildfire (http://www.projectwildfire.org/http://www.projectwildfire.org/)

By the early 1990s, frequent, destructive WUI fires had become a major concern of the State Forester, the State Fire Marshal, and the Oregon Legislature. By the mid-1990s, over 100 structures had been destroyed by wildfires. Thousands more had been threatened and suppression costs were increasing sharply. The same trends were occurring in surrounding states, at an even greater pace.

Oregon Forestland-Urban Interface Fire Protection Act

In 1988, following the very difficult and expensive fire season of 1987, Oregon developed "An Action Plan for Protecting Rural/Forest Lands from Wildfire." The work was funded by FEMA's Fire Suppression Assistance (FSA) Program. The action plan was updated in 1991 with an Awbrey Hall Fire Appendix, in response to a fire that burned 22 structures on the western fringe of Bend. The 1988 action plan and the 1991 update led to the Legislature's attachment of a Budget Note to ODF's 1995-1997 budget, which required an examination of the WUI situation and the development of *"…recommendations which may include…statutory changes on how to minimize the costs and risks of fire in the interface." Spurred by the loss of additional homes during the 1996 Skeleton Fire, these recommendations became the basis for passage of the Oregon Forestland-Urban Interface Fire Protection Act of 1997*.

The Act recognized that "…*forestland-urban interface property owners have a basic responsibility to share in a complete and coordinated protection system*..." In addition, during the 1990s, prevention and mitigation of WUI fires included enactment of the Wildfire Hazard Zone process and the inclusion of defensible space requirements in the land use planning process. Significant efforts were made to increase voluntary landowner participation, through aggressive awareness campaigns, such as FireFree, Project Wildfire, Project Impact, Firewise USA®, and other locally driven programs.

Through the years, Oregon's wildfire suppression system continued to improve. Firefighters benefited from improved training, coordination, and equipment. Better interagency initial attack cooperation, the growth of private crew and fire engine wildfire suppression resources, formation of structural incident management teams, and regional coordination of fire suppression are additional examples of these continued improvements. Technology has improved as well with the addition of lightning tracking software and fire detection cameras to support or replace deteriorating lookout towers.

Nevertheless, the frequency of wildfires threatening WUI communities continues to underscore the need for urgent action. The summer of 2002 included 11 Emergency Conflagration Act incidents, with as many as five running concurrently. More than 50 structures burned and, at one point, the entire Illinois Valley in Josephine County seemed under siege from the Biscuit Fire, Oregon's largest wildfire on record. This wildfire threatened the homes of approximately 17,000 people, with over 4,000 homes under imminent evacuation alert. At almost 500,000 acres, it was the nation's largest wildfire of the year. The summer of 2013 once again brought to bear one of the worst fire seasons in Oregon. For the first time since 1951, more than 100,000 acres burned on lands protected by the Oregon Department of Forestry. Five incident management teams were deployed in a period of three days following a dry lightning thunderstorm event in late July that sparked nearly 100 fires in southern Oregon from more than 300 lightning strikes. Another storm that passed over central and eastern Oregon in mid-August produced significant fires that threatened the communities of John Day and The Dalles. Since 1996, Oregon has had 62 declared Conflagrations under the Act. Oregon's mitigation efforts since 2002 have influenced a dramatic decrease in these types of fires, resulting in none to four per year through 2014 (See Appendix **9.1.1** for more information on Conflagrations from 1996 to 2019.)

Types of Wildfire

Wildfires burn primarily in vegetative fuels located outside highly urbanized areas. Wildfires may be broadly categorized as agricultural, forest, range, or WUI fires.

Agricultural: Fires burning in areas where the primary fuels are flammable cultivated crops, such as wheat. This type of fire tends to spread very rapidly, but is relatively easy to suppress if adequate resources are available. Structures threatened are usually few in number and generally belong to the property owner. There may be significant losses in terms of agricultural products from such fires.

Forest: The classic wildfire; these fires burn in fuels composed primarily of timber and associated fuels, such as brush, grass, and logging residue. Due to variations of fuel, weather, and topography, this type of fire may be extremely difficult and costly to suppress. In wilderness areas these types of fires are often monitored and allowed to burn for the benefits brought by the ecology of fire, but also pose a risk to private lands when these fires escape these wilderness areas.

Range: Fires that burn across lands typically open and lacking timber stands or large accumulations of fuel. Such lands are used predominantly for grazing or wildlife management purposes. Juniper, bitter-brush, and sage are the common fuels involved. These fires tend to spread rapidly and vary from being easy to difficult to suppress. They often occur in areas lacking both wildland and structural fire protection services.

Wildland-urban interface (WUI): These fires occur in portions of the state where urbanization and natural vegetation fuels are mixed together. This mixture may allow fires to spread rapidly from natural fuels to structures and vice versa. Such fires are known for the large number of structures simultaneously exposed to fire. Especially in the early stage of WUI fires, structural fire suppression resources may be quickly overwhelmed, which may lead to the destruction of a large number of structures. Nationally, wildland interface fires have frequently resulted in catastrophic structure losses.

Secondary Hazards

Increased risk of landslides and erosion are secondary hazards associated with wildfires that occur on steep slopes. Wildfires tend to denude the vegetative cover and burn the soil layer creating a less permeable surface prone to sheetwash erosion. This - in turn - increases sediment load and the likelihood of downslope failure and impact.

Wildfires can also impact water quality (e.g., drinking water intakes). During fire suppression activities some areas may need coordinated efforts to protect water resource values from negative impact.

Wildfire smoke may also have adverse effects on air quality and visibility, and create nuisance situations. Strategies to limit smoke from active wildfires are limited, but interagency programs exist to alert the public of potential smoke impact areas where hazardous health or driving conditions may occur.

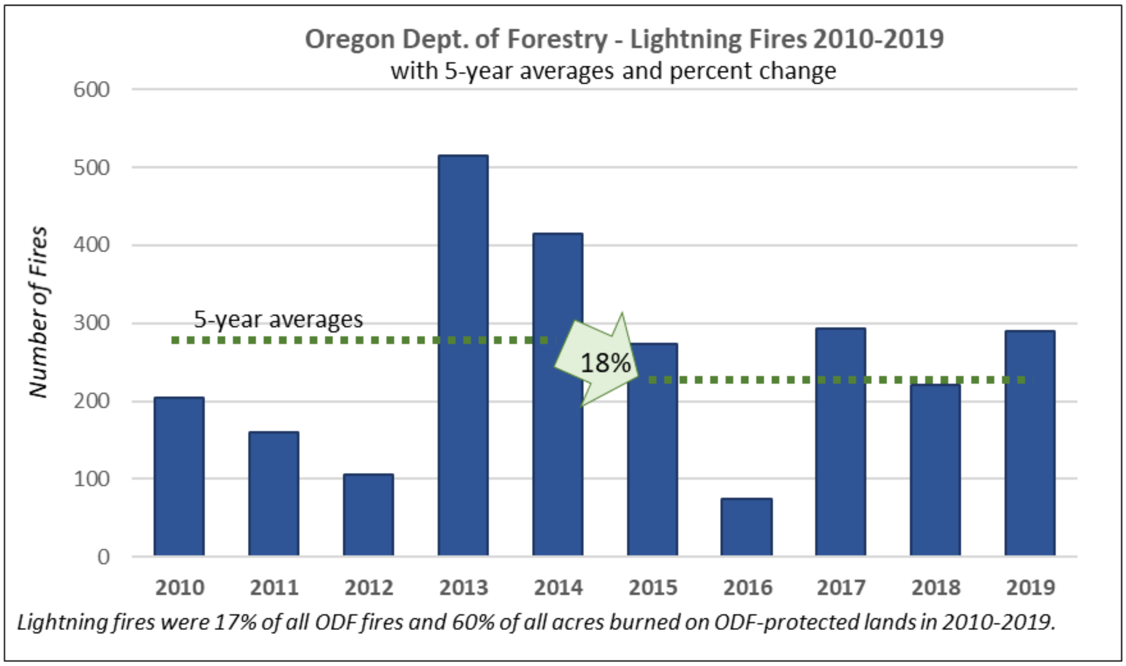
Source: Unknown

Common Sources of Wildfire

For statistical tabulation purposes, wildland fires are grouped into nine categories based on historically common wildfire ignition sources.

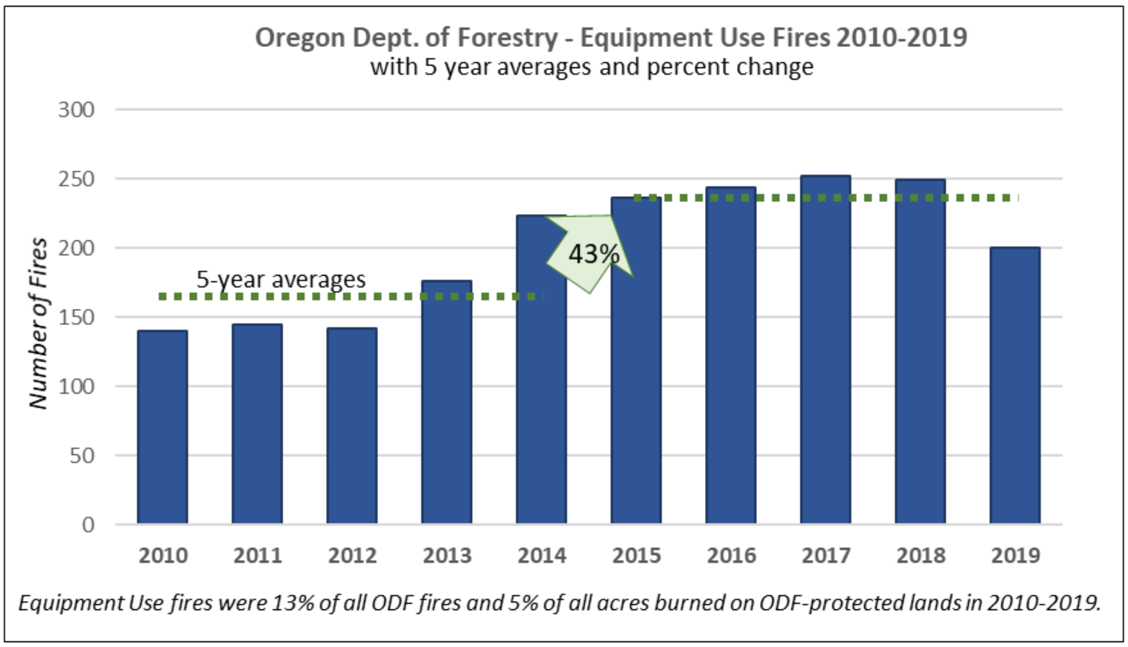
Lightning: There are tens of thousands of lightning strikes in Oregon each year. Of the nine categories, lightning is the leading ignition source of wildfires. In addition, lightning is the primary cause of fires which require activation of Oregon's Conflagration Act.

Figure 2-90. Lightning Fires 2010-2019



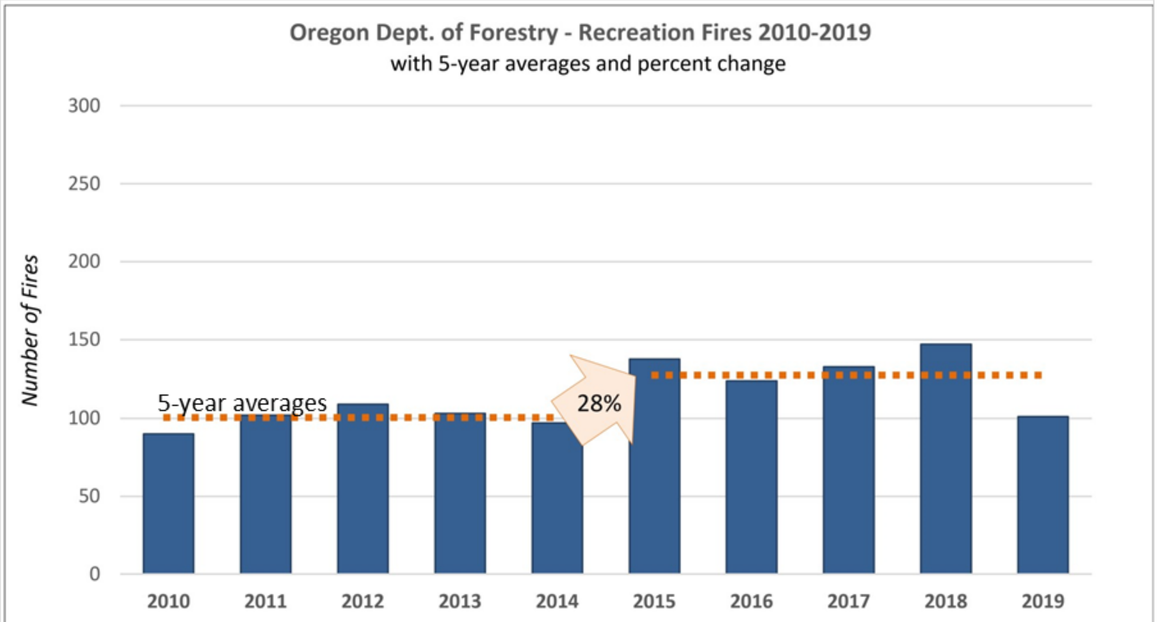
Equipment use: This source ranges from small weed eaters to large logging equipment; many different types of equipment may readily ignite a wildfire, especially if used improperly or illegally. Although fire agencies commonly limit or ban certain uses of fire-prone equipment, the frequency of fires caused by equipment has increased. Increases in fires from this source may be related to the expansion of the wildland interface, which results in more people and equipment being in close proximity to forest fuels.

Figure 2-91. Equipment Use Fires 2010-2019



Recreation: The trend in fires caused by people recreating in and near Oregon's forests has risen over the past 10 years. This trend may reflect the state's growing population and as well as a greater interest in outdoor recreation opportunities.

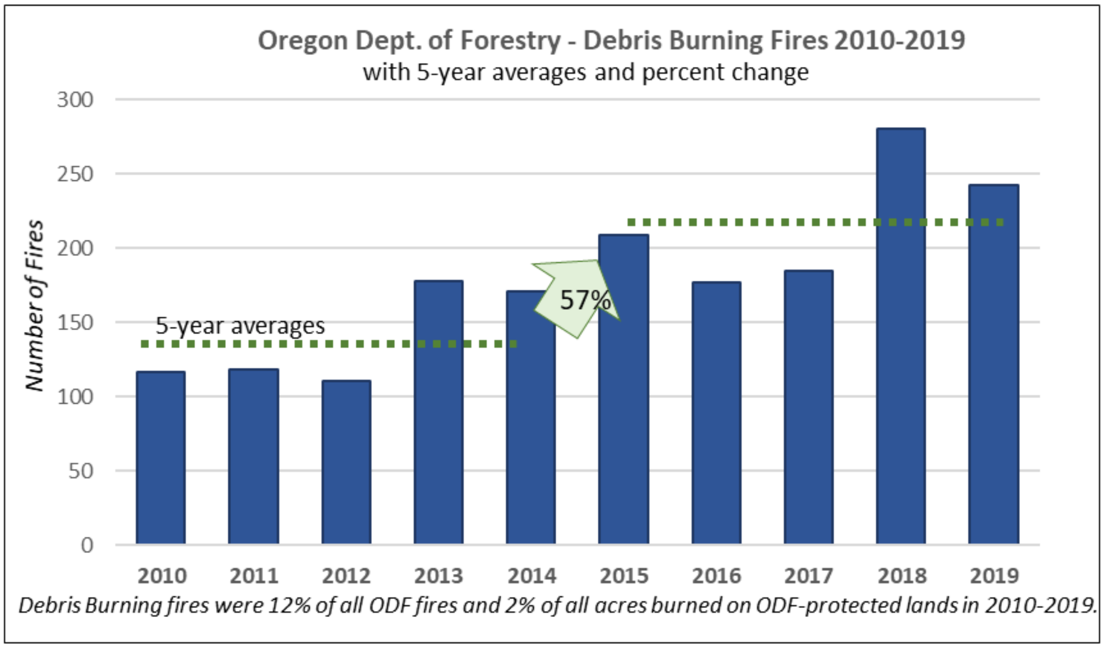
Figure 2-92. Recreation Fires 2010-2019



Recreation fires were 8% of all ODF fires and 3% of all acres burned on ODF-protected lands in 2010-2019.

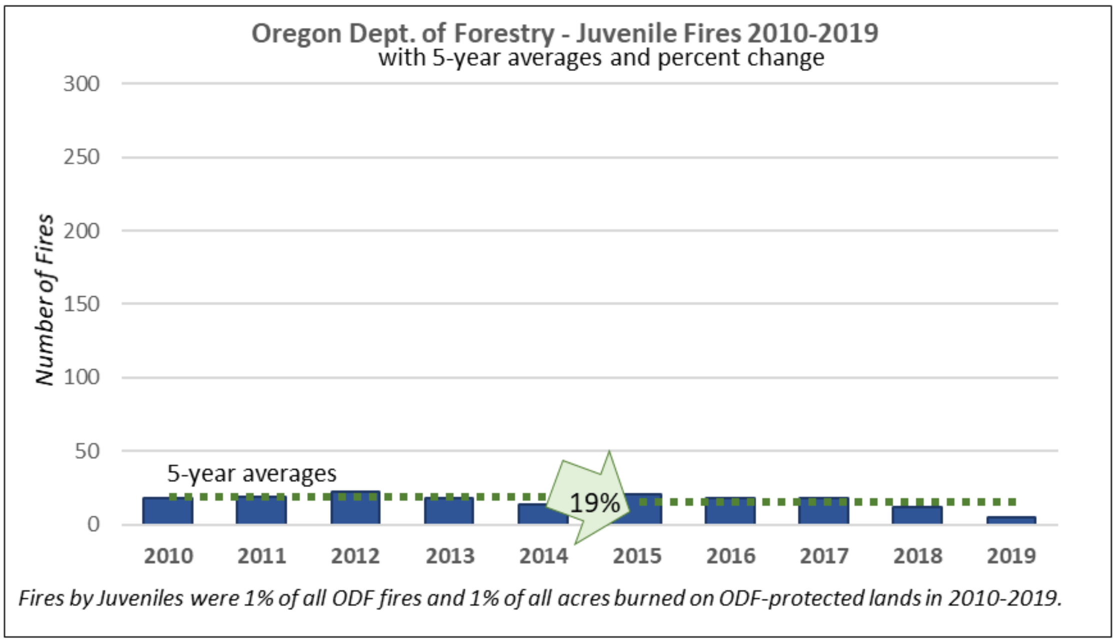
Debris burning: Historically, debris burning activities have been a leading source of human-caused wildfires. Partnering fire protection agencies, primarily through local fire defense boards, continue to seek solutions to curb ignitions and escapements. Besides consistent messaging during fire season that draws attention to the illegal activity, fire prevention professionals are beginning to provide additional education to encourage alternatives to burning and safe burning practices during fall and winter months when fire danger is less severe. Despite these efforts we have still seen a rise in the last 5 years.

Figure 2-93. Debris Burning Fires 2010-2019



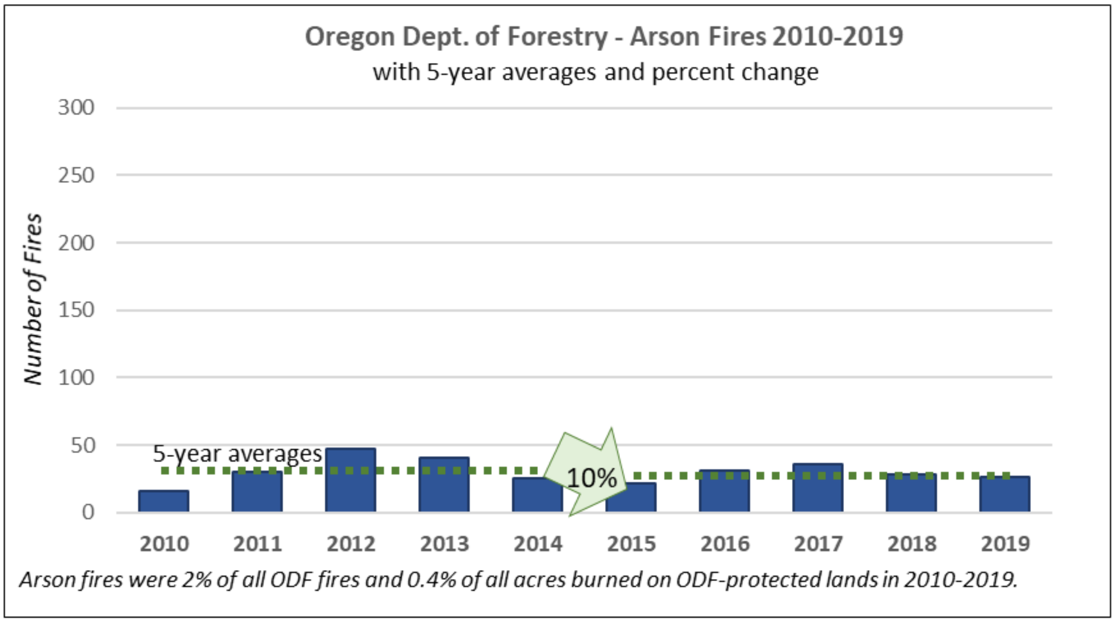
Juvenile: Concerted efforts by local fire prevention cooperatives to deliver fire prevention messages directly to school classrooms and the Office of the State Fire Marshal's (OSFM's) aggressive youth intervention program has helped address this ignition source. In 1999, according to the ODF, juveniles were reported to have started 60 wildland fires. Conversely, juveniles accounted for just 4 fires in 2019. Additionally, parents or guardians, under Oregon Law, are responsible for damages done by fires started by their children. ORS 30.765 covers the liability of parents; ORS 163.577 holds parents or guardians accountable for child supervision, ORS 477.745 makes parents liable for wildfire suppression costs of a fire by a minor child, and ORS 480.158 holds a parent liable for fireworks-caused fires. Additionally, parents may be assessed civil penalties.

Figure 2-94. Juvenile Fires 2010-2019



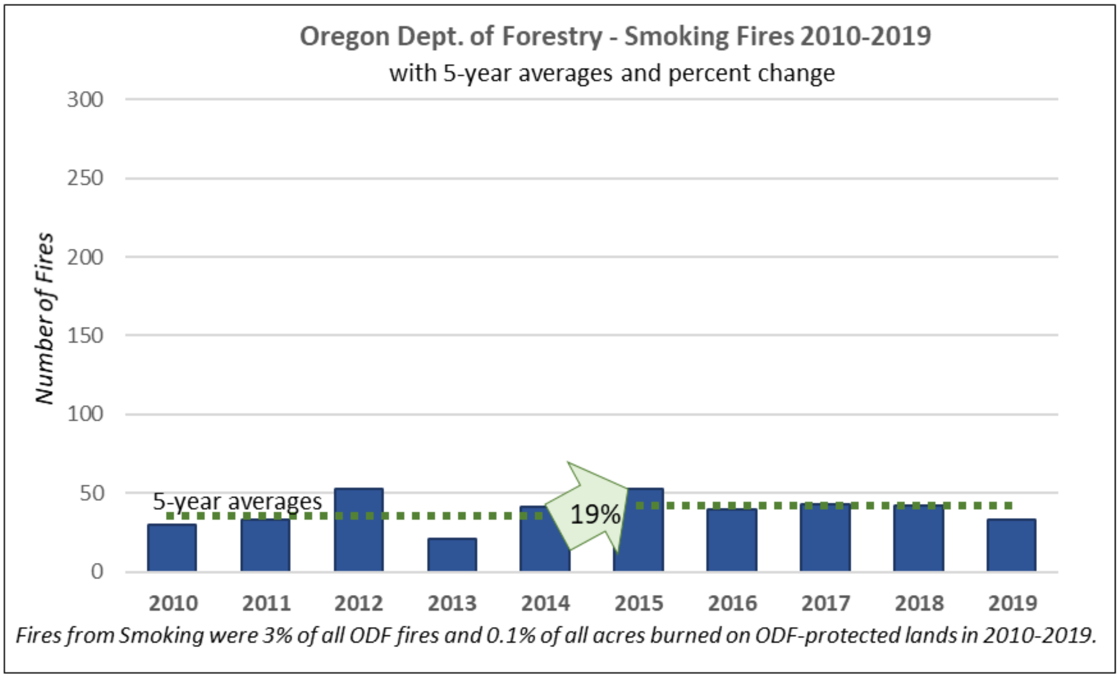
Arson: Oregon experienced a rapid rise in the frequency of arson caused fires in the early '90s. 1992 was the worst fire season for arson with 96 fires attributed to the category. In response, the state instituted aggressive arson prevention activities with solid working relationships with local law enforcement and the arson division of the Oregon State Police. The result has seen a decline in numbers with just 19 fires in 2019.

Figure 2-95. Arson Fires 2010-2019



Smoking: Fires caused by smoking and improperly discarded cigarettes has slightly risen in the last 5 years.

Figure 2-96. Smoking Fires 2010-2019



Railroad: Wildfires caused by railroad activity are relatively infrequent. In the early twentieth century, this had been a major cause of fires, but has been decreasing for many years. Over the past 10-year period, the number of railroad-caused fires has leveled out close to 0%. In the past few decades, Oregon has responded to railroad-caused fires with aggressive fire investigation and cost recovery efforts. Oregon Department of Forestry works with the railroad on hazard abatement along tracks and requires water cars and chase vehicles during high fire danger. The resulting quick return to normal fire incidence showed that railroad fires are very preventable.

Miscellaneous: Wildfires resulting from a wide array of causes: automobile accidents, burning homes, pest control measures, shooting tracer ammunition and exploding targets, and electric fence use are a few of the causes in this category. The frequency of such fires has been rising in recent years.

Historic Wildfire Events

Table 2-72. Historic Wildfires in Oregon

Date	Location	Description
1902	Clackamas, Multnomah	**Columbia Fire/Yacolt Burn** 170,000 acres caused 38 deaths in the Lewis River area, 9 deaths in Windy River, and 18 deaths in the Columbia River Gorge.
1933-1951	Tillamook, Washington, Yamhill and Clatsop	**Tillamook Burn** was a series of large fires that struck in 6 year intervals burning a combined total of 355,000 acres and killing 35 people.
1936	Coos	**Bandon Fire** was a 287,000 acre fire that destroyed 100’s of homes and killed 10 people.
2002	Josephine	**Biscuit fire** burned nearly 500,000 acres starting from lighting strikes and the product of the joining of 4 different fires and burned over 4 months long.
2006	Harney	**South End Complex** burned 117,553
2010	Jackson	**Oak Knoll Fire** in Ashland destroyed 11 homes in less than 45 minutes
2011	Wasco	**High Cascade Complex** burned on the east side of Mount Hood into **Warm Springs**, consuming 101,292 acres
2012	Tillamook, Washington, and Yamhill	**Holloway Fire** burned more than 245,000 acres in Oregon from a lightning strike and also burned more than 215,000 acres in Nevada. One firefighter was killed.
2012	Malheur and Harney	**Long Draw Fire** consumed 557,648 acres and was started by lightning.
2013	Josephine, Douglas	**Douglas Complex** burned about 49,000 acres started by lightning strikes. Made up of 3 fires: Rabbit Mountain, Dad’s Creek, and Farmer’s Fire.
2013	Jefferson	**Sunnyside Turnoff** started by a firecracker that was thrown into vegetation. It grew to 51,480 acres on the Warm Springs Indian Reservation.
2014	Wallowa	**Buzzard Complex** burned over 400,000 acres and significantly impacted rangeland and cattle farms.
2014	Grant	**South Fork Complex** started with lightning strikes burning 62,476 acres.
2015	Grant	**Canyon Creek Complex** burned 110,422 acres started by lightning. It destroyed more private property than any Oregon wildfire for 80 years before it. It destroyed 43 homes and almost 100 other structures.
2015	Wallowa	**Grizzly Bear Complex** burned 82,659 acres started by lightning. Destroyed 2 homes and dozens of other structures.
2015	Jefferson	**County Line 2** burned over 67,000 acres.
2015	Baker	**Cornet Windy Ridge** burned 103,887 Acres started by lightning strike.
2017	Curry	**Chetco Bar** burned 191,125 acres and started by lightning strike.
2017	Multnomah and Hood River	**Eagle Creek Fire** burned 48,831 acres and was caused by a 15-year- old playing with fireworks.
2017	Lake and Harney	**Cinder Butte** burned over 52,000 acres of rangeland that was human caused and threatened Tribal Archaeological Sites.
2017	Wasco	**Nena Springs** burned more than 68,000 acres, was human cause and did significant damage to the Confederate Tribes of Warm Springs.

Date	Location	Description
2018	Josephine	**Klondike** burned more than 175,258 acres and eventually merged into the Taylor Creek Fire that had burned 52,839 acres.
2018	Wasco	**Boxcar** burned 100,207 acres and started due to lightning.
2018	Jackson and Douglas	**Miles** burned 54,134 acres and was a combination of merged fires: Sugar Pine, South Umpqua Complex, and the Miles fire.
2018	Josephine	**Taylor Creek** burned 52,839 acres started by a lightning strike.
2018	Wasco	**Substation** burned 78,425 acres moving over 18 miles in just days.
2018	Lake	**Watson Creek** burned over 58,900 acres.

Source: Oregon Department of Forestry, 2020

Figure 2-97. Large Fire Costs & Acres Burned

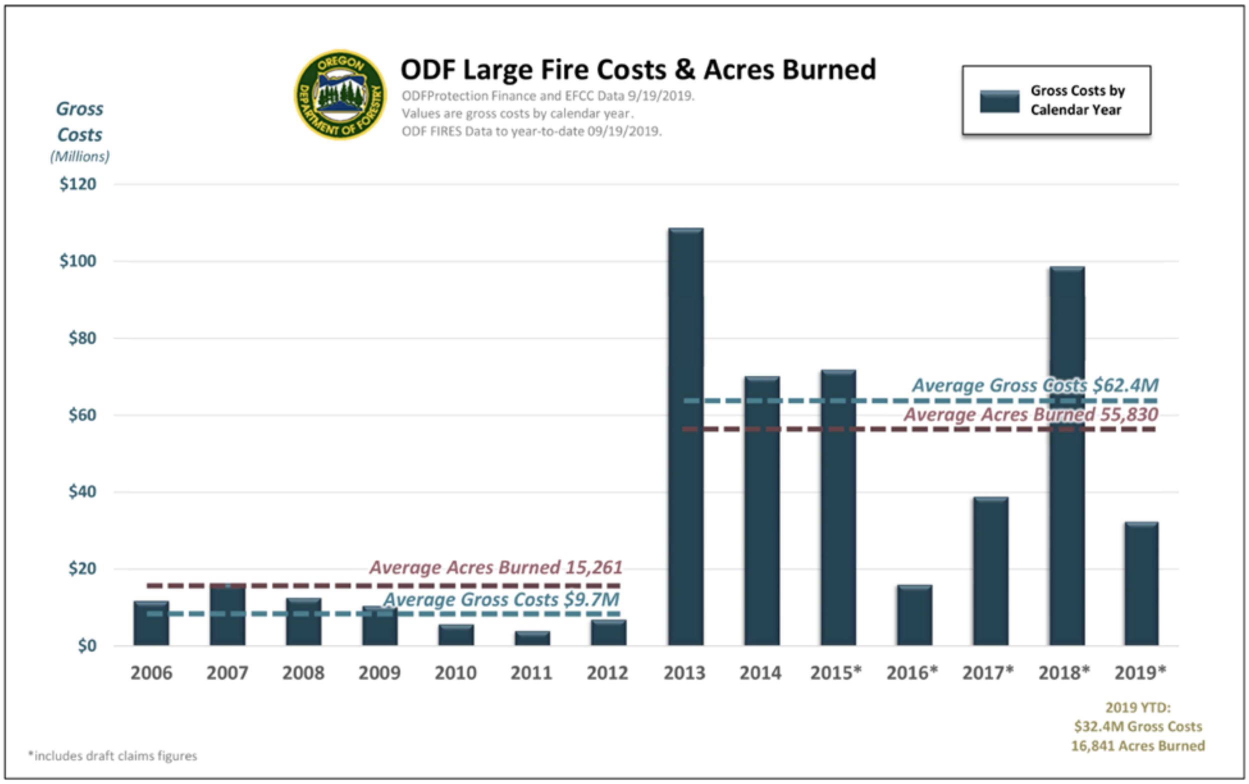


Figure 2-97 presents large fire costs and acres burned for ODF protected lands since 2006. This shows a significant shift in 2013 when the cost and burned acreage severely increased. Clearly an overall trend towards more intense fire events has emerged in the last 7 years. This observation is consistent with the trend over the last several decades of warmer and drier conditions during the summer months that have contributed to an increase in fuel aridity enabling more frequent large fires and an increase in the total area burned across the western United States. Human-caused climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

2.2.9.2 Probability

Fire is a natural component of forest and rangeland ecosystems found in all portions of the state. Many of these ecosystems are dependent upon frequent fires or a viable substitute for their continued existence. Even western Oregon forests, in the "wet" northwestern portion of the state, depend upon fire. It is a common myth that an unbroken carpet of old growth timber blanketed western Oregon prior to the beginning of European American settlement. In fact, fire and other natural forces had created a mosaic of different aged timber stands across the region. Factors now influencing the occurrence and severity of wildfires include poor forest health, invasive plant and tree species, great amounts of vegetation from long-term fire exclusion, changes in weather patterns including warmer and drier summers, and the presence of humans and human development.

Although usually thought of as being a summer occurrence, wildland fires can occur during any month of the year. The vast majority of wildfires burn during the June to August time period but in recent years have extend into September or even October months. The decline mountain snowpack and earlier spring snowmelt due to climate change has resulted in a lengthening of the fire season over the last several decades (Dalton, Dello, Hawkins, Mote, & Rupp, 2017). Dry spells during the winter months, especially when combined with winds and dead fuels, may result in fires that burn with an intensity and rate of spread that surprises many people.

During a typical year, in excess of 2,000 wildland fires are ignited on protected forestlands in Oregon. Due to growth in the WUI and changes in climate, the number of wildfires on ODF protected lands has trended upward. This trend is expected to continue increasing under continued climate warming.

The US Forest Service recently completed the Quantitative Wildfire Risk Assessment (QWRA). The Oregon Department of Forestry (ODF) has recently taken this assessment data and worked with Oregon State University Extension and Pyrologix, LLC (http://pyrologix.com) to create a portal to maps that can identify wildfire risk in the state of Oregon. The Oregon Wildfire Risk Explorer (OWRE) project makes data available for the Pacific Northwest, replacing the West-Wide Risk Assessment (WWRA) of 2013. The site will allow the user to view data through an interactive mapping tool, generate maps and reports specific to their area of interest, and access information to interpret the data for homeowners and planners. The goals of this site are to:

- Increase wildfire awareness, prevention activities, and local capacity for developing and updating Community Wildfire Protection Plans (CWPPs).
- Help communities identify and prioritize fuel treatment and other wildfire risk reduction projects.
- Improve wildfire risk planning and decision making across broad landscapes at all levels.
- Increase the number of fire adapted communities.
- Reduce losses by implementing effective coordinated emergency response

The OWRE is intended to support strategic planning at regional, state, and landscape scales. It was conducted at the dual state (Oregon and Washington) level so data is more accurate and specific than a regional assessment. Since the data is at the state level, finer-scale data may hold inaccuracies. When looking at probability, though, the OWRE is a great resource.

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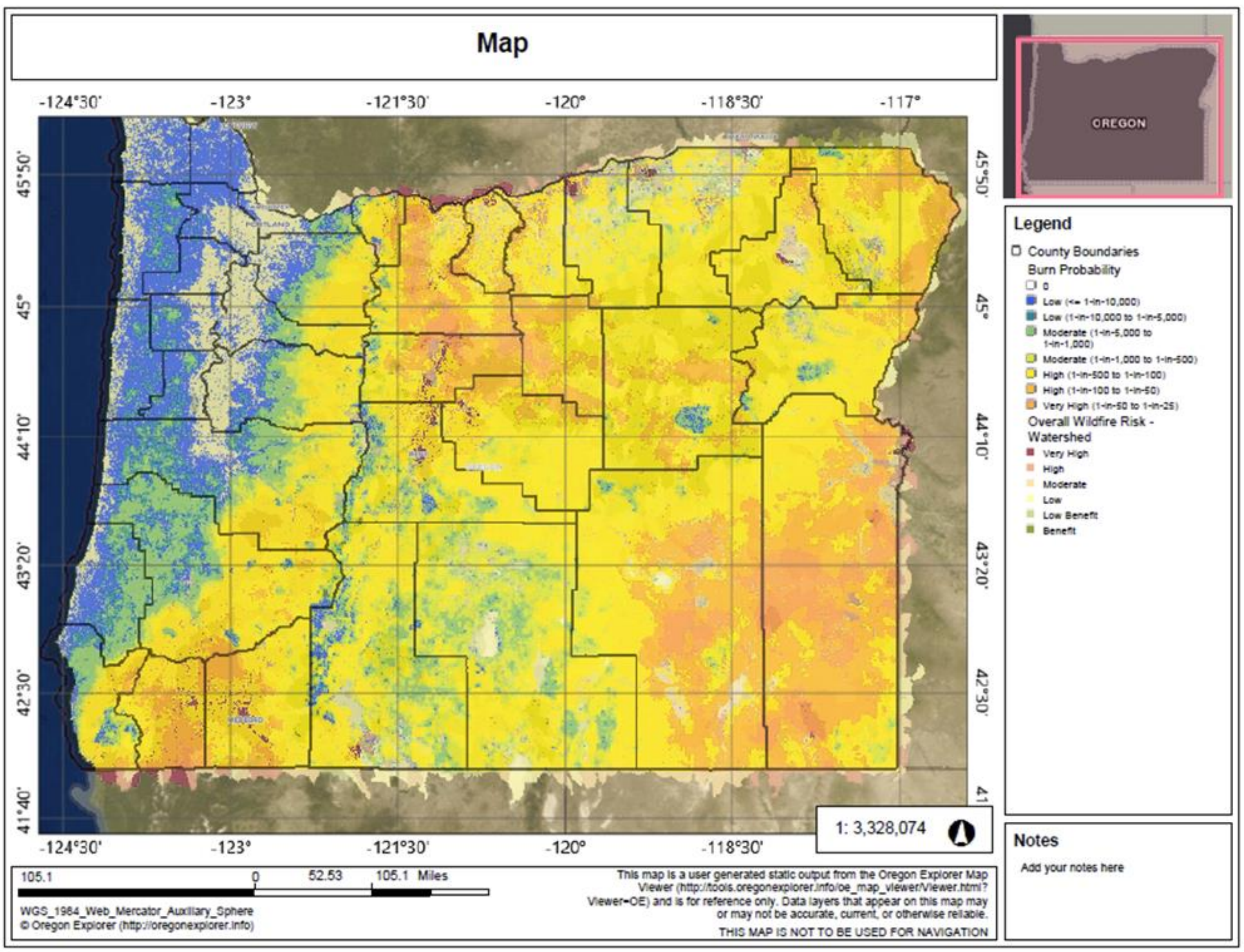
Burn Probability: Burn probability is calculated as the likelihood of a wildfire greater than 250 acres to burn a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Viewing local small fires in conjunction with wildfire >250 acres, burn probability can give a more comprehensive view of local fire history and potential. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

Figure 2-98. Burn Probability



Source: Oregon Wildfire Risk Explorer, March 2020

Low: The annual probability that a wildfire will burn a given point on the landscape. Low burn probability indicates less than approximately 1 in 5,000 chance of a wildfire >250 acres in a single year. Low represents up to the 11th percent of values across the landscape.

Moderate: The annual probability that a wildfire will burn a given point on the landscape. Moderate burn probability indicates between 1 in 5,000 and 1 in 500 chance of a wildfire >250 acres in a single year. Moderate represents the 11th up to the 29th percent of values across the landscape.

High: The annual probability that a wildfire will burn a given point on the landscape. High burn probability indicates between 1 in 500 and 1 in 50 chance of a wildfire >250 acres in a single year. High represents the 29th up to 96th percent of values across the landscape.

Very High: The annual probability that a wildfire will burn a given point on the landscape. Very High burn probability indicates greater than 1 in 50 chance of a wildfire >250 acres in a single year. Very High represents the 96th through 100th percent of values across the landscape.

Burn Probability and Exposure

To find the overall probability of wildfire for each County plus the two coastal areas of Lane and Douglas County for the 2020 Risk Assessment Methodology, we first established communities in the Wildland Urban Interface and their risk ratings using the following data and procedure. A "Community at Risk" is a geographic area within and surrounding permanent dwellings with basic infrastructure and services, under a common fire protection jurisdiction, government, or tribal trust or allotment, for which there is a significant threat due to wildfire.

The "Communities at Risk" were identified and named by using a combination of resources:

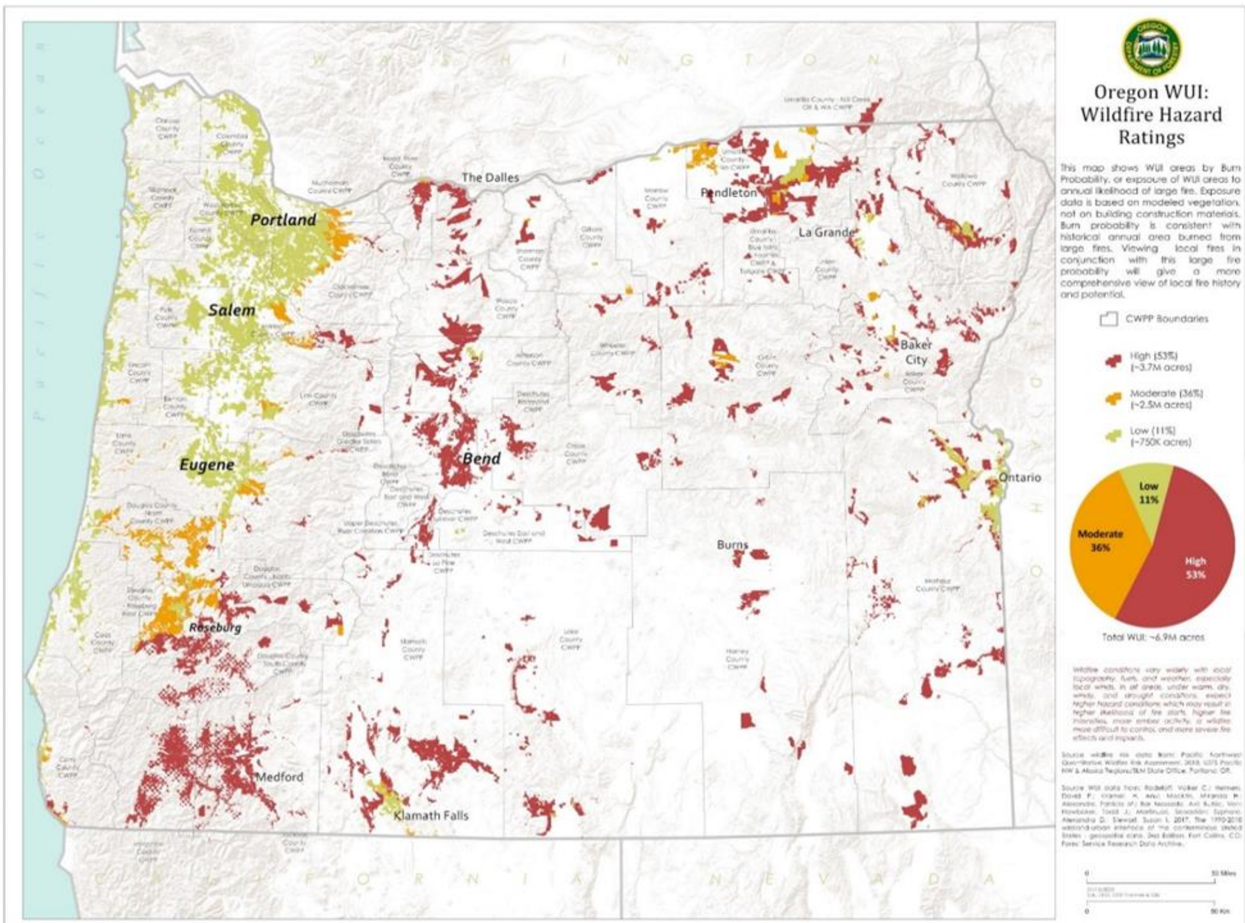
- University of Wisconsin SILVIS WUI dataset as a primary source for WUI interface and intermix areas (University of Wisconsin-Madison Silvis Lab (2010) retrieved from http://silvis.forest.wisc.edu/maps-data/)
- Oregon "Locally Named Communities at Risk" identified in Community Wildfire Protection Plans (Oregon Department of Forestry (January 2020) retrieved from https://www.oregon.gov/odf/Fire/Pages/CWPP.aspx)
- Listed communities at risk in the Federal Register (Federal Register, January 4, 2001 (66 FR 751))
- Added City Limits,
- Added Structural Fire District areas, and
- Created a 5 mile buffer of all Oregon town points to capture rural towns without established boundaries.

The identified community data were joined and cross checked with Department of Land Conservation and Development's (DLCD's) Oregon 2017 Land Use Zoning map. Polygons that were not locally named communities, Federal Register, or land use zones that appeared to be built-environments were deleted from the WUI. The mean was calculated from the Pacific Northwest Quantitative Wildfire Risk Assessment (2018) *Hazard to Structures and Burn Probability* value for each WUI polygon to show actual wildfire hazard (**Figure 2-99**). West Wide Risk Assessment was reviewed, assessed, and found to not be statistically different, so there was no need to adjust data outcomes. This created a Wildland Urban Interface layer which is associated with all administrative geographies. To create maps, the data was classified per Pyrologix/USFS/ODF/Oregon Wildfire Risk Explorer symbology themes.

Figure 2-99 shows WUI areas by burn probability, or exposure of WUI areas to annual likelihood of large fire. Exposure data is based on modeled vegetation, not on building construction materials. Burn probability is consistent with historical annual area burned from large fires. Viewing local fires in conjunction with this large fire probability provides a more comprehensive view of local fire history and potential.

All of this data will be integrated into the Oregon State University's Oregon Explorer online mapping application (known as the Oregon Wildfire Risk Explorer) by the end of 2020 as a primary data source in the Wildfire Explorer module.

Figure 2-99. Oregon Wildland-Urban Interface (WUI): Wildfire Hazard Ratings



Once the Communities at Risk were identified, they were listed by county and the number of Communities at Risk in each adjective class (Low, Medium, High) in each county was tallied. To assign a probability score from 1 to 5 (Very Low to Very High) for the purposes of the 2020 Risk Methodology, the following criteria were used:

- Counties with 10 or more Communities at Risk in the high class were considered very high due to the significant number of communities at risk in that area.

- Communities with less than 10 communities in the low class were considered very low as they had less communities at risk of wildfire in that county.
- Douglas and Lane Coastal areas were assessed individually (rather than through the model) based on the ratings of Communities at Risk in the coastal portions of those counties.

Table 2-73. Communities at Risk: Burn Probability, Adjective Classes, and Exposure Ratings

		Burn Probability	# Communities at Risk (CAR) in Each Adjective Class				Exposure Ratings	
		Low/Medium/High	Low	Medium	High	Total	# 1-5	Exposure
Region 1	Clatsop	Low	11	1	1	13	2	Low
	Coos	Low	18	0	0	18	2	Low
	Curry	High	6	2	4	12	1	Very Low
	Douglas Coastal	Medium	—	—	—	—	3	Moderate
	Lane Coastal	Low	—	—	—	—	2	Low
	Lincoln	Low	9	1	0	10	1	Very Low
	Tillamook	Low	15	1	0	16	2	Low
Region 2	Clackamas	Low	19	3	2	24	2	Low
	Columbia	Medium	8	0	0	8	1	Very Low
	Multnomah	Low	10	0	0	10	2	Low
	Washington	Low	8	1	1	10	1	Very Low
Region 3	Benton	Low	10	1	0	11	2	Low
	Lane	Medium	18	10	1	29	3	Moderate
	Linn	High	10	3	2	15	2	Low
	Marion	High	18	2	4	24	2	Low
	Polk	Low	5	0	0	5	1	Very Low
	Yamhill	Low	11	0	0	11	2	Low
Region 4	Douglas	High	13	13	22	48	5	Very High
	Jackson	High	0	4	19	23	5	Very High
	Josephine	High	0	0	8	8	4	High
Region 5	Gilliam	High	1	2	0	3	3	Moderate
	Hood River	High	1	2	0	3	3	Moderate
	Morrow	High	1	2	6	9	4	High
	Sherman	High	0	2	1	3	3	Moderate
	Umatilla	High	2	8	9	19	4	High
	Wasco	High	1	2	12	15	5	Very High
Region 6	Crook	High	1	0	3	4	4	High
	Deschutes	High	1	5	6	12	4	High
	Jefferson	High	0	0	10	10	5	Very High
	Klamath	High	2	13	5	20	3	Moderate
	Lake	High	0	8	0	8	3	Moderate
	Wheeler	High	0	1	5	6	4	High
Region 7	Baker	High	1	4	24	29	5	Very High
	Grant	High	0	2	10	12	5	Very High
	Union	High	0	8	13	21	5	Very High
	Wallowa	High	3	8	6	17	3	Moderate
Region 8	Harney	High	0	0	3	3	4	High
	Malheur	High	3	4	8	15	4	High

Note: This table shows burn probability as taken from the PNW Quantitative Wildfire Risk Assessment (2018) along with the Communities at Risk assessment (2020). Combined they were used to arrive at the exposure ratings which represented probability in the 2020 Risk Assessment Methodology and are presented in the Regional Risk Assessments as vulnerability ratings.

Source: ODF Communities at Risk Report, 2020; Oregon Wildfire Risk Explorer, 2020; PNW Quantitative Wildfire Risk Assessment

Climate Change

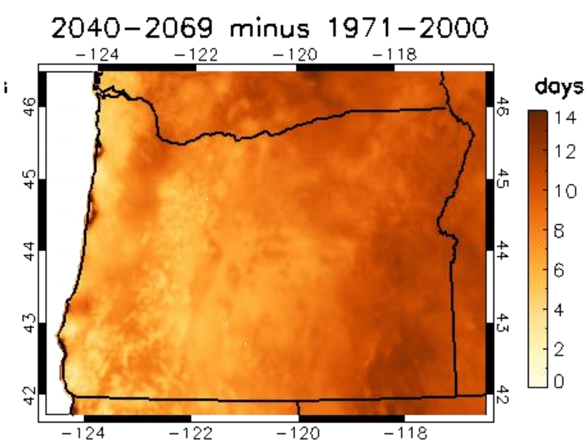
All eight regions in Oregon are projected to be affected by an increased incidence of wildfire.

Increasing wildfire frequency and intensity is greatest (very likely, >90%) in the lower elevations of the Coast and Cascade Ranges (Region 1-3) and southern Oregon (Region 4). Increasing wildfire frequency is likely (>66%) in the rest of the state as well.

Increased risk of wildfire is greater at lower elevation wildlands than at higher elevation wildlands. Areas considered wetter with higher vegetation accumulation will be at higher risk due to intensive fuel loading and drier materials.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. It is expressed as a percent of the dry weight of that specific fuel. FM100 is a common index used by the Northwest Interagency Coordination Center to predict fire danger. A majority of climate models project that FM100 would decline across Oregon by the 2050s (2040–2069) under the higher (RCP 8.5) emissions scenario (Gergel, et al., 2017). This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of “extreme” fire danger days—in which fuel moisture is below the 3rd percentile—is projected to increase across the state (**Figure 2-100**), with the largest increases in the eastern third of Oregon (Region 5, 7, 8), the Willamette Valley (Region 2, 3), and lowland areas in southern Oregon (Region 4) (Mote, Abatzoglou, Dello, Hegewisch, & Rupp, 2019). See Regional Risk Assessments for region-specific projections. Additional prevention and mitigation activities on private, state and federal lands will become more and more crucial as fire seasons change.

Figure 2-100. Projected Change in Frequency of Extreme Fire Danger Days in Summer for 2040–2069 Relative to 1971–2000 under RCP 8.5



Note: “Extreme” fire danger is defined as the number of days when the 100-hour fuel moisture in June- July-August is below the 3rd percentile of days in the baseline period.

Source: Mote, et al. (2019)

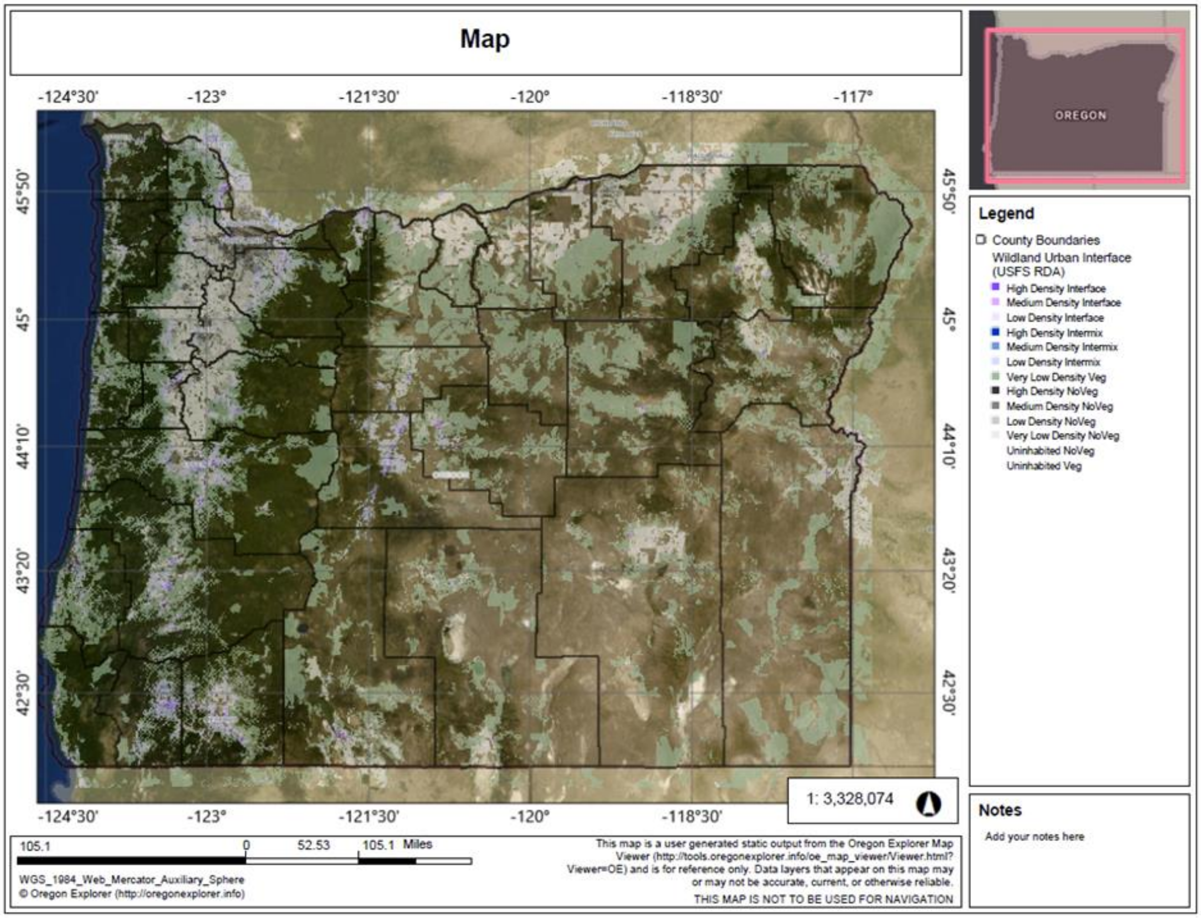
2.2.9.3 Vulnerability

Wildfires are a common and widespread natural hazard that happen annually in Oregon. Fire is a critical component of the forest and rangeland ecosystems found in all regions of the state. Over 41 million acres of forest and rangeland in Oregon are susceptible to wildfire, which now may occur during almost every month of the year. On average, 97% of the fires are suppressed at 10 acres or less. Unfortunately, the remaining 3% of the fires tend to be damaging and very difficult to manage.

The principal type of wildfire affecting Oregon communities is a wildland-urban interface (WUI) fire, which occurs where wildland and developed areas intermingle with both vegetation and structures to provide perfect fuel conditions. As more people have moved into WUI areas, the number of large wildfires impacting homes has escalated dramatically. In addition to WUI fires, Oregon experiences wildland fires that do not threaten structures but may have impacts on timberlands, economy, and habitat.

The wildland-urban interface (WUI) is a focal area for human-environment conflicts such as wildland fires, habitat fragmentation, invasive species, and biodiversity decline. This WUI map (**Figure 2-101**) was made using geographic information systems (GIS), integrating U.S. Census and USGS National Land Cover Data, to map the Federal Register definition of WUI (Federal Register 66:751, 2001) for the conterminous United States from 1990-2010.

Figure 2-101. Wildland-Urban Interface



Source: Oregon Explorer, 2020

Most Vulnerable Jurisdictions

In 2006, the Oregon Department of Forestry conducted a Statewide Forest Assessment of the communities at risk to wildfire to determine priorities for delivering landowner assistance. That assessment how now been updated with a new 2020 Communities at Risk Assessment. The new update was done with information taken from the PNW Quantitative Wildfire Risk Assessment (QWRA), Community Wildfire Protection Plans (CWPPs), Federal Registry, University of Wisconsin Silvis WUI data, city limits, towns, and Structural Fire District areas to characterize Oregon wildfire risk and vulnerabilities.

In total, five hundred and four (504) Communities at Risk were identified and assessed for their wildfire risk in Oregon. The number of structures, exposure, burn probability, and hazard were all taken into account in rating the communities.

According to **Table 2-73**, the regions most vulnerable to wildfire are Region 4 and Region 7, followed by Region 6, Region 8, and Region 5.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in “High,” “Moderate,” and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are also represented here as “Low.”

Of the 5,530 state facilities evaluated, 1,111 are within the High or Moderate wildfire hazard zone and total about $950 million in value. Three hundred sixty-five state critical facilities are within the High or Moderate wildfire hazard zone. Of the 8,757 local critical facilities evaluated, 955 were in High or Moderate hazard zones with a total value over $775 million.

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to wildfires. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. Only one of these losses, totaling less than $2,000, was due to a wildfire.

DAS’s records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS’s insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update’s reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Historic Resources

Of the 58,872 historic resources statewide, 1,824 are located in areas of high wildfire hazard, with the greatest concentration (38%) in Region 4 and over half of those in Jackson County. Many fewer are located in areas of moderate wildfire hazard. The vast majority are in areas of low wildfire hazard.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

For the 2020 vulnerability assessment, DLCD combined this index with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Morrow, Wasco, Jefferson, Klamath and Malheur Counties are the most vulnerable to impacts from wildfire hazards. These counties are located in Regions 5, 6, and 8 which are among those identified by ODF as most vulnerable to wildfire.

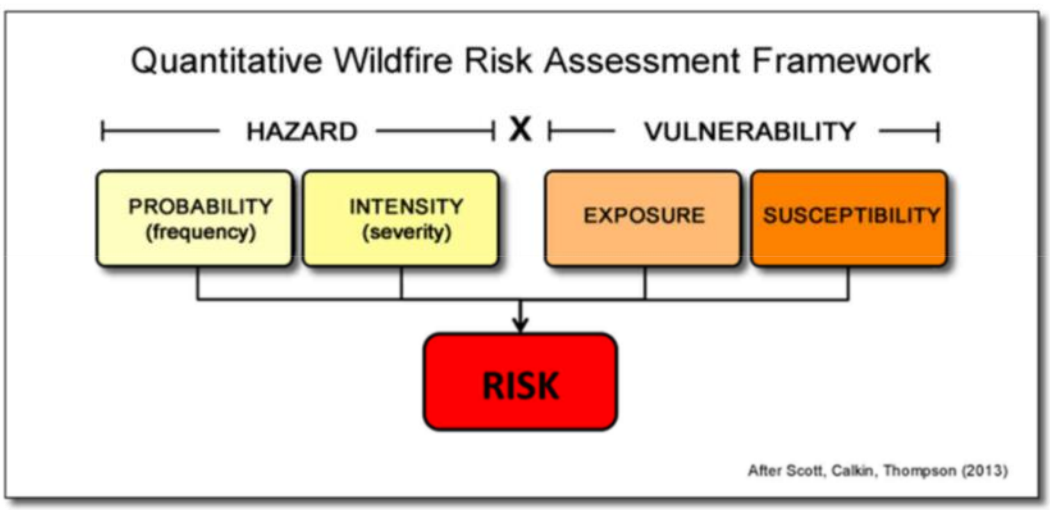
2.2.9.4 Risk

Pacific Northwest Quantitative Wildfire Risk Assessment (QWRA)

At this time, the QWRA is the most up to date assessment for fire risk utilizing the best available science across a range of disciplines for the State of Oregon. The Pacific Northwest QWRA provides foundational information about wildfire hazard and risk to highly valued resources and assets across the region.

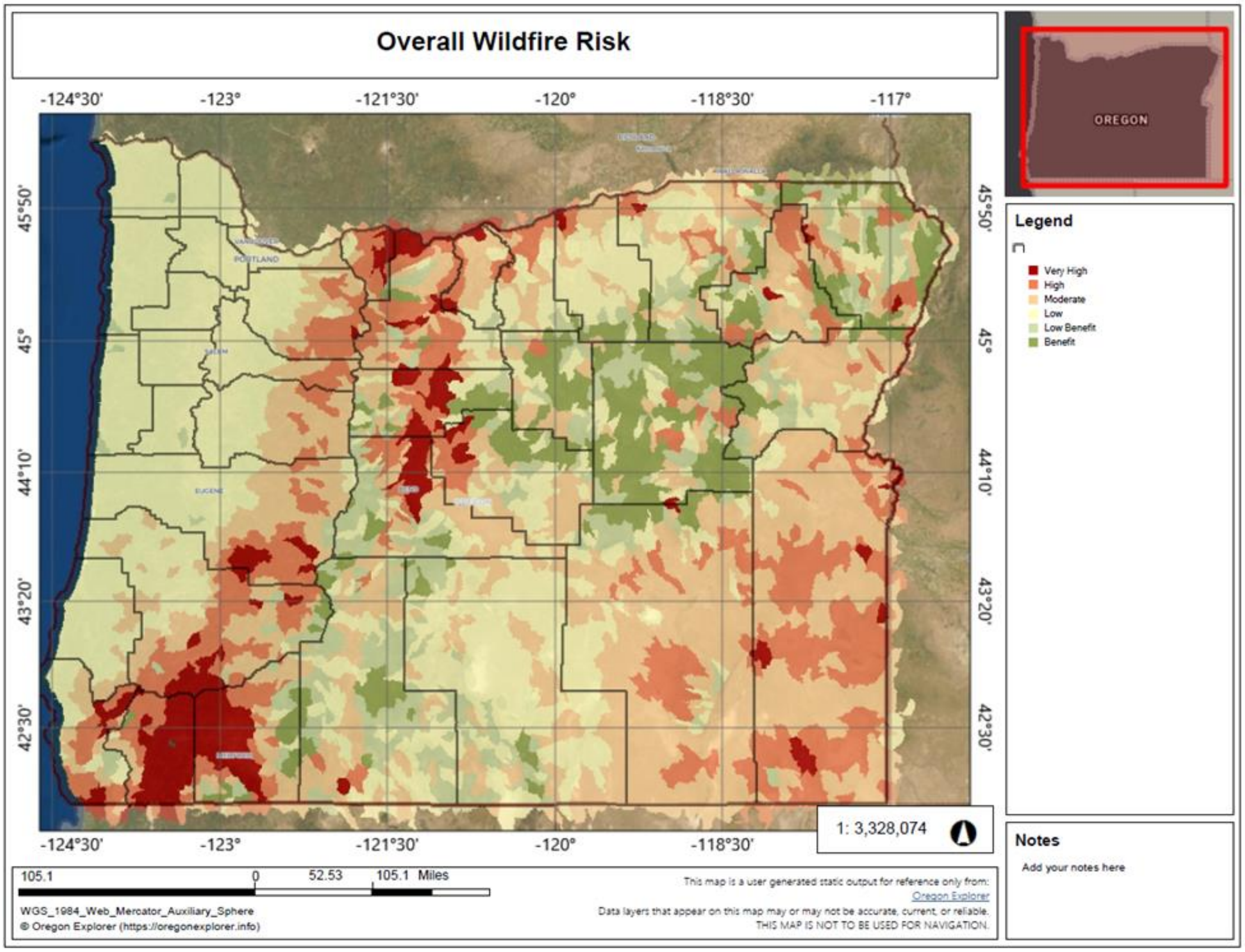
Figure 2-102 shows the general factors that contribute to risk from wildfire according to the QWRA.

Figure 2-102. Quantitative Wildfire Risk Assessment Framework



Overall Wildfire Risk is the product of the likelihood and consequence of wildfire on all mapped highly valued resources and assets combined: critical infrastructure, developed recreation, housing unit density, seed orchards, sawmills, historic structures, timber, municipal watersheds, vegetation condition, and terrestrial and aquatic wildlife habitat. This dataset considers the likelihood of wildfire >250 acres (likelihood of burning), the susceptibility of resources and assets to wildfire of different intensities, and the likelihood of those intensities. The data values reflect a range of impacts from a very high negative value, where wildfire is detrimental to one or more resources or assets (for example, structures, infrastructure, early seral stage and/or sensitive forests), to positive, where wildfire will produce an overall benefit (for example, vegetation condition/forest health, wildlife habitat).

Figure 2-103. Overall Wildfire Risk

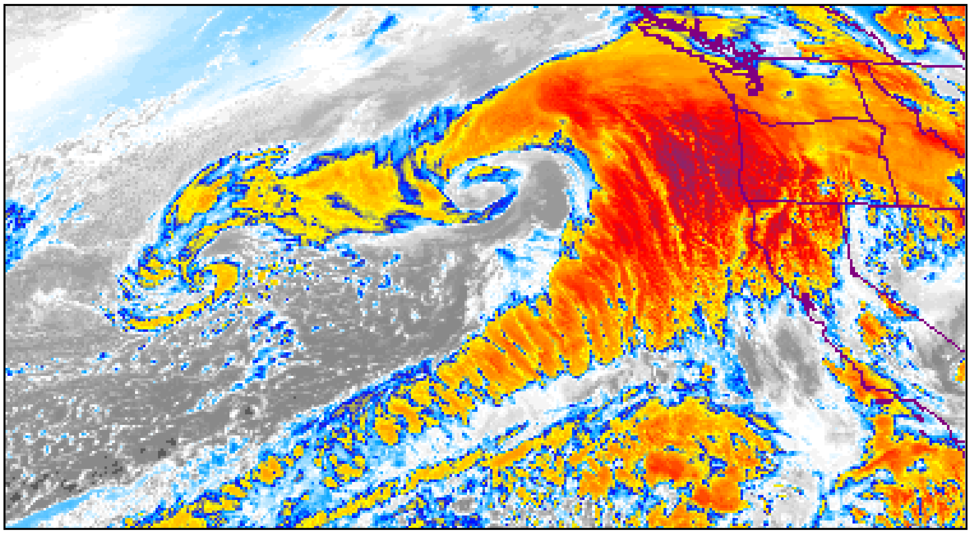


In the 2020 update DOGAMI and DLCD developed a new risk ranking system that combines the probability of the hazard with the limited vulnerability assessment to arrive at a composite risk score referred to as the 2020 Risk Score.

According to the 2020 risk assessment, Regions 4, 5, 6, 7, and 8 are at greatest risk from wildfire hazards. The counties at greatest risk are Douglas, Jackson, Josephine, Hood River, Morrow, Umatilla, Wasco, Crook, Jefferson, Klamath, Lake, Wheeler, Baker, Grant, Union, Harney, and Malheur. This is mostly consistent with **Figure 2-103**, Overall Wildfire Risk.

2.2.10 Windstorms

Figure 2-104. Satellite Image of the Type of Severe Pacific Storm that Can Bring High Winds to Western Oregon



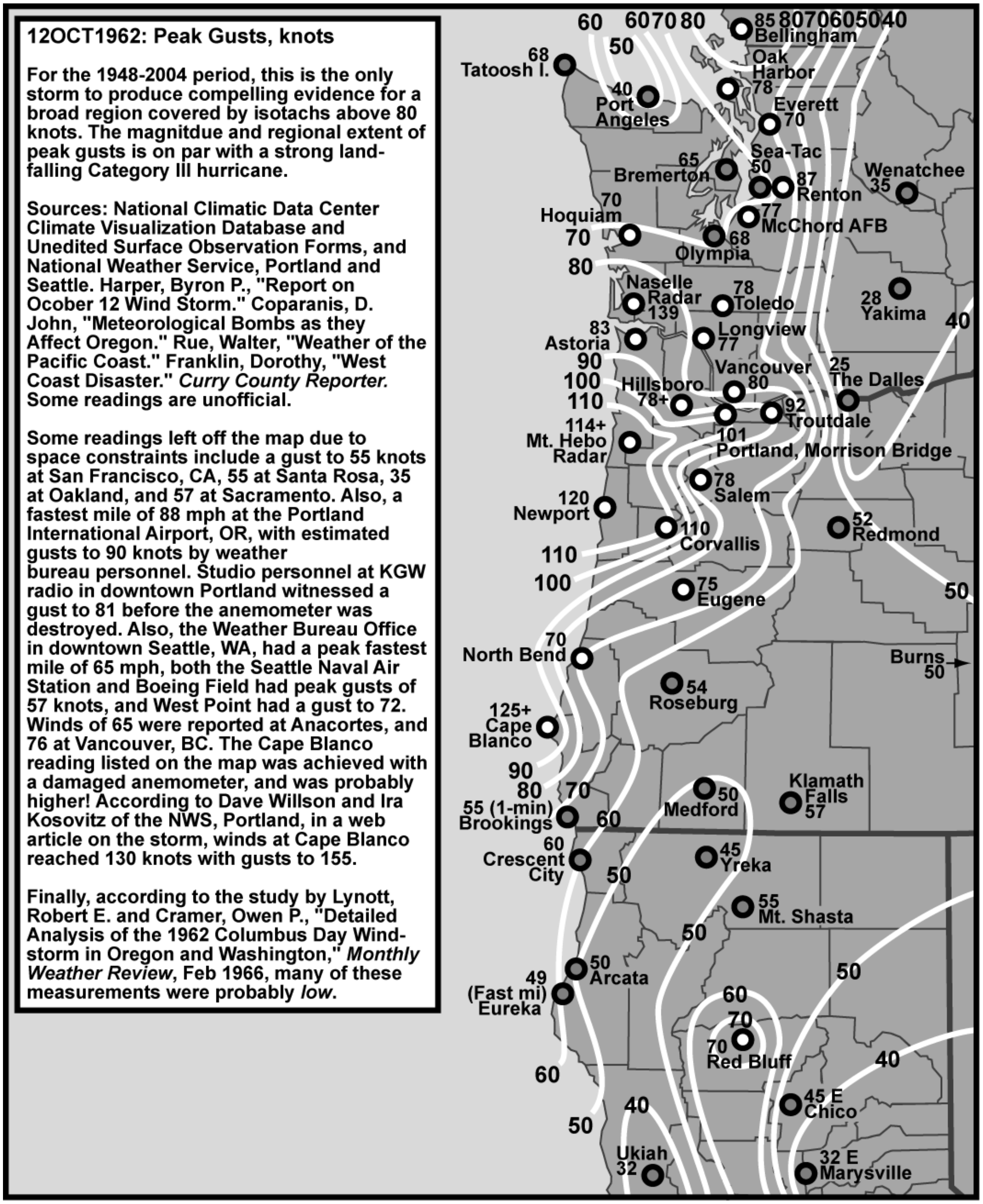
Source: NOAA

This section covers most kinds of windstorm events in Oregon, including the wind aspects of Pacific storm events. The precipitation aspects of Pacific storm events are covered earlier in the **Flood** section. Winds specifically associated with blizzards and ice storms are covered in the **Winter Storm** section.

2.2.10.1 Analysis and Characterization

High winds can be among the most destructive weather events in Oregon; they are especially common in the exposed coastal regions and in the mountains of the Coast Range. Most official wind observations in Oregon are sparse, taken at low-elevation locations where both the surface friction and the blocking action of the mountain ranges substantially decrease the speed of surface winds. Furthermore, there are few long-term reliable records of wind available. Even the more exposed areas of the coast are lacking in any long-term set of wind records. From unofficial, but reliable observations, it is reasonable to assume that gusts well above 100 mph occur several times each year across the higher ridges of the Coast and Cascades Ranges. At the most exposed Coast Range ridges, it is estimated, that wind gusts of up to 150 mph and sustained speeds of 110 mph will occur every 5–10 years.

Figure 2-105. Peak Gusts for Windstorm on October 12, 1962



Source: Wolf Read, Climatologist, Oregon Climate Center, Oregon State University

Pacific storms can produce high winds and often are accompanied by significant precipitation and low barometric pressure. These storms usually produce the highest winds in Western Oregon, especially in the coastal zone. These storms are most common from October through March. The impacts of these storms on the state are influenced by storm location, intensity, and local terrain.

Figure 2-106. Unstable Trees Near Electric Lines Left after a Logging Operation

Note: Unstable trees near electric lines left after a logging operation near electric lines pose a serious threat of personal injury, forest fire, and outages should high winds develop. Forest owners and workers need to coordinate their "leave trees" with electric utilities to prevent dangerous conditions as depicted here.

Photo source: Randy Miller, PacifiCorp

The historian Lancaster Pollard documented exceptional storms that occurred in 1880, 1888, 1920, 1931, and 1962. On January 29, 1920 a hurricane off the mouth of the Columbia River had winds estimated at 160 miles per hour (Pitzer, 1988).

One easterly windstorm that affected much of Oregon, particularly northern Oregon, was the northeasterly gale of April 21-22, 1931. This storm proved to be very destructive. Dust was reported by ships 600 miles out to sea. "While officially recorded wind speeds were not extreme, sustained wind speeds observed were 36 mph at Medford, 32 mph at Portland, 28 mph at Baker, and 27 mph at Roseburg. Unofficial wind measuring equipment reported winds of up to 78 mph. Damage was heavy to standing timber and fruit orchards." (http://www.wrh.noaa.gov/Portland/windstorm.html; for more information on this 1931 storm, see Appendix **9.1.4**.)

Effects

The damaging effects of windstorms may extend for distances of 100 to 300 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Near-surface winds and associated pressure effects exert loads on walls, doors, windows, and roofs, sometimes causing structural components to fail.

Positive wind pressure is a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Negative pressure also affects the sides and roof: passing currents create lift and suction forces that act to pull building components and surfaces outward. The effects of high-velocity winds are magnified in the upper levels of multi-story structures. As positive and negative forces impact and remove the building protective envelope (doors, windows, and walls), internal pressures rise and result in roof or leeward building component failures and considerable structural damage.

Debris carried along by extreme winds can directly contribute to loss of life and indirectly to the failure of protective building envelope components. Upon impact, wind-driven debris can rupture a building, allowing more significant positive and internal pressures. When severe windstorms strike a community, downed trees, power lines, and damaged property are major hindrances to response and recovery.

The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of a south windstorm. The storm developed from Typhoon Freda remnants in the Gulf of Alaska, deepened off the coast of California and moved from the southwest, then turned, coming into Oregon directly from the south. This was the most damaging windstorm in Oregon of the last century. Winds in the Willamette Valley topped 100 mph, while in the Coast Range they exceeded 140 mph. The Columbus Day Storm was the equivalent of a Category IV hurricane in terms of central pressure and wind speeds.

In terms of damage, "throughout the Willamette Valley, undamaged homes were the exception, not the rule. In 1962 dollars, the Columbus Day Storm caused an estimated $230 280 million in damage to property in California, Oregon, Washington and British Columbia combined, with $170 200 million happening in Oregon alone. This damage figure is comparable to eastern hurricanes that made landfall in the 1957–1961 time period... The Columbus Day Storm was declared the worst natural disaster of 1962 by the Metropolitan Life Insurance Company. In terms of timber loss, about 11.2 billion board feet was felled... in Oregon and Washington combined" (http://www.climate.washington.edu/stormking/) "The storm claimed 46 lives, injured hundreds more, and knocked power out for several million people" (http://www.wrh.noaa.gov/pqr/info/pdf/pacwindstorms.pdf).

Other Issues

The Hazard Mitigation Survey Team (HMST) Report developed in response to the February 7, 2002 windstorm the recommended that "differences in definitions of easements and allowable practices within them ('easement language') for private versus public, and urban forests vs. rural forests should be resolved." Recent wildfires, particularly the Camp Fire in California (2018), have brought attention to the importance of vegetation management within and adjacent to utility power line right of ways. Many stakeholders are now coming to the table to address the following issues that were highlighted in the report as well as newly identified.

- "Land use actions being proposed by agencies with non-utility interests, which would affect land for which utilities have an interest, should be coordinated and should address vegetation management as it affects utility system operations."
- "Agencies and organizations should be identified to work with federal and state landowners to streamline processes by which electric utilities conduct hazard mitigation work on those lands..." Currently, ODOT issues permits for right-of-way work and ODF issues permits for the use of power equipment in forested areas.

Other areas of ongoing concern from this HMST Report are:

- Under Coordination — Utility providers should receive notification, from property owners, of planned tree-harvesting operations near utility lines.
- Under Vegetation Management — Diseased, damaged, and hazard trees near power lines that could fall or hit utility lines should be removed. Some "leave trees" remaining after new building developments and tree harvesting operations pose a threat to utility line safety and reliability. See the International Society of Arboriculture's website and brochure for information about managing tree hazards and risk at https://www.treesaregood.org/portals/0/docs/treecare/TreeRisk.pdf.
- Under Engineering, Construction, and Compliance — "During initial planning and design of utility lines, identify types of geographic areas already known to pose hazards during windstorms. Inventory and analyze areas of repetitive failures to determine alternate designs and construction methods that will mitigate future damages... Consider selective undergrounding of lines where repetitive tree damage occurs, keeping in mind excavations can undermine tree root zones and create new hazards."

Increasing wildfire probability due to climate change has accelerated the need to resolve the following:

- Access to State and Federal Lands – Many utilities have identified difficulty in gaining access to these lands for vegetation management. The Oregon Department of Forestry is improving its processes to accelerate issuing permits. The Bureau of Land Management (BLM) recently updated and simplified its process for granting access to utility right-of-ways on its lands. BLM processes are consistent across all of the properties it owns. US Department of Forestry has been the most challenging to work with and there is now pressure at the Federal level to simplify and accelerate the permitting process.
- Ability to Remove Vegetation Outside of the Utility Easement — This issue is controversial in forest lands, urban areas, and rural areas. Managers of protected lands are hesitant to disturb the natural ecosystems by removing vegetation that has been identified as a potential hazard. Likewise, individuals in both urban and rural areas are very protective of vegetation that adds beauty and character to an area.

Emerging concerns include:

- Impacts of intense windstorms that can significantly reduce efficiency and impair operations of renewable energy facilities (e.g., solar panels and wind turbines), in particular, on agricultural land where producers produce renewable energy to supply their operations and to sell to diversify their revenue streams. To date, little or no data have been collected on economic impacts of this issue.

- Impacts of intense wind and precipitation events that damage crops (e.g., grain, corn, orchards); cause uncontrolled discharges from permitted animal waste holding facilities that subsequently reach waterways and can adversely impact downstream water quality and shellfish farms. Little or no data have been collected or compiled on the economic impacts of this issue.

Historic Windstorm Events

Table 2-74. Historic Windstorms in Oregon

Date	Location	Comments
Oct. 1962	W. Oregon and locations east of Cascades, Oregon	Columbus Day Storm: Oregon's most famous and most destructive windstorm; barometric pressure low of 960 mb*
Mar. 1963	W. Oregon	second strongest windstorm in the Willamette Valley since 1950
Oct. 1967	most of western and central Oregon	an intense 977 mb low produced a sudden, destructive blow (*)
Nov. 1981	Oregon coast and N. Willamette Valley, Oregon	back-to-back storms on Nov. 13 and 15
Jan. 1993	North Coast Range, Oregon	Inauguration Day Storm; major disaster declaration in Washington State
Dec. 1995	NW Oregon	FEMA-1107-DR-Oregon (*); strongest windstorm since Nov. 1981; barometric pressure of 966.1 mb (Astoria), and Oregon record low 953 mb (off the coast)
Feb. 2002	south and central coast, Southern Willamette Valley, Oregon	FEMA-1405-DR-Oregon; surprise windstorm
Feb. 2007	NW and central coast and north central Oregon	FEMA-1683-DR-Oregon; severe winter storm with a wind component
Dec. 2007	Oregon coast and Willamette Valley, Oregon	FEMA-1733-DR-Oregon; severe winter storm, including flood and landslide events
Dec. 2015	Regions 1-4	FEMA-4258-DR: severe winter storms, straight-line winds, flooding, landslides, and mudslides
Oct. 2016	Manzanita, Oceanside in Tillamook County	tornadoes; EF2 in Manzanita with estimated damages of $1M; EFU in Oceanside with no damage
Jul. 2018	Portland, Multnomah County	tornado; EF0; damage to trees and homes
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides
Feb. 2020	Regions 5 and 7: Umatilla, Union, Wallowa Counties	FEMA-4519-DR: Severe storms, tornadoes, straight-line winds and flooding

*For comparison, surface barometric pressures associated with Atlantic hurricanes are often in the range of 910 to 960 mb. The all-time record low sea level barometric pressure recorded was associated with Typhoon Tip in the Northwest Pacific Ocean on October 12, 1979 at 870 mb.

Sources: Oregon Climate Service, http://www.ocs.oregonstate.edu/; Pitzer (1988); https://www.fema.gov/disaster/; https://www.ncdc.noaa.gov/stormevents/; https://www.weather.gov/pqr/07-01-2019

2.2.10.2 Probability

Extreme weather events are experienced in all regions of Oregon. Areas experiencing the highest wind speeds are the Central and North Coast under the influence of winter low-pressure systems in the Gulf of Alaska and North Pacific Ocean, and the Columbia River Gorge, when cold air masses funnel down through the canyon in an easterly direction. For example, at Crown Point, located about 20 miles east of Portland, easterly winds with a 24-hour average of more than 53 mph and gusts in excess of 120 mph were recorded.

More recently, the coast has seen several tornados. None have been as strong as those experienced in other parts of the country but it is significant to note for Oregon.

Table 2-75. Probability of Severe Wind Events by State of Oregon Natural Hazard Region (One-Minute Average, 30 Feet above the Ground)

Location	25-Year Event *(4% annual probability)*	50-Year Event *(2% annual probability)*	100-Year Event *(1% annual probability)*
Region 1 - Oregon Coast	75 mph	80 mph	90 mph
Region 2 - Northern Willamette Valley	65 mph	72 mph	80 mph
Region 3 - Mid/Southern Willamette Valley	60 mph	68 mph	75 mph
Region 4 - Southwest Oregon	60 mph	70 mph	80 mph
Region 5 - Mid-Columbia	75 mph	80 mph	90 mph
Region 6 - Central Oregon	60 mph	65 mph	75 mph
Region 7 - Northeast Oregon	70 mph	80 mph	90 mph
Region 8 - Southeast Oregon	55 mph	65 mph	75 mph

Source: Oregon Public Utilities Commission

Additional wind hazards occur on a very localized level, due to several down-slope windstorms along mountainous terrain. These regional phenomena known as foehn-type winds, result in winds exceeding 100 mph, but they are of short duration and affect relatively small geographic areas. A majority of the destructive surface winds in Oregon are from the southwest. Under certain conditions, very strong east winds may occur, but these are usually limited to small areas in the vicinity of the Columbia River Gorge or in mountain passes.

The much more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If winds are from the west, they are often stronger on the coast than in interior valleys due to the north-south orientations of the Coast Range and Cascades. These mountain ranges obstruct and slow the westerly surface winds.

High winds occur frequently in Oregon, and they are especially common in coastal regions and in the mountains of the Coast Range between October and March. From unofficial but reliable observations, it is reasonable to assume that gusts well above 100 mph occur several times each year across the higher ridges of the Coast and Cascades Ranges. At the most exposed Coast Range ridges, it is estimated that wind gusts of up to 150 mph and sustained speeds of 110 mph will occur every 5 to 10 years. The Willamette Valley may face 40 to 60 mile per hour winds from a 100 mph+ storm on the coast. Also, the Columbia River Gorge funnels very strong winds, often from east to west.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

2.2.10.3 Vulnerability

The damaging effects of windstorms may extend for distances of 100 to 300 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Near-surface winds and associated pressure effects exert loads on walls, doors, windows, and roofs, sometimes causing considerable damage. When severe windstorms strike a community, downed trees, power lines, and damaged property are major hindrances to response and recovery.

Major windstorms that can impact large areas of the state, like the Columbus Day windstorm of 1962, are relatively rare. These storms can cause major damage to many areas of the state with the Oregon coastal counties typically suffering the most damage from this type of hazardous event.

Little or no data have been collected on the local or statewide economic impacts of windstorms on renewable energy facilities, particularly those on agricultural lands, or on the economic impacts of windstorms on agricultural operations and associated environmental impacts.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. Eight of these losses, totaling over $75,000 with one claim outstanding, were due to windstorms.

DAS's records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Most Vulnerable Jurisdictions

The Oregon Coast has several relatively harsh storms during the winter months. The seven coastal counties along the Oregon Coast (Region 1) often face 60 to 100 mile an hour winds sometime during the year. Although major damage from these storms is infrequent, the Oregon Coast Region of the state is the most vulnerable to windstorms.

While the coast is experiencing severe winds, the Willamette Valley may also face 40 to 60 mile per hour winds from the same storm. Also, the Columbia River Gorge funnels very strong winds, often from east to west. The Northern Willamette Valley/Portland Metro (Regions 3 and Region 2, respectively) and the Mid-Columbia Region (Region 5) are most vulnerable to the effects of cold and damage from this type of wind event.

Historically, the Oregon communities most vulnerable to windstorm damage and loss overall are Benton, Clatsop, Coos, Columbia, Curry, Douglas, Gilliam, Hood River, Lane, Lincoln, Linn, Marion, Morrow, Multnomah, Polk, Sherman, Tillamook, and Washington.

The identification of communities most vulnerable to windstorms is based on PUC agency staff and OCCRI/OCS staff review.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

Table 2-76. Counties Historically Most Vulnerable to Windstorms and Social Vulnerability

	County	Windstorm Type	Social Vulnerability
Region 1	Clatsop	W, SW, S winds from the Pacific Ocean	2 = Low
	Coos	W, SW, S winds from the Pacific Ocean	4 = High
	Curry	W, SW, S winds from the Pacific Ocean	2 = Low
	Coastal Douglas	W, SW, S winds from the Pacific Ocean	4 = High
	Coastal Lane	W, SW, S winds from the Pacific Ocean	3 = Moderate
	Lincoln	W, SW, S winds from the Pacific Ocean	3 = Moderate
	Tillamook	W, SW, S winds from the Pacific Ocean	2 = Low
Region 2	Columbia	W, SW, S winds from the Pacific Ocean	1 = Very Low
	Multnomah	East winds from the Columbia River Gorge	3 = Moderate
	Washington	Foehn winds	1 = Very Low
Region 3	Benton	Foehn winds	2 = Low
	Lane	Foehn winds	3 = Moderate
	Linn	Foehn winds	4 = High
	Marion	Foehn winds	5 = Very High
	Polk	Foehn winds	3 = Moderate
Region 5	Gilliam	East winds from the Columbia River Gorge	1 = Very Low
	Hood River	East winds from the Columbia River Gorge	3 = Moderate
	Morrow	East winds from the Columbia River Gorge	5 = Very High
	Sherman	East winds from the Columbia River Gorge	1 = Very Low

2.2.10.4 Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

The regions and counties listed in **Table 2-76** are not only the most likely to experience windstorms, but also the most vulnerable to their adverse impacts.

Of these counties, Coos County, the coastal portion of Douglas County, and Linn County have high social vulnerability; Marion and Morrow Counties very high. This means that the adverse effects of cold and the damage caused by windstorms will be experienced more intensely among their populations and require more resources for preparation, mitigation, and response.

Therefore, Marion and Morrow Counties are considered the most at risk to windstorms in the state, followed by Coos County, the coastal portion of Douglas County, and Linn County.

2.2.11 Winter Storms

Winter storms are among nature's most impressive spectacles. Their combination of heavy snow, ice accumulation, and extreme cold can totally disrupt modern civilization, closing down roads and airports, creating power outages, and downing telephone lines. Winter storms remind us how vulnerable we are to nature's awesome powers.

For the most part, the wind aspects of winter storms are covered in the **Windstorm** section. Heavy precipitation aspects associated with winter storms in some parts of the state, which sometimes lead to flooding, are covered in the **Flood** section. This winter storms section instead generally addresses snow and ice hazards, and extreme cold.

2.2.11.1 Analysis and Characterization

According to the National Weather Service (2003) —

"Most snowstorms need two ingredients: cold air and moisture. Rarely do the two ingredients occur at the same time over western Oregon, except in the higher elevations of the Coast Range and especially in the Cascades. But snowstorms do occur over eastern Oregon regularly during December through February. Cold arctic air sinks south along the Columbia River Basin, filling the valleys with cold air. Storms moving across the area drop precipitation, and if conditions are right, snow will occur.

However, it is not that easy of a recipe for western Oregon. Cold air rarely moves west of the Cascades Range. The Cascades act as a natural barrier, damming cold air east of the range. The only spigot is the Columbia River Gorge, which funnels the cold air into the Portland area. Cold air then begins deepening in the Columbia River valley, eventually becoming deep enough to sink southward into the Willamette valley. If the cold air east of the Cascades is deep, it will spill through the gaps of the Cascades and flow into the western valleys via the many river drainage areas along the western slope. The cold air in western Oregon is now in place. The trick is to get a storm to move near or over the cold air, which will use the cold air and produce freezing rain, sleet, and/or snow. Sometimes, copious amounts of snow are produced. Nearly every year, minor snowfalls of up to six inches occur in the western interior valleys. However, it is a rare occurrence for snowfalls of over a foot in accumulations [sic]."

Figure 2-107. Troutdale Area—December 1996

Photo source: National Weather Service

Snow is relatively rare along the coast in Oregon. There is, however, a noticeable relationship between latitude and snowfall. Appendix **9.1.6** shows average annual snowfall at various Oregon stations. Notice, in particular, Crater Lake, one of the snowiest measurement stations in the United States, which once reported nearly 900 inches of snow in one season (Taylor & Hannan, The climate of Oregon: from rain forest to desert, 1999).

Figure 2-108. Shielded Snow Gauge Used in the Pacific Northwest to Register Snowfall, 1917

Source: National Weather Service

Ice storms and freezing rain can cause severe problems when they occur. The most common freezing rain events occur in the proximity of the Columbia Gorge. The Gorge is the most significant east-west air passage through the Cascades. In winter, cold air from the interior commonly flows westward through the Gorge, bringing very cold air to the Portland area. Rain arriving from the west falls on frozen streets, cars, and other sub-freezing surfaces, creating severe problems. As one moves away from the Gorge, temperatures moderate as the marine influence becomes greater and cold interior air mixes with milder west-side air. Thus freezing rain is often confined to areas in the immediate vicinity of the Gorge: Corbett, Troutdale, perhaps as far west as Portland Airport. Downtown Portland and the western and southern suburbs often escape with no ice accumulation (Taylor & Hannan, The climate of Oregon: from rain forest to desert, 1999).

Freezing rain (also known as an ice storm) is rain that falls onto a surface with a temperature below freezing. The cold surface causes the rain to freeze so the surfaces, such as trees, utilities, and roads, become glazed with ice. Even small accumulations of ice can cause a significant hazard to property, pedestrians, and motorists.

Sleet is rain that freezes into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not stick to objects; however, it can accumulate like snow and cause roads and walkways to become hazardous.

Black ice can fool drivers into thinking water is on the road. What they may not realize is that condensation, such as dew, freezes when temperatures reach 32 ˚F or below, forming a thin layer of ice. This shiny ice surface is one of the most dangerous road conditions. Black ice is likely to form under bridges and overpasses, in shady spots and at intersections.

Meteorologists define *heavy snow* as six inches or more falling in less than twelve hours, or snowfall of eight inches or more in twenty-four hours. A *blizzard* is a severe winter weather condition characterized by low temperatures and strong winds blowing a great deal of snow. The National Weather Service defines a blizzard as having wind speeds of 35 mph or more, with a visibility of less than a quarter mile. Sometimes a condition known as a *whiteout* can occur during a blizzard. This is when the visibility drops to zero because of the amount of blowing snow.

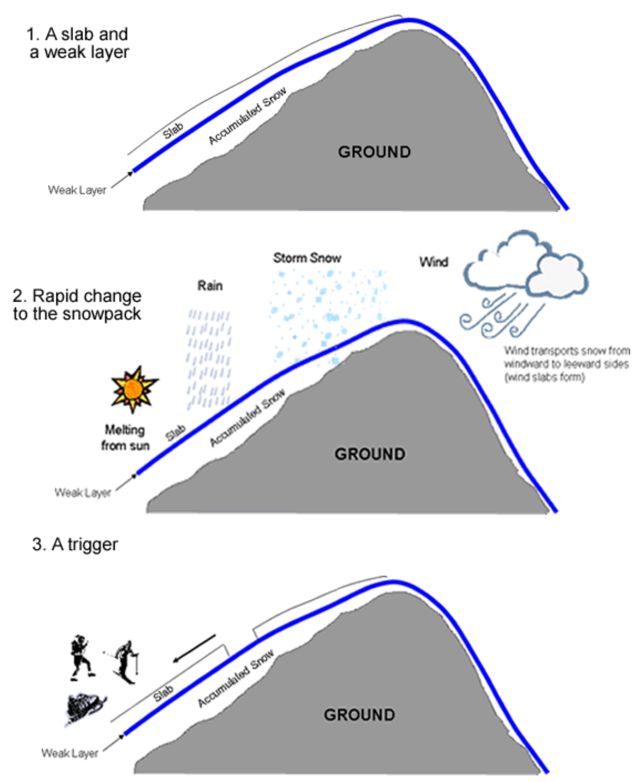
Wind blowing across your body makes you feel colder. The *wind chill* factor is a measure of how cold the combination of temperature and wind makes you feel. Wind chill of 50°F or lower can be very dangerous: exposed skin can develop frostbite in less than a minute, and a person or animal could freeze to death after just 30 minutes of exposure.

A snow avalanche is a mass of snow falling down a mountain or incline. Three variables interact to determine whether an avalanche is possible:

- *Terrain:* the slope must be steep enough to avalanche,
- *Snowpack:* the snow must be unstable enough to avalanche, and
- *Weather:* changing weather can quickly increase instability.

According to the Northwest Weather and Avalanche Center, avalanches don't happen by accident and most human involvement is a matter of choice, not chance. Most avalanche accidents are caused by slab avalanches that are triggered by the victim or a member of the victim's party. However, any avalanche may cause injury or death and even small slides may be dangerous.

Figure 2-109. Ingredients for a Slab Avalanche



Source: Northwest Weather and Avalanche

On average, about 30 people in the United States are killed in avalanches each year. For the 21 years between 1985 and 2006. With five fatalities, Oregon ranks 10th among the states for avalanche fatalities. This is based on statistics from the Colorado Avalanche Information Center. Avalanche victims are almost exclusively backcountry recreationists — snowmobilers, climbers, snowboarders, snowshoers, skiers, and hikers. Nationally snowmobilers lead the list with twice as many fatalities as any other activity.

According to Portland Mountain Rescue, most avalanche victims triggered the very avalanche that caught them. The group advises people to be aware of the constantly changing conditions in the backcountry and take a certified avalanche class to increase their avalanche awareness.

Ski areas are different from the backcountry. It is very rare for someone to get caught in an avalanche within a ski area. Professional snow safety crews rely on explosives and ski compaction to stabilize ski area snowpack.

Historic Winter Storm Events

Table 2-77. Historic Winter Storms in Oregon

Date	Location	Description
Dec. 16–18, 1884	Linn, Marion, Washington, Multnomah, Hood River and Wasco Counties	heavy snow in the Columbia River Basin from Portland to The Dalles and along the Cascades foothills in the Willamette Valley; 1-day snow totals: Albany, 16.0 inches; The Dalles, 29.5 inches; Portland, 12.4 inches
Dec. 20–23, 1892	Linn, Marion, Washington, Multnomah, and Umatilla Counties	substantial snow across most of northern Oregon; greatest snowfall in the northwest part of the state; totals from 15 to 30 inches with Albany, 15.0 inches; Corvallis, 14.0 inches; Portland, 27.5 inches; Forest Grove, 28.0 inches; Pendleton, 8.0 inches
Jan. 5–10, 1909	Josephine, Jackson, Douglas Lane, Linn, Marion, Clackamas, Hood River, and Wasco Counties	heavy snowfall in mountainous areas; 34.5 inches at Siskiyou Summit; many locations, particularly in western Oregon, received more snow in this 6-day period than they normally would receive in an entire year; snow totals: Ashland, 9.1 inches; Eugene, 15.1 inches; Forest Grove, 29.0 inches; Lakeview, 17.0 inches; Portland, 19.3 inches; The Dalles, 14.5 inches
Jan. 11–15, 1916	Josephine, Jackson, Douglas Lane, Linn, Marion, Clackamas, Hood River, and Waco Counties	5-8 inches of snow in western Oregon, except for the southwestern interior and the coastal areas; McMinnville had the most snow in one day, with 11 inches falling on January 12; another 24 inches at Siskiyou Summit; higher elevations in the Cascades received very heavy snowfall
Jan. 30–Feb. 3, 1916	Hood River, Clackamas, Marion, Wasco, Jefferson, and Multnomah Counties	snow and ice storm along the northern Oregon border; heaviest snowfall in the Hood River Valley with 29.5 inches in one day at Parkdale, and 81.5 inches total; heavy snow especially in the higher Cascades with Government Camp 41.0 inches in a day and storm total of 87.5 inches; the ice inflicted severe damage to electric light, telephone and telegraph companies, fruits and ornamental trees; many locations, earlier snow had not melted, resulting in substantial snow depths
Dec. 9–11, 1919	statewide	one of three heaviest snowfall-producing storms to hit Oregon on record; lowest statewide average temperature since record keeping began in 1890; the Columbia River froze over, closing the river to navigation from the confluence with the Willamette River upstream; nearly every part of the state affected; snow totals (inches): Albany, 25.5; Bend, 49.0; Cascade Locks, 21.5; Eugene, 8.5; Heppner, 16.0; Parkdale, 63.0; Pendleton, 15.0; Siskiyou Summit, 50.0
Feb. 10, 1933	statewide	cold outbreak across state; the city of Seneca, in northeast Oregon, recorded the state's all-time record low temperature of −54°F; the next day high was nearly 100 degrees warmer at 45°F

Date	Location	Description
Jan. 31–Feb. 4, 1937	statewide	heavy snowfalls in the western slopes of the Cascades and the Willamette Valley; deep snowdrifts blocked major highways and most minor roads in northern Oregon and passes of the Cascade Mountains for several days
Jan. 5–7, 1942	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, and Polk Counties	considerable sleet, followed by freezing rain in some areas; freezing rain, resulting in heavy accumulations of ice in upper and middle Willamette Valley; roads and streets dangerous for travel, orchard and shade trees damaged, and telephone, telegraph, and power wires and poles broken down.
Mid Jan.–Feb, 1950	statewide	extremely low temperatures injured a large number of orchard and ornamental trees and shrubs, and harmed many power and telephone lines and outdoor structures; severe blizzard conditions and a heavy sleet and ice storm together caused several hundred thousand dollars damage and virtually halted traffic for two to three days; Columbia River Highway closed between Troutdale and The Dalles leaving large numbers of motorists stranded, removed to safety only by railway; damage to orchard crops, timber, and power services, costing thousands in damages.
Jan. 9–20, 1950	Columbia, Washington, Multnomah, Hood River, Wasco, Clackamas, Yamhill, Marion, Polk, Linn, Benton, and Lane Counties	frequent snowstorms throughout January; snow heavier during this January than ever before on record; snow plus high winds created widespread blowing and drifting of snow; deep snowdrifts closed all highways west of the Cascades and through the Columbia River Gorge; sleet 4-5 inches in northwestern Oregon; sleet turned to freezing rain, creating havoc on highways, trees, and power lines; hundreds of motorists stranded in the Columbia River Gorge, only rescued by train; hundreds of thousands of dollars of damage occurred; winds reached 60–70 mph in gusts along the coast and excess of 40 mph in Portland and Grants Pass; outdoor work and school halted due to impeded traffic, down power lines, and community isolation; in Portland 32.9 inches of snow fell (5.8 inches was the January average)
Dec. 5–7, 1950	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, and Umatilla Counties	severe ice storm with light freezing rain over the Columbia Basin east of the Cascades; heavy ice accretions on trees, highways, power and telephone lines causing accidents due to broken limbs, slippery pavements, and down power lines; heavy snowfall across Oregon; Crater Lake reported 93 inches of snow for December
Jan. 18, 1956	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, and Umatilla Counties	freezing rain mixed with snow. Ice coated trees, highways, and utility lines; traffic accidents due to slick surfaces; trees heavy with ice broke, sometimes on top of houses
Jan. 11–12, 1960	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, and Polk Counties	light to moderate snows and freezing rain produced dangerous highway conditions; automobile accidents, but no known fatalities; accidents blocked arterial highways, creating serious traffic jams
Jan. 30–31, 1963	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk, Hood River, Waco, Jefferson, and Deschutes Counties	substantial snowfall amplified by moderate to severe icing created hazardous conditions on highways; power lines downed due to ice or felled trees; injuries, one reported death, and statewide school closures due to the icy streets and highways

Date	Location	Description
Jan. 25–31, 1969	Douglas, Coos, Josephine, Jackson, Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, and Polk Counties	snowfall records throughout Lane, Douglas, and Coos Counties were surpassed by incredible numbers; 2-3 feet on the valley floors; heavier amounts at higher elevations; at Eugene, a snow depth of 34 inches. Total January snowfall was 47 inches, nearly 7 times the normal monthly snowfall. Roseburg reported 27 inches and monthly snowfall of 35.2 inches; along the coast, where the average snowfall is generally less than 2 inches, January snowfall totals ranged 2-3 feet, with snow depths of 10–20 inches reported; hundreds of farm buildings and several large industrial buildings collapsed under the weight of the heavy wet snow; heavy losses in livestock; entire communities completely isolated for nearly a week; traffic on major highways west of the Cascades and central Oregon halted; total losses estimated $3 to $4 million
Jan. 17–19, 1970	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, and Umatilla Counties	Stagnant and cold air in the Columbia River Basin east of the Cascades had surface temperatures well below freezing for a week. Ice accumulated on tree branches up to 1.5 inches. Damage was mostly destroyed orchards and utilities.
Nov. 22-23, 1970	Columbia, Washington, Multnomah, Hood River, Wasco, Clackamas, Yamhill, Marion, Polk, Linn, Benton, and Lane Counties	freezing rain across western Oregon, especially in Corvallis, Albany, Salem, Independence, and Dallas; ice accumulations up to 0.5 inches broke thousands of tree limbs and telephone lines; hazardous traffic conditions, power and phone outages, and felled trees
Feb. 4–6, 1972	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, and Polk Counties	several days of sub-freezing temperatures across Oregon followed by warm moist air across northwestern Oregon; glazed roads were hazardous; 140 persons in Portland treated for sprains, fractures or head injuries; some ambulance services doing twice their normal business
Jan. 11–12, 1973	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, and Polk Counties	rains beginning in the Willamette Valley glazed streets and highways in the Portland area and into the Gorge; auto, bus and truck accidents and persons injured in falls; hospitals reported “full house” conditions; glaze of 0.25–0.75 inches in the Portland area
Jan. 1978	Columbia Gorge, Willamette Valley, Portland, Oregon and Vancouver, Washington	over an inch of rain froze, covering everything with ice; power outages (some for more than 10 days); areas east of Portland hit hardest
Jan. 9–10, 1979	Portland and Multnomah Counties	severe ice storm in Portland area as a Pacific storm moved across the state; temperatures ranged from low teens to 33°F; half inch of rain turned to ice
Jan. 5, 1986	Multnomah, Hood River, Wasco Counties	roads covered with ice and caused power outages to several thousand houses
Feb. 1–8, 1989	statewide	heavy snow across state; up to 6–12 inches of snow at the coast, 9 inches in Salem, more than a foot over the state; numerous record temperatures set; wind chill temperatures 30–60 degrees below 0°F; power failures throughout state, with home and business damage resulting from frozen plumbing; several moored boats sank on the Columbia River because of ice accumulation; five weather-related deaths (three auto accidents caused by ice and snow, and two women froze to death); damage estimates exceeded one million dollars
Feb. 14–16, 1990	Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, and Polk Counties	24–35 inches of snow in Cascade Locks and Hood River; up to 28 inches in the North Coast Range, 16 inches at Timberline Lodge; the Willamette Valley had 2–4 inches with up to 1 foot in higher hills around Portland; 10-15 inches of snow in the North Coast Range, 20–35 inches in the North Cascades, 1-2 feet in the South Cascades; snow in south-central areas included 9 inches at Chemult, 6–8 in Klamath Falls and Lakeview; 6 inches at Tipton Summit in the northeast mountains and Juntura in the southeast.
Jan. 6-7, 1991	all of eastern Oregon	constant precipitation all over Oregon; freezing rain in Willamette Valley made transportation difficult; two auto fatalities; 1–6 inches of new snow in high ground of eastern Oregon; 12 inches of snow in the Columbia Gorge

Date	Location	Description
Jan. 16–18, 1996	Columbia Gorge, Willamette Valley, Portland, Oregon Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, and Polk Counties	freezing rain with heavy accumulations of glaze ice in the Gorge, Northern Cascades and extreme eastern Portland Metro area; numerous minor traffic accidents due to power outages; freezing rain in the Willamette Valley as far south as Eugene
Feb. 2–4, 1996	Columbia Gorge, Willamette Valley, Portland, Oregon Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, and Polk Counties	ice storm caused disruption of traffic and power outages in the Willamette Valley and Coast Range valleys; freezing rain in the Willamette Valley; traffic accidents, including a 100 car pileup near Salem; one traffic fatality near Lincoln City
Dec. 26–30, 1996	Columbia Gorge, Willamette Valley, Portland, Oregon Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, and Polk Counties	ice storm paralyzed the Portland Metro area and the Columbia Gorge; ice accumulations of 4-5 inches in the Columbia Gorge; I-84 through the Gorge closed for 4 days; widespread electricity outages and hundreds of downed trees and power lines in the Portland area

Date	Location	Description
Dec.28, 2003– Jan. 9, 2004	statewide storm	

DR-1510. $10,289,394 of assistance. Baker, Benton, Clackamas, Clatsop, Columbia, Crook, Deschutes, Douglas, Gilliam, Grant, Harney, Hood River, Jefferson, Lake, Lane, Lincoln, Linn, Malheur, Marion, Morrow, Multnomah, Polk, Sherman, Tillamook, Umatilla, Union, Wallowa, Wasco, Wheeler, Yamhill declared. The most significant winter storm in several years brought snowfall to most of Oregon. The largest snowstorm to hit the Siskiyou Pass in Jackson County in a quarter century. I-5 shut down for nearly a day as ODOT maintenance crews and Oregon State Police troopers dug stranded motorists out of snowdrifts reaching 5-6 feet. Two feet of snow in the Blue Mountains in eastern Oregon. Roadside snow levels exceeded six feet along the Tollgate Highway, OR-204. The eastbound lanes of I-84 closed at Ladd Canyon east of La Grande. Additional segments of I-84 eastbound at Pendleton closed as stranded motorists filled truck stops, motels and restaurants in the La Grande area.

Wet snow on highways in the Willamette Valley, toppled power lines and trees. Oregon 34 east of Philomath closed for 30 hours while crews removed trees. Snow on the Siskiyou Pass made national news and was a top story on the CNN website. 150 miles of I-5 from Ashland to south of Redding, California closed, leaving 100 to 200 vehicles stranded on the Siskiyou Pass overnight. The American Red Cross opened a shelter on the Southern Oregon University campus, and reports out of cities from Redding to Medford confirmed that all motels were full. Emergency service delivered gasoline, food, and water to stranded motorists and hard-to-reach areas. One fatality related to the storm. (Heart attack after helping a stranded motorist.)

I-5 North on the Siskiyou Pass closed for 19 hours. The snow event turned into a major ice storm. Icy roads made driving hazardous. Trees damaged or destroyed by ice adhering to the branches. Downed power lines, often due to falling trees, caused power outages. Businesses, school districts, and government offices closed or hours shortened. Several hundred flights cancelled at the Portland International Airport. Thousands of passengers stranded at the airport. The MAX light rail system also was shut down by the storm. ODOT closed I-84 through the Columbia Gorge twice, for almost 70 hours total. Freight trucks and passenger cars had to detour over Mount Hood where, ironically, road conditions were better than they were in downtown Portland where all vehicles were required to chain up. ODOT closed US-101 over the Astoria Megler Bridge for about 14 hours as large chunks of ice fell off the bridge's superstructure. Many other highways in the state were closed. Freezing rain also in eastern Oregon. Minus 30 degrees reported in Meacham. 60 mph wind gusts in Union County created whiteout conditions, prompting the closure of I-84 between La Grande and Baker City. 2 fatalities.

President Bush issued a major disaster declaration for 26 Oregon counties affected by the winter storm, later extended to 30 of Oregon's 36 counties.

Estimated the cost of damages to public property at $16 million. A frigid arctic air mass, heavy snow, sleet and freezing rain, strong east winds and blizzard conditions through and near the Columbia River Gorge snarled travel, forced school and business closures, and resulted in widespread power outages and properly damage in Northwestern Oregon. 2-6 inches of snow along the North Oregon Coast, 2–8 inches in the Willamette Valley, 5–8 inches in the Portland Metro area, and up to 27 inches in the Cascade Mountains. Up to 2 inches of sleet and freezing rain followed the snowfall.

In Portland this winter storm:
- limited or halted most forms of travel
- resulted in the cancellation of over 1,300 flights at Portland International Airport, stranding 90,000 passengers
- shut down Portland's light rail train system
- closed most businesses and schools

Blizzard conditions in the Columbia River Gorge:
- closed I-84 between Troutdale and Hood River
- closed Washington State Route 14 between Washougal, and White Salmon, Washington
- Halted east-west travel through the Gorge and stranded hundreds of trucks at both ends of the Gorge

Weight from snow and ice buildup:
- downed trees and power lines, leaving 46,000 customers without power, and collapsed roofs at Portland's Gunderson Steel and Rail, Fred Meyer stores in Gateway and Clackamas, and a barn in Forest Grove that killed 4 horses
- collapsed a Scappoose marina roof, sinking 4 boats and damaging many others
- snowfall in the Cascades ranged from 8 inches at Blue Box Pass and Bennett Pass to 27 inches at Timberline Lodge and White River

Date	Location	Description
Mar. 8–10, 2006	Lane, Linn, Benton, Marion, Jefferson, Polk, Yamhill, Clackamas Counties	snow fell up to a few inches at the coast and through the Willamette Valley; 2–4 feet in the Coast Range, Cascades, and Cascade Foothills; many school closures
Jan. 2–Feb. 9, 2008	Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Union, Grant, Baker, Wheeler, Jefferson Deschutes, Crook Counties	heavy snow and freezing rain across eastern Oregon; 5–13 inches of snow; a multi-vehicle accident closed I-84, 15 miles west of Arlington, for 5 hours; 36 Oregon National Guard personnel helped with snow removal in Detroit and Idanha with over 12 feet of record snow. Inmate crews removed snow that cracked walls and collapsed roofs
Dec. 2008	northern Oregon coast	third unusually cold storm system that season with heavy snow in northwest Oregon; heavy snowfall across northwest Oregon; 11–24 inches of snow in the north Oregon Coast Range
Dec. 9–11, 2009	Marion, Linn, Lane Counties	freezing rain covered the central valley with a coating of ice; south of Salem, numerous road closures due to accidents caused by icy roadway; I-84 from Troutdale to Hood River closed for 22 hours
Nov. 29-30, 2010	Hood River, Multnomah, Wasco Counties	4-5 inches of snow reported in Cascade Locks and Hood River; 1/2 inch of ice in Corbett
Jan. 12–18, 2012	Hood River, Wasco Counties	4.5 inches of new snow reported in Hood River; I-84 closed due to ice and snow east of Troutdale
Jan. 2012	Multnomah County	snow and ice east of Troutdale; I- 84 closed for 9 hours
Feb. 6–10, 2014	Lane, Benton, Polk, Yamhill, Columbia, Clackamas, Multnomah, Washington, Linn, Marion, Hood River, Lincoln, Tillamook and Clatsop Counties	DR-4169 Linn, Lane, Benton and Lincoln Counties declared. A strong winter storm system affected the Pacific Northwest during the February 6–10, 2014 time period bringing a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon; a much warmer and moisture-laden storm moved across northwest Oregon after the snow and ice storm (Feb. 11-14), which produced heavy rainfall and significant rises on area rivers from rain and snowmelt runoff; during the 5-day period Feb. 6–10, 5 to 16 inches of snow fell in many valley locations and 2 to10 inches in the coastal region of northwest Oregon; freezing rain accumulations generally were 0.25 to 0.75 inches; the snowfall combined with the freezing rain had a tremendous impact on the region
Feb. 11–14, 2014	Lane, Benton, Polk, Yamhill, Columbia, Clackamas, Multnomah, Washington, Linn, Marion, Hood River, Lincoln, Tillamook and Clatsop Counties	another weather system moved across northwest Oregon during the February 11–14 time frame; this storm was distinctly different from the storm that produced the snow and ice the week prior and brought abundant moisture and warm air from the sub-tropics into the region; as this storm moved across the area, 2 to 7 inches of rain fell across many counties in western Oregon; the heavy rainfall combined with warm temperatures led to snowmelt and rainfall runoff that produced rapid rises on several rivers, which included flooding on three rivers in northwest Oregon
March 2, 2014	Hood River County, Upper Hood River Valley, Central Columbia River Gorge	East winds brought very cold air from east of the Cascades through the Columbia River Gorge as a moist front pushed in from the Pacific. The combination of the cold air mass and frontal precipitation resulted in snow and ice for the Gorge. There were numerous reports of snow and ice in the Central Columbia River Gorge with generally 6 to 8 inches of snow. There was a quarter of an inch of ice on top of the snow in Hood River and White Salmon, and as much as 0.4 to 0.5 inch of ice in Parkdale where the cold air held on the longest.

Date	Location	Description
Nov. 13, 2014	Clackamas, Marion, Linn, Multnomah and Hood River Counties (North Cascade foothills and Western Columbia River Gorge)	An early cold snap hit the Pacific Northwest before moist Pacific air moved in and resulted in one of the earliest snow, sleet, and freezing rain events in northwestern Oregon. Sleet and freezing rain in particular created hazardous commutes for tens of thousands in the western and eastern suburbs of Portland. Farther south, 1/2 of freezing rain accumulated on trees in the coast range foothills outside of Corvallis and Dallas, Oregon. Upwards of a quarter of an inch of ice fell around Dallas, Oregon. Some snow fell, but accumulations were primarily restricted to the Cascade valleys and the central Columbia River Gorge. Spotters reported around 6 to 8 inches of snow for the Cascade Foothills followed by a quarter of an inch of ice. A combination of heavy snow and ice resulted in slick driving conditions for the Western Columbia River Gorge. Areas in the gorge measured a quarter of an inch of ice whereas other areas had 5 to 8 inches of snow.
Dec. 6–23, 2015	Statewide	DR-4258. Clatsop, Columbia, Multnomah, Clackamas, Washington, Tillamook, Yamhill, Polk, Lincoln, Linn, Lane, Douglas, Coos, and Curry Counties declared. Severe winter storms, straight-line winds, flooding, landslides, and mudslides. On December 12, A series of systems brought heavy precipitation to southern Oregon. Several pacific storm systems moved across the region over the Dec 12-13 weekend from southern Oregon to northeast Oregon. Another series of storms moved across Oregon on Dec 16-17 and Dec 21-23. Each storm system brought several inches of snow to the mountain areas. Snowfall amounts in inches include: 21.0 10 miles west of La Pine, 14.0 at Tollgate, 12.0 13 miles southwest of Mitchell, and 9.0 6 miles east southeast of Granite. Another in a long series of storms brought heavy snow to portions of south central Oregon. The cooperative observer at Chemult reported 17 inches of snow in 24 hours ending Dec. 17th. A narrow but long-lived band of precipitation moved across Wallowa County the morning of December 19th. Several reports of moderate snow occurred over the Joseph and Enterprise areas. Snowfall amounts in inches ranged from 5 to 6 inches, with northern Wallowa County receiving reports of up to 9 inches just outside of Flora. On December 21st heavy snow fell over portions of central Washington and Oregon due to a cold front. Snowfall amounts are as followed: 14” recorded at the Milk Shakes Snotel and 10” in 24 hours 5 miles north northwest of La Pine. Also on the 21st a series of storms made for a long lasting winter storm over southwest and south central Oregon. Initially the heavy snows were limited to higher altitudes...but a colder air mass moved in towards the end of the event and snow fell in areas that rarely see snow...such as the southwest Oregon valley floors. Moist onshore winds produced a steady stream of showers over the foothills of the Cascades with snow levels between 1000 and 2000 feet. This resulted in heavy snow for the Northern Oregon Cascades and Coast Range. At one point after the storm, 25,000 people were without power. Several highways around Crater Lake were closed for a week due to heavy snow and fallen trees blocking the roads.
Mar. 13, 2016	Clackamas, Marion, Linn and Lane Counties (North Oregon Cascades and Cascades in Lane County)	A strong low pressure system generated frequent and persistent snow showers over the northern and central Oregon Cascades. Several SNOTEL stations measured 16 to 24 inches of snow over a 24 to 30 hour period above 3500 feet.

Date	Location	Description
Dec. 8, 2016	Multnomah, Clackamas, Washington, Columbia, and Hood River Counties (Greater Portland Area and Western Columbia River Gorge)	A strong frontal system brought strong east winds to the North Willamette Valley and a mix of snow, sleet, and freezing rain down to the Valley Floor. Four to six inches of snow fell along interstate 84 before turning to sleet and freezing rain. One to 1.5 inches of ice accumulation was also reported. The Portland Metro area generally had 1-2 inches of snow, with 0.2 to 0.3 inch of ice accumulation. Ice accumulations were higher in the West Hills and near the Columbia River Gorge, with 0.8 inch of ice accumulation reported at Council Crest in SE Portland. The NWS Office in Parkrose had 0.4 inch of ice accumulation.
Dec. 14–17, 2016	Lane, Lincoln, Benton, Marion, Clackamas Josephine and Linn Counties (Central Coast Range, Southern Willamette Valley, Cascade foothills in Lane County, Northern Cascade foothills)	DR-4296. Lane and Josephine counties declared. Severe winter storm and flooding. East winds ahead of an approaching low pressure system brought temperatures down below freezing across the area ahead of the approaching precipitation. This lead [sic] to a mix of freezing rain, sleet, and snow across the area. While areas farther north saw more of a snow/sleet mix before a changeover to freezing rain then rain, areas in Lane County saw freezing rain for most of this event, causing power outages, damage to trees, and many car accidents around Eugene and Springfield. Snow [was] followed by sleet and freezing rain. The freezing rain turned into a major ice storm occurred in Eugene and the vicinity with 0.5 to 1.0 inch of ice accumulation observed. There was significant damage to trees and power lines, and fairly widespread power outages across the region. 15,000 people were without power. There was a report of 0.4 inch of ice accumulation near Sodaville.
Dec. 19, 2016	Hood River County (Upper Hood River Valley and Central Columbia River Gorge)	A warmer low pressure system moved into to Northwest Oregon, bringing high winds along the North and Central Oregon Coast. Cold east winds through the Columbia River Gorge continued for the first part of the event, leading to light accumulations of snow and sleet in portions of far northwest Oregon and higher accumulations in the Columbia River Gorge and Hood River Valley. Estimate the Columbia Gorge had around 0.2 to 0.5 inch of ice accumulation as temperatures in the lower 30s with reports of snow and freezing rain in Hood River. A frontal system brought high winds to the Central Oregon Coast, heavy snow to the Cascades and a mix of ice and snow in the Columbia River Gorge and Hood River Valley. SNOTELs and other stations reported a range of 12 to 25 inches of snow. Some specific reports include 25 inches at Mt Hood Meadows, 22 inches at Timberline, 14 inches at Government Camp and 12 inches at McKenzie Snotel.
Dec. 26-27, 2016	Linn, Marion, Clackamas Counties (North Oregon Cascades)	A frontal system brought high winds to the Central Oregon Coast, heavy snow to the Cascades and a mix of ice and snow in the Columbia River Gorge and Hood River Valley. Estimate the Columbia Gorge had around 0.2 to 0.5 inch of ice accumulation as temperatures in the lower 30s with reports of snow and freezing rain in Hood River. SNOTELs and other stations reported a range of 12 to 25 inches of snow in the Cascades. Some specific reports include 25 inches at Mt Hood Meadows, 22 inches at Timberline, 14 inches at Government Camp and 12 inches at McKenzie Snotel.

Date	Location	Description
Jan. 7–10, 2017	Multnomah, Clackamas, Washington, Columbia, Lane, Benton, Polk, Yamhill, Linn, Marion, Josephine and Hood River Counties (Greater Portland Area, Central Coast Range, Central and Southern Willamette Valley, North Cascades foothills, Western and Central Columbia Gorge, Upper Hood River Valley and the Siskiyou Mountains)	DR-4328. Columbia, Hood River, Deschutes and Josephine Counties declared. Severe Winter Storms, Flooding, Landslides, And Mudslides. A storm system moving across southern Oregon produced heavy snow across portions of central and northeast Oregon. Also heavy snow fell over portions of the Columbia River Gorge. A broad shortwave trough brought multiple rounds of precipitation, including a wintry mix of snow and ice for many locations across Northwest Oregon. Strong easterly pressure gradients generated high winds through the Columbia River Gorge as well on January 8. General snowfall totals of 2-4 inches were reported, with the greatest total being 4.5 inches. Major ice accumulations occurred after the snow, with several locations reporting 0.50-1.00. The combination of snow and ice resulted in significant power outages and closures across the area.
Feb. 3-4, 2017	Multnomah and Hood River Counties (Western and Central Columbia River Gorge, Upper Hood River Valley)	Fronts associated with a low pressure system passing north into the Olympic Peninsula brought heavy snow and ice to the Columbia Gorge. The Hood River area reported 4 to 6 inches of snow turning to ice in the western-most part of this zone.
Feb. 8-9, 2017	Wasco, Sherman, Gilliam, Wheeler, Jefferson, Crook, and Grant Counties (Eastern Columbia River Gorge, Eastern Cascades, Central Oregon, Ochoco-John Day Highlands)	A strong Pacific storm system brought snow, sleet and freezing rain to many areas of the Interior Northwest February 7th through 9th. Winter storm produced a total snow accumulation of 5.25 inches with an ice accumulation of 0.25 inches on top of the snow. Occurred 5 miles SSW of Chenoweth in Wasco county.
Dec. 24, 2017	Multnomah and Hood River Counties (Western Columbia River Gorge	Low pressure system moving into the Pacific Northwest pulled cold air from the Columbia Basin west into the Willamette Valley, through the Columbia River Gorge. As this system started to bring moisture and precipitation into NW Oregon, temperatures were around or below freezing, allowing for a mix of snow and ice to fall all the way to the Valley Floor around the Portland Metro, in the Columbia River Gorge, and the Hood River Valley. Local Broadcast Meteorologist reported getting 2.5 inches of snow and 0.2 inch of ice in Corbett. Also, a Skywarn Spotter in Cascade Locks reported getting 4.8 inches of snow.
Feb. 22–26, 2019	Coos, Curry, Douglas, Lane, Deschutes, Jefferson, Wheeler, Wasco, Sherman, Gilliam, Morrow, Umatilla, Crook, Grant, Baker, Malheur and Union Counties (Oregon Coast Range, South and Central Coast, North Central and Central Oregon, Blue Mountains, Eastern Columbia River Gorge, Eastern Cascades, Grand Ronde Valley, Lower Columbia Basin, John Day Basin)	DR-4432. Jefferson, Lane, Douglas, Coos and Curry Counties declared. Severe Winter Storms, Flooding, Landslides, And Mudslides. Persistent troughing off the coast of the Pacific Northwest focused a stream of mid-level moisture over the Inland Northwest resulting in a long duration snow event as the plume drifted north and south several times between the 22nd and 27th of February. Snowfall rates were greatly enhanced over central Oregon with the proximity of a nearly stationary surface boundary where snowfall rates were in excess of 1 inch per hour. The low pressure system moved south into eastern Washington, bringing a cold front southeastward across western Oregon. The front then stalled across the southern Willamette Valley and Lane County Cascades as colder and colder air moved in aloft. What started as rain at low elevations turned to snow during the afternoon of the 23rd. The stalled front kept producing snow over the same areas through the next 24 hours with a direct tap of moisture from the Pacific Ocean. Storm total snowfall amounts were measured at: 40 inches in Sisters, 33 inches in Bend, 30 inches in Redmond, 26 inches in Meacham, 22 inches in Prineville, 21 inches in Elgin, 16 inches in Mitchell, 14 inches in Lostine and La Grande, 12 inches in Pendleton and Joseph and 10 inches in John Day. In Bend a few roofs collapsed under the weight of the snow.

Date	Location	Description
Jan. 15-16, 2020	Multnomah, and Hood River Counties (Western and Central Columbia River Gorge)	A 980 mb low located near 45N/130W along with an attendant warm front moved into the southern Oregon Coast and overran a cold air mass originating from the Columbia River Gorge. This resulted in snow that gradually transitioned to freezing rain in the Gorge on Wednesday night into Thursday. The amounts of snow and ice varied greatly across the Columbia River Gorge, with heaviest amounts in the Central Columbia River Gorge zone. The combination of snow, ice, and wind resulted in the closure of I-84 between Troutdale and Cascade Locks. Based on ODOT and spotter reports, 4 to 10 inches fell in the stretch from Corbett to Cascade Locks, followed by a few hours of light freezing rain. Additionally, east winds gusted to 56 mph at Corbett, with higher gusts at Crown Point (although the anemometer was frozen).

Source: The National Weather Service; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Figure 2-110. Rescuing Snowbound Vehicles, Old Oregon Trail Highway between Kamela and Meacham, 1923

Source: ODOT

Figure 2-111. Stranded Motorists on I-5 Southbound at Siskiyou Pass, Late December 2003

Note: Vehicles being towed out the "wrong way."
Source: ODOT

Figure 2-112. Detroit, Oregon, February 2, 2008, Buried from the 12 Feet of Snow

Source: ODOT

Figure 2-113. Trees Collapse from Weight of the Snow on Oregon 62 near Prospect, February 2, 2008

Source: ODOT

2.2.11.2 Probability

Winter storms occur annually in Oregon bringing snow to Oregon's mountains and much of Eastern Oregon. These winter storms are welcomed by Oregon's skiers and the ski industry and are tolerated by people traveling the numerous mountain passes and Eastern Oregon highways kept open during the winter by the Oregon Department of Transportation. Approximately every 4 years, winter storms bring extreme cold temperatures, snow, sleet and ice to Oregon's western valley floors. Because these storms are infrequent and tend to last only a few days, residents in western Oregon are often unprepared for such events.

One issue concerns the fact that there is not a statewide effort regarding winter storm impacts, either historical or for future planning. There are only limited snowfall sensors distributed mainly through the mountain ranges of the state and there is not an annual tracking system in place for snowfall statewide. A program of statewide snowfall sensors would allow us to better understand the impact of winter storms on Oregon and have a better means of predicting potential impacts in the future.

The American Society of Civil Engineers has developed a 50-year recurrence interval map of Oregon showing probabilities for ice thickness caused by freezing rain (ASCE-7-02, 2003a), found at: http://www.americanlifelinesalliance.com/pdf/PipecommFinalPosted061705.pdf

According to the Northwest Weather and Avalanche Center (NWAC), experts on the subject aren't able to predict, nor do they completely understand each and every avalanche occurrence. Regional avalanche centers across the country do have the technology to forecast avalanche danger. These forecasts are valuable tools in reducing danger to people. However, no matter what forecasts indicate even the smallest avalanche can be injurious or life threatening!

Avalanche danger ratings levels have been adopted within North America (with slight changes in Canada) and are generally accepted internationally. These levels are:

Low Avalanche Danger (green): Natural avalanches very unlikely. Human triggered avalanches unlikely. Generally stable snow. Isolated areas of instability. Travel is generally safe. Normal caution advised.

Moderate Avalanche Danger (yellow): Natural avalanches unlikely. Human triggered avalanches possible. Unstable slabs possible on steep terrain. Use caution in steeper terrain on certain aspects.

Considerable Avalanche Danger (orange): Natural avalanches possible. Human triggered avalanches probable. Unstable slabs probable on steep terrain. Be increasingly cautious in steeper terrain.

High Avalanche Danger (red): Natural and human triggered avalanches likely. Unstable slabs likely on a variety of aspects and slope angles. Travel in avalanche terrain is not recommended. Safest travel on windward ridges of lower-angle slopes without steeper terrain above.

Extreme Avalanche Danger (red with black border): Widespread natural or human triggered avalanches certain. Extremely unstable slabs certain on most aspects and slope angles. Large destructive avalanches possible. Travel in avalanche terrain should be avoided and travel confined to low-angle terrain well away from avalanche path runouts.

Based on the information in Table 2-26, Regions 2, 3, and 5, are considered to have very high probability of severe winter storm occurrence, followed Regions 6, 7, and 8 with high probability, Region 4 with moderate probability, and Region 1 with low probability.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Figure 2-114. Trucks Wait Out Winter Storm

Note: Trucks wait at a truck stop in Troutdale after ice, wind, and snow caused ODOT to close I-84 through the Columbia River Gorge – January 2004

Photo source: William Hamilton, *The Oregonian*

2.2.11.3 Vulnerability

A major winter storm can last for days and can include high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. People can become marooned at home without utilities or other services. Severe cold can cause much harm. It can damage crops and other vegetation and freeze pipes, causing them to burst. Unusually cold temperatures are especially dangerous in areas not accustomed to them because residents are generally unprepared and may not realize the dangers severe cold presents.

Heavy snowfall and blizzards can trap motorists in their vehicles and make walking to find help a deadly mistake. Heavy snow can immobilize a region and paralyze a city, stranding commuters, closing airports, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can cause roofs to collapse and knock down trees and power lines. Homes and farms may be isolated for days. In rural areas, unprotected livestock can be lost. In urban areas, the cost of snow removal, damage repair, and lost business can have severe economic impacts.

When an ice storm strikes, some landscape trees seem to be able to come through with only minor damage, while others suffer the loss of large limbs or sizable parts of their branching structure. In the worst cases, trees may be completely split in two or may have nothing left standing but a trunk. If a tree has been weakened by disease, there may be little that can be done to prevent major breakage or loss when the stresses of a storm occur. However, there are preventive measures that cities and property owners can take to help their trees be stronger and more resistant to storm damage. For more information, see Appendix **9.1.7**, *Reducing Ice Storm Damage to Trees*.

Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt power and communication for days while utility companies repair extensive damage. Even small accumulations of ice can be dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

Exposure to cold can cause frostbite and life-threatening hypothermia. Frostbite is the freezing of body tissue. It most frequently affects fingers, toes, earlobes, and the tip of the nose. Hypothermia begins to occur when a person's body temperature drops three degrees below normal temperature. On average, a person begins to suffer hypothermia if his or her temperature drops to 96 °F (35.6 °C). Cold temperatures can cause hypothermia in anyone who is not adequately clothed or sheltered in a place with adequate heat. Hypothermia can kill people, and those who survive hypothermia are likely to suffer lasting ill effects. Infants and elderly people are the most susceptible. Elderly people account for the largest percentage of hypothermia victims, many of whom freeze to death in their own homes. Most of these victims are alone and their heating systems are working improperly or not at all. People who take certain medications, who have certain medical conditions, or who have been drinking alcohol also are at increased risk for hypothermia.

Driving can be tricky in the snow, but once a storm has passed, there is another danger: flying snow from trucks and cars. When snow is warmed by the vehicle, it will begin to melt. Wind and motion cause sections to break off and hit other vehicles. The snow can also fall on the road, melt, and later turn into ice.

Winter storms are considered deceptive killers because most winter storm deaths are related only indirectly to the storms. Overall, most winter storm deaths result from vehicle or other transportation accidents caused by ice and snow. Exhaustion and heart attacks brought on by overexertion are two other common causes of deaths related to winter storms. Tasks such as shoveling snow, pushing a vehicle, or even walking in heavy snow can cause a heart attack, particularly in people who are older or who are not used to high levels of physical activity. Home fires occur more frequently in the winter because people do not take the proper safety precautions when using alternative heat sources. Fires during winter storms present a great danger because water supplies may freeze and it may be difficult for firefighting equipment to get to the fire. In addition, people can be killed by carbon monoxide emitted by fuels such as charcoal briquettes improperly used to heat homes (American Red Cross, 2007).

Winter storms, particularly east of the Cascades where snow storms are typically more intense, bring larger amounts of snow and last longer. They can strand livestock in pastures, leaving them without food and water and exposed to extreme cold for long periods of time. As a consequence, substantial losses in livestock from starvation, dehydration and freezing, significantly impact producers, and state and local economies. In addition, water quality and health hazards develop when dead livestock are not retrieved until roads are cleared and vehicles can be used to remove the carcasses. Livestock buried under snow may not be found until the snow melts. The snowmelt may carry the carcasses to streams and wash them downstream.

One issue is the lack of a statewide effort regarding winter storm impacts, either historical or for future planning. There are only a few snowfall sensors distributed mainly through the mountain ranges of the state and there is not an annual tracking system in place for snowfall statewide. A program to install snowfall sensors and track snowfall statewide would allow us to better understand the impact of winter storms on Oregon and have a better means of predicting potential impacts in the future.

Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, there have been twelve reported losses to state assets caused by winter storms, snow and ice buildup, and low temperatures from a power outage causing freezing pipes to burst since the beginning of 2015. Net claims paid totaled over $826,000. Location of the losses is not completely clear from the records, but most appear to have been in and around central and eastern Oregon. The most expensive loss, over $353,000, was to the Snake River Correctional institution.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The total value of state-owned and leased buildings and critical facilities statewide is approximately $7,252,740,000 representing the maximum potential for loss due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services (DAS) records, losses totaling $1,345,299.82 to state facilities were recorded since the beginning of 2015. Thirteen of these losses, totaling over $826,000, were due to winter storms.

DAS's records are the only evidence the State has at this time of vulnerability to state assets. Since 2015, DAS has recorded 37 claims for damages to state assets related to natural hazards. Only floods, wildfires, windstorms, and winter storms are represented. Of the 12 claims for fire damage, only one was clearly attributed to a forest fire; the others appeared to be structure fires. Similarly, the four claims for flood damages could not be clearly attributed to a natural hazard flooding event. Further, the location of each damaged state asset relative to the natural hazards mitigation planning regions was not clear, making it impossible to even speculate about the potential for damage from a particular hazard to state assets in a particular mitigation planning region. Because this is the first time the IHMT has accessed DAS's insurance information we have no baseline from which to assess changes to vulnerability of state assets.

The IHMT needs to work with DAS to improve the dataset for the next update. If we can accomplish that, the next update's reflection on changes to the vulnerability of state assets will still be lacking due to the lag involved in improving the dataset and the procedures for recording data. However, the data should be ready for a more complete analysis during the following update. If we cannot accomplish that, we will need to work on finding another method to assess impacts from natural hazards to state assets and how they change over time.

Most Vulnerable Jurisdictions

The Oregon Department of Transportation (ODOT) is the agency with primary oversight of the winter storm hazard. Based on agency staff review of the available hazard data, ODOT lists the Northern Willamette Valley (Linn, Benton, Marion, Polk, and Yamhill Counties), the Portland Metro Region (Columbia, Washington, Multnomah, and Clackamas Counties), and the Mid/Southern Willamette Region (Lane, Douglas, Josephine, and Jackson Counties) as the most vulnerable to damage and loss associated with winter storms because Oregon's most densely populated cities are located within these regions.

The Portland Metro area is the most vulnerable not only because it is the most densely populated but also because of its proximity to the Columbia River Gorge. It is not uncommon to have severe ice and sleet storms occurring as cold artic winds blow down the Gorge over east Multnomah County and Portland. These storms have delayed air traffic and even closed the Portland International Airport in the past, thus negatively affecting Oregon's economy. Winter storms often bring ice and sleet that makes driving extremely dangerous. Ice and sleet storms can cripple the movement of goods and services, thus negatively impacting Oregon's economy.

National Weather Service winter storm reports were used as the basis for determining community vulnerabilities. Unfortunately there is only the NWS storm information available for analysis. There is no statewide winter storm program to study the impacts of these storms statewide. There is no program to identify annual average snowfalls across the state either historical or for planning purposes. Hydrological precipitation information is available but not winter storm and snowfall information.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

Marion County, being very vulnerability to property damage and loss of life from winter storms as well as having very significant social vulnerability, is the county most vulnerable in the state to the effects of winter storms.

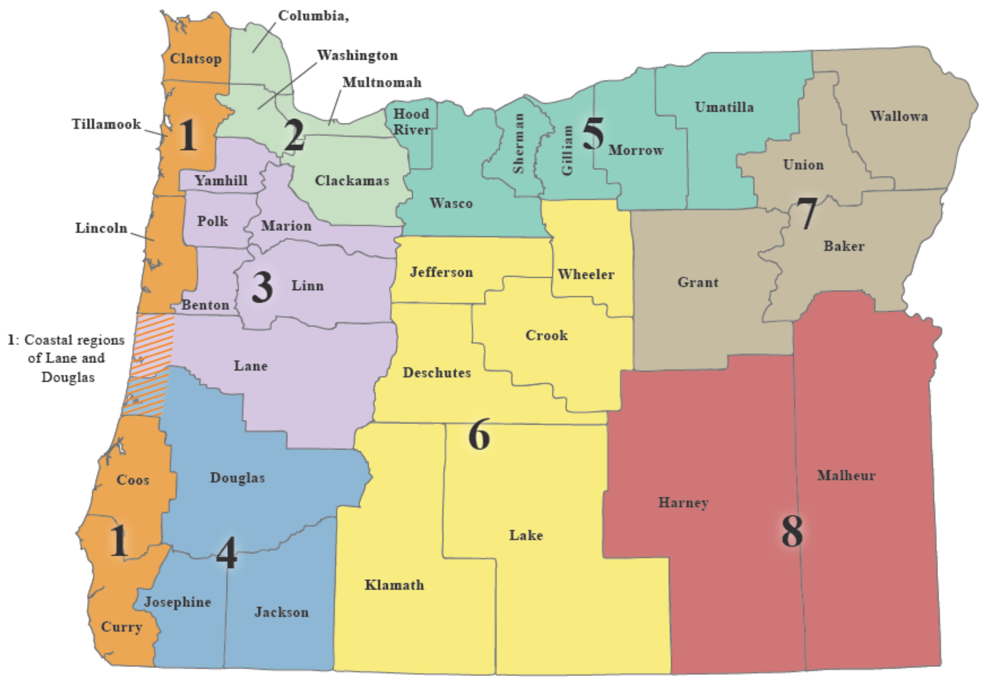
2.2.11.4 Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Regions 2 and 3 have the greatest probability and greatest vulnerability, and therefore are at the greatest risk from the adverse effects of winter storms. Marion County carries the greatest risk of any Oregon county.

2.3 Regional Risk Assessments

The purpose of the Regional Risk Assessment is to assess risks at a regional scale by profiling the characteristics, natural hazards, and vulnerabilities within the eight Oregon NHMP Natural Hazard Regions (Figure 2-115). Each region has its own Risk Assessment. Together, the eight Regional Risk Assessments combine to describe the State's overall risk to natural hazards.

Figure 2-115. Oregon NHMP Natural Hazards Regions



Each Regional Risk Assessment includes three sections:

1. The **Summary** provides a general overview of (a) the Regional Profile, (b) the Regional Hazards and Vulnerability, and (c) how climate change models predict hazards in the region will be impacted based on statewide data.
2. The **Profile** section provides an overview of the region's unique characteristics including profiles of the natural environment, social and demographic situation, economic environment, infrastructure, and built environment.

   The research of Susan Cutter, Professor of Geography at the University of South Carolina, Columbia, on vulnerability and environmental hazards provides the framework for discussion of vulnerability in the Regional Profile section. Cutter's framework helps to illustrate the geographic variability of vulnerability and allows policy makers to better understand how to prepare for, mitigate, and reduce vulnerability (Cutter, Boruff, & Shirley, 2003); (Cutter S. L., 2006).

Margin of Error (MOE)

The sociodemographic data in the regional profiles are primarily sourced from the U.S. Census Bureau's American Community Survey (ACS). The ACS's estimates are subject to sampling and nonsampling errors. Nonsampling errors are the product of survey design and measurement flaws, "while sampling error is when the characteristics of the survey group vary from those of the larger population of interest...causing the true value to fall within a range bounded by a margin of error" (Quinterno, 2014).

Through adding and subtracting the MOE from the estimate, users can calculate the 90% confidence interval for that estimate (U.S. Census Bureau, 2018). For example, in **Table 2-81. People with a Disability by Age Group in Region 1**, data from the 2017 ACS 5-year estimates indicate that 19.1% of all people in Clatsop County have a disability with a MOE of 1.4%. Through adding and subtracting the MOE from the estimate, the user can calculate the 90% confidence interval for that estimate (U.S. Census Bureau, 2018). Doing so indicates that we can be 90 percent confident that the true share of residents in Clatsop County with a disability in the 2013-2017 period falls between 17.7% and 20.5%.

Period Estimates

It should also be noted that the ACS estimates in the plan are period estimates, rather than point-in-time or cumulative counts. "A period estimate shows the average value of the variable over a specific reference period" (Quinterno, 2014). The ACS uses period estimates "to compensate for the fact [that] the sampling frame includes too few households to yield reliable annual estimates for small geographies and small population subgroups" (Quinterno, 2014). If the value presented in a table is a period estimate, the period is noted in the table's source data.

Coefficient of Variation (CV)

In addition to a MOE, many of the estimates in the plan have a coefficient of variation (CV). "The CV is a relative measure of uncertainty and expresses uncertainty as a percentage of the census estimate" (Jurjevich, et al., 2018). Generally, the lower the CV, the more reliable the data. According to the U.S. Census Bureau, there are "no hard-and-fast rules for determining an acceptable range of error in ACS estimates. Instead, data users must evaluate each application to determine the level of precision that is needed for an ACS estimate to be useful" (U.S. Census Bureau, 2018). This plan adopts CV ranges and data reporting methods recommended by the Population Research Center at Portland State University (Jurjevich, et al., 2018).

Icons are used to indicate the reliability of each estimate using the CV. High reliability (CV <15%) is shown with a green check mark, medium reliability (CV 15–30% — be careful) is shown with a yellow exclamation point, and low reliability (CV >30% — use with extreme caution) is shown with a red cross. However, as mentioned above, there are no precise rules and users should consider the MOE and their need for precision (Jurjevich, et al., 2018).

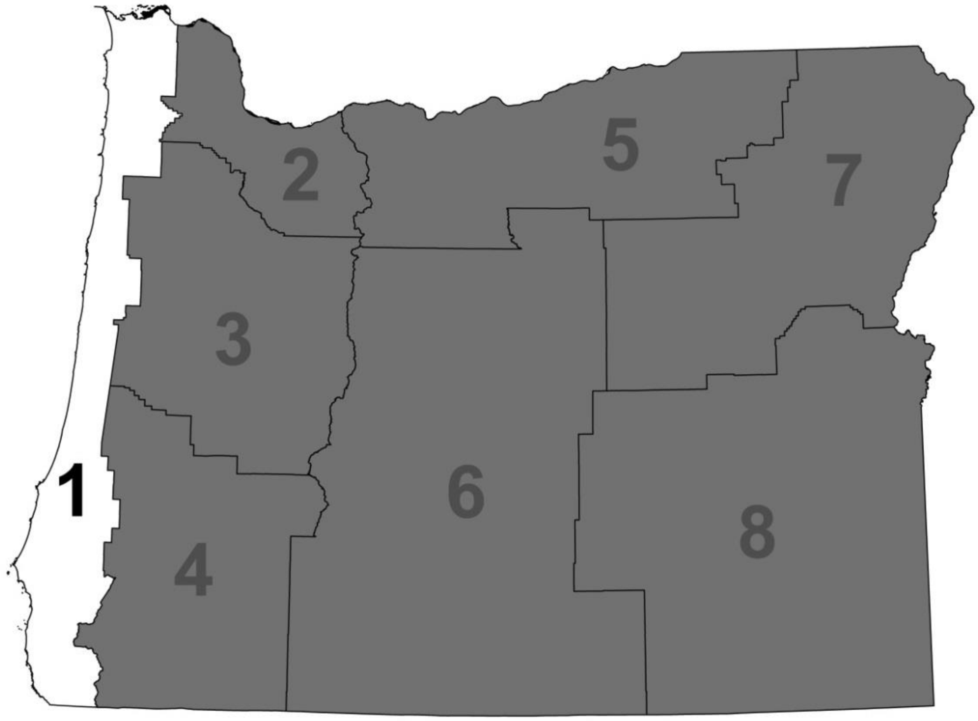
3. The **Hazards and Vulnerability** section first identifies each hazard and its characteristics in the region. Then, the historical events that have impacted the region are listed. Lastly, probabilities and vulnerabilities are discussed as identified by local and state risk assessments. Vulnerabilities

to and potential impacts from each hazard in the region are described including the identification and analysis of the region’s State owned/leased facilities and critical/essential facilities located within hazard zones and seismic lifeline vulnerabilities.

Regional Risk Assessments add to the current body of literature and technical resource guides available to Oregon communities. The three levels of government — federal, state, and local — will find the Regional Risk Assessments useful when assessing natural hazards and vulnerabilities and when planning mitigation activities. Local governments can use the Regional Risk Assessments in the development of their jurisdiction’s natural hazards mitigation plan. Information from these assessments is intended to be used as a springboard for more detailed community profiles. Likewise, information from local plans helps to inform the Oregon NHMP risk assessment overall.

2.3.1 Region 1: Oregon Coast

Clatsop, Coos, Curry, Lincoln, and Tillamook Counties and coastal areas of *Douglas and *Lane Counties



*Note: Where data specific to the coastal areas of Douglas and Lane Counties are available, the data are used in the Region 1 Risk Assessment. Where data are available only for the county as a whole, the data are reported in the Region 3 (Lane County) and Region 4 (Douglas County) Risk Assessments.

2.3.1.1 Summary

Profile

The region's demographic, economic, infrastructure, and development patterns indicate that some populations, structures, and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed toward these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

Social vulnerability in Region 1 is driven in part by a high percentage of tourists, homeless persons, seniors, and disabled populations. Coos County is the most socially vulnerable due to lack of access to a vehicle, unemployment rates, and the percentage of residents with a disability. In addition, Curry County is in the 90^{th} percentile for the share of residents at least age 65 and for the share of residents with a disability. In addition, education levels and median household incomes across the region are below statewide numbers. Conversely, communities along the coast have high levels of homeownership, indicating an ability to better withstand economic hardship during natural disaster events. Coastal communities were hit particularly hard by the financial crisis that began in 2007 and continue to suffer from low job recovery rates, especially in Curry, Coos, and Lincoln Counties. They suffer as well from the financial effects of the 2020 pandemic. There are relatively few key industries and employment sectors in the region, and they employ relatively few people. Wages are lower than the state average. Coastal economies are becoming more reliant upon tourism, which peaks in the spring and summer months. Consequently, the area is particularly vulnerable during winter months when fewer employment opportunities exist.

A Cascadia Subduction Zone (CSZ) earthquake will be catastrophic to infrastructure along the coast. Following a CSZ event, access to and from coastal communities will be limited along US-101, major roadways, and bridges. Railroads that support transport of freight and cargo and access to the Southwest Oregon Regional Airport (OTH) will also be compromised and will have implications statewide.

Currently, there are no power plants or major dams in the region, requiring energy to be transmitted long distances from other states and Canada. These energy conveyance systems are vulnerable to severe but infrequent natural hazards, such as a Cascadia Subduction Zone (CSZ) event. Older, centralized storm and wastewater infrastructure is also vulnerable to flood events.

Most of the region's drinking water is sourced from surface water that is vulnerable to flooding, erosion, and landslides. These hazard events could result in pollution entering waterways that supply the region with drinking water.

Development in Region 1 has significantly lagged behind the rest of the state. Growth that is occurring is primarily in Tillamook and Lincoln Counties. The region has a high number of manufactured home units. Almost half of all housing in Clatsop and Curry Counties was built before current seismic and floodplain management standards, creating a greater risk to damage to loss. Due to the coast's geology and geomorphology, development is limited to low-lying areas often subject to coastal hazards. Tsunami risk information and development guidance developed by the State are helping communities develop land use planning strategies to reduce tsunami hazard risk.

Hazards and Vulnerability

Region 1 is affected by 10 of the 11 natural hazards that affect Oregon communities. Volcanic hazards, with the possible exception of ash fall, do not directly impact the area.

Coastal Hazards: The Oregon coast is increasingly threatened by wave-induced erosion, wave runup and overtopping, wind-blown sand, and coastal landslides. Clatsop, Tillamook, Lincoln, and Curry Counties are principally vulnerable to these hazards. Development in low-lying areas subject to erosion or adjacent to estuaries is of particular concern. In Region 1, there is a potential loss of over $232M in state building and critical facility assets to a CSZ event. Almost half of that is in Clatsop County alone. There is a far greater potential loss in local critical facilities: over $685M. Coos County stands to lose the most, about 51% of that total, followed by Clatsop County with about 20%.

Droughts: The region is affected by droughts to a lesser extent than other areas in the state. While uncommon, when they do occur they can be problematic — impacting community water supplies and creating forest conditions conducive to wildfires.

Earthquakes and Tsunamis: Three types of earthquakes affect Region 1: (a) shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, and (c) the offshore Cascadia fault. The CSZ is the chief earthquake hazard for coastal communities. The return rate for this type of catastrophic event is 530 years. The probability of such an event occurring in the next 50 years is 7–12%.

Tsunamis may take the form of distant or local events. The CSZ earthquake and local tsunami event have the potential to affect the entire coastline through severe ground shaking, liquefaction of fine-grained soils, landslides, and flooding. In addition to causing significant loss of lives and development, a CSZ earthquake and local tsunami would dramatically affect the region's critical infrastructure, including principal roads and highways, bridges, tunnels, dams, and coastal ports. The region has the most seismically vulnerable highway system in the state. Seismic lifelines will be fragmented along US-101 and along east-west routes that connect the region to the rest of the state. There is value of over $248M in state facilities and critical facilities in the tsunami zone in Region 1. There is about a third more than that in local critical facilities.

Extreme Heat: Extreme temperatures are rare on the coast. Most years do not have temperatures above 90°F and years that do, generally only have one or two days. Extreme temperatures will continue to be rare under future climate change. However, Region 1 counties may begin to experience extreme heat days with heat index over 90°F within the next thirty years. Because extreme heat is rare in Region 1, many people may not be accustomed or prepared when an extreme heat event occurs. The value of state-owned and leased buildings and critical facilities in Region 1 is approximately $535,054,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $1,294,655,000.

Floods: Coastal communities are impacted by riverine flooding, tsunami flooding, and ocean flooding from high tides and wind-driven waves. Low lying areas adjacent to bays or the ocean are more susceptible to flooding, which can be intensified by high tides. Northern counties are considered highly vulnerable to riverine flood damage because the area is more densely populated and has more of the region's infrastructure. Local highways are susceptible to wave action because of their location and geology. Almost $19M of state facilities and critical facilities are in the tsunami hazard zone and over $73M in local critical facilities. The vast majority of the value exposed is in local critical facilities in Coos County.

Landslides: Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Many landslides occur along the coast and Coast Range Mountains. Rain-induced landslides can occur during winter months, and earthquakes can trigger landslides at any time. US-101, principal roadways, and rail lines are exposed to landslides. Landslides have the potential to cause injuries and fatalities along these transportation systems. Landslides can also sever transportation systems, causing temporary but significant economic damage regionally and beyond. Almost $56M in value of state facilities is exposed to landslide hazards in Region 1, close to 30% of it in Lincoln County followed by Clatsop, Tillamook, and the coastal portion of Lane County. The coastal portion of Douglas County has no state facilities at potential loss from landslides. In contrast, the region has critical facilities representing over $209M in value in landslide hazard areas. Together, Coos and Clatsop Counties have almost two-thirds of the value of local critical facilities followed by Lincoln and Tillamook Counties.

Volcanoes: Though the volcanic Cascade Range is outside the region, there is some risk that volcanic ashfall, lahars, and mud flows may impact communities within Region 1 following a volcanic event.

Wildfires: Though cool moist weather makes the region less susceptible to wildfire than some other areas in the state, some of the largest fires have occurred in Region 1. Wildfire events typically take place in late summer. Areas with high levels of dry vegetation (gorse, timber, etc.) are most susceptible to wildfire. Based on the 2020 Risk Assessment, Coos County and the coastal portions of Lane and Douglas Counties have a moderate risk of wildfire while the rest of Region 1 has a very low risk. In Region 1, there is a potential loss of almost $5M in state building and critical facility assets, 96% of it in Curry County. The other 4% is divided almost equally between the coastal portion of Douglas County and Coos County. There is a far greater potential loss in local critical facilities: over $11M, over twice as much. A little less than half that value is located in Coos County; a little more than half in Curry County. There are no state buildings or critical facilities exposed to wildfire hazards in Clatsop County, the coastal portion of Lane County, Lincoln or Tillamook Counties. The same is true for local critical facilities with the addition of the coastal portion of Douglas County.

Windstorms: In general, winds generated offshore and traveling inland in a northeasterly direction can create windstorms in all counties along the coast. Windstorms affect the region annually, especially between October and March. They can impact the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as the coastline, grasslands, and farmland. Two tornadoes touched down in Tillamook County in 2016. One caused estimated damages of $1M; The other caused no damage.

Winter Storms: Colder weather, snow, ice, sleet, higher precipitation, and high winds can impact the Oregon Coast annually. Heavy ice can down trees causing widespread power outages and road closures that can isolate communities. Communities that are particularly susceptible to winter storms include Astoria, Cannon Beach, Rockaway Beach, Oceanside, Lincoln City, Depot Bay, and Newport.

Climate Change

The hazards faced by Region 1 that are projected to be influenced by climate change include coastal hazards, drought, wildfire, flooding, landslides, and extreme heat.

It is *very likely* (>90%) that the Oregon coast will experience an increase in coastal erosion and flooding hazards due to climate change induced sea level rise (*high confidence*) and possible changes to wave dynamics (*medium confidence*). Local sea level rise will be greatest on the central Oregon coast; however, the north and south coasts of Oregon will see local sea level rise surpass the current rate of vertical land movement.

In addition, climate models project warmer, drier summers for Oregon, including coastal areas. In Region 1, climate change would result in increased frequency of drought due to low summer runoff (*likely*, >66%) and low summer precipitation and low summer soil moisture (*more likely than not*, >50%). It is *very likely* (>90%) that the Coast Range in Region 1 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). While extreme temperatures are rare on the coast and will continue to be rare under future climate change, Region 1 counties may begin to experience novel extreme heat conditions.

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). However, large increases in extreme flows are least likely along the Lower Columbia Basin (northern border of Region 1). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 1, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see the Section 2.2.1.2, **Introduction to Climate Change**.

2.3.1.2 Profile

Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

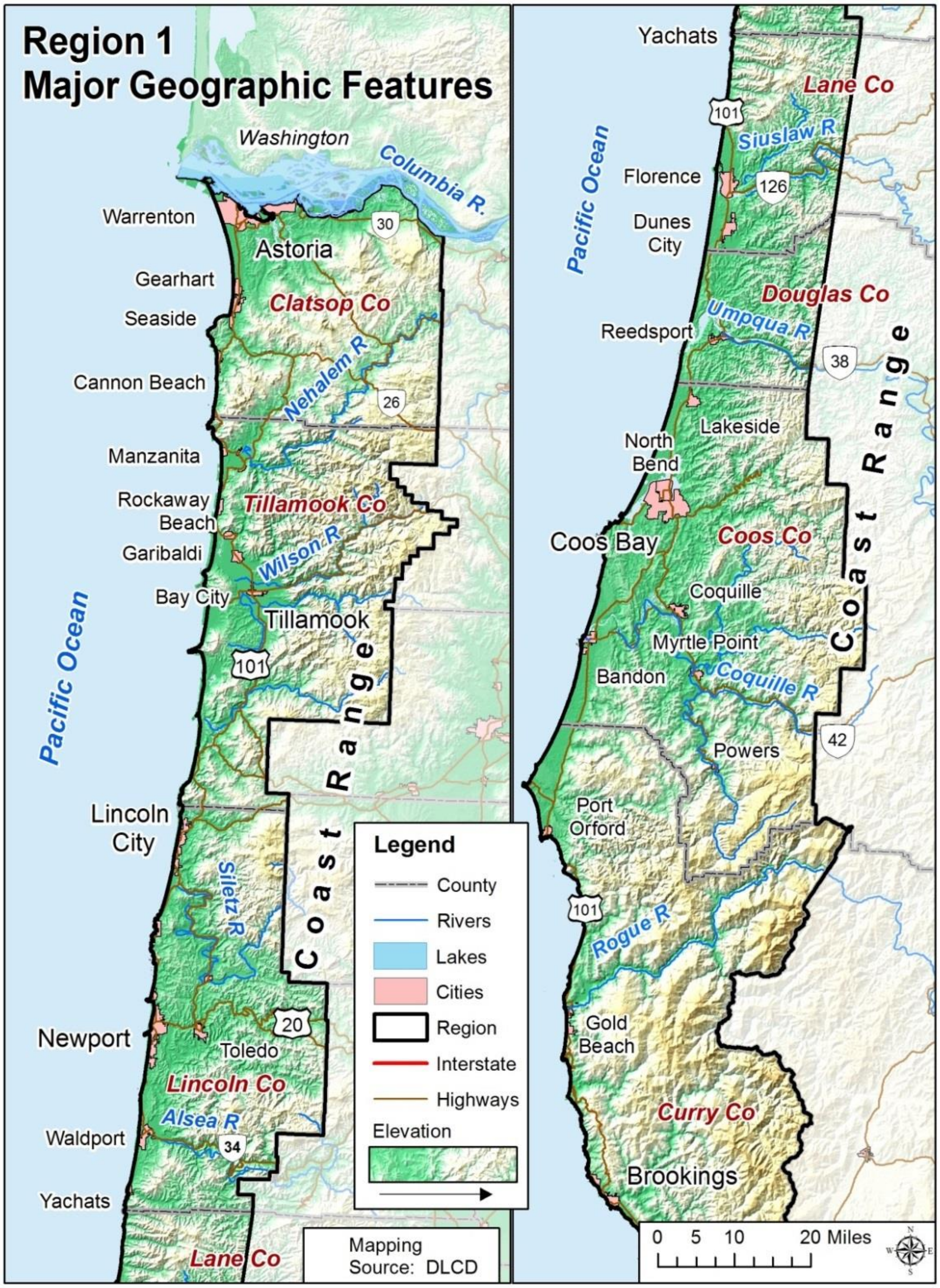
Natural Environment

Geography

The Oregon Coast is approximately 17,063 square miles in size, and includes Clatsop, Coos, Curry, Lincoln and Tillamook Counties, and coastal areas of Douglas and Lane Counties. The Coast Range mountains and waterways shape the region's topography. Region 1 begins at the Pacific Ocean on the west side and continues eastward beyond the Coast Range to the major valleys in the east. It extends from Washington State in the North to the California border in the south. Major rivers in the region include the Siuslaw, Umpqua, Nehalem, Rogue, Yaquina, Siletz, Nestucca, Trask, Wilson, Coos, and Coquille. **Figure 2-116** shows the dominant mountain ranges, major watersheds, and political boundaries of Region 1.

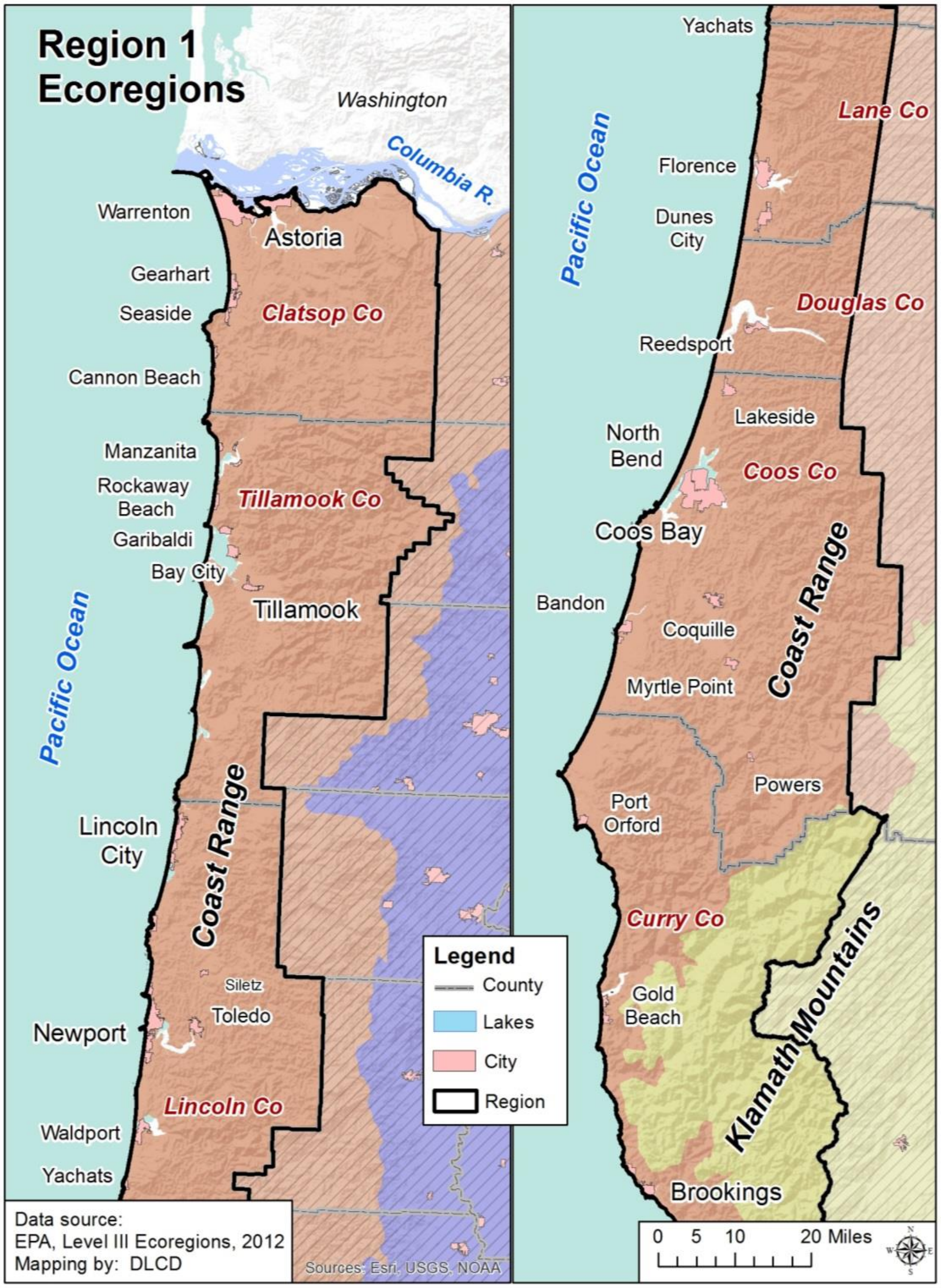
The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 1 comprises two ecoregions: the Coast Range and a smaller area of the Klamath Mountains (**Figure 2-117**).

Figure 2-116. Region 1 Major Geographic Features



Source: USGS, NGA, NASA, CGIAR

Figure 2-117. Region 1 Ecoregions



Coast Range: The Coast Range is Region 1’s dominant ecoregion. Mountains in the Coast Range are low in elevation and high in precipitation, creating lush evergreen forests. Naturally occurring diverse forests have given way to monocrop plantings for timber harvest. The Oregon Coast Range is volcanic in origin and is drained by hundreds of creeks, streams, rivers, and lakes. Sedimentary soils are more prone to failure following clear cuts and road building than are areas with volcanic soils, which may be of concern as commercial Douglas fir forests are highly productive commercial logging areas. Landslides can impact the safety of nearby infrastructure and health of the region’s waterways. Sedimentary soils create more concerns for stream sedimentation than areas with volcanic soils. Low lands include beaches, dunes, forests, lakes, marshes, and streams. Many wetlands in the ecoregion have been converted to dairy pastures (Thorson, et al., 2003).

Klamath Mountains: The majority of the Klamath Mountains found in Region 1 are classified as the Coastal Siskiyous. This area has a wet, mild maritime climate. Land cover is a mix of hard- and soft-wood forests, which is far more diverse than the predominantly coniferous forests of the Coast Range. Logging, recreation, rural residential development, and mining activities are common in this ecoregion (Thorson, et al., 2003).

Climate

This section covers historic climate information. For estimated future climate conditions and possible statewide impacts refer to the **State Risk Assessment**.

The Oregon Coast has a predominantly mild climate with average January minimum temperatures in the mid-30s and average July maximum temperatures in the low 70s. The Oregon Coast receives copious precipitation that falls predominantly in the winter months, mostly in the form of rain due to the region's low elevation. The region's wet winters can lead to flood and landslide risks while dry summers can lead to drought and wildfire risks. Winter storms are often accompanied by high winds. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-78** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 1 based on data from the NOAA National Centers for Environmental Information.

Table 2-78. Average Precipitation and Temperature in Region 1 Counties and Climate Divisions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Clatsop County	87.85” (60.53”–119.57”)	Jan: 13.36” Jul: 1.21”	49.8°F	Jan: 35/46.7 Jul: 50.7/71
Coos County	69.1” (46.95”–108.37”)	Jan: 10.62” Jul: 0.47”	52.6°F	Jan: 37/51.4 Jul: 51.8/74.3
Curry County	84.57” (51.85”–132.66”)	Jan: 13.38” Jul: 0.42”	52.7°F	Jan: 37.1/50 Jul: 52.3/77.4
Lincoln County	89.58” (63.7”–134.28”)	Jan: 13.7” Jul: 0.98”	51.2°F	Jan: 36.8/48.2 Jul: 50.7/72.5
Tillamook County	100.29” (70.77”–145.93”)	Jan: 15.22” Jul: 1.29”	49.5°F	Jan: 35.4/45.6 Jul: 50.4/70.9
Climate Division 1 Coastal Area”	83.05” (56.17”–124.60”)	Jan: 12.8” Jul: 0.77”	51.4°F	Jan: 36.3°/48.5° Jul: 51.4°/73.8°

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 8, 2019 from https://www.ncdc.noaa.gov/cag/

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community's capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

Between 2010 and 2018 the regional growth rate lagged behind the state by six percentage points. Growth in Coos County, the region's largest county, has remained relatively flat, while Clatsop County saw the greatest percent increase in population. The population in all coastal counties is aging. Some counties are experiencing slowing natural increase (the ratio of births to deaths), while others are experiencing natural decrease (more deaths than births) (Population Research Center, Portland State University , 2017 & 2018). Since 2010, population increase in all Region 1 counties has been a product of net in-migration (Population Research Center, Portland State University , 2017 & 2018).. Over the next decade, coastal counties are projected to continue to grow at a slower rate than the state as a whole, with Lincoln County projected to experience the greatest growth in the region and Coos County projected to experience the least. Across the region, in-migration is projected to continue to be the primary driver of population growth (Population Research Center, Portland State University , 2017 & 2018).

Table 2-79. Population Estimate and Forecast for Region 1

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 1	193,730	199,995	3.2%	208,066	4.0%
Clatsop	37,039	39,200	5.8%	40,079	2.2%
Coos	63,043	63,275	0.4%	63,855	0.9%
Curry	22,364	22,915	2.5%	23,976	4.6%
Lincoln	46,034	48,210	4.7%	51,909	7.7%
Tillamook	25,250	26,395	4.5%	28,247	7.0%

Sources: Population Research Center, Portland State University, 2019; U.S. Census Bureau, 2010 Decennial Census. Table DP-1

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. More than 15.5 million tourists visited and stayed at least one night at the Oregon Coast in 2018. The average travel party along the Oregon Coast contained three people (Longwoods International, 2017a). Approximately 57% of overnight trips occur from April to September (Longwoods International, 2017a). Communities in the northern and central coast attracted more tourists than the southern communities, and Lincoln County received the largest single-county share of tourists. Between 2016 and 2018, visitors in Region 1 mostly lodged in hotels, motels, campgrounds, or vacation homes rather than in private homes (Dean Runyan Associates, 2019).

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

Table 2-80. Annual Visitor Estimates in Person Nights (x1000) in Region 1

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 1	15,635	—	15,535	—	15,695	—
North Coast	6,463	100%	6,420	100%	6,473	100%
Hotel/Motel	3,152	48.8%	3,098	48.3%	3,118	48.2%
Private Home	750	11.6%	763	11.9%	777	12.0%
Other	2,561	39.6%	2,559	39.9%	2,578	39.8%
Clatsop	3,914	100%	3,871	100%	3,903	100%
Hotel/Motel	2,401	61.3%	2,358	61%	2,371	60.7%
Private Home	495	12.6%	498	13%	507	13.0%
Other	1,018	26.0%	1,016	26%	1,025	26.3%
Tillamook	2,549	100%	2,548	100%	2,570	100%
Hotel/Motel	751	29.5%	740	29.0%	747	29.1%
Private Home	255	10.0%	265	10.4%	270	10.5%
Other	1,543	60.5%	1,543	60.6%	1,553	60.4%
Central Coast*	4,981	100%	4,971	100%	5,029	100%
Hotel/Motel	2,644	53.1%	2,633	53.0%	2,672	53.1%
Private Home	625	12.5%	624	12.6%	634	12.6%
Other	1,712	34.4%	1,714	34.5%	1,723	34.3%
Lincoln	4,981	100%	4,971	100%	5,029	100%
Hotel/Motel	2,644	53.1%	2,633	53.0%	2,672	53.1%
Private Home	625	12.5%	624	12.6%	634	12.6%
Other	1,712	34.4%	1,714	34.5%	1,723	34.3%
South Coast	4,191	100%	4,144	100%	4,193	100%
Hotel/Motel	1,570	37.5%	1,551	37.4%	1,555	37.1%
Private Home	1,044	24.9%	1,038	25.0%	1,054	25.1%
Other	1,577	37.6%	1,555	37.5%	1,584	37.8%
Coos	2,592	100%	2,567	100%	2,591	100%
Hotel/Motel	1,109	42.8%	1,096	42.7%	1,096	42.3%
Private Home	816	31.5%	813	31.7%	825	31.8%
Other	667	25.7%	658	25.6%	670	25.9%
Curry	1,599	100%	1,577	100%	1,602	100%
Hotel/Motel	461	28.8%	455	28.9%	459	29%
Private Home	228	14.3%	225	14.3%	229	14%
Other	910	56.9%	897	56.9%	914	57%

*Central Coast also includes the coastal portions of Douglas and Lane Counties; data is not aggregated for coastal portions of these counties within the report. See Region 3 (Lane) and Region 4 (Douglas) profiles for the entire county tourism data.

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003).

Compared to the state as a whole, more people in Region 1 identify as having a disability. The region also has a disproportionate share of younger people (< 18) and older adults (≥ 65) with a disability. Within the region, Coos County has the largest share of older adults with a disability—approximately nine percentage points higher than the state average. Accurately measuring the number of children with a disability is challenging, especially in counties with a smaller overall population. For example, the estimate of young people with a disability for Curry County has low reliability, and estimates for all other coastal counties should be used with caution.

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Table 2-81. People with a Disability by Age Group in Region 1

	With a Disability (Total Population)			Under 18 Years with a Disability			65 Years and Over with a Disability		
	Estimate	CV**	MOE (+/–)	Estimate	CV**	MOE (+/–)	Estimate	CV**	MOE (+/–)
Oregon	14.6%	✓	0.1%	4.6%	✓	0.2%	37.1%	✓	0.4%
Region 1	21.7%	✓	0.7%	6.9%	✓	1.0%	41.5%	✓	1.5%
Clatsop	19.1%	✓	1.4%	5.6%	⊙	1.6%	38.5%	✓	3.1%
Coos	23.4%	✓	1.5%	8.0%	⊙	2.3%	46.3%	✓	3.0%
Curry	23.4%	✓	2.1%	6.5%	⊗	4.2%	42.0%	✓	4.4%
Lincoln	21.7%	✓	1.1%	6.7%	⊙	1.7%	39.0%	✓	2.4%
Tillamook	20.2%	✓	1.7%	6.6%	⊙	1.8%	37.8%	✓	3.7%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau, 20013–2017 American Community Survey 5-Year Estimates, Table DP02

Homeless Population

The U.S. Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count (PIT), a biennial count of both sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors. They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing and Community Services, 2019, Nov. 21). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing and Community Services, 2019, Nov. 21).

The majority of families experiencing homelessness—over 3,000 people—live in coastal counties or southern Oregon (Oregon Housing and Community Services, 2019, Nov. 21). Additionally, both Coos and Clatsop Counties have concentrations of children living on their own and experiencing homelessness (Oregon Housing and Community Services, 2019, Nov. 21). According to the PIT, between 2015 and 2019 the region reported a 34.1% increase in its unhoused population. Homelessness in Lincoln County grew most quickly, vastly outpacing other regional counties. However, Coos and Clatsop counties have the largest absolute number of people experiencing homelessness. Coos County reported a drop in its unhoused population in 2017 but reported a similar number in 2019 as in 2015.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate their vulnerability. Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-82. Homeless Population Estimate for Region 1

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 1	1,540	1,655	2,065	1,753
Clatsop	682	680	894	752
Coos	612	397	613	541
Curry	86	161	118	122
Lincoln	54	186	260	167
Tillamook	106	231	180	172

Source: Oregon Point in Time Homeless Count, Oregon Housing and Community Services.

Biological Sex and Gender

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019, Apr. 3). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019, Apr. 3).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019, Apr. 3). According to the survey, there are slightly more women than men in Region 1 (96.6 men to every 100 women) (U.S. Census Bureau, 2019, Mar. 31). This is true for all counties in the region, except Tillamook, which has a more even split. The regional ratio is slightly below the statewide split (98.3 men to every 100 women) (U.S. Census Bureau, 2019, Mar. 31).

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognized (Enarson, 2017). This is an area deserving of more attention as the field develops.

Age

Older adults, those 65 and older, comprise a larger share of the population in Region 1 than they do in the state as a whole. This is true for all counties in the region, and is likely influenced by a high number of retirees in the region. An older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

Children also represent a vulnerable segment of the population. Though the share of children in Region 1 is less than the share statewide, at least 15% of all people in each coastal county are under 18 years old. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. In addition, parents might lose time and money when their children's childcare facilities and schools are impacted by disasters.

Table 2-83. Population by Vulnerable Age Group, in Region 1

	Total Population	Under 18 Years Old			65 Years and Older		
	Estimate	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
Oregon	4,025,127	21.5%	☑	0.1%	16.3%	☑	0.1%
Region 1	196,466	18.1%	☑	0.1%	24.7%	☑	0.2%
Clatsop	38,021	19.6%	☑	0.2%	20.1%	☑	0.3%
Coos	62,921	18.6%	☑	0.1%	24.4%	☑	0.2%
Curry	22,377	15.2%	☑	0.3%	32.3%	☑	0.4%
Lincoln	47,307	17.2%	☑	0.1%	25.9%	☑	0.1%
Tillamook	25,840	19.1%	☑	0.3%	23.7%	☑	0.3%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau, 20013–2017 American Community Survey 5-Year Estimates, Table DP05

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to language and culturally appropriate outreach materials. In the Oregon Coast Region, most residents speak English as their primary language. Due to sampling techniques employed by the American Community Survey, some estimates for Region 1 should be used with caution. Including the margin of error, however, it is clear that from 0.7% to 3.9% of each county does not speak English "very well." Communities creating outreach materials used to communicate with and plan for populations who do not speak English very well should take into consideration the language needs of these populations.

Table 2-84. English Usage in Region 1

	Speak English Less Than "Very Well"				
	Estimate	MOE (+/−)	CV**	Percent	% MOE (+/−)
Oregon	222,428	4,116	☑	5.9%	0.1%
Region 1	4,008	1,063	⊙	2.1%	0.6%
Clatsop	957	226	☑	2.7%	0.6%
Coos	902	235	⊙	1.5%	0.4%
Curry	308	144	⊙	1.4%	0.7%
Lincoln	1,131	224	☑	2.5%	0.5%
Tillamook	710	234	⊙	2.9%	1.0%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

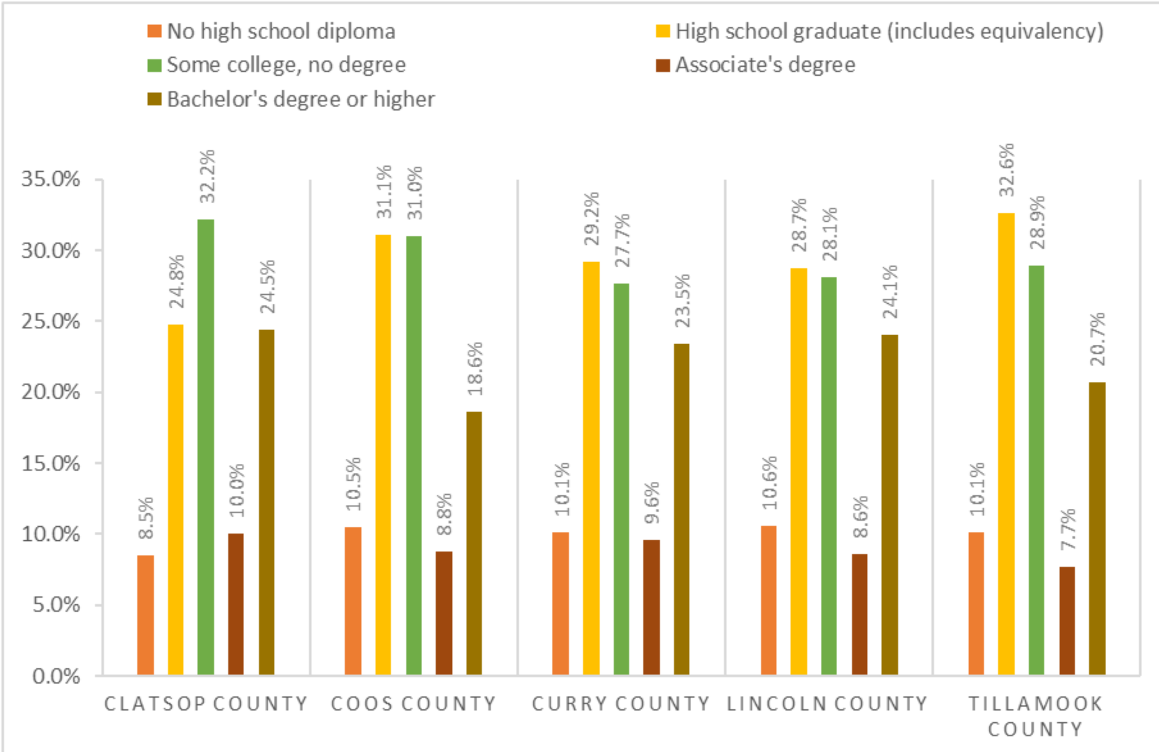
Source: U.S. Census Bureau, 20013–2017 American Community Survey 5-Year Estimates, Table DP02

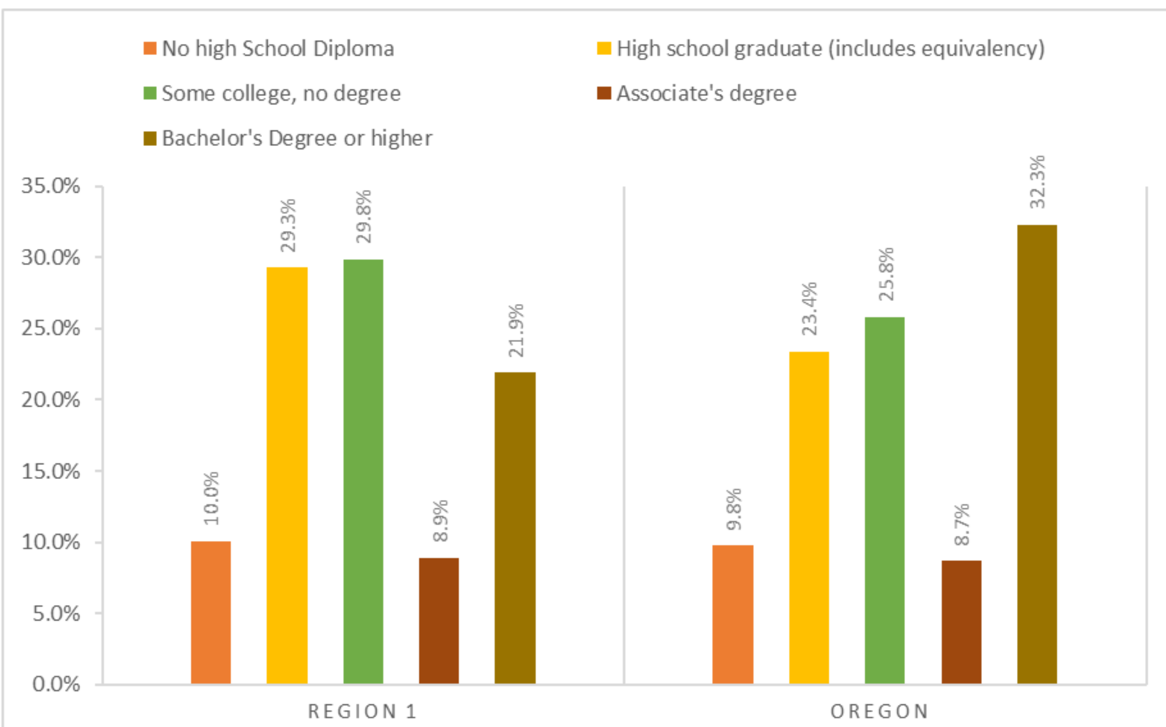
Education Level

Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual's ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

Nearly 22 % of the population in Region 1 has a bachelor's degree or higher, which is ten percentage points lower than the statewide estimate. The portion of the population without a high school diploma closely matches the statewide number, and approximately one third of the population in each coastal county has received some college credit. Within the region, Clatsop and Lincoln Counties have the highest levels of attainment, with a greater share of residents holding a degree at the associate's level or higher.

Figure 2-118. Educational Attainment in Region 1





Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, Table DP02

Income and Poverty

The impact of a disaster in terms of loss and the ability to recover varies among population groups. "The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event" (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public (Stahl, P., 2000). Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, and less likely to have the savings to rebuild after a disaster. They are also less likely to have access to transportation and medical care.

Across the region, median household income is approximately $6,000 to $15,000 lower than the statewide median. Additionally, from 2012 to 2017, no county in the region experienced a statistically significant change in median household income.

Table 2-85. Median Household Income in Region 1

	2008–2012			**2013–2017**			**Statistically Different***
	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)	
Oregon	$53,427	☑	$338	$56,119	☑	$370	Yes
Region 1	—	—	—	—	—	—	—
Clatsop	$47,325	☑	$1,892	$49,828	☑	$1,932	No
Coos	$40,647	☑	$2,175	$40,848	☑	$1,581	No
Curry	$41,020	☑	$2,433	$42,519	☑	$6,221	No
Lincoln	$44,678	☑	$1,930	$43,291	☑	$1,854	No
Tillamook	$45,102	☑	$1,776	$45,061	☑	$2,463	No

Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

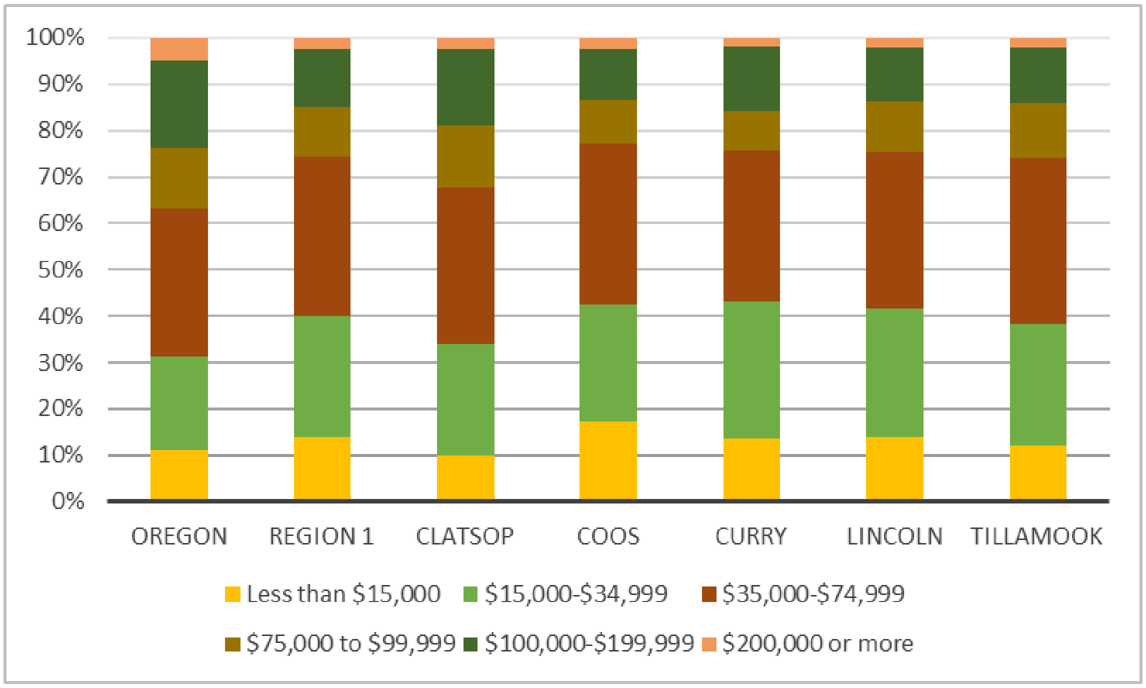
*Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2002 and 2013-2017. American Community Survey – 5-Year Estimates. Table CP03.

Approximately 40% of Region 1 households earn less than $35,000 per year. Clatsop County has the highest percentage of households in the top income brackets, earning more than $75,000. Compared to the statewide estimate, a smaller percentage—by approximately eleven percentage points—of households in coastal counties are in the top income brackets.

Figure 2-119. Median Household Income Distribution in Region 1



Source: U.S. Census Bureau, 2013-2017, American Community Survey 5-Year Estimates, Table DP03

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018). A greater share of the regional population is living in poverty compared to the state as a whole. The same is true for all counties in the region, with the exception of Clatsop County. Among the coastal counties, Lincoln County has the greatest percentage of residents living in poverty. The county share increased by more than two percentage points from 2012 to 2017. Conversely, poverty in Clatsop County declined by a statistically significant amount—approximately three and a half percentage points—during that same period.

A greater proportion of children in coastal communities are living in poverty than in the state as a whole; there is a four percentage point difference between the coastal and the statewide share. From 2012 to 2017, child poverty decreased by over ten percentage points in Clatsop County—a statistically significant amount. Conversely, in Lincoln County, child poverty increased by ten percentage points.

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources.

Table 2-86. Poverty Rates in Region 1

	Total Population in Poverty						
	2008–2012			2013–2017			Statistical Difference?*
	Estimate	CV**	MOE (+/–)	Estimate	CV**	MOE (+/–)	
Oregon	15.5%	☑	0.3%	14.9%	☑	0.3%	No
Region 1	16.3%	☑	0.9%	16.3%	☑	1.0%	No
Clatsop	15.8%	☑	1.8%	12.2%	☑	1.6%	Yes
Coos	17.3%	☑	1.7%	17.9%	☑	2.1%	No
Curry	13.7%	☑	2.4%	15.5%	☑	2.7%	No
Lincoln	16.0%	☑	1.6%	18.4%	☑	1.7%	Yes
Tillamook	17.2%	☑	2.6%	15.5%	☑	2.4%	No

*Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2012 and 2013-2017. American Community Survey – 5-Year Estimates, Table S1701

Table 2-87. Child Poverty in Region 1

	Children Under 18 in Poverty						
	2008–2012			2013–2017			Statistical Difference?*
	Estimate	CV**	MOE (+/–)	Estimate	CV**	MOE (+/–)	
Oregon	20.6%	☑	0.5%	19.0%	☑	0.6%	Yes
Region 1	22.6%	☑	2.2%	23.4%	☑	2.6%	No
Clatsop	25.0%	☑	4.8%	14.6%	⊙	3.7%	Yes
Coos	23.1%	☑	3.9%	25.2%	☑	5.6%	No
Curry	14.8%	⊙	5.6%	20.6%	⊙	9.6%	No
Lincoln	20.5%	☑	4.4%	30.4%	☑	4.9%	Yes
Tillamook	26.7%	⊙	6.8%	22.9%	⊙	5.7%	No

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2012 and 2013-2017. American Community Survey – 5-Year Estimates, Table S1701

Housing Tenure

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

Oregon's coastal counties have a slightly greater percentages of homes that are owner-occupied than the state as a whole. Tillamook County has the greatest percentage of owner-occupied homes in the region. Clatsop County has the greatest percentage of renters.

Table 2-88. Housing Tenure in Region 1

	Total Occupied Units	Owner Occupied			Renter Occupied		
		Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
Oregon	1,571,631	61.7%	☑	0.3%	38.3%	☑	0.3%
Region 1	83,959	64.8%	☑	1.2%	35.2%	☑	1.1%
Clatsop	15,976	61.1%	☑	2.1%	38.9%	☑	2.1%
Coos	26,473	65.2%	☑	1.9%	34.8%	☑	1.9%
Curry	10,382	67.5%	☑	2.9%	32.5%	☑	2.9%
Lincoln	20,674	63.6%	☑	1.9%	36.4%	☑	1.9%
Tillamook	10,454	69.2%	☑	2.5%	30.8%	☑	2.5%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP04: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households. Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only. While the majority of households in Region 1 are family households, every county in the region has a smaller proportion of family households compared to the statewide estimate. The region also has a smaller share of households with children compared to the statewide proportion; roughly one fifth of all family households in the region have children versus a quarter of all households in the state. The region's percentage of single-parent households is slightly lower than the state average but is still approximately 7% of family households

Table 2-89. Family vs. Non-Family Households in Region 1

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
Oregon	1,571,631	63.3%	☑	0.2%	36.7%	☑	0.2%	27.7%	☑	0.2%
Region 1	83,959	60.6%	☑	1.2%	39.4%	☑	1.2%	32.4%	☑	1.1%
Clatsop	15,976	60.6%	☑	2.1%	39.4%	☑	2.1%	32.2%	☑	1.8%
Coos	26,473	62.5%	☑	1.9%	37.5%	☑	1.9%	32.1%	☑	1.9%
Curry	10,382	55.8%	☑	3.3%	44.2%	☑	3.3%	36.3%	☑	3.5%
Lincoln	20,674	59.8%	☑	1.8%	40.2%	☑	1.8%	31.9%	☑	1.7%
Tillamook	10,454	62.1%	☑	3.3%	37.9%	☑	3.3%	30.8%	☑	3.1%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. https://data.census.gov/cedsci/. Table DP02: Selected Social Characteristics

Table 2-90. Family Households with Children by Head of Household in Region 1

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
Oregon	26.2%	✓	0.2%	8.1%	✓	0.2%
Region 1	19.2%	✓	0.8%	7.1%	✓	0.6%
Clatsop	22.6%	✓	1.6%	7.7%	✓	1.3%
Coos	21.1%	✓	1.5%	7.4%	✓	1.3%
Curry	14.5%	✓	2.7%	5.2%	⊙	1.9%
Lincoln	15.9%	✓	1.2%	6.8%	✓	1.0%
Tillamook	20.3%	✓	1.9%	7.5%	✓	1.6%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. https://data.census.gov/cedsci/. Table DP02: Selected Social Characteristics. 2013-2017 American Community Survey 5-Year Estimates

Social and Demographic Trends

The demographic analysis shows Region 1 is particularly vulnerable to a hazard event in the following ways:

- The region has a large number of tourists, with Lincoln County receiving the largest single-county share.
- A higher percentage of the overall population has a disability compared to the statewide estimates. Moreover, a higher percentage of vulnerable age groups (< 18) and (≥ 65) have a disability compared to the statewide estimates.
- Homelessness has increased in the region over the past three years. Moreover, the majority of families experiencing homelessness—over 3,000 people—live in coastal counties and southern Oregon.
- The region has a higher percentage of older adults (≥ 65) compared to the state
- Educational attainment is lower in all coastal counties compared to statewide estimates.
- Median household income is approximately $6,000 to $15,000 lower than the statewide median. Moreover, no county in the region has experienced a statistically significant change in median income.
- A higher percentage of Region 1 residents are in the bottom income brackets, earning less than $35,000 annually, compared to the state

Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses' labor, capital, suppliers, and customers are all relevant factors (Zhang, Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang, Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent.

Employment and Unemployment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 1 have been steadily declining since they peaked in 2010 during the Great Recession. The counties in the north coast consistently have lower rates than the counties in the central and southern parts of the state; however, rates in these counties are near record lows (2019, May 29). Nevertheless, Curry County has the highest unemployment rate in the region and the smallest labor force. Coos County has the largest labor force in the region but has the second highest unemployment rate.

Table 2-91. Civilian Labor Force in Region 1, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 1	87,824	83,491	95.1%	4,333	4.9%
Clatsop	19,344	18,549	95.9%	795	4.1%
Coos	26,460	25,027	94.6%	1,433	5.4%
Curry	8,948	8,399	93.9%	549	6.1%
Lincoln	21,215	20,184	95.1%	1,031	4.9%
Tillamook	11,857	11,332	95.6%	525	4.4%

Source: Oregon Employment Department, 2019

Table 2-92. Civilian Unemployment Rates in Region 1, 2014-2018

	2014	2015	2016	2017	2018	Change (2014-2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	−2.6%
Region 1	8.0%	6.7%	5.7%	4.9%	4.9%	−3.1%
Clatsop	6.6%	5.5%	4.7%	4.1%	4.1%	−2.5%
Coos	9.0%	7.4%	6.4%	5.5%	5.4%	−3.6%
Curry	10.1%	8.2%	6.7%	6.1%	6.1%	−4.0%
Lincoln	7.8%	6.6%	5.6%	4.8%	4.9%	−2.9%
Tillamook	6.9%	5.6%	4.9%	4.2%	4.4%	−2.5%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups "economic units that have similar production processes" according to a six-digit hierarchical structure (Office of Management and Budget, n.d.). "The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry" (Office of Management and Budget, n.d.). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors (U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 1 were:

1. Leisure and Hospitality
2. Trade, Transportation and Utilities
3. Local Government
4. Education and Health Services
5. Manufacturing

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region's resiliency. A business establishment is an "economic unit… that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity" (U.S. Bureau of Labor Statistics, 2019, Sept. 4). In Region 1, the following supersectors comprise a significant share of all business establishments.

- The Trade, Transportation, and Utilities supersector includes the highest number of establishments in Region 1, 18% of all business units (QCEW, 2018).
- Other Services is the second largest, with 15.5% of all business establishments (QCEW, 2018).
- The Leisure and Hospitality supersector follows closely with 15.1% of the regional share (QCEW, 2018).
- Professional and Business comprises 10% of all business establishments (QCEW, 2018)

- The Construction sector is the fifth largest, making up 9% of all establishments (QCEW, 2018).

While supersectors are useful abstractions, it's important to remember that within each supersector are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event.

Table 2-93. Covered Employment by Sector in Region 1

	Region 1	Clatsop County		Coos County		Curry County		Lincoln County		Tillamook County	
Industry	Percent	Employment	Percent	Employment	Percent	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	18,808	100.0%	23,091	100.0%	6,579	100.0%	18,516	100.0%	9,654	100.0%
Total Private Coverage	80.6%	16,120	85.7%	17,647	76.4%	5,338	81.1%	14,804	80.0%	7,856	81.4%
Natural Resources & Mining	3.4%	334	1.8%	944	4.1%	288	4.4%	306	1.7%	751	7.8%
Construction	4.5%	947	5.0%	959	4.2%	398	6.0%	814	4.4%	367	3.8%
Manufacturing	8.9%	1,757	9.3%	1,726	7.5%	669	10.2%	1,098	5.9%	1,555	16.1%
Trade, Transportation & Utilities	17.9%	3,514	18.7%	4,265	18.5%	1,180	17.9%	3,358	18.1%	1,425	14.8%
Information	0.7%	143	0.8%	173	0.7%	54	0.8%	149	0.8%	50	0.5%
Financial Activities	3.0%	607	3.2%	672	2.9%	210	3.2%	615	3.3%	199	2.1%
Professional & Business Services	6.0%	828	4.4%	2,063	8.9%	276	4.2%	1,055	5.7%	403	4.2%
Education & Health Services	12.8%	2,386	12.7%	3,341	14.5%	793	12.1%	2,117	11.4%	1,148	11.9%
Leisure & Hospitality	19.5%	4,873	25.9%	2,704	11.7%	1,222	18.6%	4,659	25.2%	1,506	15.6%
Other Services	3.7%	726	3.9%	798	3.5%	245	3.7%	620	3.3%	451	4.7%
Unclassified	0.0%	5	0.0%	2	0.0%	3	0.0%	14	0.1%	2	0.0%
Total All Government	19.4%	2,689	14.3%	5,443	23.6%	1,241	18.9%	3,711	20.0%	1,799	18.6%
Total Federal Government	1.3%	203	1.1%	313	1.4%	90	1.4%	319	1.7%	106	1.1%
Total State Government	1.9%	309	1.6%	459	2.0%	112	1.7%	292	1.6%	306	3.2%
Total Local Government	16.1%	2,177	11.6%	4,672	20.2%	1,038	15.8%	3,100	16.7%	1,387	14.4%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Retail businesses are concentrated in the larger cities of the region and disruption of the transportation system could sever the connectivity between people living throughout the region and these retail hubs.

Leisure and Hospitality: This sector primarily serves regional residents with disposable income and tourists. Following a natural disaster, residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Education and Health Services: The importance of Health and Social Assistance industries is underscored in Region 1 because of the significant share of older adults and individuals with a disability. Health care is a relatively stable revenue sector regionally with an abundant distribution of businesses primarily serving a local population. Following a disaster, Health and Social Assistance industries will play important roles in emergency response and recovery.

Manufacturing: This sector is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons, the manufacturing sector may be susceptible to disruptions in transportation infrastructure. However, manufacturers are frequently less dependent on local markets for sales, which may contribute to the economic resilience of this sector.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. In Region 1, the two largest subsectors by share of employment are Food Services and Drinking Places and Accommodation; both subsectors fit within the region's largest supersector by share of employment, Leisure and Hospitality. These subsectors also constitute the largest employers across the states. More unique to the region is the high percentage of employment in Food Manufacturing subsector.

Table 2-94. Industries with Greatest Share of Employment in Region 1, 2018

Industry	Employment Share	Employment (2018)
Food Services and Drinking Places	14%	11,587
Accommodation	9%	7,388
Educational Services	6%	5,106
Administrative and Support Services	5%	3,734
Ambulatory Health Care Services	4%	3,419
Hospitals	4%	3,297
Food Manufacturing	4%	2,918
Food and Beverage Stores	3%	2,714
Social Assistance	3%	2,609
Executive, Legislative, and Other General Government Support	3%	2,567

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for employment share and average employment by DLCD

Industry Concentration and Employment Change

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

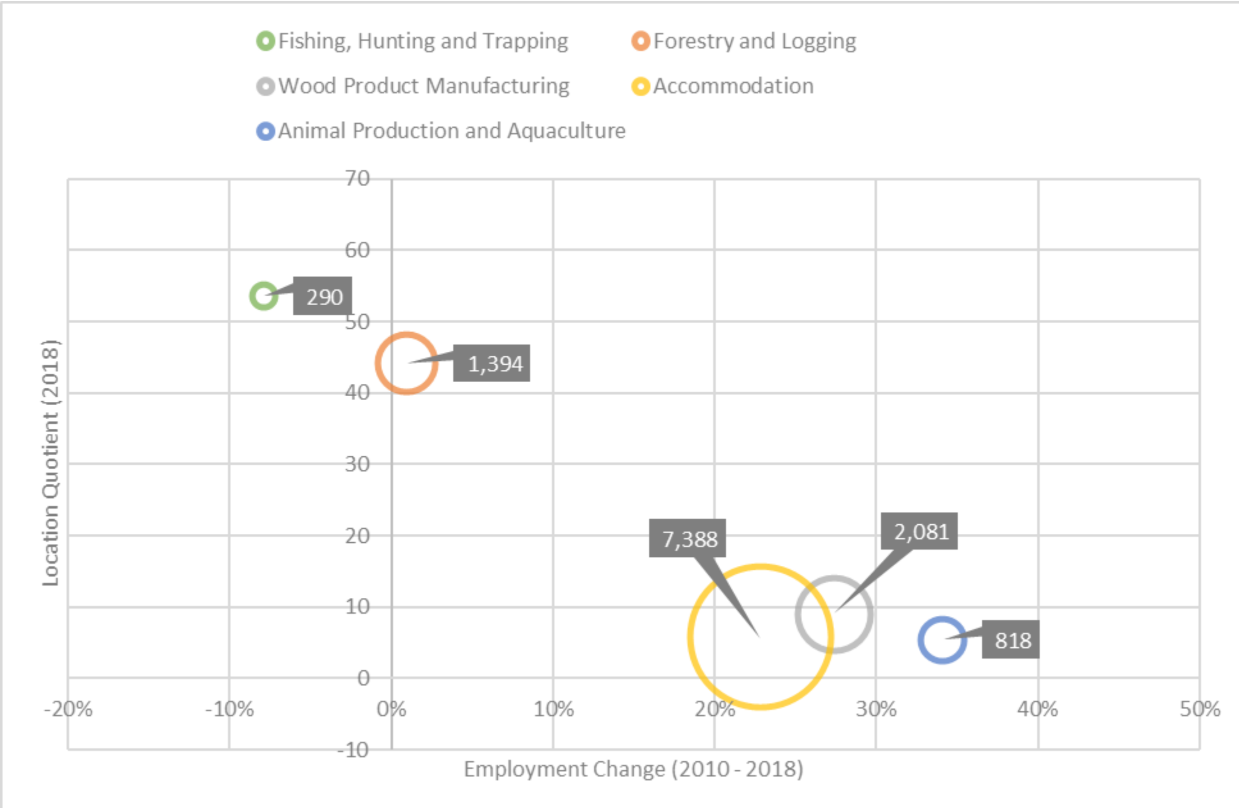
Table 2-95. Most Concentrated Industries and Employment Change in Region 1, 2018

Industry	Location Quotient	Employment	Employment Change (2010–2018)
Fishing, Hunting and Trapping	53.6	290	−8%
Forestry and Logging	44.1	1,394	1%
Wood Product Manufacturing	8.9	2,081	27%
Accommodation	5.9	7,388	23%
Animal Production and Aquaculture	5.4	818	34%

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 1 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-120. Location Quotients, Employment Change, and Total Employment in Region 1, 2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

Four of the region's five most concentrated industries are natural resource based. Fishing, Hunting, and Trapping is much more concentrated in the region vis-à-vis the nation. The sector represents a small share of overall regional employment, however, and shed jobs over the last eight years. The Forestry and Logging industry is also much more concentrated in Region 1 than the nation. From 2010 to 2018, employment remained relatively constant in the sector. Wood Manufacturing is a related area of competitive advantage; moreover, the industry is one of the larger employers and experienced significant growth in the past eight years.

Fastest Growing and Declining Industries

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang, Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining. Between 2010 and 2018, the Private Households and Beverage and Tobacco Product Manufacturing industries experienced significant increases in employment within the region—both also have more than one-hundred employees. Growth in the Beverage and Tobacco Product Manufacturing industry is likely driven by Oregon's thriving craft-beer scene, which continues to grow despite a crowded market (Lehner, 2020). The Private Households industry employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019). The increase in employment in the Private Households industry mirrors a statewide trend (Wallis, 2019). Demand is driven in part by an aging population's need for in-home care workers (Wallis, 2019). Continuing a decade's long statewide trend, the Paper Manufacturing industry in Region 1 shed nearly nine-hundred positions from 2010 to 2018 (Knoder, Paper cuts: Oregon's declining paper industry, 2018, December 6). Increased competition from abroad is a key driver of employment loss statewide (Knoder, Paper cuts: Oregon's declining paper industry, 2018, December 6).

Table 2-96. Fastest Growing and Declining Industries in Region 1, 2010-2018

Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Warehousing and Storage	497%	8	48
Performing Arts, Spectator Sports, & Related Industries	387%	13	65
Other Information Services	127%	37	83
Private Households	127%	333	757
Beverage and Tobacco Product Manufacturing	126%	120	270
Fastest Declining			
Paper Manufacturing	−100%	875	0
Air Transportation	−100%	68	0
Plastics and Rubber Products Manufacturing	−100%	31	0
Textile Product Mills	−100%	25	0
Furniture and Related Product Manufacturing	−72%	23	6

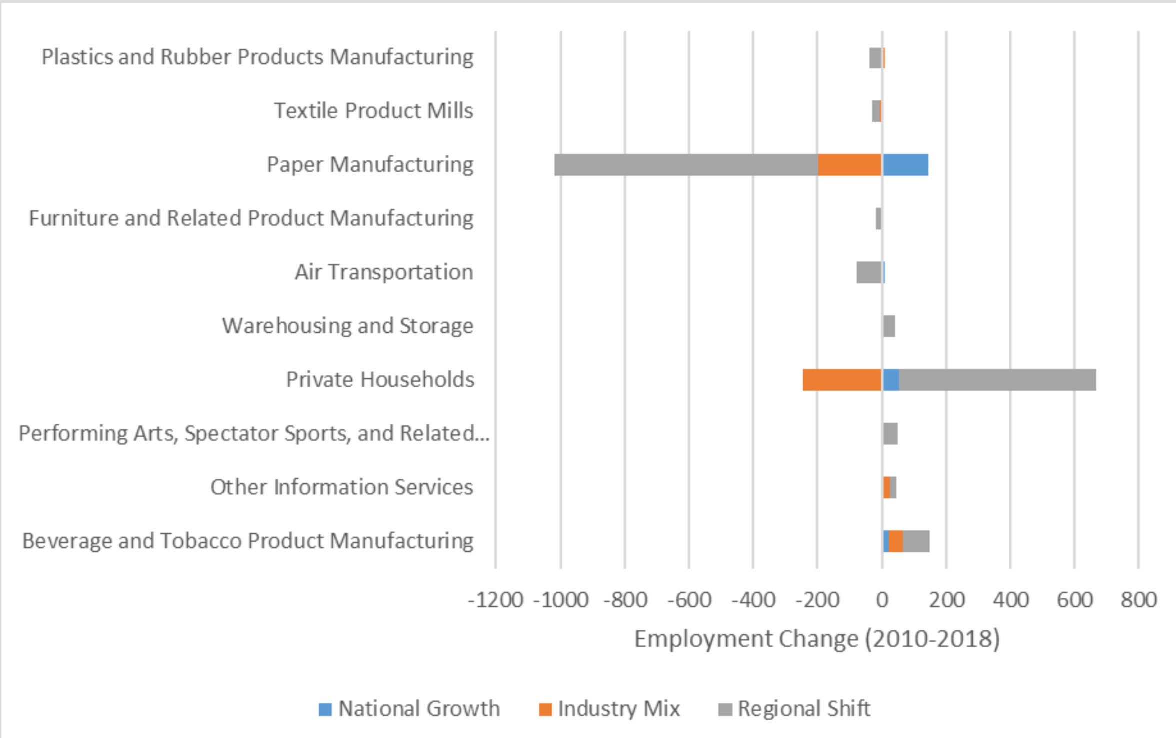
U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors.

The bar chart below depicts a shift-share analysis for Region 1's fastest growing and declining industries. As mentioned previously, the paper manufacturing industry shed 875 jobs from 2010 to 2018. If during this period the industry had kept pace with national economic growth (across all industries), the region would have 144 additional Paper Manufacturing jobs. If employment losses had mirrored changes in the Paper Manufacturing industry nationwide, there would only be 199 fewer Paper Manufacturing jobs in the region. This indicates that vast majority, 821 positions, were lost due to some regional factors, such as a factory closing.

Much of the growth (613 jobs) in the regional Private Household industries can be attributed to regional factors, again, likely driven by an aging population. Although some of the expansion in the Beverage and Tobacco Product Manufacturing industry can be understood by growth in the industry nationwide (44 jobs), the majority of employment was unique to the region (87 jobs); again, this is likely an indication of Oregon's booming craft beer business.

Figure 2-121. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 1, 2010-2018



U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Table 2-97. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 1, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Beverage and Tobacco Product Manufacturing	151	20	44	87
Other Information Services	47	6	19	22
Performing Arts, Spectator Sports, and Related Industries	51	2	1	48
Private Households	423	55	-245	613
Warehousing and Storage	40	1	6	32
Fastest Declining				
Air Transportation	−68	11	−4	−75
Furniture and Related Product Manufacturing	−16	4	−1	−19
Paper Manufacturing	−875	144	−199	−821
Textile Product Mills	−25	4	−5	−25
Plastics and Rubber Products Manufacturing	−31	5	1	−37

U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by

Economic Trends and Issues

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the following situations increase Oregon Coastal communities' level of vulnerability to natural hazard events:

- Unemployment rates are higher than the state average in Curry, Coos, and Lincoln and Tillamook Counties;
- The region's most competitive industries (according to LQ) employ a small share of the overall population;
- The regional economy is heavily dependent on tourism and seasonal employment;
- The regional economy is lacking in opportunities for highly skilled employees, limiting the income potential of coastal residents;
- Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- From 2010 to 2018, the decade's long trend of declining employment in the Paper Manufacturing subsector continued—shedding skilled manufacturing jobs in the region.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl, et al., 2000).

Infrastructure

Transportation

There are two primary modes of transportation in the region: highways and railroad. There are also many small airports scattered throughout the region that are used for passenger and freight service.

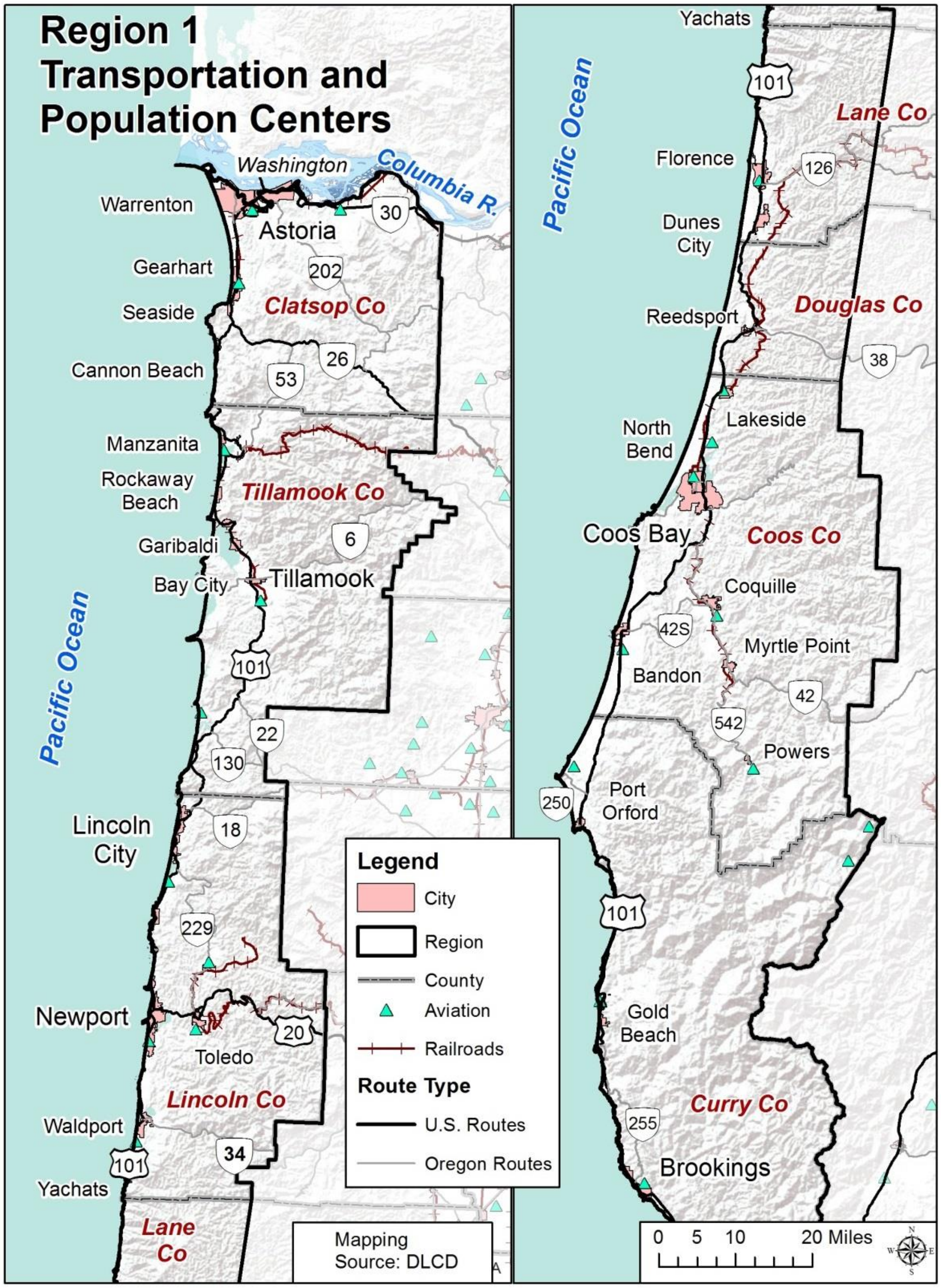
Roads

Most of the population bases in Region 1 are located along the region's major freeway, US-101. US-101 runs north-south and is the only continuous passage for automobiles and trucks traveling along the Oregon Coast. Coastal communities are connected to the interior of the state by many routes.

Natural hazards and emergency events disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuations and other emergency operations difficult. Localized flooding can render roads unusable. A severe winter storm or tsunami has the potential to disrupt the daily driving routine of thousands of people.

According to the Oregon Department of Transportation's (2014, October)Seismic Plus Report (Appendix **9.1.13**), the region has high exposure to earthquakes, especially a Cascadia Subduction Zone event. Therefore, the seismic vulnerability of the region's lifelines, including roadways and bridges, is an important issue. For information on ODOT's 2012 Seismic Lifelines Report findings for Region 1, see **Seismic Lifelines**.

Figure 2-122. Region 1 Transportation and Population Centers



Source: Department of Land Conservation and Development, 2014

Bridges

ODOT lists 750 bridges in the counties that comprise Region 1.

As mentioned, the region's bridges are highly vulnerable to seismic activity. Non-functional bridges disrupt local and freight traffic, emergency operations, and sever lifelines. These disruptions exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or that are part of regional and local systems maintained by the region's counties and cities.

Table 2-98 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. The ratings do not imply that a bridge is unsafe (ODOT, 2020). A significant improvement in the condition of the region's bridges reduced to 6% (from 29% in 2012 and 2013) the percentage of the region's bridges that are distressed or deficient. About 2% (from 42% in 2012 and 2013) of the region's ODOT bridges are distressed.

Table 2-98. Bridge Inventory for Region 1

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 1	6	313	2%	29	374	8%	4	22	18%	3	41	7%	42	750	6%
Clatsop	2	73	3%	4	52	8%	1	17	6%	3	9	33%	10	151	7%
Coos	0	62	0%	3	114	3%	1	2	50%	0	11	0%	4	189	2%
Curry	0	29	0%	3	31	10%	0	0	N/A	0	0	N/A	3	60	5%
Lincoln	2	73	3%	10	85	12%	2	2	100%	0	6	0%	14	166	8%
Tillamook	2	76	3%	9	92	10%	0	1	0%	0	15	0%	11	184	6%

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total of Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2020)

Railroads

Railroads that run throughout Region 1 support cargo and trade flows. All of the region's rail lines are short lines and freight routes, connecting the coast to larger rail lines and inland metropolitan areas. Curry County is the only coastal community without rail service. The region's rail providers are the Portland & Western Railroad (PNWR), Port of Tillamook Bay Railroad (POTB), and the Coos Bay Rail Link (CBRL). The PNWR lines in Clatsop County connect Astoria and the Portland Metro Area. The POTB line connects Tillamook to inland railways operated by PNWR. Oregon's rail system is critical to the state's economy, energy, and food systems. Rail systems export lumber and wood products, pulp and paper, and other goods produced in Oregon and products from other states that are shipped to and through Oregon by rail (Cambridge Systematics, 2014). Though there is no commuter rail line in the region, there is a local passenger line.

Rails are sensitive to storms. Disruptions in the rail system can result in economic losses. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

Southwest Oregon Regional Airport is the only commercial airport in the region and is the fifth busiest airport in Oregon (Federal Aviation Administration [FAA], 2012). The airport is owned, operated and administered by Coos County Airport District. It serves two hubs and two air carriers (Southwest Oregon Regional Airport, n.d.).

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

Table 2-99. Public and Private Airports in Region 1

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Heliport	Private Heliport	Total
Region 1	16	6	0	10	32
Clatsop	2	1	0	4	7
Coos	4	2	0	2	8
Curry	3	2	0	1	6
Lincoln	4	1	0	2	7
Tillamook	3	0	0	1	4

Source: FAA Airport Master Record (Form 5010) (2014)

Ports

Ports in the Oregon Coast Region are a major contributor to the local, regional, and national economies. Oregon's ports have historically been used for timber transport and commercial and recreational fishing. With the decline in the timber industry, ports have evolved to embrace economic development and tourism by offering industrial land and infrastructure (river, rail, road, and air) and by promoting fresh seafood, fishing trips, and ecotourism. Oregon's coastal ports are divided by region: north, central and south (Coastal Oregon Marine Experiment Station, n.d.). The North Coast ports include: Astoria, Nehalem, and Garibaldi (including Tillamook Bay). The Astoria

Port includes facilities for cruise ships while the Port of Garibaldi/Tillamook Bay encompass more than 1,600 acres of industrial zoned land. The central coast ports include: Newport, Toledo, Alsea, and Siuslaw. The Newport and Siuslaw are active fishing ports that also provide an array of businesses catering to tourists. South coast ports include Umpqua, Coos Bay, Bandon, Port Orford, Gold Beach, and Brookings-Harbor. The Port of Coos Bay is Oregon's largest coastal deep-draft harbor and supports cargo ships that link to the Coos Bay Rail Link (Coastal Oregon Marine Experiment Station, n.d.). The Port of Brookings-Harbor is the busiest recreational port in Oregon with more than 31,000 visitor trips for more than 95,000 recreational boaters (Port of Brookings-Harbor, http://www.port-brookings-harbor.com).

Figure 2-123. Liquefied Natural Gas Pipelines in Region 1

Source: Retrieved from http://gs-press.com.au/images/news_articles/cache/Pacific_Connector_Gas_Pipeline_Route-0x600.jpg

Energy

Electricity

There are no power plants in Region 1. The region is served by several investor-owned, public, cooperative, and municipal utilities. The Bonneville Power Administration is the area's wholesale electricity distributor. Pacific Power and Light (Pacific Power) is the largest investor-owned utility company serving the region. The Blachly-Lane Electric Cooperative, Coos-Curry Electric Cooperative, and Western Oregon Electric Cooperative serve portions of the region. The Bandon Municipal Utility District serves an area around the City of Bandon in Coos County. In addition, the Tillamook People's Utility District, Central Lincoln People's Utility District, and Consumers Power Inc. provide electricity for portions of Region 1.

Hydropower

There are no major dams in the Oregon Coast region, but just east of the region, in the Cascades, there are several major dams — Bonneville, Round Butte, Lookout Point, Carmen-Smith, Detroit, and Pelton dams — that combined have maximum generating capacities of over 100 megawatts of electricity that service the state (Loy, 2001).

Natural Gas

Natural gas provides about 12% of the region's energy. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. The Jordan Cove Energy Project is a proposed liquefied natural gas (LNG) storage facility and power plant within the Port of Coos Bay. If built, this facility would provide LNG storage (320,000 cubic meters), liquefaction capacity (6 million metric tons per year), and sendout capacity (1,000,000 decatherms per day) via the Pacific Connector Gas Pipeline. It would include marine facilities — a single LNG marine berth and a dedicated tractor tug dock —

and the South Dunes Power Plant capable of providing energy for the facility and the local grid (Jordan Cove Energy Project, L.P., n.d.). If developed, the pipeline would extend 235 miles through both public and private lands. **Figure 2-123** shows existing LNG pipelines (in blue) and the proposed Pacific Connector Gas Pipeline (in red) (Oregon Department of Environmental Quality, 2014). LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life, safety, and environmental impacts in the case of a spill.

Utility Lifelines

Most of the Oregon Coast's oil and gas pipelines are connected to main lines that run through the Willamette Valley. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy, and is therefore crucial to consider during the natural hazard planning process. A network of electrical transmission lines, owned by Bonneville Power Administration and Pacific Power, runs through the region. Most of the natural gas Oregon uses originates in Alberta, Canada. Northwest Natural Gas serves the central portion of the Oregon Coast (Loy, 2001). These electric, oil, and gas lines may be vulnerable to severe, but infrequent, natural hazards such as earthquakes. If these lines fail or are disrupted, the essential functions of the community can become severely impaired.

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Parts of Region 1 are included in the Southern Oregon, the South Valley, and the North Coast Operational Areas under The Oregon State Emergency Alert System Plan (OEM, 2013), which also includes parts Jackson, Josephine and Klamath Counties. There is a memorandum of understanding between these counties that facilitates the launching of emergency messages for counties by Jackson County. Counties in this area can launch emergency messages by contacting the Oregon Emergency Response System (OERS) that in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communications capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation's status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The local primary stations identified as emergency messengers by the Oregon State Emergency Alert System Plan are:

- KOBI-TV Channel 36, Coos Bay;
- KOBI-TV Channel 8, Coos Bay;
- KOBI-TV Channel 25, Coos Bay; and
- KOBI-TV Channel 7, Coos Bay.

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband providers serve Region 1. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is becoming more readily available in the region with a greater number of providers and service types available within major communities and along major transportation corridors such as I-5, US-199, etc. (NTIA, n.d.). Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 1 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for Region 1 are (Oregon OEM, 2013):

- KIX-37, 162.550 MHZ, Brookings;
- WIX-32, 162.400 MHZ, Coos Bay;
- WNG-596, 162.425 MHZ, Port Orford;
- WNG-674, 162.525 MHZ, Florence;

- WZ-2509, 162.525 MHZ, Reedsport;
- KIH-33, 162.550 MHZ, Newport;
- WWF-95, 162.475 MHZ, Tillamook;
- KOGL, 89.3 MHZ, Gleneden Beach;
- KTMK, 91.1 MHZ, Tillamook; and
- KWAX-FM, 91.3 MHZ, Toledo.

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). Region 1 is served by Amateur Radio Emergency Service (ARES) District 5. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency Management, n.d.). The official ham emergency station calls for Region 1 include (American Relay Radio League Oregon Chapter, www.arrloregon.org):

- Clatsop County: WA7FIV, KD7IBA;
- Tillamook County: KF7ARK;
- Lincoln County: none available at this time;
- West Lane County: K7BHB;
- Douglas County: K7AZW;
- Coos County: KE7EIB; and
- Curry County: W7VN.

Water

Drinking water, stormwater, and wastewater systems all possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In Region 1 the majority of the municipal drinking water supply is primarily obtained from surface water. Each county's water is drawn from several major waterways, including the Youngs, Nehalem, Wilson, Nestucca, Siletz, Yaquina, Alsea, Siuslaw, Umpqua, Coos, Coquille, and Rogue Rivers. Most urbanized areas also have infrastructure for groundwater wells in case of a surface water shortage. Because of high levels of turbidity in streams during heavy rain events, many communities are investing in new well fields. However, groundwater drawn within the floodplain is often heavy in iron, causing undesirable odor and taste, although no health risks have been associated with heavy iron levels. Earthquakes pose a major threat to the region's water supply because of the risk of dam failure at the region's reservoirs.

Rural residents may get water primarily from groundwater wells. These wells generally have low flow levels due to the region's predominantly volcanic soils. Areas with sedimentary and volcanic soils may be subject to high levels of arsenic, hydrogen sulfide, and fecal coliform bacteria, which can impact the safety of groundwater sources, although the coast is less subject to concerns about arsenic than inland areas of Oregon.

Water rights for rivers and streams in the region have reached a tipping point due to low summer water flows. New water rights cannot be purchased in Region 1. However, conservation approaches now allow landowners to share or sell a portion of their water rights to downstream users. To supplement high demand during summer irrigation, many farmers in the region are turning to above-ground water storage gathered from streams in the winter.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. Non-point source pollution is a major threat to surface water quality, and may include stormwater runoff from roadways, agricultural operations, timber harvest, erosion, and sedimentation. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Landslides, flood events, and earthquakes and resulting liquefaction can cause increased erosion and sedimentation in waterways.

Underground water supplies and aging or outdated infrastructure — such as reservoirs, treatment facilities, and pump stations — can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, thus limiting access to potable water. This can lead to unsanitary conditions that may threaten human health and limit fire suppression. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enters surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers) flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 1, most local building codes and stormwater management plans emphasize use of centralized storm sewer systems to manage stormwater. Low impact development (LID) mitigation strategies can alleviate or lighten the burden to a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, lower speeds, and lower temperatures. No jurisdictions in Region 1 refer to LID techniques in their stormwater management plans. Requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems, and increase a community's resilience to flooding and seismic events, among other hazards.

Infrastructure Trends and Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack, or poor condition, of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance in infrastructure systems help create system resiliency (Meadows, 2008).

The effects of road, bridge, rail, and airport failures on the economy and residents could be devastating. Of special concern is the impact to US-101 and bridges following a Cascadia earthquake event and resulting tsunami. This infrastructure is at risk of damage, collapse, and blockage by landslides, flooding, and debris.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. Transmission lines extend long distances to provide the region with power, making the system and region more vulnerable to possible disruptions and infrastructure damage during a disaster event. The proposed Jordan Cove LNG facility, if developed, would provide a local energy supply.

Multiple telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services do not cover many rural areas of the region that are distant from the region's major transportation corridor along US-101. This may present a communication challenge in the wake of a disaster. Encouraging residents to keep AM/FM radios available for emergency situations could aid in communicating important messages throughout the region.

Older centralized water systems are particularly vulnerable to hazard events. The region is also at risk of pollutants entering waterways through stormwater runoff and combined sewer overflows (CSOs) during high-water events. The implementation of decentralized LID stormwater systems can increase the region's capacity to better manage high-precipitation events.

Built Environment

Settlement and Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program is the 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD, https://www.oregon.gov/lcd/OP/Pages/Goal-7.aspx).

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people or an "urban cluster" of at least 2,500 people (but less than 50,000). Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-100**and **Table 2-101** remain from the 2010 Census.

Over the 10 year period between 2000 and 2010, growth in urban areas in Region 1 was only half that of the state. However, two counties — Curry and Tillamook — experienced more than 30% urban growth. Rural development in the coastal communities decreased by 3% overall, growing only slightly in Lincoln and Coos Counties. Notably, rural populations declined by 22% in Curry County.

The percent growth of housing units in urban areas was twice that in rural areas. Curry and Tillamook Counties experienced at least 3 times more urban growth than other counties in the region. Lincoln and Tillamook Counties experienced the most growth in rural housing units.

Unsurprisingly, populations tend to cluster around major road corridors and waterways. Population centers include the Cities of Astoria, Tillamook, Newport, Florence, Coos Bay, Brookings, and some unincorporated areas. The population distribution in Region 1 is presented in **Figure 2-124.**

Table 2-100. Urban and Rural Populations in Region 1, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	−0.1%
Region 1	103,534	111,575	7.8%	84,753	82,155	−3.1%
Clatsop	20,976	22,604	7.8%	14,654	14,435	−1.5%
Coos	38,999	38,864	-0.3%	23,780	24,179	1.7%
Curry	10,030	13,702	36.6%	11,107	8,662	−22.0%
Lincoln	27,640	28,730	3.9%	16,839	17,304	2.8%
Tillamook	5,889	7,675	30.3%	18,373	17,575	−4.3%

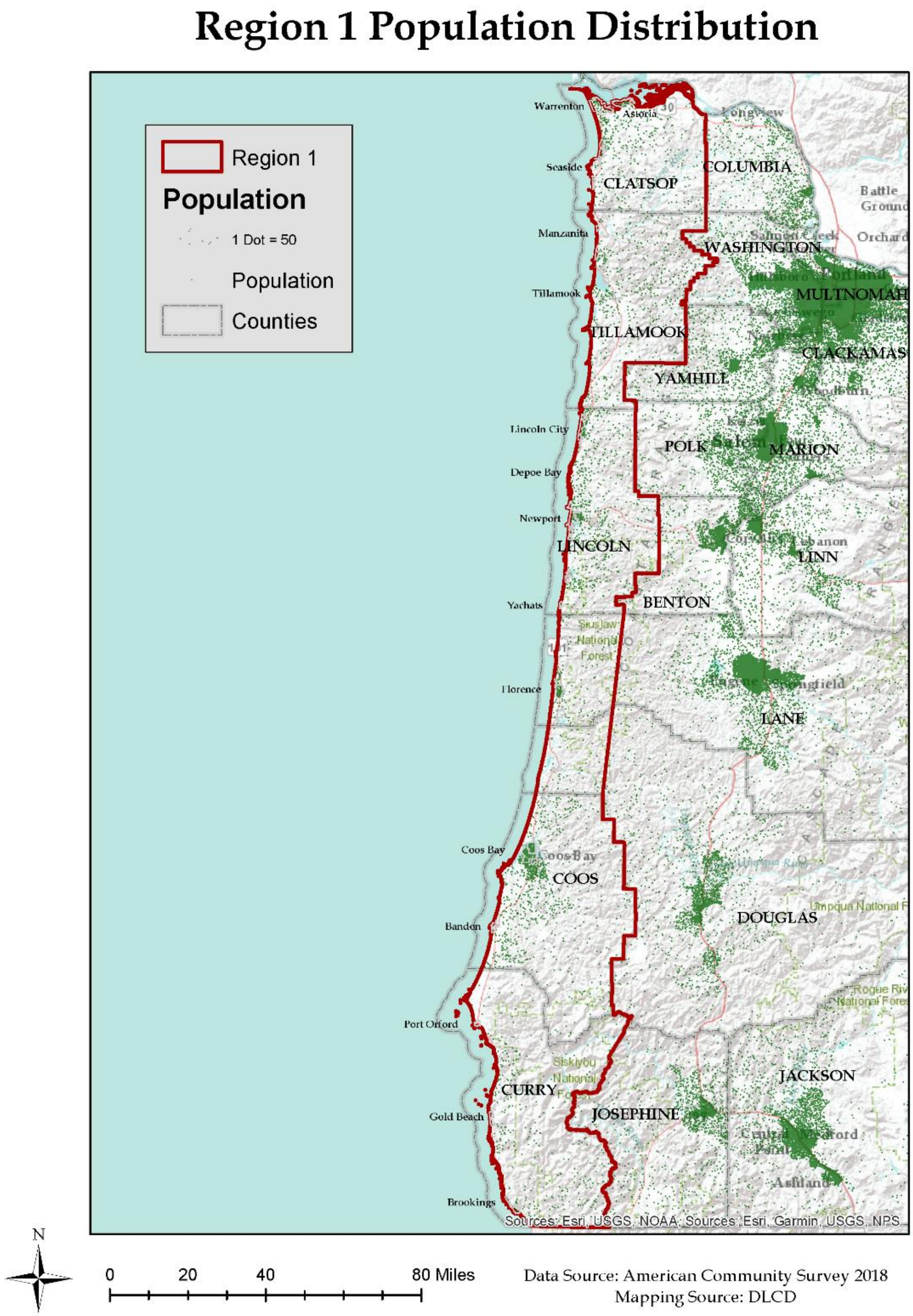
U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2

Table 2-101. Urban and Rural Housing Units in Region 1, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 1	54,599	61,938	13.4%	48,534	51,783	6.7%
Clatsop	11,639	12,866	10.5%	8,046	8,680	7.9%
Coos	17,957	18,578	3.5%	11,290	12,015	6.4%
Curry	5,331	7,428	39.3%	6,075	5,185	−14.7%
Lincoln	17,152	19,534	13.9%	9,737	11,076	13.8%
Tillamook	2,520	3,532	40.2%	13,386	14,827	10.8%

Source: Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2

Figure 2-124. Region 1 Population Distribution



Source: U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. **Table 2-102** provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

Approximately 72% of the region's housing stock is single-family homes. The share of multi-family units is slightly above the share of manufactured homes across the region. In Curry County, nearly one-fifth of all homes are manufactured units. In natural hazard events such as earthquakes and floods, manufactured homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997). The concern is especially acute for occupants of older manufactured housing in the tsunami zone. Once shifted off of their foundations, egress can be severely compromised, potentially delaying occupants' departure for tsunami safety.

Table 2-102. Housing Profile for Region 1

	Total Housing Units	Single Family			Multi-Family			Manufactured Homes		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	68.1%	☑	0.3%	23.5%	☑	0.3%	8.2%	☑	0.1%
Region 1	115,880	72.0%	☑	0.9%	14.7%	☑	0.8%	12.7%	☑	0.7%
Clatsop	22,174	73.1%	☑	2.0%	21.1%	☑	0.8%	5.6%	☑	0.8%
Coos	30,870	71.4%	☑	2.0%	12.5%	☑	1.5%	15.5%	☑	1.7%
Curry	12,847	63.5%	☑	3.3%	15.0%	☑	2.6%	19.7%	☑	2.7%
Lincoln	31,200	71.1%	☑	1.6%	15.4%	☑	1.3%	12.6%	☑	1.1%
Tillamook	18,789	79.2%	☑	2.0%	9.1%	☑	1.5%	11.5%	☑	1.4%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-103. Housing Vacancy in Region 1

		Vacant^		
	Total Housing Units	**Estimate**	**CV ****	**MOE (+/−)**
Oregon	1,733,041	5.6%	☑	0.2%
Region 1	115,880	7.9%	☑	0.7%
Clatsop	22,174	8.9%	☑	1.8%
Coos	30,870	9.1%	☑	1.4%
Curry	12,847	10.2%	⊙	2.6%
Lincoln	31,200	6.6%	☑	1.0%
Tillamook	18,789	5.5%	☑	1.2%

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.
**Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red “x” icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table B25004: Vacancy Status

Aside from location and type of housing, the year structures were built (**Table 2-104**) has implications for level of vulnerability to natural hazards. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for a Cascadia Subduction Zone (CSZ) catastrophic earthquake event (Judson, 2012). Therefore, homes built before 1994 within an earthquake hazard zone are more vulnerable to damage and loss caused by seismic events. Less than one third of the region’s housing stock was built after 1990 and the codification of seismic building standards. Note: This does not reflect the number of structures that are exposed to seismic activity. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Almost 40% of the region’s housing stock was built prior to 1970, before the implementation of floodplain management ordinances. More than 47% of homes in Clatsop and Coos Counties were built prior to 1970. Note: This does not reflect the number of structures that are built within special flood hazard areas. Additionally, as shown in **Table 2-105**, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the late 1970s or mid-1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-104. Age of Housing Stock in Region 1

	Total Housing Units	Pre 1970			1970 to 1989			1990 or Later		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	34.6%	☑	0.3%	30.5%	☑	0.3%	34.9%	☑	0.3%
Region 1	115,880	38.7%	☑	1.2%	30.6%	☑	1.0%	30.7%	☑	1.0%
Clatsop	22,174	46.5%	☑	3.0%	23.9%	☑	2.0%	29.6%	☑	2.0%
Coos	30,870	44.9%	☑	2.9%	31.0%	☑	2.3%	24.1%	☑	1.8%
Curry	12,847	27.5%	☑	3.2%	35.6%	☑	4.1%	36.9%	☑	3.8%
Lincoln	31,200	32.9%	☑	1.9%	34.4%	☑	1.9%	32.6%	☑	1.6%
Tillamook	18,789	36.7%	☑	2.7%	28.1%	☑	2.3%	35.2%	☑	2.6%

** Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25034: Year Structure Built, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood damage is minimized. **Table 2-105** shows the initial and current FIRM effective dates for Region 1 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, **Flood** section.

Table 2-105. Community Flood Map History in Region 1

	Initial FIRM	Current FIRM
Clatsop County	July 3, 1978	June 20, 2018
Astoria	Aug. 1, 1978	Sep. 17, 2010
Cannon Beach	Sep. 1, 1978	June 20, 2018
Gearhart	May 15, 1978	June 20, 2018
Seaside	Sep. 5, 1979	June 20, 2018
Warrenton	May 15, 1978	June 20, 2018
Coos County	Nov. 15, 1984	Dec. 7, 2018
Bandon	Aug. 15, 1984	Dec. 7, 2018
Coos Bay	Aug. 1, 1984	Dec. 7, 2018
Coquille	Sep. 28, 1984	Dec. 7, 2018
Lakeside	Aug. 1, 1984	Dec. 7, 2018
Myrtle Point	July 16, 1984	Dec. 7, 2018
North Bend	Aug. 1, 1984	Dec. 7, 2018
Curry County	Apr. 3, 1978	Nov. 16, 2018
Brookings	Sep. 18, 1985	Nov. 16, 2018
Gold Beach	Nov. 15, 1985	Nov. 16, 2018
Port Orford	Jan. 29, 1980	Nov. 16, 2018
Douglas County	Dec. 15, 1978	Feb. 17, 2010
Reedsport	Apr. 3, 1984	Feb. 17, 2010
Lane County	Dec. 18, 1985	June 2, 1999
Dunes City	Mar. 24, 1981	June 2, 1999 (M)
Florence	May 17, 1982	June 2, 1999
Lincoln County	Sep. 30, 1980	Oct. 18, 2019
Depoe Bay	Oct. 15, 1980	Oct. 18, 2019
Lincoln City	Apr. 17, 1978	Oct. 18, 2019
Newport	Apr. 15, 1980	Oct. 18, 2019
Siletz	Mar. 1, 1979	Oct. 18, 2019
Toledo	Mar. 1, 1979	Oct. 18, 2019
Waldport	Mar. 15, 1979	Oct. 18, 2019
Yachats	March 1, 1979	Oct. 18, 2019
Tillamook County	Aug. 1, 1978	Sep. 28, 2018
Bay City	Aug. 1, 1978	Sep. 28, 2018
Garibaldi	April 17, 1978	Sep. 28, 2018
Manzanita	May 1, 1978	Sep. 28, 2018
Nehalem	Apr. 3, 1978	Sep. 28, 2018
Rockaway	Sep. 29, 1978	Sep. 28, 2018
Tillamook, City	May 1, 1978	Sep. 28, 2018
Wheeler	Nov. 16, 1977	Sep. 28, 2018

Note: M means no base flood elevation.

Source: Federal Emergency Management Agency (2019), Community Status Book Report, https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 1 can be found in **Table 2-106**. The region contains 5.5% of the total value of all identified local critical facilities and state-owned and –leased critical and non-critical facilities in the state. Cumulatively, these assets are valued at nearly two billion dollars.

Table 2-106. Value of State-Owned/Leased Critical and Essential Facilities in Region 1

Value of Local and State-Owned/Leased Facilities					
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$2,630,306,288	$4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 1	$ 282,477,153	$ 252,576,890	$ 1,294,654,689	$ 1,829,708,732	5.5%
Clatsop	$ 62,556,375	$ 157,741,272	$ 237,032,454	$ 457,330,101	1.4%
Coos	$ 1,590,339	$ 2,297,303	$ 30,193,508	$ 34,081,150	0.1%
Curry	$ 39,128,292	$ 7,580,255	$ 65,128,199	$ 111,836,746	0.3%
Douglas	$ 39,904,416	$ 40,013,590	$ 586,411,664	$ 666,329,670	2.0%
Lane	$ 25,605,268	$ 1,766,898	$ 85,170,579	$ 112,542,745	0.3%
Lincoln	$ 47,815,308	$ 15,378,931	$ 197,176,497	$ 260,370,736	0.8%
Tillamook	$ 65,877,155	$ 27,798,641	$ 93,541,788	$ 187,217,584	0.6%

Source: DOGAMI, 2020

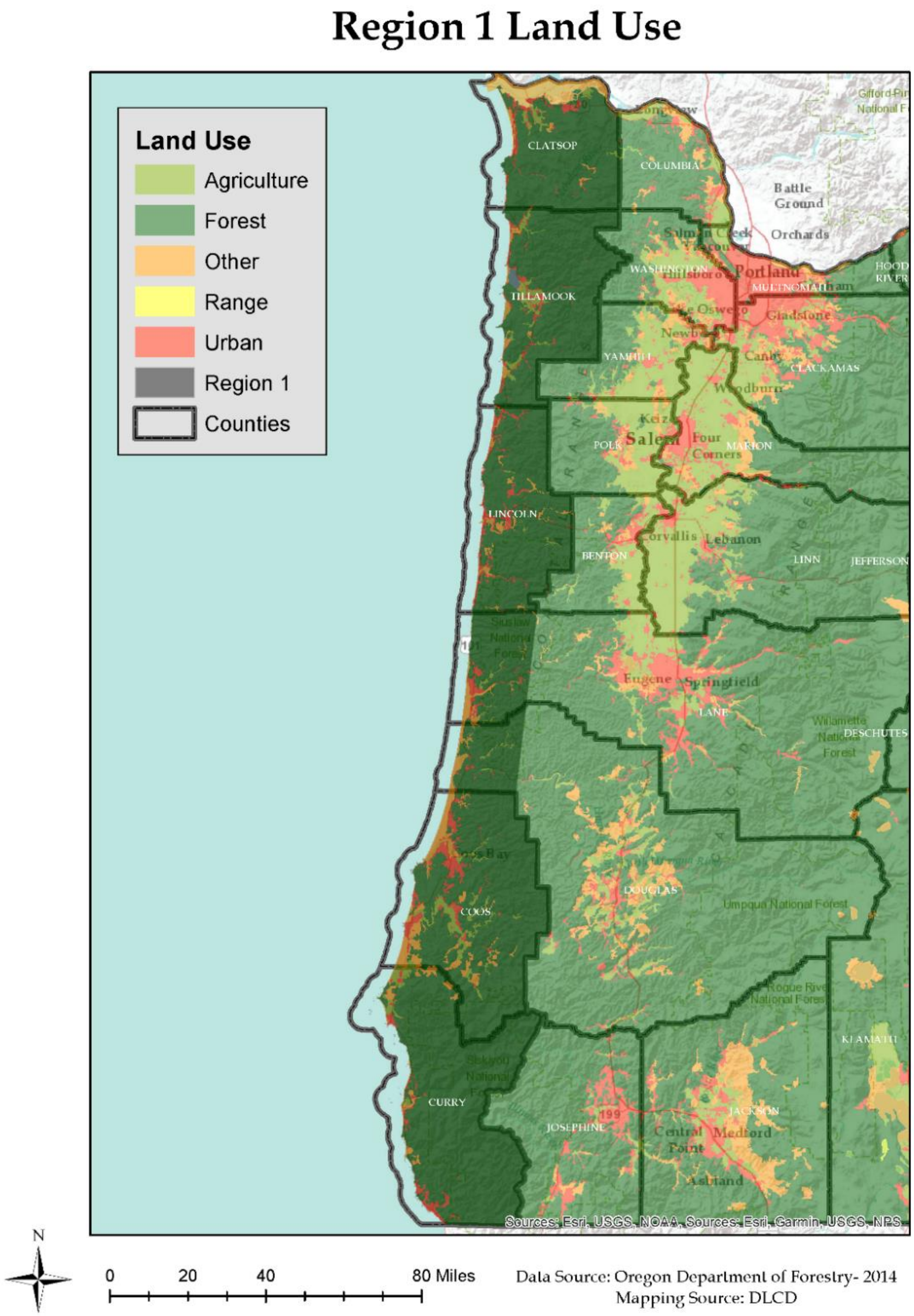
Land Use Patterns

Just over half of the land ownership of the Coast Region is privately owned, with an additional 33.8% in federal ownership, and roughly 14% in state ownership. The vast majority of this land is dedicated to forestry. From the period of 1974 to 2009 the north coast area has had the lowest conversion rate of private land from resource land uses to low-density residential and urban uses (Lettman G. J., 2011). Overall, the coastal communities have experienced little development in the past 5 years, although recently building permitting has increased, mostly for infill of existing subdivisions (DLCD, internal communication, 2014).

During 2012-2013, the Department of Geology and Mineral Industries released tsunami inundation maps displaying five scenarios of a potential impact of a Cascadia Subduction Zone tsunami, reflecting the full range of what was experienced in the past and is projected for the future. Then in January, 2014, the Department of Land Conservation and Development distributed *Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities* (https://www.oregon.gov/LCD/Publications/TsunamiLandUseGuide_2015.pdf). This guide is intended to help communities develop land use planning strategies to reduce tsunami hazard risk.

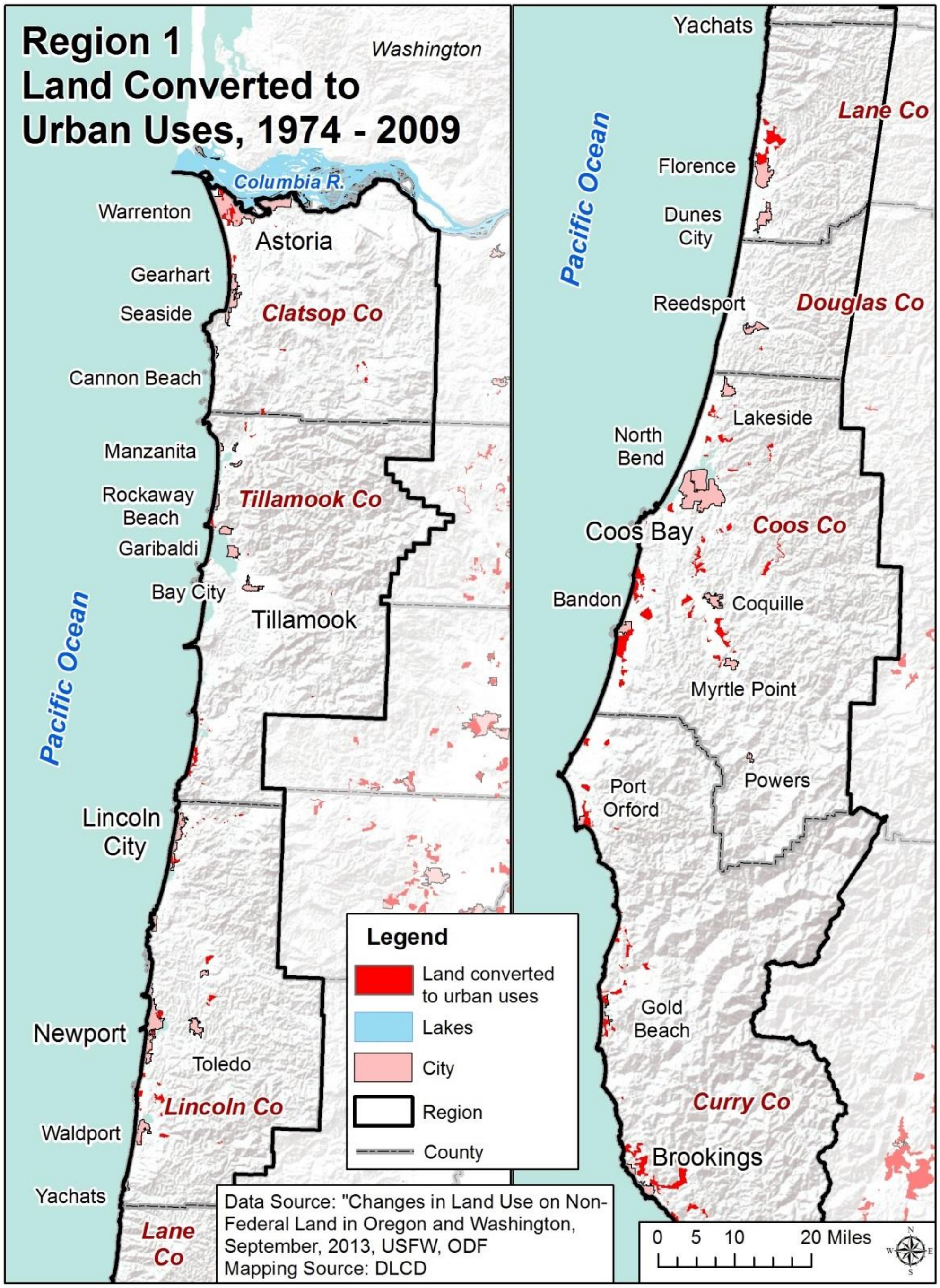
According to the Oregon Department of Forestry's most recent land-use study, "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray, Hubner, McKay, & Thompson, 2016). In Region 1, approximately 2,591 acres of resource lands were converted to more urban uses during the six-year period. Moreover, **Table 2-107** shows that during the six-year period, the percentage of resource lands converted in each county in Region 1 was less than one percent.

Figure 2-125. Region 1 Land Use



Source: Oregon Department of Forestry, 2014

Figure 2-126. Region 1 Land Converted to Urban Uses, 1974–2009



Source: Lettman (2013), http://www.oregon.gov/odf/RESOURCE_PLANNING/land_use_in_OR_WA_web_edited.pdf

Table 2-107. Region 1 Resource Lands Converted to Urban Uses, 2009–2014

	Land Use Change 2009–2014		
	Total Resource Acres (2009)	Acres Converted to Urban Use	Percent Converted
Region 1	2,722,239	1,315	0.05%
Clatsop	496,977	330	0.07%
Lincoln	399,119	241	0.06%
Tillamook	548,032	283	0.05%
Coos	733,819	227	0.03%
Curry	335,719	163	0.05%
Douglas	131,763	9	0.01%
Lane	76,810	23	0.03%

Source: Oregon Department of Forestry, 2014; Oregon Department of Land Conservation and Development, 2020

Built Environment Trends and Issues

Trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion. Generally, however, population growth in the region has significantly lagged behind the statewide rate of growth, a trend that is projected to continue over the next decade. Please refer to the Region 1 Risk Assessment **Demography** section for more information on population trends and forecast. All coastal counties and communities in the region have updated their FIRM in the past decade to more accurately reflect flood exposure.

Tsunami inundation maps created by DOGAMI provide coastal communities new tsunami risk information. In response, DLCD's publication *Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities* (https://www.oregon.gov/lcd/Publications/TsunamiLandUseGuide_2015.pdf) was developed to help communities develop land use planning strategies to reduce tsunami hazard risk.

In terms of the housing stock, the region has a higher share of single-family homes vis-à-vis the state as a whole, and nearly double the state's percentage of manufactured housing. Curry County has the region's highest percentage of manufactured housing. Moreover, over 40% of all housing in Clatsop and Coos Counties was built prior to 1970 — prior to current seismic and floodplain management building standards. Manufactured housing and housing built prior to 1970 are more vulnerable to damage from earthquakes and flood hazards than other housing types.

2.3.1.3 Hazards and Vulnerability

Coastal Hazards

Characteristics

The Pacific Northwest (PNW) coast of Oregon is without doubt one of the most dynamic coastal landscapes in North America, evident by its long sandy beaches, sheer coastal cliffs, dramatic headlands and vistas, and ultimately the power of the Pacific Ocean that serves to erode and change the shape of the coast. Coastal communities in Oregon are increasingly under threat from a variety of natural hazards, including coastal erosion (both short and long term), landslides, earthquakes, and potentially catastrophic tsunamis generated by the Cascadia Subduction Zone (CSZ). Over time, these hazards are gradually being compounded, in part due to the degree of development that has evolved along the Oregon coast in recent decades. A particular concern is that the local geology and geomorphology of the region have restricted development to low-lying areas, chiefly along dunes, barrier spits, or along coastal bluffs present along the open coast that are subject to varying rates of erosion, and to low-lying areas adjacent to the numerous estuaries that make up the coast. All of these sites are highly susceptible to increased impacts as erosion processes and flood hazards intensify, driven by rising sea level and increased storminess

Historic Coastal Hazard Events

Table 2-108. Historic Coastal Erosion and Flood Hazard Events in Region 1

Date	Location	Description
Jan. 1914	Newport	damage (Nicolai Hotel)
1931	Rockaway	coastal damage from December storm
Oct–Dec. 1934	Waldport and Rockaway	flooding (Waldport) coastal damage (Rockaway Beach)
Dec. 1935	Cannon Beach and Rockaway Beach	coastal damage
Jan. 1939	coastwide	severe gale; damage coastwide severe flooding (Seaside, and Ecola Creek near Cannon Beach): • multiple spit breaches (southern portion of Netarts Spit) • storm damage (along the shore of Lincoln City and at D River) • flooding (Waldport) • extensive damage (Sunset Bay Park) • storm surge overtopped foredune (Garrison Lake plus Elk River lowland)
Dec. 1940	Waldport	flooding
1948	Newport	wave damage (Yaquina Arts Center)
Jan. 1953	Rockaway	70-ft dune retreat; one home removed
Apr. 1958	Sunset Bay State Park and Newport	flooding (Sunset Bay); wave damage (Yaquina Arts Center in Newport)
Jan–Feb. 1960	Sunset Bay State Park	flooding
1964	Cannon Beach	storm damage
Dec. 1967	Netarts Spit, Lincoln City, Newport, and Waldport	damage: coastwide State constructed wood bulkhead to protect foredune along 600 ft section (Cape Lookout State Park campground) flooding and logs (Lincoln City) wave damage (Yaquina Arts Center, Newport) flooding (Waldport) storm damage (Beachside State Park washed up driftwood (Bandon south jetty parking lot)
1971–73	Siletz Spit	high-tide line eroded landward by 300 ft February 1973, one home completely destroyed; spit almost breached logs through Sea Gypsy Motel (Nov. 1973)
1982–83	Alsea Spit	northward migration of Alsea Bay mouth; severe erosion
1997–98	Lincoln and Tillamook Counties	El Niño winter (second strongest on record); erosion: considerable
Jan–Mar. 1999	coastwide	five storms; coastal erosion extensive, including: • significant erosion (Neskowin, Netarts Spit, Oceanside, Rockaway beach) • overtopping and flooding (Cape Meares) • significant erosion along barrier beach (Garrison Lake) • overtopping 27-ft-high barrier
Dec. 2007	Tillamook and Clatsop Counties	extreme wind storm extreme coastal storm waves exceeding 40 ft on the northern Oregon coast on Dec. 7
Dec. 7-11, 2015	Tillamook and Clatsop Counties	coastal and riverine flooding in response to several days of heavy rain. Large storm waves exceeding 30 ft on Dec 11 resulted in coastal erosion issues in several communities.
Feb. 2018	Curry County	major coastal landslide at Hooskanaden, located in southern Curry County

Date	Location	Description
2019-2020	Siletz Spit	significant erosion over the 2019-20 winter resulted in several homes impacted and the need for emergency permits for coastal engineering.

Sources: Schlicker, et al. (1972), (1973); Stembridge (1975); Komar & McKinney (1977); Komar (1986), (1987), (1997), (1998); Allan, et al. (2003), (2009), and many others.

Table 2-109 lists historic landslides at the Oregon Coast. Landsliding in these areas will almost certainly continue due to the combination of steep terrain, local geology (seaward dipping tertiary sediments), and high precipitation.

Table 2-109. Historic Coastal Landslide Hazards in Region 1

Date	Location	Description
Ongoing	Clatsop County (Cannon Beach)	several large landslides exist along the Clatsop County coastline, particularly in the vicinity of Cannon Beach; these include: • large landslide block failure at Ecola State Park occurred in 1961 • Silver Point landslide in 1974 damaged several homes and affected US-101 • Slow-moving S-Curves landslide (1995) • landslide/rockfall at the south end of Falcon Cove about 2003 • landslide failure at Hug Point in 2016 • landslide failure at Ecola State Park in 2020
Ongoing	Tillamook County	several large landslides exist along the Tillamook County coastline; these include: • The Capes development on the north side of Netarts Bay and south of Oceanside • a large active landslide exists on the north side of Cape Meares and affects the southern portion of the community of Cape Meares • the Three Capes landslide, located to the south of Tierra del Mar, occurred during the 1997-98 El Niño and affected the Three Capes Scenic byway road; this landslide has been remediated • a small landslide failure developed on Aug. 21, 2011, above Happy Camp in Netarts; this landslide has been remediated
Ongoing	Lincoln County (Newport area)	Several large translational landslide blocks exist throughout Lincoln County. The majority of these are in the Newport/Beverly Beach area and include: • Cape Foulweather landslide failed in Dec. 1999 (since remediated) • Johnson Creek • Carmel Knoll • Moolack Shores • NW 73rd St landslide • Schooner Creek • landslide block failed immediately adjacent to the Jump-Off Joe headland destroying multiple homes over a period in 1942-1943 • Mark St
Jan. 2000	Lane County	Cape Cove landslide (immediately adjacent to the tunnel located between the Heceta Head lighthouse and the Sea Lion caves)
Ongoing	Curry County	Multiple large active landslide block failures exist along US-101 along the Curry County coastline; these include: • Gregory Point landslide 2.2 miles south of Port Orford occurred in Jan. 2006 • multiple landslides between Gregory Point and Humbug Mountain • Arizona landslide south of Humbug Mountain, north of Ophir • Hooskanaden Slide failure in February 2019

Sources: Schlicker, et al. (1961), (1972), (1973); Komar (1997); Allan & Hart (2009); Witter, et al. (2009); SLIDO web database (http://www.oregongeology.org/slido/index.html)

Probability

Table 2-110. Assessment of Combined Coastal Hazards Probability in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	VH	VL	L	VL	VL	H	VH

Source: DOGAMI, 2020

For the 2020 probability assessment, DOGAMI scored probability and exposure for each coastal hazard (coastal sand inundation, coastal erosion, coastal flooding, and coastal landslides) and combined them into one overall probability score. Details of the methodology are in Section 2.2.1.3, Coastal Hazards, **Probability of Coastal Hazards in Each Coastal County**.

The erosion of the Oregon coast is exceedingly complex, reflecting processes operating over both short and long time scales, and over large spatial scales. However, the most significant erosion effects are largely controlled by high-magnitude (relatively infrequent) events that occur over the winter (the months of October to March), when wave heights and ocean water levels tend to be at their highest.

Previous analyses of extreme waves for the Oregon coast estimated the "100-year" (1%) storm wave to be around 33 feet. In response to a series of large wave events that occurred during the latter half of the 1990s, the wave climate was subsequently re-examined and an updated projection of the 1% storm wave height was determined, which is now estimated to reach approximately 47 to 52 feet (**Table 2-111**), depending on which buoy is used. These estimates are of considerable importance to the design of coastal engineering structures and in terms of defining future coastal erosion hazard zones.

Table 2-111. Projection of Extreme Wave Heights for Various Recurrence Intervals: Each Wave Height Is Expected to Occur on Average Once during the Recurrence Interval

	Extreme Wave Heights (feet)	
Recurrence Interval (years)	NDBC buoy #46002*(Oregon)	NDBC buoy #46005+(Washington)
10	42.5	41.7
25	46.2	44.0
50	48.8	—
75	50.1	45.7
100	51.2	47.1

Sources: *DOGAMI analyses; +Ruggiero, et al. (2010)

In order to understand the potential extent of erosion for different communities, DOGAMI has completed coastal erosion hazard maps for Lincoln, Tillamook, and Clatsop Counties, as well in the Nesika Beach area in Curry County. Maps were undertaken for these areas mainly because they contain the largest concentration of people living along the coastal strip, and in the case of Nesika Beach in response to a specific request by the Oregon Department of Land Conservation and Development. In all cases, the maps depict erosion hazard zones that fall into four categories: Active, High, Medium, and Low. The High and Medium hazard zones reflect erosion associated with a 2% and 1% storm, respectively. The Low hazard zone includes a 1% storm coupled with a Cascadia subduction zone earthquake and has a much lower probability of occurrence. The erosion scenarios were defined using a combination of probabilistic (waves) and deterministic (water levels) approaches.

In July 2014, DOGAMI completed new updated maps for the dune-backed beaches in Tillamook County using a fully probabilistic approach of the waves and water levels to map the erosion hazard zones. The revised modeling used three total water level scenarios (10%, 2% and 1% events) produced by the combined effect of extreme wave runup (R) plus the measured tidal elevation (T), and erosion due to sea level rise (low/mean/maximum estimates) at 2030, 2050, and 2100. In total 81 scenarios of coastal erosion were modeled; an additional two scenarios were also modeled that considered the effects of a Cascadia subduction zone earthquake, and the effects of a single (1%) storm, where the storm's duration was taken into account. The completed study ultimately recommended five hazard zones for consideration. A sixth hazard zone was also proposed. This latter zone was defined using a more sophisticated dune erosion model that accounted for the effect of the duration of a storm. Table 2-112 provides the calculated erosion associated with an extreme (1%) storm for Tillamook County, after accounting for the storm's duration. The results indicate that the storm induced erosion ranges from about 47 to 73 ft. When the duration of the storm is removed from consideration the amount of beach and dune erosion increases substantially to about 70 to 260 ft. Finally, modeling coastal change by nature is fraught with large uncertainty that is a function of variations in the morphology of the beach and the beach sediment budget.

Table 2-112. Storm-Induced Erosion Defined for Selected Sites in Tillamook County after Having Accounted for the Duration of the Event

	Maximum 1% Erosion Distance	
	(meters)	**(feet)**
Neskowin	20.6	67.6
Nestucca Spit	14.5	47.6
Sand Lake	18.7	61.4
Netarts Spit	22.2	72.8
Bayocean Spit	17.6	57.7
Rockaway	19.9	65.3
Nehalem Spit	19.3	63.3

Modeled erosion is for a 1% storm.

Between July 2009 and 2014, DOGAMI completed new coastal erosion and flood modeling for the entire Oregon coast in order to update FEMA flood insurance rate maps derived for each coastal community. These updated maps contain probabilistic estimates of the effects of the 10-, 50- and 100-year extreme storm wave flooding (combined with high tides) and coastal erosion responses.

Although some coastal landslide failures have been remediated, the majority are considered active and hence will continue to move and fail. Without detailed knowledge of every slide, it is impossible to assign probabilities of failure. However, it is a high probability that all of these existing landslide sites would be activated following a Cascadia earthquake, and more new landslides would occur.

Climate Change

It is very likely (>90%) that the Oregon coast will experience an increase in coastal erosion and flooding hazards due to climate change induced sea level rise (high confidence) and possible changes to storminess patterns (medium confidence). Global sea levels are rising and will continue to rise at an accelerated pace under continued climate warming. In Oregon, the rates of relative sea level rise—those experienced along Oregon's coastlines—are not the same as rates of change in global mean sea levels, because of a number of factors related to ocean conditions and vertical movement of the land. Oregon's western edge is uplifting, so the rates of relative sea level rise in Oregon are not as high as rates seen in other West Coast locations. But even after factoring in local conditions, sea levels along most of Oregon's coast are rising. For locations in which sea level is not currently rising, the projected rate of future sea level rise is expected to outpace the current rate of vertical land movement in the 21st century. For more information on coastal erosion, sea level rise, and changing wave dynamics, see **2.2.1.3, Coastal Hazards, Analysis and Characterization, Climate Change and Sea Level Rise.**

The following information presents past and projected changes in local sea level for the north coast (Astoria), central coast (Newport), and south coast (Charleston) of Oregon based on the Intermediate-Low and Intermediate-High global sea level scenarios used in the 2018 U.S. National Climate Assessment (Sweet, Horton, Kopp, LeGrande, & Romanou, 2017a). This range of sea level rise scenarios is similar to the very likely range projected for the higher emissions scenario, RCP8.5, by 2100. These local sea level projections include vertical land movement trend estimates derived from GPS measurements and tide gauge platforms (Sweet, et al., 2017b). This means that the future sea level rise projections are relative to the future land position as opposed to the existing land position.

Local sea level at Astoria (NOAA water level station at Astoria–Tongue Point) has lowered by about two inches during 1947–2013 due to the land uplifting at a faster pace than sea level rise over that period. However, the pace of sea level rise is expected to accelerate such that sea level rise over the 21st century would outpace the uplifting land. Local sea level at Astoria is projected to rise by 0.8 to 4.8 feet by 2100 relative to the 1992 mean high tide line (Dalton, Future Climate Projections: Clatsop County, 2020).

Local sea level at Newport (NOAA water level station at South Beach–Yaquina River) has risen about four inches during 1967–2013 and is projected to rise by 1.7 to 5.7 feet by 2100 relative to the 1992 mean high tide line (Dalton, Future Climate Projections: Lincoln County, 2020).

Local sea level at Charleston (NOAA water level station at Charleston–Coos Bay) has risen about one inch during 1978–2013 and is projected to rise by 1.2 to 5.3 feet by 2100 relative to the 1992 mean high tide line (Climate Central, 2020).

Local sea level rise will be greatest on the central Oregon coast; however, the north and south coasts of Oregon will see local sea level rise surpass the current rate of vertical land movement.

Vulnerability

Table 2-113. Local Assessment of Vulnerability to Coastal Erosion in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	—	H	H	—	—	—	—

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-114. State Assessment of Coastal Hazards Combined Vulnerability in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	L	M	VL	M	L	M	L

Source: DOGAMI and DLCD, 2020

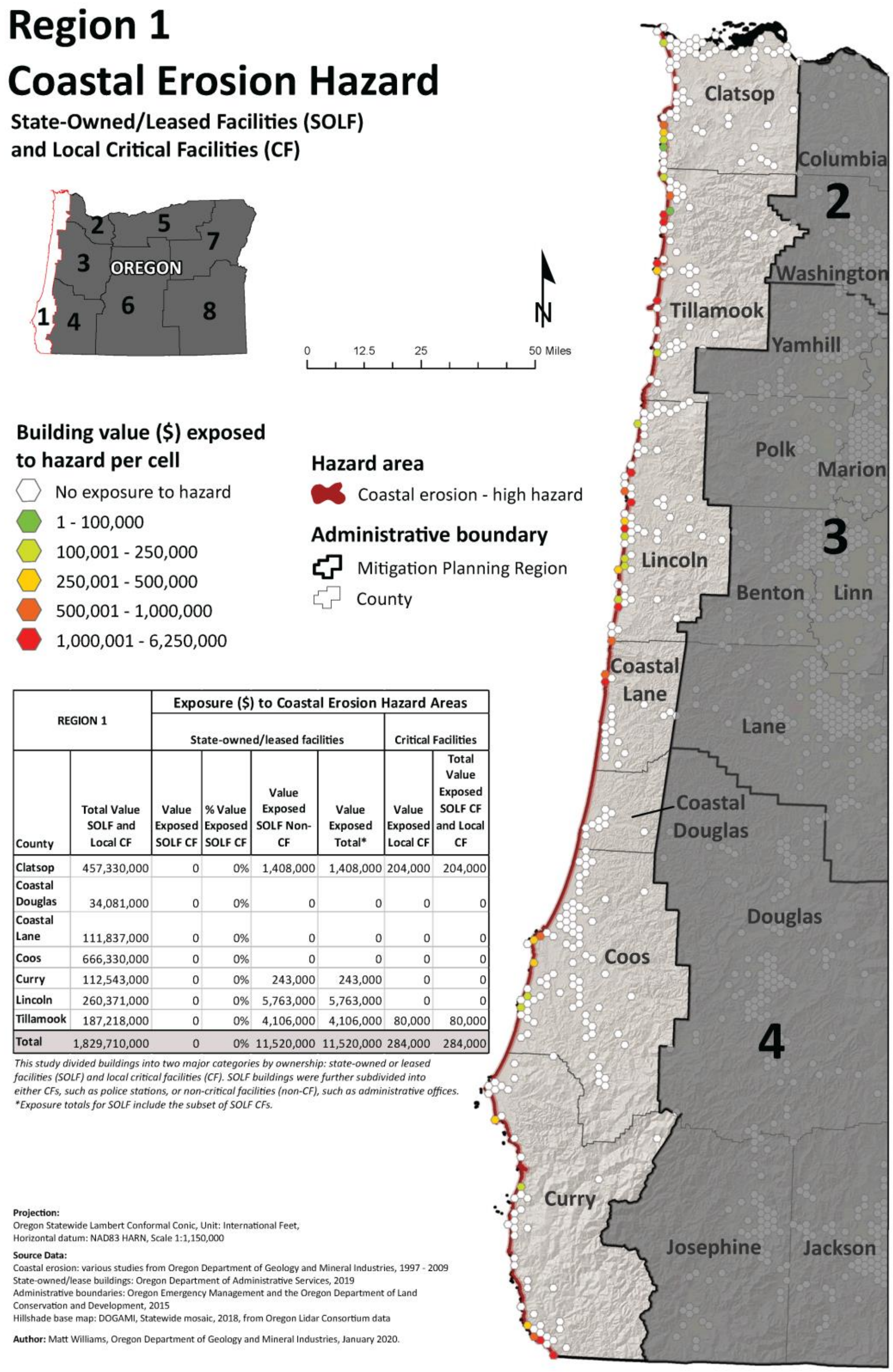
Chronic hazards are clearly evident along Oregon's shores, including beach, dune, and bluff erosion, landslides, slumps, gradual weathering of sea cliffs, and flooding of low-lying coastal lands during major storms. The damage caused by chronic hazards is usually gradual and cumulative. The regional, oceanic, and climatic environments that result in intense winter storms determine the severity of chronic hazards along the coast. These hazards threaten property and, in extreme events, human life.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

In Region 1, there is about an $11.5M potential loss in value of state buildings and state critical facilities located in coastal erosion hazard areas. The majority of that value (86%) is located in Lincoln and Tillamook Counties followed by Clatsop and Curry Counties. None is located in Coos, Coastal Douglas, or Coastal Lane Counties. Region 1 faces a potential loss of about $285K of value in local critical facilities located in coastal erosion hazard areas. Seventy-two percent of that value is located in Clatsop County and 28% in Tillamook County; none of the other coastal counties have local critical facilities located in coastal erosion hazard areas.

Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one minor loss of just over $700 to a state facility was recorded in Region 1 since the beginning of 2015. It was not caused by coastal erosion.

Figure 2-127. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Coastal Erosion Zone in Region 1. High-resolution, full-size image linked from Appendix 9.1.26.



REGION 1		Exposure ($) to Coastal Erosion Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Clatsop	457,330,000	0	0%	1,408,000	1,408,000	204,000	204,000
Coastal Douglas	34,081,000	0	0%	0	0	0	0
Coastal Lane	111,837,000	0	0%	0	0	0	0
Coos	666,330,000	0	0%	0	0	0	0
Curry	112,543,000	0	0%	243,000	243,000	0	0
Lincoln	260,371,000	0	0%	5,763,000	5,763,000	0	0
Tillamook	187,218,000	0	0%	4,106,000	4,106,000	80,000	80,000
Total	1,829,710,000	0	0%	11,520,000	11,520,000	284,000	284,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,150,000

Source Data:
Coastal erosion: various studies from Oregon Department of Geology and Mineral Industries, 1997 - 2009
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

Of the 3,121 historic resources located in Oregon's coastal counties, none are located in coastal erosion high hazard areas. Only one, in Tillamook County, is located in a moderate coastal erosion hazard area, and 54 are located in low or other coastal erosion hazard areas. Of the 54 in low or other coastal erosion hazard areas, 33 are located in Clatsop county and ten in Tillamook County.

Archaeological Resources

Of the 369 archaeological resources in Oregon's coastal counties, 119 are located in an area of high coastal erosion hazards. Of those, 30 are listed on the National Register of Historic places and 2 are eligible for listing. Eighty-seven have not been evaluated as to their eligibility for listing. The 32 listed and eligible archaeological resources in high coastal erosion hazard areas are located in Clatsop, Lincoln, and Tillamook Counties. Twenty-one other listed and eligible archaeological resources are located in moderate coastal erosion hazard areas in the same three counties. Sixty-seven listed and eligible archaeological resources are located in areas of low or other coastal erosion hazard areas in throughout the coastal counties. The coastal portions of Lane and Douglas Counties were not included in this assessment.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Coos County, the coastal portion of Douglas County and Lincoln County are more vulnerable than the other counties in Region 1, but still are only moderately vulnerable.

The Department of Geology and Mineral Industries is the agency with primary oversight of coastal hazards. Based on agency staff review of the available hazard data, DOGAMI ranks Tillamook, Lincoln, Clatsop, and Curry Counties one through four respectively as the counties most vulnerable to coastal hazards in the state.

Coastal hazards in Coos, Lane, and Douglas Counties are considered to be generally negligible. This is because the bulk of these coastlines have little population base and hence are largely unmodified. In Coos County, coastal hazards can be found in a few discrete communities such as adjacent to the Coquille jetty in Bandon and along Lighthouse Beach near Cape Arago. Similarly, coastal hazards in Lane County are confined almost entirely to the Heceta Beach community and adjacent to the Siuslaw River mouth, particularly within the lower estuary mouth where development lines coastal bluffs that is gradually being eroded by riverine processes.

The counties and communities most vulnerable to coastal hazards on the Oregon Coast include:

Tillamook County (ranked #1):

- Neskowin (erosion and flooding)
- Pacific City (erosion (1970s); replaced by recent sand inundation),
- Tierra del Mar (erosion and flooding)
- Cape Meares (flooding and landsliding)
- Twin Rocks (erosion and flooding),
- Rockaway Beach (erosion and flooding)
- Nehalem (flooding during extreme high tides)

Lincoln County (ranked #2):

- Yachats to Alsea Spit (erosion)
- Waldport (erosion and flooding)
- Alsea Spit (erosion (1982/83 and 1997/98 El Niños); replaced by recent sand inundation)
- Seal Rock (erosion and landsliding)
- Ona Beach to Southbeach (erosion and landsliding)
- Newport (landsliding)
- Beverly Beach (erosion and landsliding)
- Gleneden Beach to Siletz Spit (erosion, landsliding, and flooding)
- Lincoln City (erosion and landsliding)

Clatsop County (ranked #3):

- Falcon Cove (erosion and landsliding)
- Arch Cape (erosion and flooding)
- Tolovana to Cannon Beach (erosion and flooding)
- Cannon Beach (erosion; sand inundation north of Ecola Creek),
- Ecola State Park (landsliding), and
- Seaside (Flooding);

Curry County (ranked #4):

- Multiple coastal section affecting Highway 101 (landsliding and erosion)
- Gold Beach, Hunter Creek (erosion)
- Nesika Beach (erosion and landsliding)
- Port Orford (flooding at Garrison Lake)

Coos County (ranked #5):

- North Coos Spit (erosion)
- Lighthouse Beach (bluff erosion)
- Bandon (erosion and flooding, particularly adjacent to the Coquille River south jetty)

Lane County (ranked #6):

- Heceta Beach (erosion and flooding; erosion especially significant in the north at the mouth to Sutton Creek)

Douglas County (ranked #7):

- Coastal hazards in Douglas County are considered to be negligible.

Risk

Table 2-115. Combined Risk of Coastal Hazards in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	H	M	L	M	L	H	H

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the coastal hazards probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Clatsop, Lincoln, and Tillamook Counties are at greatest risk from coastal hazards. This is consistent with DOGAMI's independent assessment.

Droughts

Characteristics

Drought is not a common occurrence in Region 1. From 1995–2015, the Governor has declared drought only once in Region 1, in Coos and Curry Counties during 2002 when much of the state was facing drought conditions. In 2015, all Region 1 counties received a drought declaration, and in 2018 Lincoln County received a drought declaration. In the emerging drought in 2020 (as of April 30, 2020), the Governor has declared drought in Curry County. Although Region 1 is less vulnerable to drought impacts than most of Oregon, droughts can still be problematic, especially given that they often precede major wildfires. Severe drought conditions resulted in the four disastrous Tillamook fires (1933, 1939, 1945, 1951), collectively known as the Tillamook Burn.

Historic Drought Events

Table 2-116. Historic Droughts in Region 1

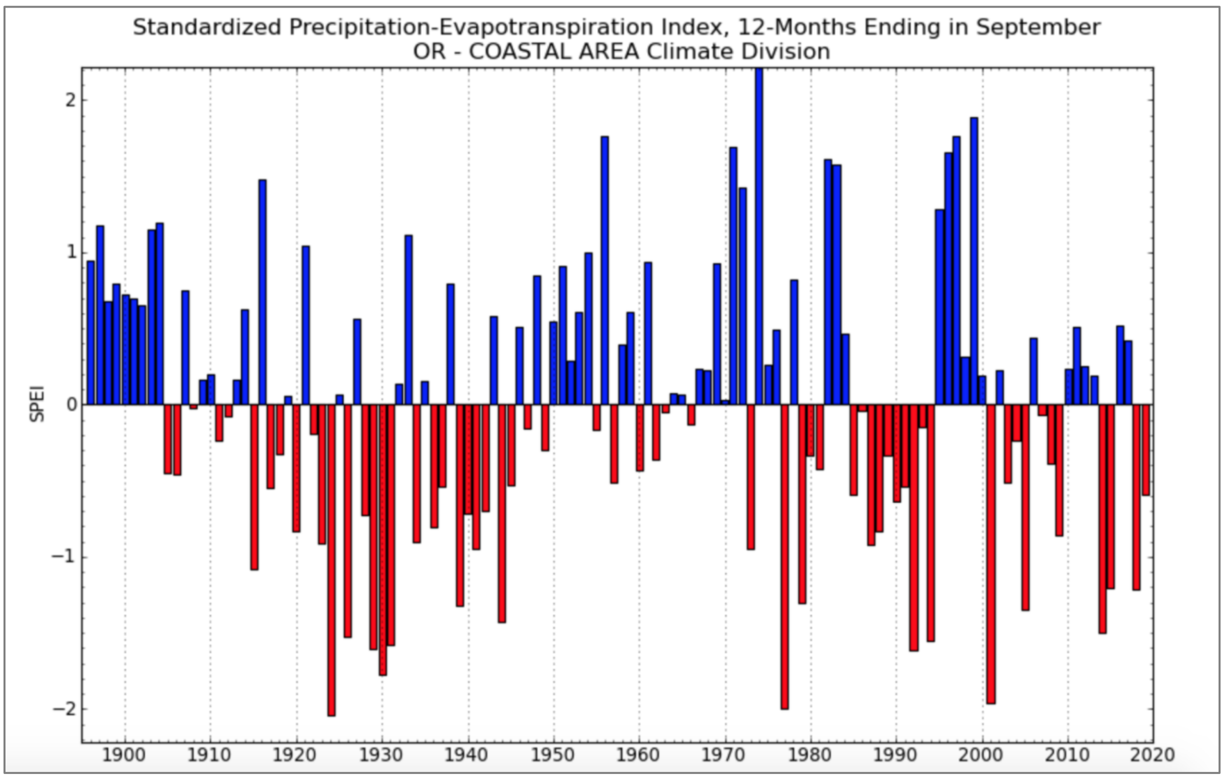
Date	Location	Description
1924	statewide	prolonged statewide drought that caused major problems for agriculture
1930	Regions 1, 2, 3, 5, 6, & 7	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country; moderate to severe drought affected much of the state
1939	statewide	Water Year 1939 was one of the more significant drought years in Region 1 during that period; the second of the three Tillamook Burns started in 1939
1992	statewide, especially Regions 1, 2, 3, 4, 8	1992 fell toward the end of a generally dry period, which caused problems throughout the state; the 1992 drought was most intense in eastern Oregon, with severe drought occurring in Region 1; the winter of 1991-1992 was a moderate El Niño event, which can manifest itself in warmer and drier winters in Oregon; Governor declared a drought for all 36 counties in September 1992
2001-02	affected all regions, except Regions 2 & 3	the second most intense drought in Oregon's history; 18 counties with state drought declaration (2001); 23 counties state-declared drought (2002); some of the 2001 and 2002 drought declarations were in effect through June or December 2003; Coos and Curry Counties in Region 1 were not under a drought declaration until December of 2002
2015	statewide	All 36 Oregon counties receive federal drought declarations; Coos and Curry were the only counties in Region 1 to receive a Governor's declaration.
2018	Regions 4-8, 1	Governor-declared drought in 11 counties
2020	Region 1, 6	Governor-declared drought in Klamath, Curry, and Jackson Counties as of May 1, 2020.

Sources: Taylor and Hatton (1999); NOAA's Climate at a Glance. Western Regional Climate Center's Westwide Drought Tracker, http://www.wrcc.dri.edu/wwdt; personal communication, Kathie Dello, Oregon Climate Service, Oregon State University; Governor-declared drought declarations obtained from the Oregon State Archives division

Historical drought information can also be obtained from the West Wide Drought Tracker, which provides climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. **Figure 2-128** shows years where drought or dry conditions affected the coastal areas of Oregon (Climate Division 1). Based on this index, Water Years 1924 and 1977 were extreme drought years for the coastal region (**Table 2-117**). Years with at least moderate drought have occurred 17 times during 1895–2019.

U.S Climate Divisions

Figure 2-128. Standard Precipitation-Evapotranspiration Index for Region 1



Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-117. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 1 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
1944	2001	1924
2005	1930	1977
1939	1992	
1979	1929	
2018	1931	
2015	1994	
1915	1926	
	2014	

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Probability

Table 2-118. Probability of Drought in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	VL	L	M	H	L	L	VL

Source: OWRD, DLCD

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases. A comprehensive risk analysis is needed to fully assess the probability and impact of drought to Oregon communities. Such an analysis should be completed statewide in order to analyze and compare the risk of drought across the state.

Douglas County has received drought declarations in 24% of the years since 1992 accounting for its high probability rating, and Curry County 14% accounting for its moderate rating. Whether the drought declarations pertained to the coastal portion of Douglas County is unknown.

Climate Change

Even though drought is infrequent in coastal Oregon, Region 1 is prone to summertime water scarcity, as evidenced in the 2015 statewide drought. Climate models project warmer, drier summers for Oregon, including coastal areas, leading to lower summer soil moisture and runoff. In Region 1, climate change would result in increased frequency of drought due to low summer runoff (likely, >66%) and low summer precipitation and low summer soil moisture (more likely than not, >50%). In addition, Region 1, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-119. Local Assessment of Vulnerability to Drought in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	NA	H	—	L	—	M	—

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-120. State Assessment of Vulnerability to Drought in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	L	H	L	H	M	M	L

Source: OWRD, DLCD

Oregon has yet to undertake a comprehensive, statewide analysis to identify which communities are most vulnerable to drought.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

Douglas and Coos Counties have high social vulnerability ratings, Lane and Lincoln Counties moderate. This indicates the extent of impact that any natural hazard, including drought, is likely to have on their populations. The high and moderate social vulnerability ratings for Douglas and Lane Counties, respectively, are for each county as a whole and may not accurately reflect the social vulnerability situation in their coastal areas. Without finer-grained data, we must give less weight to these ratings.

Even short term droughts can be problematic. Potential impacts to community water supplies are the greatest threat. Long-term drought periods of more than a year can impact forest conditions and set the stage for potentially devastating wildfires.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

In Region 1, there is about an $11.5M potential loss in value of state buildings and state critical facilities located in coastal erosion hazard areas. The majority of that value (86%) is located in Lincoln and Tillamook Counties followed by Clatsop and Curry Counties. None is located in Coos, Coastal Douglas, or Coastal Lane Counties. Region 1 faces a potential loss of about $285K of value in local critical facilities located in coastal erosion hazard areas. Seventy-two percent of that value is located in Clatsop County and 28% in Tillamook County; none of the other coastal counties have local critical facilities located in coastal erosion hazard areas.

The value of state-owned and leased buildings and critical facilities in Region 1 is approximately $535,054,000 representing the total potential for loss of state assets due to coastal hazards. The value of locally owned critical facilities is $1,294,655,000. Because drought, while uncommon in Region 1, could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one minor loss of just over $700 to a state facility was recorded in Region 1 since the beginning of 2015. It was not caused by drought.

Risk

Table 2-121. Risk of Drought in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	L	M	M	H	M	M	L

Source: OWRD, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based on social vulnerability (considering the limitations of the data for Douglas and Lane Counties) and a review of Governor-declared drought declarations since 1992, Region 1 is considered to be generally at low to moderate risk from drought.

Earthquakes

Characteristics

The geographic position of Region 1 makes it susceptible to earthquakes from three sources: (a) the off-shore Cascadia Fault Zone, (b) deep intra-plate events within the subducting Juan de Fuca plate, and (c) shallow crustal events within the North America Plate. All have some tie to the subducting or diving of the dense, oceanic Juan de Fuca Plate under the lighter, continental North America Plate. Stresses occur because of this movement.

There is no historic record of major damaging crustal earthquakes centered in Region 1 in the past 156 years, although the region has experienced small crustal earthquakes and crustal earthquakes that originated outside the region. The geologic record shows that movement has occurred along numerous offshore faults as well as a few onshore faults in Coos and Tillamook Counties. The faulting has occurred over the last 20,000 years. Intraplate earthquakes are very rare in Oregon, although such earthquakes originating outside of the state have been felt in Region 1. It is believed that the M7.3 near Brookings in 1873 was an intraplate quake.

In Region 1, geologic earthquake hazards include severe ground shaking, liquefaction of fine-grained soils, landslides, and flooding from local and distant tsunamis. The severity of these effects depends on several factors, including the distance from earthquake source, the ability of soil and rock to conduct seismic energy composition of materials, and ground and ground water conditions.

Historic Earthquake Events

Table 2-122. Significant Earthquakes Affecting Region 1

Date	Location	Magnitude (M)	Comments
Approximate Years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	offshore, Cascadia Subduction Zone	Probably 8-9	these are the mid-points of the age ranges for these six events
Jan. 1700	offshore, Cascadia Subduction Zone	about 9.0	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Nov. 1873	Brookings area, Oregon	7.3	intraplate event; origin probably Gorda block of the Juan de Fuca plate; chimneys fell (Port Orford, Grants Pass, and Jacksonville); no aftershocks
Nov. 1962	Portland, Oregon	5.2 to 5.5	crustal event; damage to many homes (chimneys, windows, etc.)
Mar. 1993	Scotts Mills, Oregon	5.6	crustal event; FEMA-985-DR-OR; damage: $28 million (homes, schools, businesses, state buildings [Salem])
Sep. 1993	Klamath Falls, Oregon	5.9 to 6.0	crustal event; FEMA-1004-DR-OR; two earthquakes; fatalities: two; damage $7.5 million (homes, commercial, and government buildings)
May 8, 2015	Pacific Ocean, west of Coos Bay, OR	4.4	
Nov. 29, 2019	Port Orford, OR	4.5	
Feb. 8, 2020	Pacific Ocean west of Coos Bay, Oregon	4.7	

*BCE: Before Common Era.

Sources Wong & Bott (1995); Pacific Northwest Seismic Network, https://pnsn.org/

Probability

Table 2-123. Assessment of Earthquake Probability in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	VH	VH	VH	H	H	H	H

Source: DOGAMI, 2020

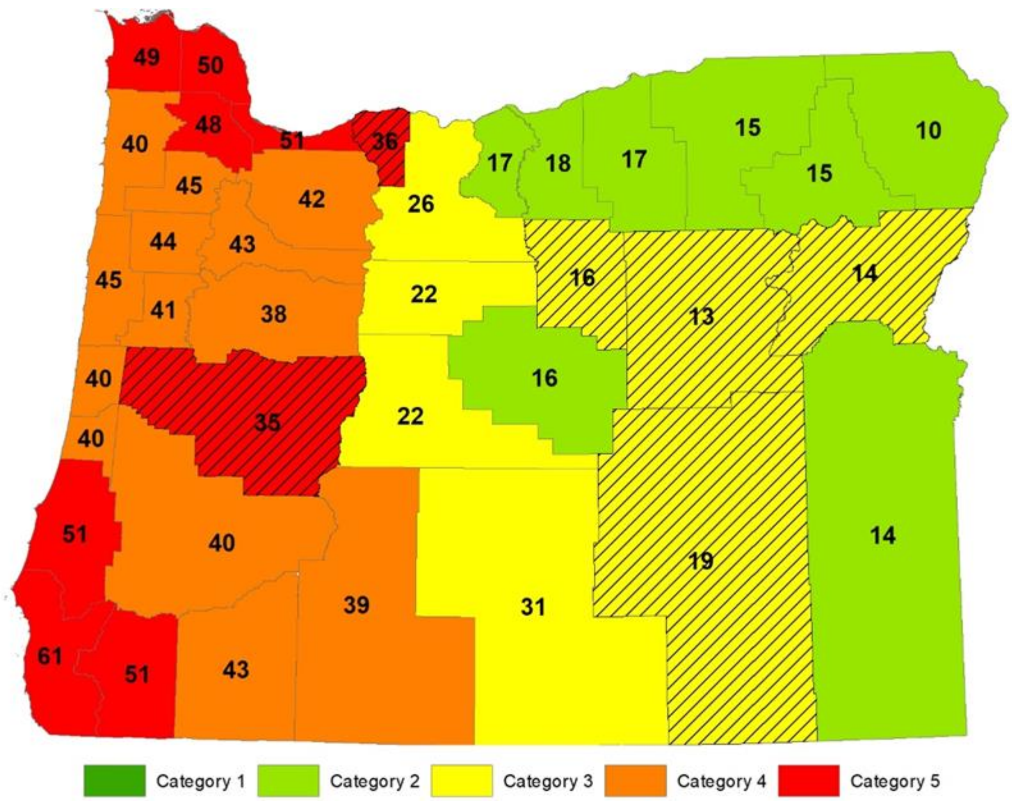
The probability of damaging earthquakes varies widely across the state. In Region 1, the hazard is dominated by Cascadia Subduction Zone (CSZ) earthquakes originating from a single fault with a well-understood recurrence history.

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-129**.

Figure 2-129. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.

Source: DOGAMI 2020

For Oregon west of the crest of the Cascades, the CSZ is responsible for most of the hazard shown in **Figure 2-129**. The paleoseismic record includes 18 magnitude 8.8–9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7 to 12%. An additional 10 to 20 smaller, magnitude 8.3–8.5, earthquakes affected only the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37–43%.

Vulnerability

Table 2-124. Local Assessment of Vulnerability to Earthquakes in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	H	M	H	H	—	H	H

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-125. State Assessment of Vulnerability to Earthquakes in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	VH	H	VH	VH	VH	M

Source: DOGAMI and DLCD, 2020

Region 1 is especially vulnerable to earthquake hazards. This is because of the built environment's proximity to the CSZ, regional seismicity, topography, bedrock geology, and local soil profiles. For example, a large number of buildings are constructed of unreinforced masonry (URM) or are constructed on soils that are subject to liquefaction during severe ground shaking. Also, some principal roads and highways are susceptible to earthquake-induced landslides. Bridges and tunnels need to be retrofitted to withstand ground shaking and the dams should be able to withstand earthquake forces to prevent uncontrolled releases. This is especially important as 12 dams in Region 1 have been designated as "high hazard." Problem areas within the region are readily identifiable online at Oregon's hazard viewer at http://www.oregongeology.org/sub/hazvu/index.htm and on earthquake hazard maps prepared by DOGAMI (available at website: http://www.oregongeology.org/pubs/ofr/p-O-13-06.htm).

Table 2-126 shows the number of school and emergency response buildings surveyed in each county with their respective rankings.

Table 2-126. Region 1 School and Emergency Response Building Collapse

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Clatsop	24	19	20	1
Tillamook	19	9	23	5
Lincoln	30	18	12	3
Lane*	8	4	5	—
Douglas**	3	2	10	—
Coos	41	11	48	7
Curry	15	10	10	2

*Includes only the Lane County coastal communities of Deadwood, Florence, Mapleton, and Swisshome.

**Includes only the Douglas County coastal communities of Gardiner, Reedsport, and Winchester Bay.

Source: Lewis (2007), available at http://www.oregongeology.org/sub/projects/rvs/default.htm

Other useful resources for planning for earthquakes include the following:

- Maps of earthquake hazard areas: DOGAMI has mapped all of the Region 1 counties and has statewide GIS earthquake hazard layers available through Open-File Report O-13-06 (Madin & Burns, 2013).
- Map of coastal critical facilities vulnerable to hazards: DOGAMI has developed these maps for all Region 1 counties. For more information about critical facilities in Region 1 see **State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities**.
- Environmental geology maps: DOGAMI has developed these maps for all Region 1 counties (DOGAMI Bulletins 74, 79, 81, 84, 85, and 87).
- Nuclear energy and hazardous waste sites inventories: No Region 1 counties have nuclear facilities.

DOGAMI developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) the Cascadia Subduction Zone (CSZ), and (b) combined crustal events (500-year model). Both models use Hazus, a software program developed by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event is based on a potential M8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from such an event. The 500-year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults. Neither model takes unreinforced masonry buildings into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning and policy making purposes. Despite their limitations, the models do provide some approximate estimates of damage and are useful to understand the relative relationships between the counties.

Table 2-127 shows the projected dollar losses based on both models. Please note that the losses are in 1999 dollars. Since that time, additional growth and inflation has occurred, thus the values are too low. However, the relative rankings are between the counties likely remains the same. For example, the economic base (column 2) for Clatsop County remains lower than Coos County, and the expected losses from a magnitude 8.5 Cascadia earthquake (column 3) in Clatsop County remain lower than Coos County.

Table 2-127. Projected Dollar Losses in Region 1, Based on an M8.5 Subduction Event and a 500-Year Model

Region 1 Counties	Economic Base in Thousands (1999)	Greatest Absolute Loss in Thousands (1999) from an M8.5 CSZ Event[1]	Greatest Absolute Loss in Thousands (1999) from a 500-Year Model[2]
Clatsop	$2,198,000	$549,000	$760,000
Coos	$3,263,000	$1,339,000	$1,429,000
Curry	$1,093,000	$371,000	$388,000
Douglas[3]	$4,631,000	$275,000	$546,000
Lane[3]	$15,418,000	$1,614,000	$3,044,000
Lincoln	$2,668,000	$624,000	$793,000
Tillamook	$1,539,000	$226,000	$364,000

Notes:

[1] "…there are numerous unreinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat" (Wang, 1998, p. 5).

[2] Every part of Oregon is subject to earthquakes. The 500-year model is an attempt to quantify the risk across the state. The estimate does not represent a single earthquake. Instead, the 500-year model includes many faults. More and higher magnitude earthquakes than used in this model may occur (Wang & Clark, 1999).

[3] Entire county.

Source: Wang & Clark (1999)

Table 2-128 shows the projected dollar losses associated with the magnitude 8.5 Cascadia model.

Table 2-128. Estimated Losses in Region 1 Associated with a M8.5 Subduction Zone Event

	Region 1 Counties						
	Clatsop	Coos	Curry	Douglas[1]	Lane[1]	Lincoln	Tillamook
Injuries	298	854	221	151	1,036	358	132
Deaths	6	16	3	2	19	7	3
Displaced Households	788	2,069	430	255	2,345	592	158
Operational the "day after" the event[2]:							
Fire stations	16%	10%	9%	66%	49%	26%	31%
Police stations	15%	6%	5%	57%	42%	22%	44%
Schools	16%	8%	6%	44%	46%	19%	32%
Bridges	58%	44%	34%	74%	76%	51%	58%
Economic losses to[2]:							
Highways	$18 mil	$44 mil	$48 mil	$43 mil	$39 mil	$16 mil	$25 mil
Airports	$5 mil	$20 mil	$11 mil	$5 mil	$11 mil	$9 mil	$7 mil
Communications	$6 mil	$25 mil	$18 mil	$7 mil	$11 mil	$9 mil	$5 mil
Debris Generated (thousands of tons)	383	853	267	222	1,341	446	158

Notes:

The Cascadia Subduction Zone (CSZ) is the most dangerous fault in Oregon. The entire coastline is essentially the epicenter. The earthquake could be M8.5 (or M9.0). The event might last as long as 4 minutes. Within a few minutes a tsunami would follow. (Tsunami damages are not included in the estimates for this earthquake but would dramatically increase losses for coastal counties.) A CSZ earthquake could affect a very large area. If the entire fault ruptures, destruction could occur from northern California to Canada. The number of deaths and injuries depends on the time of day, building type, occupancy class, and traffic pattern. (DOGAMI Special Paper 29 (Wang & Clark, 1999, p. 4).

[1] Entire county.

[2] "…there are numerous unreinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat" (Wang, 1998, p. 5).

Source: Wang & Clark (1999)

Table 2-129 shows the estimated losses associated with the 500-year model.

Table 2-129. Estimated Losses in Region 1 Associated with a 500-Year Model

	Clatsop	Coos	Curry	Douglas[1]	Lane[1]	Lincoln	Tillamook
Injuries	397	845	212	294	2,254	436	181
Deaths	8	16	3	4	45	9	4
Displaced households	1,182	2,521	486	534	4,543	847	275
Economic losses for buildings[2]	$760 mil	$1.4 bil	$328 mil	$546 mil	$3 bil	$792 mil	$364 mil
Operational the "day after" the event[3]:							
Fire stations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Police Stations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Schools	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bridges	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Economic losses to[2]:							
Highways	$33 mil	$49 mil	$44 mil	$69 mil	$74 mil	$22 mil	$39 mil
Airports	$7 mil	$20 mil	$12 mil	$9 mil	$20 mil	$12 mil	$8 mil
Communications	$8 mil	$2 mil	$15 mil	$12 mil	$20 mil	$10 mil	$6 mil
Debris generated (thousands of tons)	474	864	261	411	2,424	525	224

Note: Every part of Oregon is subject to earthquakes. The 500-year model is an attempt to quantify the risk across the state. The estimate does not represent a single earthquake. Instead, the 500-year model includes many faults. More and higher magnitude earthquakes than used in this model may occur (DOGAMI, 1999).

[1]Entire county.

[2]"…there are numerous unreinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat" (Wang, 1998, p. 5).

[3]Because the 500-year model includes several earthquakes, the number of facilities operational the "day after" cannot be calculated.

Source: Wang & Clark (1999)

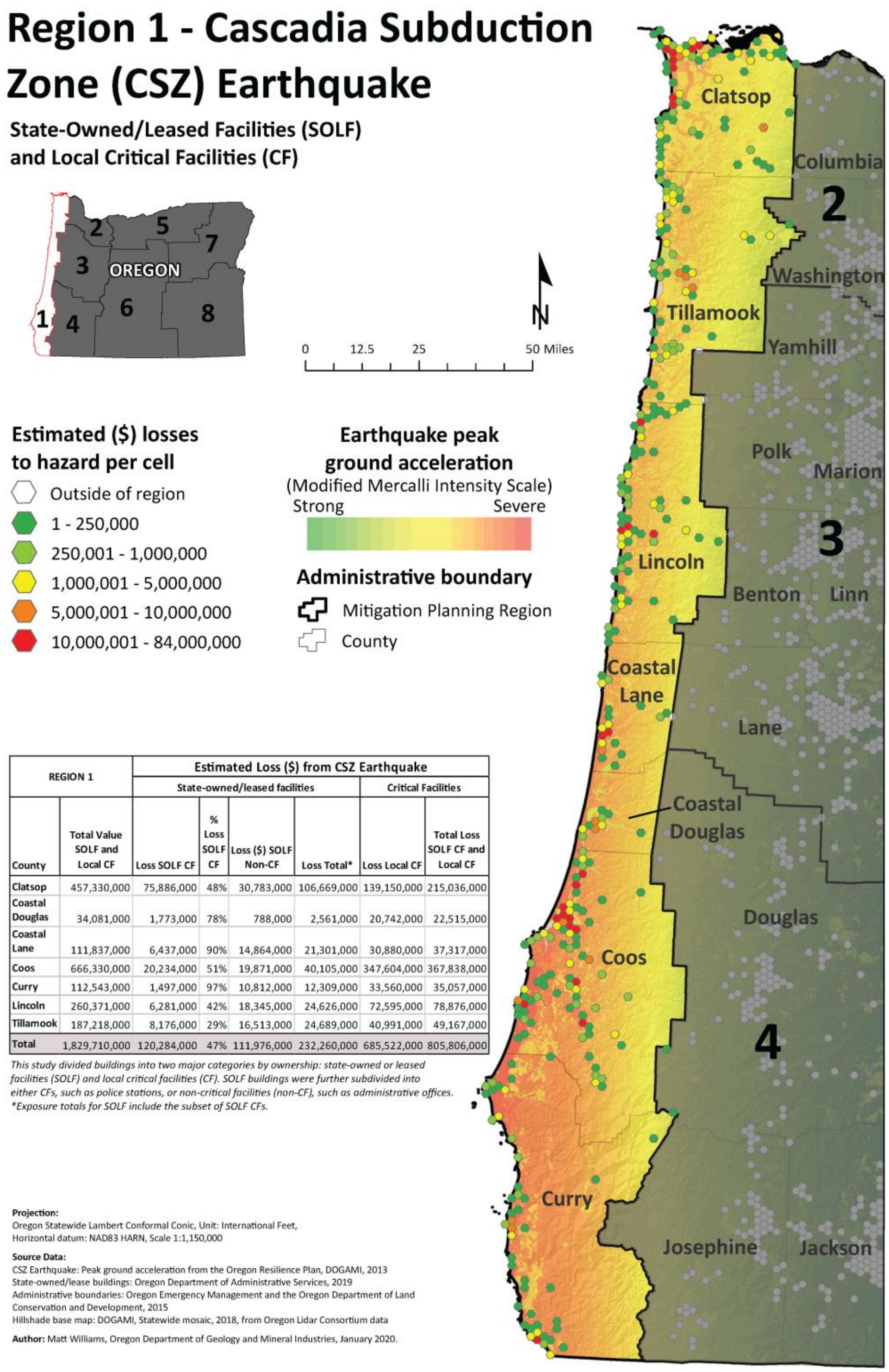
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a Magnitude 9 Cascadia Subduction Zone (CSZ) event in Region 1. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 1, there is a potential loss of over $232M in state building and critical facility assets to a CSZ event. Almost half of that is in Clatsop County alone. There is a far greater potential loss in local critical facilities: over $685M. Coos County stands to lose the most, about 51% of that total, followed by Clatsop County with about 20%. **Figure 2-130** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

Figure 2-130. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Cascadia Subduction Zone Earthquake Hazard Zone in Region 1. High-resolution, full-size image linked from Appendix 9.1.26.



REGION 1		Estimated Loss ($) from CSZ Earthquake						
		State-owned/leased facilities				Critical Facilities		
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*	Loss Local CF	Total Loss SOLF CF and Local CF
Clatsop	457,330,000	75,886,000	48%	30,783,000	106,669,000	139,150,000	215,036,000
Coastal Douglas	34,081,000	1,773,000	78%	788,000	2,561,000	20,742,000	22,515,000
Coastal Lane	111,837,000	6,437,000	90%	14,864,000	21,301,000	30,880,000	37,317,000
Coos	666,330,000	20,234,000	51%	19,871,000	40,105,000	347,604,000	367,838,000
Curry	112,543,000	1,497,000	97%	10,812,000	12,309,000	33,560,000	35,057,000
Lincoln	260,371,000	6,281,000	42%	18,345,000	24,626,000	72,595,000	78,876,000
Tillamook	187,218,000	8,176,000	29%	16,513,000	24,689,000	40,991,000	49,167,000
Total	1,829,710,000	120,284,000	47%	111,976,000	232,260,000	685,522,000	805,806,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,150,000

Source Data:
CSZ Earthquake: Peak ground acceleration from the Oregon Resilience Plan, DOGAMI, 2013
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

Of the 3,121 historic resources in Region 1, one hundred sixty-five are in an area of high or very high liquefaction potential. One hundred thirty-eight or 84% are located in Coos County. One thousand, one hundred seventy-two historic resources (38%) in Region 1 are located in areas with high or very high potential for ground shaking amplification.

Archaeological Resources

Of the 1,198 archaeological resources located in earthquake hazard areas in Region 1, two hundred forty are in areas of high earthquake hazards. Of those, 22 are listed on the National Register of Historic Places and 41 are eligible for listing. Nine have been determined not eligible, and 189 have not been evaluated. Thirteen of the 22 listed resources are in Tillamook County and 18 of the 20 eligible resources are in Coos County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Coos, the coastal portions of Douglas and Lane, and Lincoln Counties are the most vulnerable to earthquake hazards in Region 1.

Seismic Lifelines

"Seismic lifelines" are the state highways ODOT has identified as most able to serve response and rescue operations, reaching the most people and best supporting economic recovery. The process, methodology, and criteria used to identify them are described in Section **2.1.6, Seismic Transportation Lifeline Vulnerabilities**, and the full report can be accessed at Appendix **9.1.16**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification*. According to that report, seismic lifelines in Region 1 have the following vulnerabilities.

Region 1 has the most seismically vulnerable highway system of all the geographic zones and is the most difficult to access due to multiple geographic constraints. While it could be argued that the region's critical post-earthquake needs should dictate that all coastal area routes be Tier 1 (first priority roadways), the reality is that — to make the entire lifeline system resilient — the vulnerabilities in Region 1 are so extensive that the majority of the cost would be incurred for repairs done within this region. Furthermore, because of the high vulnerability of the region, it is paramount that emergency services and recovery resources are able to reach this region from other regions. Consequently, all needs are best served with a conservative Tier 1 backbone system, selected according to the criteria described earlier in this Plan.

The Tier 1 (first roadway priority) system in Region 1 consists of three access corridors:

- OR-30 from Portland to Astoria,
- OR-18 from the Willamette Valley to US-101 and north and south on US-101 between Tillamook and Newport, and
- OR-38 from I-5 to US-101 and north and south on US-101 from Florence to Coos Bay.

The Tier 2 (second roadway priority) system in Region 1 consists of three access corridors:

- US-26 from OR-217 in Portland to US-101 and north and south on US-101 from Seaside to Nehalem,
- OR-126 from the Valley to US-101 at Florence, and
- US-101 from Coos Bay to the California border.

The Tier 3 (third roadway priority) system in Region 1 would complete an integrated coastal lifeline system and consists of the following corridors:

- US-101 from Astoria to Seaside,
- US-101 from Nehalem to Tillamook,
- OR-22 from its junction with OR-18 to the Valley,
- OR-20 from Corvallis to Newport,
- OR-42 from I-5 to US-101, and
- US-199 from I-5 to the California border.

Regional Impact. Coastal highways, most importantly US-101, will be fragmented in many areas. In some areas there are possible detours inland from US-101, but many of those routes are also vulnerable to ground shaking, landslides, and other hazards.

- Ground shaking: In Region 1 ground shaking will be intense and prolonged. Most unreinforced structures and many unreinforced roadbeds and bridges will be damaged to varying extents, and it is likely that many damaged areas will become impassable without major repairs.
- Landslides and Rockfall: Many areas along the coast highway, US-101, are cut into or along landslide prone features. Removal of slide and rockfall material is an ongoing responsibility of ODOT Maintenance crews on long stretches of the highway. A major seismic event will increase landslide and rockfall activities and may reactivate ancient slides that are currently inactive.
- Tsunami: Some reaches of US-101 and connecting and parallel routes will be inundated by tsunami. Tsunami debris may block large areas of the street and highway network.
- Liquefaction: Structures in wetland, estuarine, alluvial and other saturated areas will be subject to liquefaction damage; the total area of such impacts will vary with the extent of saturated soils at the time of the event.

Regional Loss Estimates. Highway-related losses include disconnection from supplies and replacement inventory, and the loss of tourists and other customers who must travel to do business with affected businesses.

Most Vulnerable Jurisdictions. The vulnerabilities studied in the OSLR project are geographic rather than jurisdictional. Other research suggests that the risks of a subduction zone seismic event are somewhat higher along the Southern Oregon Coast, but the risks assessed in this study pertain to the vulnerability of highway facilities in the case of a CSZ event and the higher vulnerabilities are generally low lying areas, active and ancient landslide and rockfall areas, and where critical bridges may not be easily repaired or detoured around. Vulnerability also relates to a current conditions context — high groundwater and saturated soils, high tides, and time of day as it relates to where people are relative to the highway system and other vulnerable facilities. Coos, Curry, Douglas, Lane, Lincoln, Tillamook, and Clatsop Counties are all highly vulnerable to a CSZ event.

Risk

Table 2-130. Risk of Earthquake Hazards in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	VH	VH	VH	VH	VH	VH	H

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, all the counties in Region 1 except Tillamook County are at very high risk from earthquake hazards; Tillamook County is at high risk.

Extreme Heat

Characteristics

Extreme temperatures are rare on the coast. Most years do not have temperatures above 90°F and years that do, generally only have one or two days. In fact, the relatively cooler temperatures make the coast a destination for relief when the Willamette Valley experiences extreme heat.

Historic Extreme Heat Events

Table 2-131. Historic Extreme Heat Events in Region 1

Date	Location	Notes
June 24–26, 2006	Region 1–3, 5	A broad upper ridge of unusually high height coupled with a thermally induced surface trough of low pressure lingered over the Pacific Northwest for several days. This pattern resulted in persistent offshore flow, and therefore many days of record-smashing high temperatures. Astoria had 85 degrees on June 24 breaking the old record at 81 degrees in 2000.
July 20-24, 2006	Region 1–3, 5, 7	An unusually strong ridge of high pressure brought several days of record breaking hot and humid weather to NW Oregon. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row. On July 21, Astoria reported 81°F.
August 25-26, 2016	Region 1, 2	Ridge of high pressure and offshore winds brought temperatures along the North Oregon Coast up into the mid 80s to mid 90s on August 25. News reported 8 runners were taken to the hospital with heat-related injuries during the Hood-to-Coast relay through Portland.

Source: https://www.ncdc.noaa.gov/stormevents

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning “very low.” Region 1’s relative probability rankings are shown in **Table 2-132**.

All coastal counties in Region 1 were in the bottom quintile indicating extreme heat is and will continue to be rare on the coast and lowest in frequency of extreme heat days relative to the rest of the state. It is important to note that in counties with “very low” probability like those in Region 1, extreme heat is rare, yet frequency is expected to increase due to climate change.

Table 2-132. Probability of Extreme Heat in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	VL	VL	VL	—	—	VL	VL

Note: Coastal portions of Douglas and Lane counties were not included in Region 1, but in Region 4 and 3, respectively, for this assessment.

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Extreme temperatures are rare on the coast (Region 1) and will continue to be rare under future climate change. However, climate model projections indicate that Region 1 counties that are accustomed to no and one days per year may begin to experience extreme heat days with heat index over 90°F by the 2050s under the higher emissions scenario (RCP 8.5) in place. **Table 2-133** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 1.

Table 2-133. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 1 Counties

County	Historic Baseline	2050s Future
Clatsop	1	5
Coos	1	7
Curry	3	15
Lincoln	1	6
Tillamook	0	4

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

Vulnerability

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, **Extreme Heat**. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are house-less.

Because extreme heat is rare in Region 1 ("very low" probability), many people may not be accustomed or prepared when an extreme heat event occurs ("moderate" adaptive capacity). In Cooling Zone 1, which includes coastal areas in Region 1, 58% of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1-2 earned a ranking of 1 (very low); scores of 3-4 earned a ranking of 2 (low); scores of 5-6 earned a ranking of 3 (moderate); scores of 7-8 earned a ranking of 4 (high); and scores of 9-10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region rounded to the nearest whole number.

Table 2-134 displays the vulnerability rankings as well as rankings for sensitivity and adaptive capacity for each county in NHMP Region 1. Table 2-135 provides the summary descriptors of Region 1's vulnerability.

Combining sensitivity and adaptive capacity, Region 1's total relative vulnerability to extreme heat is "Moderate." Only Coos County's vulnerability is high. Coos County is the most vulnerable to extreme heat in Region 1.

Table 2-134. Relative Vulnerability Rankings for Region 1 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 1	**3**	**3**	**3**
Clatsop	2	3	3
Coos	4	3	4
Curry	2	3	3
Lincoln	3	3	3
Tillamook	2	3	3

Source: Oregon Climate Change Research Institute

Table 2-135. Vulnerability to Extreme Heat in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	M	H	M	–	–	M	M

Source: Oregon Climate Change Research Institute

Region 1 counties did not rank vulnerability to extreme heat.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 1 is approximately $535,054,000 representing the total potential for loss of state assets due to coastal hazards. The value of locally owned critical facilities is $1,294,655,000. Because extreme heat, while uncommon in Region 1, could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one minor loss of just over $700 to a state facility was recorded in Region 1 since the beginning of 2015. It was not caused by extreme heat.

Risk

With respect to extreme heat, risk is defined as the combination of the probability of extreme heat events and vulnerability to them, in this assessment sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

The total relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total risk scores of 1–2 earned a ranking of 1 (“very low”); scores of 3–4 earned a ranking of 2 (“low”); scores of 5–6 earned a ranking of 3 (“moderate”); scores of 7–8 earned a ranking of 4 (“high”); and scores of 9–10 earned a ranking of 5 (“very high”). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-136 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 1. Table 2-137 provides the summary descriptors of Region 1’s risk to extreme heat.

Combining probability and vulnerability, Region 1’s total relative risk to extreme heat is “Low.”

Table 2-136. Risk Rankings for Region 1 Counties

County	Probability	Vulnerability	Risk
Region 1	**1**	**3**	**2**
Clatsop	1	3	2
Coos	1	4	3
Curry	1	3	2
Lincoln	1	3	2
Tillamook	1	3	2

Source: Oregon Climate Change Research Institute

Table 2-137. Risk of Extreme Heat in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	L	M	L	–	–	L	L

Source: Oregon Climate Change Research Institute

Floods

Characteristics

In general, three types of flooding occur in Region 1. These are riverine, ocean flooding from high tides and wind-driven waves, and flooding associated with a tsunami event. Tsunami flooding is not addressed in this section.

Riverine

There are two distinct periods of riverine flooding in Region 1 — winter and late spring — with the most serious occurring December through February. The lower Siletz and Siuslaw rivers in Lincoln and Lane Counties respectively and the rivers that feed Tillamook Bay in Tillamook County have all experienced significant flooding resulting in losses. The situation is especially severe when riverine flooding, caused by prolonged rain and melting snow, coincides with high tides and coastal storm surges. In short, the rivers back up and flood the lowlands. This type of flooding is especially troublesome in the Tillamook Bay area where homes and livestock can be isolated for several days. Several northern coastal rivers carry heavy silt loads that originated in areas burned during the “Tillamook Burn” fires (1933 to 1951) or from areas covered with volcanic ash during the Mount St. Helens eruption (1980). Consequently, some rivers actually may be elevated above local floodplains, which increases flood hazards. The costs and long-term benefits of dredging these rivers have not been determined.

In general, the northern half of Region 1 is more vulnerable to riverine flood damage than the southern half because it is more densely populated and consequently contains much of the region’s infrastructure.

Table 2-138 lists the principal riverine flood sources in Region 1.

Ocean Flooding and Wave Action

Low-lying coastal areas in Region 1 are particularly vulnerable to flood hazards that can be exacerbated by high tides. Flooding from wind-driven waves is common during the winter, during El Niño events, and when spring and perigean tides occur. The Federal Emergency Management Agency has identified and mapped coastal areas subject to direct wave action (V zones) and sand dune over-topping (AH and AO zones). Direct wave action was especially severe during the winter storm events of 1972 (Siletz Spit), 1978 (Nestucca Spit), and the El Niño events of 1982-83 and 1997-98. Significant beach and cliff erosion occurred during these periods and a number of homes were destroyed.

Oregon coastal processes are complex and dynamic, sometimes eroding, sometimes aggrading stream banks. Erosion rates vary and are dependent on several factors including storm duration and intensity, composition of sea cliff, time of year, and impact of human activities (e.g., altering the base of sea cliffs, interfering with the natural movement of beach sand).

While the exact number of buildings, parks, infrastructure, and critical facilities in Region 1 vulnerable to ocean storms is unknown, the low-lying areas adjacent to bays or the ocean are known to be at risk. Bayocean, Salishan Spit, Jumpoff Joe, Rogue Shores, and The Capes are examples of development in such areas whose buildings and infrastructure have been destroyed by wave attack. A number of local governments in Region 1 have initiated and accomplished building elevation and/or buy-out programs. Also, dairy farmers and other businesses have made considerable progress in protecting their investments.

Flood Insurance Rate Maps (FIRM) show flood conditions. The following is a list of Region 1 counties and the dates of their most recent FIRMs:

- Clatsop, September 17, 2010 and June 20, 2018;
- Coos, March 17, 2014 and December 7, 2018;
- Curry, November 16, 2018;
- Douglas, February 17, 2010, revised mapping in preliminary stage;
- Lane, June 2, 1999, revised mapping in preliminary stage;
- Lincoln, October 18, 2019; and
- Tillamook, September 28, 2018.

Historic Flood Events

Table 2-138. Historic Floods in Region 1

Date	Location	Description	Type of Flood
1813	NW Oregon	said to exceed “Great Flood” of 1861 (source: Native Americans)	unknown
Dec. 1861	coastal rivers	the “Great Flood”; largest flood of known magnitude on the Rogue	rain on snow
Feb. 1890	coastal rivers	widespread flooding; Siuslaw River dammed by a large debris flow	rain on snow
Jan. 1923	Lower Columbia	mild temperatures; large amount of rain; flooded roads and railroads	rain on snow
Mar. 1931	western Oregon	extremely wet and mild; saturated ground	rain on snow
Dec. 1933	northern Oregon	intense warm rains; Clatskanie River set record	rain on snow
Dec. 1937	western Oregon	heavy coastal rain; large number of debris flows	rain on snow
Oct. 1950	SW Oregon coast	heavy October rain	rain on snow
Dec. 1953	western Oregon	heavy rain accompanied major windstorm; serious log hazards on Columbia	rain on snow
Dec. 1955	Columbia and coastal streams	series of storms; heavy, wet snow; many homes and roads damaged	rain on snow
Dec. 1962	SW Oregon	severe flooding, especially the Rogue River	rain on snow
Mar. 1964	coast and Columbia River estuary	Ocean flooding	tsunami
Dec. 1964	entire state	two storms; intense rain on frozen ground	rain on snow
Jan. 1972	northern coast	severe flooding and mudslides; 104 evacuated from Tillamook	rain on snow
Jan. 1974	western Oregon	series of storms with mild temperatures; large snowmelt; rapid runoff	rain on snow
Dec. 1978	coastal streams	Intense warm rain; two fatalities on Yaquina River; widespread flooding	rain on snow
Feb. 1986	entire state	warm rain and melting snow; numerous homes evacuated	rain on snow

Date	Location	Description	Type of Flood
Feb. 1987	western Oregon	heavy rain; mudslides; flooded highways; damaged homes	rain on snow
Dec. 1989	Clatsop, Tillamook and Lincoln	warm Pacific storm system; high winds; fatalities; mudslides	rain on snow
Jan. 1990	W. Oregon	significant damage in Tillamook County; many streams had all-time records	rain on snow
Apr. 1991	Tillamook County	48-hour rainstorm. Wilson River 5 ft. above flood stage; businesses closed	rain on snow
Feb. 1996	NW Oregon	deep snowpack; warm temperatures; record-breaking rains	rain on snow
Nov. 1996	W. Oregon	record-breaking precipitation; flooding; landslides (FEMA-1149-DR-Oregon)	rain on snow
Dec. 1998	Lincoln and Tillamook Counties		
Nov. 1999	Coastal rivers in Lincoln and Tillamook Counties	heavy rainfall and high tides	riverine and ocean flooding
Jan. 2000	Curry, Douglas and Josephine Counties	A Flood Warning was issued for the South fork of the Coquille River from Myrtle Point to Coquille City, North and South forks of the Coquille River. Brookings recorded 4.72 inches of rain, a record for the date. Two Small Stream Flood Advisories were issued, the first, for Elk Creek, the second for Deer Creek. A Flood Warning was issued for the lower Rogue River from Agness to Gold Beach.	riverine
Dec. 2005	Coos, Curry, and Douglas Counties	$2,840,000.00 in property damage (includes Jackson and Josephine Counties)	riverine
Nov. 2006	Tillamook County	heavy rains caused major flooding in Nehalem and Tillamook, causing $1 million in damage in Nehalem and $15 million in Tillamook (DR-1672)	riverine
Nov. 2006	Lincoln County	Siletz River crested at 7 feet above flood stage	riverine
Dec. 2006	Coos County	two floods in Coos County on the Coquille River inundated several roads, including OR-42 and OR-42S	riverine
Dec. 2007	Clatsop County	storm total of 7.3 inches of rain, causing many rivers to overflow their banks. $9.15 million in damages	riverine
Dec. 2007	Columbia County	Nehalem (Vernonia)	riverine
Dec. 2007	Tillamook County	heavy rains led to flooding in Tillamook along the Wilson River damaging businesses, homes, the railroad to the Port; county-wide damages total 26 million	riverine
Dec. 2007	Lincoln County	Siletz River had moderate flooding, causing flood damage near Siletz and Lincoln City; total county-wide damages include $124,000 in damages inland and $31,000 damages for coastal property	riverine
Dec. 2007	Lane County	flooding along coast, $31,000 in property damage	riverine
Dec. 2007	Curry County	Rogue river exceeds flood stage, but no known damages	riverine
Dec. 2008	Tillamook County	Flooding caused by convergence of heavy precipitation and high tides; heavy rainfall caused flooding in downtown Tillamook; estimate of $3.8 million in damages throughout Tillamook County	riverine/ocean flooding

Date	Location	Description	Type of Flood
Jan. 2011	Clackamas, Clatsop, Douglas, Lincoln, and Tillamook Counties	severe winter storm, flooding, mudslides, landslides, and debris flows (DR-1956)	riverine
Jan. 2012	Coos, Curry, Lincoln, and Tillamook Counties	a severe winter storm including flooding, landslides, and mudslides affected mostly the southern Oregon coastal counties	riverine
Nov. 2012	Curry and Josephine Counties	heavy precipitation caused over $4 million in damages to public infrastructure	riverine, sheet flow
Sep. 2013	Tillamook County	heavy rain caused flooding at the Wilson River	riverine
Feb. 2014	Lane, Coos, Marion and Tillamook and Counties	A series of fronts resulted in a prolonged period of rain for Northwest Oregon, and minor flooding of several of the area's rivers from February 12th through February 17th. Heavy rains caused the Coquille River at Coquille to flood. The flood was categorized as a moderate flood. The Nehalem River near Foss in Tillamook County exceeded flood stage on February 18th, 2014.	riverine
Mar. 2014	Tillamook County	Heavy rain resulted in the Nehalem River to flood near Foss. The river reached flood stage around 2 pm March 6, and crested at 14.8 feet at 8 pm	riverine
Dec. 2014	Tillamook, Lincoln, Lane, Coos, and Douglas Counties	A slow moving front produced heavy rain over Northwest Oregon which resulted in the flooding of eight rivers. Another impact from the rain were a couple of land/rock slides that both blocked two highways. Heavy rain brought flooding to several rivers in southwest Oregon.	riverine
Feb. 2015	Curry, Coos, and Douglas Counties	Heavy rains caused flooding on the Rogue River at Agness and along the Coquille River at Coquille.	riverine
Nov. 2015	Tillamook County	A very moist frontal system produced heavy rain across the region resulting in flooding. Rain rates of 0.3 to 0.5 inch per hour was observed for several hours at many locations. The 5 day rainfall total ending in the morning on November 17th for Lees Camp, OR was 14.60 inches.	riverine
Dec. 2015	Tillamook, Lincoln, Washington, Lane, Coos, Douglas and Curry Counties	A moist pacific front produced heavy rainfall across Northwest Oregon which resulted in river flooding, urban flooding, small stream flooding, landslides, and a few sink holes. After a wet week (December 5 through Dec 11), several rivers were near bank full ahead of another front on December 12th. Flooding from the Nehalem River and Rock Creek in Vernonia resulted in evacuation of homes and the implementation of the Vernonia Emergency Command Center. Heavy rain resulted in a land slide that closed OR47 at mile marker 8. More than $15 million dollars in property damage reported in these counties combined.	riverine
Jan. 2016	Curry and Coos Counties	Heavy rain brought flooding to some areas of southwest Oregon. Minor flooding on the Rogue at Agness and moderate flooding on the Coquille River at Coquille.	riverine
Oct. 2016	Tillamook County, Northern Oregon Coast	The combination of heavy rain, large swell, and high tides brought minor tidal overflow flooding during high tides to the North Oregon Coast.	riverine/ocean flooding

Date	Location	Description	Type of Flood
Nov. 2016	Columbia, Tillamook, Lincoln, and Washington Counties	A moist Pacific front moving slowly across the area produced heavy rainfall, resulting in flooding of several rivers across Northwest Oregon and at least two landslides.	riverine
Dec. 2016	Douglas, Coos and Curry Counties	Heavy rain brought some areal flooding to parts of southwest Oregon.	riverine
Jan. 2017	Coos and Curry Counties	An extended period of heavy rain combined with snowmelt to cause flooding of the Coquille River the South Fork of the Coquille River and, the Rogue River flooded at Agness flooded twice that month.	riverine/rain on snow
Feb. 2017	Washington, Columbia, Tillamook, Lane, Coos, and Curry Counties	High river flows combined with high tide to flood some areas near the southern Oregon coast. Heavy rain combined with snow melt caused flooding along the Coquille River and the Rogue River twice this month in southwest Oregon. Heavy rain combined with snow melt caused flooding along the Sprague River in south central Oregon. Flows on the John Day river reached flood levels downstream of Monument due to the breaking up of an ice jam.	riverine/ocean flooding/rain on snow
Oct. 2017	Tillamook County	A very potent atmospheric river brought strong winds to the north Oregon Coast and Coast Range on October 21st. What followed was a tremendous amount of rain for some locations along the north Oregon Coast and in the Coast Range, with Lees Camp receiving upwards of 9 inches of rain. All this heavy rain brought the earliest significant Wilson River Flood on record, as well as flooding on several other rivers around the area.	riverine
June 2018	Lane County	In Lane County an upper-level trough moved across the area from the southwest, generating strong thunderstorms which produced locally heavy rainfall, lightning, hail, and gusty winds.	riverine
Dec. 2018	Tillamook County	A strong low pressure system over the Gulf of Alaska brought a strong cold front through. This generated strong winds across northwest Oregon, and also brought heavy rain which caused flooding on the Tillamook river. Large seas also caused damage in spots along beaches.	riverine/ocean flooding
Jan. 2019	Coos and Curry Counties	A weekend of very heavy rain led to river rises across southern Oregon. The Rogue River at Agness exceeded flood stage and the Coquille River at Coquille flooded as well.	riverine
Feb. 2019	Douglas, Coos and Curry Counties	Very heavy rain along with the melting of recent snowfall caused flooding at several locations in southern Oregon in late February. Deer Creek at Roseburg, South Fork of the Coquille at Myrtle Point, North Fork of the Coquille at Myrtle Point, the Coquille River at Coquille and the Rogue River at Agness all exceeded flood stage.	riverine/rain on snow
April 2019	Douglas, Coos and Curry Counties	Two days of very heavy rainfall (compared to April normals) combined with snowmelt led to areal flooding in southwest and south central Oregon.	riverine/rain on snow

Source: Taylor and Hannan (1999), Source: Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://hvri.geog.sc.edu/SHELDUS/index.cfm?page=faq. National Climatic Data Center, Storm Events, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms; NOAA Storm Event Database, (http://www.ncdc.noaa.gov/stormevents/), January 2020; Planning for Natural Hazards: Flood TRG (Technical Resource Guide), July 2000, DLCD, Community Planning Workshop.

Table 2-139. Principal Riverine Flood Sources by County in Region 1

Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Lewis and Clark R	Coquille R	Chetco R	Umpqua R	Siuslaw R	Alsea R	Kilchis R
Little Walluski R	Willicoma R	Elk R	Smith R	Munsel Cr	Salmon R	Miami R
Necanicum R	Ten Mile Cr	Pistol R	Scholfield Cr		Siletz R	Nehalem R
Nehalem R	Palouse Cr	Rogue R			Yachats R	Nestucca R
Bear Cr	Larson Cr	Sixes R			Yaquina R	Three Rivers
Beerman Cr	Kentuck Sl	Winchuck R			Drift Cr	Tillamook R
Big Cr	Willanch Sl	Hunter Cr			Depot Cr	Trask R
Cow Cr	Pony Cr				Ollala Cr	Wilson R
Fishhawk Cr					Schooner Cr	Dogherty Sl
Humbug Cr						Hoquarten Sl
Little Cr						
Neacoxi Cr						
Neawanna Cr						
Northrup Cr						
Plymton Cr						

Note: R = river, Cr = creek, Sl = slough.

Sources: Federal Emergency Management Agency (FEMA), Clatsop County Flood Insurance Study (FIS), July 17, 2001, FEMA, Coos County FIS, May 15, 1984, FEMA, Curry County FIS, Feb. 04, 1998, FEMA, Douglas County FIS, Apr. 21, 1999, FEMA, Lane County FIS, June 02, 1999, FEMA, Lincoln County FIS, Mar. 1, 1980, FEMA, Tillamook County FIS, Aug. 20, 2002.

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the "OEM Hazard Analysis Methodology" used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in Appendix **9.1.19**.

The purpose of the probability and vulnerability scores is to identify high-priority areas to which local and state governments can target mitigation actions.

Probability

Local Assessment

Participants in each county's Natural Hazard Mitigation Plan update process used the OEM Hazard Analysis Methodology to analyze the probability that Region 1 will experience flooding. The resulting estimates of probability are shown in **Table 2-140**.

Table 2-140. Local Assessment of Flood Probability in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	H	H	H	H	H

Source: Clatsop County NHMP (2020 draft), Coos County NHMP (2016), Curry County NHMP (2016), Douglas County NHMP (2016), Lane County NHMP (2018), (Lincoln County NHMP (2015, rev. 2017), Tillamook County NHMP (2017).

State Assessment

Using the methodology described in Section **2.2.5.2**, Floods > Probability, the state assessed the probability of flooding in the counties that comprise Region 1. The results are shown in **Table 2-141**.

Table 2-141. State Assessment of Flood Probability in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	VH	VH	VH	VH*	VH*	VH	VH

*The coastal portions of Douglas and Lane Counties could not be split out from the probability analysis of the whole county. For the purposes of the 2020 Risk Assessment calculations, the coastal portions of Douglas and Lane Counties were assigned a probability value consistent with the other coastal counties

Source: DOGAMI

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. However, large increases in extreme flows are least likely along the Lower Columbia Basin (northern border of Region 1).

Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-142. Local Assessment of Vulnerability to Flood in Region 1

	Clatsop	Coos	Curry	Douglas (coastal)	Lane	Lincoln	Tillamook
Vulnerability	H	M	H	M	H	M	H

Source: Clatsop County NHMP (2020 draft), Coos County NHMP (2016), Curry County NHMP (2016), Douglas County NHMP (2016), Lane County NHMP (2018), (Lincoln County NHMP (2015, rev. 2017), Tillamook County NHMP (2017)

Table 2-143. State Assessment of Vulnerability to Flood in Region 1

	Clatsop	Coos	Curry	Douglas (coastal)	Lane	Lincoln	Tillamook
Vulnerability	L	H	VL	H	M	L	L

Source: DOGAMI, DLCD

As part of Multi-Hazard Hazard Risk Reports, DOGAMI performed flood loss estimate analyses in Clatsop, Coos, and Curry Counties by overlaying building locations on the 100-year flood extent. By comparing the number of non-damaged buildings from Hazus-MH with exposed buildings in the flood zone, DOGAMI estimated the number of buildings that could be elevated above the level of flooding. In Clatsop County of the 3,011 buildings that are exposed to flooding, DOGAMI estimate that 482 are above the height of the 100-year flood. In Coos County, of the 2,055 buildings that are exposed to flooding, 185 are above the height of the 100-year flood. In Curry County, of the 464 buildings that are exposed to flooding, 55 are estimated to be above the height of the 100-year flood. This evaluation can also shed some light on the number of residents that might have mobility or access issues due to surrounding water. In Clatsop County, 4,498 residents might have mobility or access issues due to surrounding water. In Coos County, 2,116 residents might have mobility or access issues and in Curry County 411 residents might have mobility or access issues due to flooding of surrounding land.

The DOGAMI Risk Assessment and exposure analysis found that 14 of Clatsop County's critical facilities are at risk to flood hazard. Of these the majority are located in Warrenton including the Port of Astoria, Providence Medical Clinic – Warrenton, US Coast Guard Air Station, Warrenton Grade School and High School, the Warrenton Police Department, Fire Department and Public Works Department. The exposure analysis for Coos County found that 13 of the county's critical facilities could be damaged by flooding. The majority of these are located in Coos Bay including Blossom Gulch Elementary School, the Coos Bay Police Department, the Wastewater Department, the International Port of Coos Bay Port Office, the US Coast Guard Station – Cutter Orcas, the Coos Bay Coast Guard Station, and the offices of Pacific Power, as well as Coquille High School, Lakeside Water Treatment plant and Myrtle Point and Bandon's Water Plants. In Curry County only one critical facility was found to be exposed to flooding that being the Port of Port Orford.

For Douglas, Lane, Lincoln and Tillamook Counties the most recent NHMPs do not include analyses of vulnerabilities of specific critical infrastructure. They do include general observations about population, economic, infrastructure, critical facilities, built environment and cultural and historic resources at risk of damage from flooding.

Repetitive Losses

FEMA has identified 138 Repetitive Loss (RL) properties in Region 1, three of which are Severe Repetitive Loss (SRL) properties. This region has the most repetitive flood losses of any of the Oregon NHMP Natural Hazard Regions, reflecting the high rainfall amounts characteristic of the coastal region and the high density of watercourses. The coast is also subject to flooding from the Pacific Ocean.

Table 2-144. Flood Severe/Repetitive Loss Buildings and Community Rating System Communities by County in Region 1

County	RL/SRL	# of CRS Communities per County
Clatsop	5	0
Coos	16	0
Curry	3	0
*Douglas	—	0
*Lane	—	0
Lincoln	47	0
Tillamook	62	2
Total	**133**	**2**

* Not currently possible to include only coastal sections of Douglas and Lane Counties.

Source: FEMA NFIP Community Information System, https://portal.fema.gov/famsVuWeb/home, accessed February 2020

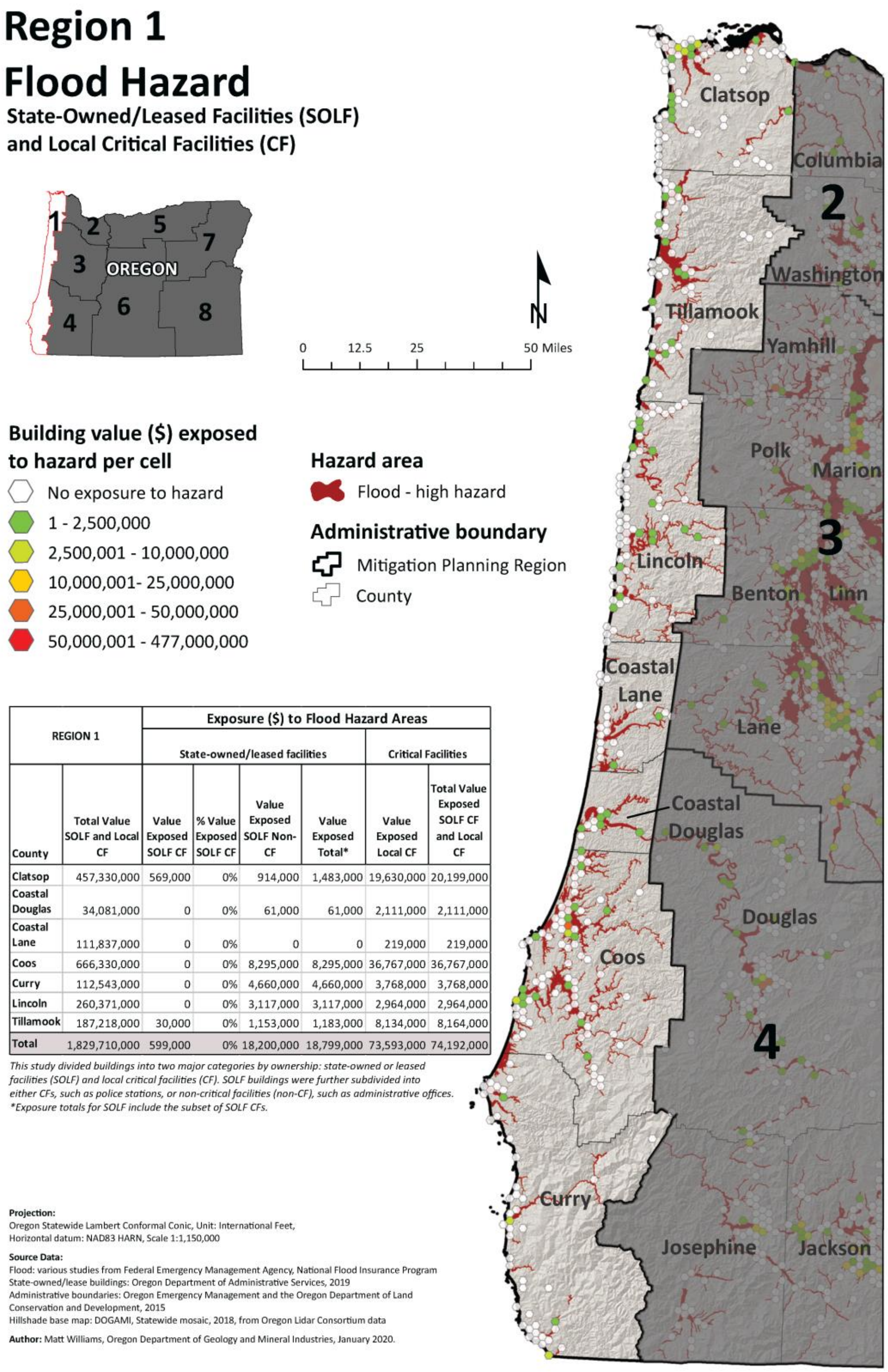
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. Lane Counties participates in CRS, as do the cities of Nehalem and Tillamook.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 1, there is a potential loss from flooding of close to $19M in state building and critical facility assets, 44% of it in Coos County, about 25% in Curry County, and about 17% in. Lincoln County. Clatsop, Tillamook, and the coastal portion of Douglas County each have less than 10% and the coastal portion of Lane County has none. There is a far greater potential loss due to flood in local critical facilities: over $73M, almost four times as much. Fifty percent of that value is located in Coos County; 27% in Clatsop County. The other counties have 11% or less. **Figure 2-131** illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding.

Figure 2-131. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 1. High-resolution, full-size image linked from Appendix 9.1.26.



REGION 1		Exposure ($) to Flood Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Clatsop	457,330,000	569,000	0%	914,000	1,483,000	19,630,000	20,199,000
Coastal Douglas	34,081,000	0	0%	61,000	61,000	2,111,000	2,111,000
Coastal Lane	111,837,000	0	0%	0	0	219,000	219,000
Coos	666,330,000	0	0%	8,295,000	8,295,000	36,767,000	36,767,000
Curry	112,543,000	0	0%	4,660,000	4,660,000	3,768,000	3,768,000
Lincoln	260,371,000	0	0%	3,117,000	3,117,000	2,964,000	2,964,000
Tillamook	187,218,000	30,000	0%	1,153,000	1,183,000	8,134,000	8,164,000
Total	1,829,710,000	599,000	0%	18,200,000	18,799,000	73,593,000	74,192,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 3,121 historic resources in Region 1, two hundred fifty-three (8%) are located in an area of high flood hazard, 40% of those in Curry County alone. Clatsop County, the coastal portion of Douglas County, and Tillamook County follow with 19%, 16%, and 13%, respectively.

Archaeological Resources

Of the 536 archaeological resources located in high flood hazard areas in Region 1, almost half (45%) are located in Coos County. Close to 20% are located in Lincoln County. Seventy-five (14%) are listed on the National Register of Historic Places and 41 (8%) are eligible for listing. Twenty-seven have been determined not eligible and 393 have not been evaluated as to their eligibility. Together, Coos and Curry Counties are the location of almost 60% of the listed and eligible archaeological resources in Region 1. At 49%, Coos County has significantly more of the unevaluated resources than any other county in Region 1.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Coos County and the coastal portion of Douglas County are most vulnerable to flooding with high scores. Lane County follows with a moderate score, and the other counties all have low or very low vulnerability. The two high scores are driven by high social vulnerability. Region 1 has very low to moderate scores for potential loss to state buildings and critical facilities and local critical facilities.

Most Vulnerable Jurisdictions

While all the counties in Region 1 are vulnerable to flooding, Coos County is the most vulnerable with its high social vulnerability, significant trove of archaeological resources, significant number of repetitive or severe repetitive loss properties, high percentages of state building, state critical facility, and local critical facility value in a high flood hazard area, and low percentage of buildings exposed to flood hazards that are above flood level.

Risk

Table 2-145. Risk of Flood Hazards in Region 1

	Clatsop	Coos	Curry	Douglas (coastal)	Lane	Lincoln	Tillamook
Risk	VH	VH	H	VH	VH	VH	VH

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, all the counties in Region 1 are at high or very high risk from flooding. Given its significant vulnerabilities, Coos County is at greatest risk.

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to the owner's property and waters below the dam to community destruction with mass fatalities. The 1889 Johnston Flood in Pennsylvania was caused by a dam failure and resulted in over 2000 lives lost.

Oregon's first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Table 2-146. Historic Significant Dam Failures in Region 1

Year	Location	Description
1996	Powers Log Pond in Powers in south Coos Co.	Damaged road and limited damage to dwellings

Source: Oregon Water Resources Department Dam Safety Program records

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 12 High Hazard dams and 5 Significant Hazard dams in Region 1.

Table 2-147. Summary: High Hazard and Significant Hazard Dams in Region 1

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 1	**12**	**5**	**0**
Clatsop	4	1	0
Coos	2	4	0
Curry	1	0	0
Lincoln	5	0	0
Tillamook	0	0	0

Source: Oregon Water Resources Department, 2019

Table 2-148. High Hazard and Significant Hazard Dams in Region 1

County	Name	Rating	Regulator
Clatsop	Bear Creek	High	State
Clatsop	Middle	High	State
Clatsop	Seaside City	High	State
Clatsop	Wickiup Lake (Astoria)	High	State
Clatsop	Fishhawk Lake	Significant	State
Coos	Pony Creek - Lower	High	State
Coos	Pony Creek - Upper	High	State
Coos	Jackson Farms Dam	Significant	State
Coos	Powers Log Pond	Significant	State
Coos	Rink Creek Reservoir	Significant	State
Coos	Windhurst	Significant	State
Curry	Ferry Creek	High	State
Lincoln	Big Creek #1 (Lower)	High	State
Lincoln	Big Creek #2 (Upper)	High	State
Lincoln	Mill Creek	High	State
Lincoln	Olalla	High	State
Lincoln	Spring Lake	High	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and regulated. A dam's condition is considered public information for state-regulated dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when

uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.

- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Only two of the twelve state-regulated high hazard dams are in satisfactory condition. Five are in poor or unsatisfactory condition.

Table 2-149. Summary: Condition of High Hazard State-Regulated Dams in Region 1

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	Fair	Poor	Unsatisfactory	Not Rated
Region 1	2	5	2	3	0
Clatsop	0	3	1	0	0
Coos	1	0	1	0	0
Curry	0	0	0	1	0
Lincoln	1	2	0	2	0
Tillamook	0	0	0	0	0

Source: Oregon Water Resources Department, 2019

Table 2-150. Condition of High Hazard State-Regulated Dams in Region 1

County	Dam Name	Condition
Clatsop	Middle	Fair
Clatsop	Seaside City	Fair
Clatsop	Wickiup Lake (Astoria)	Fair
Clatsop	Bear Creek	Poor
Coos	Pony Creek - Lower	Poor
Coos	Pony Creek - Upper	Satisfactory
Curry	Ferry Creek	Unsatisfactory
Lincoln	Mill Creek	Fair
Lincoln	Olalla	Fair
Lincoln	Spring Lake	Satisfactory
Lincoln	Big Creek #1 (Lower)	Unsatisfactory
Lincoln	Big Creek #2 (Upper)	Unsatisfactory

Source: Oregon Water Resources Department, 2019

State-Regulated High Hazard Dams not Meeting Safety Standards

There are five state-regulated high hazard dams in Region 1 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). These dams and the population at risk, based on a screen using the screening tool DSS-WISE, are shown in Table 2-151. As the dam safety program conducts analysis over time, the number of dams in less than satisfactory condition may change. Currently dams that are in poor or unsatisfactory condition are in need of rehabilitation or other action to bring them into a fully safe condition. As of

December 2019, these are the dams in Region 1 that are not yet demonstrably unsafe, but that do pose unacceptable risk. When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Table 2-151. State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 1

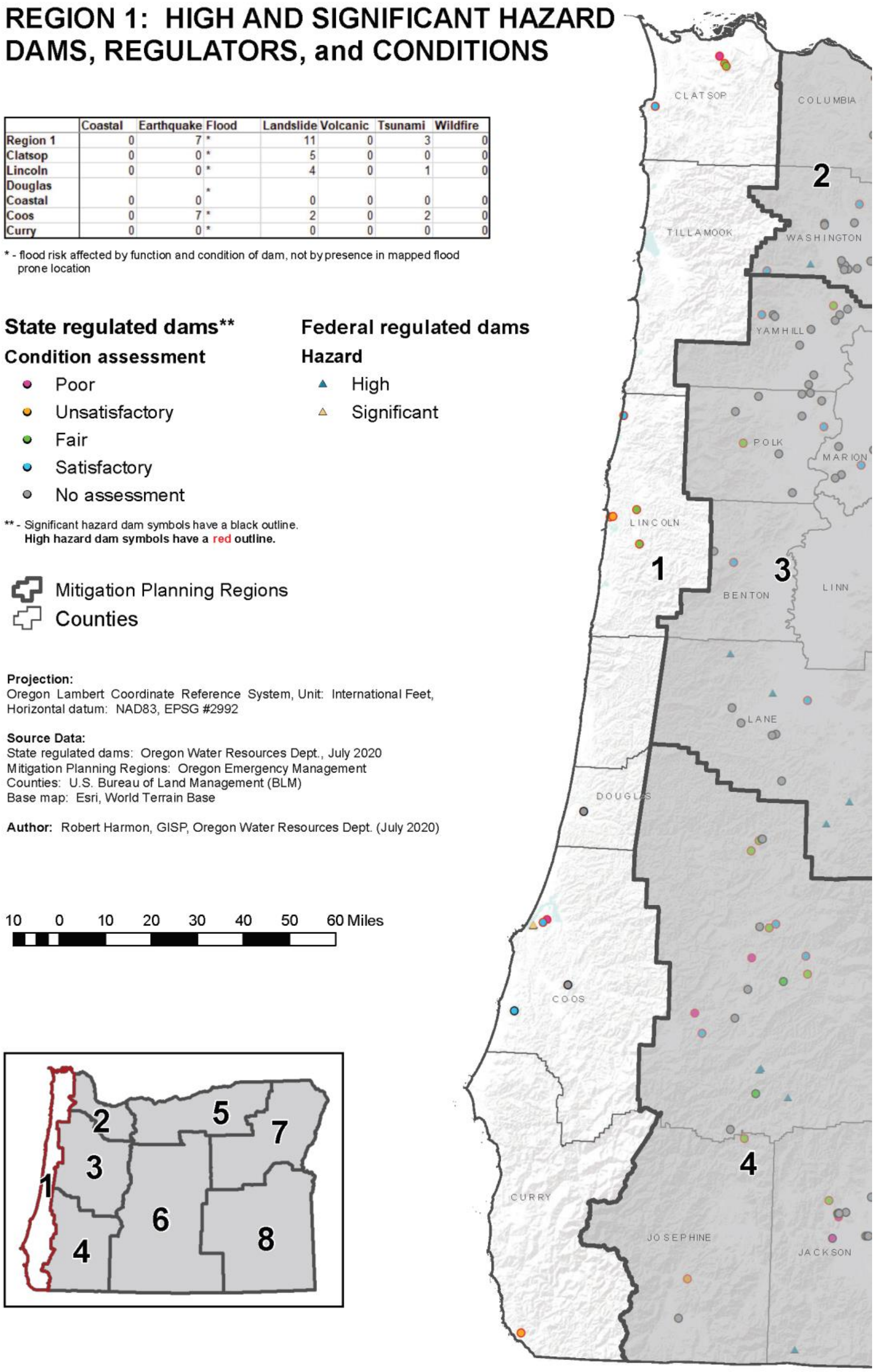
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Bear Creek (Astoria)	OR00449	POOR	20	57	Clatsop
Pony Creek Lower	OR00070	POOR	687	408	Coos
Ferry Creek	OR00437	UNSAT	84	25	Curry
Big Creek Reservoir #1 (Lower)	OR00225	UNSAT	16	35	Lincoln
Big Creek Reservoir #2 (Upper)	OR00473	UNSAT	26	52	Lincoln

Note: "PAR" is number of "Persons At Risk" in the dam failure inundation zone based on a conservative estimate using DSS-Wise dam breach estimator. It includes all persons that normally could be in the inundation area. Actual impacts depend on the velocity and depth of water and will be determined as part of Oregon's HHPD grant tasks.

Source: DSS-Wise output

Figure 2-132 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 1. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-132. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 1



	Coastal	Earthquake	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 1	0	7	*	11	0	3	0
Clatsop	0	0	*	5	0	0	0
Lincoln	0	0	*	4	0	1	0
Douglas Coastal	0	0	*	0	0	0	0
Coos	0	7	*	2	0	2	0
Curry	0	0	*	0	0	0	0

Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

Table 2-151, State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 1, indicates the number of people currently anticipated to be impacted by potential failure of the state-regulated high hazard dams in poor or unsatisfactory condition. OWRD plans to do more analysis to determine the number and value of structures that may be impacted as well.

Dams in Region 1 often have a higher vulnerability from earthquakes and landslides than dams in other regions. Most dams in this region were constructed prior to an understanding that the Cascadia subduction Zone can and will produce extreme earthquakes. And because of dense forest cover, very large landslides above some dams were not identified. As a result, some dams in this region were built below areas prone to large, rapidly moving landslides. One dam in this region was recently removed due to risk from a very large landslide area above the dam and reservoir. Also because of the often dense forest cover, this region is prone to debris loading after wildfires or windstorms. This debris can reduce spillway capacity and the ability of a dam to safely pass a large flood without overtopping. Other coastal and tsunami hazards do not generally add much to the risk to dams, and there is negligible volcanic hazard to dams in this region.

Five dams in Region 1 meet FEMA HHPD eligibility criteria. Critical infrastructure, including water intake and water supply treatment plants for three cities, and one major highway (lifeline to coastal communities) lies below four of them.

Most Vulnerable Jurisdictions

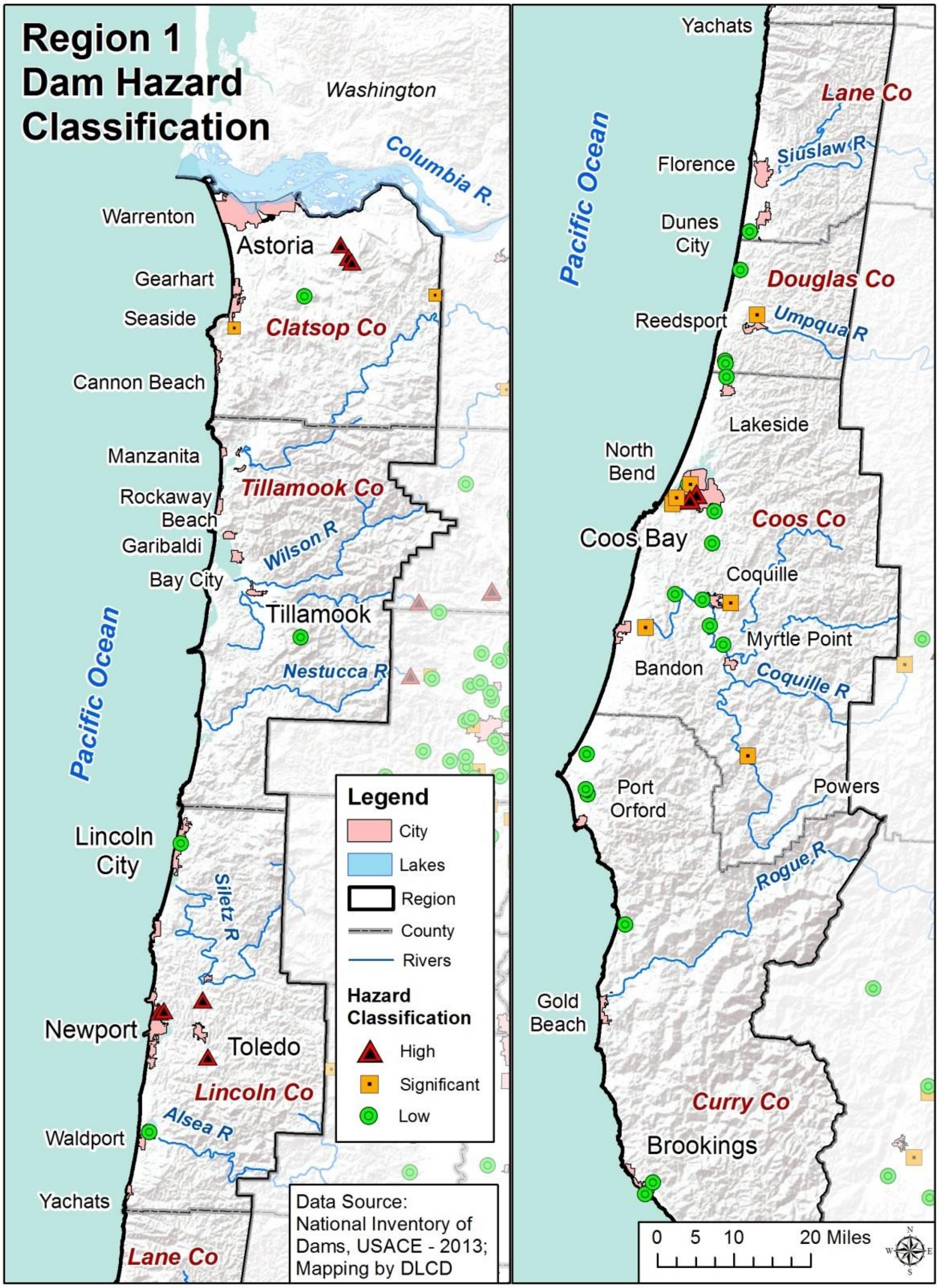
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), the counties in Region 1 with high hazard dams in poor or unsatisfactory condition are considered most vulnerable: Clatsop, Coos, Curry, Lincoln. Of those, by far the greatest number of people in potentially dangerous locations if a dam were to fail are in Coos County.

As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable jurisdictions” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The county with the most state-regulated significant hazard dams is Coos County (4).

Risk

With FEMA and State funding, OWRD will be completing risk assessments for Region 1's state-regulated high hazard dams in poor or unsatisfactory condition over the next several years. For now, the potential for damage to the dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-133. Region 1 Dam Hazard Classification



Source: National Inventory of Dams, 2013

Note: Federally regulated significant hazard dams are not shown.

Landslides

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the coast and Coast Range Mountains have a very high incidence of landslides. On occasion, major landslides occur on U.S. or state highways and sever these major transportation routes (including rail lines), causing temporary but significant economic damage to the state. Less commonly, landslides and debris flows in this area cause loss of life.

Historic Landslide Events

Table 2-152. Historic Landslides in Region 1

Date	Location	Description
Feb. 1926	between Coos Bay and Coquille, Oregon	damages: $25,000; closed Roosevelt Highway
Feb. 1961		large section of Ecola State Park slid into the Pacific Ocean
Feb. 1996		FEMA-1099-DR-Oregon; heavy rains and rapidly melting snow contributed to hundreds of landslides and debris flows across the state, many on clear cuts that damaged logging roads
Nov. 1996	Lane and Douglas Counties	FEMA-1149-DR-Oregon; heavy rain triggered mudslides (Lane and Douglas Counties); five fatalities; several injuries (Douglas County)
Feb. 1999	south of Florence, Oregon	two timber workers killed in a mud and rockslide (south of Florence)
Jan. 2000	north of Florence, Oregon	a landslide (north of Florence) closed US-101 for 3 months, resulting in major social and economic disruption to nearby communities
Dec. 2004	Lane, Polk, and Lincoln Counties	property damage: $12,500
Dec. 2007	Clatsop and Tillamook	property damage: $300,000
Dec. 2008	Clatsop and Tillamook Counties	DR-1824; landslide closed Wilson River highway
Jan. 2011	Clatsop, Tillamook, Lincoln, and Douglas Counties	DR-1956; landslide closed OR 22; landslides along OR 6, US 20, and US 26
Mar. 2011	Lincoln, Coos, and Curry Counties	DR-1964
Jan. 2012	Tillamook, Lincoln, Lane, Douglas, Coos, Curry	DR-4055
Feb. 2014	Lincoln, Lane	DR-4169; portions of US 101 closed
Dec. 2015	Clatsop, Tillamook, Lincoln, Lane, Douglas, Coos, and Curry Counties	DR-4258; several homes destroyed in north Newport; OR 42 closed from landslide; fatality in Florence from landslide; many other roads closed
Dec. 2016	Lane	DR-4296
Feb. 2019	Lane, Douglas, Coos, and Curry Counties	DR-4432; Hooskanaden landslide closed US 101
Apr. 2019	Douglas and Curry Counties	DR-4452; several roads closed

Sources: Taylor and Hatton (1999)*;* and FEMA After-Action Report, 1996 events; and interviews, Oregon Department of Transportation representatives; https://www.fema.gov/disasters

Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from: http://www.sheldus.org

Probability

Table 2-153. Assessment of Landslide Probability in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	VH	VH	VH	VH	VH	VH	VH

Source: DOGAMI 2020

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in Oregon in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-154. Local Assessment of Vulnerability to Landslides in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	M	H	L	M	—	H	M

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-155. State Assessment of Vulnerability to Landslides in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	L	H	L	H	H	VH	H

Source: DOGAMI and DLCD, 2020

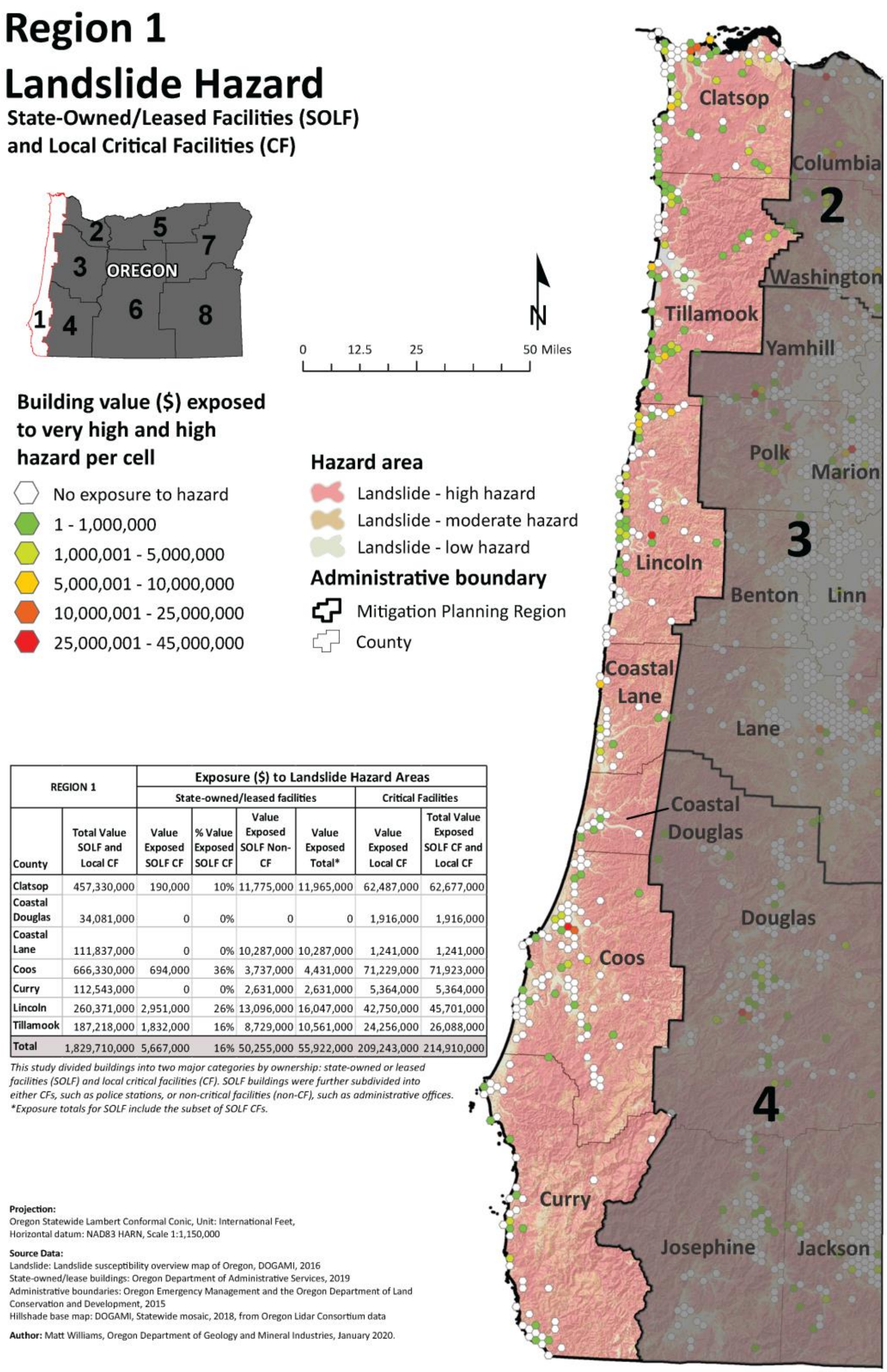
Rain-induced landslides and debris flows can potentially occur during any winter in this region. This area is also subject to future very large earthquakes, which will trigger landslides. Many of the communities in Region 1 have a high exposure to the landslide hazard, for example Astoria. A study of the landslide hazard and risk of Astoria found 121 landslides within the city limits and losses in a major earthquake are likely to be 50% greater than somewhere with low or no landslide hazards (Burns & Mickelson, 2013).

Some of the greatest exposure in Region 1 is the east-west roadways that carry traffic to and from the coast, with the potential for injuries and loss of life from rapidly moving landslide events.

State-Owned/Leased Facilities and Critical/Essential Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 1. Almost $56M in value of state facilities is exposed to landslide hazards in Region 1, close to 30% of it in Lincoln County followed by Clatsop, Tillamook, and the coastal portion of Lane County. The coastal portion of Douglas County has no state facilities at potential loss from landslides. In contrast, the region has critical facilities representing over $209M in value in landslide hazard areas. Together, Coos and Clatsop Counties have almost two-thirds of the value of local critical facilities followed by Lincoln and Tillamook Counties. **Figure 2-134** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

Figure 2-134. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 1. High-resolution, full-size image linked from Appendix 9.1.26.



REGION 1		Exposure ($) to Landslide Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Clatsop	457,330,000	190,000	10%	11,775,000	11,965,000	62,487,000	62,677,000
Coastal Douglas	34,081,000	0	0%	0	0	1,916,000	1,916,000
Coastal Lane	111,837,000	0	0%	10,287,000	10,287,000	1,241,000	1,241,000
Coos	666,330,000	694,000	36%	3,737,000	4,431,000	71,229,000	71,923,000
Curry	112,543,000	0	0%	2,631,000	2,631,000	5,364,000	5,364,000
Lincoln	260,371,000	2,951,000	26%	13,096,000	16,047,000	42,750,000	45,701,000
Tillamook	187,218,000	1,832,000	16%	8,729,000	10,561,000	24,256,000	26,088,000
Total	1,829,710,000	5,667,000	16%	50,255,000	55,922,000	209,243,000	214,910,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,150,000

Source Data:
Landslide: Landslide susceptibility overview map of Oregon, DOGAMI, 2016
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

Of the 3,121 historic resources in Region 1, all but 14 are exposed to landslide hazards: 1,439 are in an area of very high or high landslide hazard susceptibility; 729 in moderate; and 939 in low. The greatest numbers of historic resources exposed to landslide hazards are in Clatsop, Coos, and Tillamook Counties.

Archaeological Resources

Of the 547 archaeological resources located in landslide hazard areas in Region 1, eighty-six percent (557) are in high landslide hazard areas. Of those, 72 are listed on the National Register of Historic Places and 33 are eligible for listing. Twenty have been determined not eligible, and 432 have not been evaluated as to their eligibility. About one-third of the archaeological resources in a high landslide hazard area are located in Curry County and another 30% in Coos County. Curry County is home to the most archaeological resources listed and eligible for listing on the National Register. Together, Coos and Curry Counties contain 64% of the archaeological resources in landslide hazard areas in Region 1.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Lincoln County is the most vulnerable to landslide hazards in Region 1 followed by Coos, Douglas, Lane, and Tillamook Counties. Lincoln County's overall vulnerability is driven primarily by the presence of state buildings and state and local critical facilities, somewhat by social vulnerability. Coos and Douglas Counties' vulnerability score is driven by the presence of local critical facilities and its high social vulnerability. Lane County's vulnerability is driven by the presence of state buildings and local critical facilities together with social vulnerability. Tillamook County's vulnerability is driven by the presence of state and local critical facilities.

Risk

Table 2-156. Assessment of Risk to Landslides in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	H	VH	H	VH	VH	VH	VH

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 risk scores and DOGAMI expertise, all of the coastal counties are “most vulnerable jurisdictions” with either very high or high risk ratings. All communities should be prioritized for mitigation actions.

Tsunamis

Characteristics

Tsunami waves are infrequent events, but tsunamis can be extremely destructive. They may be generated by earthquakes, submarine volcanoes, or landslides, and travel hundreds of miles before striking land. Hardly discernible at sea, tsunami waves travel as fast as 500 mph across open water until, at landfall, they slow down significantly and rapidly increase in height that range from 20 to about 100 feet. Seward, Alaska, experienced tsunami waves as high as 25 feet during the 1964 earthquake-tsunami event.

Most tsunami waves have been described as an onrushing, rapidly rising tide, which can be seen in the few motion pictures that have captured the tsunami phenomenon. The size and behavior of tsunamis depend on a number of factors, including distance traveled, submarine topography and the shape and orientation of the coastline. Much of the damage results from water-borne debris, which can act as battering rams against on-shore development. Wave-borne fuel drums are especially hazardous because of their propensity to cause or exacerbate fires.

All Region 1 counties are susceptible to tsunami hazards. Oregon’s coastal communities have experienced, to various degrees, tsunamis that have originated in the oceanic regions near Russia’s Kamchatka Peninsula, Japan, Chile, Hawaii, the Gulf of Alaska, and northern California. Additionally, the geologic record indicates that over the last 10,200 years approximately 45 tsunamis have been generated locally off the Oregon Coast along the Cascadia Subduction Zone (CSZ). Nineteen of these tsunamis were from full-margin ruptures of the CSZ and arrived in all parts of the coast about 10–20 minutes after the earthquake; the remaining 25 events occurred on the southern (south of the vicinity of Cape Blanco) Oregon coast. Any locally generated tsunamis would cause significant damage to coastal ports and pose a threat to those near waterfront areas. This is the region’s greatest concern.

Historic Tsunami Events

Table 2-157 describes the effects of distant tsunami events that have impacted the Oregon Coast (Region 1).

Table 2-157. Historic Tsunamis Affecting the Oregon Coast

Date	Origin of Event	Affected Community	Damage	Remarks
04/1868	Hawaii	Astoria, Oregon		observed
08/1868	N. Chile	Astoria, Oregon		observed
08/1872	Aleutian Is	Astoria, Oregon		observed
11/1873	N. California	Port Orford, Oregon		debris at high tide line
04/1946	Aleutian Is	Bandon, Oregon		barely perceptible
04/1946		Clatsop Spit, Oregon		water 3.7 m above MLLW
04/1946		Depoe Bay, Oregon		bay drained; water returned as a wall
04/1946		Seaside, Oregon		wall of water swept up Necanicum River
11/1952	Kamchatka	Astoria, Oregon		observed
11/1952		Bandon, Oregon	log decks broke loose	
05/1960	S. Cent. Chile	Astoria, Oregon		observed
05/1960		Seaside, Oregon	bore on Necanicum River damaged boat docks	
05/1960		Gold Beach, Oregon		observed
05/1960		Newport, Oregon		observed for about four hours
05/1960		Netarts, Oregon	some damage observed	
Mar. 1964	Gulf of Alaska	Cannon Beach, Oregon	bridge and motel unit moved inland; $230,000 damage	
Mar. 1964		Coos Bay, Oregon	$20,000 damage	
Mar. 1964		Depoe Bay, Oregon	$5,000 damage; four children drowned at Beverly Beach	
Mar. 1964		Florence, Oregon	$50,000 damage	
Mar. 1964		Gold Beach, Oregon	$30,000 damage	
Mar. 1964		Seaside, Oregon	one fatality (heart attack); damage to city: $41,000; private: $235,000; four trailers, 10-12 houses, two bridges damaged	
05/1968	Japan	Newport, Oregon		observed
04/1992	N. California	Port Orford, Oregon		observed
10/1994	Japan	Oregon Coast		tsunami warning issued, but no tsunami observed
3/2011	Japan	Oregon Coast	$6.7 million; extensive damage to the Port of Brookings	tsunami warning issued, observed ocean waves

Date	Origin of Event	Affected Community	Damage	Remarks
Oct. 2012	Haida Gwaii, BC	coast		M 7.7 caused a tsunami with local runup of more than 7 meters and amplitudes up to 0.8 meter on tide gauges 4,000 kilometers away in Hawaii. Source: NOAA
Jan. 2018	Kodiak Is., AK	coast		minor tsunami impacts in AK, HI and US west coast; the largest tsunami amplitude was recorded at 25cm in Crescent City CA 4-5 hrs after the magnitude 7.9 earthquake

Sources: NOAA, 1993, Tsunamis Affecting the West Coast of the United States: 1806-1992; FEMA, 2011, Federal Disaster Declaration; NOAA, https://www.ngdc.noaa.gov/hazel/view/hazards/tsunami/event-more-info/5673, downloaded on 4/15/20; NOAA https://www.ngdc.noaa.gov/hazel/view/hazards/tsunami/event-more-info/5673 downloaded on 4/15/20

Probability

Table 2-158. Local Probability Assessment of Tsunami in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	VH	VH	H	H	H	H

Source: DOGAMI, 2020

With respect to distant sources, Oregon has experienced 25 tsunamis in the last 145 years with only 3 causing measurable damage. Thus, the average recurrence interval for tsunamis on the Oregon coast from distant sources would be about 6 years. However, the time interval between events has been as little as one year and as much as 73 years. The two most destructive tsunamis occurred only 4 years apart (1960 and 1964) and originated from two different source areas: south central Chile and the Gulf of Alaska. Because only a few tsunamis caused measurable damage, a recurrence interval for distant tsunamis does not have much meaning for this region with respect to losses. However, every time NOAA issues a distant tsunami warning for the coast, evacuation plans are triggered at significant cost to local government and business.

Geologists estimate a 16-22% chance that a CSZ tsunami will be triggered by a shallow, undersea earthquake offshore Oregon in the next 50 years, causing a tsunami that will strike all parts of the Oregon coast about 10–20 minutes after the earthquake. This forecast comes from the 10,000-year geologic record of 19 CSZ fault ruptures extending the entire length of the Oregon coast (i.e., recurrence of approximately 500 years) (Wang & Clark, 1999). As previously mentioned, the southern Oregon coast has a higher chance of experiencing a local tsunami and earthquake, estimated to be approximately 43% in the next 50 years. At the time of this update, the last CSZ event occurred 320 years ago (Satake K., Shimazaki K., Tsuji Y., & Ueda K., 1996).

Owing to their much faster wave arrival and generally larger size, tsunamis originating from the CSZ will cause much larger life and property losses. Inundation from the largest distant tsunamis approximates inundation from the “Small” Cascadia tsunami on Oregon Tsunami Inundation Maps (TIMs).

Vulnerability

Table 2-159. Local Assessment of Vulnerability to Tsunamis in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	—	M	M	H	--	H	M

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-160. State Assessment of Vulnerability to Tsunamis in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	VH	VH	L	H	VH	M	L

Source: DOGAMI, 2020

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the Cascadia Subduction Zone (CSZ) happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

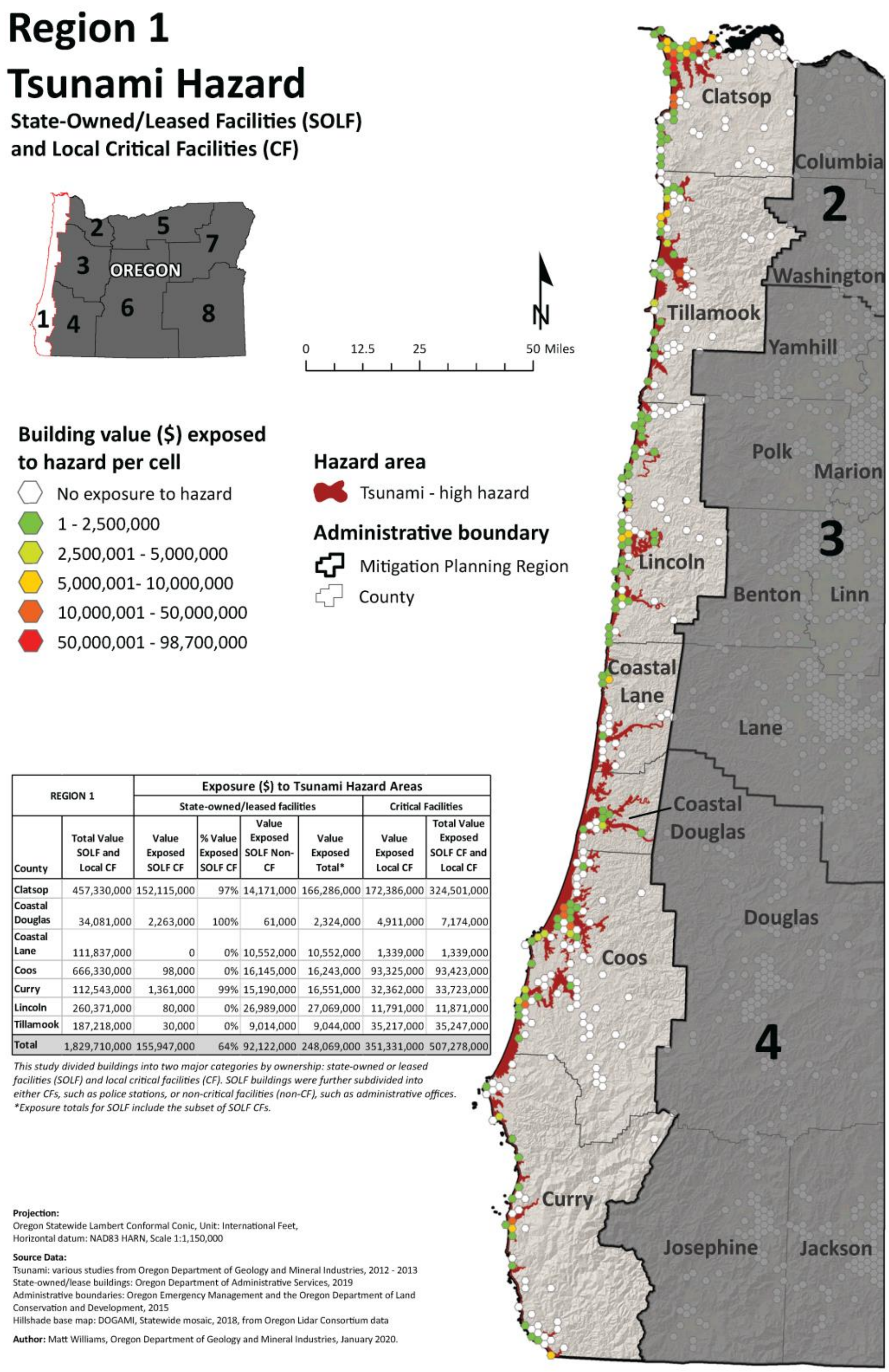
Most Vulnerable Jurisdictions

For the 2020 vulnerability assessment, DOGAMI considered all Cascadia Subduction Zone (CSZ) tsunami hazard zones as high hazard areas.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from tsunami hazards to state buildings and critical facilities as well as to local critical facilities statewide. Over $248M in value of state buildings and state critical facilities is located in tsunami hazard areas, and 67% of that value is located in Clatsop County. Eleven percent is located in Lincoln County; about 7% is located in each of Coos and Curry Counties; about 4% in each of the coastal portion of Lane County and Tillamook only 1% in the coastal portion of Douglas County. More than $351K of value in local critical facilities is located in tsunami hazard areas. Again, most of that value, 49%, is located in Clatsop County. Twenty-seven percent is located in Coos County; about 10% in each of Tillamook and Curry Counties; and 3% or less in Lincoln County and the coastal portions of Lane and Douglas Counties.

Figure 2-135. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Tsunami Hazard Zone in Region 1. High-resolution, full-size image linked from Appendix 9.1.26.



Source: DOGAMI

Historic Resources

Of the 3,121 historic resources located in Oregon's coastal counties, 794 (25%) are located in tsunami hazard areas. Of those located in tsunami hazard areas, 73% (582) are located in Clatsop County; 21% (170) in Coos County; and 4% or less in Lincoln, Curry, and Tillamook Counties, respectively. None are located in the coastal portions of Douglas or Lane Counties.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

For the 2020 vulnerability assessment, DLCD combined this index with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Clatsop County, Coos County, and the coastal portion of Lane County are the most vulnerable to the CSZ tsunami hazard followed by the coastal portion of Douglas County.

All communities in Region 1 are especially vulnerable to local tsunamis because of their coastal settings and locations in low-lying areas. Seaside is the most vulnerable city due to its low elevation and high resident and tourist populations, and its county, Clatsop, is the most vulnerable county, having the largest exposed population (**Figure 2-136**) (Wood N. , 2007). Although many communities have evacuation maps and evacuation plans, many casualties are expected. The built environment in the inundation zone will be especially hard hit.

The United States Geological Survey (USGS) completed a comprehensive study (Wood N. , 2007) of coastal cities' exposure and sensitivity to a CSZ tsunami similar to the most likely "Medium" scenario depicted in the 2010–2013 DOGAMI Tsunami Inundation Map series. The tsunami zone of the USGS study is the 1995 regulatory inundation zone that was previously used by the Oregon Building Code to limit new construction of critical/essential, hazardous, and high-occupancy facilities; this restriction was recently rescinded by the Oregon legislature. Results from the (Wood N. , 2007) study indicated that the regulatory inundation zone contained approximately 22,201 residents (4% of the total population in the seven coastal counties), 14,857 employees (6% of the total labor force), and 53,714 day-use visitors on average every day to coastal Oregon State Parks within the tsunami-inundation zone. The zone also contained 1,829 businesses that generate approximately $1.9 billion in annual sales volume (7% and 5% of study-area totals, respectively) and tax parcels with a combined total value of $8.2 billion (12% of the study-area total). Although occupancy values are not known for each facility, the tsunami-inundation zone also contains numerous dependent-population facilities (for example, adult-residential-care facilities, child-day-care facilities, and schools), public venues (for example, religious organizations and libraries), and critical facilities (for example, police stations).

Additionally, results indicate that vulnerability, described in the study by exposure (the amount of assets in tsunami-prone areas) and sensitivity (the relative percentage of assets in tsunami-prone areas) varies considerably among 26 incorporated cities in Region 1 (Wood N. , 2007). City exposure and sensitivity to tsunami hazards is highest in the northern portion of the coast. The City of Seaside in Clatsop County has the highest exposure, the highest sensitivity, and the highest combined relative exposure and sensitivity to tsunamis. Results also indicate that the amount of city assets in tsunami-prone areas is weakly related to the amount of a community's land in this zone; the percentage of a city's assets, however, is strongly related to the percentage of its land that is in the tsunami-prone areas.

Using U.S. 2010 census data, Wood and others (2015) performed similar analyses as Wood (2007) for the Oregon coast using the L1 tsunami inundation line. This latter tsunami zone is akin to an approximate 3,333 year event and covers 95% of the expected inundation defined from the full geologic record. Analyses of these data indicate that 33,244 people live in the tsunami zone. However, the number of employees and businesses identified had decreased to 10,237 and 624 respectively; further analysis of the data indicated 109 dependent care located in the tsunami zone. As with Wood (2007), the largest population exposures to the tsunami hazard occur on the northern Oregon coast in Clatsop and Tillamook Counties (**Figure 2-137**). Localized hotspots are also apparent in communities such as Gold Beach, Port Orford and Reedsport.

Figure 2-136. Number (A) and Percentage (B) of Residents in the Oregon Regulatory Tsunami Inundation Zone (Wood N. , 2007)

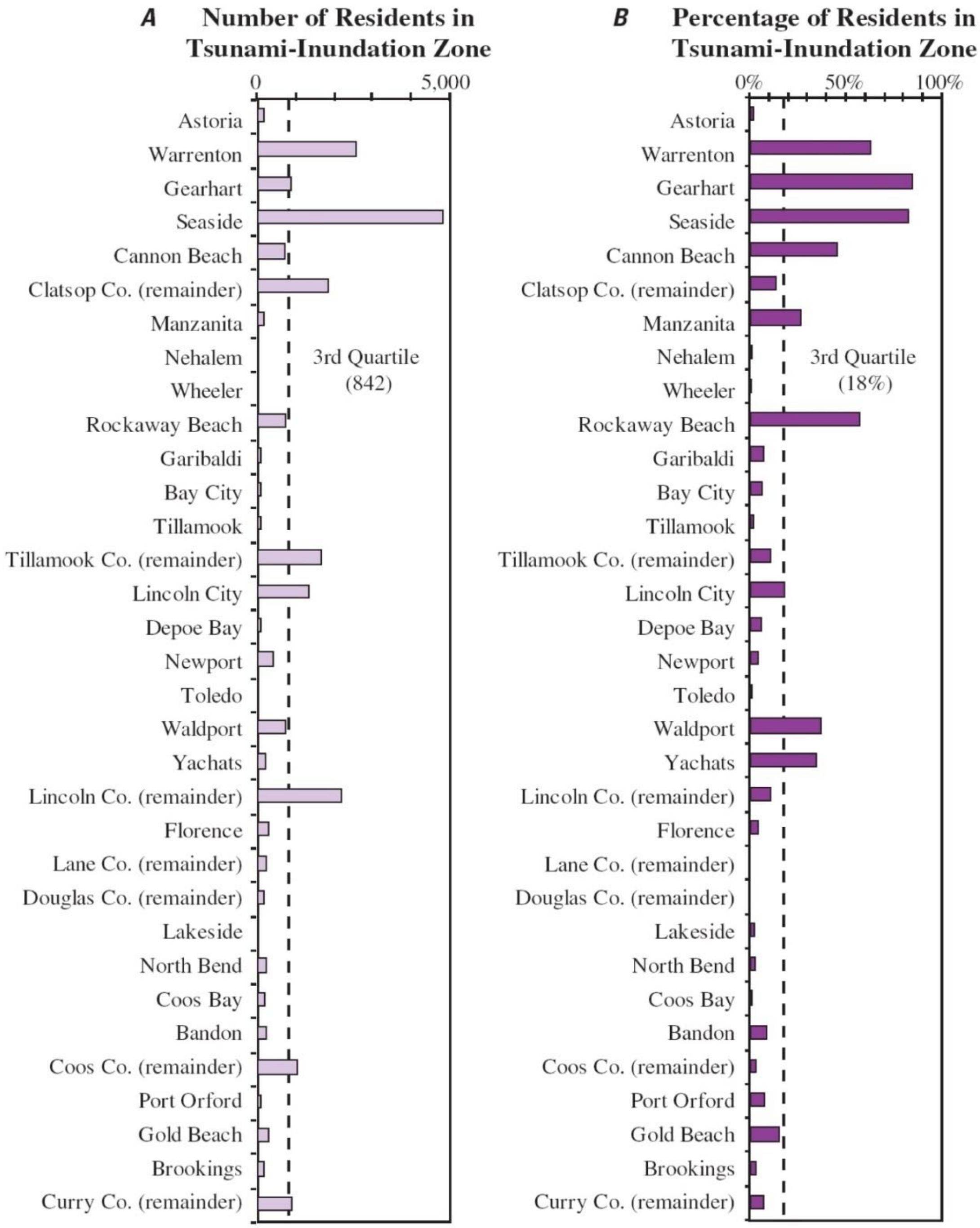
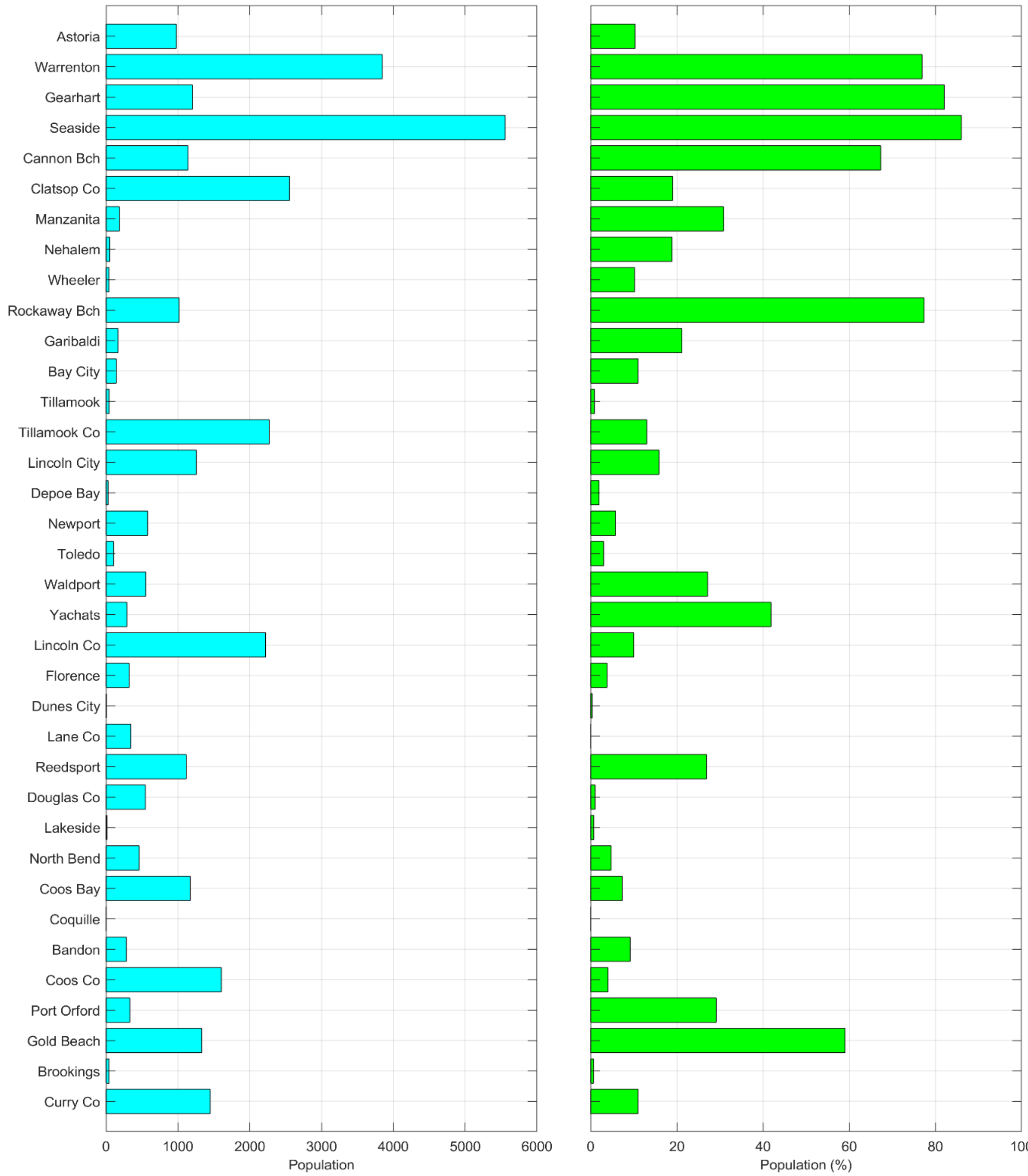


Figure 2-137. Number (A) and Percentage (B) of Residents in the Oregon Regulatory Tsunami Inundation Zone (data from Wood and others, 2015)



Risk

Table 2-161. Risk from Tsunami Hazard in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	VH	VH	M	VH	VH	H	M

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the coastal hazards probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Clatsop, Coos, and the coastal portions of Douglas and Lane Counties are at greatest risk from coastal hazards, followed by Lincoln County. By all measures discussed in this chapter, Clatsop County is at greatest risk from the tsunami hazard.

Volcanoes

Characteristics

The volcanic Cascade Mountain Range is not within Region 1 counties; consequently, the risk from local volcano-associated hazards (e.g., lahars, pyroclastic flows, lava flows, etc.) is not a priority consideration for Coastal Oregon. However, there is some risk from volcanic ashfall. This fine-grained material, blown aloft during a volcanic eruption, can travel many miles from its source. For example, the cities of Yakima (80 miles) and Spokane (150 miles), Washington, were inundated with ash during the May 1980, Mount St. Helens eruption. Ashfall can reduce visibility to zero, and bring street, highway, and air traffic to an abrupt halt. The material is noted for its abrasive properties and is especially damaging to machinery. It would be prudent for communities that may be exposed to ashfall to identify disposal areas for large quantities of ash. Part of Clatsop County borders the Columbia River, which in theory makes it vulnerable to lahars or mudflows carried by the river. Although unlikely, such an event cannot be dismissed out of hand. A lahar or mudflow that traveled down Washington's Cowlitz River following the eruption of Mount St. Helens, filled the Columbia River channel overnight from its previous 40-foot depth to a mere 14 feet. This delayed ship movements in the vicinity of the Cowlitz for months (Wolfe & Pierson, 1995).

Historic Volcanic Events

There are no significant volcanoes within Region 1 and no historic volcano-related events.

Probability

Table 2-162. Assessment of Volcanic Hazards Probability in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	VL	VL	VL	VL	VL	VL	VL

Source: DOGAMI, 2020

Mount St. Helens is a probable source of ashfall and lahars that can reach the Columbia River. The probability of coastal counties receiving ashfall is about 1 in 10,000 — with a large portion of Curry County having even less probability (Sherrod, Mastin, Scott, & Schilling, 1997). A lahar mudflow that traveled down Washington's Cowlitz River following the 1980 eruption of Mount St. Helens filled the Columbia River channel overnight from its previous 40-foot depth to a mere 14 feet. This delayed ship movements for months.

Vulnerability

Table 2-163. Local Assessment of Vulnerability to Volcanic Hazards in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	M	—	H	—	—	L	L

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-164. State Assessment of Vulnerability to Volcanic Hazards in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	VL	M	VL	M	L	L	VL

Source: DOGAMI and DLCD, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 1. There is over $1.8B of value in state buildings, state critical facilities, and local critical facilities in Region 1; none of it exposed to volcanic hazards. Similarly, none of the 3,121 historic buildings in Region 1 are exposed to volcanic hazards. See Appendix **9.1.12** for details.

Historic Resources

None of the 3,121 historic buildings in Region 1 are exposed to volcanic hazards. See Appendix **9.1.12** for details.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

According to the 2020 vulnerability scores, none of the communities identified by DOGAMI as being most vulnerable to volcano hazards are located in Region 1. Coos County and the coastal portion of Douglas County scored moderately vulnerable due to high social vulnerability.

Risk

Table 2-165. Assessment of Risk to Volcanic Hazards in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	VL	VL	VL	VL	VL	VL	VL

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of volcanic hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

All communities in Region 1 all have very low (VL) risk ratings. However, as noted earlier, there is some risk of ashfall that can be especially damaging to machinery. Although remote, the threat of lahars or volcanic related mudflows could impact the shipping industry on the Columbia River in Region 1 (Ewart, Diefenbach, & Ramsey, 2018).

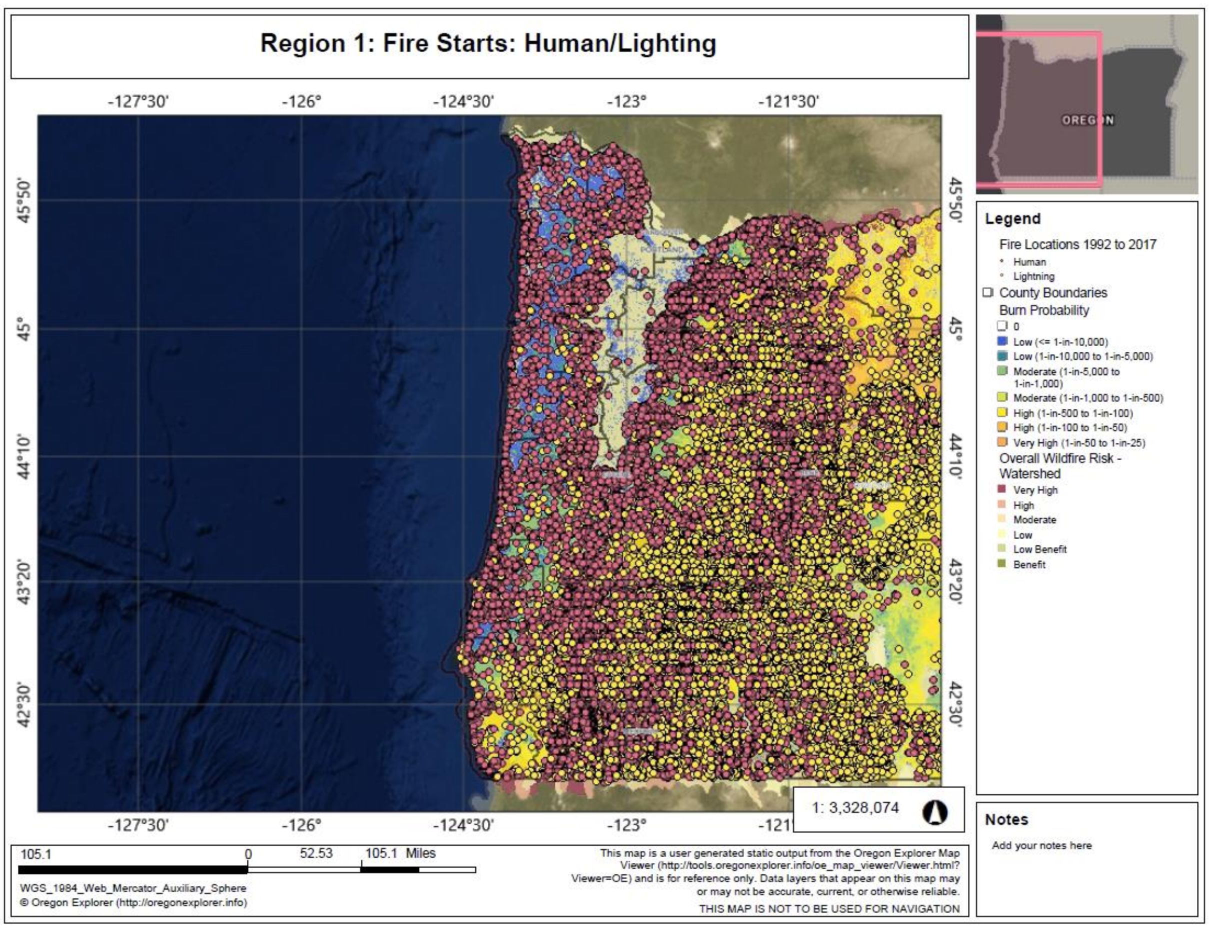
Wildfires

Characteristics

Existing development near wildland areas combined with the spread of gorse and other flammable plant species throughout the region is increasing the level of wildfire risk. Wildfires in the wildland-urban interface (WUI) pose serious threats to life and endanger property, critical infrastructure, water resources, and valued commercial and ecological forest resources. While the region is characterized as moist and regarded as lower than normal fire danger, historically some the largest fire events have occurred in this area. The Tillamook Burn, comprising devastating wildfires every 6 years between 1933 and 1951, burned a total of 355,000 acres. Much of the burn was attributed to powerful east wind events and heavy fuels.

Historically, lighting has been the primary ignition source of wildfires in the region. Weather patterns from May through October are characterized by periods of drought separated by storms that produce dry forest fuels followed by frequent lightning strikes, a common source of ignitions. During the past two decades, though, fires caused by human activities in this area were more frequent than those ignited by natural processes.

Figure 2-138. Fires Caused by Humans and Lightning



Source: Oregon Wildfire Risk Explorer, 2020

Long periods of drought are common during the summer and electrical storms are a common cause of wildfire. These types of storms are most frequent from May through October. Long periods of drought during the summer months also create challenges for wildfire responders. Many small rural communities lack the type of water systems that make water accessible for fire suppression. Instead fire fighters in these areas are often dependent on water from ponds, creeks, and rivers. Often in the mid- to late summer months, these sources are low or completely dry.

Wind direction changes to an easterly flow in early fall when landscapes are at their driest. These "east wind events" resemble the well-known Santa Anna winds of southern California that produce large, destructive wildfires.

Wildfires have played a significant role in shaping the species composition and forest structure in the region. Intensive fire suppression has resulted in forest fuel buildup and changes in species composition and structure in the past 65 years.

Coastal and Lower Columbia River counties are heavily timbered and have a long history of devastating forest fires. Some of the history is derived from Native Americans who recall extensive forest fires before the arrival of Euro-Americans. Fires involving the wildland interface occur in portions of the state where urbanization and natural vegetation fuels allow a fire to spread rapidly from natural fuels to structures and vice versa. Especially in the early stage of such fires, structural fire suppression resources can be quickly overwhelmed increasing the number of structures destroyed. Such fires are known for the large number of structures that are simultaneously exposed to fire, increasing the total losses per structure ignited. Nationally, wildland interface fires commonly produce widespread, extreme losses. Thus far, Oregon has escaped the level of property losses experienced by neighboring states.

Gorse, a spiny evergreen shrub, was introduced in south coastal Oregon from Europe. It has become an established invasive weed that displaces native vegetation, significantly altering the native vegetation patterns. Because Gorse is highly flammable, it increases wildfire risk wherever it spreads. Infestations of Gorse are particularly common along the coastal area; these areas are a major concern for wildfire managers. Currently there is a group of federal and state agencies, non-profit organizations, private industry, and landowners who have formed the Gorse Action Group (GAG). This group has made it their mission to control and reduce the spread of gorse and minimize the impact on economy and natural resources.

Wildfire managers in the southern part of the region are also concerned with the spread of Port-Orford-Cedar root disease and Sudden Oak Death. Trees infected by these pathogens are at increased risk to wildfire and vegetation management activities need to be conducted in a way that minimizes the spread of disease pathogens. The Rogue River-Siskiyou National Forest, Bureau of Land Management, Oregon Department of Forestry, and Oregon State Parks have implemented actions to manage the spread of these pathogens.

Historic Wildfire Events

Table 2-166. Historic Wildfires in Region 1

Date	Name of Fire	Location	Characteristics	Remarks
1846	Yaquina	Lincoln and Lane Counties	> 450,000 acres	event related by Native American hunters
1853	Nestucca		> 320,000 acres	
1868	Coos Bay	Coos	296,000 acres	
1922	Astoria	downtown City of Astoria	many buildings (32 city blocks burned!)	early December structural fire most likely not related to wildfire
1933	Tillamook		240,000 acres	the Tillamook Forest burned every 6 years between 1933 and 1951; total acreage burned was over 350,000 acres; together, the four events are called the Tillamook Burn; dry forest conditions seems to have been a major factor (Taylor)
1936	Bandon	Coos	143,000 acres	destroyed 100s of homes and killed 10 people.
1939	Saddle Mountain	Clatsop County	207,000 acres	
1945	Wilson River / Salmonberry	Tillamook County	173,000 acres	
1951	North Fork / Elkhorn	Tillamook County	33,000 acres	
2002	Florence / Biscuit	Curry County	almost 500,000 acres (perimeter)	largest forest fire in Oregon since arrival of Euro-Americans; the perimeter contained many unburned islands within the overall acreage
	Holloway Fire	Tillamook	more than 245,000 acres	Holloway Fire burned more than 245,000 acres in Oregon from a lightning strike and also burned more than 215,000 acres in Nevada. One firefighter was killed.
	Chetco Bar	Curry	burned 191,125 acres	started by lightning strike

Source: Brian Ballou, 2002, A Short History of Oregon Wildfires, Oregon Department of Forestry, unpublished; unknown sources from previous versions of the Oregon NHMP; Oregon Department of Forestry, 2020

Probability

Table 2-167. Assessment of Wildfire Probability in Region 1

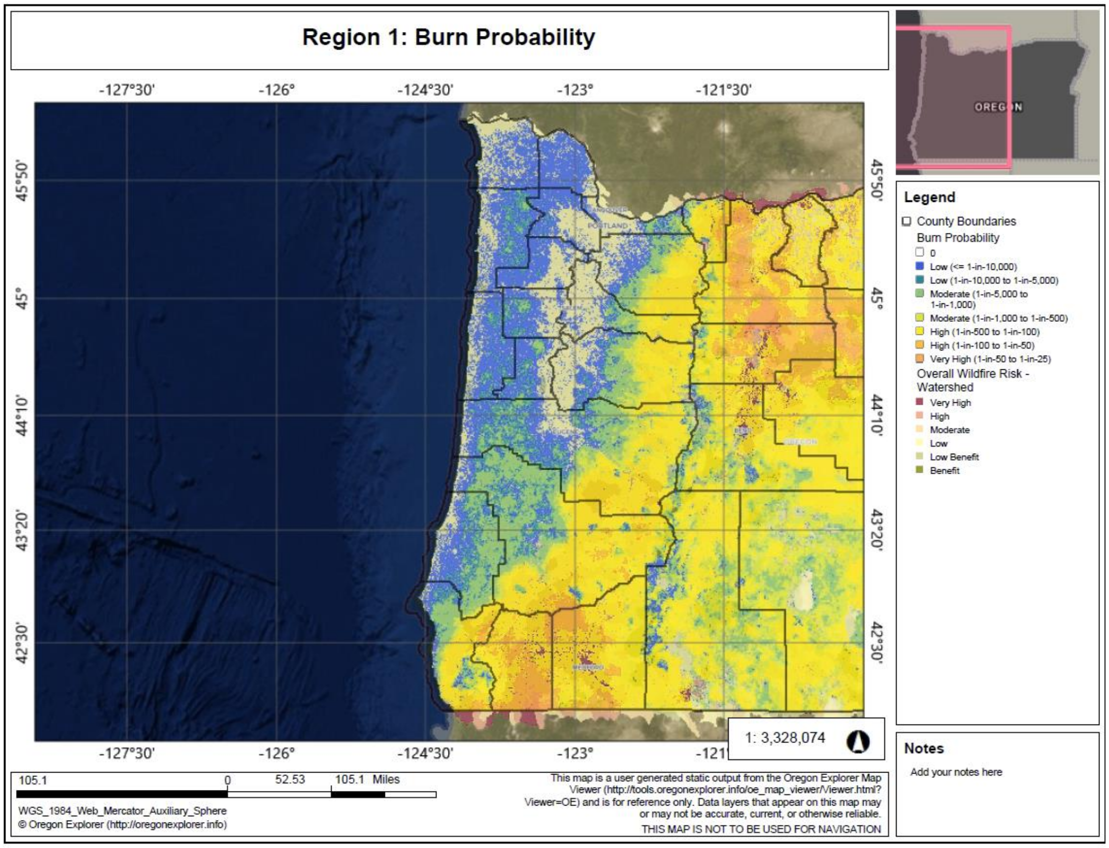
	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	L	L	H	M	L	L	L

Source: Oregon Wildfire Risk Explorer, March 2020; PNW Quantitative Wildfire Risk Assessment: Burn Probability, March 2020

The PNW Quantitative Wildfire Risk Assessment utilizes fire history, topography, weather, infrastructure, and fuels data to determine probability and vulnerability scores for each county. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with statewide assessments and methodologies is that scale and values of the data have to be applicable to the entire state, so local level information may show some inaccuracy. Interpretation of the data is not necessarily the same at local levels. Community Wildfire Protection Plans (CWPPs) still play a crucial role in addressing additional vulnerability and probability of wildfire due to “on the ground” information such as ingress/egress, building materials, landscaping, and location of fire response, etc. The state recognizes these inconsistencies and has partnerships that will be working on more of a parcel level assessment in the future. A description of how the Very High (VH), High (H), Moderate (M), Low (L), and Very Low (VL) scores in the local probability and vulnerability tables in this section were determined is provided in the Probability section of the state risk assessment for wildfires.

Figure 2-139 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

Figure 2-139. Burn Probability

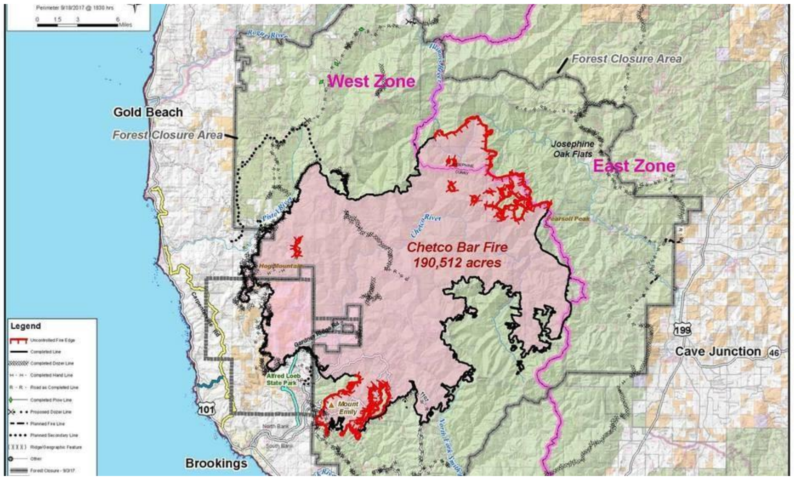


Source: Oregon Wildfire Risk Explorer, March 2020

The potential that wildland fires, both small and large, will threaten life, property and natural resources is a reality. Fire statistics show that fire incident rates, and therefore risks, are prevalent in the WUI areas. Population growth and development continue to encroach into and fragment forests. The natural ignition of forest fires is largely a function of weather and fuel; human-caused fires add another dimension to the probability. Dry and diseased forests can be mapped accurately and some statement can be made about the probability of lightning strikes. Each forest is different and consequently has different probability/recurrence estimates.

The probability of significant fire activity occurring in Region 1 is most likely during the late summer and early fall months when temperatures remain high, vegetation has had the entire summer to dry out and east winds are more prevalent coming out of the Columbia Gorge in the north and Chetco drainages in the south portions of the region. The Chetco Bar Fire was a classic example of this, starting July 12, 2017 and burning 191,125 acres until November 4, 2017 when it was finally 100% contained. The Chetco Effect (warm, dry winds in this area) and high pressure over the Great Basin both had significant impact on this fire.

Figure 2-140. Chetco Bar Fire



Source: Chetco Bar Fire Map, September 20, 2017. (InciWeb.org)

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

In moisture-limited forest systems, such as those in the Coast Range, warming winters will lead to more fine fuels from greater cold season growth. Hotter and drier conditions will lead to large fuel quantities, which lead to large and severe fires. It is very likely (>90%) that the Coast Range in Region 1 will experience increasing wildfire frequency and intensity under future climate change. Modeled projections of future fire frequency indicate more frequent fires for the Pacific Northwest, particularly west of the Cascade Mountains where fires have been infrequent historically. In coastal areas, fire frequency is projected to change from approximately every 100 years to every 60 years.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 1 counties (**Table 2-168**).

Table 2-168. Projected Increase in Annual Very High Fire Danger Days in Region 1 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Clatsop	10	27%
Coos	11	31%
Curry	11	30%
Lincoln	14	37%
Tillamook	11	30%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-169. Local Assessment of Vulnerability to Wildfire in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	M	M	H	M	—	L	M

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-170. Assessment of Vulnerability to Wildfire in Region 1 – Communities at Risk

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	L	L	VL	M	L	VL	L

Source: Trentadue & Alcock, ODF Communities at Risk Report (2020)

Table 2-171. Assessment of Vulnerability to Wildfire in Region 1 – 2020 Vulnerability Assessment

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	VL	M	VL	M	M	L	VL

Source: DOGAMI, DLCD

According to ODF's assessment of Communities at Risk, counties within Region 1 have very low to moderate risk from wildfire based primarily on cool, moist weather conditions. However, this region has had some of the largest wildfires that posed threats to communities when they occurred. The 1936 Bandon Fire is a prime example of a fire that, when combined with heavy fuels (gorse) and powerful dry east winds, an entire city was destroyed killing 13 people.

Gorse, brush, and timber still make up much of the landscape in Region 1. Given the right conditions, this region's vulnerability to wildfire exists. However, due to infrequent fire activity, the level of vulnerability can be categorized as moderate. A large wildfire in this region would affect local economies that rely on tourism and recreation dollars.

The economic stability of the region is dependent on a major state highway (US-101) that runs along the Oregon Coast. Should a major wildfire or other natural event (such as a tsunami) threaten or impact this major thoroughfare, coastal tourism and recreational economies would come to a halt.

Each year a significant number of people build homes within or on the edge of the forest (urban-wildland interface), thereby increasing wildfire hazards. These communities have been designated "Wildland-Urban Interface Communities" and are listed in **Table 2-172**.

Table 2-172. Wildland-Urban Interface Communities in Region 1

Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Arch Cape	Bandon	Agness	Azalea	Bohemia City	Depoe Bay	Bay City
Astoria	Bridge	Brookings	Camas Valley	Coburg	Elk City	Beach
Beach	Bunker Hill	Cape Ferrelo	Canyonville	Cottage Florence	Lincoln City	Beaver
Brownsmead	Charleston	Gold Beach	Cavitt Creek	Crestwell	Newport	Blaine
Brownsville	Coos Bay	Harbor	Cow Creek	Deadwood	Otter Rock	Camp Cloverdale
Cannon Costal Strip	Coquille	Illahe	Curtin	Dexter	Rose Lodge	Cape Meares
Elsie-Vinemaple	Dora	Langlois	Days Creek	Dorena	Salishan	Foley Creek
Fern Hill	Fairview	Nesika Beach	Diamond Lake	Dunes City	Seal Rock	Garibaldi
Fort Clatsop	Greenacres	Ophir	Dillard	Eugene	Siletz	Hebo
Gearhart	Hauser	Pistol River	Dixonville	Glenwood	Spring Valley St. Park	Hemlock
Hamlet	Lakeside	Port Orford	Drain	Goshen	Tidewater	Jordan Creek
Hewell	Libby	Sixes	Drew	Grove	Toledo	Kilchis
Knappa	Millington	Upper Chetco	Dry Creek	Hazeldell	Waldport	Lees Camp
Lewis and Clark	Myrtle Point		Elkton	Junction City	Yachats	Magruder
Necanicum	North Bay		Fair Oaks	London Springs		Manhattan
Seaside	North Bend		Fortune Branch	Lorane		Wheeler
Svensen	Powers		Cow Creek	Lowell		Manzanita
Warrenton	Saunders Lake		Freezeout Creek	Lower Mckenzie		Nedonna Beach
Westport	Sitkum		Gardiner	Lower Willamette		Nehalem
	Sumner		Glenbrook	Mapleton		Neskowin
			Glendale	McKenzie		Netarts
			Glide	Mohawk		Oceanside
			Green Acres	Morcola		Oretown
			Kellogg	Oakridge		Pacific City
			Lemolo	Pleasant Hill		Pleasant Valley
			Lemolo Lake	Rainbow		Rockaway Beach
			Little River	Santa Clara		Sandlake
			Lookingglass	Siuslaw		Siskeyville
			Loon Lake	Springfield		Tierra del Mar
			Milo	Swisshome		Tillamook
			Myrtle Creek	Triangle Lake		Winema Beach
			N. Umpqua	Upper McKenzie		Woods
			North Umpqua Village	Upper Willamette		
			Oakland			
			Reedsport			
			Rice Hill			

Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
			Riddle	Veneta		
			Roseburg	Waldon		
			Scottsburg	Walker		
			South Umpqua	West Valley		
			Steamboat	Westfir		
			Susan Creek	Willakenzie		
			Sutherlin			
			Tenmile			
			Tiller			
			Tokette			
			Tri City			
			Umpqua			
			Union Gap			
			Upper Ollala			
			Camas Tenmile			
			Wiber			
			Winchester Bay			
			Winston			
			Wolf Creek			
			Yoncalla			

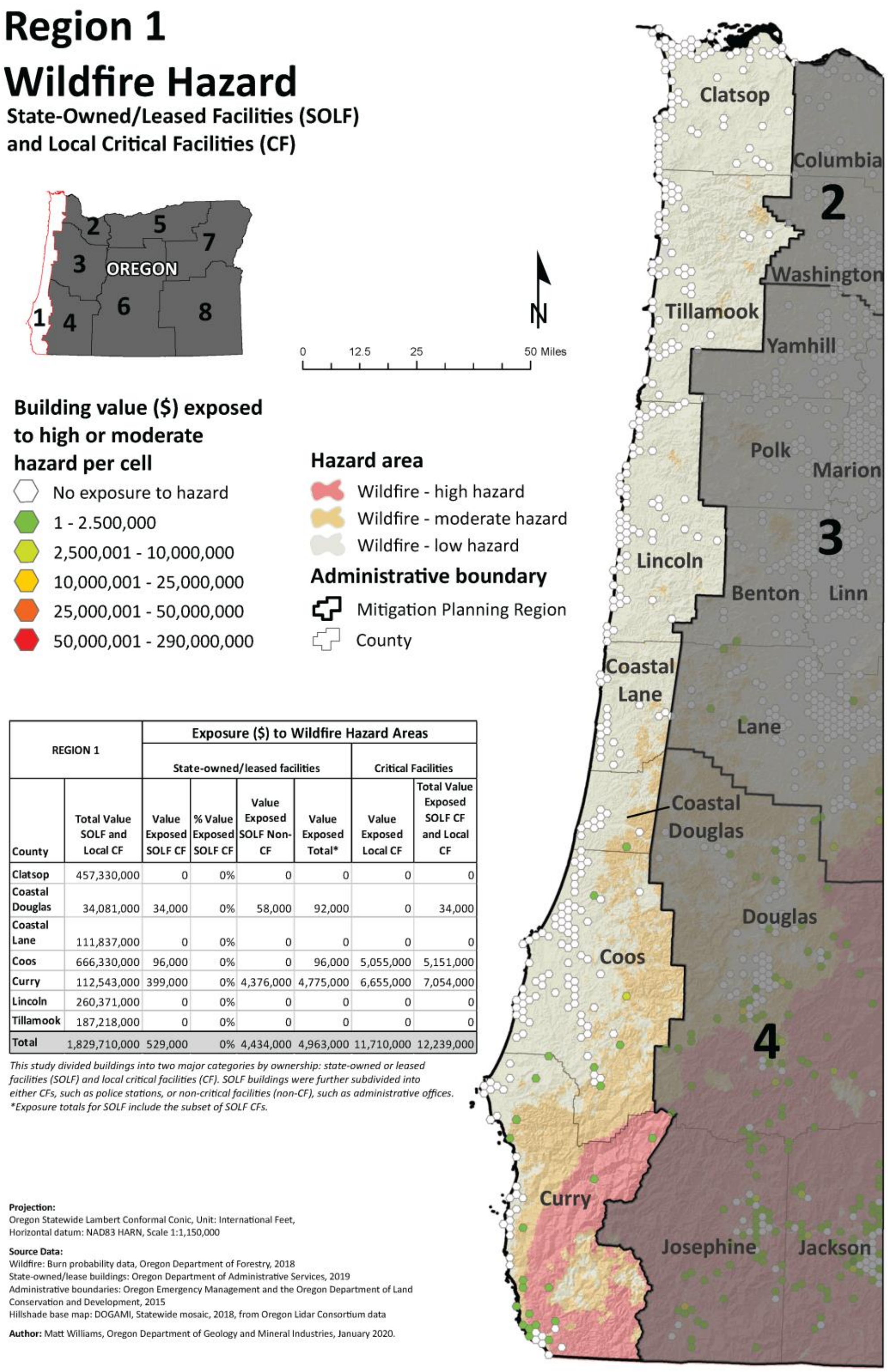
Source: Oregon Dept. of Forestry Statewide Forest Assessment September, 2006

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in “High,” “Moderate,” and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as “Low.”

In Region 1, there is a potential loss of almost $5M in state building and critical facility assets, 96% of it in Curry County. The other 4% is divided almost equally between the coastal portion of Douglas County and Coos County. There is a far greater potential loss in local critical facilities: over $11M, over twice as much. A little less than half that value is located in Coos County; a little more than half in Curry County. There are no state buildings or critical facilities exposed to wildfire hazards in Clatsop County, the coastal portion of Lane County, Lincoln or Tillamook Counties. The same is true for local critical facilities with the addition of the coastal portion of Douglas County. **Figure 2-141** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a wildfire event.

Figure 2-141. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 1. High-resolution, full-size image linked from Appendix 9.1.26.



REGION 1		Exposure ($) to Wildfire Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Clatsop	457,330,000	0	0%	0	0	0	0
Coastal Douglas	34,081,000	34,000	0%	58,000	92,000	0	34,000
Coastal Lane	111,837,000	0	0%	0	0	0	0
Coos	666,330,000	96,000	0%	0	96,000	5,055,000	5,151,000
Curry	112,543,000	399,000	0%	4,376,000	4,775,000	6,655,000	7,054,000
Lincoln	260,371,000	0	0%	0	0	0	0
Tillamook	187,218,000	0	0%	0	0	0	0
Total	1,829,710,000	529,000	0%	4,434,000	4,963,000	11,710,000	12,239,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,150,000

Source Data:
Wildfire: Burn probability data, Oregon Department of Forestry, 2018
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

Of the 3,121 historic resources in Region 1, only three are located in an area of high wildfire hazard, all of them in Curry County. Eight are located in an area of moderate wildfire hazard: three in the coastal portion of Douglas County, four in Coos County, and one in Tillamook County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, none of the counties is Region 1 is particularly vulnerable to wildfire. Scores range from very low to moderate vulnerability. While the scores based on Communities at Risk and from the 2020 vulnerability assessment only match for Coos and the coastal portion of Douglas County, in both assessments scores range from very low to moderate vulnerability. Overall, vulnerability to wildfire in Region 1 is low.

Most Vulnerable Jurisdictions

None of the counties in Region 1 are most vulnerable to wildfire hazards.

Risk

Table 2-173. Risk of Wildfire Hazards in Region 1

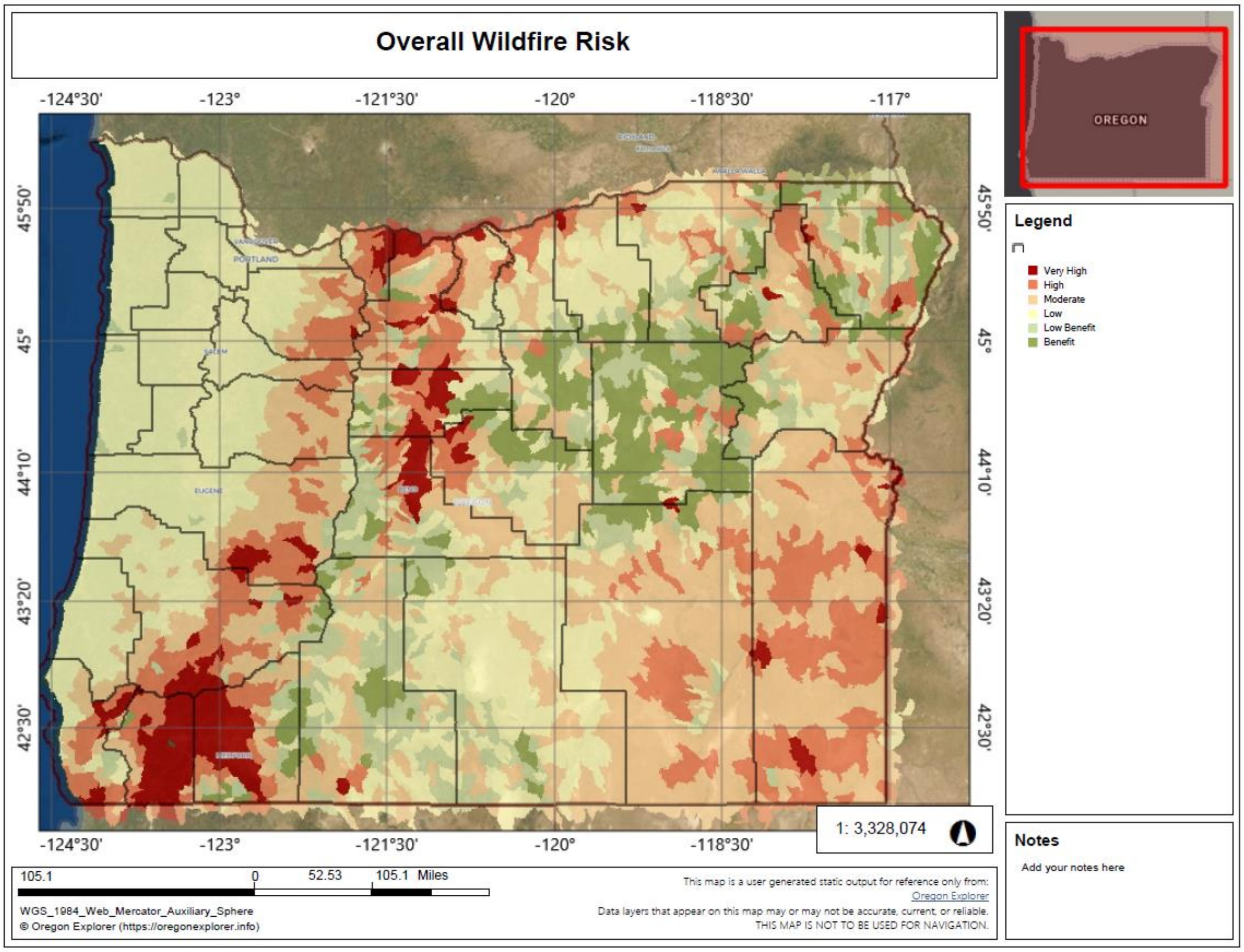
	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	L	H	L	H	H	L	L

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, the risk from wildfire is high in Coos County and the coastal portions of Douglas and Lane Counties.

This outcome is inconsistent with that which would be expected from combining ODF's probability and vulnerability ratings: Coos County has a high risk rating. With low probability and low vulnerability Coos County would be expected to have low risk. Similarly, for the coastal portion of Lane County, a high risk rating is inconsistent with its moderate and low probability and vulnerability ratings. Among all these measures, the coastal portion of Douglas County consistently rates higher, and therefore is the county at greatest risk of wildfire in Region 1.

Figure 2-142. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

High winds can be expected throughout Region 1, due to their coastal location. Destructive windstorms are less frequent, and their pattern is fairly well known. They form over the North Pacific during the cool months (October through March), move along the coast, and swing inland in a northeasterly direction. Wind speeds vary with the storms. Gusts exceeding 100 miles per hour have been recorded at several coastal locations (**Table 2-174**) but lessen as storms move inland. These storms, such as the Columbus Day Storm of October, 1962, can be very destructive. Less destructive storms can topple trees and power lines and cause building damage. Flooding can be an additional problem. A large percentage of Oregon's annual precipitation comes from these events (Taylor & Hatton (1999); FEMA-1405-DR-OR, 2002YEAR, Reducing Windstorm Damage to Property and Electrical Utilities).

Tornadoes

Most people do not associate tornadoes with the State of Oregon, and certainly not in coastal areas. Nevertheless, tornadoes have occurred in Region 1. They are characteristically brief and small, but also damaging. The first recorded tornado on the Oregon Coast occurred in 1897 (**Table 2-175**). Two more occurred in 2016 in Tillamook County; one caused about $1M in damage.

Historic Windstorm Events

Table 2-174. Historic Windstorms in Region 1

Date	Location	Description	Remarks
Jan. 1880	western Oregon	very high winds, 65-80 mph near Portland	flying debris; fallen trees
Jan. 1921	Oregon coast / Lower Columbia	winds 113 mph at mouth of Columbia; gusts at Astoria, 130 mph	widespread damage
Apr. 1931	western Oregon	unofficial reports of wind speeds up to 78 mph	widespread damage
Nov. 1951	most of Oregon	winds 40–60 mph with 75–80 mph gusts	widespread damage, especially to transmission lines
Dec. 1951	most of Oregon	winds, 60–100 mph, strongest along coast	many damaged buildings; telephone/power lines down
Dec. 1955	western Oregon	wind gusts at North Bend 90 mph	significant damage to buildings and farms
Jan. 1956	western Oregon	heavy rains, high winds, mud slides	estimated damage: $95,000 (1956 dollars)
Nov. 1958	most of Oregon	wind gusts to 75 mph at Astoria; gusts to 131 mph at Hebo	damage to buildings and utility lines
Nov. 1962	statewide	wind speeds of 131 mph on the Oregon coast (Columbus Day Windstorm Event)	Oregon's most destructive storm: 23 fatalities; damage at $170 million
Mar. 1963	Coast and NW Oregon	100 mph gusts (unofficial)	widespread damage
Oct. 1967	western and N. Oregon	winds on Oregon Coast 100–115 mph	significant damage to buildings, agriculture, and timber

Date	Location	Description	Remarks
Mar. 1971	most of Oregon	notable damage in Newport	falling trees took out power lines; building damage
Jan. 1986	N and central Oregon coast	75 mph winds	damaged trees, buildings, power lines
Jan. 1987	Oregon coast	wind gusts to 96 mph at Cape Blanco	significant erosion (highways and beaches); several injuries
Dec. 1987	Oregon coast / NW Oregon	winds on coast 60 mph	saturated ground enabled winds to uproot trees
Mar. 1988	N. and central coast	wind gusts 55–75 mph	one fatality near Ecola State Park; uprooted trees
Jan. 1990	statewide	100 mph winds in Netarts and Oceanside	one fatality; damaged buildings; falling trees (FEMA-853-DR-Oregon)
Feb. 1990	Oregon coast	wind gusts of 53 mph at Netarts	damage to docks, piers, boats
Jan. 1991	most of Oregon	winds of 63 mph at Netarts; 57 at Seaside	75-foot trawler sank NW of Astoria
Nov. 1991	Oregon coast	slow-moving storm; 25-foot waves off shore	buildings, boats, damaged; transmission lines down
Jan. 1992	southwest Oregon	wind gusts of 110 mph at Brookings	widespread damage
Jan. 1993	Oregon coast / N. Oregon	Tillamook wind gusts at 98 mph	widespread damage, esp. Nehalem Valley
Dec. 1995	statewide	wind gusts over 100 mph; Sea Lion Caves: 119 mph; followed path of Columbus Day Storm (Dec. 1962)	four fatalities; many injuries; widespread damage (FEMA-1107-DR-Oregon)
Nov. 1997	western Oregon	winds of 89 mph at Florence; 80 mph at Netarts and Newport	severe beach erosion; trees toppled
Feb. 2002	SW Oregon	75–100 mph on the SW coast (Douglas, Coos, and Curry Counties)	widespread loss of electricity and damage to public utility infrastructure (FEMA-1405-DR-Oregon)
Apr. 2004	Lane County		$5,000 in property damage (figure includes damages outside of Lane County)
Dec. 2004	Lane County		$6,250 in property damage (figure includes damages outside of Lane County)
Dec. 2004	Lincoln County		$6,250 in property damage (figure includes damages outside of Lincoln County)
Dec. 2004	Tillamook County		$6,250 in property damage (figure includes damages outside of Tillamook County)
Dec. 2004	Clatsop County		$6,250 in property damage (figure includes damages outside of Clatsop County)
Jan. 2006	Clatsop, Tillamook, Lincoln, Lane Counties	two storm events with high winds of 86 mph and 103 mph	$244,444 and $144,444 in estimated property damage among all four coastal counties; the storm also impacted 5 other counties outside Region 1; total damages equal $300,000 and $200,000, respectively
Feb. 2006	Clatsop, Tillamook, Lincoln, Lane Counties	wind storm event with winds measured at 77 mph	$150,000 and $91,600 in estimated property damage among all four coastal counties; the storm also impacted nine other counties outside of Region 1; total damages equal $300,000 and $275,000

Date	Location	Description	Remarks
Mar. 2006	Clatsop, Tillamook, Lincoln, Lane Counties	two wind storm events with winds measured at 60 mph and 75 mph	$75,000 and $211,000 in estimated property damage among all four coastal counties; the storms also impacted 10 other counties outside of Region 1; total damages equal $75,000 and $475,000
Nov. 2006	Coos, Curry, Douglas Counties	storm with winds measured at 70 mph.	total of $10,000 in damages
Dec. 2006	Coos, Curry, Douglas Counties	storm with winds measured at 90 mph	total of $225,000 in estimated damages for Coos, Curry, and Douglas Counties; the storm also impacted Josephine County, leading to a total storm damage of $300,000
Dec. 2006	Clatsop, Tillamook Counties	storm with high winds	total of $10,000 in damages
Nov. 2007	Clatsop, Tillamook Counties	storm with high winds	total of $10,000 in damages
Dec. 2007	Clatsop, Tillamook Counties	series of powerful Pacific storms	resulted in Presidential Disaster Declaration; $180 million in damage in the state, power outages for several days, and five deaths attributed to the storm
Dec. 2008	Clatsop, Lane, Tillamook, Lincoln Counties	intense wind and rain events	resulted in nearly $8 million in estimated property and crop damages for Clatsop, Lane, Tillamook, and Lincoln Counties
Dec. 2015	Regions 1-4	FEMA-4258-DR: severe winter storms, straight-line winds, flooding, landslides, and mudslides	
Oct. 2016	Manzanita, Oceanside in Tillamook County	tornadoes	EF2 in Manzanita with estimated damages of $1M; EFU in Oceanside with no damage
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides	
Jul. 2018	Portland, Multnomah County	tornado	EF0; damage to trees and homes
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides	Apr. 2019
Feb. 2020	Region 7: Umatilla, Union, Wallowa Counties	FEMA-4519-DR: Severe storms, tornadoes, straight-line winds and flooding	

Sources: Taylor and Hatton (1999); Hazards and Vulnerability Research Institute (2007); Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; https://www.fema.gov/disaster/

Table 2-175. Tornadoes Recorded in Region 1

Date	Location	Remarks
June 1897	Bay City, Oregon	observed, but no damage recorded
Oct. 1934	Clatskanie, Oregon	observed; no damage
Apr. 1960	Coquille, Oregon	accompanied by heavy rain; no damage
Nov. 1965	Rainier, Oregon	crossed Columbia River; two buildings damaged
Oct. 1966	Seaside, Oregon	windows broken, telephone lines down, outdoor signs destroyed
Oct, 1967	Near Astoria, Oregon airport	began over ocean and moved inland. Several homes and commercial buildings damaged
Dec, 1973	Newport, Oregon	some roof damage
Dec. 1975	Tillamook, Oregon	90 mph wind speed; damage to several buildings
Aug. 1978	Scappoose, Oregon	manufactured home destroyed; other damage
Mar. 1983	Brookings, Oregon	minor damage
Nov. 1984	Waldport, Oregon	damage to automobiles and roofs
Feb. 1994	Near Warrenton, Oregon	damage in local park
Nov. 2002	Curry County, Oregon	$500,000.00 in property damage
Nov. 2009	Lincoln County, Oregon	$35,000 in property damage, damage to homes and automobiles
Oct. 2016	Manzanita, Tillamook County, Oregon	EF2; peak winds of 125-130 mph. Began as waterspout over the ocean and move onshore with estimated damages of $1M
Oct. 2016	Oceanside, Tillamook County, Oregon	EFU; no damage

Sources: National Weather Service, Portland; Taylor and Hatton (1999); National Climatic Data Center (2013) Storm Events Database, http://www.ncdc.noaa.gov/stormevents/; Hazards and Vulnerability Research Institute (2007); the Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org ; National Climatic Data Center (2013); U.S. Tornado Climatology, http://www.ncdc.noaa.gov/oa/climate/severeweather/tornadoes.html; ; https://www.ncdc.noaa.gov/stormevents/; https;//www.weather.gov/pqr/07-01-2019

Probability

Table 2-176. Local Assessment of Vulnerability to Windstorms in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	H	H	H	H	—	H	H

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-177. State Assessment of Windstorm Probability in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	H	H	H	H	H

Source: PUC and OCCRI

High winds occur yearly in Region 1. Two tornadoes touched down in Tillamook County in 2016, one that caused about $1M in damage. The 100-year event is considered to be a storm with 1-

minute average winds of 90 miles per hour. A 50-year event has average winds of 80 mph, and a 25-year event has winds of 75 miles per hour.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-178. Assessment of Vulnerability to Windstorms in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	H	H	M	H	H	H

Source: PUC and OCCRI

Many buildings, utilities, and transportation systems within Region 1 are vulnerable to wind damage. This is especially true in open areas, such as along the Oregon Coast, natural grasslands, or farmland. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes.

Oregon's history of wind damage underscores the need for a comprehensive wind-hazard mitigation program. The necessity of such an action is partly supported in an after-action report focusing on western Oregon's high-wind event of February 7, 2002 (Hazard Mitigation Survey Team Report, FEMA-1405-DR-OR). Other historic events (e.g., 1962 Columbus Day Storm) provide additional insights.

Structures most vulnerable to high winds in Region 1 include insufficiently anchored manufactured homes and older buildings in need of roof repair. Section 307 of the Oregon Building Code identifies high-wind areas along the Oregon Coast and sets anchoring standards for manufactured homes located in those areas. It is essential that coastal counties ensure that the standards are enforced. The Oregon Department of Administrative Service's inventory of state-owned and operated buildings includes an assessment of roof conditions as well as the overall condition of the structure.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, uprooted or shattered trees can down power and/or utility lines, effectively bringing local economic activity and other essential activities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed by uprooted ancient trees growing next to a house. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establish a tree maintenance and removal program.

Tree-lined coastal roads and highways present a special problem. This is because much of the traveling public enjoys the beauty of forested corridors and most certainly would be concerned with any sort of tree removal program. In short, any safety program involving tree removal must be convincing, minimal, and involve a variety of stakeholders.

Wind-driven waves are common along the Oregon coast and are responsible for road and highway wash-outs and the erosion of beaches and headlands. These problems are addressed in the **Flood** section of this regional analysis. Unlike Oregon's Willamette Valley (Region 3), there are no water-borne ferry systems in Region 1 whose operations would be affected by high winds. Bridges spanning bays or the lower Columbia River would be closed during high-wind periods.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 1 is approximately $535,054,000 representing the total potential for loss of state assets due to coastal hazards. The value of locally owned critical facilities is $1,294,655,000. Because windstorms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one minor loss of just over $700 to a state facility was recorded in Region 1 since the beginning of 2015. It was caused by a windstorm.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

All the coastal counties are most vulnerable to windstorm damage. Coos County's high social vulnerability compounds the effects of windstorms on its population and requires more resources for preparation, mitigation, and response.

Risk

Table 2-179. Risk from Windstorms in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	M	H	M	M	M	M	M

Source: PUC, OCCRI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. In Region 1 the probability of windstorms occurring is high. All counties are highly vulnerable to damage from windstorms, but heavy damages are rare. Coos County's social vulnerability is higher than that of Region 1's other counties, and this will intensify the impacts from windstorms the County experiences. Considering the Region's high overall probability high vulnerability, along with Coos County's high social vulnerability, the risk from windstorms is considered high throughout Region 1. Coos County carries the greatest risk.

Winter Storms

Characteristics

Severe winter weather in Region 1 is characterized by extreme cold, snow, ice, and sleet. Snow and ice are less common in the coastal regions, but often bring flooding after snow melts. Flooding is where the problem begins. See the **Flood** section in this regional analysis for more about flooding along the Oregon Coast.

Historic Winter Storm Events

Table 2-180. Historic Winter Storms in Region 1

Date	Location	Description
Jan. 1998	Clatsop County	trees and large tree limbs were knocked down causing widespread power outages; citizens urged to stay home; 3 known fatalities
Jan. 2002	statewide	strong winter storm with high winds at coast and heavy snows to the inland areas of Northwest Oregon; Florence had 46 mph sustained winds and 36 mph gusts to 63 mph, Newport Jetty 39 mph with gusts to 53 mph, and Garibaldi 42 mph; 32 inches of snow at Timberline Lodge on Mount Hood and 30 inches at Santiam Pass
Jan. 2004	statewide	frigid arctic air mass, heavy snow, sleet and freezing rain; weight from the snow and ice buildup resulted in widespread downed trees and power lines, leaving 46,000 customers without power, and collapsed roofs; Oregon Governor Kulongoski estimated cost of damages to public property at $16 million
Dec. 2008	northern Oregon coast	third unusually cold storm system that season with heavy snow in northwest Oregon; heavy snowfall across northwest Oregon; 11–24 inches of snow in the north Oregon Coast Range
Feb. 6–10, 2014	Lincoln, Tillamook and Clatsop Counties	a strong winter storm system affected the Pacific Northwest during the February 6–10, 2014 time period bringing a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon; a much warmer and moisture-laden storm moved across northwest Oregon after the snow and ice storm (Feb. 11–14), which produced heavy rainfall and significant rises on area rivers from rain and snowmelt runoff; during the 5-day period Feb. 6–10, 2 to10 inches fell in the coastal region of northwest Oregon; freezing rain accumulations generally were 0.25 to 0.75 inches; the snowfall combined with the freezing rain had a tremendous impact on the region
Feb. 11–14, 2014	Lincoln, Tillamook and Clatsop Counties	DR-4169 Linn, Lane, Benton and Lincoln Counties declared. Another weather system moved across northwest Oregon during the February 11–14 time frame; this storm was distinctly different from the storm that produced the snow and ice the week prior and brought abundant moisture and warm air from the sub-tropics into the region; as this storm moved across the area, 2 to 7 inches of rain fell across many counties in western Oregon; the heavy rainfall combined with warm temperatures led to snowmelt and rainfall runoff that produced rapid rises on several rivers, which included flooding on three rivers in northwest Oregon
Dec. 6-23, 2015	Statewide storm events	DR-4258 Clatsop, Columbia, Multnomah, Clackamas, Washington, Tillamook, Yamhill, Polk, Lincoln, Linn, Lane, Douglas, Coos, and Curry Counties declared. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Each storm system brought several inches of snow to the mountain areas. Moist onshore winds produced a steady stream of showers over the foothills of the Cascades with snow levels between 1,000 and 2,000 feet. This resulted in heavy snow for the Northern Oregon Cascades and Coast Range.

Date	Location	Description
Feb. 22-26, 2019	Coos, Curry, Douglas, (Oregon Coast Range)	DR-4432 Jefferson, Lane, Douglas, Coos and Curry Counties declared. Persistent troughing off the coast of the Pacific Northwest focused a stream of mid-level moisture over the Inland Northwest resulting in a long duration snow event as the plume drifted north and south several times between the 22nd and 27th of February.

Source: National Weather Service; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Probability

Table 2-181. Probability Assessment of Winter Storms in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	—	H	L	—	H

Source: Oregon Office of Emergency Management, November 2013, County Hazard Analysis Scores

On the basis of historical data, severe winter storms could occur about every 4 years in Region 1. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-182. Local Assessment of Vulnerability to Winter Storms in Region 1

	Clatsop	Coos	Curry	Douglas*	Lane*	Lincoln	Tillamook
Vulnerability	—	L	—	L	—	M	H

*Coastal portions of Douglas and Lane Counties

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-183. State Assessment of Vulnerability to Winter Storms in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	H	—	M	L	—	H

Source: Oregon Office of Emergency Management, November 2013, County Hazard Analysis Scores

Severe winter weather in Region 1 is characterized by extreme cold, snow, ice, and sleet. These conditions bring widespread power outages and road closures due to downed trees from the heavy ice. These events close roads and isolate communities. Due to the logistics of the coastal regions many of the communities may become isolated due to winter storms. Countywide road closures can cause considerable travel delays. Communities in Region 1 that may be impacted by severe winter storms include Astoria, Cannon Beach, Rockaway Beach, Oceanside, Lincoln City, Depot Bay and Newport.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Coos County and Coastal Douglas County are the most socially vulnerable in the region; however, the social vulnerability score for Coastal Douglas County is not distinct from that of Douglas County as a whole. For information on social vulnerability in Douglas County, see Region 4. Coos County's vulnerability is driven by the share of households without access to a vehicle, unemployment rates, and the percentage of residents with a disability. Social vulnerability is low in Curry County; however, the county is in the 90th percentile for the share of residents aged 65 and older and also for the share of residents with a disability.

Coos County is not one of the counties in Region 1 considered most vulnerable to loss of life or property damage from winter storms. Therefore, its high social vulnerability is not anticipated to have a significant impact on its overall vulnerability to winter storms.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 1 is approximately $535,054,000 representing the total potential for loss of state assets due to coastal hazards. The value of locally owned critical facilities is $1,294,655,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one minor loss of just over $700 to a state facility was recorded in Region 1 since the beginning of 2015. It was not caused by a winter storm.

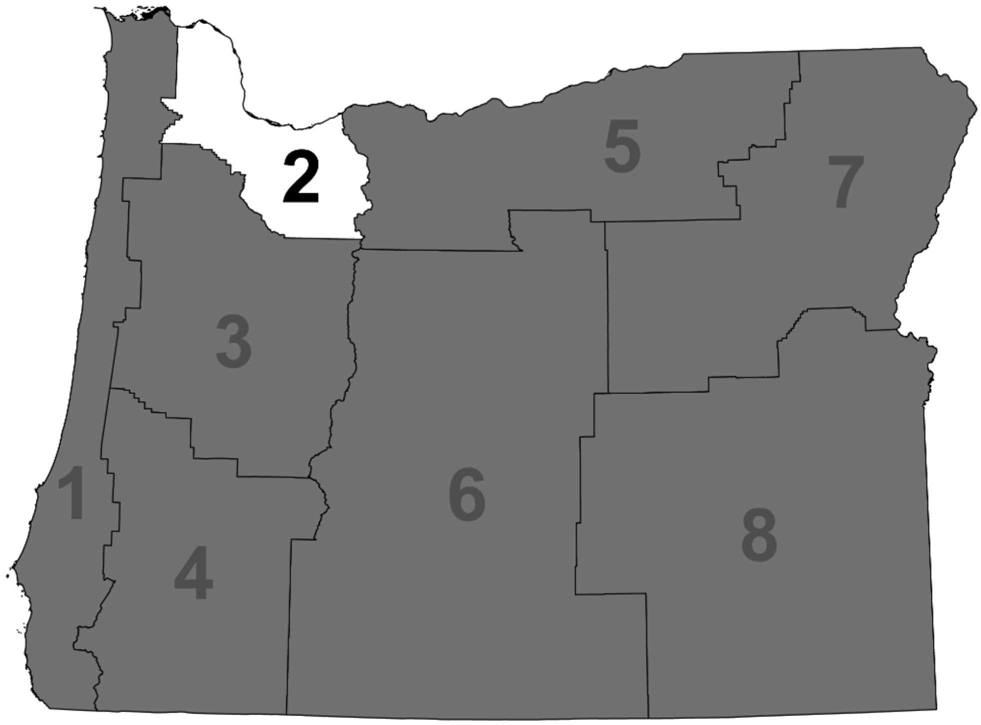
Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

Clatsop, Tillamook, and Lincoln Counties are considered at greater risk from winter storms than the other counties in Region 1.

2.3.2 Region 2: Northern Willamette Valley / Portland Metro

Clackamas, Columbia, Multnomah, and Washington Counties



2.3.2.1 Summary

Profile

The region's demographic, economic, infrastructure, and development patterns indicate that some populations, structures, and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

Regionally, social vulnerability is driven by a high number of tourists who are likely not familiar with the hazard types and level of risk in the region. At the county level, high numbers of disabled persons in Multnomah County; a dramatic increase in the homeless population in Clackamas County; and higher numbers of renters and of persons who do not speak English "very well" in Multnomah and Washington Counties increase the level of risk to these populations. Columbia County's low incomes and high poverty rates make it especially vulnerable to heightened economic hardship that often follows a hazard event.

Compared to other areas of the state, communities around the Portland Metro area weathered the financial crisis that began in 2007 due to the diversity of key industries, employment sectors, and higher wages than the state average. The region's resilience is bolstered by strong Professional and Business Services, Health and Social Assistance, and Government sectors, which have low vulnerability to natural disasters and are key to post-disaster recovery efforts. Columbia County's economy is struggling the most, with higher unemployment and lower wages. However, the impacts of the novel coronavirus pandemic of 2020 on Multnomah and Washington Counties is among the greatest in the State. This is due to the population density and other demographics: the large percentage of population 65 years of age and older with a disability in both counties, and the large homeless population in Multnomah County.

Transportation networks across the state are vulnerable to natural hazard events, especially seismic events. Following a Cascadia earthquake event, access across the Willamette River and along I-5 may be limited due to bridge collapse. The region has two ports with facilities, including the Portland International Airport, that are key to the statewide economy and are vulnerable to disruptions in service that can impact the transport of people, goods, and emergency services.

Older centralized water infrastructure is vulnerable to earthquakes, landslides, flooding, and pollution. Upstream pollution in the Willamette and Columbia Rivers threaten ecosystems and public health.

Eight power-generating facilities and many dams — including Bonneville Power Administration's main dam, the Bonneville Dam — are in this region. Additionally, the site of Oregon's Critical Energy Infrastructure Hub, located in Portland, is subject to seismically induced liquefaction, making it exceptionally vulnerable to a Cascadia earthquake. Disruption or failure to these systems could be devastating to the region and state.

Region 2 is developing at a slightly faster pace than the rest of the state. The majority of growth is occurring in urban areas surrounding Portland. Over half the homes in Multnomah County were built prior to current seismic and floodplain management standards, making them particularly vulnerable to seismic and flood events.

Hazards and Vulnerability

Region 2 is affected by nine of the 11 natural hazards that affect Oregon communities. Coastal hazards and tsunamis do not directly impact this region.

Droughts: The region is affected by droughts to a lesser extent than other areas in the state. Moderate-type drought years have occurred in Region 2 more than a dozen times between 1939 and 2001.

Earthquakes: Four types of earthquakes affect Region 2 (a) shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) the offshore Cascadia Subduction Zone (CSZ) Fault, and (d) earthquakes associated with renewed volcanic activity. The CSZ is the chief earthquake hazard for the Northern Willamette Valley. The region is particularly vulnerable to earthquakes due to the amount of area that is susceptible to earthquake-induced landslide, liquefaction, and ground shaking. Region 2 is home to the majority of the state's population, employment, and built environment. A CSZ event will dramatically impact the region's critical infrastructure, including seismic lifelines along Interstate-5 and Oregon's Critical Energy Hub in North Portland. In Region 2, a CSZ event could cause a potential loss of almost $167M in state building and critical facility assets. Columbia County's potential loss is the least, over $1.6M. The other counties' potential losses range from $42.6M to $67.3M with the greatest potential loss in Multnomah County. There is a far greater potential loss in local critical facilities: over $2.1B. Washington County stands to lose the most, about 46% of that total, followed by Multnomah County with about 36% and Clackamas County with about 17%. Again Columbia County's potential loss is the least, at 3%.

Extreme Heat: Climate conditions in the Willamette Valley are described as Mediterranean, with rainy winters and warm dry summers. Historically, extreme heat and heat waves have not been common, but days above 90°F occur nearly every year. Portland has an average of about 10 days per year above 90°F. The frequency of prolonged periods of high temperatures is expected to increase. Because extreme heat is relatively rare in Region 2, many people may not be accustomed or prepared when an extreme heat event occurs. Similar to drought, prolonged elevated temperatures pose risks to agriculture, involving health and welfare to farmers, farm workers, crops and livestock.

Some livestock, especially dairy cattle, are sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms. Impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. The value of state-owned and leased buildings and critical facilities in Region 2 is approximately $1,134,896,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $10,224,815,000.

Floods: All counties in the Northern Willamette Valley are affected by riverine flooding. Rain-on-snow events and heavy rain events leading to tributary backups are common in this region. Clackamas and Columbia Counties are most vulnerable to flooding events. Following floods in 1996 and 2007, elevation and acquisition projects initiated by the City of Vernonia helped reduce flood risk in Columbia County. In Region 2, there is a potential loss from flooding of over

$142M in state building and critical facility assets, 95% of it in Multnomah County alone. There is a far greater potential loss due to flood in local critical facilities: close to $484M, almost three-and-a-half times as much. Again the vast majority, 86%, is located in Multnomah County.

Landslides: Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Rain-induced landslides can occur during winter months, and earthquakes can trigger landslides. Vulnerability is increased in populated areas such as the Portland Metro Area and in the Coast and Cascade Mountain Ranges. In general, the counties of Washington, Multnomah, and Clackamas have relatively high vulnerability. Over $25M in value of state facilities is exposed to landslide hazards in Region 2, 32% of it in in Multnomah County with the other counties containing between 21% and 24%. However, the potential loss to local critical facilities is much greater at over $145M. Columbia and Multnomah Counties stand to suffer the greatest losses, $55.7M (38%) and $49.7M (34%), respectively.

Volcanoes: The region can be impacted by volcanic activity, particularly within parts of eastern Clackamas and Multnomah Counties (including Portland) that coincide with the crest of the Cascade Mountain Range. Most volcanic activity is considered local. However, some activity, such as lahars and ashfall, can travel many miles and could impact the communities of Government Camp, Rhododendron, and Welches. Over $26M in value is exposed to volcanic hazards in Region 2, all of it in Clackamas County.

Wildfires: The region's vulnerability to wildfire is moderate at best. Wildfires are most common during the late summer. The areas of greatest vulnerability are within the wildland-urban interface communities. Much of the risk to wildfire in Region 2 is mitigated by large expanses of urban development and quick response times. In Region 2, there is a potential loss to wildfire of close to $16M in state building and critical facility assets, about two-thirds of it in Multnomah County and about one-third in Clackamas County. There is a much smaller potential loss in local critical facilities: about $6M, approximately one-third as much. Neither Columbia County nor Washington County has state assets or local critical facilities located in a wildfire hazard area.

Windstorms: Windstorms affect the region annually. The most frequent and strongest originate in the Pacific Ocean and travel in a northeasterly direction. Columbia, Multnomah, and Washington Counties are most vulnerable to these types of storms. To a lesser degree, east winds traveling through the Columbia River Gorge also affect Region 2 communities. Windstorms can impact the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland.

Winter Storms: Winter storms occur annually. The Columbia River Gorge can bring colder weather, higher precipitation, and high east winds to the region causing severe weather for short periods of time. Because these storms are infrequent and short lived, communities including the Portland Metro Area are often unprepared for them.

Climate Change

The hazards faced by Region 2 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon. Coupled with projected decreases in mountain snowpack due to warmer winter temperatures, Region 2 is expected to be affected by an increased incidence of drought and wildfire. In Region 2, climate change would result in increased frequency of drought due to low spring snowpack (*very likely*, >90%), low summer runoff (*likely*, >66%), and low summer precipitation and low summer soil moisture (*more likely than not*, >50%). It is *very likely* (>90%) that Region 2 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*).

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 2, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section **2.1.4**, **Introduction to Climate Change**.

2.3.2.2 Profile

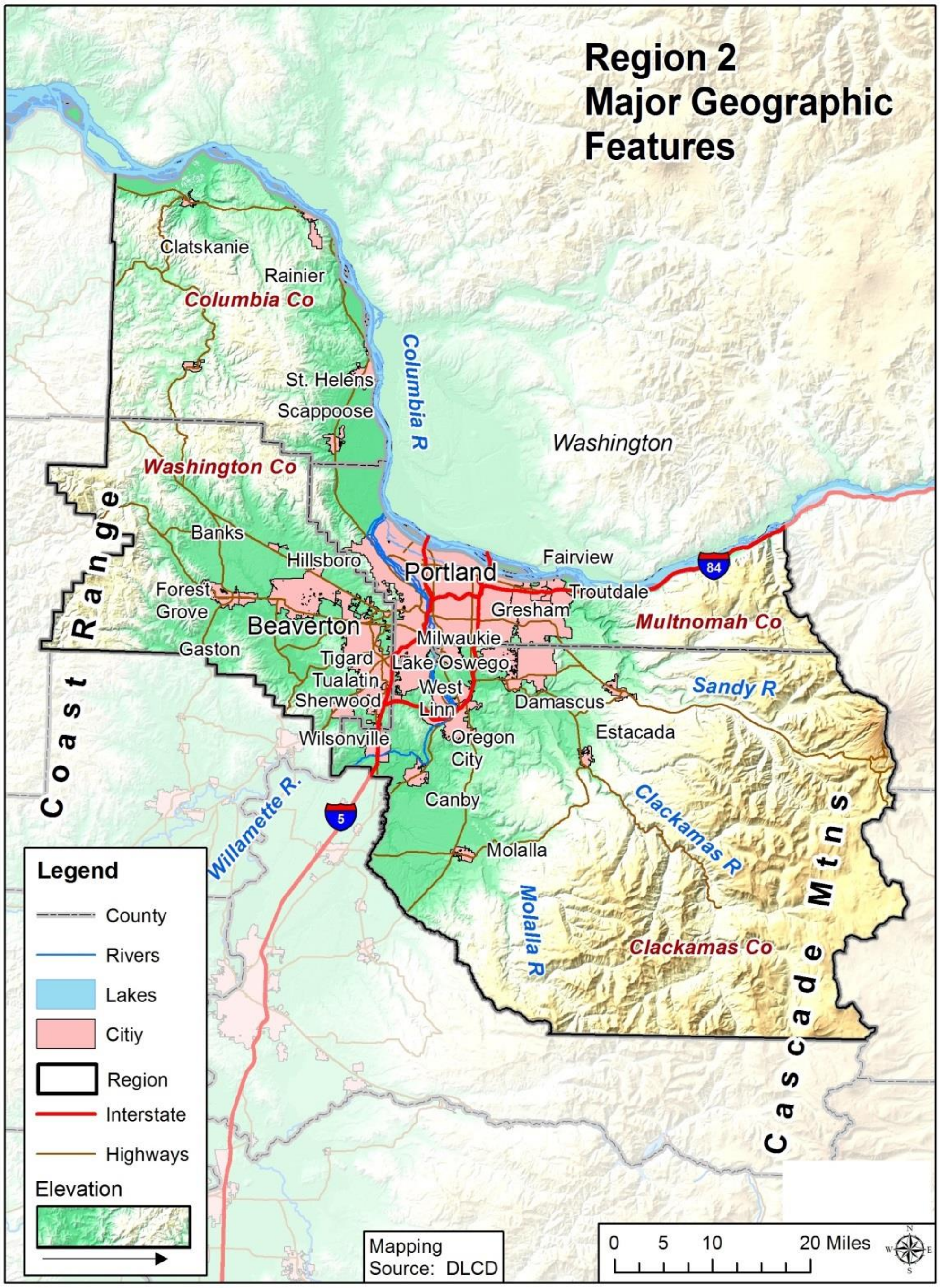
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

The Northern Willamette Valley and Portland Metro Area is approximately 3,758 square miles in size, and includes Clackamas, Columbia, Multnomah, and Washington Counties. Mountain ranges and watersheds shape the region's topography. Region 2 begins at the Cascade Mountain Range in the east and extends westward through the Willamette Valley and into the Coast Range and southward from the Columbia River in the North to the Mid-Willamette Valley. Two rivers shape the region's main watersheds, the Columbia River and the Willamette River. **Figure 2-143** shows the dominant mountain ranges, major watersheds, and political boundaries of Region 2.

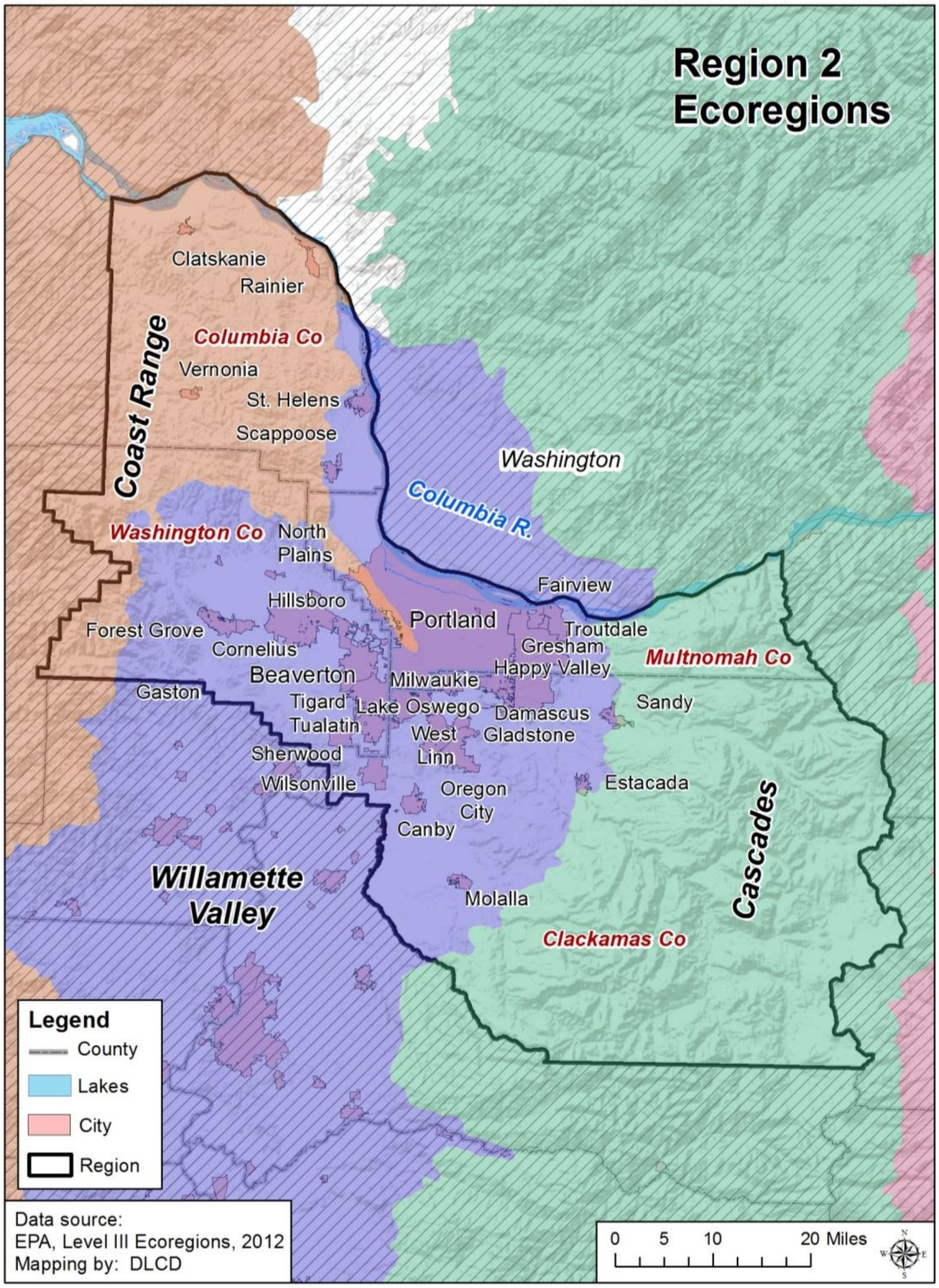
Figure 2-143. Region 2 Major Geographic Features



Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 2 is composed of three ecoregions: the Coast Range, the Willamette Valley, and the Cascades (**Figure 2-144**).

Figure 2-144. Region 2 Ecoregions



Cascades: Soil in this ecoregion is volcanic. Mixed conifer forests have given way to predominantly Douglas fir forests that are managed for commercial logging. Logging activities have put a strain on the ecological health of streams in the area (Thorson, et al., 2003). Waterways in the steeper valleys support threatened cold-water salmonids including Chinook salmon, steelhead, and bull trout. Streams, lakes, reservoirs, rivers, and glacial lakes at higher elevations are key sources of water (Thorson, et al., 2003).

Willamette Valley: Terraces and floodplains dominate the nearly flat central Willamette Valley. The valley floor is dotted with scattered hills, buttes, and bordered by the adjacent foothills. Historically, valley waterways meandered throughout floodplains on the nearly flat valley floor, contributing to the valley's highly fertile soil and supporting the dominance of oak savannah and prairie ecosystems. Today the Willamette River and its tributaries are highly channelized, restricting the flow of these waterways, helping protect property but also threatening stream health. The productive soils and temperate climate make this ecoregion one of the most important agricultural areas in Oregon. The valley's flat terraces have made urban and suburban development possible in the valley (Thorson, et al., 2003).

Coast Range: The east slope of the Coast Range is located within Region 2. Soils are a mix of sedimentary and volcanic composition. Sedimentary soils can create more concerns for stream sedimentation than areas with volcanic soils (Thorson, et al., 2003). Volcanic soils are underlain by basaltic rocks resulting in more consistent summer stream flows. This soil composition supports runs of spring Chinook salmon and summer steelhead. On the other hand, sedimentary soils are prone to failure following clear cuts. This may be of concern as the commercial Douglas fir forests are highly productive commercial logging areas.

Climate

This section covers historic climate information only. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment**.

The Willamette Valley's mild climate, long growing season, and abundant moisture supports the most diversified agriculture in the state. Precipitation generally occurs in the winter months, falling mostly as rain in the valley, but building snowpack in the mid-elevations of the Cascade foothills. The region's wet winters can lead to flood, landslide, and winter storm risks while dry summers can lead to drought and wildfire risks. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-184** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 2 based on data from the NOAA National Centers for Environmental Information.

Table 2-184. Average Precipitation and Temperature in Region 2 Counties and Climate Divisions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Clackamas County	74.96” (56.54”–117.92”)	Jan: 10.55” Jul: 1.03”	48.4°F	Jan: 31.3°F /42.3°F Jul: 50.7°F /75.3°F
Columbia County	56.42” (37.79”–82.72”)	Jan: 8.41” Jul: 0.73”	50.6°F	Jan: 33.9°F /45.0°F Jul: 51.8°F /76.1°F
Multnomah County	62.81” (44.69”–96.98”)	Jan: 8.96” Jul: 0.9”	51.4°F	Jan: 34.2°F /44.6°F Jul: 53.6°F /77.9°F
Washington County	55.66” (35.53”–89.01”)	Jan: 8.63” Jul: 0.6”	51.0°F	Jan: 34.2°F /44.8°F Jul: 52.4°F /77.2°F
Climate Division 2 “Willamette Valley”	58.11” (39.98”–92.22”)	Jan: 8.35” Jul: 0.69”	51.5°F	Jan: 34.6°F /45.9°F Jul: 52.2°F /78.6°F
Climate Division 4 “Northern Cascades”	80.7” (59.67”–127.71”)	Jan: 11.41” Jul: 1.05”	45.7°F	Jan: 28.5°F/39.8°F Jul: 48.2°F/74.2°F

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 15, 2019 from https://www.ncdc.noaa.gov/cag/.

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community's capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

Between 2010 and 2018, the region grew more quickly than the state as a whole. Washington County grew most quickly—approximately two and a half percentage points above the statewide rate; growth occurred through both natural increase (the ratio of births to deaths) and net in-migration, with natural-increase contributing more than in-migration (Population Research Center, Portland State University, 2017). Conversely, the primary driver of growth in Clackamas County was in-migration (Population Research Center, Portland State University, 2017).. Over the next decade, Washington and Clackamas Counties are expected to experience the most significant gains, and all counties, except for Multnomah, are expected to experience faster growth than the state as a whole.

Table 2-185. Population Estimate and Forecast for Region 2

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 2	1,690,387	1,890,905	11.9%	2,174,128	15.0%
Clackamas	375,992	419,425	11.6%	490,011	16.8%
Columbia	49,351	51,900	5.2%	58,580	12.9%
Multnomah	735,334	813,300	10.6%	906,904	11.5%
Washington	529,710	606,280	14.5%	718,633	18.5%

Population Research Center, Portland State University (2018), Certified Population Estimates; Population Research Center, Portland State University (2019), Current Forecast Summaries for All Areas & Oregon Final Forecast Table by Age (2019); U.S. Census Bureau, 2010 Decennial Census. Table DP-1

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 2 are largely centered on special events (such as fairs, festivals or sporting events), city trips, and touring (traveling to experience scenic beauty, history and culture) (Longwoods International, 2017b). Approximately one-third of all overnight trips in Oregon included time in the Portland Region (Longwoods International, 2017b). The average travel party contains approximately three persons and approximately 74% of these trips originate from Oregon, Washington, or California. Multnomah County receives the greatest number of overnight visitors.

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

Table 2-186. Annual Visitor Estimates in Person Nights (x1000) in Region 2

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 2	28,961	—	29,532	—	29,690	—
Clackamas	7,392	100%	7,430	100%	7,383	100%
Hotel/Motel	1,496	20%	1,524	21%	1,473	20%
Private Home	5,275	71%	5,288	71%	5,285	72%
Other	621	8%	618	8%	625	8%
Columbia	665	100%	677	100%	685	100%
Hotel/Motel	50	8%	51	8%	52	8%
Private Home	521	78%	533	79%	539	79%
Other	94	14%	93	14%	94	14%
Multnomah	12,553	100%	12,745	100%	12,945	100%
Hotel/Motel	6,592	53%	6,745	53%	6,879	53%
Private Home	5,489	44%	5,532	43%	5,591	43%
Other	472	4%	468	4%	474	4%
Washington	8,351	100%	8,680	100%	8,677	100%
Hotel/Motel	2,067	25%	2,330	27%	2,377	27%
Private Home	6,123	73%	6,188	71%	6,137	71%
Other	162	2%	162	2%	163	2%

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003).

As a region, a smaller share of the population identifies as having a disability; however, the share in Columbia County is two percentage points more than the statewide estimate. Columbia County also has the largest share of older adults with a disability, although the margin of error should be noted. In the region as a whole, however, disability status is less prevalent among vulnerable age groups, younger people (< 18) and older adults (≥ 65).

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Table 2-187. People with a Disability by Age Group in Region 2

	With a Disability (Total Population)*			Under 18 Years with a Disability			65 Years and Over with a Disability		
	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
Oregon	14.6%	✓	0.1%	4.6%	✓	0.2%	37.1%	✓	0.4%
Region 2	12.0%	✓	0.2%	4.0%	✓	0.3%	34.9%	✓	0.6%
Clackamas	11.8%	✓	0.4%	4.0%	✓	0.5%	32.9%	✓	1.2%
Columbia	16.7%	✓	1.3%	4.2%	⊙	1.2%	40.6%	✓	3.6%
Multnomah	13.1%	✓	0.3%	4.4%	✓	0.5%	37.7%	✓	0.9%
Washington	10.2%	✓	0.1%	3.5%	✓	0.4%	32.2%	✓	1.2%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% - be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Homeless Population

The U.S. Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count (PIT), a biennial count of both sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors. They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing and Community Services, 2019, Nov. 21). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing and Community Services, 2019, Nov. 21).

Approximately 25% of people experiencing homelessness in the State of Oregon are concentrated in the Portland Metropolitan Area (Oregon Housing and Community Services, 2019, Nov. 21). According to the PIT, between 2015 and 2019, the region reported a 5% increase in people experiencing homelessness.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate their vulnerability. Disasters that result in damage to the built environment can place additional stress on temporary shelters, a vital service for many people experiencing homelessness (Peacock, Dash, Zhang, & Van Zandt, 2017). Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-188. Homeless Population Estimate for Region 2

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 2	5,103	5,376	5,358	5,279
Clackamas	494	497	471	487
Columbia	317	158	342	272
Multnomah	3,801	4,177	4,015	3,998
Washington	491	544	530	522

Source: Oregon Point in Time Homeless Count, Oregon Housing and Community Services.

Biological Sex and Gender

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019, Apr. 3). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019, Apr. 3).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019, Apr. 3). According to the survey, there are slightly more women than men in Region 2 (97.8 men for every 100 women) (U.S. Census Bureau, 2019, Mar. 31). This is similar to the statewide ratio.

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognized (Enarson, 2017). This is an area deserving of more attention as the field develops.

Age

Older adults comprise a smaller share of the population in Region 2 than they do in the state as a whole. Clackamas County has a similar proportion to the state while the share in Clatsop County is slightly higher. In Multnomah and Washington Counties, there is a smaller share of older adults; however, due to large populations overall the absolute number of older adults is still significant. An older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to elderly (Morrow, 1999).

The region's share of children is similar to the statewide share, with Washington County's share slightly higher and Multnomah County's share slightly lower. Special consideration should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. Parents may lose time and money when their children's childcare facilities and schools are impacted by disasters.

Table 2-189. Population by Vulnerable Age Group, in Region 2

	Total Population	Under 18 Years Old			65 Years and Older		
	Estimate	Percent	CV**	% MOE (+/−)	Percent	CV**	% MOE
Oregon	4,025,127	21.5%	✓	0.1%	16.3%	✓	0.1%
Region 2	1,810,699	21.6%	✓	0.0%	13.3%	✓	0.0%
Clackamas	399,962	22.1%	✓	*	16.5%	✓	0.1%
Columbia	50,207	22.0%	✓	0.1%	17.5%	✓	0.3%
Multnomah	788,459	19.6%	✓	*	12.3%	✓	0.1%
Washington	572,071	24.0%	✓	*	12.1%	✓	0.1%

*Indicates that the estimate has been controlled to be equal to a fixed value and so it has no sampling error.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau, 20013–2017 American Community Survey 5-Year Estimates, Table DP05

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations can be harder to reach with outreach materials. They are less likely to be prepared if special attention is not given to language and culturally appropriate outreach techniques. In the region, Multnomah and Washington Counties have the highest percentages of residents who do not speak English very well. Estimates for Clatsop County should be used with caution due to the sampling techniques used in the American Community Survey. Communities creating outreach materials used to communicate with and plan for populations who do not speak English very well should take into consideration the language needs of these populations.

Table 2-190. English Usage in Region 2

	Speak English Less Than "Very Well"				
	Estimate	CV**	MOE (+/−)	Percent	% MOE (+/−)
Oregon	222,428	✓	4,116	5.9%	0.1
Region 2	128,038	✓	3,115	7.5%	0.2
Clackamas	15,780	✓	1,006	4.2%	0.3
Columbia	671	⊙	224	1.4%	0.5
Multnomah	62,863	✓	2,112	8.5%	0.3
Washington	48,724	✓	2,044	9.1%	0.4

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

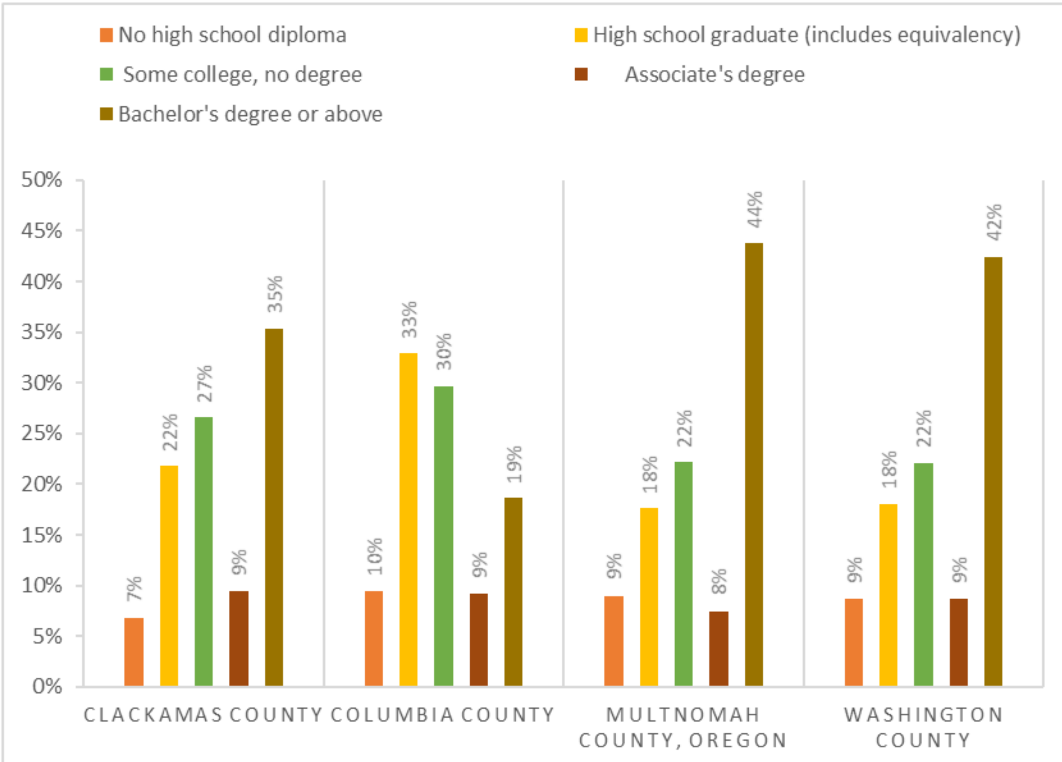
Source: U.S. Census Bureau, 20013–2017 American Community Survey 5-Year Estimates, Table DP02

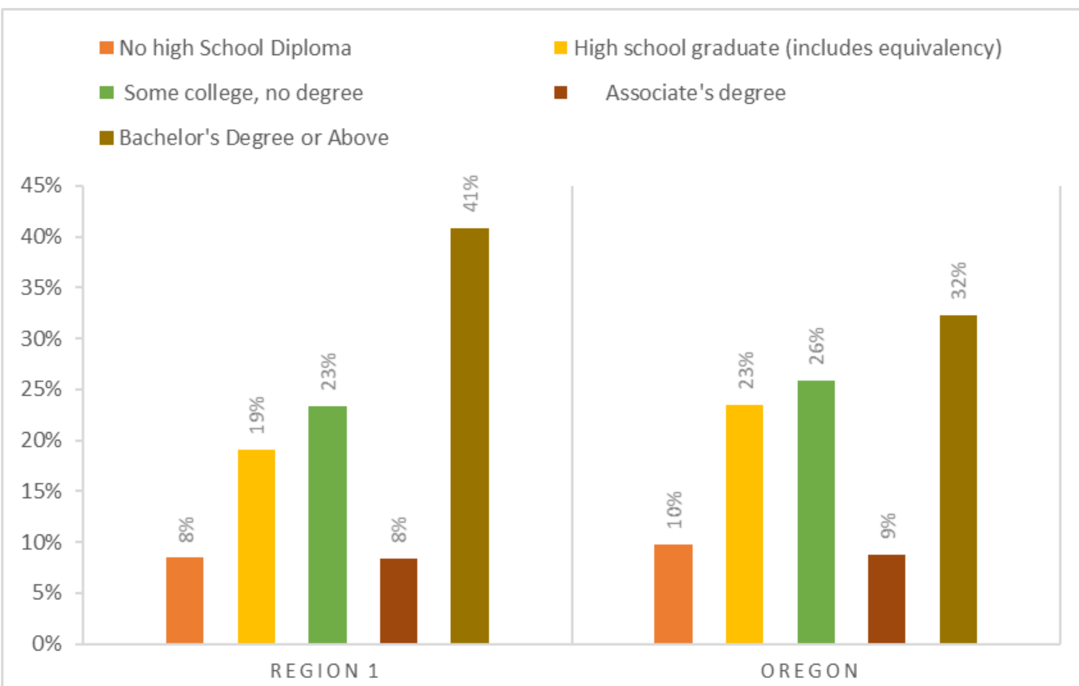
Education Level

Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual's ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

There is a higher percentage of bachelor's and graduate or professional degrees in the Northern Willamette Valley and Portland Metro Area compared to statewide numbers. Multnomah and Washington County have similar levels of educational attainment. Over 40% of residents in both counties hold a bachelor's degree or higher. Conversely, the share of residents with a four-year degree or more in Columbia County is nearly half that, but approximately 30% of the county's residents have some college credit. The levels of attainment within Clackamas County are similar to the statewide levels, with approximately 35% holding a bachelor's degree or more.

Figure 2-145. Educational Attainment in Region 2: (top) by County, (bottom) Regional vs. Statewide





Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, Table DP02

Income and Poverty

The impact of a disaster in terms of loss and the ability to recover varies among population groups. "The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event" (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public. Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, are less likely to have the savings to rebuild after a disaster, and less likely to have access to transportation and medical care.

Across the region, median household income is $1,000 to nearly $18,000 higher than the statewide median. With the exception of Columbia County, all other regional counties saw a statistically significant change in median household income from 2012 to 2017.

Table 2-191. Median Household Income in Region 2

	2008–2012			2012–2017			Statistically Different*
	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)	
Oregon	$53,427	☑	$338	$56,119	☑	370	Yes
Region 2	—	—	—	—	—	—	—
Clackamas	$68,427	☑	$1,133	$72,408	☑	$1,110	Yes
Columbia	$59,154	☑	$2,724	$57,449	☑	$2,724	No
Multnomah	$55,219	☑	$739	$60,369	☑	$846	Yes
Washington	$68,948	☑	$728	$74,033	☑	$851	Yes

Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

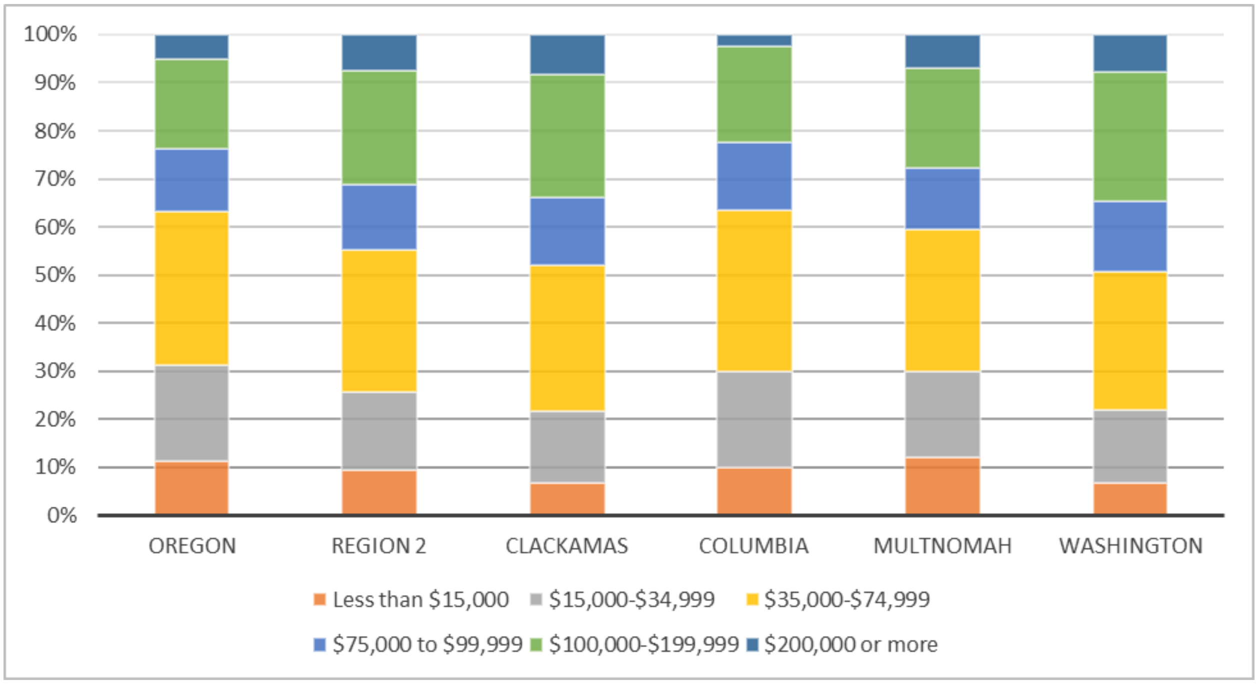
*Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2002 and 2013-2017. American Community Survey – 5-Year Estimates. Table CP03

Compared to the statewide share, regional counties have a smaller percentage of households in the lowest income bracket, earning less than $35,000 per year. With the exception of Columbia County, all regional counties have a greater share of households in the highest income brackets, which are those earning $75,000 or more. Clackamas and Washington Counties have the largest percentages of households earning more than $75,000 per year.

Figure 2-146. Median Household Income Distribution in Region 2



Source: U.S. Census Bureau; 2008–2012 American Community Survey 5-Year Estimates, Table DP03

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018).

A smaller share of the regional population is living in poverty compared to the state as a whole. Multnomah County has the highest percentage of its population living in poverty; higher than the statewide percentage. However, since 2012, no county has experienced a significant change in the portion of its overall population living in poverty. Conversely, child poverty within the region has decreased by a statistically significant amount since 2012. Moreover, the share of the population under 18 living in poverty has decreased in three of the four regional counties; Washington County, which has a relatively low child poverty rate, is the one exception.

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources.

Table 2-192. Poverty Rates in Region 2

	Total Population in Poverty						
	2008–2012			2013–2017			Statistical Difference?*
	Estimate	CV**	MOE (+/–)	Estimate	CV**	MOE (+/–)	
Oregon	15.5%	✓	0.3%	14.9%	✓	0.30%	No
Region 2	13.4%	✓	0.3%	12.7%	✓	0.30%	No
Clackamas	9.7%	✓	0.7%	9.0%	✓	0.60%	No
Columbia	13.9%	✓	1.5%	12.3%	✓	1.70%	No
Multnomah	17.1%	✓	0.6%	16.4%	✓	0.50%	No
Washington	10.9%	✓	0.5%	10.3%	✓	0.60%	No

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Table 2-193. Child Poverty in Region 2

	Children Under 18 in Poverty						
	2008–2012			2013–2017			Statistical Difference?*
	Estimate	CV**	MOE (+/–)	Estimate	CV**	MOE (+/–)	
Oregon	20.6%	✓	0.5%	19.0%	✓	0.6%	Yes
Region 2	17.5%	✓	0.7%	15.8%	✓	0.7%	Yes
Clackamas	12.7%	✓	1.4%	10.8%	✓	1.3%	Yes
Columbia	19.6%	✓	3.5%	15.3%	⊙	4.1%	Yes
Multnomah	23.1%	✓	1.3%	20.6%	✓	1.1%	Yes
Washington	14.3%	✓	1.1%	13.7%	✓	1.3%	No

*Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Housing Tenure

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinate of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

The percentage of people that own their home in Region 2 is nearly identical to the statewide share. However, tenure varies considerably across the region. Homeownership is most common in Columbia County and least in Multnomah County. With the exception of Columbia County, the vacancy rate in each regional county is lower than the statewide rate.

Table 2-194. Housing Tenure in Region 2

	Total Occupied Units	Owner Occupied			Renter Occupied		
		Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
Oregon	1,571,631	61.7%	☑	0.3%	38.3%	☑	0.3%
Region 2	703,986	60.1%	☑	0.4%	39.9%	☑	0.4%
Clackamas	153,822	69.6%	☑	0.8%	30.4%	☑	0.8%
Columbia	19,213	73.0%	☑	1.8%	27.0%	☑	1.8%
Multnomah	318,173	54.3%	☑	0.5%	45.7%	☑	0.5%
Washington	212,778	60.8%	☑	0.6%	39.2%	☑	0.6%

Source: U.S. Census Bureau, 2013–2017 American Community Survey 5-Year Estimates, Table DP04

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households (Cutter, Boruff, & Shirley, 2003). Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only.

Every county in the region except Multnomah has a higher share of family households when compared to statewide number. In Multnomah County, the share of family households is approximately nine percentage points lower than the statewide share—reflecting a greater proportion of people living either alone, or with nonrelatives only. The region has a slightly higher share of family households with children than the state as a whole. This is also true for all regional counties, with the exception of Multnomah. Excluding Columbia County, the proportion of single parent households across the region is slightly lower than the statewide share.

Table 2-195. Family vs. Non-family Households in Region 2

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	63.3%	☑	0.2%	36.7%	☑	0.2%	27.7%	☑	0.2%
Region 2	703,986	62.0%	☑	0.4%	38.0%	☑	0.4%	28.0%	☑	0.4%
Clackamas	153,822	68.5%	☑	0.6%	31.5%	☑	0.6%	24.5%	☑	0.7%
Columbia	19,213	67.4%	☑	2.2%	32.6%	☑	2.2%	26.1%	☑	2.0%
Multnomah	318,173	54.7%	☑	0.5%	45.3%	☑	0.5%	32.3%	☑	0.6%
Washington	212,778	67.9%	☑	0.7%	32.1%	☑	0.7%	24.2%	☑	0.7%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. https://data.census.gov/cedsci/. Table DP02: Selected Social Characteristics

Table 2-196. Family Households with Children by Head of Household in Region 2

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
Oregon	26.2%	☑	0.2%	8.1%	☑	0.2%
Region 2	28.0%	☑	0.3%	7.8%	☑	0.2%
Clackamas	28.9%	☑	0.5%	7.2%	☑	0.5%
Columbia	26.1%	☑	1.6%	8.1%	☑	1.2%
Multnomah	24.7%	☑	0.4%	7.9%	☑	0.3%
Washington	32.3%	☑	0.5%	7.9%	☑	0.5%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. https://data.census.gov/cedsci/. Table DP02: Selected Social Characteristics

Social and Demographic Trends

- The social and demographic analysis shows that Region 1 is particularly vulnerable during a hazard event in the following categories:
- The region welcomes many tourists annually. In 2018, nearly 8.8 million overnight person-trips, or 29 million person-nights.
- The number of people experiencing homelessness has increased over the past three years. Approximately 25% of people experiencing homelessness in the state are concentrated in the Portland Metropolitan Area
- More people in Region 2 do not speak English “very well” than anywhere else in the state.
- The percentage of renters in Multnomah County exceeds that of the region and the state overall.

Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses’ labor, capital, suppliers, and customers are all relevant factors (Zhang, Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang, Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent.

Employment and Unemployment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Region 2 accounts for approximately half of all employment in the state. Unemployment rates across the region have been steadily declining since they peaked in May of 2009 during the Great Recession. Columbia County has by far the smallest workforce and consistently has the highest unemployment rates within the region.

Table 2-197. Civilian Labor Force in Region 2, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 2	1,022,845	985,258	96.3%	37,587	3.7%
Clackamas	218,998	210,750	96.2%	8,248	3.8%
Columbia	24,387	23,148	94.9%	1,239	5.1%
Multnomah	456,886	440,043	96.3%	16,843	3.7%
Washington	322,574	311,317	96.5%	11,257	3.5%

Source: Oregon Employment Department, 2019

Table 2-198. Civilian Unemployment Rates in Region 2, 2014-2018

	2014	2015	2016	2017	2018	Change (2014–2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	−2.6%
Region 2	5.9%	4.9%	4.2%	3.6%	3.7%	−2.2%
Clackamas	6.1%	5.1%	4.3%	3.7%	3.8%	−2.3%
Columbia	8.4%	7.1%	6.1%	5.1%	5.1%	−3.3%
Multnomah	5.9%	4.9%	4.2%	3.6%	3.7%	−2.2%
Washington	5.6%	4.7%	4.1%	3.5%	3.5%	−2.1%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups "economic units that have similar production processes" according to a six-digit hierarchical structure (Office of Management and Budget, n.d.). "The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry" (Office of Management and Budget, n.d.). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors (U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 1 were:

1. Trade, Transportation and Utilities
2. Professional and Business Services
3. Education and Health Services
4. Manufacturing
5. Leisure and Hospitality

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region's resiliency. A business establishment is an "economic unit… that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity" (U.S. Bureau of

Labor Statistics, 2019, Sept. 4). In Region 2, the following supersectors comprise a significant share of all business establishments.

- The Professional and Business Services supersector includes the highest number of establishments in Region 2, 18% of all businesses (QCEW, 2018).
- Trade Transportation and Utilities is second largest, with 17.1% of all business establishments (QCEW, 2018).
- Other Services is third with 15.7% of the regional share (QCEW, 2018).
- Education and Health Services is fourth, comprising 10.1% of all business (QCEW, 2018).
- Financial Activities is the fifth largest with up 9.1% of all businesses (QCEW, 2018).

While supersectors are useful abstractions, it's important to remember that within are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event.

Table 2-199. Covered Employment by Sector in Region 2, 2019

Industry	Region 2	Clackamas		Columbia	
	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	166,026	100.0%	11,634	100.0%
Total Private Coverage	88.5%	150,002	90.3%	9,654	83.0%
Natural Resources & Mining	1.0%	4,827	2.9%	396	3.4%
Construction	5.6%	13,517	8.1%	678	5.8%
Manufacturing	10.7%	18,019	10.9%	1,633	14.0%
Trade, Transportation & Utilities	18.3%	34,058	20.5%	2,190	18.8%
Information	2.2%	2,057	1.2%	45	0.4%
Financial Activities	5.4%	7,876	4.7%	391	3.4%
Professional & Business Services	16.3%	21,340	12.9%	877	7.5%
Education & Health Services	14.3%	24,081	14.5%	1,434	12.3%
Leisure & Hospitality	10.6%	16,836	10.1%	1,366	11.7%
Other Services	4.1%	7,272	4.4%	638	5.5%
Unclassified	0.0%	118	0.1%	5	0.0%
Total All Government	11.5%	16,025	9.7%	1,980	17.0%
Total Federal Government	1.4%	1,022	0.6%	70	0.6%
Total State Government	0.8%	1,297	0.8%	161	1.4%
Total Local Government	9.2%	13,705	8.3%	1,749	15.0%

Industry	Region 2	Multnomah		Washington	
	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	512,137	100.0%	295,463	100.0%
Total Private Coverage	88.5%	439,742	85.9%	273,022	92.4%
Natural Resources & Mining	1.0%	1,559	0.3%	3,067	1.0%
Construction	5.6%	24,295	4.7%	16,644	5.6%
Manufacturing	10.7%	35,133	6.9%	51,013	17.3%
Trade, Transportation & Utilities	18.3%	93,442	18.2%	50,599	17.1%
Information	2.2%	11,948	2.3%	7,556	2.6%
Financial Activities	5.4%	29,748	5.8%	14,880	5.0%
Professional & Business Services	16.3%	83,556	16.3%	54,611	18.5%
Education & Health Services	14.3%	79,040	15.4%	36,659	12.4%
Leisure & Hospitality	10.6%	58,562	11.4%	27,414	9.3%
Other Services	4.1%	22,210	4.3%	10,478	3.5%
Unclassified	0.0%	248	0.0%	101	0.0%
Total All Government	11.5%	72,395	14.1%	22,442	7.6%
Total Federal Government	1.4%	12,270	2.4%	814	0.3%
Total State Government	0.8%	4,270	0.8%	2,027	0.7%
Total Local Government	9.2%	55,855	10.9%	19,601	6.6%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within this sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region and are most numerous in the Portland Metro area.

Professional and Business Services: This sector is composed of professional service providing industries including scientific and technical, management professionals and administrative and support services (e.g., engineering, law, headquarters, temp help, etc.). In general, this sector has low vulnerability to natural disasters. Vulnerability is increased if suppliers are affected or physical infrastructure such as buildings, roads, telecommunications, or water systems is damaged. Mitigation efforts for this sector should include preparing business continuity and recovery plans.

Leisure and Hospitality: This sector primarily serves regional residents with disposable income and tourists. Following a natural disaster, residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Education and Health Services: The Health and Social Assistance industries play important roles in emergency response in the event of a disaster. The importance of the health care and social assistance sector is underscored in Region 2 because the region serves as a hub for health care.

Manufacturing: This sector is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons the manufacturing sector may be susceptible to disruptions in transportation infrastructure. However, manufacturers are often less dependent on local markets for sales, which may contribute to the economic resilience of this sector.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. In Region 2, the two largest subsectors by share of employment are Food Services and Drinking Places and Educational Services; the former fits into the Leisure and Hospitality supersector and the latter into the Educational and Health Services Supersector. Notably, the region has significant shares of employment in Management of Companies and Computer and Electronic Product Manufacturing, both are featured below as subsectors with high employment concentrations vis-à-vis the nation and higher than average wages.

Table 2-200. Industries with Greatest Share of Employment in Region 2, 2018

Industry	Employment Share	Employment (2018)
Food Services and Drinking Places	9%	102,610
Educational Services	8%	87,951
Administrative and Support Services	7%	82,080
Professional, Scientific, and Technical Services	7%	78,969
Ambulatory Health Care Services	5%	54,795
Specialty Trade Contractors	4%	43,781
Management of Companies and Enterprises	4%	41,522
Social Assistance	3%	35,980
Computer and Electronic Product Manufacturing	3%	33,453
Hospitals	2%	28,780

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for employment share and average employment by DLCD

Industry Concentration and Employment Change

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

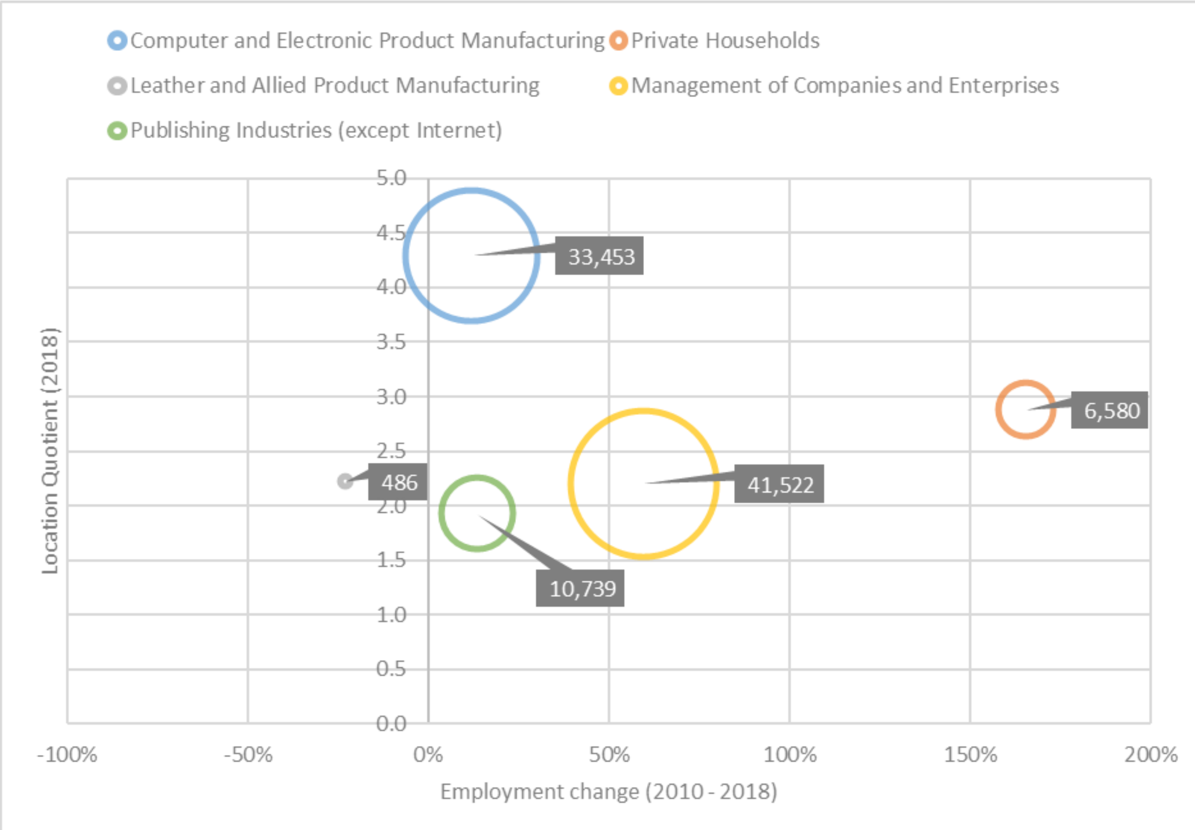
Table 2-201. Most Concentrated Industries and Employment Change in Region 2, 2018

Industry	Location Quotient	Employment (2018)	Employment Change (2010–2018)
Computer and Electronic Product Manufacturing	4.3	33,453	12%
Private Households	2.9	6,580	166%
Leather and Allied Product Manufacturing	2.2	486	−23%
Management of Companies and Enterprises	2.2	41,522	60%
Publishing Industries (except Internet)	1.9	10,739	13%

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 2 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-147. Location Quotients, Employment Change, and Total Employment in Region 2, 2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

Advanced technology manufacturing—namely the production of semiconductors—is a major employer and critical part of Oregon's economy. Employment in the Computer and Electronic Product Manufacturing sector grew modestly during the eight-year period but total employment has dropped since its peak in the early 2000s (Lehner, 2016). Still, the region continues to have a significant employment concentration in the subsector (4.3 LQ) vis-à-vis the nation. The Management of Companies and Enterprises, part of the Professional and Business Services supersector, is also highly concentrated in the region (2.2 LQ). Moreover the subsector has grown significantly since 2010 and employs a significant total number of employees. Wages tend to be high in the subsector, which is comprised largely of company headquarters and bank holding companies (Rooney, 2019). Although the subsector lost employment during the eight-year period and the total number of employees is small, there is an employment concentration in the Leather and Allied Product Manufacturing subsector; this is likely do to the presence of companies like Danner Boots in Portland.

Fastest Growing and Declining Industries

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang, Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining. Between 2010 and 2018, the construction subsector added over 8,500 jobs—driven largely by demographic changes in the metro area. Private Households and Beverage and Tobacco Product Manufacturing industries experienced significant increases in employment within the region. Both, however, comprise a smaller share of employment vis-à-vis the other fastest growing industries.

Lessors of Nonfinancial Intangible Assets experienced the largest percentage decline, but employs a relatively small number of people. Looking at raw numbers, the Wholesale Electronic Markets and Agents and Brokers subsector, which coordinate the sale of goods owned by others, saw the greatest decline—shedding over 4,500 positions from 2010-2018.

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-growth controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the regional-shift tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 2's fastest growing and declining industries.

Table 2-202. Fastest Growing and Declining Industries in Region 2, 2010-2018

Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Private Households	166%	2,477	6,580
Beverage and Tobacco Product Manufacturing	125%	859	1,931
Warehousing and Storage	119%	3,304	7,219
Construction of Buildings	85%	10,227	18,903
Miscellaneous Store Retailers	83%	5,572	10,192
Fastest Declining			
Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	-64%	240	87
Wholesale Electronic Markets and Agents and Brokers	-42%	10,940	6,349
Leather and Allied Product Manufacturing	-23%	632	486
Printing and Related Support Activities	-22%	4,337	3,401
Electronics and Appliance Stores	-19%	5,543	4,501

U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

Growth in the Beverage and Tobacco Product Manufacturing industry is likely driven by Oregon's thriving craft-beer scene, which continues to grow despite increased competition (Lehner, 2020). Indeed, while a portion of new employment in the region can be attributed to the industry-mix—growth in the industry at the national level—regional-growth represented the largest driver of new employment in the shift-share analysis (615 jobs).

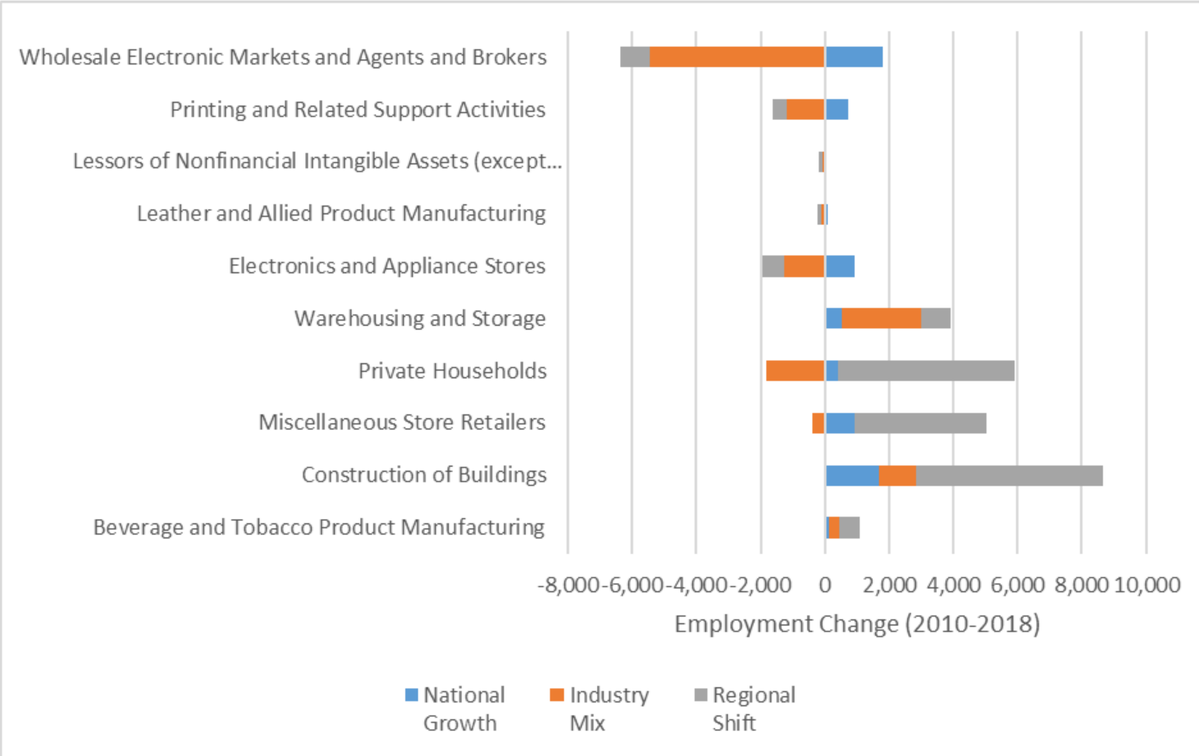
The Private Households industry employs workers “that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers” (Wallis, 2019). The increase in employment in the Private Households industry mirrors a statewide trend (Wallis, 2019). According to the shift-share analysis, growth in the sector was almost entirely a driven by regional forces.

Employment in the Warehousing and Storage subsector is likely a reflection of the global revolution in retail sales. With an increased share of retail shopping occurring online, growth in transportation, storage, and distribution infrastructure has been increasing nationally. Although the character of work is quite different, new employment in this in the subsector has helped to offset job loss in traditional “Brick and Mortar” retail (Lehner, Oregon's Shifting Retail Landscape, 2017). Growth in the region is driven by access to a relatively large consumer market and strong existing transportation infrastructure—rail, water, and air.

The Portland metro area has experienced considerable economic growth since the last recession; one driver of growth has been the strong in-migration of young college graduates, who are attracted to Portland's urban amenities and high quality of life (Lehner, Portland in Transition, 2017). In-migration has in turn driven demand for new housing, resulting in strong employment growth in the construction subsector. Migration patterns can also help to explain growth in median household income and likely have helped support employment growth in the Establishments in the Miscellaneous Store Retailer subsector. This subsector includes stores with “unique characteristics,” such as stationery stores, gift shops, pet and pet supply stores, florists, and used merchandise stores (U.S. Bureau of Labor Statistics, 2020, April 17). The vast majority of growth in this subsector can be attributed to regional factors (4,106 jobs).

As mentioned, the Wholesale Electronic Markets and Agents and Brokers subsector saw the largest total number of jobs lost during the 2010 to 2018 period. The Electronics and Appliance Stores and Printing and Related Support Activities subsectors lost approximately one-thousand jobs each. Job loss in all three subsectors was driven more by the industrial-mix, or changes in the industry at the national level, as opposed to regional factors. For example, employment decline in the Electronics and Appliance Stores was likely the result of aforementioned changes in retail shopping—changes that have resulted in the shuttering of retail giants like Sears.

Figure 2-148. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 2, 2010-2018



U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Table 2-203. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 2, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Beverage and Tobacco Product Manufacturing	1,073	140	317	615
Construction of Buildings	8,676	1,673	1,154	5,848
Miscellaneous Store Retailers	4,620	912	−398	4,106
Private Households	4,103	405	−1,818	5,515
Warehousing and Storage	3,915	540	2,472	902
Fastest Declining				
Electronics and Appliance Stores	−1,043	907	−1,248	−702
Leather and Allied Product Manufacturing	−146	103	−108	−141
Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	−153	39	−63	−129
Printing and Related Support Activities	−936	709	−1,179	−467
Wholesale Electronic Markets and Agents and Brokers	−4,592	1,790	−5,449	−932

U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Economic Trends and Issues

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the economy in Region 2 has experienced strong growth in recent years and has a diversity of high paying, traded industries. The following situations increase Region 2's level of vulnerability to natural hazard events:

- Unemployment in Clatsop County is consistently higher than its regional peers and higher than the statewide average
- The Portland metro area is the economic hub for the state. Any disruptions caused by a natural hazard could ripple throughout the other regions.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl, et al., 2000).

Infrastructure

Transportation

<u>*Roads*</u>

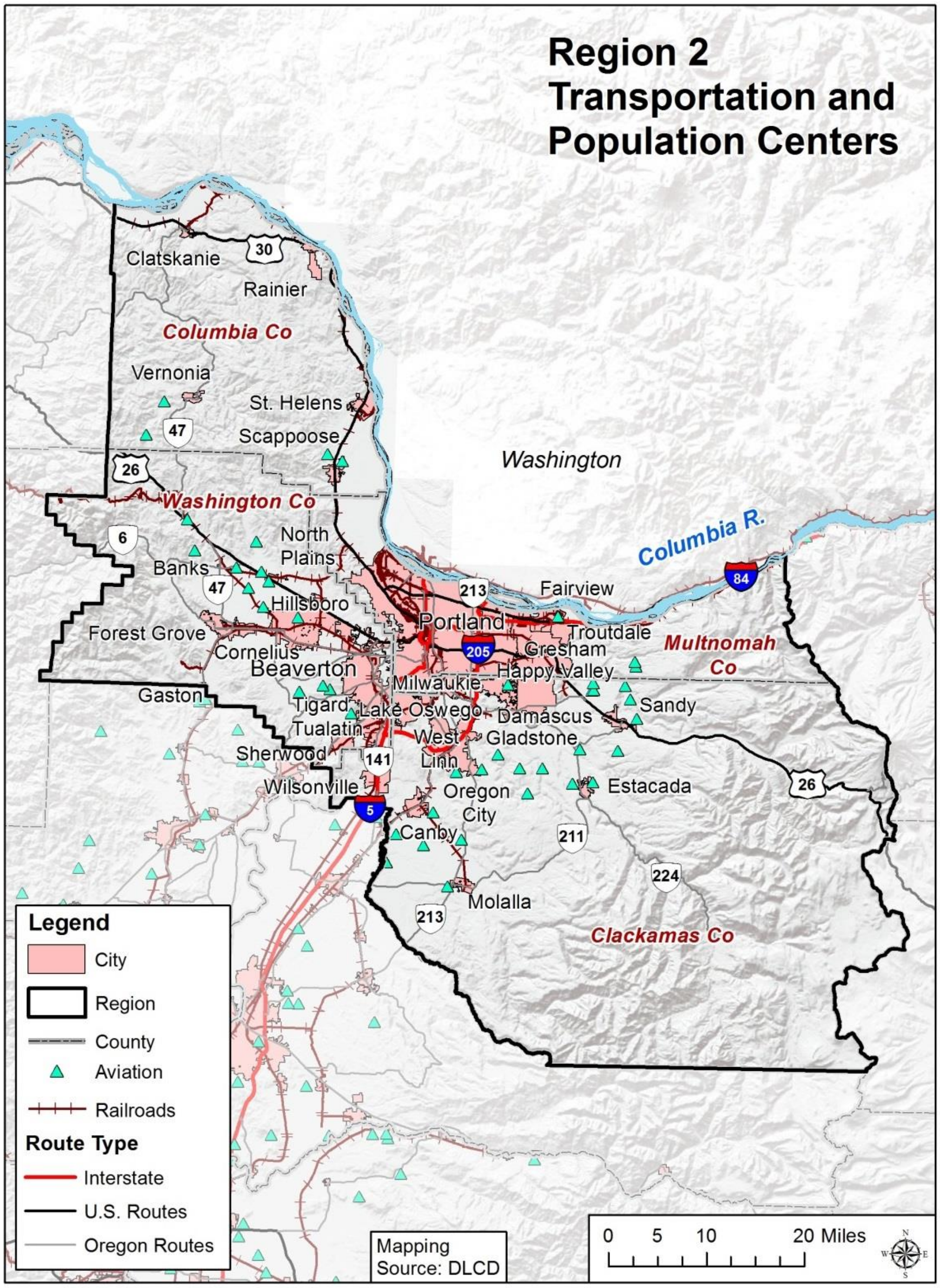
The largest population bases in Region 2 are located along the region's major freeways: I-5, I-205, and I-84. I-5 runs north-south through Region 2 and is the main passage for automobiles and trucks traveling along the West Coast. I-205 is a loop route that serves Portland and Vancouver and provides access through the eastern edge of the Portland area. I-84 runs east-west and is the main passage for automobiles and trucks traveling between Oregon and central and eastern states.

Region 2's growing population centers bring more workers, automobiles and trucks onto roads. Collectively, these create additional stresses on transportation systems through added maintenance, congestion, and oversized loads. Furthermore, a high percentage of workers driving alone to work, coupled with interstate and international freight movement on the interstate corridors, can cause added traffic congestion and accidents.

Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuations and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

The region has high exposure to earthquakes, especially a Cascadia Subduction Zone event. Therefore, the seismic vulnerability of the region's lifelines, including roadways and bridges, is an important issue. For information on ODOT's 2012 Seismic Lifelines Report findings for Region 2, see **Seismic Lifelines**.

Figure 2-149. Region 2 Transportation and Population Centers



Source: Oregon Department of Land Conservation and Development, 2014

Bridges

ODOT lists 1,194 bridges in the counties that comprise Region 2.

As mentioned, the region's bridges are highly vulnerable to seismic activity. Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or that are part of regional and local systems that are maintained by the region's counties and cities.

Table 2-204 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency. A deficient bridge (De) is a federal performance measure used for non-ODOT bridges. These ratings do not imply that a bridge is unsafe (ODOT, 2020). A significant improvement in the condition of the region's bridges reduced to 4% (from 30% in 2012 and 2013) the percentage of region's bridges that are distressed or deficient. About 2% (from 28% in 2012 and 2013) of the region's ODOT bridges are distressed.

Table 2-204. Bridge Inventory for Region 2

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	ST	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 2	12	549	2%	22	425	5%	5	195	3%	4	25	16%	43	1194	4%
Clackamas	3	118	3%	7	158	4%	1	19	5%	0	0	N/A	11	295	4%
Columbia	1	33	3%	2	81	2%	1	9	11%	0	2	0%	4	125	3%
Multnomah	5	280	2%	4	36	11%	2	129	2%	4	15	27%	15	460	3%
Washington	3	118	3%	9	150	6%	1	38	3%	0	8	0%	13	314	4%

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2020)

Railroads

Railroads that run through Region 2 support cargo and trade flows. The region's major (Class I) freight rail providers are the Union Pacific (UP) and the Burlington Northern-Santa Fe (BNSF) railroads. The Port of Portland is a major marine gateway for rail freight. There are six major rail yards and terminals in the region — all of which are in Portland — operated by UP or BNSF. Oregon's freight rail system is critical to the state's economy, energy, and food systems. Rail systems export lumber and wood products, pulp and paper, and other goods produced in the state, as well as products from other states that are shipped to and through Oregon by rail.

Amtrak provides passenger rail service throughout the region. In addition, the Portland Westside Express Service provides passenger rail options for commuters in Washington County. The area is also serviced by a regional transit system (TriMet) that provides both bus and light rail service through the greater Portland Metropolitan area.

Rails are sensitive to icing from winter storms that can occur in Region 2. Disruptions in the rail system can result in economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, especially if hazardous materials are involved.

Airports

The Portland International Airport is the only primary commercial airport in the region and is the busiest airport in Oregon (Federal Aviation Administration [FAA], 2012). The airport is owned, operated, and administered by the Port of Portland. It serves 17 passenger air carriers and seven cargo carriers with approximately 183,000 annual commercial flights, 20,300 cargo flights, and 21,000 military and general aviation annual flights (Portland International Airport, 2014). The Port of Portland also operates two relief airports, Portland-Hillsboro and Portland-Troutdale, that serve the region.

Table 2-205. Public and Private Airports in Region 2

	Number of Airports by FAA Designation				
	Public Airport	**Private Airport**	**Public Heliport**	**Private Heliport**	**Total**
Region 2	12	33	1	24	70
Clackamas	5	19	0	6	30
Columbia	2	2	0	0	4
Multnomah	2	1	1	10	14
Washington	3	11	0	8	22

Source: FAA Airport Master Record (Form 5010) (2014)

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

Ports

Oregon's ports have historically been used for timber transport and for commercial and recreational fishing. With the decline in the timber industry, ports have evolved to embrace economic development and tourism by offering industrial land and river, rail, road, and air infrastructure. There are two ports within Region 2, the Port of St. Helens and the Port of Portland. The Port of St. Helens includes 93 acres of light industrial and is approximately 30 miles from Portland (Port of St. Helens, http://www.portsh.org/index.php). The Port of Portland is responsible for overseeing the Portland International Airport and other aviation and marine activities in the Portland Metro area. The Port of Portland includes four marine terminals, five industrial parks, and three airports (Port of Portland, http://www.portofportland.com).

Energy

Electricity

The region is served by several investor-owned, public, cooperative, and municipal utilities. Portland General Electric (PGE) is the largest investor-owned utility in the region, serving large areas of Clackamas, Multnomah, and Washington Counties. Pacific Power and Light (Pacific Power) is another investor-owned utility company serving a small portion of Multnomah County. Additionally, the Western Oregon Electric Cooperative, Inc. provides electricity for portions of Region 2. Three municipal utility districts support the region: City of Cascade Locks, City of Forest Grove, and City of Canby. In addition, the Clatskanie People's Utility District and the Columbia River PUD serve portions of the region.

The Northern Willamette Valley / Portland Metro area has eight power-generating facilities: six generate hydroelectric and two generate natural gas. In total, these facilities have the ability to produce up to 1,121 megawatts (MW) of electricity.

Table 2-206. Power Plants in Region 2

	Hydro-electric	Natural Gas	Wind	Coal	Other*	Total
Region 2	6	2	0	0	0	8
Clackamas	6	0	0	0	0	6
Columbia	0	2	0	0	0	2
Multnomah	0	0	0	0	0	0
Washington	0	0	0	0	0	0
Energy Production (MW)	203	918	0	0	0	1,121

*Other includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

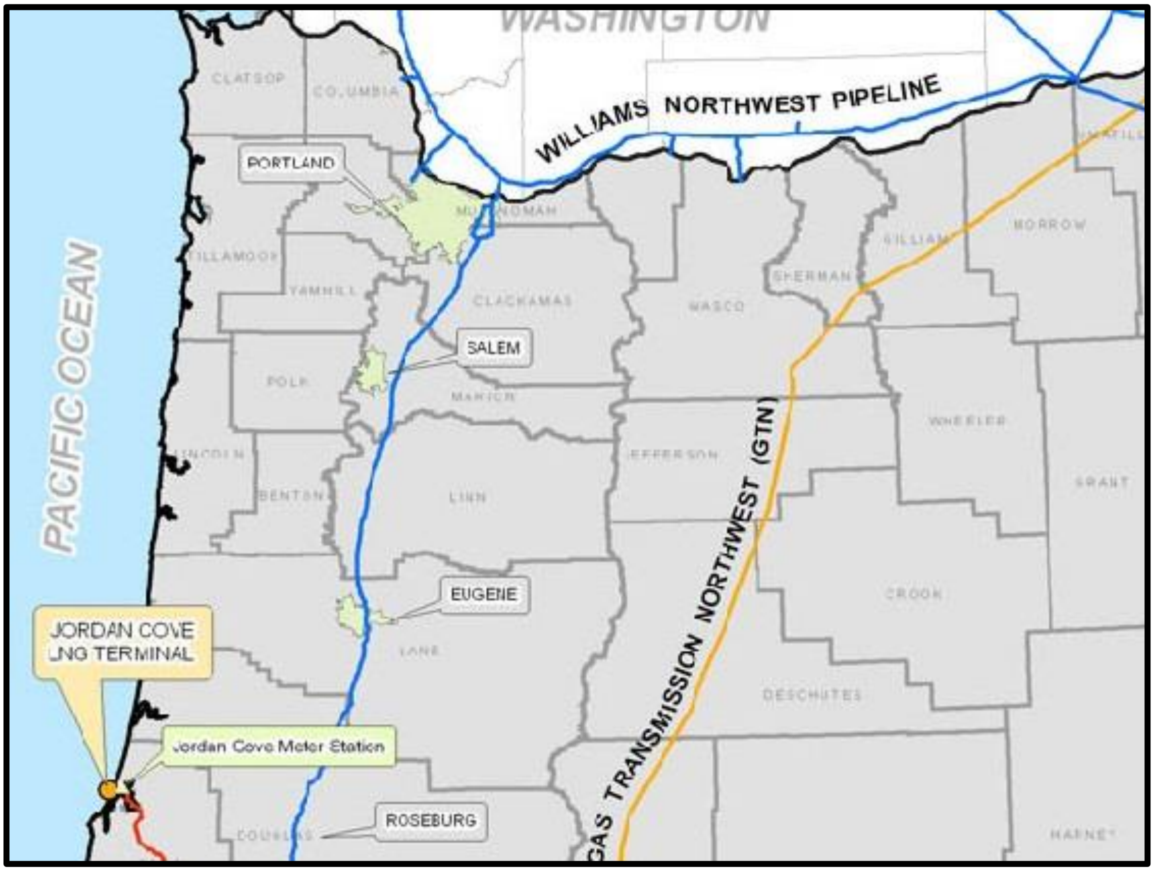
Hydropower

Bonneville Power Administration (BPA) provides hydro-generated electricity to the state's consumer-owned utilities. The Bonneville Dam is BPA's major dam in the region, located on the Columbia River. Other dams in the region are located on the Willamette, Clackamas, and Sandy Rivers.

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to the region's energy portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-150** shows the Williams Northwest Pipeline, which runs through Clackamas and Multnomah Counties (in blue) (Pipelines International, 2009). LNG pipelines, like other buried pipe infrastructure are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

Figure 2-150. Liquefied Natural Gas Pipelines in Region 2



Source: Retrieved from http://gs-press.com.au/images/news_articles/cache/Pacific_Connector_Gas_Pipeline_Route-0x600.jpg

Oregon's Critical Energy Infrastructure Hub

Oregon's critical energy infrastructure hub (CEI Hub) is located in north Portland on the lower Willamette River between the south tip of Sauvie Island and the Fremont Bridge along US-30. Over 90% of Oregon's refined petroleum is imported to Oregon via the Puget Sound and arrives to Oregon CEI Hub via pipeline or marine vessels (Wang, Bartlett, & Miles, 2013). In addition, much of Oregon's natural gas passes through the CEI Hub and a high voltage electrical transmission corridor crosses, and supplies distribution for, the area. The CEI Hub includes the following energy sector facilities (Pipelines International, 2009):

- All of Oregon's major liquid fuel port terminals,
- Liquid fuel transmission pipelines and transfer stations,
- Natural gas transmission pipelines,
- A liquefied natural gas storage facility,
- High-voltage electric substations and transmission lines, and
- Electrical substations for local distribution.

In 2013, the Oregon Department of Geology and Mineral Industries (DOGAMI) conducted a study of the CEI Hub's earthquake risk entitled Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub (Wang, Bartlett, & Miles, 2013) https://www.oregongeology.org/pubs/ofr/p-O-13-09.htm). The study determined (a) the vast majority of facilities are constructed on soils susceptible to liquefaction and (b) significant seismic risk exists within the various energy sector facilities. The CEI Hub was identified as being highly vulnerable to a Cascadia Subduction Zone (CSZ) event: "western Oregon is likely to face an electrical blackout, extended natural gas service outages, liquid fuel shortage, as well as damage and losses in the tens of billions of dollars" (Pipelines International, 2009). Significant pro-active seismic mitigation projects are recommended to be integrated into the affected energy sector companies' business practices in order to allow Oregon to adequately recover from a CSZ event within a reasonable period of time. For more information see the full report.

Utility Lifelines

The Northern Willamette Valley / Portland Metro region is an important thoroughfare for oil and gas pipelines and electrical transmission lines, connecting Oregon to California and Canada. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe, but infrequent natural hazards, such as earthquakes. If these lines fail or are disrupted essential functions of the community can become severely impaired.

Region 2 primarily receives oil and gas from Alaska by way of the Puget Sound through pipelines and tankers. Oil and gas are supplied by Northern California from a separate network. The electric, oil, and gas lifelines that run through the region are municipally and privately owned (Loy, Allan, & Patton, 1976).

Portland General Electric and Bonneville Power Administration primarily operate the electrical transmission lines running through Region 2, and these lines produce and distribute power locally (Loy, Allan, & Patton, 1976). Most of the natural gas Oregon uses originates in Alberta, Canada. Avista Utilities owns the main natural gas transmission pipeline (Loy, Allan, & Patton, 1976).

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Region 2 is part of the Portland Operational Area under The Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013), which also includes Clark County, Washington. There is a memorandum of understanding between these counties that facilitates the launching of emergency messages. Counties in this area can launch emergency messages by contacting the Oregon Emergency Response System (OERS), which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communications capabilities during disaster events and other emergency situations helps keep citizens safe by keeping them informed of the situation's status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The Oregon State Emergency Alert System Plan does not identify a local primary station for emergency messages.

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 2. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is readily available throughout most parts the region with a smaller number of providers and service types available in eastern Multnomah County and a small area of central Columbia County (NTIA, n.d.). Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 2 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for the Portland Operational Area are (Oregon Office of Emergency Management, 2013):

- KXL-FM, 10.1 MHZ, Portland;
- KGON-FM, 92.3 MHZ, Portland; and
- KOPB-FM, 91.5 MHZ, Portland.

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). Region 2 is served by ARES District 1. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency Management, n.d.). The official ham emergency station calls for Region 2 include (American Relay Radio League Oregon Chapter, http://www.arrloregon.org):

- Clackamas County: KA7OZO;
- Columbia County: W7OR;
- Multnomah County: N9VCU; and
- Washington County: KE7WKM.

Water

Drinking water, stormwater, and wastewater systems all possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In Region 2 the majority of the municipal drinking water supply is obtained primarily from surface water sources such as rivers. These surface water sources are often backed up by groundwater that is drawn from an aquifer when surface water levels get low, especially in summer months. For many communities in Regions 2 and 3, the Willamette River is both a source of potable water and a discharge location for wastewater treatment facilities. Cities that draw water from the Willamette River face water rights disputes and issues related to water quality. The Bull Run watershed is the primary drinking source for the City of Portland and its 19 wholesale customers and does not face the same water quality issues as the Willamette River. However, Portland residents have expressed concerns about the well field that is the City's backup water source. Portlanders have complained of the water's unpleasant taste and expressed concern that water quality may be compromised due to the well field's close proximity to industrial facilities.

Rural residents in the region draw water from surface water, groundwater wells, or springs. Areas with sedimentary and volcanic soils may be subject to high levels of arsenic, hydrogen sulfide, and fecal coliform bacteria, which can impact the safety of groundwater sources. In areas where no new live-flow water rights are available, farmers and ranchers are turning to above-ground storage to help supply water for crop irrigation during dry seasons. At times, urban water districts with an abundant supply have sold water to rural areas. The City of Portland has a long history of these transactions and in recent years has faced competition from other sellers.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. Non-point source pollution is a major threat to surface water quality, and may include stormwater runoff from roadways, agricultural operations, timber harvest, erosion and sedimentation. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Landslides, flood events, and earthquakes and resulting liquefaction can cause increased erosion and sedimentation in waterways

Underground water supplies and aging or outdated infrastructure such as reservoirs, treatment facilities, and pump stations can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, thus limiting access to potable water. This can lead to unsanitary conditions that may threaten human health and limit fire suppression. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enter surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 2, most local building codes and stormwater management plans emphasize the use of centralized storm sewer systems to manage stormwater. Requirements for stormwater mitigation vary in Region 2. Low-impact development (LID) mitigation strategies can alleviate or lighten the burden to a jurisdiction’s storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, lower speeds, and lower temperatures. The City of Portland has been recognized as a national innovator in stormwater management and code because of its progressive LID stormwater mitigation strategies in the City’s building code. However, the majority of jurisdictions in the region do not require LID strategies in their building code. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems and increase a community’s resilience to many types of hazard events.

Infrastructure Trends and Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community’s ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

Roads, bridges, and rail systems in the region support Oregon's largest population centers and freight moving through the Pacific Northwest. These transportation systems and are vulnerable to a variety of natural hazards that could disrupt transportation of goods, block evacuation routes and sever lifelines. The effects of road, bridge, and rail failures on the economy and health of the region's residents could be devastating. ODOT understands this risk and began seismically upgrading five of the area's key bridges within the Portland Metro area in summer 2014.

In addition, the region has two ports with marine terminals, industrial parks and aviation facilities. The Portland International Airport is the busiest in the state, moving the majority of passengers and freight. These ports, including airports, face potential disruptions in services due to natural hazard events.

The region is an energy hub for the state. There are multiple dams and eight power-generating facilities. The Bonneville Power Administration (BPA) provides hydro-generated electricity to the state's consumer owned utilities. BPA's main dam, the Bonneville Dam, is located on this region on the Columbia River. Liquid Natural Gas is transported through the region via the Williams Northwest Pipeline that runs through Clackamas and Multnomah Counties. Of particular concern is Oregon's critical energy infrastructure hub, located in north Portland, which is highly vulnerable to a Cascadia event.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services may not cover rural areas of the region that are distant from Portland, especially central Columbia and eastern Multnomah Counties. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Water systems in the region are particularly vulnerable to hazard events because they tend to be centralized and lacking in system redundancies. Furthermore, because most drinking water is sourced from surface water, the region is vulnerable to high levels of pollutants entering waterways during high-water events. The City of Portland has been recognized as a leader in stormwater management best practices because of its decentralized Low Impact Development (LID) stormwater systems.

Built Environment

Settlement and Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's land use program is 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD, https://www.oregon.gov/lcd/OP/Pages/Goal-7.aspx).

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people or an "urban cluster" of at least 2,500 people (but less than 50,000). Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-207** and **Table 2-208** remain from the 2010 Census.

Washington and Columbia Counties experienced the region's greatest percent urban growth during the decade from 2000 to 2010, roughly 5% and 7% more than the state average respectively. Similar to the state, the region is becoming less rural. However, Columbia County, the least populated county along the coast, is the only county in the region to increase its rural population.

The region's urban housing units grew eight times those in rural areas. Multnomah County was the only county to decrease its share of rural residences, notably by 11%. Columbia County had the largest percent growth in in both urban and rural units 24.1% and 10.8% respectively.

Not surprisingly, populations tend to cluster around major road corridors and waterways. The region's largest population is clustered around the Portland Metro area. The population distribution in Region 2 is presented in **Figure 2-151.**

Table 2-207. Urban and Rural Populations in Region 2, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	−0.1%
Region 2	1,352,896	1,561,409	15.4%	134,883	128,978	−4.4%
Clackamas	266,367	308,018	15.6%	72,024	67,974	−5.6%
Columbia	22,769	27,828	22.2%	20,791	21,523	3.5%
Multnomah	649,010	725,464	11.8%	11,476	9,870	−14.0%
Washington	414,750	500,099	20.6%	30,592	29,611	−3.2%

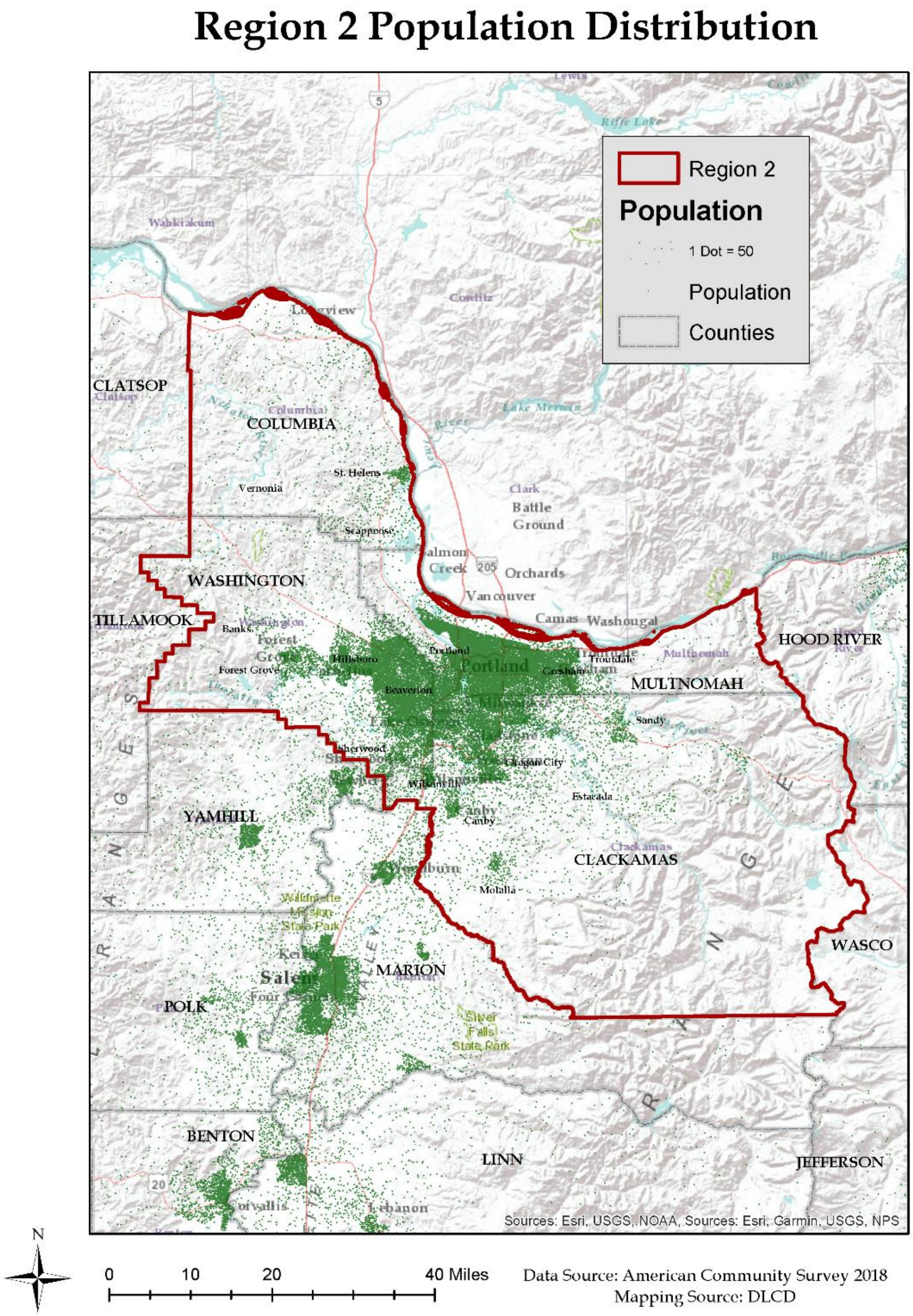
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2

Table 2-208. Urban and Rural Housing Units in Region 2, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 2	569,834	661,845	16.1%	52,166	53,080	1.8%
Clackamas	109,047	128,740	18.1%	27,907	28,205	1.1%
Columbia	9,247	11,474	24.1%	8,325	9,224	10.8%
Multnomah	283,957	320,735	13.0%	4,604	4,097	−11.0%
Washington	167,583	200,896	19.9%	11,330	11,554	2.0%

Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2

Figure 2-151. Region 2 Population Distribution



Source: U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. **Table 2-209** provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

The majority of the region's housing stock is single-family homes. Nearly half of the region's multi-family units are located in Multnomah County, in the Portland area in particular. Manufactured dwellings make up only 3.4% of all housing in the region. Columbia County has the greatest percentage of manufactured homes (14.5 %), and Clackamas County has the highest number of units (10,471). In natural hazard events such as earthquakes and floods, manufactured homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997).

Table 2-209. Housing Profile for Region 2

	Total Housing Units	Single Family			Multi-Family			Mobile Homes		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	68.1%	☑	0.3%	23.5%	☑	0.3%	8.2%	☑	0.1%
Region 2	745,872	65.5%	☑	0.3%	31.0%	☑	0.4%	3.4%	☑	0.1%
Clackamas	163,650	73.1%	☑	0.6%	20.4%	☑	0.8%	6.4%	☑	0.3%
Columbia	21,007	74.2%	☑	2.1%	11.1%	☑	1.6%	14.5%	☑	1.5%
Multnomah	337,821	60.6%	☑	0.5%	37.3%	☑	0.7%	1.9%	☑	0.2%
Washington	223,394	66.5%	☑	0.6%	31.0%	☑	0.8%	2.5%	☑	0.2%

Notes: *Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-210. Housing Vacancy in Region 2

		Vacant^		
	Total Housing Units	**Estimate**	**CV ****	**MOE (+/−)**
Oregon	1,733,041	5.6%	☑	0.2%
Region 2	745,872	4.5%	☑	0.2%
Clackamas	163,650	4.0%	☑	0.5%
Columbia	21,007	7.6%	☑	1.5%
Multnomah	337,821	4.8%	☑	0.3%
Washington	223,394	4.1%	☑	0.4%

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.
**Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table B25004: Vacancy Status

Aside from location and type of housing, the year a structure was built (Table 2-211) has implications for level of vulnerability to natural hazards. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally, 36.7% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances. Notably, over 53% of homes in Multnomah County were constructed before 1970. Regionally, approximately two thirds of the housing stock was built before 1990 and the codification of seismic building standards. Washington County has the highest percentage (46.4%) and largest number (103,575) of units built after 1990. Additionally, as shown in Table 2-212, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the late 1970s or mid-1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-211. Age of Housing Stock in Region 2

	Total Housing Units	Pre 1970			1970 to 1989			1990 or Later		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	34.6%	✓	0.3%	30.5%	✓	0.3%	34.9%	✓	0.3%
Region 2	745,872	36.7%	✓	0	28.7%	✓	0.4%	34.6%	✓	0.4%
Clackamas	163,650	27.1%	✓	0	34.8%	✓	0.8%	38.1%	✓	0.9%
Columbia	21,007	37.0%	✓	0	26.9%	✓	1.9%	36.1%	✓	2.2%
Multnomah	337,821	53.6%	✓	0	21.4%	✓	0.5%	25.1%	✓	0.6%
Washington	223,394	18.1%	✓	0	35.6%	✓	0.7%	46.4%	✓	0.9%

Notes: *Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25034: Year Structure Built, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood, damage is minimized. **Table 2-212** shows the initial and current FIRM effective dates for Region 2 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, **Flood** section.

Table 2-212. Community Flood Map History in Region 2

	Initial FIRM	Current FIRM
Clackamas County	Mar. 1, 1978	Jan. 18, 2019
Barlow	May 5, 1981	June 17, 2008
Canby	June 15, 1984	June 17, 2008
Damascus	July 19, 2000	June 17, 2008
Estacada	June 17, 2008	June 17, 2008
Gladstone	Mar. 15, 1977	June 17, 2008
Happy Valley	Dec. 4, 1979	June 17, 2008
Lake Oswego	Aug. 4, 1987	June 17, 2008
Milwaukie	June 18, 1980	June 17, 2008
Molalla	June 17, 2008	June 17, 2008
Oregon City	Dec. 15, 1980	June 17, 2008
Portland	see Multnomah County	see Multnomah County
Rivergrove	Aug. 4, 1987	June 17, 2008
Sandy	Dec. 11, 1979	Jan. 18, 2019
Tualatin	see Washington County	see Washington County
West Linn	Mar. 15, 1977	June 17, 2008
Wilsonville	Jan. 6, 1982	June 17, 2008
Columbia County	Aug. 16, 1986	Nov. 26, 2010
Clatskanie	September 29, 1986	Nov. 26, 2010
Columbia, City	June 5, 1985	Nov. 26, 2010
Prescott	Aug. 16, 1988	Nov. 26, 2010
Rainier	Aug. 16, 1988	Nov. 26, 2010
St. Helens	September 29, 1986	Nov. 26, 2010
Scappoose	Dec. 19, 1975	Nov. 26, 2010
Vernonia	Aug. 16, 1986	Nov. 26, 2010
Multnomah County	June 15, 1982	Feb. 1, 2019
Fairview	Mar. 18, 1986	Feb. 1, 2019
Gresham	July 16, 1979	Feb. 1, 2019
Lake Oswego	see Clackamas County	see Clackamas County
Milwaukie	see Clackamas County	see Clackamas County
Portland	Oct. 15, 1980	Nov. 26, 2010
Troutdale	Sept. 30, 1988	Feb. 1, 2019
Wood Village	Dec. 18, 2009	Dec. 18, 2009
Washington County	Sept. 30, 1982	Oct. 19, 2018
Beaverton	Sept. 28, 1984	Oct. 19, 2018
Cornelius	Jan. 6, 1982	Nov. 4, 2016
Durham	Jan. 6, 1982	Nov. 4, 2016
Forest Grove	Mar. 15, 1982	Oct. 19, 2018
Gaston	July 5, 1982	Nov. 4, 2016
Hillsboro	May 17, 1982	Oct. 19, 2018
King City	Feb. 18, 2005	Oct. 19, 2018
Lake Oswego	see Clackamas County	see Clackamas County
North Plains	April 1, 1982	Oct. 19, 2018
Portland	see Multnomah County	see Multnomah County
Rivergrove	see Clackamas County	see Clackamas County
Sherwood	Jan. 6, 1982	Oct. 19, 2018
Tigard	Mar. 1, 1982	Oct. 19, 2018
Tualatin	May 2, 1978	Oct. 19, 2018
Wilsonville	see Clackamas County	see Clackamas County

Source: Federal Emergency Management Agency, Community Status Book Report (2019), https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 2 can be found in Table 2-213. The region contains roughly one-third of the total value of all local critical facilities and state-owned and –leased critical and non-critical facilities in the state. Cumulatively, these assets are valued at over eleven billion dollars.

Table 2-213. Value of State-Owned/Leased Critical and Essential Facilities in Region 2

	Value of Local and State-Owned/Leased Facilities				
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$2,630,306,288	$4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 2	$ 257,430,784	$ 877,465,291	$ 10,224,814,827	$ 11,359,710,902	33.9%
Clackamas	$ 122,919,532	$ 244,339,312	$ 2,627,327,079	$ 2,994,585,923	8.9%
Columbia	$ 9,995,844	$ 5,974,800	$ 319,380,450	$ 335,351,094	1.0%
Multnomah	$ 73,405,014	$ 254,444,106	$ 4,104,558,180	$ 4,432,407,300	13.2%
Washington	$ 51,110,394	$ 372,707,073	$ 3,173,549,118	$ 3,597,366,585	10.7%

Source: DOGAMI, 2020

Land Use Patterns

Approximately 63.3% of the land in Region 2 is in private ownership, while 30.7% is owned by the federal government, and 4% by the state government. The remainder is non-resource lands owned by other public entities. Subtracting the Cascade Mountain area leaves nearly the entire Region 2 in private holdings.

Not surprisingly, between 1974 and 2009, the Portland area, followed by the North Willamette Valley area, demonstrated the greatest rates of change in the state in the conversion of private land in resource land uses to low-density residential and urban uses. Within the Portland area, the highest rate of increase took place in Washington County, followed by Clackamas County. Both counties experienced much higher rates of conversion to low-density residential and urban uses than was the case in highly urbanized Multnomah County (Lettman G. J., 2011).

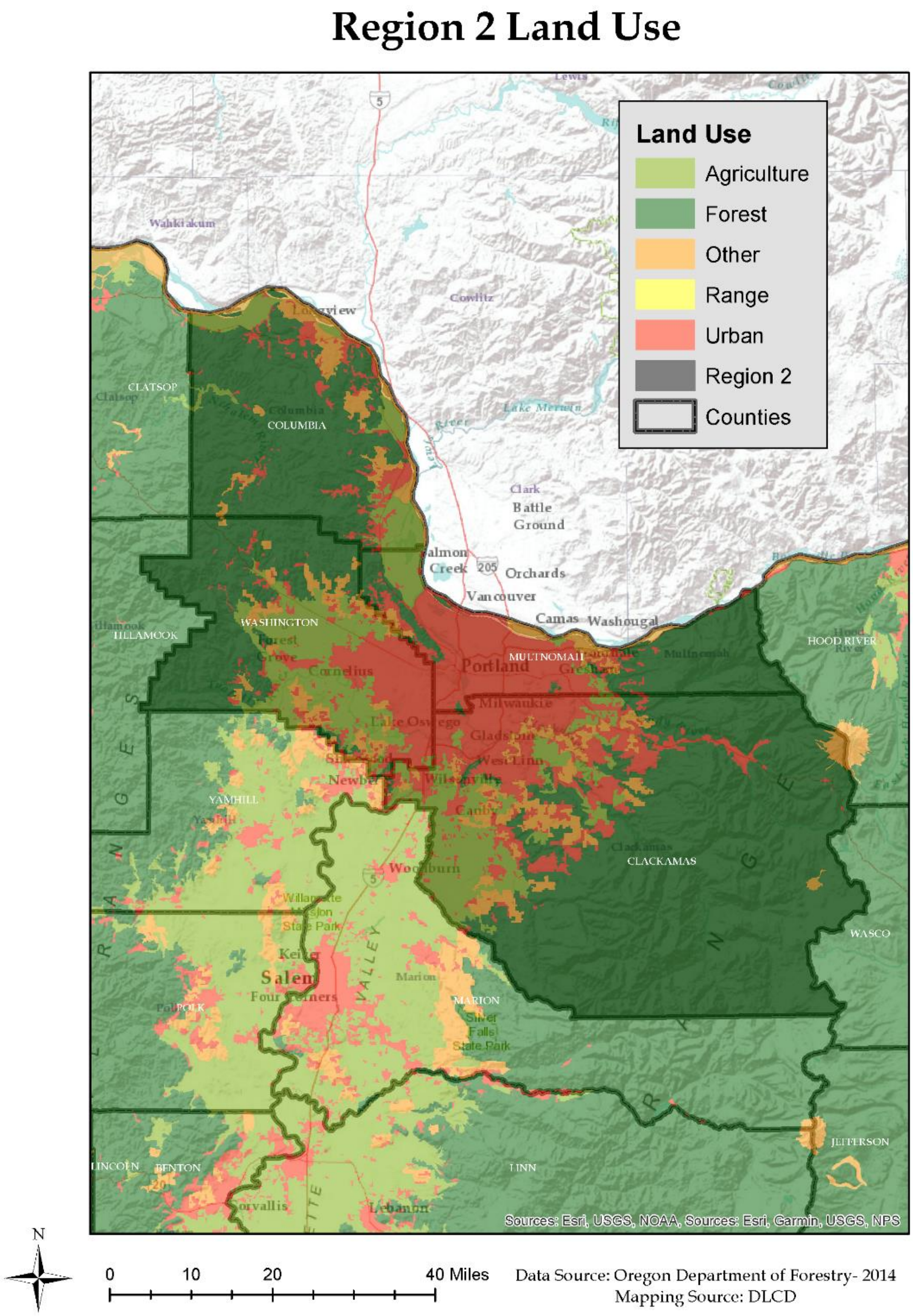
More recently, much of the new residential growth in the Portland area has been either infill or redevelopment. For example, from 2007-2009, 58% of new development in the Portland area fell into one of these two categories (Lettman G. J., 2011). The rest of the residential construction in that time, about 42%, has been on vacant land (Lettman G. J., 2011).

According to the Oregon Department of Forestry’s most recent land-use study., “development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon’s farms, forests, and rangeland shifted to low-density residential or urban uses” (Lettman G. J., Gray, Hubner, McKay, & Thompson, 2016). In Region 2, approximately 3,693 acres of resource lands were converted to more urban uses during the six-year period. Table 2-214 shows that during the six-year period, the percentage of resource lands converted in each county in Region 2 was less than one percent of each county’s total acreage. Consistent with the longer trends mentioned above, most of the conversion during this period happened in Washington and Clackamas Counties.

Under Oregon law, each of the state's cities and metropolitan areas has created around its perimeter an urban growth boundary (UGB), which is a land use planning line to control urban expansion onto farm and forest lands. The UGB is assessed every 6 years, in a process that involves various levels of government and the public. In 2018, the Metro Council voted to expand the region's urban growth boundary, adding 2,181 acres to the region (Metro, 2020).

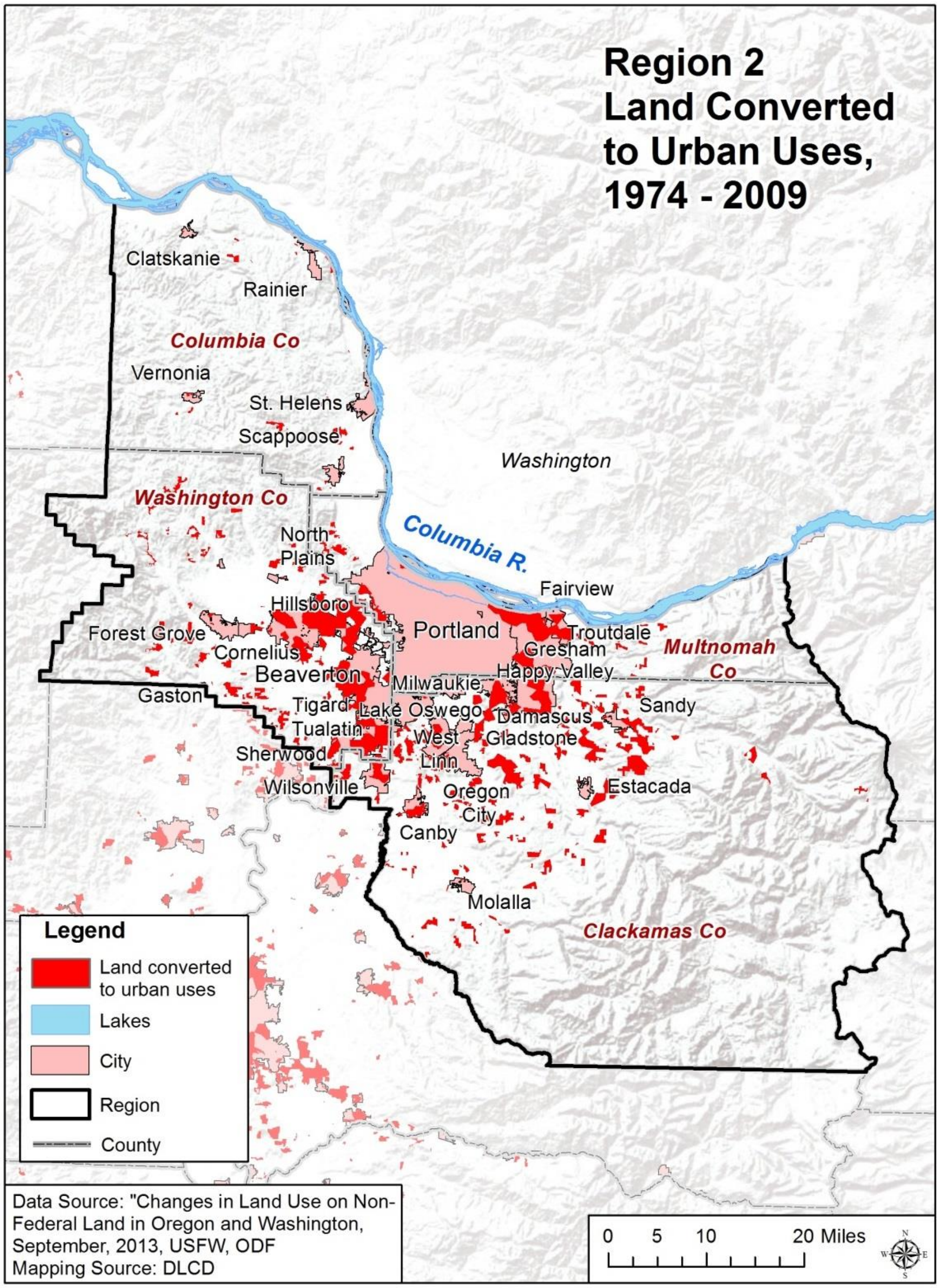
Potential upgrades to the 28 miles of levees that protect the north Portland area from the Columbia River remain a continuing land use issue for the region. As of January 2020, potential costs to the four drainage districts involved were approximately $157 million dollars (U.S. Army Corps of Engineers, 2020). Failure to maintain certification and FEMA accreditation may result in thousands of property owners and businesses subject to federal flood insurance regulations (DLCD, internal communication, 2014).

Figure 2-152. Region 2 Land Use



Source: Oregon Department of Forestry 2014

Figure 2-153. Region 2 Land Converted to Urban Uses, 1974–2009



Source: "Changes in Land Use on Non-Federal Land in Oregon and Washington," September 2013, USFS, ODF

Table 2-214. Region 2 Resource Lands Converted to Urban Uses, 2009-2014

	Lost Resource Lands 2009-2014		
	Total Resource Acres (2009)	Acres Converted to Urban Use	Percent Converted
Region 2	1,200,888	3,693	0.30%
Columbia	377,030	774	0.20%
Washington	354,859	1,277	0.35%
Multnomah	75,266	122	0.16%
Clackamas	393,733	1,520	0.38%

Source: Oregon Department of Forestry, 2014; Oregon Department of Land Conservation and Development, 2020

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 2 is largely an urban county with urban development focused around the Portland Metropolitan area. Between 2010 and 2018, population grew at a rate somewhat faster than the state as a whole. This trend is project to continue over the next ten years. Please refer to the Region 2 Risk Assessment **Demography** section for more information on population trends and forecast. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion. In the early part of the last decade, much of the land conversion from natural resource production to urban uses is occurring in Washington and Clackamas Counties.

The region's housing stock is largely single-family homes. However, the region has a slightly higher percentage of multi-family units than the state as a whole; Multnomah County has the highest percentage (37%). Conversely, the region has a lower percentage of manufactured housing compared to the state as a whole, with the exception of Columbia County. Approximately 53% of housing in Multnomah was built prior to 1970, prior to current seismic and floodplain management standards. In contrast, over 46% of housing in Washington County was built after 1990. All of the region's FIRMs have been modernized or updated within the past decade to more accurately depict flood risk in the region.

2.3.2.3 Hazards and Vulnerability

Droughts

Characteristics

Droughts are uncommon in Region 2. In 1992, the Governor declared a drought for all 36 counties in Oregon. Since 1992, no Governor-declared droughts have occurred in Region 2, however, Region 2 counties received federal drought declarations in 2015.

Even though drought may not be declared as often in Western Oregon as in counties east of the Cascades, when drought conditions do develop in the Willamette Valley, the impacts are widespread and severe when both winter snow and spring/summer rain are low. Reasons for broad and significant impact include:

- Higher population density and growing population in the Willamette Valley;
- Dependence on surface water supplies for many municipalities, agriculture and industries from large flood control reservoirs in the Willamette river system;
- Agriculture is a major industry becoming increasingly dependent on irrigation;
- Increased frequency of toxic algal blooms in the Willamette system reservoirs, resulting in restrictions on use of water from reservoirs for drinking (i.e., for human and animals). Affected waters may not be safe for agricultural irrigation, and other uses; necessitating purchasing and transporting water from alternative sources;
- Since drought is typically accompanied by earlier onset of snowmelt (e.g., during flood control or early storage season), little or no snowmelt runoff is stored until later;
- Earlier start to growing season, before the start of the irrigation season, means that crops may not be irrigated until the irrigation season begins;
- Insufficient number of farm workers available because the growing season began before the workers were scheduled to arrive; and
- Responsibilities to recovering anadromous fish.

These are relatively recent and developing concerns, in particular on livestock and some other agricultural operations, and therefore there is no single comprehensive source or other sources for information to assess economic impacts. Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms.

Historic Drought Events

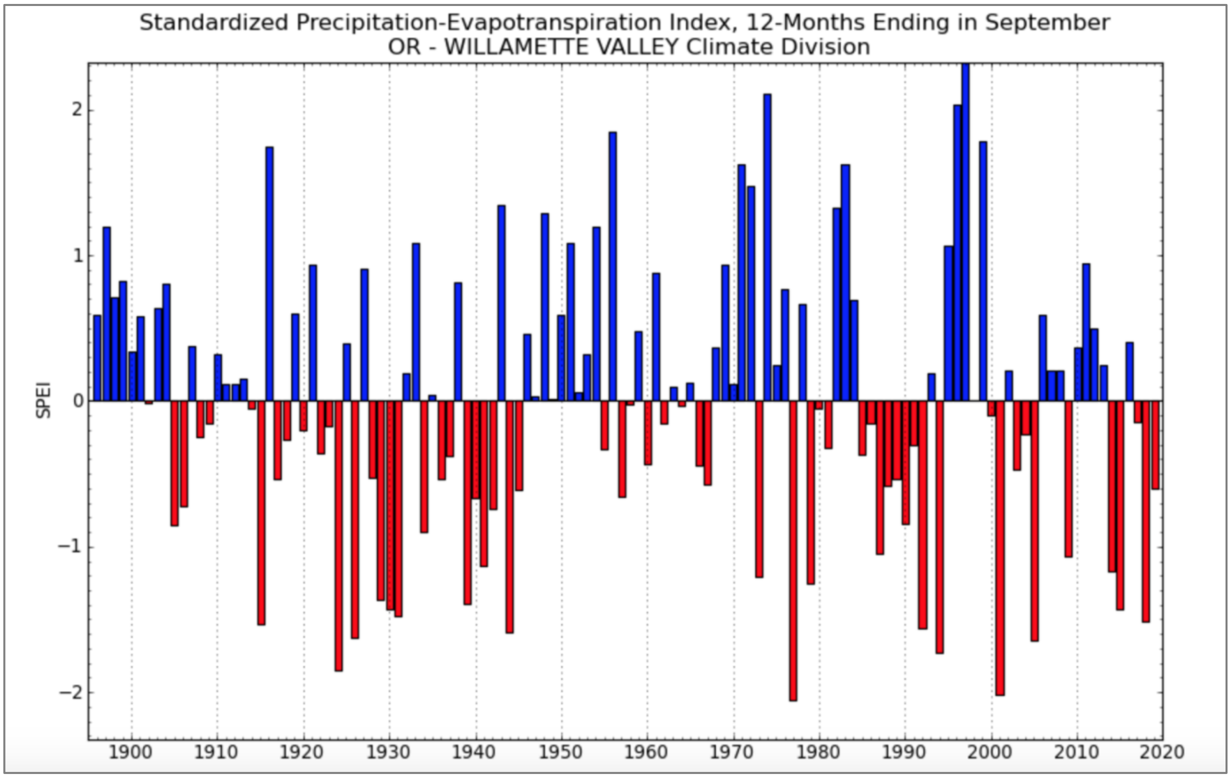
Table 2-215. Historic Droughts in Region 2

Date	Location	Description
1924	statewide	prolonged statewide drought that caused major problems for agriculture
1930	Regions 1–3, 5–7	moderate to severe drought affected much of the state; the worst years in Region 2 were 1928–1930, which kicked off an era of many drier than normal years
1939	statewide	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country
1992	statewide, especially Regions 1–4, 8	1992 fell toward the end of a generally dry period, which caused problems throughout the state; the 1992 drought was most intense in eastern Oregon, with severe drought occurring in Region 1
2001	Regions 2–4, 6, 7	the driest water year on record in the Willamette Valley (NOAA Climate Division 2); warmer than normal temperatures combined with dry conditions
2015	statewide	All 36 Oregon counties receive federal drought declarations; No counties in Region 2 received a Governor's declaration.

Sources: Taylor and Hatton (1999); Oregon Secretary of State's Archives Division; NOAA's Climate at a Glance; Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt; personal Communication, Kathie Dello, Oregon Climate Service, Oregon State University

Historical drought information can also be obtained from the West Wide Drought Tracker, which provides historical climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. **Figure 2-154** shows years where drought or dry conditions affected the Willamette Valley (Climate Division 2). Based on this index, Water Years 1977 and 2001 were extreme drought years for the Willamette Valley. Years with at least moderate drought have occurred 21 times during 1895–2019 (**Table 2-216**).

Figure 2-154. Standard Precipitation-Evapotranspiration Index for Region 2



Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-216. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 2 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
1931	1924	1977
1930	1994	2001
2015	2005	
1939	1926	
1929	1944	
1979	1992	
1973	1915	
2014	2018	
1941		
2009		
1987		

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Although not shown here, drought data from Climate Division 4, "the High Cascades," could also be analyzed to show a broader picture of drought impacts in Hazard Regions 2 and 3.

Probability

Table 2-217. Probability of Drought in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	VL	VL	VL	VL

Source: OWRD, DLCD

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases.

A comprehensive risk analysis is needed to fully assess the probability and impact of drought to Oregon communities. Such an analysis could be completed statewide to analyze and compare the risk of drought across the state.

A review of Governor drought declarations indicates that Region 2 has received a drought declaration in only 3% of the years since 1992. The probability of drought in Region 2 is therefore very low.

Climate Change

Even though drought is infrequent in the northern Willamette Valley, climate models project warmer, drier summers for Oregon, including Region 2. These summer conditions coupled with projected decreases in mid-to-low elevation mountain snowpack due to warmer winter temperatures increases the likelihood that Region 2 would experience increased frequency of one or more types of drought under future climate change. In Region 2, climate change would result in increased frequency of drought due to low spring snowpack (very likely, >90%), low summer runoff (likely, >66%), and low summer precipitation and low summer soil moisture (more likely than not, >50%). In addition, Region 2, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-218. Local Assessment of Vulnerability to Drought in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	L	L	—	M

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-219. State Assessment of Vulnerability to Drought in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	VL	VL	M	VL

Source: OWRD, DLCD

The impacts of drought on agriculture in Region 2 can be severe and widespread. Because these impacts are recent and developing, there is no single comprehensive source or other sources for information to assess economic impacts locally or at the state level or to state assets. Oregon has yet to undertake a comprehensive, statewide analysis to identify which communities are most vulnerable to drought.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than "well" and for its share of minority residents.

Multnomah County's social vulnerability score is moderate, while those of the other counties are very low. This means that any natural hazard would have a moderate impact on Multnomah County's population and little to no impact on the other counties' populations. None of the Region 2 counties is considered most vulnerable to drought.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 2 is approximately $1,134,896,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $10,224,815,000. Because drought, while uncommon in Region 2, could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one loss of over $111,000 to a state facility was recorded in Region 2 since the beginning of 2015. It was not caused by drought.

Risk

Table 2-220. Risk of Drought in Region 2

	Columbia	Clackamas	Multnomah	Washington
Risk	VL	VL	L	VL

Source: OWRD, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based on very low probability of drought and very low vulnerability except in Multnomah County, Region 2 is generally considered to be at very low risk from drought; Multnomah County is at low risk.

Earthquakes

Characteristics

The geographic position of Region 2 makes it susceptible to earthquakes from four sources: (a) the off-shore Cascadia Fault Zone, (b) deep intraplate events within the subducting Juan de Fuca plate, (c) shallow crustal events within the North America Plate, and (d) earthquakes associated with renewed volcanic activity. All have some tie to the subducting or diving of the dense, oceanic Juan de Fuca Plate under the lighter, continental North America Plate. Stresses occur because of this movement and there appears to be a link between the subducting plate and the formation of volcanoes some distance inland from the off-shore fault zone.

Region 2 has had at least seven crustal earthquakes of magnitude 4 or greater since 1877. The region's largest earthquakes were the 1877 M5.3 and the 1962 M5.2. In addition, the region has been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. There is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region and along the Cascadia Fault Zone. Deep-seated intraplate events, as occurred near Olympia, Washington in 1949 and 2001, could generate magnitudes as large as M7.5, but none have been identified in the region's historical or prehistoric records.

Earthquakes produced through volcanic activity could possibly reach magnitudes of 5.5. The 1980 Mount St. Helens eruption was preceded by a magnitude 5.1 earthquake. Despite the fact that Cascade volcanoes are some distance away from the major population centers in Region 2, earthquake shaking and secondary earthquake-related hazards such as lahars could cause major damage to these centers.

The City of Portland has been built on three identified crustal faults that stretch the length of Portland: the Oatfield Fault west of the northwest hills; the East Bank Fault, traversing the Willamette into Oregon City and the Portland Hills Fault which runs parallel to Forest Park into downtown Portland. Each of these crustal faults is capable of generating large earthquakes of M6.0–6.8.

Historic Earthquake Events

Table 2-221. Significant Earthquakes Affecting Region 2

Date	Location	Magnitude (M)	Description
Approximate Years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	Offshore, Cascadia Subduction Zone (CSZ)	probably 8.0–9.0	these are the mid-points of the age ranges for these six events
Jan. 1700	CSZ	about 9.0	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Oct, 1877	Portland area, Oregon	5.2	two events in one day; affected area: 41,000 sq km; damage: chimney damage
Feb. 1892	Portland area, Oregon	5.0	no major damage occurred
Dec. 1941	Portland area, Oregon	4.5	felt by most Portland residents; damage: shattered windows and cracked plaster (Hillsboro and Sherwood)
Apr. 1949	Olympia, Washington	7.1	damage: in Washington and NW Oregon
Dec. 1953	Portland area, Oregon	4.5	cracked plaster and caused objects to fall (Portland)
Nov. 1961	Portland area, Oregon	5.0	principal damage: from cracked plaster
Nov. 1962	Portland area, Oregon	5.5	shaking: up to 30 seconds; damage: chimneys cracked, windows broken, furniture moved
Dec. 1963	Portland area, Oregon	4.5	damage: books and pictures fell (Plains)
Mar. 25, 1993	Scotts Mills, Oregon	5.6	FEMA-985-DR-Oregon; center: Mt. Angel-Gales Creek fault; damage: $30 million (including Oregon Capitol Building in Salem)
Feb. 2001	Nisqually, Washington	6.8	felt in the region, no damage reported

Note: No significant earthquakes have affected Region 2 since February 2001.

*BCE: Before Common Area.

Sources: Wong & Bott (1995); Pacific Northwest Seismic Network, https://pnsn.org/

Probability

Table 2-222. Assessment of Earthquake Probability in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	H	VH	VH	VH

Source: DOGAMI, 2020

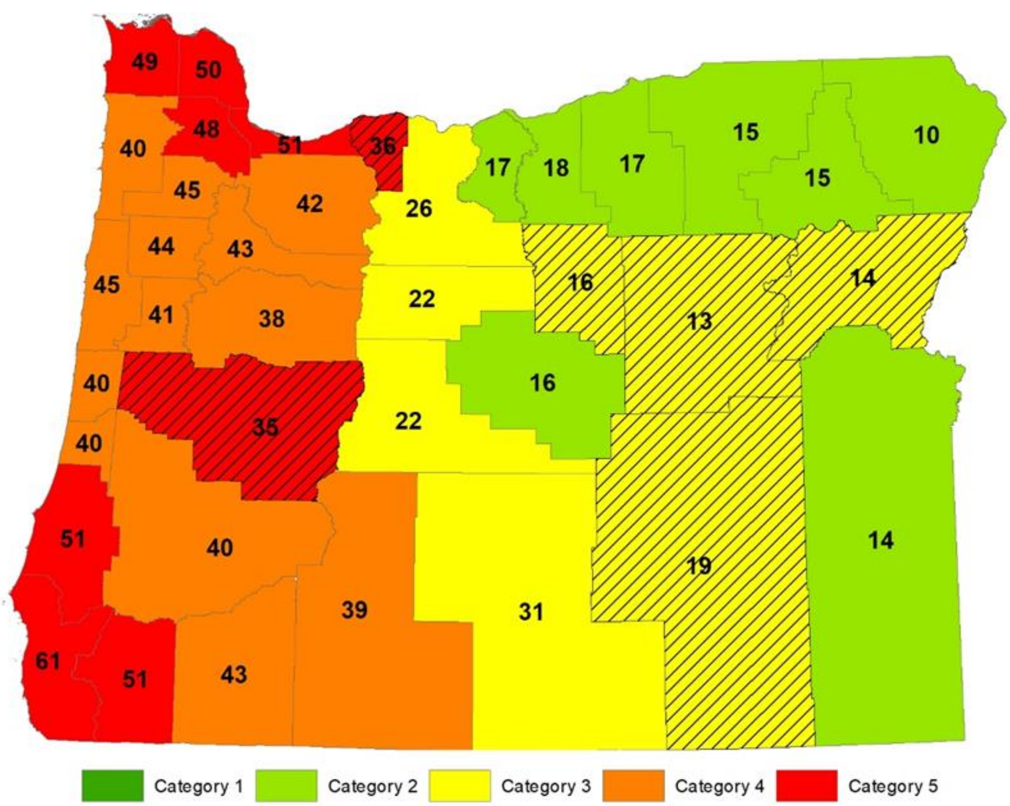
The probability of damaging earthquakes varies widely across the state. In Region 2 the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well-understood recurrence history.

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-155**.

Figure 2-155. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.

Source: DOGAMI, 2020

For Oregon west of the crest of the Cascades, the CSZ is responsible for most of the hazard shown in **Figure 2-155**. The paleoseismic record includes 18 magnitude 8.8–9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7 to 12%. An additional 10 to 20 smaller, magnitude 8.3–8.5, earthquakes affected only the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37–43%.

Vulnerability

Table 2-223. Local Assessment of Vulnerability to Earthquakes in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	H	H	H	H

Source: Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-224. State Assessment of Vulnerability to Earthquakes in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	VL	VL	M	L

Source: OWRD, DLCD

Table 2-225 shows the number of school and emergency response buildings surveyed in each county with their respective rankings.

Table 2-225. School and Emergency Response Building Collapse Potential in Region 2

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Clackamas	123	48	40	6
Columbia	19	13	15	3
Multnomah	68	118	116	29
Washington	81	69	80	6

Source: Lewis (2007), available at http://www.oregongeology.org/sub/projects/rvs/default.htm.

The Oregon Department of Geology and Mineral Industries (DOGAMI) developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) the Cascadia Subduction Zone (CSZ), and (b) combined crustal events (500-year model). Both models use Hazus, a software program developed by the Federal Emergency Management Agency (FEMA), as a means of determining potential losses from earthquakes. The CSZ event is based on a potential M8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from such an event. The 500-year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults. Neither model takes unreinforced masonry buildings into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning and policy making purposes. Despite their limitations, the models do provide some approximate estimates of damage and are useful to understand the relative relationships between the counties. Results are found in **Table 2-226**.

Metro (the elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington Counties and the 24 cities in the Portland Metro area) has likewise evaluated earthquake potential and losses for its three-county area. The analysis included an inventory of over 50,000 commercial and multi-family dwellings at risk. Single-family dwellings within the Metro boundary were not evaluated because their structural similarity (Metro, 1998).

Other useful resources for planning for earthquakes include the following:

Maps of earthquake hazard areas: DOGAMI has mapped all of the Region 2 counties and has statewide GIS earthquake hazard layers available (Madin & Burns, 2013).

Map of critical facilities vulnerable to hazards: DOGAMI has developed these maps for all Region 2 counties.

Environmental geology maps: DOGAMI has developed these maps for all Region 2 counties.

Nuclear energy/hazardous waste sites inventories: No Region 2 counties have nuclear facilities.

Table 2-226. Projected Dollar Losses in Region 2, Based on an M8.5 Subduction Event and a 500-Year Model

	M8.5 CSZ Event					500-Year Model[1]			
	Multnomah	Washington	Columbia	Clackamas		Multnomah	Washington	Columbia	Clackamas
Injuries	1,521	555	36	128		8,659	2,910	150	1,402
Deaths	28	10	0	2		186	62	3	29
Displaced households	2,803	2,062	94	426		13,777	7,666	326	2,525
Economic losses for buildings[2]	$1.9 b	$931 m	N/A	$316 m		$9.2 b	$3.8 b	$267 m	$2.1 b
Operational “day after” the quake									
Fire Stations	78%	66%	unknown	84%		N/A[3]	*	*	*
Police Stations	76%	64%	45%	84%		N/A	*	*	*
Schools	81%	64%	63%	84%		*	*	*	*
Bridges	94%	79%	82%	90%		*	*	*	*
Economic losses to									
Highways	$21 m	$15 m	$2 m	$6 m		$437 m	$61 m	$10 m	$74 m
Airports	$2 m	$5 m	$2 m	$3 m		$12 m	$23 m	$8 m	$32 m
Communications	$3 m	$752,000	$97,000	$232,000		$31 m	$4 m	$950,000	$4 m
Debris generated (thousands of tons)	1,598	763	57	237		6,745	2,817	184	1,588

Notes: “b” is billion; “m” is million

[1] Every part of Oregon is subject to earthquakes. The 500-year model is an attempt to quantify the risk across the state. The estimate does not represent a single earthquake. Instead, the 500-year model includes many faults. More and higher magnitude earthquakes than used in this model may occur (DOGAMI, 1999).

[2] “…there are “numerous unreinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat” (Wang, 1998, p. 5).

[3] Because the 500-year model includes several earthquakes, the number of facilities operational the “day after” cannot be calculated.

Source: Wang & Clark (1999)

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

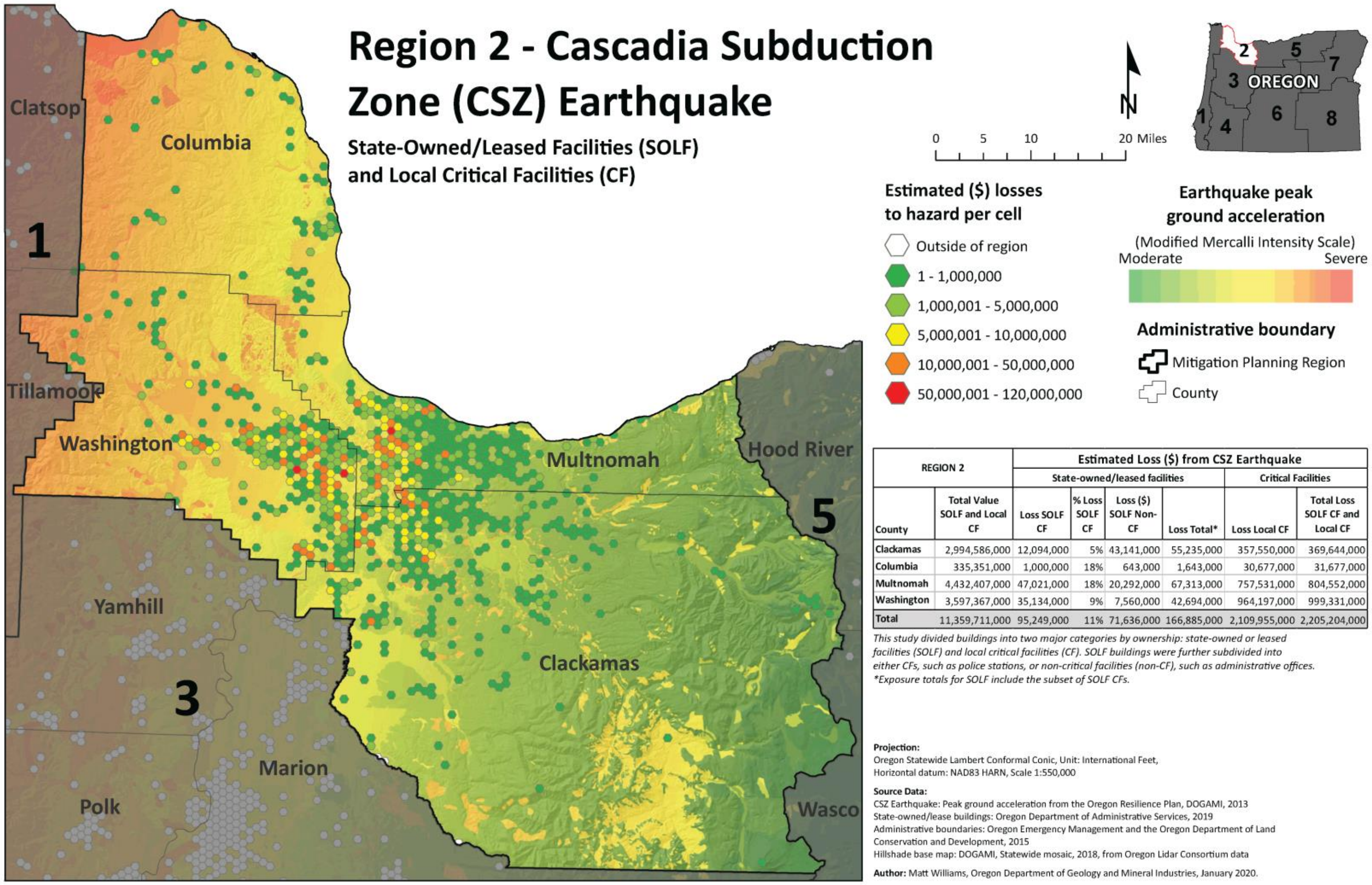
For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a Magnitude 9 Cascadia Subduction Zone (CSZ) event in Region 2. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 2, a CSZ event could cause a potential loss of almost $167M in state building and critical facility assets. Columbia County's potential loss is the least, over $1.6M. The other counties' potential losses range from $42.6M to $67.3M with the greatest potential loss in Multnomah County.

There is a far greater potential loss in local critical facilities: over $2.1B. Washington County stands to lose the most, about 46% of that total, followed by Multnomah County with about 36% and Clackamas County with about 17%. Again Columbia County's potential loss is the least, at 3%. **Figure 2-156** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

Figure 2-156. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Cascadia Subduction Zone Earthquake Hazard Zone in Region 2.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 2		Estimated Loss ($) from CSZ Earthquake					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*	Loss Local CF	Total Loss SOLF CF and Local CF
Clackamas	2,994,586,000	12,094,000	5%	43,141,000	55,235,000	357,550,000	369,644,000
Columbia	335,351,000	1,000,000	18%	643,000	1,643,000	30,677,000	31,677,000
Multnomah	4,432,407,000	47,021,000	18%	20,292,000	67,313,000	757,531,000	804,552,000
Washington	3,597,367,000	35,134,000	9%	7,560,000	42,694,000	964,197,000	999,331,000
Total	11,359,711,000	95,249,000	11%	71,636,000	166,885,000	2,109,955,000	2,205,204,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:550,000

Source Data:
CSZ Earthquake: Peak ground acceleration from the Oregon Resilience Plan, DOGAMI, 2013
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI

Historic Resources

Of the 23,605 historic resources in Region 2, only 335 are in an area of high or very high liquefaction potential. Over half, 53%, are located in Clackamas County. Almost all of the rest, 42%, are located in Washington County. Many more (68%) of Region 2's historic resources are located in areas of high or very high potential for ground shaking amplification. Multnomah County is home to 62% while Clackamas and Washington Counties are home to 20% and 17% respectively.

Archaeological Resources

Nine hundred forty-eight archaeological resources are located in earthquake hazard areas in Region 2. No archaeological resources listed on the National Register of Historic Places and only three eligible for listing are located in areas of high earthquake hazards. Four have been determined not eligible, and 67 have not been evaluated. Two of the three found eligible are in Clackamas County and one is in Columbia County. Overall, most of the archaeological resources in earthquake hazard areas in Region 2 are in Clackamas County followed by Multnomah County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than "well" and for its share of minority residents.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Multnomah County is the most vulnerable in Region 2 with a moderate rating. Washington County has a low rating and Clackamas and Columbia Counties both have a low rating. Washington County's "low" overall vulnerability score is higher than the "very low" scores of Clackamas and Columbia Counties due to greater vulnerability of local critical facilities.

Seismic Lifelines

"Seismic lifelines" are the state highways ODOT has identified as most able to serve response and rescue operations, reaching the most people and best supporting economic recovery. The process, methodology, and criteria used to identify them are described in Section **2.1.6, Seismic Transportation Lifeline Vulnerabilities**, and the full report can be accessed at Appendix **9.1.16**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification* (OSLR). According to that report, seismic lifelines in Region 2 have the following vulnerabilities.

The following geographic zones identified in the OSLR are located within Region 2:

- *Portland Metro Geographic Zone:* In addition to encompassing the largest population concentration in the state, this zone contains extensive facilities (such as transportation, communication, and fuel depots) that are critical to statewide earthquake response and recovery. For these reasons, it has a higher concentration of lifeline routes than the other geographic zones and redundant Tier 1 crossings of the Willamette River.

  The Tier 1 system (highest priority roadway) in the Portland Metro Geographic Zone consists of the following corridors:

    - I-5, excluding the section between the northern and southern I-405 interchanges,
    - I-405,
    - I-205, and
    - OR-99 W from I-5 to OR-217.

  The Tier 2 system (second highest priority roadway) in the Portland Metro Geographic Zone consists of three access corridors:

    - I-84,
    - I-5 between the northern and southern I-405 interchanges, and
    - US-26 from OR-217 to I-405.

  The Tier 3 system in the Portland Metro Geographic Zone consists of the following corridors:

    - OR-217,
    - US-26 from I-5 to I-205, and
    - OR-43.

- *Cascades Geographic Zone:* This region also includes part of the OSLR Cascades Zone. The recommended seismic lifelines for this region include three crossings of the Cascades from western to central Oregon that have areas vulnerable to landslides and may be subject to damage from ground shaking. These routes connect the highly seismically impacted western portion of the state to the less seismically impacted central portion of the state. The Tier 1 system in the Cascades Geographic Zone that serves this region is I-84. The Tier two routes in the Cascades Geographic Zone that serve this region are OR-212 and US-26. There are no corridors designated as Tier 3 in the Cascades Geographic Zone.

REGIONAL IMPACT.

- Ground shaking: In the Northern Willamette Valley / Portland Metro Region, the level of damage from ground shaking levels depends upon its intensity and duration. Unreinforced structures, roadbeds, and bridges will be damaged to varying extents, and it is expected that river crossings and areas with limited surface transportation alternatives will isolate some neighborhoods hindering rescue and recovery activities. There are also several localized faults in the region about which not much is known; it is possible that a major CSZ event could activate local faults.
- Landslides and rockfall: Many roadways in the area are cut into or along landslide prone features. Removal of slide and rockfall material is an ongoing responsibility of

ODOT Maintenance crews in hilly areas and the parts of the Cascades and Coast Regions that fall within Region 2. A major CSZ event may increase landslide and rockfall activities in this region and may reactivate ancient slides that are currently inactive. In the Lower Columbia River basin, ground shaking may change the shipping channel and other features.

- Tsunamis: There may be tsunami impacts in the Lower Columbia area, with variables including the size and force of the tsunami, whether jetties hold up to the tsunami and water levels in the river. Damage to ports, shipping channels, water-dependent uses, and other low lying areas is possible.
- Liquefaction: Structures in wetland, estuarine, alluvial, and other saturated areas may be subject to liquefaction damage; the total area of such impacts will vary with the extent of saturated soils at the time of the event. Bridge approaches, low lying roadways, and transportation fuel supplies are all at risk in this region.

Regional Loss Estimates. Highway-related losses include disconnection from supplies and replacement inventory, and the loss of tourists and other customers who must travel to do business with affected businesses.

Most Vulnerable Jurisdictions. Columbia and Multnomah Counties are the most vulnerable to water related effects, particularly liquefaction. The whole region, including Clackamas and Washington Counties, is likely to have significant impacts related to ground shaking. Landslides are likely in some hilly areas. Vulnerabilities with both regional and statewide transportation impacts in Multnomah County, Portland, and the Portland Metro area include potential loss of stored fuels and distribution infrastructure; interruption of services at Portland International Airport; interruption of intermodal freight capacity due to river channel changes; damage to onshore facilities and surface transportation facilities; and bridge or bridge approach failures across both the Willamette and Columbia Rivers.

Table 2-227. Risk of Earthquake Hazards in Region 2

	Columbia	Clackamas	Multnomah	Washington
Risk	L	M	VH	M

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, only Multnomah County is at very high risk from earthquakes.

Extreme Heat

Characteristics

Climate conditions in the Willamette Valley are described as Mediterranean, with rainy winters and warm dry summers. Historically, extreme heat and heat waves have not been common, but days above 90°F occur nearly every year. Portland has an average of about 10 days per year above 90°F. The frequency of prolonged periods of high temperatures is expected to increase.

Historic Extreme Heat Events

Table 2-228. Historic Extreme Heat Events in Region 2

Date	Location	Notes
July 26–28, 1998	Region 2	A three-day heat wave brought record high temperatures to western Oregon. The high temperature of 99 degrees at Portland International Airport on the 26th eclipsed the previous record for that date of 98 set in 1988, and the high of 101 on the 28th broke the previous daily record of 99 set in 1973. In Eugene, the high of 102 on the 26th broke the previous daily record of 101 set in 1988, and the 105 degrees on the 27th tied the record high for the month of July. There was one reported death from heat-related illness.
June 24–26, 2006	Region 1–3, 5	A broad upper ridge of unusually high height coupled with a thermally induced surface trough of low pressure lingered over the Pacific Northwest for several days. This pattern resulted in persistent offshore flow, and therefore many days of record-smashing high temperatures. Portland International Airport had 101 degrees on June 26 breaking the old record at 94 degrees in 1987.
July 20-24, 2006	Region 1–3, 5, 7	An unusually strong ridge of high pressure brought several days of record breaking hot and humid weather to NW Oregon. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row. On July 21, Portland reported 104°F.
June 28–30, 2008	Region 2, 3, 5, 7	An upper level ridge and thermal trough across the Pacific Northwest produced temperatures above 100 degrees for two consecutive days breaking records in many locations. Two people died of heat-related illness.
Summer 2015	Region 2, 3	A series of heat waves struck western Oregon in the summer of 2015, Oregon's hottest year on record, driven by a strong, persistent upper level ridge over the region. Heat waves occurred June 7–9, June 26–28, July 1–5, July 28–30, and August 18–19. Heat-related illnesses and deaths were markedly greater during these heat wave periods and cooling shelters were opened. High temperatures were 10–20°F above normal and overnight low temperatures were also unseasonably warm. Many locations broke both daytime high temperature records as well as warm overnight low temperature records.
August 11–14, 2016	Region 2	Ridge of high pressure lead to hot temperatures across Northwest Oregon. Temperatures in the upper 80s to mid 90s lead to people seeking relief at local rivers. Two river drownings were reported in the Greater Portland Metro area during this heat event.
August 25-26, 2016	Region 1, 2	Ridge of high pressure and offshore winds brought temperatures along the North Oregon Coast up into the mid 80s to mid 90s on August 25. News reported 8 runners were taken to the hospital with heat-related injuries during the Hood-to-Coast relay through Portland.
May 22-23, 2017	Region 2	Ridge of high pressure brought a couple days of warm weather. Temperatures climbed up into the upper 80s to low 90s in many locations across the area. Early season heat led people to seek relief in local rivers and lakes. While air temperatures were warm, river and lake temperatures were still cold, leading to two drownings across the area.
August 1–4, 2017	Region 2–4, 6	Excessive Heat Event: Strong high pressure brought record breaking heat to many parts of southwest, south central, and northwest Oregon. Region 2–3: The record-breaking heat led people to seek relief at local rivers. Two people drowned while swimming.

Date	Location	Notes
July 12–17, 2018	Region 2, 3, 4	Region 2–3: High pressure over the region led to a stretch of hot day July 12 through July 17th. Hot temperatures led people to cool off in local rivers. There were two drownings recorded on July 16 and July 18. Temperatures on July 16th near the Sandy River in Troutdale got up to 98 degrees

Source: https://www.ncdc.noaa.gov/stormevents

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning "very low." Region 2 relative probability rankings are shown in **Table 2-229**.

The probability of extreme heat events in Multnomah County is moderate; in Washington County low; and in Clackamas and Columbia Counties very low. It is important to note that in counties with "very low" probability, extreme heat is rare, yet frequency is expected to increase due to climate change.

Table 2-229. Probability of Extreme Heat in Region 2

	Clackamas	Columbia	Multnomah	Washington
Probability	VL	VL	M	L

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Extreme temperatures are relatively rare in Region 2, but are projected to increase under future climate change. **Table 2-230** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 2.

Table 2-230. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 2 Counties

County	Historic Baseline	2050s Future
Clackamas	2	15
Columbia	2	16
Multnomah	4	24
Washington	4	21

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

Vulnerability

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, **Extreme Heat**. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than "well" and for its share of minority residents.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are house-less.

Because extreme heat is relatively rare in Region 2 ("low" probability), many people may not be accustomed or prepared when an extreme heat event occurs ("moderate" adaptive capacity). In Cooling Zones 1 and 2, which include Region 2, just over half of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1-2 earned a ranking of 1 (very low); scores of 3-4 earned a ranking of 2 (low); scores of 5-6 earned a ranking of 3 (moderate); scores of 7-8 earned a ranking of 4 (high); and scores of 9-10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-231 displays the vulnerability rankings as well as rankings for sensitivity and adaptive capacity for each county in NHMP Region 2. Table 2-232 provides the summary descriptors of Region 2's vulnerability.

Combining sensitivity and adaptive capacity, Region 2's relative vulnerability to extreme heat is "Low." Only Multnomah County's relative vulnerability is "moderate." None of the Counties in Region 2 is most vulnerable to extreme heat.

Table 2-231. Relative Vulnerability Rankings for Region 2 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 2	**2**	**3**	**2**
Clackamas	1	3	2
Columbia	1	3	2
Multnomah	3	3	3
Washington	1	3	2

Source: Oregon Climate Change Research Institute

Table 2-232. Vulnerability to Extreme Heat in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	L	L	M	L

Source: Oregon Climate Change Research Institute

Region 1 counties did not rank vulnerability to extreme heat.

Similar to drought, prolonged elevated temperatures pose risks to agriculture, involving health and welfare to farmers, farm workers, crops and livestock. Higher temperatures, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. High temperature and insufficient water stunt plant growth and cause areas of crops to wither.

Some livestock, especially dairy cattle, are sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms.

Similar to drought, impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. Since heat waves are more recent to the Willamette Valley, appropriate data have not been collected to assess economic impacts to the state.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 2 is approximately $1,134,896,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $10,224,815,000. Because extreme heat, while relatively uncommon in Region 2, could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one loss of over $111,000 to a state facility was recorded in Region 2 since the beginning of 2015. It was not caused by extreme heat.

Risk

With respect to extreme heat, risk is defined as the combination of the probability of extreme heat events, sensitivity to extreme heat, and level of adaptive capacity in response to extreme heat.

The total relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total risk scores of 1–2 earned a ranking of 1 (“very low”); scores of 3–4 earned a ranking of 2 (“low”); scores of 5–6 earned a ranking of 3 (“moderate”); scores of 7–8 earned a ranking of 4 (“high”); and scores of 9–10 earned a ranking of 5 (“very high”). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-233 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 2. Table 2-234 provides the summary descriptors of Region 2’s risk to extreme heat.

Combining probability and vulnerability, Region 2’s total relative risk to extreme heat is “Low.”

Table 2-233. Risk Rankings for Region 2 Counties

County	Probability	Vulnerability	Risk
Region 2	**2**	**2**	**2**
Clackamas	1	2	2
Columbia	1	2	2
Multnomah	3	3	3
Washington	2	2	2

Source: Oregon Climate Change Research Institute

Table 2-234. Risk of Extreme Heat in Region 2

	Clackamas	Columbia	Multnomah	Washington
Risk	L	L	M	L

Source: Oregon Climate Change Research Institute

Floods

Characteristics

The northern Willamette Valley (including the Portland Metro area) has a lengthy flood history with significant floods occurring about every 7-15 years (**Table 2-235**). The Willamette and Columbia Rivers have produced numerous floods, some of which are shown in **Table 2-235**. Most Willamette River flooding is a winter phenomenon. The common pattern includes the accumulation of heavy wet snow in higher elevations followed by a mild, rainy, weather system. The resulting snowmelt on saturated or frozen ground sometimes produces devastating flood conditions. These conditions would be worse were it not for many dams (used for, among other purposes, flood control) on the upper reaches of the Willamette and some of its tributaries.

Clackamas County is the third most populated county in the state, with nearly all development concentrated in the western half of the county, downstream from significant sources of mountain runoff.

Columbia County, smaller in area and less populated than Clackamas County, receives more annual rainfall and, as a result, has a denser stream network. The City of Vernonia suffered extensive flooding in 2007 resulting in damage to over 300 buildings. Mitigation activities in Vernonia, including relocation of the K–12 school buildings, following the 2007 flood event have significantly reduced damage potential in this small city.

The Columbia River Estuary is the second largest river in the United States and the largest river to flow into the eastern North Pacific. Columbia River floods usually occur in the early summer and are associated with seasonal runoff from melting snow. Although unusually extreme, the Vanport Flood (1948) provides an example of such an event. The 20-day flood was the greatest single disaster in the recorded history of the Columbia River Basin. The toll was 32 dead and 7 missing in the Portland area. Flooding occurred when the Columbia River broke through a dike surrounding the community of Vanport and forced 50,000 people to evacuate their homes. Economic losses reportedly exceeded $100 million. Vanport, a Vancouver-Portland suburban community and the largest public housing project ever built in the United States, was not rebuilt. Prolonged winter rain, debris dams, and breeched dikes have produced flood conditions at several Columbia County locations. Tidal influences are observed on the Columbia River inland to the Bonneville Dam and on the Willamette in Portland.

A common Willamette Valley phenomenon involves tributary stream backup during periods of high water. When tributary streams cannot enter swollen main stem rivers during periods of high water, tributary streams are forced out of their banks. During the February 1996 flood, dams controlled Columbia River flows. This allowed the Willamette River to enter the Columbia, averting flooding in downtown Portland, but other streams produced widespread flooding throughout the region. **Table 2-236** summarizes the sources of flooding for each of the major rivers in the region.

All Region 2 counties have Flood Insurance Rate Maps (FIRMs) depicting the extent of the 1% (“100-year”) flood. The FIRM maps were issued as follows:

- Clackamas County, June 7, 2008 with some panels issued November 26, 2010 and January 18, 2019 to correct errors or omissions;

- Multnomah County, November 19, 2004, June 17, 2008 and December 18, 2009 with some panels issued January 18, 2019 and February 1, 2019 to correct errors or omissions;
- Washington County, October 19, 2004, June 17, 2008, November 26, 2010 and November 4, 2016; and
- Columbia County, November 2010.

Historic Flood Events

Table 2-235. Significant Historic Floods in Region 2

Date	Location	Description	Type of Flood
Dec. 1861	coastal rivers	the "Great Flood;" largest flood of known magnitude on the Willamette River; every town on the river was flooded or washed away; widespread damage	rain on snow and snow melt
Dec. 1862	Willamette River Basin	widespread flooding	rain on snow
Jan. 1881	Willamette Basin	Lane, Linn, Benton, Marion, Polk, Yamhill, Clackamas, Multnomah Counties	
Feb. 1890	Willamette Basin	second largest flood of known magnitude; water levels in Portland: 22.3 ft	rain on snow
June 1894	main stem Columbia	largest flood ever observed on the river; current small in Portland; little damage	snow melt
June 1913	Columbia		
Jan. 1923	Willamette and Columbia Rivers	rain and mild weather; widespread damage to roads and railroads	rain on snow
May 1928	Columbia		
Mar. 1931	Umatilla, Sandy, Clackamas, and Santiam		Mar. 1931
Dec. 1937	Willamette Basin	considerable flooding; landslides	rain on snow
Dec. 1945	Willamette Basin / NW Oregon	very warm temperatures; considerable flood damage	rain on snow
Dec. 1946	Willamette, Clackamas, Luckiamute, and Santiam		Dec. 1946
June 1948	main stem of the Columbia	Vanport near Portland completely destroyed	snow melt
Dec. 1955	Columbia River and Willamette Basin	strong winds/flooding; five fatalities	rain on snow
Dec. 1964	entire state	record-breaking December rainfall; widespread damage; warm temperatures	rain on snow
Jan. 1972	Willamette and Sandy Rivers	widespread damage; many fish buildings, etc. destroyed; five fatalities	rain on snow
Jan. 1974	western Oregon	mild storms followed heavy snow and freezing rain; nine counties declared disasters	rain on snow
Jan. 1978	Willamette River and NW Oregon	intense rain/snowmelt; widespread flooding	rain on snow
Feb. 1986	entire state	numerous homes evacuated; intense rain and melting snow	snow melt
Feb. 1987	western Oregon	Willamette and tributaries; mud slides, flooded highways, damaged homes	rain on snow

Date	Location	Description	Type of Flood
Jan. 1990	western Oregon	10 rivers in eight counties flooded; many bridges washed away	rain on snow
Feb. 1996	NW Oregon	warm temperatures / record breaking rains; widespread flooding (FEMA-1099-DR-OR. 1996)	rain on snow
Dec. 1996	western Oregon	mild subtropical moisture led to extensive flooding. 14 county disaster	rain on snow
Sept. 2000	Clackamas County	Heavy rain, estimated at 3 inches in places, plus glacial melt associated with abnormally warm temperatures, acted together to trigger floods and rock and mud slides on the western slopes of Mount Hood.	
Jan. 2006	Washington County	Tualatin River in Dilley and Farmington reached above flood stages	riverine
Nov. 2006	Clackamas County	heavy rain caused the Sandy River and Clackamas River to flood, causing damage in Estacada and Oregon City. Total county-wide damages of $3 million	riverine
Dec. 2007	Washington County	flooding of the Tualatin River following heavy rainfall from a tropical storm; old OR-47 and OR-47 closed temporarily; total of $2.3 million in damages	riverine
Dec. 2007	Columbia County	flooding of the Nehalem River caused widespread damage in Vernonia, flooding numerous homes and causing a total of $36 million in damages for Columbia County	riverine
Jan. 2009	Washington County	severe winter storm/snow event that included snow, high winds, freezing rain, ice, blizzard conditions, mudslides, and landslides	rain on snow
Jan. 2011	Clackamas County	severe winter storm, flooding, mudslides, landslides, and debris flows, DR-1956	
Jan. 2012	Columbia, Hood River, Tillamook, Polk, Marion, Yamhill, Lincoln, Benton, Linn, Lane, Douglas, Coos, and Curry Counties	heavy rain and wind; ice (DR-4055); flooding in the Willamette Valley; 130 homes and seven businesses were damaged in the City of Turner; 21 streets were closed in the City of Salem; the state Motor Pool lost 150 vehicles and thousands of gallons of fuel; Thomas Creek in the City of Scio overtopped, damaging several buildings	
Sep. 2013	Multnomah County	heavy rain resulted in damage to the Legacy Good Samaritan Medical Center and several businesses in northwest Portland	riverine
August 2014	Clackamas County	Heavy rain resulted in the Sandy River to rapidly rise. A foot bridge near Ramona Falls broke loose sending a man into the turbulent waters. The man drowned in the river.	
Dec. 2014	Tillamook, Lincoln, Lane, Polk Clackamas, Benton Coos and Douglas Counties	A slow moving front produced heavy rain over Northwest Oregon which resulted in the flooding of eight rivers. Another impact from the rain were a couple of land/rock slides that both blocked two highways. Heavy rain brought flooding to several rivers in southwest Oregon.	
Dec. 2015	Tillamook, Lincoln, Washington, Clackamas, Multnomah, Lane, Columbia, Hood River, Polk, Coos, Douglas, Jackson and Curry Counties	A moist pacific front produced heavy rainfall across Northwest Oregon which resulted in river flooding, urban flooding, small stream flooding, landslides, and a few sink holes. After a wet week (December 5 through Dec 11), several rivers were near bank full ahead of another front on December 12th. Flooding from the Nehalem River and Rock Creek in Vernonia resulted in evacuation of homes and the implementation of the Vernonia Emergency Command Center. Heavy rain resulted in a land slide that closed OR47 at mile marker 8. More than $15 million dollars in property damage reported in these counties combined.	
Nov. 2016	Columbia, Tillamook, Lincoln, Benton, Washington, Polk, and Yamhill Counties	A moist Pacific front moving slowly across the area produced heavy rainfall, resulting in flooding of several rivers across Northwest Oregon and at least two landslides.	
Feb. 2017	Marion, Polk, Yamhill, Washington, Columbia, Benton, Tillamook, Lane,	High river flows combined with high tide to flood some areas near the southern Oregon coast. Heavy rain combined with snow melt caused flooding along the Coquille River and the Rogue River twice this month in southwest Oregon. Heavy rain combined with snow melt caused flooding	

Date	Location	Description	Type of Flood
	Coos, Curry, Klamath, Wheeler and Malheur Counties	along the Sprague River in south central Oregon. Flows on the John Day river reached flood levels downstream of Monument due to the breaking up of an ice jam.	
May 2017	Multnomah County and Wallowa County	Heavy rain from a strong thunderstorm in addition to a log jam caused the rapid rise of Oneonta Creek in the Oneonta Gorge. Two hikers were injured in the flash flood. In Wallowa County the Imnaha River at Imnaha had minor flooding early on May 6th, due to snow melt.	
Oct. 2017	Tillamook, Benton, and Clackamas Counties	A very potent atmospheric river brought strong winds to the north Oregon Coast and Coast Range on October 21st. What followed was a tremendous amount of rain for some locations along the north Oregon Coast and in the Coast Range, with Lees Camp receiving upwards of 9 inches of rain. All this heavy rain brought the earliest significant Wilson River Flood on record, as well as flooding on several other rivers around the area.	
Feb. 2019	Columbia, Washington and Multnomah Counties	Back-to-back low pressure systems dropping south along the coast of British Columbia and Washington brought cold air south into NW Oregon as well as plenty of moisture. Flooding along Fox Creek in Rainier, 40 county roads in Washington County, and in Multnomah County Northwest Rocky Point Road between U.S. 30 and Skyline Boulevard was closed because of a large crack in the road caused by heavy rains and snowmelt.	
April 2019	Lane, Benton, Marion, Clackamas and Linn Counties	A particularly strong atmospheric river took aim for the south Willamette Valley, sitting over areas south of Salem for two days, producing anywhere from 2.5 to 5 inches of rain over a 48 hour period. Some areas in the Cascades and Cascade Foothills saw 5 to 7 inches of rain over that 48 hour period. Heavy rain combined with snow melt from all the snow from a few weeks prior in this same area caused flooding along most of our rivers in this area as well as along the main-stem Willamette River up to around Oregon City.	

Sources: Taylor and Hatton (1999); National Climatic Data Center; KPTV_KPDX (2013); NOAA Storm Event Database, (http://www.ncdc.noaa.gov/stormevents/), January 2020; Planning for Natural Hazards: Flood TRG (Technical Resource Guide), July 2000, DLCD, Community Planning Workshop

Table 2-236. Principal Riverine Flood Sources in Region 2

Clackamas	Columbia	Multnomah	Washington
Willamette River and tributaries:	Clatskanie River	Columbia and Willamette Rivers and tributaries:	Willamette River and tributaries:
Abernethy Creek	Columbia River	Sandy River	Tualatin River
Clackamas River	Conyers Creek	Multnomah Channel	Fanno Creek
Clear Creek	McNulty Creek	Johnson Creek	Summer Creek
Dear Creek	Milton Creek	Fairview Creek	Ash Creek
Eagle Creek	Multnomah Channel	Columbia Slough	Rock Creek
Johnson Creek	Nehalem Creek	Ponding within Drainage Dist. #1	Cedar Creek
Kellogg Creek	Rock Creek	Beaver Creek	Butternut Creek
Milk Creek	Scappoose Creek	Fairview Creek	Dawson Creek
Molalla River		Kelley Creek	Beaverton Creek
Mt. Scott Creek		Mitchell Creek	Bronson Creek
Nyberg Slough			Willow Creek
Oswego Channel			Cedar Mill Creek
Phillips Creek			Johnson Creek
Pudding River			Dairy Creek
Salmon River			McKay Creek
Sandy River			Council Creek
Still Creek			Gales Creek
Tualatin River			Wapato Creek
Zig Zag River			Nyberg Slough
Tickle Creek			

Sources: FEMA, Clackamas County Flood Insurance Study (FIS), January 18, 2019; FEMA, Columbia County FIS, November 26, 2010, FEMA; Multnomah County FIS, February 1, 2019, FEMA, Washington County FIS, October 19, 2018

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the "OEM Hazard Analysis Methodology" used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in Appendix **9.1.19**.

The purpose of the probability and vulnerability scores is to identify high-priority areas to which local and state governments can target mitigation actions.

Probability

Local Assessment

Participants in each county's Natural Hazard Mitigation Plan update process used the OEM hazard analysis methodology to analyze the probability that Region 2 will experience flooding. The resulting estimates of probability are shown in **Table 2-237**.

Table 2-237. Local Assessment of Flood Probability in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	H	H	M	H

Source: Columbia County NHMP (2020 draft), Clackamas County NHMP (2019), Multnomah County NHMP (2017) – average of all jurisdictions, Washington County NHMP (2016)

State Assessment

Using the methodology described in the **Floods 2.2.5.2, Probability**, the state assessed the probability of flooding in the counties that comprise Region 2. The results are shown in Table **2-238**.

Table 2-238. State Assessment of Flood Probability in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	VH	VH	VH	H

Source: DOGAMI

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Along the Willamette River and its tributaries (Regions 2, 3, and 4), the largest increases in extreme river flows are more likely to be upstream (toward Cascades headwaters), and less likely as one travels downstream. Along the Lower Columbia Basin, large increases in extreme flows are least likely. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-239. Local Assessment of Vulnerability to Flood in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	H	M	M	M

Source: Columbia County NHMP (2020 draft), Clackamas County NHMP (2019), Multnomah County NHMP (2017) – average of all jurisdictions, Washington County NHMP (2016)

Table 2-240. State Assessment of Vulnerability to Flood in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	VL	VL	VH	VL

Source: DOGAMI, DLCD

DOGAMI prepared a Risk Report for the Lower Columbia-Sandy River Watershed Area of Clackamas County. This report referenced in the Clackamas County NHMP determined that within the unincorporated portion of the county within the study area for that report, 74 buildings are expected to be damaged by the 100-year flood event. Channel migration may expose double that number of buildings to flood damage. Within the City of Government Camp, 12 buildings are expected to be damaged by the 100-year flood event with no impact from channel migration. Within the Villages at Mt. Hood 161 buildings are expected to be damaged with 1,307 buildings exposed to damage from channel migration. No critical facilities are among these buildings. Clackamas County performed a GIS analysis for its NHMP and determined that of the 235 critical facilities in the county only two are at risk of damage from the 100-year flood.

In Multnomah County, the most recent NHMP reports analysis by DOGAMI regarding damage from channel migration along the Sandy River. In the Sandy River Channel Migration Zone, the study identifies 186 structures at risk of damage along with 8.4 miles of transportation infrastructure, 6.9 miles of electric transmission lines, 6 bridges and 8 electric transmission towers. These figures are not reflected in Special Flood Hazard Area impacts because channel migration zones are not mapped as such; however, flooding still remains a risk in channel migration zones.

In Washington County There are four county bridges and 19 state-owned bridges that have been identified as seismically vulnerable. Impacts to the transportation system can result in the isolation of vulnerable populations, limit access to critical facilities such as hospitals and adversely impact local commerce, employment and economic activity. There are three "high threat potential" dams located in the county: Kay Lake, Trask River Reservoir, and Scoggins (Hagg Lake).

Repetitive Losses

Table 2-241. Severe/Repetitive Flood Losses and Community Rating System Communities by County in Region 2

County	RL/SRL	# of CRS Communities per County
Clackamas	39	2
Columbia	5	1
Multnomah	2	2
Washington	30	0
Totals:	**76**	**5**

Source: FEMA NFIP Community Information System, https://portal.fema.gov/famsVuWeb/home, accessed February 2020

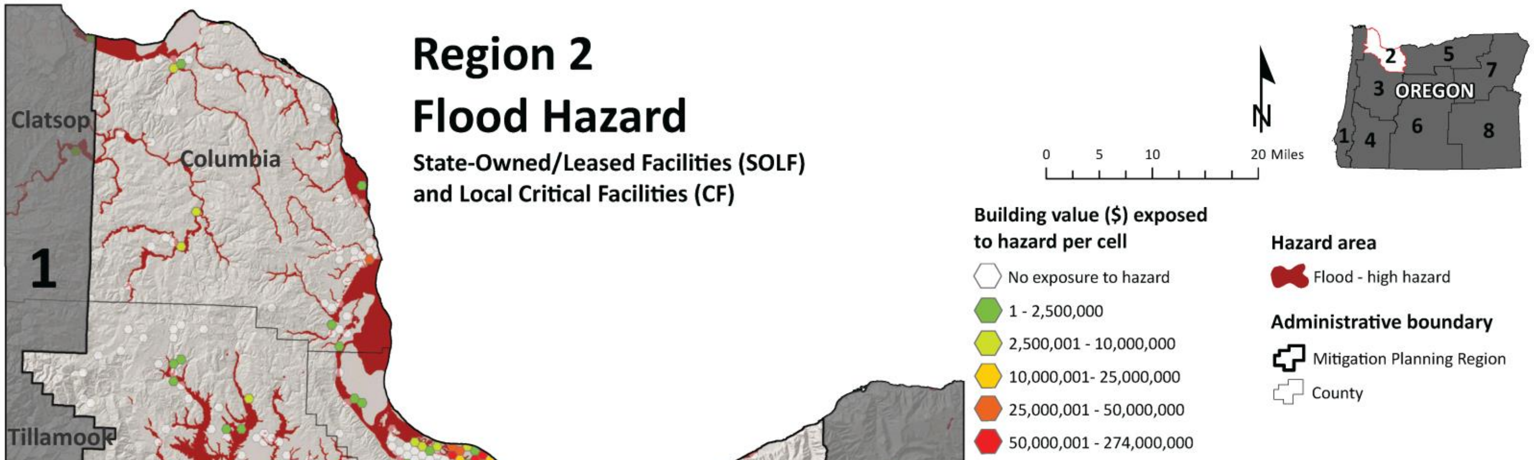
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. Clackamas County participates in CRS, as do the cities of Oregon City, Portland, Scappoose, and Troutdale.

State-Owned/Leased Facilities and Critical/Essential Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 2, there is a potential loss from flooding of over $142M in state building and critical facility assets, 95% of it in Multnomah County alone. There is a far greater potential loss due to flood in local critical facilities: close to $484M, almost three-and-a-half times as much. Again the vast majority, 86%, is located in Multnomah County. **Figure 2-157** illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding.

Figure 2-157. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 2.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 2		Exposure ($) to Flood Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Clackamas	2,994,586,000	0	0%	4,581,000	4,581,000	16,540,000	16,540,000
Columbia	335,351,000	0	0%	1,268,000	1,268,000	22,759,000	22,759,000
Multnomah	4,432,407,000	134,321,000	53%	791,000	135,112,000	414,292,000	548,613,000
Washington	3,597,367,000	1,051,000	0%	531,000	1,582,000	30,148,000	31,199,000
Total	11,359,711,000	135,372,000	16%	7,171,000	142,543,000	483,739,000	619,111,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:550,000

Source Data:
Flood: various studies from Federal Emergency Management Agency, National Flood Insurance Program
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

Of the 23,605 historic resources in Region 2, eight hundred sixty-nine (4%) are located in an area of high flood hazard. Of those, 393 (45%) and 358 (41%) are located in Multnomah and Clackamas Counties, respectively.

Archaeological Resources

Of the 307 archaeological resources located in high flood hazard areas in Region 2, 50% are located in Multnomah County. Only three are listed on the National Register of Historic Places and 15 are eligible for listing. Twenty-eight have been determined not eligible and 261 have not been evaluated as to their eligibility. The listed resources are located in Clackamas and Multnomah Counties. The eligible resources are spread throughout Region 2.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than "well" and for its share of minority residents.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, all the counties score very low for vulnerability except Multnomah County which scores very high. Multnomah County's very high score is indicative of the high value of state buildings, state critical facilities, and local critical facilities located in the County as well as its moderate social vulnerability.

Most Vulnerable Jurisdictions

Multnomah County is the county most vulnerable to flood in Region 2.

Risk

Table 2-242. Risk of Flood Hazards in Region 2

	Columbia	Clackamas	Multnomah	Washington
Risk	M	M	VH	VL

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, only Multnomah County is at a very high risk from flood.

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owner's property to community destruction with mass fatalities. The 1889

Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost. Oregon's first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Historic Significant Dam Failures in Region 2

Region 2 has not experienced any historic significant dam failures.

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 20 High Hazard dams and 34 Significant Hazard dams in Region 2.

Table 2-243. Summary: High Hazard and Significant Hazard Dams in Region 2

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 2	10	34	10
Clackamas	2	13	7
Columbia	0	2	0
Multnomah	6	4	2
Washington	2	15	1

Source: Oregon Water Resources Department, 2019

Table 2-244. High Hazard and Significant Hazard Dams in Region 2

County	Name	Rating	Regulator
Clackamas	Bull Run Dam 2 (Lower)	High	Federal
Clackamas	Faraday Diversion Dam	High	Federal
Clackamas	Faraday Forebay	High	Federal
Clackamas	North Fork Dam (Clackamas)	High	Federal
Clackamas	River Mill Dam	High	Federal
Clackamas	Timothy Lake	High	Federal
Clackamas	Willamette Falls	High	Federal
Clackamas	Buche (Clackamas)	High	State
Clackamas	Mompano	High	State
Clackamas	Beyer Reservoir	Significant	State
Clackamas	Cedar Grove Lake	Significant	State
Clackamas	Day Reservoir	Significant	State
Clackamas	Deardorff, Betty Jane	Significant	State
Clackamas	Drescher Reservoir	Significant	State
Clackamas	Haberlach Dam	Significant	State
Clackamas	Oswego Lake Dam	Significant	State
Clackamas	Rogers - Joseph Reservoir	Significant	State
Clackamas	Rose Reservoir	Significant	State
Clackamas	Sandy Farms No. 1-A	Significant	State
Clackamas	Teasel Creek	Significant	State
Clackamas	Veterans Reservoir	Significant	State
Clackamas	Zielinski Farm Reservoir	Significant	State
Columbia	Rainier City Reservoir	Significant	State
Columbia	Salmonberry Reservoir	Significant	State
Multnomah	Bonneville Dam	High	Federal
Multnomah	Bull Run Dam 1 (Upper)	High	Federal
Multnomah	Portland #1 (Mt. Tabor)	High	State
Multnomah	Portland #3 (Washington Park)	High	State
Multnomah	Portland #4 (Washington Park)	High	State
Multnomah	Portland #5 (Mt. Tabor)	High	State
Multnomah	Portland #6 (Mt. Tabor)	High	State
Multnomah	Van Raden	High	State
Multnomah	Binford Dam	Significant	State
Multnomah	Mt. Hood Community College Dam	Significant	State
Multnomah	Peyralans Reservoir	Significant	State
Multnomah	Sester, William H. Reservoir 1	Significant	State
Washington	Scoggins	High	Federal
Washington	Barney	High	State
Washington	Kay Lake	High	State
Washington	Burkhalter #2	Significant	State
Washington	Cook Reservoir (Wash)	Significant	State
Washington	Dierickx	Significant	State

County	Name	Rating	Regulator
Washington	Dober Reservoir	Significant	State
Washington	Ettinger Pond	Significant	State
Washington	Hoefer-Pierson Reservoir	Significant	State
Washington	Jesse Enlargement	Significant	State
Washington	Lind Reservoir	Significant	State
Washington	Maple Headquarters Reservoir	Significant	State
Washington	Paul Chobin Dam	Significant	State
Washington	Pierson-Upper	Significant	State
Washington	Tualatin Park	Significant	State
Washington	Unger-Bill Dam	Significant	State
Washington	Walters, Glenn #1 - Large	Significant	State
Washington	Walters, Glenn #5	Significant	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and regulated. A dam’s condition is considered public information for state-regulated dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA’s condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA’s condition classifications are:

- “Satisfactory” means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- “Fair” means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- “Poor” means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- “Unsatisfactory” means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- “Not Rated” means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Eight of the ten state-regulated high hazard dams are in satisfactory condition. None are in poor or unsatisfactory condition.

Table 2-245. Summary: Condition of High Hazard State-Regulated Dams in Region 2

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	Fair	Poor	Unsatisfactory	Not Rated
Region 2	8	2	0	0	0
Clackamas	1	1	0	0	0
Columbia	0	0	0	0	0
Multnomah	5	1	0	0	0
Washington	2	0	0	0	0

Source: Oregon Water Resources Department, 2019

Table 2-246. Condition of High Hazard State-Regulated Dams in Region 2

County	Dam Name	Condition
Clackamas	Buche (Clackamas)	Fair
Clackamas	Mompano	Satisfactory
Multnomah	Van Raden	Fair
Multnomah	Portland #1 (Mt. Tabor)	Satisfactory
Multnomah	Portland #3 (Washington Park)	Satisfactory
Multnomah	Portland #4 (Washington Park)	Satisfactory
Multnomah	Portland #5 (Mt. Tabor)	Satisfactory
Multnomah	Portland #6 (Mt. Tabor)	Satisfactory
Washington	Barney	Satisfactory
Washington	Kay Lake	Satisfactory

Source: Oregon Water Resources Department, 2019

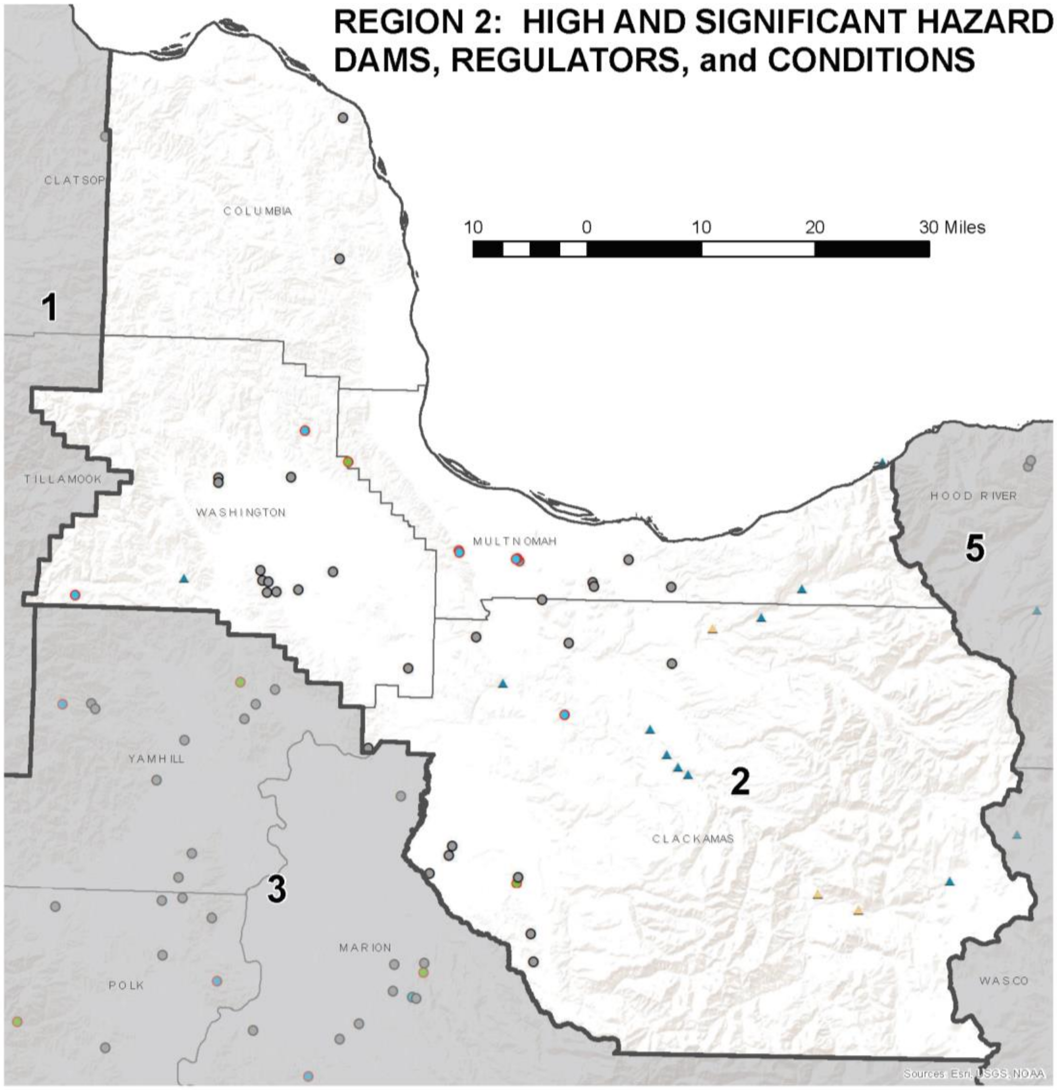
State-Regulated High Hazard Dams not Meeting Safety Standards

There are no state-regulated high hazard dams in Region 2 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). When Oregon's new dam safety laws take effect July 1, 2020, the condition of some dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Figure 2-158 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 2. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-158. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 2



	Coastal	Earthquake	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 2	0	29	*	16	0	0	0
Clackamas	0	15	*	6	0	0	0
Columbia	0	0	*	2	0	0	0
Multnomah	0	3	*	4	0	0	0
Washington	0	11	*	4	0	0	0

* - flood risk affected by function and condition of dam, not by presence in mapped flood prone location

State regulated dams**

Condition assessment

- Poor
- Unsatisfactory
- Fair
- Satisfactory
- No assessment

** - Significant hazard dam symbols have a black outline. High hazard dam symbols have a red outline.

Federal regulated dams

Hazard

- High
- Significant

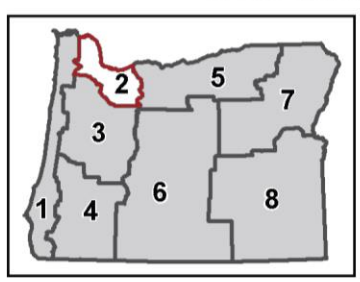
Mitigation Planning Regions

Counties

Projection:
Oregon Lambert Coordinate Reference System, Unit: International Feet, Horizontal datum: NAD83, EPSG #2992

Source Data:
State regulated dams: Oregon Water Resources Dept., July 2020
Mitigation Planning Regions: Oregon Emergency Management
Counties: U.S. Bureau of Land Management (BLM)
Base map: Esri, World Terrain Base

Author: Robert Harmon, GISP, Oregon Water Resources Dept. (July 2020)



Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

State-regulated high hazard dams in Region 2 are currently meeting safety standards.

Dams in in the western and northern portions of Region 2 can have high risks from earthquakes. Some dams in this region may have a moderately increased risk from landslide and wildfire, with some risk of large woody debris from wildfire. State-regulated dams in this region are not close to volcanic hazards; some federally regulated dams are closer.

No dams in Region 2 meet FEMA HHPD eligibility criteria.

Most Vulnerable Jurisdictions

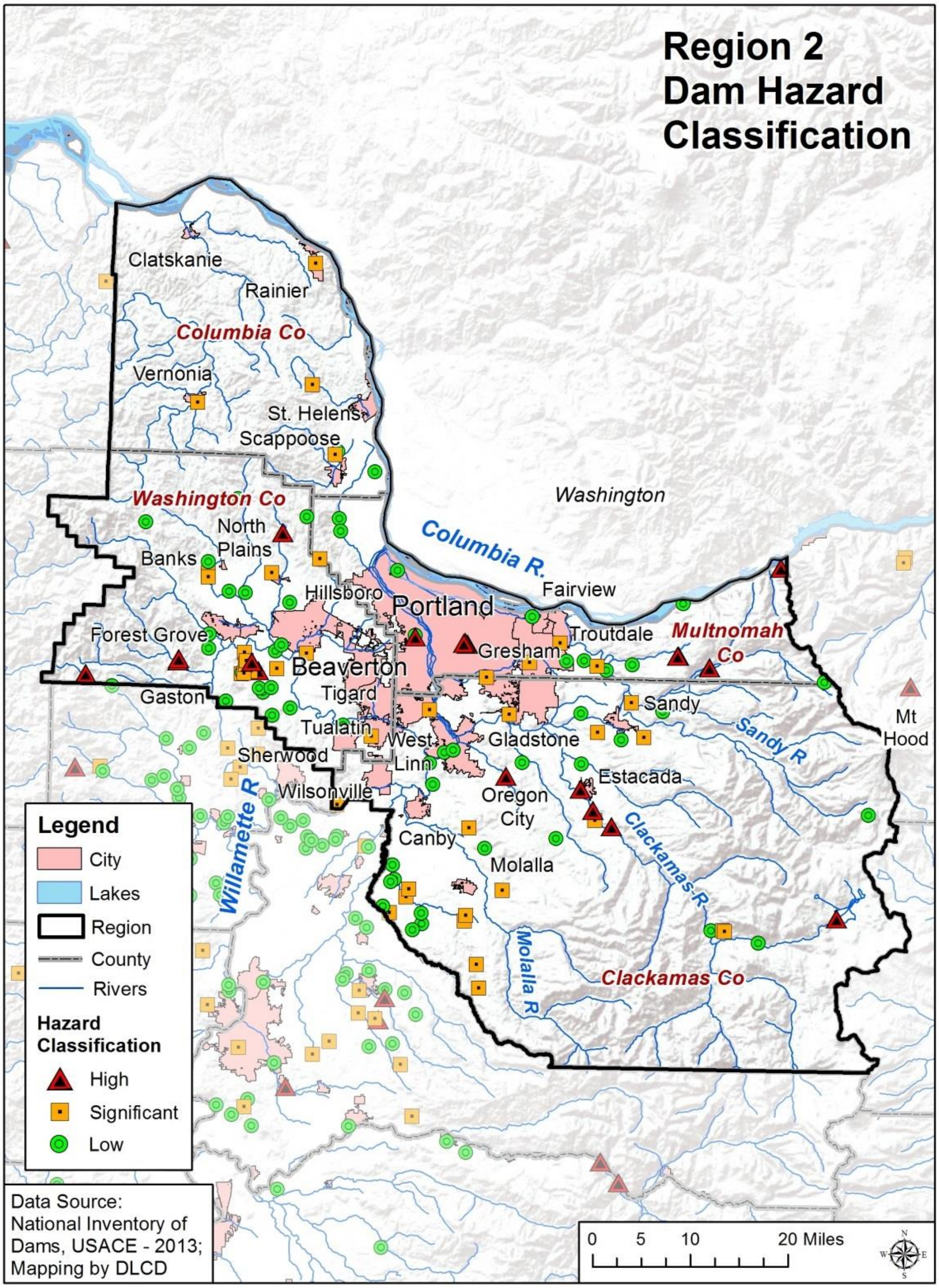
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), no Region 2 counties are considered “most vulnerable jurisdictions” because none have high hazard dams in poor or unsatisfactory condition.

As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable jurisdictions” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The counties with the most state-regulated significant hazard dams are Washington (15) and Clackamas (13).

Risk

The potential for damage to a dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-159. Region 2 Dam Hazard Classification



Source: USACE National Inventory of Dams, 2013

Note: Federally regulated significant hazard dams are not shown.

Landslides

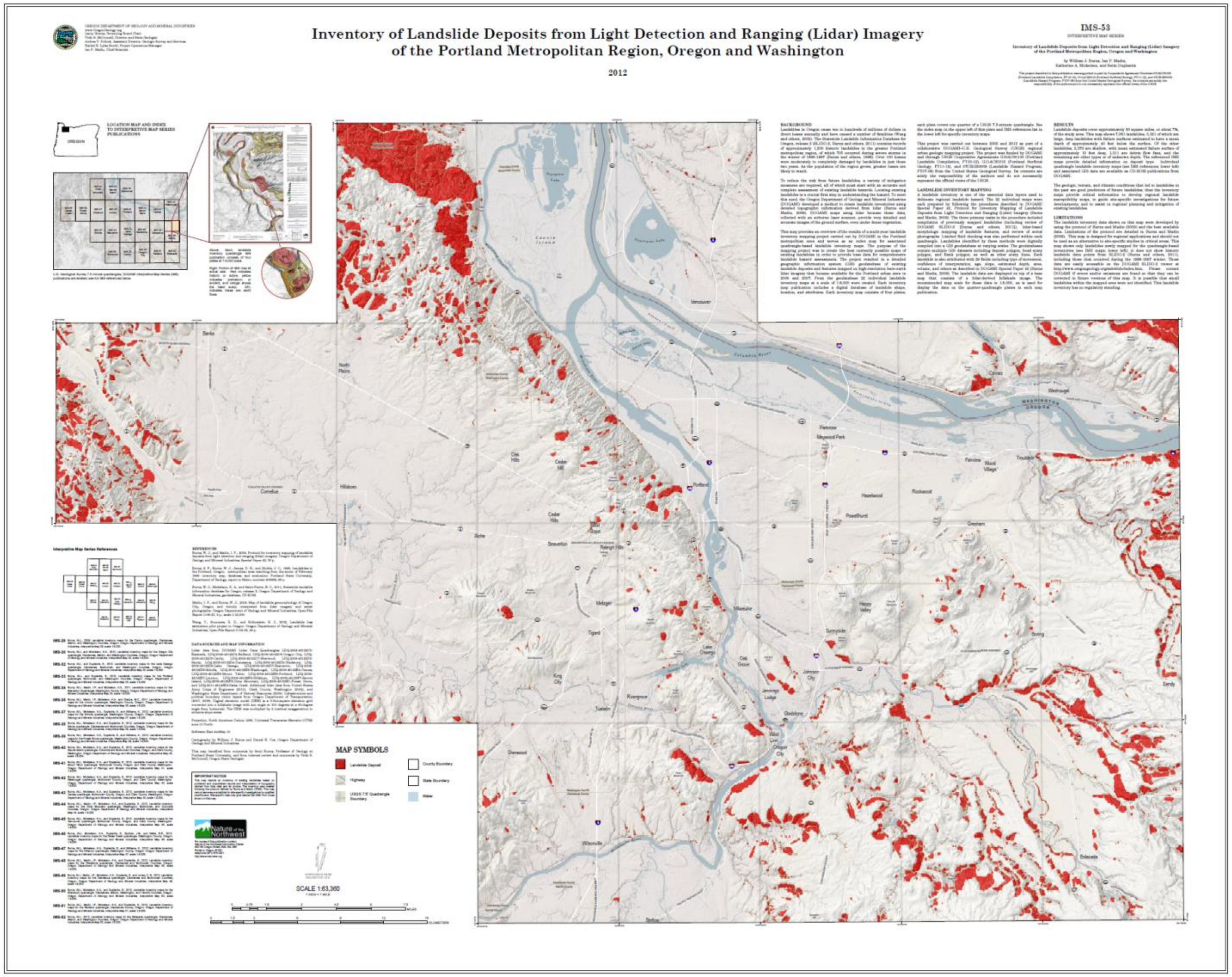
Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the Coast Range and Cascade Mountains have a very high incidence of landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage to the state.

In Multnomah County (including the city of Portland) landslide activity has been a recurring problem for many years. In February 1996, landslide activity that occurred in Portland and the Dodson-Warrendale area (east Multnomah County) was notable and severely impacted homeowners and transportation routes. In fact, I-84 in the Columbia River Gorge was closed for a number of days by fast moving debris flows that covered the roadway and the east-west railroad tracks.

Lidar-based landslide inventory mapping was completed for most of the Portland Metro area (Burns, Madin, Mickelson, & Duplantis, 2012b). Landslide deposits cover approximately 83 square miles, or about 7%, of the study area. This map shows 7,081 landslides, 3,321 of which are large, deep landslides with failure surfaces estimated to have a mean depth of approximately 40 feet below the surface. Of the other landslides, 2,376 are shallow, with mean estimated failure surface of approximately 10 feet deep; 1,311 are debris flow fans; and the remaining are other types or of unknown depth. The geologic, terrain, and climatic conditions that led to landslides in the past are good predictors of future landslides; thus the inventory maps provide critical information to develop regional landslide susceptibility maps, to guide site-specific investigations for future developments, and to assist in regional planning and mitigation of existing landslides

Figure 2-160. Inventory of Landslide Deposits from Lidar Imagery of the Portland Metro region, Oregon and Washington



Source: Burns, et al. (2012b)

Historic Landslides

In 1996-1997, 700 landslides occurred in the Portland Metro area. Over 100 homes were moderately to completely damaged by landslides in just those two years (Burns, Burns, James, & Hinkle, 1998). As the population of the region grows, greater losses are likely to result.

Table 2-247. Historic Landslides in Region 2

Date	Location	Description
Mar. 1972	near Portland, Oregon	mud and rock slide on I-5; injured: three motorists
Oct. 1984	I-84 near Cascade Locks, Oregon	rockslide; fatalities: two children; cost of stabilizing the slide area: $4 million
Sep. 1990	near Troutdale, Oregon	landslide; injuries: four highway workers
Feb. 1996	Dodson-Warrendale, Portland Metro area, Oregon	FEMA-1099-DR-Oregon; heavy rains and rapidly melting snow contributed to thousands of landslides and debris flows across the state; many occurred on clear cuts that damaged logging roads; I-84 closed at Dodson-Warrendale (700 in the Portland Metro area)
Dec. 2007	Clatsop, Columbia, Tillamook, Washington, and Yamhill Counties, Oregon	landslide due to heavy rains from a strong winter storm; damages: $1.5 million total (Clatsop, Columbia, Tillamook, Washington, and Yamhill Counties); $300,000 (to Columbia County alone)
Dec. 2008	Clackamas, Columbia, Multnomah, Washington	DR-1824; HWY6 closed from landslide.
Jan. 2011	Clackamas	DR-1956; Landslide along bull run watershed water conduit damaged pipe. NW Thompson road closed. Several landslides close areas in the gorge. HWY 26 closed.
Jan. 2012	Columbia	DR-4055; Several landslides in the west hills of Portland.
Dec. 2015	Clackamas, Columbia, Multnomah, Washington	DR-4258; At least 10 roads closed because of landslides in the Portland metro area.
Jan. 2017	Columbia	DR-4328; Several roads closed.

Sources: ODOT Emergency Operations Plan, May, 2002; Interagency Hazard Mitigation Team Report, FEMA-1099-DR-OR, June, 1997; Interagency Hazard Mitigation Team Report, FEMA-1149-DR-OR, March, 1997; Taylor and Hatton, (1999); Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina; https://www.fema.gov/disasters

Probability

Table 2-248. Assessment of Landslide Probability in Region 2

	Clackamas	Columbia	Multnomah	Washington
Probability	H	VH	H	H

Source: DOGAMI, 2020

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in Oregon in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-249. Local Assessment of Vulnerability to Landslides in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	L	—	M	L

Source: Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-250. State Assessment of Vulnerability to Landslides in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	H	H	H	H

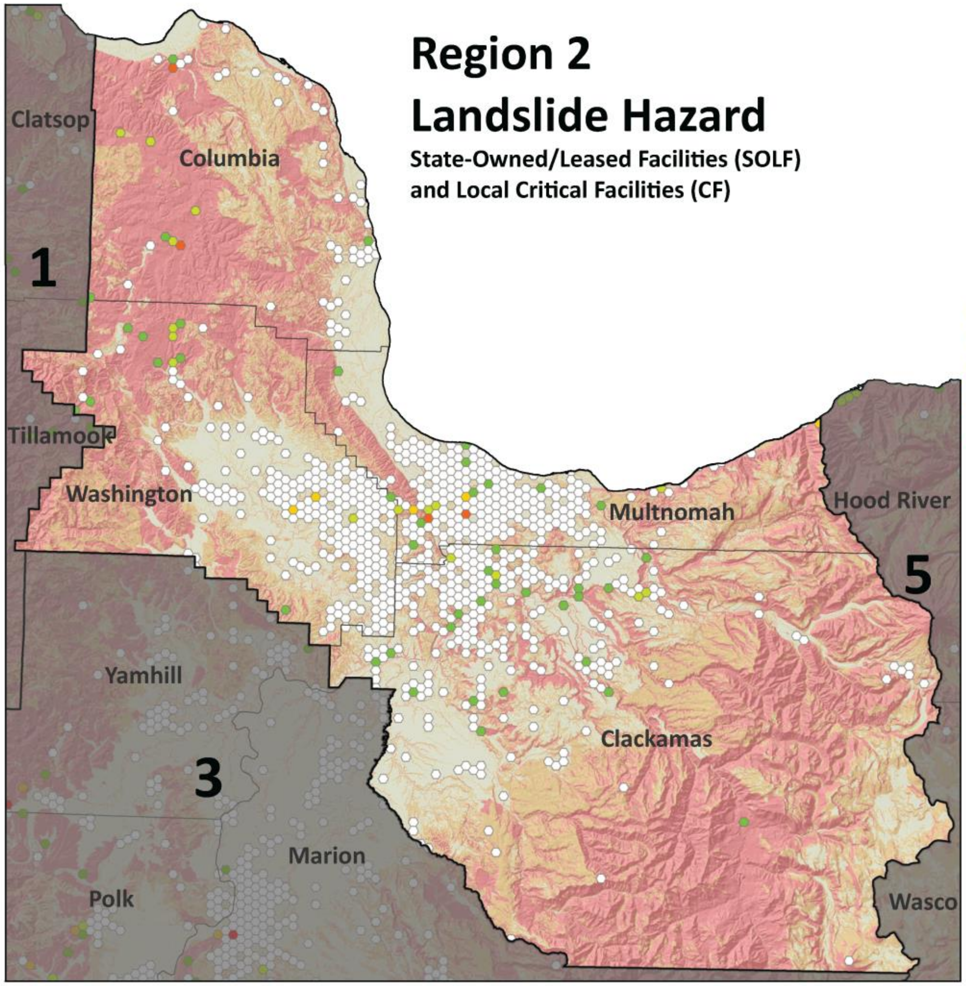
Source: DOGAMI and DLCD, 2020

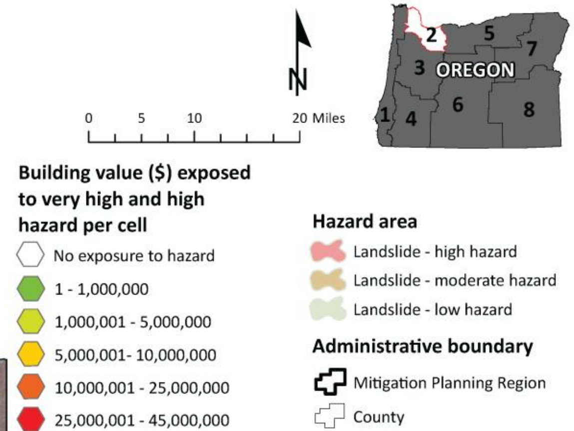
Many communities in this region are vulnerable to landslides; for example, the Portland Hills and the Oregon City area both have high exposure to landslides. In general, Washington, Multnomah, and Clackamas Counties have relatively high vulnerability.

State-Owned/Leased Facilities and Critical/Essential Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 2. Over $25M in value of state facilities is exposed to landslide hazards in Region 2, 32% of it in in Multnomah County with the other counties containing between 21% and 24%. However, the potential loss to local critical facilities is much greater at over $145M. Columbia and Multnomah Counties stand to suffer the greatest losses, $55.7M (38%) and $49.7M (34%) respectively. **Figure 2-161** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

Figure 2-161. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 2.High-resolution, full-size image linked from Appendix 9.1.26.





REGION 2		Exposure ($) to Landslide Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Clackamas	2,994,586,000	0	0%	5,235,000	5,235,000	17,900,000	17,900,000
Columbia	335,351,000	0	0%	6,147,000	6,147,000	55,736,000	55,736,000
Multnomah	4,432,407,000	774,000	1%	7,258,000	8,032,000	49,681,000	50,455,000
Washington	3,597,367,000	0	1%	5,687,000	5,687,000	22,133,000	22,133,000
Total	11,359,711,000	774,000	1%	24,327,000	25,101,000	145,450,000	146,224,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:550,000

Source Data:
Landslide: Landslide susceptibility overview map of Oregon, DOGAMI, 2016
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

Of the 23,605 historic resources in Region 2, all but seven are exposed to landslide hazards: 1,496 are in an area of very high or high landslide hazard susceptibility; 6,633 in moderate; and 15,469 in low. Of those in areas of very high or high landslide hazards, over half are located in Multnomah County and a third are located in Clackamas County. The greatest number of historic resources exposed to landslide hazards is in Multnomah County.

Archaeological Resources

Of the 570 archaeological resources located in landslide hazard areas in Region 2, four hundred twenty-three (74%) are in high landslide hazard areas. Of those, three are listed on the National Register of Historic Places and 43 are eligible for listing. Fifty-one have been determined not eligible, and 326 have not been evaluated as to their eligibility. Over half the resources in high landslide hazard areas are located in Clackamas County and 94% of the resources in landslide hazard areas in Region 2 overall are also located in Clackamas County. The resources that are listed and eligible for listing are located in Clackamas, Columbia, and Multnomah Counties; none are located in Washington County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau’s American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than “well” and for its share of minority residents.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Clackamas and Washington Counties have very low vulnerability to landslides and Columbia and Multnomah Counties have low vulnerability.

However, DOGAMI’s expert assessment is that each of the four counties is a “most vulnerable community” with a high vulnerability rating. Multnomah County should be prioritized for mitigation actions statewide as it contains the City of Portland, which is the largest city in the state.

A 2018 DOGAMI publication **IMS-57, Landslide hazard and risk study of central and western Multnomah County, Oregon,** (Burns, Calhoun, Franczyk, Lindsey, & Ma, 2018), and **Open-File Report O-17-03, Landslide Inventory of Eastern Multnomah County** (Burns & Lindsey, 2017) provide details about the landslide hazard and risk in Multnomah County. **Open-File Report O-13-08, Landslide hazard and risk study of northwestern Clackamas County, Oregon** (Burns, et al., 2013b) provides details about landslide hazard and risk in Clackamas County. A 2018 DOGAMI publication, **Open-File Report O-18-02, Earthquake regional impact analysis for**

Clackamas, Multnomah, and Washington counties, Oregon, (Bauer, Burns, & Madin, 2018), provides information about potential impacts to Clackamas, Multnomah, and Washington counties from earthquakes, including a magnitude 9 Cascadia Subduction Zone earthquake. By using updated data, current subduction zone science and the latest mapping and modelling techniques, the study greatly improves understanding of potential earthquake impacts for the region. The study's estimates of injuries and fatalities, building damages, and other impacts helps communities, the region, and the state better prepare for, respond to, and recover from major earthquakes (https://www.oregongeology.org/pubs/ofr/p-O-18-02.htm). Major earthquakes will trigger landslides.

Risk

Table 2-251. Assessment of Risk to Landslides in Region 2

	Clackamas	Columbia	Multnomah	Washington
Risk	H	H	H	H

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 risk scores and DOGAMI expertise combining the probability of landslides in Region 2 with its vulnerability, risk of landslides in Region 2 is high, and very high in Columbia County. All communities should be prioritized for mitigation actions.

Volcanoes

Characteristics

The eastern boundaries of Clackamas and Multnomah Counties coincide with the crest of the Cascade Mountains. Volcanic activity in the Cascades will continue, but questions regarding how, to what extent, and when remain. Most volcano-associated hazards are local (e.g., explosions, debris, lava, and pyroclastic flows). However, lahars can travel considerable distances through stream valleys, and ashfall can blanket areas many miles from the source.

Historic Volcanic Events

Table 2-252. Historic Volcanic Events in Region 2

Date	Location	Description
about 20,000 to 13,000 YBP	Polallie eruptive episode, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
about 1,500 YBP	Timberline eruptive period, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
1760–1810	Crater Rock/Old Maid Flat on Mount Hood	pyroclastic flows in upper White River; lahars in Old Maid Flat; dome building at Crater Rock
1859/1865	Crater Rock on Mount Hood	steam explosions/tephra falls
1907 (?)	Crater Rock on Mount Hood	steam explosions
1980	Mount St. Helens (Washington)	debris avalanche, ashfall, flooding on Columbia River

Note: YBP is years before present.

Sources: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/; Wolfe and Pierson (1995); Scott, et al. (1997a)

Probability

Table 2-253. Assessment of Vulnerability to Volcanic Hazards in Region 2

	Clackamas	Columbia	Multnomah	Washington
Probability	M	L	M	L

Source: DOGAMI and DLCD, 2020

Region 2 communities are closest to Mount Hood (Clackamas County), a stratovolcano. Stratovolcanoes have wide ranging modes of eruption, making future volcanic activity difficult to predict definitively. Mount Hood’s eruptive history can be traced to late Pleistocene times (15,000–30,000 years ago) and will no doubt continue. However, the central question remains: When?

The most recent series of events (1760–1907) consisted of small lahars, debris avalanches, steam explosions, and minor ashfalls. Mount Hood’s recent history also includes ashfalls, dome building, lahars, pyroclastic flows, and steam explosions. These occurred approximately 200 years ago. Geoscientists have provided estimates of future activity in the vicinity of Crater Rock, a well-known feature on Mount Hood. They estimate a 1 in 300 chance that some dome activity will take place in a 30-year period (1996–2026). For comparison, the 30-year probability of a house being damaged by fire in the United States is about 1 in 90 (Scott, et al., 1997a).

The probability of 1 cm or more of ashfall from eruptions throughout the Cascade Range include (Sherrod, Mastin, Scott, & Schilling, 1997):

- Clackamas County: between 1 in 500 and 1 in 1000;
- Multnomah County: between 1 in 500 and 1 in 1,000;
- Washington County: between 1 in 1,000 and 1 in 5,000; and
- Columbia County: between 1 in 5,000 to 1 in 10,000.

Mount St. Helens is less than 50 air miles from some Columbia County communities and is still active. Prevailing wind direction is of paramount importance. Because the prevailing winds are westerly in Columbia County, the risk of ashfall is considerably reduced.

Table 2-254 summarizes the probability of volcano-related hazards for each county. Debris from the 1980 eruption of Mount St. Helens impacted the shipping channel on the Columbia River by reducing water depth to such an extent that dredging was required.

Table 2-254. Probability of Volcano-Related Hazards in Region 2

Volcano Related Hazards	Washington	Multnomah	Clackamas	Columbia	Remarks
Volcanic ash (annual probability of 1cm or more accumulation from eruptions throughout the Cascade Range)	1 in 5,000 to 1 in 10,000	1 in 1,000 to 1 in 5,000	1 in 1,000 to 1 in 5,000	1 in 5,000 to 1 in 10,000	Sherrod, et al. (1997)
Lahar	no risk	Source: Mount Hood	Source: Mount Hood	no risk	Scott, et al. (1997a)
Lava flow	no risk	no risk	Source: Mount Hood	no risk	Scott, et al. (1997a)
Debris flow / avalanche	no risk	Source: Mount Hood	Source: Mount Hood	Mount St. Helens	Scott, et al. (1997a)
Pyroclastic flow	no risk	no risk	Source: Mount Hood	no risk	Scott, et al. (1997a)

Sources: Sherrod, et al. (1997) and Scott, et al. (1997a)

Vulnerability

Table 2-255. Local Assessment of Vulnerability to Volcanic Hazards in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	M	M	M	H

Source: Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-256. State Assessment of Volcanic Hazards Vulnerability in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	L	VL	L	VL

Source: DOGAMI and DLCD, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 2 (Figure 2-XX). Over $26M in value is exposed to volcanic hazards in Region 2, all of it in Clackamas County.

Historic Resources

Of the 23,605 historic buildings in Region 2, 197 are exposed to volcanic hazards. In Clackamas County, 111 are in a high hazard area, 50 in a moderate hazard area, and 16 in a low hazard area. In Multnomah County, 20 are in a low hazard area. See Appendix 9.1.12 for details.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than "well" and for its share of minority residents.

According to the 2020 vulnerability scores, none of the communities identified by DOGAMI as being most vulnerable to volcano hazards are located in Region 2. All communities in Region 2 have either very low (VL) or low (L) vulnerability ratings. While Clackamas County's slightly higher vulnerability score is driven by exposure of state buildings and critical facilities, Multnomah's County's score is driven by social vulnerability.

Risk

Table 2-257. Assessment of Risk to Volcanic Hazards in Region 2

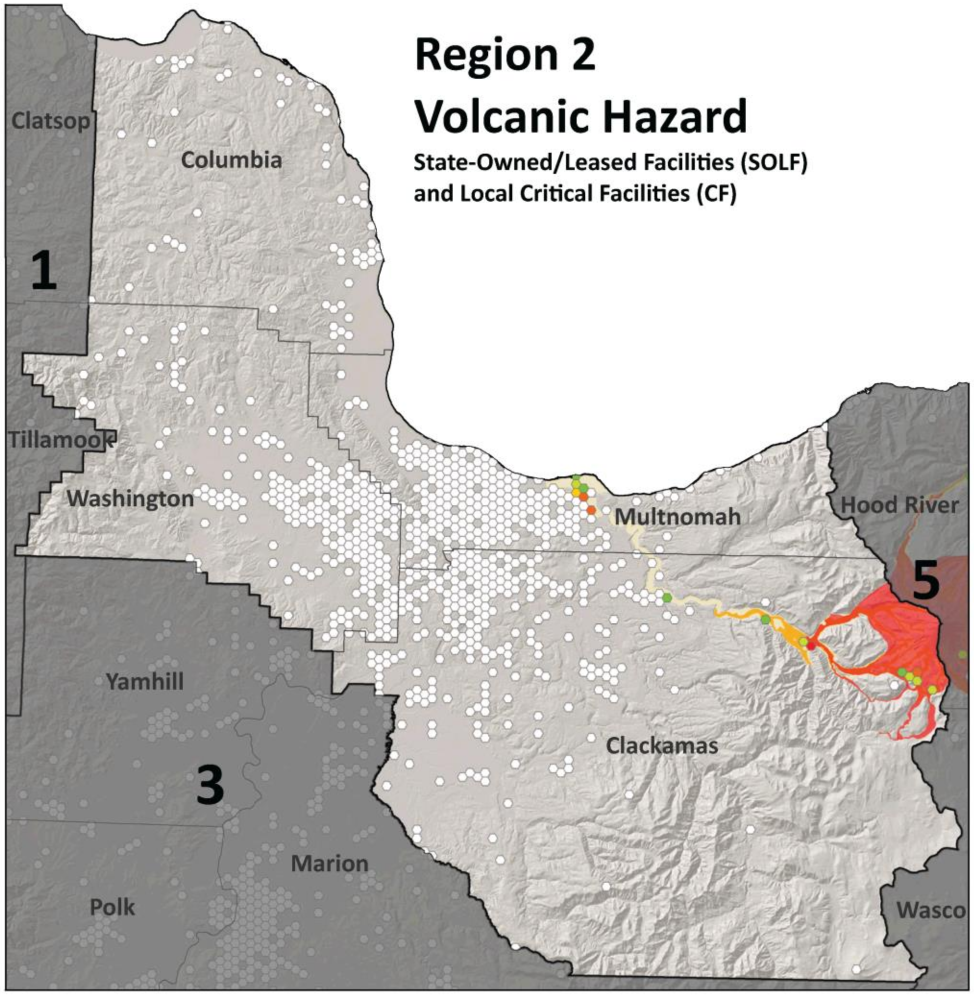
	Clackamas	Columbia	Multnomah	Washington
Risk	M	VL	M	VL

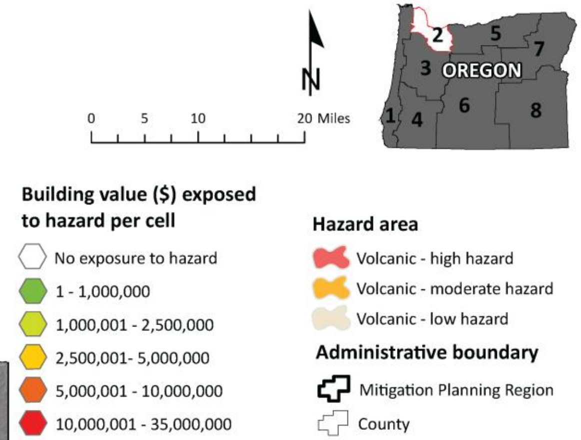
Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The probability of the hazard is moderate in both Clackamas and Multnomah Counties. Their vulnerability scores are both low, and they are driven by different variables. Clackamas County's vulnerability is due to the presence of state and local critical facilities in the hazard area. Multnomah County's is due to social vulnerability.

The U.S. Geological Survey has addressed volcanic hazards at Mount Hood (Scott, et al., 1997a) and Mount St. Helens (Wolfe & Pierson, 1995). These reports include maps depicting the areas at greatest risk. Clackamas and Multnomah Counties, including the Portland Metro area, are at risk and should consider the impact of volcano-related activity on small mountain communities, dams, reservoirs, energy-generating facilities, and highways. These counties also should consider probable impacts on the local economy (e.g., wood products and recreation). The communities of Government Camp, Rhododendron, and Welches merit special attention. There is virtually no risk from volcanoes in Washington County, although normal prevailing winds could shift and carry ash into that area. Debris entering the Columbia River from eruptions at Mount St. Helens or Mount Hood may disrupt shipping operations based in Columbia and Multnomah Counties.

Figure 2-162. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Volcanic Hazard Zone in Region 2.High-resolution, full-size image linked from Appendix 9.1.26.





REGION 2		Exposure ($) to Volcanic Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Clackamas	2,994,586,000	9,824,000	4%	2,240,000	12,064,000	17,091,000	26,915,000
Columbia	335,351,000	0	0%	0	0	0	0
Multnomah	4,432,407,000	0	0%	0	0	0	0
Washington	3,597,367,000	0	0%	0	0	0	0
Total	11,359,711,000	9,824,000	1%	2,240,000	12,064,000	17,091,000	26,915,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:550,000

Source Data:
Volcanic: various studies of proximal and distal volcanic hazards from United States Geological Survey
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI

Wildfires

Characteristics

There is extensive forested land in Columbia, Clackamas, Multnomah, and Washington Counties, both in undeveloped National Forest land and developing wildland-urban interface areas. All of it is at risk, but especially within the interface areas. In recent years, the cost of fire suppression has risen dramatically. A large number of homes has been threatened or burned, more firefighters have been placed at risk, and fire protection in wildland areas has been reduced. These factors have prompted communities and protection agencies to come together and use or create extensive fire prevention/mitigation programs. Community Wildfire Protection Plans lead the way for the development of Firewise Communities and fuel reduction projects throughout the region.

Fire return intervals for these areas is long, but due to the high amounts of vegetation and wind, when a fire does go though, it can be very large and damaging. Areas in this region are also experiencing more risk due to the current trend toward rural home site development. The age of the surrounding timber stands can be a factor in determining whether a non-threatening ground fire will spread to the canopy and become a dangerous crown fire. Clearings and fuel breaks will disrupt a slow moving wildfire enabling successful suppression. Agricultural and ranching activities throughout the area increase the risk of a human-caused wildfire spreading to forested areas. Large expanses of fallow fields or non-annual cash crops provide areas of continuous fuels that have potential to threaten several homes and farmsteads. Under extreme weather conditions, escaped agricultural fires could threaten individual homes or a town site; however, this type of fire is usually quickly controlled. High winds increase the rate of fire spread and intensity of fires.

Table 2-258 shows the single significant fire affecting Region 2.

Historic Wildfire Events

Table 2-258. Historic Wildfires in Region 2

Year	Name of Fire	Counties	Acres Burned
1902	Columbia	Clackamas/Multnomah	170,000
2012	Holloway	Washington	>254,000
2017	Eagle Creek	Tillamook, Washington, Yamhill	48,831

Source: Oregon Department of Forestry

Probability

Table 2-259. Assessment of Wildfire Probability in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	L	M	L	L

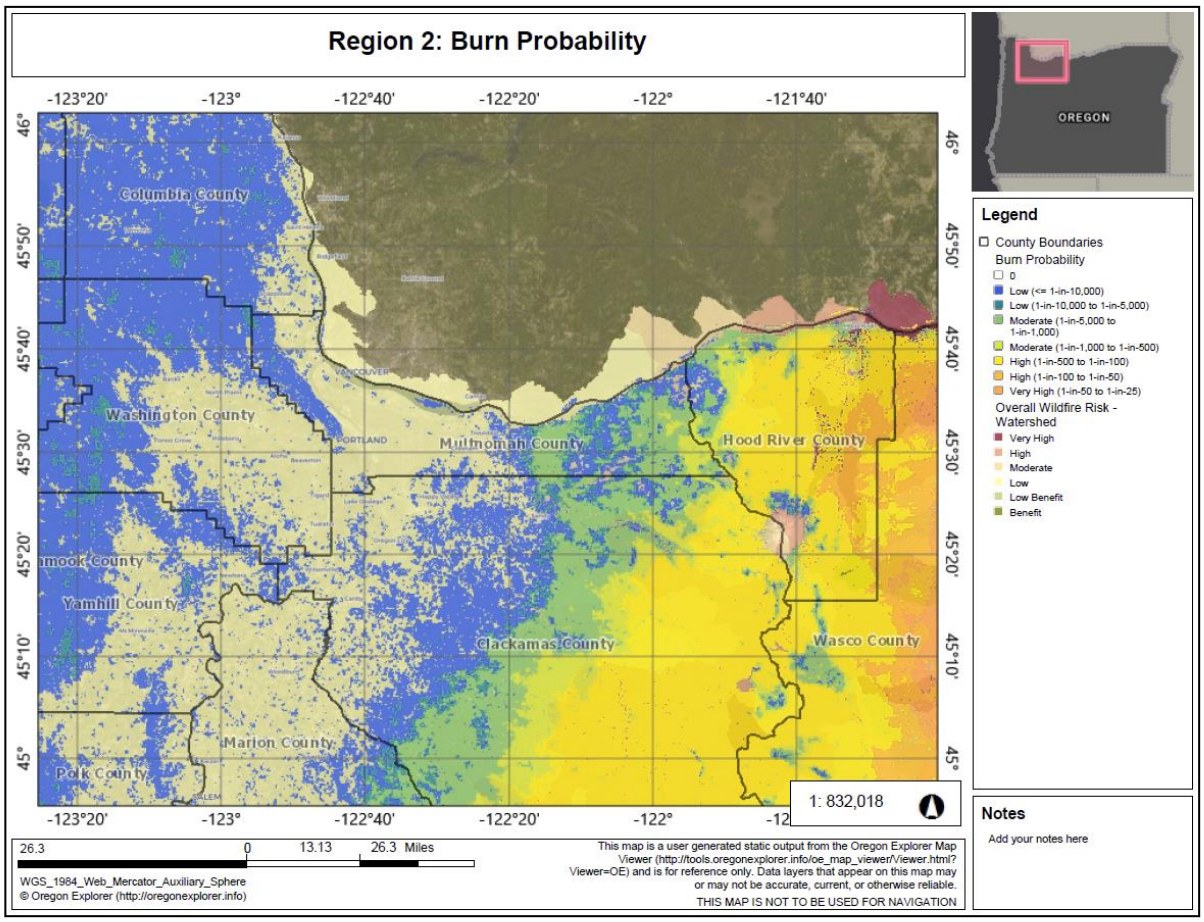
Source: PNW Quantitative Wildfire Risk Assessment and Oregon Explorer, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to assess the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-163 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

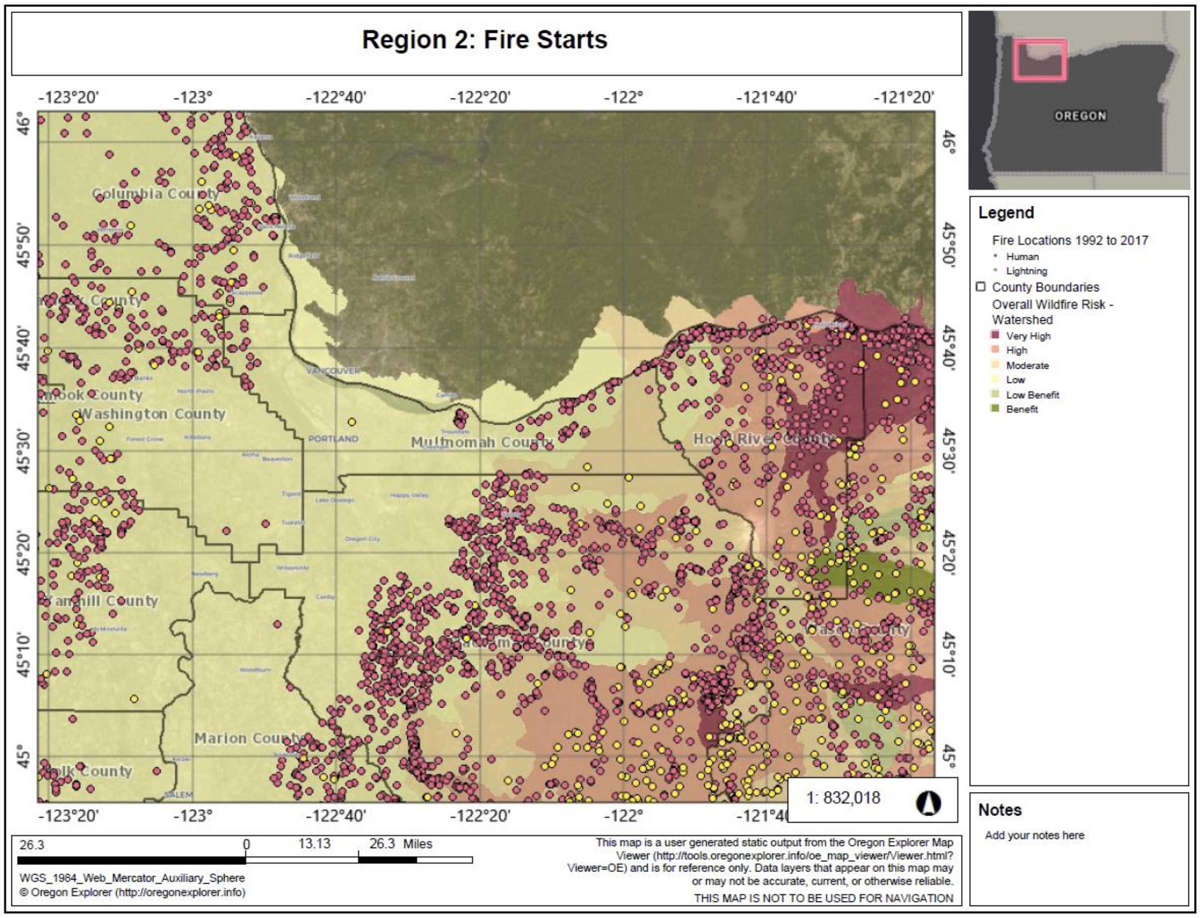
Figure 2-163. Burn Probability



Source: Oregon Wildfire Risk Explorer, March 2020

Wildfire is defined as an uncontrolled burning of forest, brush, or grassland. Wildfires have always been a part of these ecosystems, sometimes with devastating effects. Wildfire may result from natural causes (e.g., lightning strikes), a mechanical failure (Oxbow Fire), or human causes (unattended campfire, debris burning, or arson). Most wildfires can be linked to human carelessness.

Figure 2-164. Human- and Lightning-Caused Wildfires in Region 2, 1992-2017



Source: Oregon Wildfire Risk Explorer, March 2020

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

In moisture-limited forest systems, such as those in the Coast and Cascade Ranges, warming winters will lead to more fine fuels from greater cold season growth. Hotter and drier conditions will lead to large fuel quantities, which lead to large and severe fires. It is very likely (>90%) that the Coast Range and lower elevations of the Cascade Range in Region 2 will experience increasing wildfire frequency and intensity under future climate change. Modeled projections of future fire frequency indicate more frequent fires for the Pacific Northwest, particularly west of the Cascade Mountains where fires have been infrequent historically. In coastal areas, fire frequency is projected to change from approximately every 100 years to every 60 years.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of “very high” fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 2 counties (Table 2-260).

Table 2-260. Projected Increase in Annual Very High Fire Danger Days in Region 2 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Clackamas	14	39%
Columbia	13	35%
Multnomah	14	39%
Washington	13	34%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-261. Local Assessment of Vulnerability to Wildfire in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	L	L	—	M

Source: Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-262. Assessment of Vulnerability to Wildfire in Region 2 – Communities at Risk

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	VL	L	L	VL

Source: ODF Communities at Risk Report, 2020

Table 2-263. Assessment of Vulnerability to Wildfire in Region 2 – 2020 Vulnerability Assessment

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	VL	VL	L	VL

Source: DOGAMI and DLCD, 2020

According to ODF's assessment of Communities at Risk, vulnerability in this region is mild. The Northern Willamette Valley / Portland Metro area is dominated by a highly populated rural interface as well as metropolitan areas. Timber and agriculture land line suburban areas. A cooler climate and reduced fire danger results in fewer wildfires. In addition, response times are typically much quicker in this region due to large populations and several fire agencies nearby.

Each year a significant number of people build homes within or on the edge of the forest (wildland-urban interface), thereby increasing wildfire hazards. These communities have been designated "Wildland-Urban Interface Communities" and include those n **Table 2-264**.

Table 2-264. Wildland-Urban Interface Communities in Region 2

Clackamas	Columbia	Multnomah	Washington
Beaver Creek	Alston	Bonneville	Banks
Boring	Clatskanie	Burlington	Buxton
Bull Run	Columbia City	Corbett	Cedar Mill
Canby	Deep Island	Crystal Spring	Cherry Grove
Cedarhurst Park	Globe	Fairview	Cornelius
Clackamas	Mist Birkenfeld	Gresham	Durham
Colton	Pittsburg	Holbrook	Forest Grove
Damascus	Prescott	Lower Columbia Gorge	Gales Creek
Dickey Prairie	Quincy	Maywood Park	Gaston
Eagle Creek	Rainier	Portland	Glenwood
Estacada	Scappoose	Riverdale	Hillsboro
Fallsview	Spitzenberg	Sauvie Island	Rock Creek
Firgrove	St. Helens	Shelternoon	Shady Brook
Gladstone	Stimson Mill	Skyline	Stimson Mill
Government Camp	Swedetown	Troutdale	Timber
Happy Valley	Vernonia	Warrendale	Tualatin Valley
Hoodland	Yankton		
Lake Grove	Warren		
Lake Oswego			
Maple Grove			
Molalla			
Molino			
Oregon City			
Redland			
Sandy			
Springwater			
Timber Grove			
Timber Park			
West Linn			
Wilsonville			

ODF Communities at Risk Report, 2020

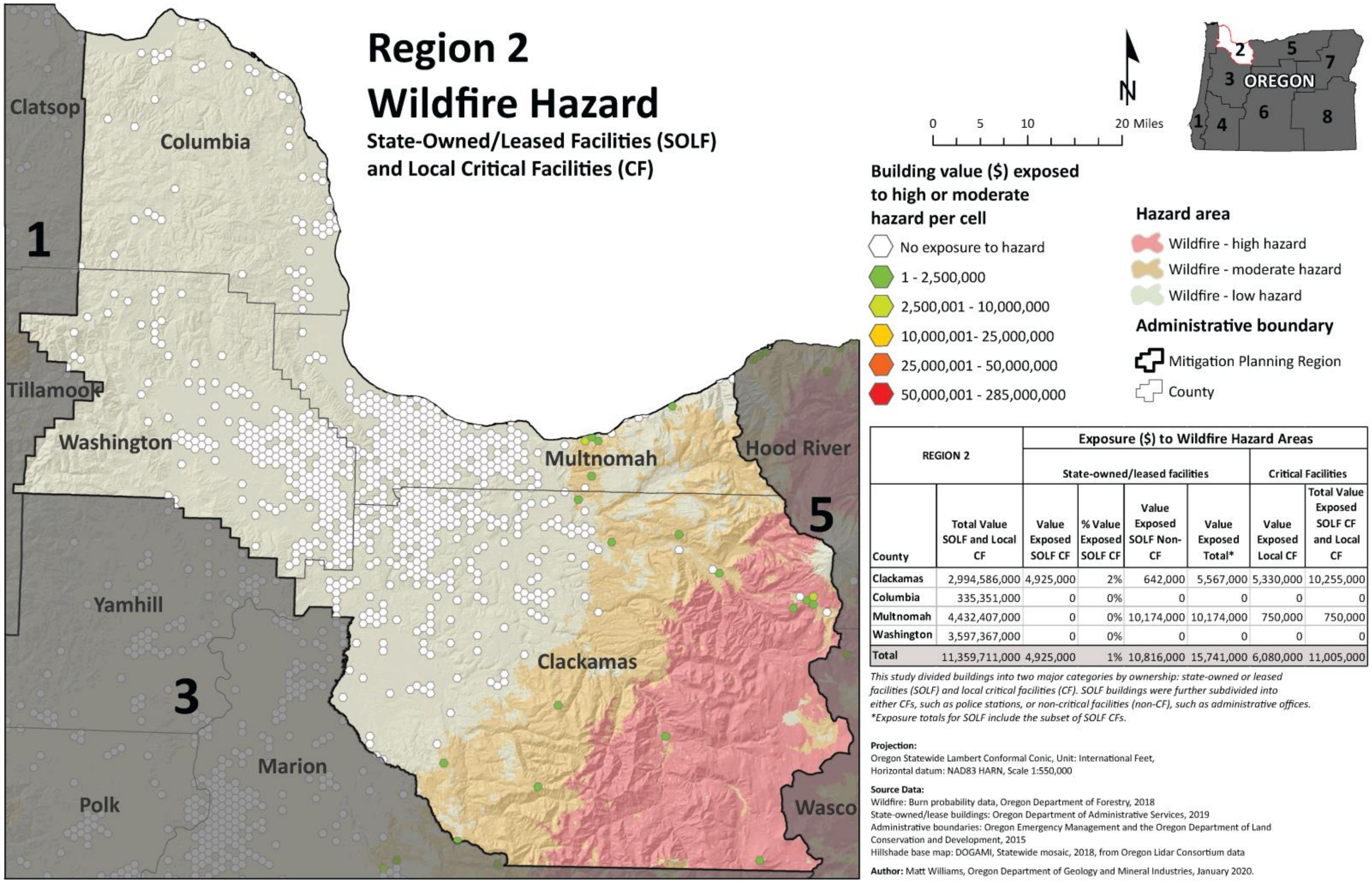
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in "High," “Moderate,” and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as “Low.”

In Region 2, there is a potential loss to wildfire of close to $16M in state building and critical facility assets, about two-thirds of it in Multnomah County and about one-third in Clackamas County. There is a much smaller potential loss in local critical facilities: about $6M, approximately one-third as much. Neither Columbia County nor Washington County has state assets or local critical facilities located in a wildfire hazard area.

Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, there has been one reported loss to a state asset caused by a wildfire since the beginning of 2015. It was located in the Columbia River Gorge; whether in Region 2 or Region 5 is not clear. The net claim paid was under $2,000.

Figure 2-165. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 2.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 2		Exposure ($) to Wildfire Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Clackamas	2,994,586,000	4,925,000	2%	642,000	5,567,000	5,330,000	10,255,000
Columbia	335,351,000	0	0%	0	0	0	0
Multnomah	4,432,407,000	0	0%	10,174,000	10,174,000	750,000	750,000
Washington	3,597,367,000	0	0%	0	0	0	0
Total	11,359,711,000	4,925,000	1%	10,816,000	15,741,000	6,080,000	11,005,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:550,000

Source Data:
Wildfire: Burn probability data, Oregon Department of Forestry, 2018
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI,2020

Historic Resources

Of the 23,605 historic resources in Region 2, forty-one are located in an area of high wildfire hazard, all of them in Clackamas County. One hundred forty-four are located in an area of moderate wildfire hazard: one hundred twenty-nine in Clackamas County, and fifteen in Multnomah County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than "well" and for its share of minority residents.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, all the counties in Region 2 have very low vulnerability to wildfire except Multnomah County whose low vulnerability is slightly greater. With the exception of Clackamas County (low/very low), the scores based on Communities at Risk and the 2020 vulnerability assessment scores agree.

None of the counties in Region 2 are most vulnerable to wildfire.

Risk

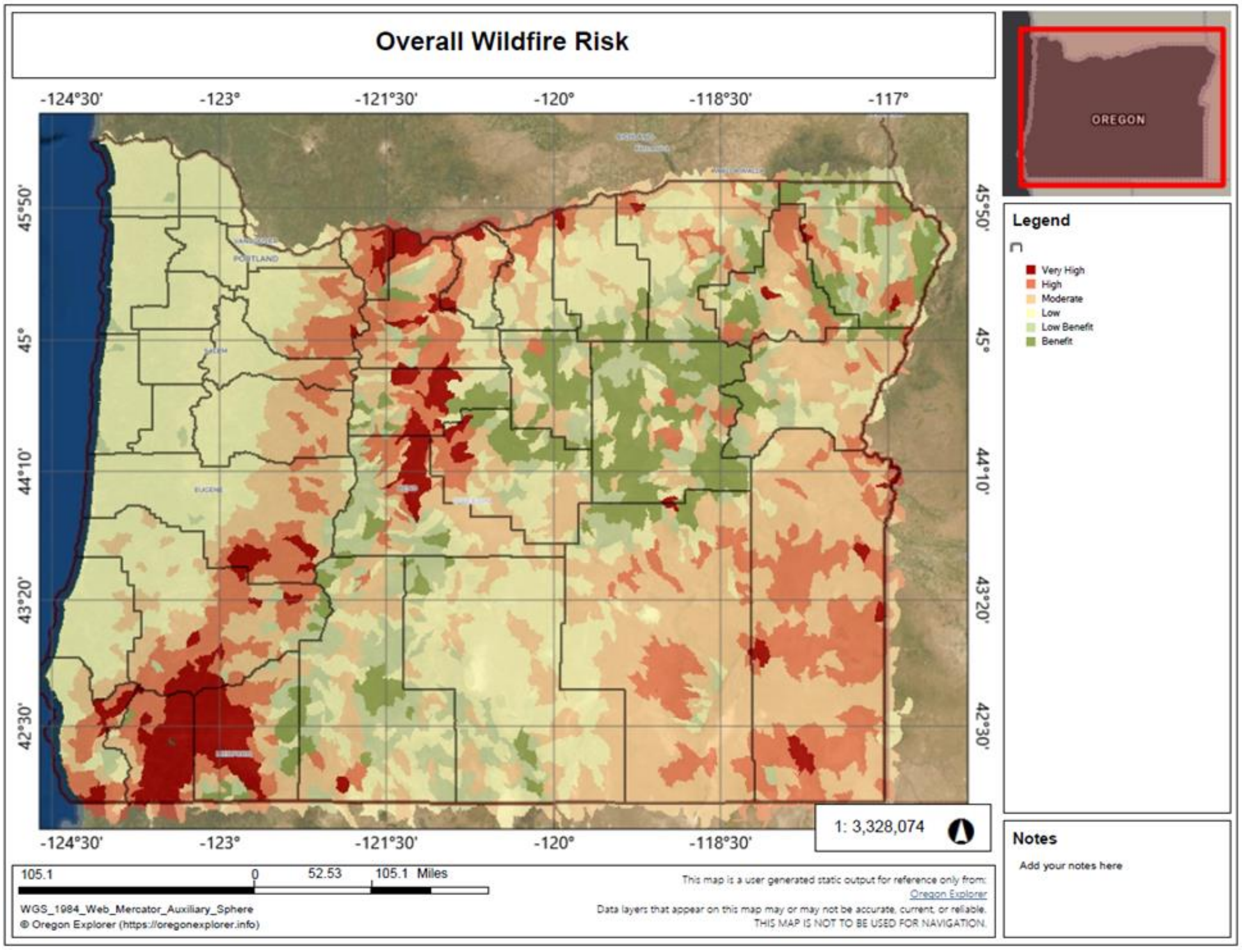
Table 2-265. Risk of Wildfire Hazards in Region 2

	Columbia	Clackamas	Multnomah	Washington
Risk	VL	VL	VL	VL

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, all of the counties in Region 2 are at very low risk from wildfire. This is consistent with ODF's assessment for the western portion of Region 2, but not the eastern portions of Multnomah and Clackamas Counties. The 2020 risk assessment is not granular enough to account for geographic differences in probability, vulnerability, or risk within a county.

Figure 2-166. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

Extreme winds (other than tornadoes) are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge; these areas have special building code standards. Tornados and thunderstorms are increasing in frequency in the Willamette Valley. A majority of the destructive surface winds in Region 2 are from the southwest. Under certain conditions, very strong east winds may occur, but these usually are limited to small areas in the vicinity of the Columbia River Gorge or other low mountain passes.

The much more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they may be stronger on the coast than in the interior valleys because of the north-south orientation of the Coast Range and Cascades. These mountain ranges obstruct and slow down the westerly surface winds. The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of such a storm, and its effects were so devastating that it has become the benchmark from which other windstorms in Oregon are measured. The storm caused significant damage in Region 2.

Historic Windstorm Events

Table 2-266. Historic Windstorms in Region 2

Date	Location	Description
Apr. 1931	western Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; wind speed 40-60 mph; gusts 75–80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 75-mph gusts; damage to buildings and utility lines
Dec.1955	statewide	wind speeds 55–65 mph with 69-mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71-mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon's most destructive storm to date; 116-mph winds in Willamette Valley; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Nov. 1981	most of Oregon	highest winds since Oct. 1962; wind speed 71 mph in Salem; marinas, airports, and bridges severely damaged
Jan. 1990	statewide	heavy rain with winds exceeding 75 mph; significant damage; one fatality
Dec. 1995	statewide	followed path of Columbus Day Storm; wind speeds 62 mph in Willamette Valley; damage to trees (saturated soil a factor) and homes (FEMA-1107-DR-Oregon)
Nov. 1997	western Oregon	wind speed 52 mph in Willamette Valley; trees uprooted; considerable damage to small airports
Feb. 2002	western Oregon	strongest storm to strike western Oregon in several years; many downed power lines (trees); damage to buildings; water supply problems (lack of power); estimated damage costs: $6.14 million (FEMA-1405-DR-Oregon)

Date	Location	Description
June 2004	Washington Count	$100 in property damage from a tornado
Dec. 2004	Clackamas County	$6,250 in property damage *damage estimate includes areas outside of Region 2
June 2005	Multnomah County	lightning causes $50,000 in damage
Dec. 2005	Clackamas, Multnomah, and Washington Counties	$9,000 in property damage
Jan. 2006	Clackamas, Columbia, Washington, and Multnomah Counties	wind storm with winds up to 58 mph caused a total of $500,000 in damages spread out over all four counties and included Yamhill, Marion, and Polk Counties as well
Feb. 2006	Columbia, Multnomah, Clackamas, Washington Counties	strong wind storm caused $167,000 in damage for all four counties; storm also impacted counties in Regions 3 and 1 for a total storm damage of $575,000
May 2007	Clackamas County	windstorm brought wind gusts up to 50 mph and produced extensive hail, causing $5000 in damages
July 2007	Multnomah and Washington Counties	heavy windstorm with 58-mph winds downed several trees, caused $5000 in damage/$1000 in damage in Beaverton
Sep. 2007	Multnomah County	severe storm that produced hail and a tornado, caused $5000 in damages
June 2008	Clackamas County	severe storms produced heavy winds and hail near the Cascades, caused $5000 in damages
Mar. 2009	Columbia County	72-mph winds caused $20,000 in property damage
Nov. 2012	Lincoln County	97-mph winds at Newport cost $1 million in property damage
Dec. 2015	Regions 1-4	FEMA-4258-DR: severe winter storms, straight-line winds, flooding, landslides, and mudslides
Jul. 2018	Portland, Multnomah County	tornado; EF0; damage to trees and homes

Sources: Taylor and Hatton (1999); and FEMA-1405-DR-OR: February 7, 2002, Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon; Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; National Climatic Data Center, Storm Events, Database http://www.ncdc.noaa.gov/stormevents/; https://www.fema.gov/disaster/; https;//www.weather.gov/pqr/07-01-2019

Probability

Table 2-267. Assessment of Windstorm Probability in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	M	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

The 100-year storm in Region 2 is considered to be one-minute average winds of 80 mph. A 50-year storm is 72 mph. And a 25-year storm is 65 mph in this region.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-268. Local Assessment of Vulnerability to Windstorms in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	L	—	M	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-269. State Assessment of Vulnerability to Windstorms in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	L	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Columbia, Multnomah, and Washington Counties are listed as most vulnerable to windstorms, as determined by the staff of the Oregon Public Utilities Commission and OCCRI.

Many buildings, utilities, and transportation systems within Region 2 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome. They can block roads and rails for long periods and affect emergency operations. In addition, uprooted or shattered trees can down power and other utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed by uprooted ancient trees growing next to a house. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establish a tree maintenance and removal program.

Additional considerations include ferry systems and bridges, which may be closed during high-wind periods.

Impacts to agriculture related to windstorms, or related to windstorms with heavy and/or freezing precipitation, include crop damage or loss (e.g., grain crops, orchards), and impacts to buildings and infrastructure important for supporting agriculture, for example, Oregon State University Extension and USDA Agricultural Research stations that provide services and support to agricultural communities and conduct valuable research on pest control, irrigation efficiency, soil health, crop research, livestock raising and health, and other topics.

Data have not yet been collected to assess the economic impacts to the state as a consequence of wind-related damage to agriculture and associated infrastructure.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than "well" and for its share of minority residents.

Multnomah's County's relatively higher social vulnerability in Region 2 indicates that the effects of windstorms will be felt more intensely by its population than by the populations of the other Region 2 counties and will require more resources for preparation, mitigation, and response. Therefore, Multnomah County is the county most vulnerable to windstorms in Region 2.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 2 is approximately $1,134,896,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $10,224,815,000. Because windstorms, while primarily impacting the Columbia River Gorge in Region 2, could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one loss of over $111,000 to a state facility was recorded in Region 2 since the beginning of 2015. It was not caused by a windstorm.

Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

Due to its greater vulnerability, Multnomah County is at greater risk from windstorms than the other counties in Region 2.

Winter Storms

Characteristics

Winter storm events occur annually in Region 2, sometimes becoming severe. Severe winter weather in this region is characterized by extreme cold, snow, ice, and sleet. While most communities are prepared for severe winter weather, some are unprepared financially and otherwise. This is particularly true in the vicinity of Portland, where frigid air sometimes moves westward through the Columbia River Gorge. During these periods, it is not unusual for northern Willamette Valley communities to receive snow or ice storms known as “silver thaws.” Severe weather conditions do not last long in Region 2. Consequently, winter preparedness is a moderate priority.

Historic Winter Storms

Table 2-270. Historic Winter Storms in Region 2

Date	Location	Description
Dec. 1861	statewide	snowfall 1-3 ft; snow in Willamette Valley until late Feb.
1862, 1866, 1884, 1885, 1890, 1892, 1895	Portland area / Northern Willamette Valley	severe winter conditions, especially in the Portland area; record-breaking snowfalls
Jan. 1916	statewide	two snow storms, each totaling 5 inches or more
Dec. 1919	Portland area	third heaviest snowfall on record; Columbia River froze, closing navigation
1927, 1936, 1937, 1943, 1949	Portland area, Western Oregon	heavy snowfalls recorded
Jan. 1950	statewide	heaviest snowfall since 1890; many highway closures; considerable property damage
1956, 1960, 1962	western Oregon	packed snow became ice; automobile accidents throughout the region
Mar. 1960	statewide	snowfall: 3-12 inches, depending on location
Jan. 1969	statewide	record-breaking snowfalls; $3 to $4 million in property damage
Jan. 1980	statewide	a series of storms bringing snow, ice, wind, and freezing rain; six fatalities
Feb. 1985	statewide	western valleys received between 2-4 inches of snow; massive power failures (tree limbs broke power lines)
Dec. 1985	Willamette Valley	heavy snowfall throughout valley
Mar. 1988	statewide	strong winds and heavy snow
Feb. 1989	statewide	heavy snowfall and record low temperatures
Feb. 1990	statewide	average snowfall from one storm about 4 inches (Willamette Valley)
Dec. 1992	western Oregon	heavy snow; interstate highway closed
Feb. 1993	western Oregon	record snowfalls
Winter 1998-1999	statewide	series of storms; one of the snowiest winters in Oregon history
Dec. 2007	Columbia County	resulted in Presidential Disaster Declaration; $180 million in damage in the state; severe flooding in Vernonia; power outages for several days; five fatalities
Dec. 2008	Columbia County	snow and freezing rain in the Portland Metro area; $300,000 in property damage
Dec. 2009	statewide	snow and freezing rain in Salem, and Portland to Hood River; I-84 closed for 22 hours
Nov. 2010	statewide	snow, freezing rain, and ice accumulation in Portland to Hood River
Jan. 2012	Multnomah County	snow and ice east of Troutdale; I- 84 closed for 9 hours
Feb. 6–10, 2014	Columbia, Clackamas, Multnomah, and Washington Counties	DR-4169 Linn, Lane, Benton and Lincoln Counties declared. A strong winter storm system affected the Pacific Northwest during the February 6–10, 2014 time period bringing a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon; during the 5-day period Feb. 6–10, 2 to10 inches of snow fell in the coastal region of northwest Oregon; freezing rain accumulations generally were 0.25 to 0.75 inches; the snowfall combined with the freezing rain had a tremendous impact on the region

Date	Location	Description
Feb. 11–14, 2014	Clackamas, Multnomah, and Washington Counties	Another weather system moved across northwest Oregon during the February 11–14 time frame; this storm was distinctly different from the storm that produced the snow and ice the week prior and brought abundant moisture and warm air from the sub-tropics into the region; as this storm moved across the area, 2 to 7 inches of rain fell across many counties in western Oregon; the heavy rainfall combined with warm temperatures led to snowmelt and rainfall runoff that produced rapid rises on several rivers, which included flooding on three rivers in northwest Oregon
Nov. 13, 2014	Clackamas, and Multnomah Counties (Western Columbia River Gorge)	An early cold snap hit the Pacific Northwest before moist Pacific air moved in and resulted in one of the earliest snow, sleet, and freezing rain events in northwestern Oregon. Sleet and freezing rain in particular created hazardous commutes for tens of thousands in the western and eastern suburbs of Portland. Snow accumulations was primarily restricted to the Cascade valleys and the central Columbia River Gorge. Spotters reported around 6 to 8 inches of snow for the Cascade Foothills followed by a quarter of an inch of ice. A combination of heavy snow and ice resulted in slick driving conditions for the Western Columbia River Gorge. Areas in the gorge measured a quarter of an inch of ice whereas other areas had 5 to 8 inches of snow.
Dec. 6-23, 2015	Statewide storm events	DR-4258 Clatsop, Columbia, Multnomah, Clackamas, Washington, Tillamook, Yamhill, Polk, Lincoln, Linn, Lane, Douglas, Coos, and Curry Counties declared. Severe winter storms, straight-line winds, flooding, landslides, and mudslides. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Each storm system brought several inches of snow to the mountain areas. At first the snow was limited to higher elevations...but lowered with time to some of the west side valley floors.
Mar. 13, 2016	Clackamas, County (North Oregon Cascades)	A strong low pressure system generated frequent and persistent snow showers over the northern and central Oregon Cascades. Several SNOTEL stations measured 16 to 24 inches of snow over a 24 to 30 hour period above 3500 feet.
Dec. 8, 2016	Multnomah, Clackamas, Washington and Columbia Counties (Greater Portland Area and Western Columbia River Gorge)	A strong frontal system brought strong east winds to the North Willamette Valley and a mix of snow, sleet, and freezing rain down to the Valley Floor. Four to six inches of snow fell along interstate 84 before turning to sleet and freezing rain. One to 1.5 inches of ice accumulation was also reported. The Portland Metro area generally had 1-2 inches of snow, with 0.2 to 0.3 inch of ice accumulation. Ice accumulations were higher in the West Hills and near the Columbia River Gorge, with 0.8 inch of ice accumulation reported at Council Crest in SE Portland. The NWS Office in Parkrose had 0.4 inch of ice accumulation.
Dec. 14-15, 2016	Clackamas County (Northern Cascade foothills)	DR-4296 Lane and Josephine counties declared. Severe winter storm and flooding disaster declared in Lane and Josephine counties. East winds ahead of an approaching low pressure system brought temperatures down below freezing across the area ahead of the approaching precipitation. This lead to a mix of freezing rain, sleet, and snow across the area.
Dec. 26-27, 2016	Clackamas County (North Oregon Cascades)	A frontal system brought high winds to the Central Oregon Coast, heavy snow to the Cascades and a mix of ice and snow in the Columbia River Gorge and Hood River Valley. Estimate the Columbia Gorge had around 0.2 to 0.5 inch of ice accumulation as temperatures in the lower 30s with reports of snow and freezing rain in Hood River.

Date	Location	Description
Jan. 7-8, 2017	Multnomah, Clackamas, Washington, and Columbia Counties (Greater Portland Area)	DR-4328 Columbia, Hood River, Deschutes and Josephine Counties declared. Severe Winter Storms, Flooding, Landslides, And Mudslides. A broad shortwave trough brought multiple rounds of precipitation, including a wintry mix of snow and ice for many locations across Northwest Oregon. Strong easterly pressure gradients generated high winds through the Columbia River Gorge as well on January 8. General snowfall totals of 2-4 inches were reported, with the greatest total being 4.5 inches. Major ice accumulations occurred after the snow, with several locations reporting 0.50-1.00. The combination of snow and ice resulted in significant power outages and closures across the area.
Feb. 3-4, 2017	Multnomah County (Western Columbia River Gorge)	Fronts associated with a low pressure system passing north into the Olympic Peninsula brought heavy snow and ice to the Columbia Gorge.
Dec. 24, 2017	Multnomah County (Western Columbia River Gorge	Low pressure system moving into the Pacific Northwest pulled cold air from the Columbia Basin west into the Willamette Valley, through the Columbia River Gorge. As this system started to bring moisture and precipitation into NW Oregon, temperatures were around or below freezing, allowing for a mix of snow and ice to fall all the way to the Valley Floor around the Portland Metro, in the Columbia River Gorge, and the Hood River Valley.
Jan. 15-16, 2020	Multnomah County (Western Columbia River Gorge)	A 980 mb low located near 45N/130W along with an attendant warm front moved into the southern Oregon Coast and overran a cold air mass originating from the Columbia River Gorge. This resulted in snow that gradually transitioned to freezing rain in the Gorge on Wednesday night into Thursday.

Source: Taylor and Hatton (1999); https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Probability

Table 2-271. Probability Assessment of Winter Storms in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Winter storms occur annually in Region 2. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-272. Local Assessment of Vulnerability to Winter Storms in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	M	H	M	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-273. State Assessment of Vulnerability to Winter Storms in Region 2

	Clackamas	Columbia	Multnomah	Washington
Vulnerability	M	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Due to the large population and large truck commodity transport through this region, it is extremely costly when the roads are closed due to severe winter storms.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Multnomah County is moderately socially vulnerable and the most vulnerable in Region 2. Multnomah County has the highest percentage of multi-unit housing structures and the highest share of households that lack access to a vehicle. Although vulnerability in Washington and Clackamas Counties is relatively low, both counties are in the 90th percentile for their share of multi-unit housing structures. Washington County is also in the top 10% of counties for its percentage of residents that speak English less than "well" and for its share of minority residents.

Multnomah County's relatively higher social vulnerability in Region 2 indicates that the effects of windstorms will be felt more intensely by its population than by the populations of the other Region 2 counties and will require more resources for preparation, mitigation, and response. Considered in combination with the importance of large truck commodity transport through this region and the costs associated with road closures, Multnomah County is the county most vulnerable to winter storms in Region 2.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 2 is approximately $1,134,896,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $10,224,815,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to

Department of Administrative Services records, only one loss of over $111,000 to a state facility was recorded in Region 2 since the beginning of 2015. It was indeed caused by a winter storm.

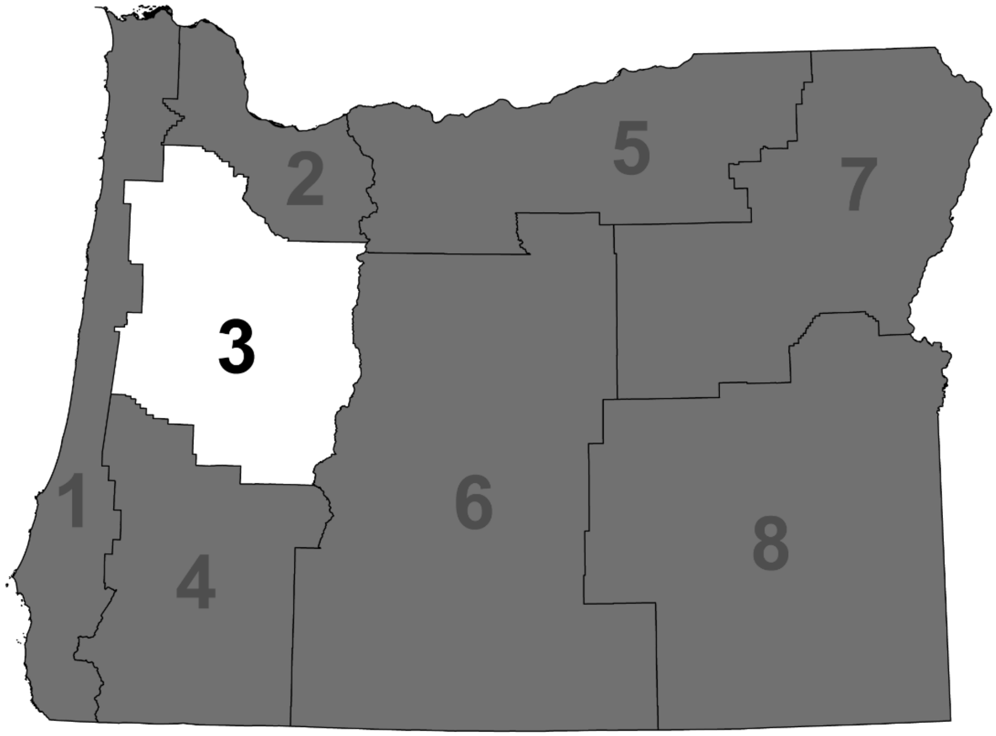
Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

While all the counties in Region 2 are at high risk from winter storms, Multnomah County's elevated vulnerabilities put it at greater risk than the others.

2.3.3 Region 3: Mid/Southern Willamette Valley

Benton, *Lane (non-coastal), Linn, Marion, Polk, and Yamhill Counties



Note: The coastal portion of Lane County is within Region 1. Where data are available for the coastal areas of Lane County, the data are provided within the Region 1 profile; otherwise, countywide datasets are reported in this profile.

2.3.3.1 Summary

Profile

The region's demographic, economic, infrastructure, and development patterns indicate that some populations, structures, and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion and Linn Counties rankings are driven by high numbers of people aged 17 or younger, high percentage of single-parent households, low per capita income, and percentage of occupied housing units with more people than rooms. The Marion County is also in the 90th percentile for its share of residents that speak English less than "well." Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters. The region has a number of key industries and employment sectors providing economic stability for the region. The exceptions are Linn and Yamhill Counties, which rely heavily on fewer key industries. Except for in Benton County, wages are lower in Region 3 than statewide. All the counties are contending with the financial impacts of the novel coronavirus pandemic.

Transportation networks across the region are vulnerable to natural hazard events, especially seismic events. Following a Cascadia earthquake event, access across the Willamette River and along I-5 may be limited due to bridge collapse. The Eugene Airport, the state's second largest airport, could become a staging ground after a natural disaster, but is also vulnerable to a catastrophic seismic event.

Energy facilities and conveyance system infrastructure in the region support the regional economy and are vulnerable to natural hazard events. Most state-regulated dams do not generate electricity and the few that do, do not generate large wattage. Some federally-regulated dams in Region 3 may generate power. Liquid Natural Gas is transmitted via pipelines that run through Marion, Linn, and Lane Counties.

Water systems in the region are particularly vulnerable to hazard events because they tend to be older, centralized, lacking in system redundancies and sourced from surface water. Combined sewer overflow (CSO) during high-water events is one such threat. Low impact development (LID) stormwater systems, such as those employed by the City of Eugene, can help communities better manage high-precipitation events.

Urban growth in Region 3 is 4 times rural growth. The majority of growth is occurring in urban areas along I-5, in the region's major cities: Eugene, Albany, Corvallis, Salem, and the Portland Metro Area. Linn County has the highest percentage of manufactured homes, which are inherently more vulnerable to natural hazards events. Almost two thirds of all homes in the region were built before 1990 and seismic building standards. Over one third of all homes in Polk and Yamhill Counties were built before floodplain management standards.

Hazards and Vulnerability

Region 3 is affected by nine of the 11 natural hazards that affect Oregon communities. Coastal hazards and tsunamis do not directly impact this region.

Droughts: Even though drought may not be declared as often in Western Oregon as in counties east of the Cascades, when drought conditions do develop in the Willamette Valley, the impacts are widespread and severe. Reasons for broad and significant impact include insufficient water for crop irrigation; lack of farmworkers when the growing season begins early; and increased frequency of toxic algal blooms in the Willamette system reservoirs, among other reasons.

Earthquakes: Four types of earthquakes affect Region 3: (a) shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) the offshore Cascadia Subduction Zone (CSZ) Fault, and (d) earthquakes associated with renewed volcanic activity. The CSZ is the chief earthquake hazard for the Mid/Southern Willamette Valley. This area is particularly vulnerable due to the large area susceptible to earthquake-induced landslide, liquefaction, and ground shaking. In a 500-year model for a CSZ event or combined crustal events, five of the 15 counties with highest expected damages and losses are in this region: Lane, Marion, Benton, Linn, and Yamhill. Seismic lifelines will be affected by prolonged ground shaking with several roadways susceptible to landslide, rockfall, or liquefaction. In Region 3, a CSZ event could cause a potential loss of almost $843M in state building and critical facility assets, 93% of it in Marion County alone. The potential loss in local critical facilities is somewhat greater at almost $1.2B. Again, Marion County's potential loss is greatest at 48%. Potential losses in Lane Line, Polk, and Yamhill Counties are similar, ranging 9-14%. Benton County's potential loss is significantly less.

Extreme Heat: Extreme temperatures aren't as common in western Oregon compared to other parts of the state; however, Region 3 does experience days above 90°F nearly every year. Eugene has an average of about 13 days per year above 90°F. The frequency of prolonged periods of high temperatures is expected to increase. Because extreme heat isn't as common in western Oregon compared to other parts of the state, many people may not be accustomed or prepared when an extreme heat event occurs.

Similar to drought, prolonged elevated temperatures pose risks to agriculture, involving health and welfare to farmers, farm workers, crops and livestock. Some livestock, especially dairy cattle, are sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms. Impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. The value of state-owned and leased buildings and critical facilities in Region 3 is approximately $3,107,827,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $7,490,014,000.

Floods: The most common types of flooding events affecting the Mid/Southern Willamette Valley are riverine and sheet flooding. The most damaging floods are rain-on-snow events and the backing up of tributaries that takes place in December and January in association with La Niña events. While all of the region's counties are considered moderately vulnerable to flooding, the coastal portion of Lane County and the cities of Eugene-Springfield, Salem, Scio, and Sheridan are considered the most vulnerable. In Region 3, there is a potential loss from flooding of over $676M in state building and critical facility assets, 93% of it in Marion County alone. The next greatest share is about $37M, only one-half percent, in Lane County. There is a similar potential loss due to flood in local critical facilities: close to $677.6M, forty percent and 32% in Lane and Marion Counties, respectively. The next greatest share, 14% is in Benton County.

Landslides: Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Rain-induced landslides can occur during winter months. Earthquakes can also trigger landslides. Vulnerability is increased in highly populated areas, such as in the Cities of Corvallis, Eugene, and Salem, and in the Coast and Cascade Mountains. More than $21.7M in value is exposed to landslide hazards in Region 3, over half of it in Lane County. The potential loss to local critical facilities is more than six times the value of state facilities at over $140.7M. Yamhill County has 37% of the value of local critical facilities followed by Polk, Lane, and Marion Counties whose shares range from 17% to 24%.

Volcanoes: Volcanic activity may occur within the eastern areas of Lane, Linn, and Marion Counties that coincide with the crest of the Cascade mountain range. Most volcanic activity is considered local; however, lahars and ashfall can travel many miles. As such, small mountain communities, dams, reservoirs, energy-generating facilities, and highways in the region may be vulnerable to volcanic activity. Over $153M in value is exposed to volcanic hazards in Region 3, all of it in Marion, Lane, and Linn Counties.

Wildfires: Wildfire risk is low to moderate in the Mid/Southern Willamette Valley. Wildfires that do occur usually happen in the late summer. The areas of greatest vulnerability are wildland-urban interface communities. In Region 3, there is a potential loss to wildfire of about $45M in state building and critical facility assets, 65% of it in Lane County, 21% in Linn County, and 15%d in Marion County. Benton Polk, and Yamhill Counties have no state assets in wildfire hazard areas. There is a similar potential loss in local critical facilities: about $42.6M. Eighty-three percent of that value is located in Lane County, 9% in Linn County, 6% in Marion County, and 2% in Benton County. Neither Polk nor Yamhill County has local critical facilities located in a wildfire hazard area.

Windstorms: Windstorms can occur when winds generated in the Pacific Ocean travel inland in a northeasterly direction. Strong winds from the south are also possible in this region and often cause the most damage. Windstorms affect the region annually. These storms generally impact the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland. The value of state-owned and leased buildings and critical facilities in Region 3 is approximately $3,107,827,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $7,490,014,000.

Winter Storms: Colder weather and higher precipitation and can occur in the region annually. More severe winter storms occur about every 4 years. Due to the infrequent nature of severe storms in Region3, winter storm preparedness is not a priority of most communities. The value of state-owned and leased buildings and critical facilities in Region 3 is approximately $3,107,827,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $7,490,014,000.

Climate Change

The hazards faced by Region 3 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon. Coupled with projected decreases in mountain snowpack due to warmer winter temperatures, Region 3 is expected to be affected by an increased incidence of drought and wildfire. In Region 3, climate change would result in increased frequency of drought due to low spring snowpack (*very likely*, >90%), low summer runoff (*likely*, >66%), and low summer precipitation and low summer soil moisture (*more likely than not*, >50%). It is *very likely* (>90%) that Region 3 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*).

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 3, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section 2.2.1.2, **Introduction to Climate Change**.

2.3.3.2 Profile

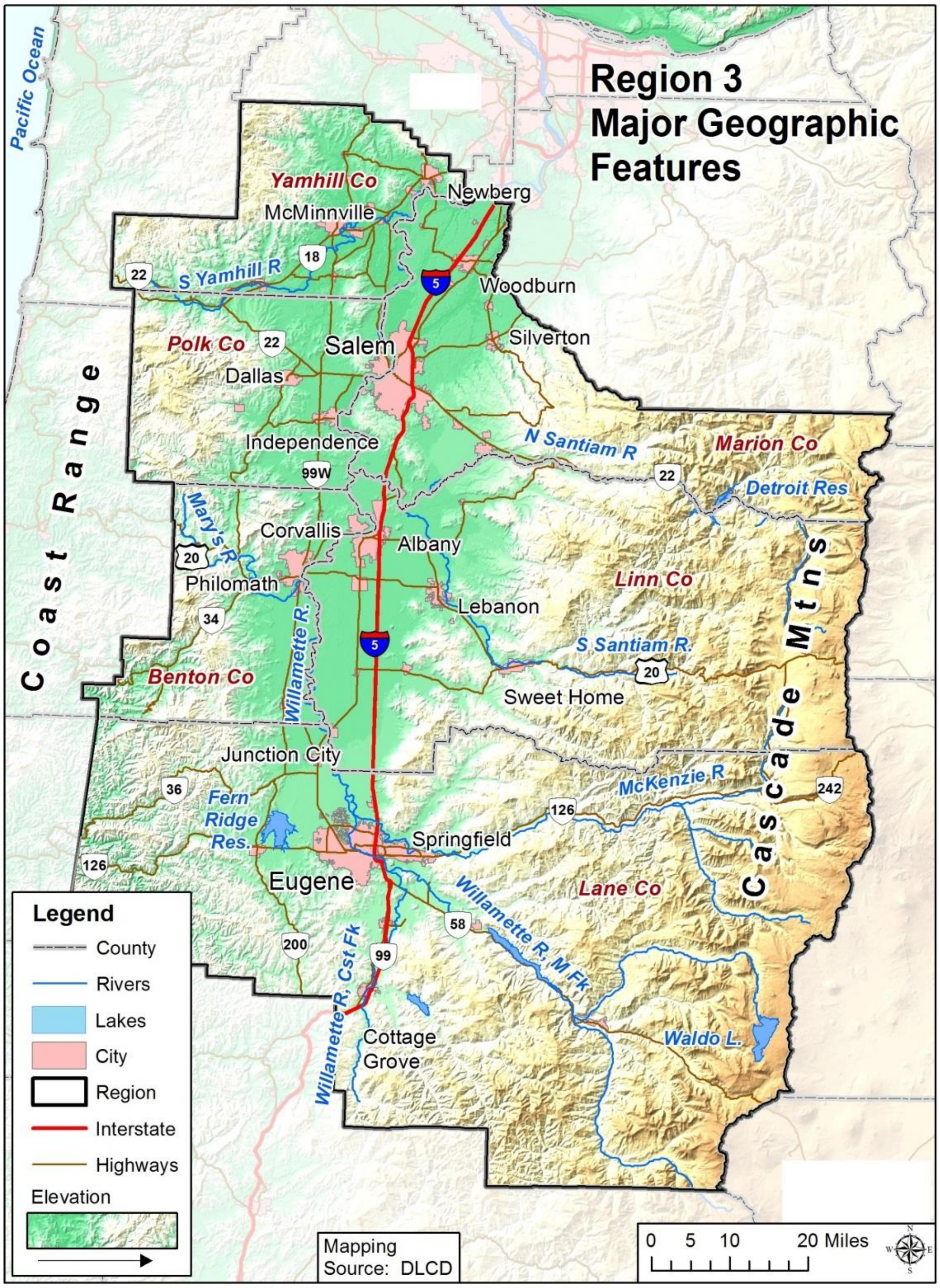
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

The Mid/Southern Willamette Valley is approximately 10,163 square miles in size, and includes Benton, Lane (non-coastal), Linn, Marion, Polk, and Yamhill Counties. Mountain ranges and watersheds shape the region's topography. Region 3 begins at the Cascades crest in the east, and extends to the Coast Range in the west. It extends from the base of the Calapooya Mountains in the south to the Portland suburbs in the north. The major watershed is the Willamette River with smaller water bodies feeding it as it flows north into the Columbia River. The original Oregon Trail settlers sought out the fertile soil and ample rainfall of the Willamette Valley for their homesteads. The region is still an agriculturally vital area.

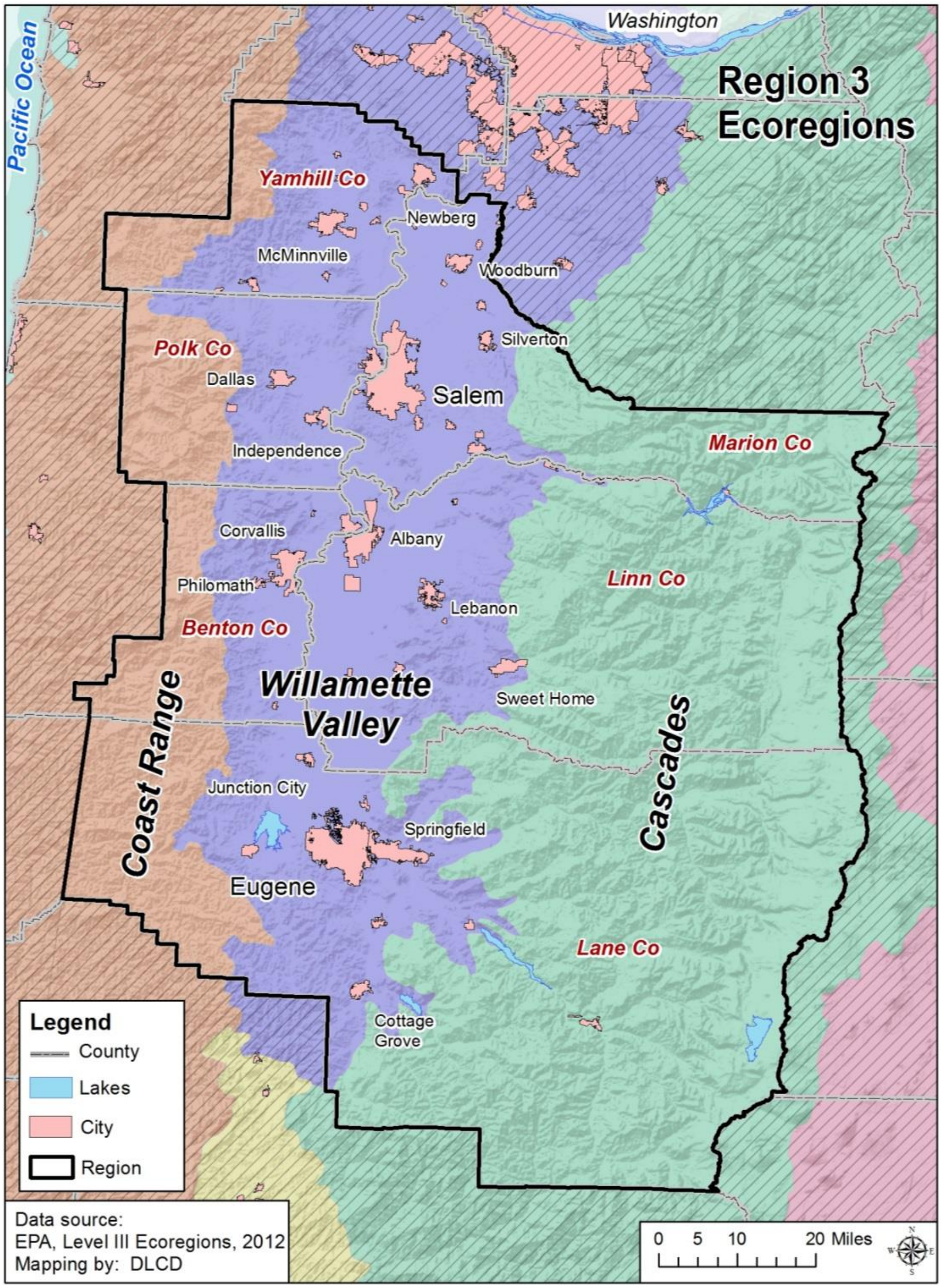
Figure 2-167. Region 3 Major Geographic Features



Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 3 is composed of three ecoregions: the Cascades, the Willamette Valley, and the Coast Range.

Figure 2-168. Region 3 Ecoregions



Cascades: This ecoregion is underlain by volcanic soils. Naturally occurring mixed conifer forests have given way to predominantly Douglas fir forests that are managed for commercial logging. Logging activities have put a strain on the ecological health of streams in the area (Thorson, et al., 2003). Waterways in the steeper valleys support threatened cold-water salmonids including Chinook salmon, steelhead, and bull trout. Streams, lakes, reservoirs, rivers, and glacial lakes at higher elevations are key sources of water. Large volcanic peaks, glaciers, and year-round snowfields punctuate the alpine and subalpine areas of the ecoregion (Thorson, et al., 2003).

Coast Range: The eastern slope of the Coast Range is located within Region 3. Soils in this ecoregion are a mixture of sedimentary and volcanic composition. Volcanic soils are underlain by basaltic rocks resulting in more consistent summer stream flows and supporting runs of spring Chinook salmon and summer steelhead. Sedimentary soils in this ecoregion are prone to failure following clearcuts, which may be of concern as the commercial Douglas fir forests located here are highly productive commercial logging areas. Landslides can impact the safety of nearby infrastructure and health of the region's waterways. The ecoregion's sedimentary soils can create more concerns for stream sedimentation than areas with volcanic soils (Thorson, et al., 2003).

Willamette Valley: Terraces and floodplains dominate the nearly flat central Willamette Valley. The valley floor is dotted with scattered hills and buttes and is bordered by the adjacent foothills. Historically, valley waterways meandered throughout floodplains on the nearly flat valley floor, contributing to the valley's highly fertile soil and supporting the dominance of oak savannah and prairie ecosystems. Today the Willamette River and its tributaries are highly channelized, helping to protect property, but also restricting the flow of these waterways and threatening stream health. Productive soils and temperate climate make this ecoregion one of the most important agricultural areas in Oregon. The valley's flat terraces have made urban and suburban development possible (Thorson, et al., 2003).

Climate

This section covers historic climate information only. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment**.

The Willamette Valley's mild climate, long growing season, and abundant moisture supports the most diversified agriculture in the state. Precipitation generally occurs in the winter months, falling mostly as rain in the valley, but building snowpack in the mid-elevations of the Cascade foothills. The region's wet winters can lead to flood, landslide, and winter storm risks while dry summers can lead to drought and wildfire risks. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-274** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 3 based on data from the NOAA National Centers for Environmental Information.

Table 2-274. Average Precipitation and Temperature in Region 3 Counties and Climate Divisions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Benton County	58.91” (38.67”–94.51”)	Jan: 9.17” Jul: 0.53”	52.1°F	Jan: 34.9°F /46.8°F Jul: 51.6°F /80.2°F
Lane County	64.72” (46.07”–101.5”)	Jan: 9.09” Jul: 0.77”	49.9°F	Jan: 33.3°F /44.8°F Jul: 50.8°F /77.0°F
Linn County	70.78” (51.06”–112.43”)	Jan: 9.95” Jul: 0.87”	49.2°F	Jan: 32.1°F /43.7°F Jul: 50.1°F /77.4°F
Marion County	64.66” (44.46”–102.94”)	Jan: 9.25” Jul: 0.84”	49.8°F	Jan: 32.6°F /44.1°F Jul: 51.1°F /77.3°F
Polk County	66.62” (42.46”–108.27”)	Jan: 10.55” Jul: 0.59”	51.6°F	Jan: 34.9°F /46.1°F Jul: 51.7°F /78.9°F
Yamhill County	59.91” (38.41”–97.23”)	Jan: 9.39” Jul: 0.59”	51.7°F	Jan: 35.1°F /45.8°F Jul: 52.2°F /78.6°F
Climate Division 2 “Willamette Valley”	58.11” (39.98”–92.22”)	Jan: 8.35” Jul: 0.69”	51.5°F	Jan: 34.6°F /45.9°F Jul: 52.2°F /78.6°F
Climate Division 4 “Northern Cascades”	80.7” (59.67”–127.71”)	Jan: 11.41” Jul: 1.05”	45.7°F	Jan: 28.5°F/39.8°F Jul: 48.2°F/74.2°F

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 15, 2019 from https://www.ncdc.noaa.gov/cag/.

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community’s capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

Between 2010 and 2018, the region grew less quickly than the state as a whole. Benton County saw the largest percentage increase and Lane County saw the smallest. Over the next decade, all counties in the region are expected to increase in population. Polk and Yamhill Counties are projected to grow most quickly. Net in-migration is expected to increase and be the main driver of population growth in Yamhill County, with the cities of Newberg and McMinnville leading the way (Population Research Center, Portland State University, 2020, Mar. 31). Lane County is projected to continue growing, albeit more slowly than its regional peers. Like many places in Oregon, Lane County has an aging population and the majority of growth is projected to occur from in-migration (Population Research Center, Portland State University, 2019 [Lane County]).

Table 2-275. Population Estimate and Forecast for Region 3

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 3	1,043,897	1,127,835	8.0%	1,257,889	11.5%
Benton	85,579	93,590	9.4%	106,498	13.8%
Lane	351,715	375,120	6.7%	396,195	5.6%
Linn	116,672	125,575	7.6%	140,871	12.2%
Marion	315,335	344,035	9.1%	388,420	12.9%
Polk	75,403	82,100	8.9%	98,501	20.0%
Yamhill	99,193	107,415	8.3%	127,404	18.6%

Source: Population Research Center, Portland State University (2018), Certified Population Estimates; Population Research Center, Portland State University (2019), Current Forecast Summaries for All Areas & Oregon Final Forecast Table by Age (2019); U.S. Census Bureau, 2010 Decennial Census. Table DP-1Tourists

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 3 are largely centered on touring (traveling to experience scenic beauty, history, and culture), special events, and outdoor activities (Longwoods International, 2017c). The average travel party contains 2.8 persons, and 81% of their trips originate from California, Oregon, or Washington. In this region, the average trip length is 2.3 nights (Longwoods International, 2017c). Within the region, Lane County has the greatest number of tourists from 2016 to 2018. The presence of the University of Oregon in Eugene is likely a key driver of tourism in Lane County; however, conventions, outdoor recreation and touring has also been cited as important (Omundson, 2019).

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

Table 2-276. Annual Visitor Estimates in Person Nights (x1000) in Region 3

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 3	19,743		19,706		20,130	
Benton	1,427	100%	1,432	100%	1,523	100%
Hotel/Motel	451	31.6%	442	31%	495	33%
Private Home	889	62.3%	903	63%	941	62%
Other	87	6.1%	86	6%	87	6%
Lane	8,173	100%	8,042	100%	8,286	100%
Hotel/Motel	2,042	25.0%	1,974	25%	2,057	25%
Private Home	4,766	58.3%	4,713	59%	4,857	59%
Other	1,365	16.7%	1,354	17%	1,372	17%
Linn	1,972	100%	1,965	100%	1,992	100%
Hotel/Motel	393	20%	389	20%	391	20%
Private Home	1,243	63%	1,244	63%	1,264	63%

	2016		2017		2018	
Other	336	17%	332	17%	337	17%
Marion	5,387	100%	5,436	100%	5,408	100%
Hotel/Motel	1,137	21%	1,158	21%	1,124	21%
Private Home	3,701	69%	3,735	69%	3,733	69%
Other	549	10%	544	10%	551	10%
Polk	1,101	100%	1,125	100%	1,148	100%
Hotel/Motel	199	18.1%	196	17.4%	201	17.5%
Private Home	793	72.0%	820	72.9%	837	72.9%
Other	110	10.0%	109	9.7%	110	9.6%
Yamhill	1,683	100%	1,706	100%	1,773	100%
Hotel/Motel	539	32%	551	32%	592	33%
Private Home	1,050	62%	1,061	62%	1,087	61%
Other	95	6%	94	6%	95	5%

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003). A similar percentage of the people in Region 3 identify as having a disability as do people throughout the state.

The region also has a similar share of younger people (< 18) and older people (≥ 65) with a disability. Within the region, Linn and Lane Counties have the highest percentages of people with a disability. Benton County has the smallest percentage among its overall population and among its younger and older populations.

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Table 2-277. People with a Disability by Age Group in Region 3

	With a Disability (Total Population)			Under 18 Years with a Disability			65 Years and Over with a Disability		
	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	14.6%	✓	0.1%	4.6%	✓	0.2%	37.1%	✓	0.4%
Region 3	15.5%	✓	0.3%	5.3%	✓	0.4%	37.9%	✓	0.7%
Benton	10.5%	✓	0.6%	4.8%	✓	1.1%	30.6%	✓	2.5%
Lane	16.8%	✓	0.5%	5.4%	✓	0.7%	37.7%	✓	1.1%
Linn	17.4%	✓	0.9%	5.4%	✓	1.2%	41.4%	✓	1.9%
Marion	14.8%	✓	0.5%	5.4%	✓	0.7%	37.9%	✓	1.5%
Polk	14.4%	✓	0.9%	4.9%	⊙	1.4%	36.7%	✓	2.7%
Yamhill	15.7%	✓	0.9%	5.7%	✓	1.3%	40.4%	✓	2.6%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau, 20013–2017 American Community Survey 5-Year Estimates, Table DP02

Homeless Population

The U.S. Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count (PIT), a biennial count of both sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors. They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing and Community Services, 2019, Nov. 21). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing and Community Services, 2019, Nov. 21).

With the exception of Marion County, all counties in the region reported an increase in the overall number of homeless persons between 2017 and 2019. Linn County reported the largest percentage increase during this period (54%), while Lane County reported the greatest increase in the total number of people experiencing homelessness. Lane County also reported an increase in its unsheltered homeless population during this period and has one of the largest homeless populations in the state (Oregon Housing and Community Services, 2019).

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate their vulnerability. Disasters that result in damage to the built environment can place additional stress on temporary shelters, a vital service for many people experiencing homelessness (Peacock, Dash, Zhang, & Van Zandt, 2017). Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of

Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-278. Homeless Population Estimate for Region 3

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 3	3,091	3,640	4,575	3,769
Benton	127	287	331	248
Lane	1,473	1,529	2,165	1,722
Linn	222	180	277	226
Marion	732	1,049	974	918
Polk	42	102	121	88
Yamhill	495	493	707	565

Source: Oregon Point in Time Homeless Count, Oregon Housing and Community Services.
http://www.oregon.gov/ohcs/pages/ra_point_in_time_homeless_count.aspx

Biological Sex and Gender

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019). According to the survey, there are slightly more women than men (98.3 men for every 100 women) (U.S. Census Bureau, 2019). The same is true for all counties in the region, except Benton County, which has slightly more men (101.9 men for every 100 women) (U.S. Census Bureau, 2019). Within the region, Polk County has the greatest male to female disparity (94.5 men for every 100 women) (U.S. Census Bureau, 2019).

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognized (Enarson, 2017). This is an area deserving of more attention as the field develops

Age

Region 3 has the same proportion of older adults, persons aged 65 and older, as the state as a whole. Within the region, Benton and Marion Counties have the smallest share of older adults (14.6%) and Lane and Linn Counties have the greatest (17%). Older adults require special consideration in the planning process. They are more likely to have a disability and require assistance from others to complete routine tasks. Family or neighbors who might ordinarily assist them might be unable to help during a disaster event (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Moreover, an older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

Children, persons under the age of 18, also represent a vulnerable segment of the population. Within the region, Benton County has the smallest share (16.7%) of children and Marian County has the greatest (25.3%). Special consideration should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. Parents may lose time from work and money when their children's childcare facilities and schools are impacted by disasters (Cutter, Boruff, & Shirley, 2003).

Table 2-279. Population by Vulnerable Age Group, in Region 3

	Total Population	Under 18 Years Old			65 Years and Older		
	Estimate	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	4,025,127	21.5%	☑	0.1%	16.3%	☑	0.1%
Region 3	1,085,279	21.9%	☑	0.0%	16.3%	☑	0.0%
Benton	88,249	16.7%	☑	0.1%	14.6%	☑	0.1%
Lane	363,471	19.0%	☑	*	17.7%	☑	0.1%
Linn	121,074	23.1%	☑	*	17.6%	☑	0.1%
Marion	330,453	25.3%	☑	*	14.6%	☑	0.1%
Polk	79,666	23.3%	☑	*	16.9%	☑	0.1%
Yamhill	102,366	23.1%	☑	0.1%	15.9%	☑	0.1%

*Indicates that the estimate has been controlled to be equal to a fixed value and so it has no sampling error.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP05: ACS Demographics and Housing Estimates, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Language

Special consideration should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to language and culturally appropriate outreach materials. Similar to the state, almost 94% of the region's population speaks English "very well". Notably, approximately 11% of the people in Marion County speak English less than "very well". Outreach materials used to communicate with and plan for this community should take into consideration their language needs.

Table 2-280. English Usage in Region 3

	Speak English Less Than "Very Well"				
	Estimate	CV**	MOE (+/−)	Percent	% MOE (+/−)
Oregon	222,428	☑	4,116	5.9%	0.1%
Region 3	57,156	☑	2,058	5.6%	0.2%
Benton	3,550	☑	466	4.2%	0.6%
Lane	9,080	☑	861	2.6%	0.2%
Linn	2,352	☑	404	2.1%	0.4%
Marion	33,206	☑	1,578	10.8%	0.5%
Polk	3,797	☑	587	5.1%	0.8%
Yamhill	5,171	☑	529	5.4%	0.5%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP02

Education Level

Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual's ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

Approximately 28% of residents in Region 3 have a bachelor's degree or higher, which is approximately five percentage points lower than the statewide estimate. One tenth of residents in the region do not have a high school diploma, which is similar to the statewide share. Approximately one-quarter of the population has received some college credit. Similar to the statewide share, roughly 9% of Region 3 residents, or between 5%-10% in each county, has an associate's degree.

Benton County is a notable outlier in the region and state, with nearly 54% of residents holding a four-year degree or more. This is likely a result of a relatively small population and the presence of Oregon State University in Corvallis. Within the region, Linn County has the smallest share of residents with at a bachelor's degree or more (18.6%) and Marion County has the highest share of residents without a high school diploma (15.1%).

Figure 2-169. Educational Attainment in Region 3: (top) by County, (bottom) Regional vs. Statewide

Source: U.S. Census Bureau (2018). Table DP02: Selected Social Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Income and Poverty

The impact of a disaster in terms of loss and the ability to recover varies among population groups. “The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event” (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public (Stahl, P., 2000). Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, are less likely to have the savings to rebuild after a disaster, and are less likely to have access to transportation and medical care.

Across the region, median household income generally declines with distance from the Portland Metropolitan Area. Yamhill County has the highest median household income, approximately $2,000 above the statewide median. Lane County has the lowest and is approximately $8,000 below the statewide estimate. From 2012 to 2017, only Lane County and Marion County experienced a statistically significant change in median household income—both increased.

Table 2-281. Median Household Income in Region 3

	2008–2012			2013–2017			Statistically Different*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	$53,427	☑	$338	$56,119	☑	$370	Yes
Region 3	—	—	—	—	—	—	—
Benton	$51,963	☑	$2,574	$54,682	☑	$2,361	No
Lane	$45,680	☑	$858	$47,710	☑	$857	Yes
Linn	$50,518	☑	$1,304	$49,515	☑	$1,904	No
Marion	$49,750	☑	$848	$53,828	☑	$1,048	Yes
Polk	$56,343	☑	$2,001	$56,032	☑	$2,412	No
Yamhill	$57,650	☑	$2,043	$58,392	☑	$2,118	No

Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

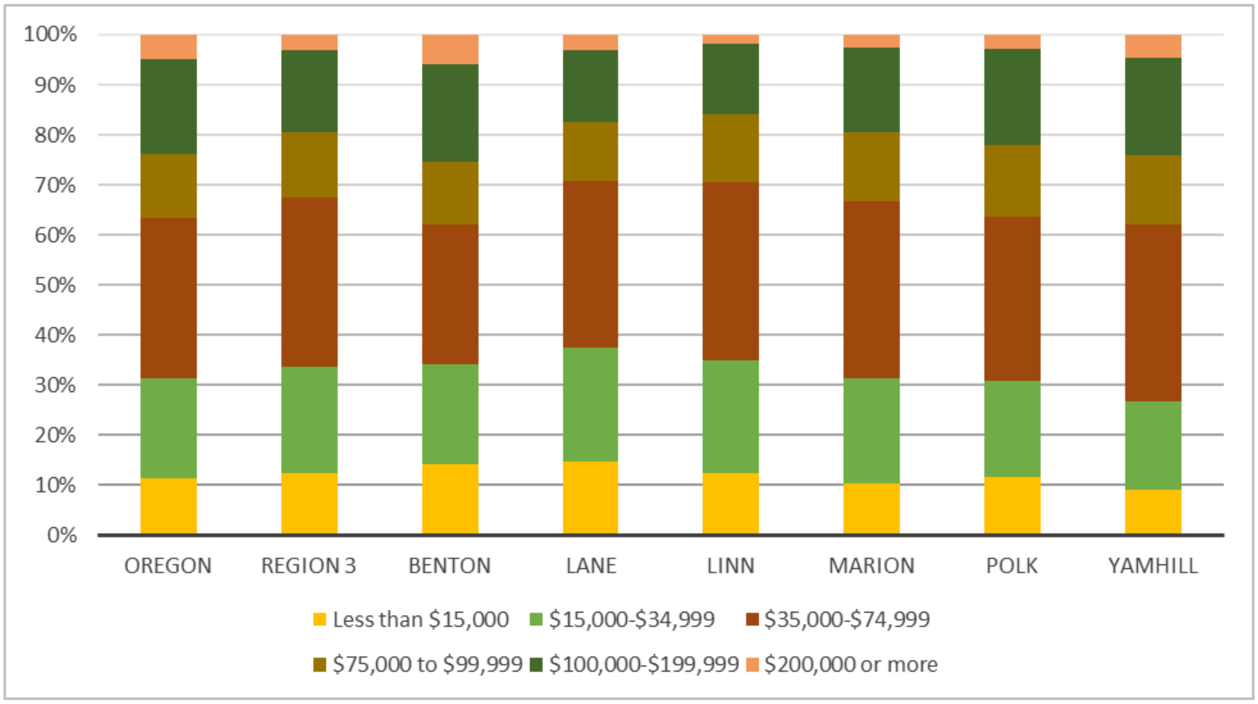
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2002 and 2013-2017. American Community Survey – 5-Year Estimates. Table CP03

The region has a larger share of its households earning less than $35,000 per year than the state as a whole. Within the region, Lane County has the highest percentage of people in the lowest income bracket, less than $15,000 per year, and Yamhill has the smallest share. Benton and Yamhill Counties have a higher percentage of households earning more than $75,000 per year than the state.

Figure 2-170. Median Household Income Distribution in Region 3



Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP03

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018).

A greater share of the regional population overall is living in poverty compared to the state as a whole. Marion County was the only county in the region to experience a statistically significant change—a decrease—in the share of people experiencing poverty from 2012 to 2017. All counties in the region, with the exception of Yamhill County, have a higher percentage of people living in poverty than the state as a whole. Benton County has the largest share of people living in poverty, approximately six percentage points more than the statewide estimate and 3.7 above the regional share. However, it should be noted that poverty rates can be influenced by college students living off-campus. Past U.S. Census Bureau research found that Benton, Lane, and Polk Counties saw statistically significant decreases in poverty rates after the exclusion of off-campus college students (Benson & Bishaw, 2017). The majority of counties in their research saw decreases of five percentage points or less in their poverty rates when college students living off campus were excluded from the sample (Benson & Bishaw, 2017).

A higher percentage of children in Region 3 are living in poverty compared to the statewide share. Although Marion County continues to have the highest percentage of child poverty in the region, it was the only county that experienced a statistically significant decrease from 2012 to 2017. Benton County has the lowest estimate in the region, approximately six percentage points below the regional share.

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources.

Table 2-282. Poverty Rates in Region 3

	Total Population in Poverty						
	2008-2012			2013-2017			Statistical Difference?*
	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)	
Oregon	15.5%	☑	0.3%	14.9%	☑	0.3%	No
Region 3	17.8%	☑	0.5%	17.0%	☑	0.4%	No
Benton	21.6%	☑	1.3%	20.7%	☑	1.1%	No
Lane	18.8%	☑	0.7%	18.8%	☑	0.7%	No
Linn	16.7%	☑	1.3%	16.1%	☑	1.5%	No
Marion	18.0%	☑	1.0%	15.9%	☑	0.9%	Yes
Polk	14.6%	☑	1.5%	15.4%	☑	1.5%	No
Yamhill	13.9%	☑	1.4%	13.7%	☑	1.3%	No

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2012 and 2013-2017. American Community Survey – 5-Year Estimates, Table S1701

Table 2-283. Child Poverty in Region 3

	Children Under 18 in Poverty						
	2008-2012			2013-2017			Statistical Difference?*
	Estimate	**CV****	**MOE (+/−)**	**Estimate**	**CV****	**MOE (+/−)**	
Oregon	20.6%	☑	0.5%	19.0%	☑	0.6%	Yes
Region 3	22.7%	☑	1.0%	20.7%	☑	1.0%	Yes
Benton	16.4%	☑	3.4%	12.8%	☑	2.9%	No
Lane	20.3%	☑	1.7%	20.3%	☑	1.8%	No
Linn	25.2%	☑	2.7%	21.6%	☑	3.0%	No
Marion	27.1%	☑	1.8%	23.2%	☑	2.0%	Yes
Polk	18.9%	☑	3.4%	17.5%	☑	3.7%	No
Yamhill	18.8%	☑	2.7%	19.5%	☑	2.9%	No

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2012 and 2013-2017. American Community Survey – 5-Year Estimates, Table S1701

Housing Tenure

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

The percentage of homeownership exceeds that of the state in Linn, Polk, and Yamhill Counties. Benton County has a higher rate of renter occupied units than other counties in the region. This number is likely driven by rental demand for off campus housing for students attending Oregon State University in Corvallis.

Table 2-284. Housing Tenure in Region 3

	Total Occupied Units	Owner Occupied			Renter Occupied		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	61.7%	☑	0.3%	38.3%	☑	0.3%
Region 3	410,949	60.7%	☑	0.4%	39.3%	☑	0.5%
Benton	34,775	56.9%	☑	1.5%	43.1%	☑	1.5%
Lane	148,752	58.8%	☑	0.7%	41.2%	☑	0.7%
Linn	46,265	64.1%	☑	1.5%	35.9%	☑	1.5%
Marion	116,077	59.8%	☑	0.8%	40.2%	☑	0.8%
Polk	29,128	64.6%	☑	1.9%	35.4%	☑	1.9%
Yamhill	35,952	67.9%	☑	1.4%	32.1%	☑	1.4%

Source: U.S. Census Bureau, 2013–2017 American Community Survey 5-Year Estimates, Table DP04; https://data.census.gov/cedsci/

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households (Cutter, Boruff, & Shirley, 2003). Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only.

Region 3 is predominantly composed of family households. Benton and Lane Counties have higher percentages of non-family households and single-person households, estimates which are likely influenced by the presence of large universities. The region as a whole has approximately the same percentage of households with children as the state, but a greater share of single-parent households. Marion County has the highest percentage of single-parent households, followed closely by Linn and Yamhill Counties.

Table 2-285. Family vs. Non-family Households in Region 3

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	63.3%	☑	0.2%	36.7%	☑	0.2%	27.7%	☑	0.2%
Region 3	410,949	64.0%	☑	0.5%	36.0%	☑	0.5%	26.8%	☑	0.4%
Benton	34,775	55.9%	☑	1.5%	44.1%	☑	1.5%	27.9%	☑	1.4%
Lane	148,752	59.1%	☑	0.7%	40.9%	☑	0.7%	29.6%	☑	0.7%
Linn	46,265	68.1%	☑	1.4%	31.9%	☑	1.4%	24.7%	☑	1.2%
Marion	116,077	68.2%	☑	0.8%	31.8%	☑	0.8%	25.5%	☑	0.8%
Polk	29,128	67.9%	☑	1.5%	32.1%	☑	1.5%	24.0%	☑	1.5%
Yamhill	35,952	70.5%	☑	1.6%	29.5%	☑	1.6%	23.2%	☑	1.5%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. https://data.census.gov/cedsci/. Table DP02: Selected Social Characteristics

Table 2-286. Family Households with Children by Head of Household in Region 3

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
Oregon	26.2%	☑	0.2%	8.1%	☑	0.2%
Region 3	26.3%	☑	0.4%	8.5%	☑	0.3%
Benton	21.8%	☑	1.0%	4.6%	☑	0.8%
Lane	22.6%	☑	0.5%	7.8%	☑	0.5%
Linn	27.7%	☑	1.0%	9.6%	☑	1.0%
Marion	30.4%	☑	0.8%	10.2%	☑	0.8%
Polk	27.9%	☑	1.4%	7.4%	☑	1.3%
Yamhill	29.1%	☑	1.2%	9.1%	☑	1.1%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. https://data.census.gov/cedsci/. Table DP02: Selected Social Characteristics

Social and Demographic Trends

The social and demographic analysis shows that Region 3 is particularly vulnerable during a hazard event in the following categories:

- Except for Marion County, all counties in the region experienced an increase in the overall number of homeless persons between 2015 and 2019.
- Lane County has one of the largest homeless populations in the state and experienced an increase in its unsheltered population during the same period.
- Approximately 11% of the population in Marion County does not speak English "very well".
- A greater share of the regional population is living in poverty compared to the statewide percentage. Moreover, a higher percentage of children are living in poverty in the region compared to the state as a whole. Marion County has the highest child poverty rate.
- Marion, Linn, and Yamhill have a higher share of single-parent households compared to the statewide estimate.

Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses' labor, capital, suppliers, and customers are all relevant factors (Zhang, Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang, Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent.

Employment and Unemployment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 3 have been steadily declining since they peaked in 2009 during the Great Recession. Within the region, rates are similar to the statewide average and consistently lowest in Benton County and highest in Linn County. Reflecting largest populations, the majority of employment is in Marion and Lane Counties.

Table 2-287. Civilian Labor Force in Region 3, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 3	544,552	521,334	95.7%	23,218	4.3%
Benton	48,345	46,810	96.8%	1,535	3.2%
Lane	181,761	173,596	95.5%	8,165	4.5%
Linn	58,551	55,780	95.3%	2,771	4.7%
Marion	161,676	154,716	95.7%	6,960	4.3%
Polk	39,695	37,959	95.6%	1,736	4.4%
Yamhill	54,524	52,473	96.2%	2,051	3.8%

Source: Oregon Employment Department, 2019

Table 2-288. Civilian Unemployment Rates in Region 3, 2014-2018

	2014	2015	2016	2017	2018	Change (2014-2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	−2.6%
Region 3	6.9%	5.8%	5.0%	4.3%	4.3%	−2.7%
Benton	5.1%	4.2%	3.9%	3.2%	3.2%	−1.9%
Lane	6.9%	5.8%	5.1%	4.4%	4.5%	−2.4%
Linn	8.1%	6.7%	5.7%	4.7%	4.7%	−3.4%
Marion	7.4%	6.0%	5.1%	4.3%	4.3%	−3.1%
Polk	6.8%	5.6%	5.0%	4.3%	4.4%	−2.4%
Yamhill	6.4%	5.3%	4.6%	3.8%	3.8%	−2.6%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups “economic units that have similar production processes” according to a six-digit hierarchical structure (Office of Management and Budget, n.d.). “The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry” (Office of Management and Budget, n.d.). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors (U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 1 were:

1. Trade, Transportation and Utilities
2. Education and Health Services
4. Local Government
5. Manufacturing
6. Leisure and Hospitality

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region’s resiliency. A business establishment is an “economic unit… that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity” (U.S. Bureau of Labor Statistics, 2019, Sept. 4). In Region 3, the following supersectors comprise a significant share of all business establishments.

- The Other Services supersector includes the highest number of establishments in Region 3, 17.7% of the share (QCEW, 2018).
- Trade Transportation and Utilities is second largest, with 15.8% of all establishments (QCEW, 2018).

- Professional and Business Services is third with 13.5% of the regional share (QCEW, 2018).
- Professional and Business comprises is fourth, comprising 10.7% of all establishments (QCEW, 2018).
- The Construction supersector is fifth largest, making up 9.9% of all businesses (QCEW, 2018).

While supersectors are useful abstractions, it’s important to remember that within are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event.

Table 2-289. Covered Employment by Sector in Region 3

Industry	Region 3	Benton County		Lane County		Linn County	
	%	Employment	%	Employment	%	Employment	%
Total All Ownerships	100.0%	38,058	100.0%	156,759	100.0%	47,341	100.0%
Total Private Coverage	81.4%	28,542	75.0%	132,431	84.5%	40,649	85.9%
Natural Resources & Mining	4.6%	1,083	2.8%	2,360	1.5%	2,447	5.2%
Construction	5.4%	1,198	3.1%	7,204	4.6%	3,030	6.4%
Manufacturing	10.0%	3,013	7.9%	14,195	9.1%	8,263	17.5%
Trade, Transportation & Utilities	17.0%	4,589	12.1%	29,873	19.1%	9,948	21.0%
Information	1.1%	600	1.6%	2,411	1.5%	393	0.8%
Financial Activities	3.5%	1,123	3.0%	6,200	4.0%	1,387	2.9%
Professional & Business Services	9.3%	4,284	11.3%	18,188	11.6%	2,959	6.3%
Education & Health Services	16.6%	6,760	17.8%	27,763	17.7%	6,438	13.6%
Leisure & Hospitality	9.9%	4,260	11.2%	17,558	11.2%	3,893	8.2%
Other Services	4.0%	1,622	4.3%	6,630	4.2%	1,872	4.0%
Unclassified	0.0%	11	0.0%	48	0.0%	19	0.0%
Total All Government	18.6%	9,516	25.0%	24,328	15.5%	6,692	14.1%
Total Federal Government	1.0%	476	1.3%	1,802	1.1%	306	0.6%
Total State Government	4.9%	216	0.6%	1,680	1.1%	599	1.3%
Total Local Government	12.7%	8,824	23.2%	20,846	13.3%	5,787	12.2%

Industry	Region 3	Marion County		Polk County		Yamhill County	
	%	Employment	%	Employment	%	Employment	%
Total All Ownerships	100.0%	155,949	100.0%	20,442	100.0%	36,339	100.0%
Total Private Coverage	81.4%	121,028	77.6%	15536	76.0%	32155	88.5%
Natural Resources & Mining	4.6%	9,565	6.1%	1750	8.6%	3,669	10.1%
Construction	5.4%	9,993	6.4%	1031	5.0%	1,977	5.4%
Manufacturing	10.0%	10,862	7.0%	2272	11.1%	6896	19.0%
Trade, Transportation & Utilities	17.0%	25,739	16.5%	2467	12.1%	4844	13.3%
Information	1.1%	1,288	0.8%	65	0.3%	242	0.7%
Financial Activities	3.5%	5,714	3.7%	463	2.3%	1007	2.8%
Professional & Business Services	9.3%	13,555	8.7%	1232	6.0%	1940	5.3%
Education & Health Services	16.6%	24,704	15.8%	3325	16.3%	6392	17.6%
Leisure & Hospitality	9.9%	13,642	8.7%	1995	9.8%	3792	10.4%
Other Services	4.0%	5,916	3.8%	924	4.5%	1386	3.8%
Unclassified	0.0%	51	0.0%	11	0.1%	9	0.0%
Total All Government	18.6%	34,921	22.4%	4,905	24.0%	4,184	11.5%
Total Federal Government	1.0%	1,294	0.8%	112	0.5%	440	1.2%
Total State Government	4.9%	19,350	12.4%	343	1.7%	211	0.6%
Total Local Government	12.7%	14,277	9.2%	4,450	21.8%	3,532	9.7%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment sector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region.

Education and Health Services: The Health and Social Assistance industries play important roles in emergency response in the event of a disaster. Health care is a relatively stable revenue sector regionally with an abundant distribution of businesses primarily serving a local population.

Manufacturing: This supersector is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons the manufacturing sector may be susceptible to disruptions in transportation infrastructure. However, manufacturers are often less dependent on local markets for sales, which may contribute to the economic resilience of this sector. The timber manufacturing industry is particularly vulnerable to droughts, landslides, and wildfires.

Leisure and Hospitality: This supersector primarily serves regional residents with disposable income and tourists. The behavior of both of these social groups would be disrupted by a natural disaster. Regional residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. Notably, in Region 2, three of the largest subsectors by share of employment are healthcare related, Ambulatory—also known as outpatient services—Health Care Services, Nursing and Residential Care Facilities, and Hospitals. Many of the top employment subsectors are similar across regions. For example, Food Services and Drinking Places and Educational Services are the two largest employment subsectors in Region 6. These subsectors also rank highly in other regions. Conversely, other subsectors, such as Crop Production, are more unique to the region.

Table 2-290. Industries with Greatest Share of Employment in Region 3, 2018

Industry	Employment Share	Employment (2018)
Educational Services	9%	49,375
Food Services and Drinking Places	8%	45,386
Administrative and Support Services	6%	30,211
Ambulatory Health Care Services	5%	24,936
Nursing and Residential Care Facilities	4%	19,834
Hospitals	4%	18,981
Specialty Trade Contractors	3%	18,456
Social Assistance	3%	18,306
Professional, Scientific, and Technical Services	3%	18,050
Crop Production	3%	16,292

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for employment share and average employment by DLCD

Industry Concentration and Employment Change

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

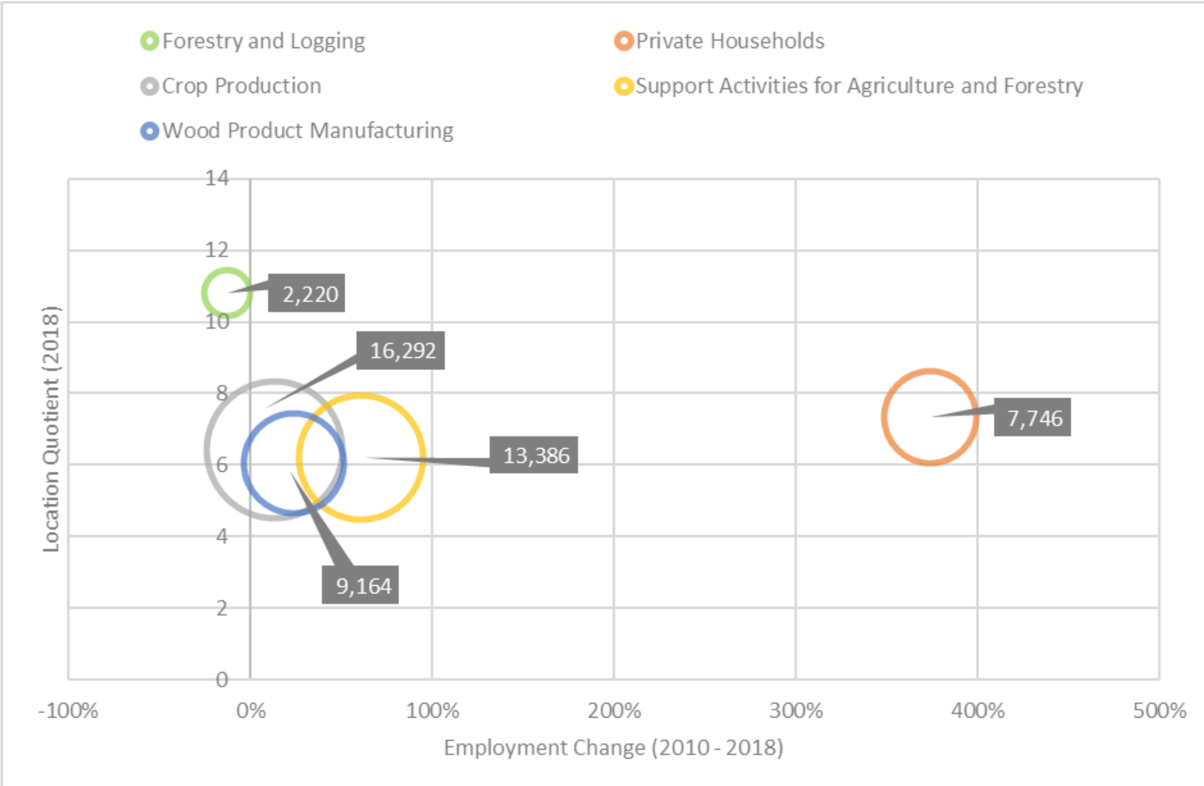
Table 2-291. Most Concentrated Industries and Employment Change in Region 3, 2018

Industry	Location Quotient	Employment (2018)	Employment Change (2010–2018)
Forestry and Logging	10.8	2,220	−13%
Private Households	7.3	7,746	374%
Crop Production	6.4	16,292	13%
Support Activities for Agriculture and Forestry	6.2	13,386	61%
Wood Product Manufacturing	6.1	9,164	24%

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 3 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-171. Location Quotients, Employment Change, and Total Employment in Region 3, 2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

Four of the region's five most concentrated industries are natural resource based—three have ties to timber. The Forestry and Logging subsector has the highest location quotient, but constitutes a small share of overall employment and shed jobs from 2010 to 2018. The Wood Product Manufacturing subsector has a location quotient over six—a value five-hundred percent higher than would be expected vis-à-vis the nation; the sector increased employment by nearly a quarter during the eight-year period. Employment concentrations in Crop Production and Support Activities of Agriculture and Forestry reflects the rich agricultural economy of the Mid-Willamette Valley and together comprise a significant number of jobs.

Fastest Growing and Declining Industries

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang, Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining.

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 3's fastest growing and declining industries.

Table 2-292. Fastest Growing and Declining Industries in Region 3, 2010-2018

Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Private Households	374%	1,636	7,746
Motion Picture and Sound Recording Industries	265%	771	2,811
Other Information Services	208%	224	692
Air Transportation	144%	446	1,086
Construction of Buildings	101%	4,474	9,009
Fastest Declining			
Apparel Manufacturing	−67%	472	155
Paper Manufacturing	−41%	1,344	797
Executive, Legislative, and Other General Government Support	−37%	13,019	8,210
Wholesale Electronic Markets and Agents and Brokers	−31%	1,772	1,227
Publishing Industries (except Internet)	−23%	3,614	2,776

U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

Mirroring a statewide trend, employment in the Private Households subsector grew quickly in Oregon from 2010 to 2018 (Wallis, 2019). The Private Households industry employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019).

While most employment in the Motion Picture and Sound Recording Industries subsector is concentrated in the Portland metro area, Region 3 experienced strong growth in the subsector during the eight-year period. This regional specialty is indicated in the shift-share analysis, which shows the regional-shift as the largest driver of growth. Part of the increase is likely driven by the state's reputation as a hub for multimedia artists and animators (Starbuck, 2016).

Growth in the Construction of Buildings subsector was strong and mostly driven by regional factors. One reason for strong growth through the period, however, is that the subsector was severely impacted by the housing-bubble that led to the Great Recession. The decline in employment began around 2007 and was at its lowest point in 2010 (Cooke, 2019).

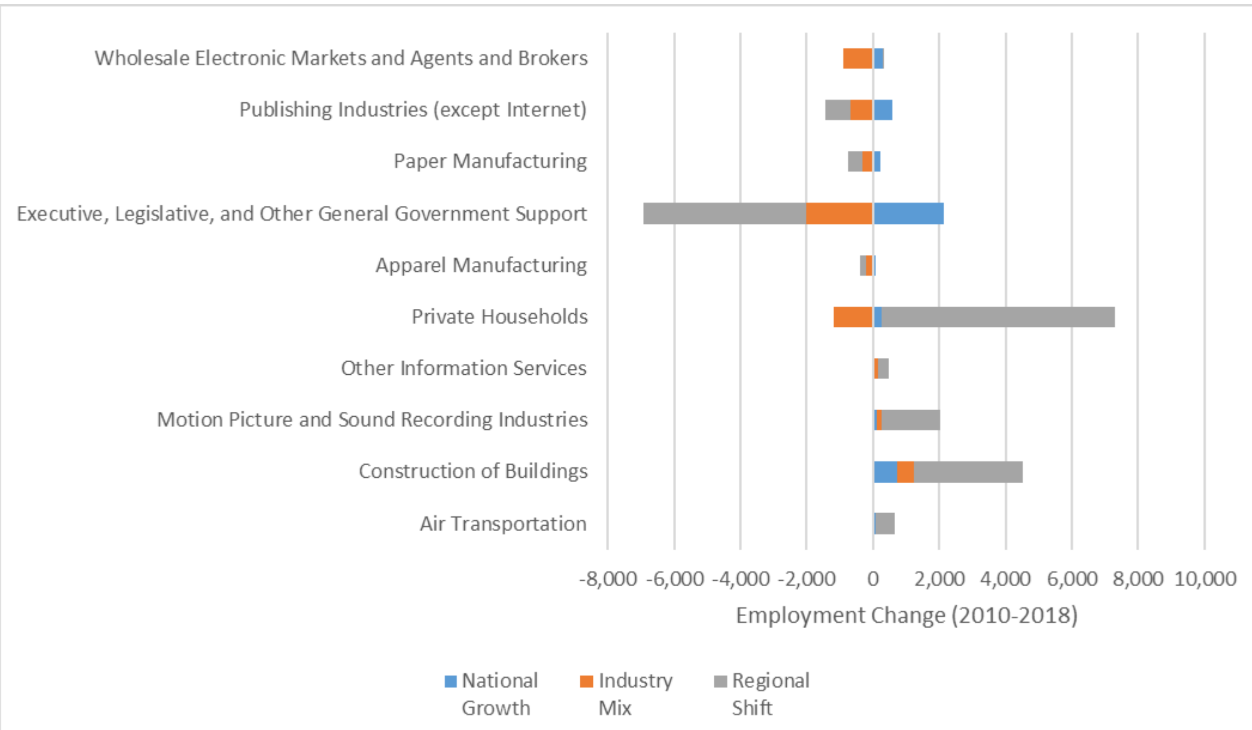
The Air Transportation and Other Information Services subsectors also experienced strong growth during the period. Growth in the Air Transportation subsector was likely drive in part by increased service and passenger travel in Eugene. According to the shift-share analysis, most of the growth in both subsectors was driven by regional factors.

The Wholesale Electronic Markets and Agents and Brokers subsector—which coordinates the sale of goods owned by others, typically for a commission or fee—lost jobs during the 2010 to 2018 period. According to the shift-share analysis, the job loss was not driven by regional factors but forces impacting the industry nationwide. The subsector is part of the larger Wholesale

Trade Sector, which generally saw an increase in employment in the state since the end of the Great Recession (Tauer, 2019).

The largest decline occurred in the Executive, Legislative, and Other General Government support. While some of the loss can be explained by trends in the subsector nationally, the regional shift suggests something unique happened in the region during the period. The same is true for trends in the Paper Manufacturing, Publishing Industries (Except Internet), and Apparel Manufacturing subsectors. Losses in the Paper Manufacturing subsector represent the continuation of a decade's long statewide trend (Knoder, Paper cuts: Oregon's declining paper industry, 2018, December 6). Increased competition from abroad is a key driver of employment loss statewide (Knoder, Paper cuts: Oregon's declining paper industry, 2018, December 6). Job loss in Publishing Industries (Except Internet), a subsector comprised of newspaper and periodical businesses, is likely driven by shifts in the media landscape, away from print materials to online platforms.

Figure 2-172. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 3, 2010-2018



U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Table 2-293. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 2, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Air Transportation	640	740	−24	591
Construction of Buildings	4,535	732	505	3,298
Motion Picture and Sound Recording Industries	2,040	126	116	1,798
Other Information Services	467	37	114	316
Private Households	6,110	268	−1,200	7,043
Fastest Declining				
Apparel Manufacturing	−317	77	−209	−185
Executive, Legislative, and Other General Government Support	−4,808	2,130	−2,028	−4,910
Paper Manufacturing	−547	220	−304	−464
Publishing Industries (except Internet)	−838	591	−683	−746
Wholesale Electronic Markets and Agents and Brokers	−545	290	−882	48

U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Economic Trends and Issues

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the following situations increase Region 3’s level of vulnerability to natural hazard events:

- Unemployment in Linn County is consistently higher than its regional counterparts and higher than the statewide average;
- Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- The Forestry and Logging subsector, an area of competitive advantage for the region, shed jobs from 2010-2018.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl, et al., 2000).

Infrastructure

Transportation

Roads

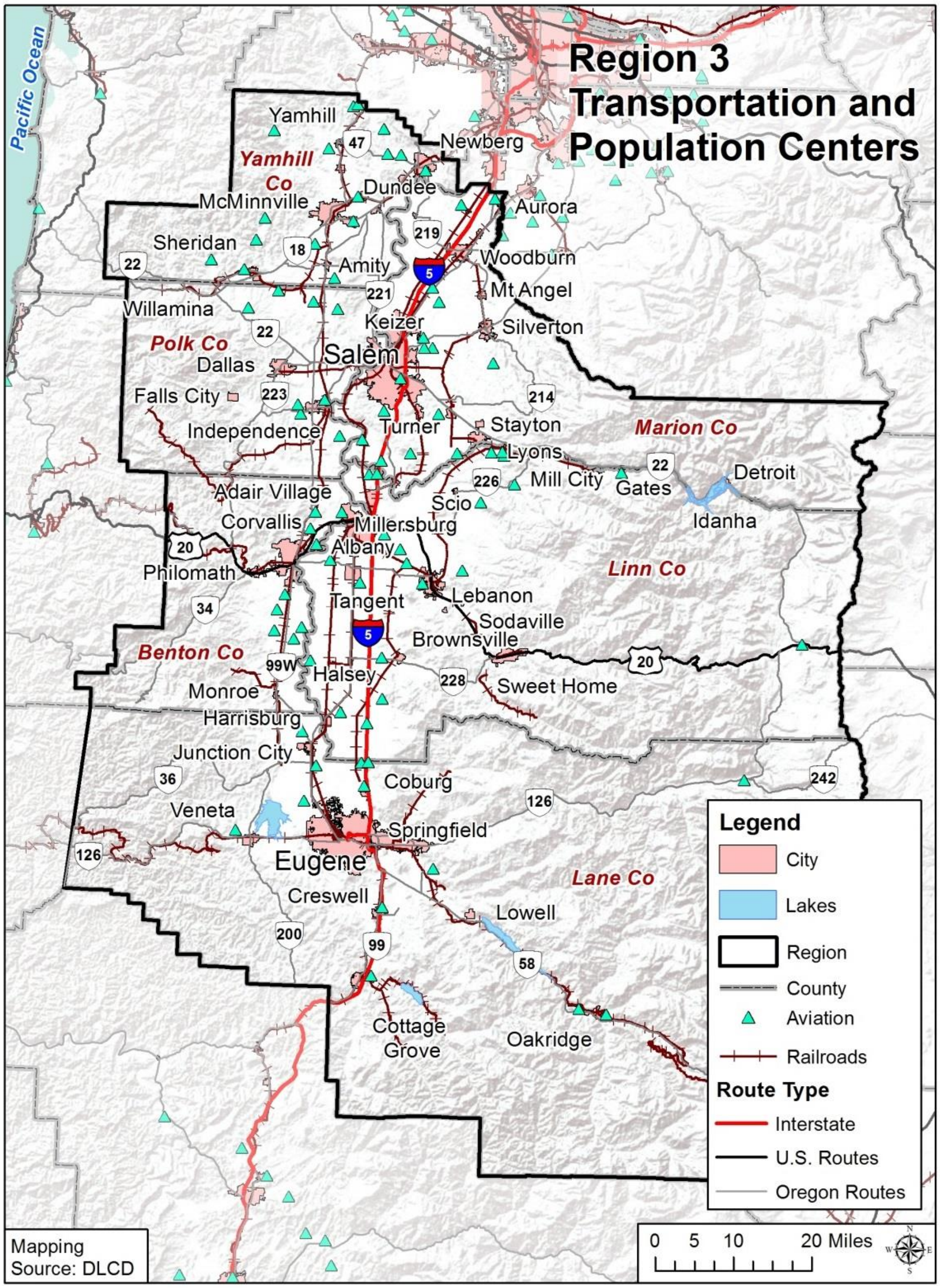
The highway system in the Region 3 centers on I-5 and the major east-west highways that intersect it. Recent population growth in the region has increased the number of vehicles on the roads. Many trips through the region originate outside the region in the Portland Metropolitan Area. Portland drivers commonly enter the region to reach Salem, The Spirit Mountain Casino, and coastal destinations. Many new residents of Yamhill County commute to Portland for work. **Figure 2-173** shows Region 3's highways and population centers.

Region 3's growing population centers bring more workers, automobiles and trucks onto roads. A high percentage of workers driving alone to work coupled with interstate and international freight movement on the I-5 corridor create additional stresses on transportation systems. Some of these include added maintenance, congestion, oversized loads, and traffic accidents.

Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuations and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

According to the Oregon Department of Transportation's (2014, October) Seismic Plus Report (Appendix **9.1.13**), the region has high exposure to earthquakes, especially a Cascadia Subduction Zone event. Therefore, the seismic vulnerability of the region's lifelines, including roadways and bridges, is an important issue. For information on ODOT's 2012 Seismic Lifelines Report findings for Region 3, see **Seismic Lifelines**.

Figure 2-173. Region 3 Transportation and Population Centers



Source: Oregon Department of Transportation, (2014, October)

Bridges

ODOT lists 2,096 bridges in the counties that comprise Region 3.

Because of earthquake risk in Region 3, the seismic vulnerability of the region's bridges is an important issue. Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or that are part of regional and local systems that are maintained by the region's counties and cities.

Table 2-294 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. These ratings do not imply that a bridge is unsafe (ODOT, 2020). A significant improvement in the condition of the region's bridges reduced to 7% (from 29% in 2012 and 2013) the percentage of the region's bridges that are distressed or deficient. About 2% (from 22% in 2012 and 2013) of the region's ODOT bridges are distressed. Seventeen percent of all bridges in Linn County are categorized as such, the highest percentage for any county in Oregon. Thirteen percent of city owned bridges in Linn County and 25% of Linn County owned bridges are categorized by ODOT as distressed or deficient.

Table 2-294. Bridge Inventory for Region 3

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 3	12	717	2%	119	1126	11%	11	227	5%	4	26	15%	146	2096	7%
Benton	0	44	0%	11	93	12%	2	29	7%	0	2	0%	13	168	8%
Lane	7	290	2%	7	410	2%	2	74	3%	2	11	18%	18	785	2%
Linn	2	142	1%	77	306	25%	5	40	13%	0	4	0%	84	492	17%
Marion	0	138	0%	10	139	7%	1	71	1%	0	6	0%	11	354	3%
Polk	0	52	0%	5	89	6%	1	13	8%	2	2	100%	8	156	5%
Yamhill	3	51	6%	9	89	10%	0	0	N/A	0	1	0%	12	141	9%

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2020)

Railroads

Railroads are major providers of regional and national cargo and trade flows. Railroads that run through the Mid/Southern Willamette region primarily run in a north-south direction. The Union Pacific Railroad (UP) is the major freight railroad. An Amtrak passenger train also runs on the UP line. It runs north to Spokane and south to Southern California where the tracks turn east and continue to Texas. Other freight railroads in the region include the Central Oregon and Pacific, the Albany and Eastern, the Portland and Western, the Hampton Railway, the Willamette and Pacific, and the Willamette Valley Railway.

Oregon's rail system is critical to the state's economy, energy, and food systems. Rail systems export lumber and wood products, pulp and paper, and other goods produced in Oregon and products from other states that are shipped to and through Oregon by rail (Cambridge Systematics, 2014).

Rails are sensitive to icing from winter storms that can occur in the Mid/Southern Willamette Valley. Disruptions to the rail system can result in economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

Fifteen public airports, 73 private airports, two public helipads, and 16 private helipads serve Region 3. The Eugene Airport is the largest public airport in the region and the second busiest in Oregon (Federal Aviation Administration [FAA], 2012). The airport is owned, operated, and administered by the City of Eugene. It serves 10 hubs and six air carriers with approximately 56 arriving and departing flights daily (Eugene, Oregon website, Visitors page, https://www.eugene-or.gov/index.aspx?NID=1715).

Table 2-295. Public and Private Airports in Region 3

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Helipad	Private Helipad	Total
Region 3	15	73	2	16	106
Benton	1	9	0	1	11
Lane	7	9	1	5	22
Linn	3	20	0	2	25
Marion	2	13	1	6	22
Polk	1	7	0	0	8
Yamhill	1	15	0	2	18

Source: FAA Airport Master Record (Form 5010), (2014)

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

Energy

Electricity

The region is served by several investor-owned, public, cooperative, and municipal utilities. The Bonneville Power Administration is the area's wholesale electricity distributor. Pacific Power and Light (Pacific Power) is the largest investor-owned utility company serving primarily Linn, Polk, and Marion Counties. Portland General Electric is another investor-owned utility and serves Marion and Yamhill Counties. The Blachly-Lane Electric Cooperative, Lane County Electric Cooperative, and Western Oregon Electric Cooperative each serve a portion of Region 3. Four municipal utility districts serve the region: Eugene Water and Electric Board, Monmouth, McMinnville, and Springfield Utility Board. In addition, the Central Lincoln People's Utility District, Consumer's Power, Inc., Emerald People's Utility District, and Salem serve portions of the region.

The Mid/Southern Willamette Valley has a total of 16 power-generating facilities: 11 hydroelectric power facilities, one natural gas power facility, and four "other" facilities (primarily biomass and solar photovoltaic). In total, the power-generating facilities have the ability to produce up to 668 megawatts (MW) of electricity.

Table 2-296. Power Plants in Region 3

	Hydro-electric	Natural Gas	Wind	Coal	Other*	Total
Region 3	11	1	0	0	4	16
Benton	0	0	0	0	0	0
Lane	7	1	0	0	1	9
Linn	4	0	0	0	1	5
Marion	0	0	0	0	0	0
Polk	0	0	0	0	0	0
Yamhill	0	0	0	0	2	2
Energy Production (MW)	585	51	0	0	32	668

*"Other" includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

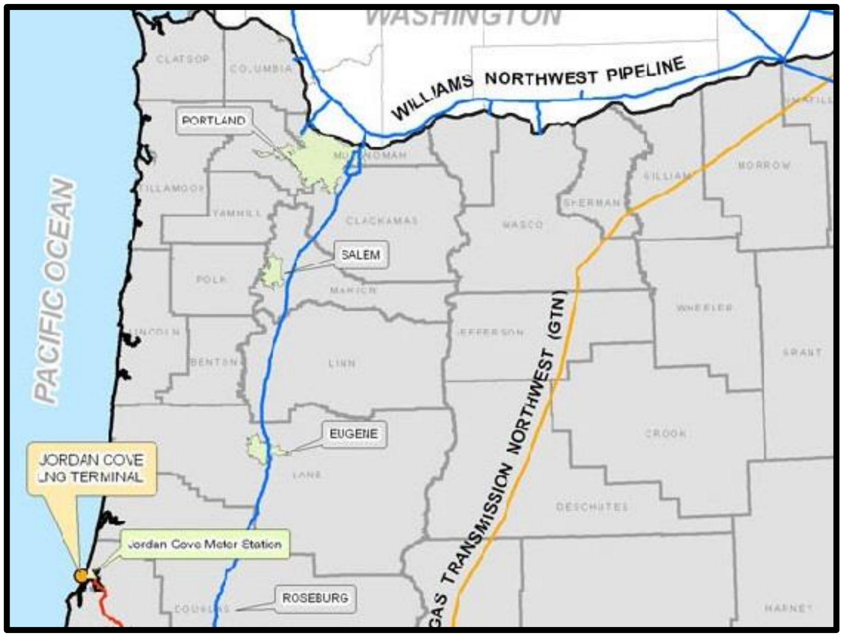
Hydropower

The majority of electrical power in Region 3 is generated hydroelectrically. The Detroit, Carmen-Smith, and Lookout Point dams generate the most power for the region. They are each capable of generating over 100 MW. There are also several power plants that use biomass as their energy source (Loy, 2001). Bonneville Power Administration (BPA) provides hydro-generated electricity to the state's consumer-owned utilities. BPA's major dams in Region 3 are located on the following rivers: North Santiam River (Big Cliff and Detroit), South Santiam River (Foster and Green Peter), McKenzie River (Cougar), and Middle Fork of the Willamette River (Dexter, Lookout Point and Hills Creek).

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to Pacific Power's portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-174** shows the Williams Northwest Pipeline, which runs through Marion, Linn, and Lane Counties (in blue) (Pipelines International, 2009). LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

Figure 2-174. Liquefied Natural Gas Pipelines in Region 3



Source: Retrieved from http://gs-press.com.au/images/news_articles/cache/Pacific_Connector_Gas_Pipeline_Route-0x600.jpg

Utility Lifelines

The Mid/Southern Willamette Valley is an important thoroughfare for oil and gas pipelines and electrical transmission lines, connecting Oregon to California and Canada. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe but infrequent natural hazards such as earthquakes. If these lines fail or are disrupted, the essential functions of the community can become severely impaired.

The electric, oil, and gas lines that run through the Mid/Southern Willamette region are both municipally and privately owned. A network of electrical transmission lines running through the region allows Oregon utility companies to exchange electricity with other states and Canada. Most of the natural gas Oregon uses originates in Alberta, Canada. Northwest Natural Gas owns one main natural gas transmission pipeline. An oil pipeline originating in the Puget Sound runs through the region and terminates in Eugene.

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio) under the Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013). Marion, Yamhill, and Polk Counties are part of the Capitol Operational Area. Lane, Benton, Linn, and coastal Douglas Counties are part of the South Valley Operational Area. Counties in this area can launch emergency messages by contacting the Oregon Emergency Response System (OERS) which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communication capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation's status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The local primary station identified as the emergency messengers by the Oregon State Emergency Alert System Plan in Region 3 is KWVT-TV Channel 17 in Salem.

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 3. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is becoming more readily available in the region with a greater number of providers and service types available within major communities and along major transportation corridors (I-5, OR-99, etc.). The majority of areas that lack access to broadband service are in Coast Range and the Cascades mountains (NTIA, n.d.). Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 3 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for the Capitol Operational Area are:

- KOPB-FM, 91.5 MHZ, Salem; and
- WXL-96.475 MHZ, Salem.

Radio transmitters for the South Valley Operational Area are (Oregon Office of Emergency Management, 2013):

- KWAX-FM, 91.1 MHZ, Eugene; 91.6 MHZ, Florence; 101.9 MHZ, Cottage Grove;
- KKNU-FM, 93.3 MHZ Eugene; 100.9 MHZ, Florence; 101.9 MHZ, Cottage Grove; and
- KOAC-AM, 550 KHZ, Albany, 103.1 MHZ, Corvallis.

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). Region 3 is served by ARES District 4. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency

Management, n.d.). The official ham emergency station calls for Region 3 include (American Relay Radio League Oregon Chapter, www.arrloregon.org) include:

- Benton County: W7DMR;
- Lane County: K7BHB, N7NFS;
- Linn County: W7ACW;
- Marion County: KE70LU, KD7MGF, KC7BRZ, WA7ABU, KE7EXX, W7SDP;
- Polk County: KG7G; and
- Yamhill County: W7IG.

Water

Water infrastructure includes drinking water, stormwater, and wastewater systems. All of these systems possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In Region 3 the majority of the municipal drinking water supply is obtained primarily from surface water sources. Surface water is drawn from rivers and smaller tributaries. These surface water sources are often backed up by groundwater that is drawn from an aquifer when surface water levels get low, especially in summer months

Rural residents draw water from surface water, groundwater wells, or springs. Areas with sedimentary and volcanic soils may be subject to high levels of arsenic, hydrogen sulfide, and fecal coliform bacteria, which can impact the safety of groundwater sources. In Polk County, saltwater naturally occurs in some aquifers, which presents a challenge during water shortages when aquifers are relied upon for backup water supply. In areas where no new live-flow water rights are available, farmers and ranchers are turning to above-ground storage to help supply water for crop irrigation during dry seasons.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. Non-point source pollution is a major threat to surface water quality, and may include stormwater runoff from roadways, agricultural operations, timber harvest, erosion and sedimentation. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Landslides, flood events, and liquefaction from earthquakes can cause increased erosion and sedimentation in waterways.

Underground water supplies and aging or outdated infrastructure — such as reservoirs, treatment facilities, and pump stations — can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, limiting access to potable water. This can lead to unsanitary conditions that may threaten human health and limit fire suppression. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enter surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 3, most local building codes and stormwater management plans emphasize use of centralized storm sewer systems to manage stormwater. Requirements for stormwater mitigation vary in Region 3. Low impact development (LID) mitigation strategies can alleviate or lighten the burden to a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, at lower speed, and at lower temperatures. Most cities in Region 3 use the State of Oregon Residential Specialty Code, which does not address the issue of stormwater mitigation on new or existing construction. However, some cities, such as Eugene, require LID stormwater mitigation strategies in their building code. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems, and increase a community's resilience to many types of hazard events.

Infrastructure Trends and Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

Roads, bridges, railroads, and airports are vulnerable to natural hazards. Failures of this infrastructure can be devastating to the economy and health of the region's residents. Bridges are particularly vulnerable to seismic events. Forty-four percent of all state-owned bridges in the region that have been identified as distressed or deficient are within Lane County. Railroads are sensitive to icing from winter storms. The second largest airport in the Oregon is in Region 3, along with several smaller airports and helipads.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. The majority of power in the region is generated hydroelectrically and there are 16 power-generating facilities in the Mid/Southern Willamette Valley. The majority of dams are in Marion and Yamhill Counties. The three major dams are Detroit, Carmen-Smith, and Lookout Point. Roughly 14% (53) of all dams in the region are either Significant or High Threat Potential. Liquid Natural Gas is transported through the region via the Williams Northwest Pipeline that runs through Marion, Linn, and Lane Counties.

Decentralization and redundancy in the region’s telecommunication systems can help boost the area’s ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services do not cover many rural areas of the region that are distant from major transportation corridors. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Water systems in the region are particularly vulnerable to hazard events because they tend to be centralized and lacking in system redundancies. Furthermore, because most drinking water is sourced from surface water, the region is at risk of high levels of pollutants entering waterways such as through combined sewers that overflow during high-water events. Older, centralized infrastructure in storm and wastewater infrastructure creates vulnerability in the system during flood events. The City of Eugene employs decentralized, low-impact development (LID) stormwater systems to better manage high-precipitation events.

Built Environment

Settlement and Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program is 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD, https://www.oregon.gov/lcd/OP/Pages/Goal-7.aspx).

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people or an "urban cluster" of at least 2,500 people (but less than 50,000). Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-297** and **Table 2-298** remain from the 2010 Census.

Regionally, between 2000 and 2010, urban areas in the Mid/Southern Willamette Valley have grown comparably to other urban areas statewide, with the greatest increases in population occurring in Linn, Polk, and Yamhill Counties. Benton is the only county in the region to experience a more even distribution of population growth in both urban and rural areas, roughly 9%. The most extreme shifts between urban and rural areas occurred in Yamhill County — 28% increase in urban populations and a 10.8% decrease in rural populations.

The percent growth of housing units in urban areas between 2000 and 2010 is almost 4 times that in rural areas. Linn, Polk, and Yamhill Counties have had the greatest increases in urban housing. Rural housing has increased by almost 16% in Benton County.

Unsurprisingly, populations tend to cluster around major road corridors and waterways. This holds true for the major cities of Eugene, Albany, Corvallis, and Salem and for the cities of Portland Metro area. The population distribution in Region 3 is presented in **Figure 2-175**.

Table 2-297. Urban and Rural Populations in Region 3, 2010

	Urban			Rural		
	2000	2010	% Change	2000	2010	% Change
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	-0.1%
Region 3	738,040	850,560	15.2%	198,347	193,337	-2.5%
Benton	63,378	69,521	9.7%	14,775	16,058	8.7%
Lane	260,514	290,084	11.4%	62,445	61,631	-1.3%
Linn	65,349	79,759	22.1%	37,720	36,913	-2.1%
Marion	241,260	274,046	13.6%	43,574	41,289	-5.2%
Polk	47,672	60,378	26.7%	14,708	15,025	2.2%
Yamhill	59,867	76,772	28.2%	25,125	22,421	-10.8%

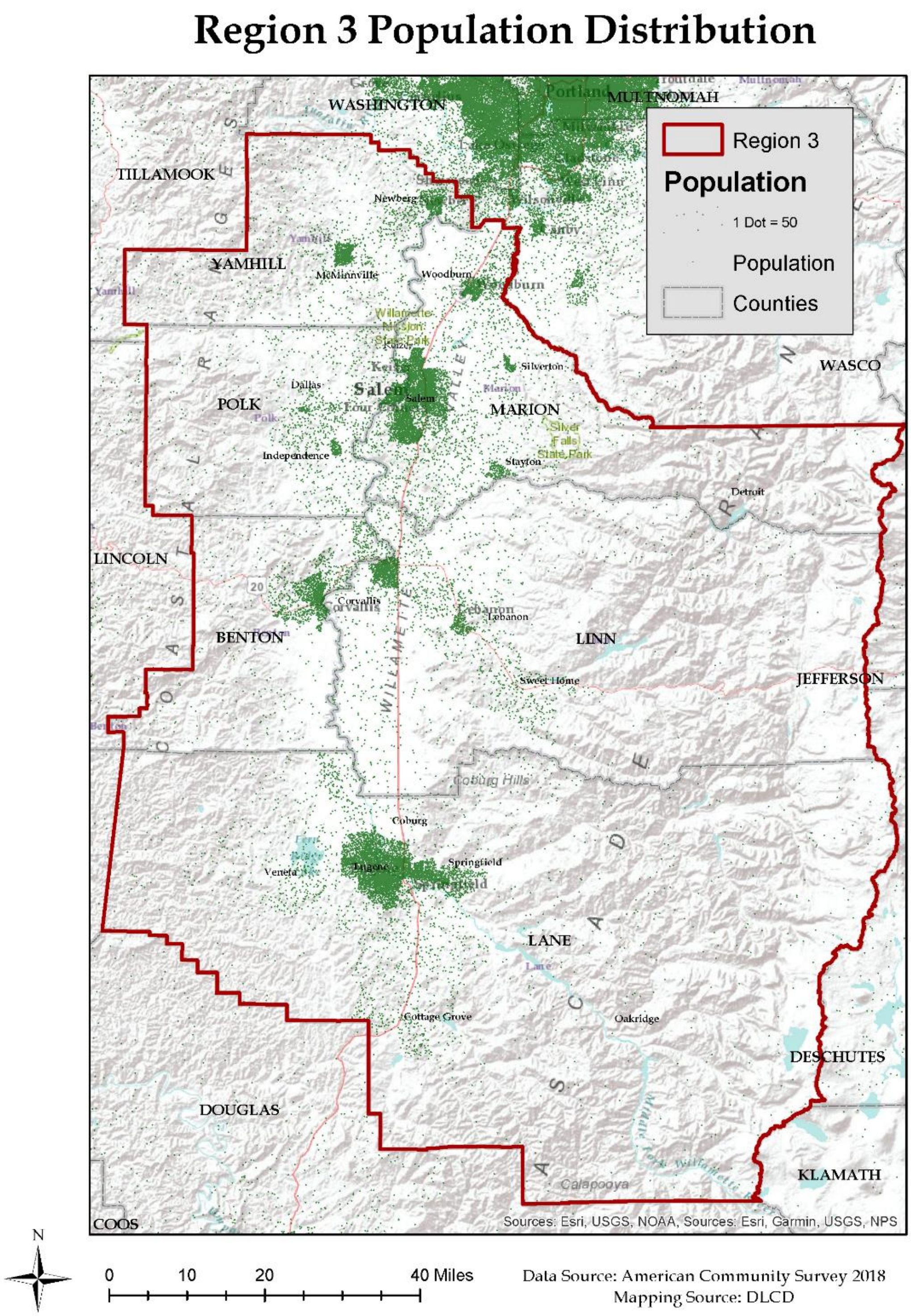
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2

Table 2-298. Urban and Rural Housing Units in Region 3, 2010

	Urban			Rural		
	2000	2010	% Change	2000	2010	% Change
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 3	298,306	348,148	16.7%	78,046	81,390	4.3%
Benton	26,115	29,459	12.8%	5,865	6,786	15.7%
Lane	112,750	128,267	13.8%	26,196	27,845	6.3%
Linn	27,712	33,467	20.8%	14,809	15,354	3.7%
Marion	91,846	104,590	13.9%	16,328	16,358	0.2%
Polk	18,851	24,204	28.4%	5,610	6,098	8.7%
Yamhill	21,032	28,161	33.9%	9,238	8,949	-3.1%

Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2.

Figure 2-175. Region 3 Population Distribution



Source: U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. **Table 2-299** provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

The majority of the region's housing stock is single-family homes. Manufactured residences make up 9.0% of Region 3's housing overall. Linn and Yamhill Counties have the highest shares of manufactured homes. In natural hazard events such as earthquakes and floods, manufactured homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997).

Table 2-299. Housing Profile for Region 3

		Single Family			Multi Family			Manufactured Homes		
	Total Housing Units	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	68.1%	✓	0.3%	23.5%	✓	0.3%	8.2%	✓	0.1%
Region 3	441,923	68.3%	✓	0.5%	22.4%	✓	0.5%	9.0%	✓	0.3%
Benton	37,789	64.7%	✓	1.5%	29.0%	✓	1.9%	6.0%	✓	6.0%
Lane	160,440	67.5%	✓	0.7%	23.2%	✓	0.9%	8.8%	✓	0.4%
Linn	49,688	71.9%	✓	1.3%	16.4%	✓	1.3%	11.5%	✓	0.9%
Marion	124,317	66.4%	✓	1.0%	24.5%	✓	1.0%	8.9%	✓	0.5%
Polk	31,403	72.6%	✓	2.0%	19.7%	✓	1.9%	7.6%	✓	1.0%
Yamhill	38,286	73.6%	✓	1.8%	15.3%	✓	1.5%	10.6%	✓	1.0%

Notes: *Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-300. Housing Vacancy in Region 3

	Total Housing Units	Vacant^		
		Estimate	CV **	MOE (+/−)
Oregon	1,733,041	5.6%	☑	0.2%
Region 3	441,923	5.6%	☑	0.3%
Benton	37,789	7.0%	☑	1.1%
Lane	160,440	5.1%	☑	0.5%
Linn	49,688	5.7%	☑	0.9%
Marion	124,317	5.7%	☑	0.6%
Polk	31,403	6.4%	☑	1.4%
Yamhill	38,286	5.3%	☑	1.1%

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.

**Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table B25004: Vacancy Status

Aside from location and type of housing, the year structures were built (**Table 2-301**) has implications for level of vulnerability to natural hazards. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally 34.2% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances. Just under one third of the region's housing stock was built after 1990 and the codification of seismic building standards. Additionally, as shown in **Table 2-302**, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the late 1970s or mid-1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-301. Age of Housing Stock in Region 3

	Total Housing Units	Pre 1970			1970 to 1989			1990 or Later		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	34.6%	☑	0.3%	30.5%	☑	0.3%	34.9%	☑	0.3%
Region 3	441,923	34.2%	☑	0.5%	32.6%	☑	0.5%	33.3%	☑	0.5%
Benton	37,789	34.5%	☑	2.0%	31.2%	☑	1.9%	34.3%	☑	1.8%
Lane	160,440	37.5%	☑	0.9%	32.3%	☑	0.9%	30.2%	☑	0.8%
Linn	49,688	38.7%	☑	1.8%	30.0%	☑	1.6%	31.3%	☑	1.4%
Marion	124,317	31.5%	☑	1.0%	36.4%	☑	1.1%	32.0%	☑	1.0%
Polk	31,403	28.5%	☑	2.0%	26.6%	☑	1.9%	44.9%	☑	2.1%
Yamhill	38,286	27.3%	☑	1.7%	30.4%	☑	1.7%	42.3%	☑	1.9%

Notes: *Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red “x” icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau. 2013-2017. American Community Survey 5-Year Estimates. Table B25034

Table 2-302 shows the initial and current FIRM effective dates for Region 3 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, Flood section.

Table 2-302. Community Flood Map History in Region 3

	Initial FIRM	Current FIRM
Benton County	Aug. 5, 1986	Dec. 8, 2016
Albany	see Linn County	see Linn County
Corvallis	Jan. 3, 1985	June 2, 2011
Monroe	Sept. 26, 1975	June 2, 2011
Philomath	June 15, 1982	June 2, 2011
Lane County	Dec. 18, 1985	June 2, 1999
Coburg	Jan. 6, 1985	6/2/1999 (M)
Cottage Grove	Nov. 15, 1985	June 2, 1999
Creswell	Sept. 18, 1985	June 2, 1999
Dunes City	Mar. 24, 1981	6/2/1999 (M)
Eugene	Sept. 29, 1986	June 2, 1999
Florence	May 17, 1982	June 2, 1999
Junction City	June 15, 1982	June 2, 1999
Lowell	June 2, 1999	6/2/1999 (M)
Oakridge	June 3, 1986	June 2, 1999
Springfield	Sept. 27, 1985	June 2, 1999
Veneta	Feb. 1, 1984	June 2, 1999
Westfir	Aug. 19, 1985	June 2, 1999
Linn County	Sept. 29, 1986	Dec. 8, 2016
Albany	Apr. 3, 1985	Dec. 8, 2016
Brownsville	Aug. 17, 1981	Sept. 29, 2010
Halsey	Sept. 29, 2010	Sept. 29, 2010
Harrisburg	Feb. 3, 1982	Sept. 29, 2010
Idanha	Mar. 1, 1979	Jan. 19, 2000
Lebanon	July 2, 1981	Sept. 29, 2010
Lyons	Dec. 15, 1981	Sept. 29, 2010
Mill City	Mar. 1, 1979	Sept. 29, 2010
Millersburg	June 15, 1982	Dec. 8, 2016
Scio	Aug. 1, 1984	Sept. 29, 2010
Sweet Home	Mar. 1, 1982	Sept. 29, 2010
Tangent	May 17, 1982	Sept. 29, 2010
Waterloo	Sept. 29, 2010	Sept. 29, 2010
Marion County	Aug. 15, 1979	Oct. 18, 2019
Aumsville	Mar. 1, 1979	Jan. 19, 2000
Aurora	June 5, 1979	Jan. 19, 2000
Detroit	June 30, 1976	Jan. 19, 2000
Gates	Dec. 4, 1979	Jan. 19, 2000
Gervais	June 30, 1976	June 30, 1976
Hubbard	Feb. 5, 1986	Jan. 19, 2000
Jefferson	Mar. 1, 1979	Jan. 19, 2000
Keizer	May 1, 1985	Jan. 19, 2000
Mt. Angel	Jan. 19, 2000	Jan. 19, 2000
Salem	June 15, 1979	Oct. 18, 2019
Scotts Mills	Mar. 1, 1979	Jan. 19, 2000
Silverton	Mar. 1, 1979	Jan. 19, 2000
St. Paul	Jan. 19, 2000	Jan. 19, 2000
Stayton	Mar. 1, 1979	Jan. 19, 2000
Turner	Apr. 2, 1979	Oct. 18, 2019
Woodburn	Mar. 1, 1979	Jan. 19, 2000
Polk County	Feb. 15, 1978	Dec. 19, 2006
Dallas	Apr. 5, 1988	Dec. 19, 2006
Falls City	July 7, 1981	Dec. 19, 2006
Independence	Apr. 5, 1988	Dec. 19, 2006
Monmouth	Apr. 5, 1988	Dec. 19, 2006
Salem	see Marion County	see Marion County
Yamhill County	Sept. 30, 1983	Mar. 2, 2010
Amity	Dec. 1, 1981	Mar. 2, 2010
Carlton	June 30, 1976	Mar. 2, 2010
Dayton	June 1, 1982	Mar. 2, 2010
Dundee	Mar. 1, 1982	Mar. 2, 2010
Lafayette	June 15, 1982	Mar. 2, 2010
McMinnville	Dec. 1, 1982	Mar. 2, 2010
Newberg	Mar. 1, 1982	Mar. 2, 2010
Sheridan	Aug. 1, 1990	Mar. 2, 2010
Willamina	Mar. 15, 1982	Mar. 2, 2010
Yamhill, City	Mar. 1, 1982	Mar. 2, 2010

(M) = no elevation determined; all Zone A, C, and X.

Source: Federal Emergency Management Agency (2019), Community Status Book Report, https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 3 can be found in **Table 2-303**. The region contains just under one-third of the total value of all local critical facilities and state-owned and –leased critical and non-critical facilities in the state. These assets have a combined value of over ten billion dollars. Many of the facilities are associated with the universities in Eugene and Corvallis and with state offices in Salem.

Table 2-303. Value of State-Owned/Leased Critical and Essential Facilities in Region 3

	Value of Local and State-Owned/Leased Facilities				
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$2,630,306,288	$4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 3	$1,647,256,264	$1,460,570,293	$ 7,490,014,345	$ 10,597,840,902	31.6%
Benton	$ 19,658,758	$ 21,711,757	$ 601,049,400	$ 642,419,915	1.9%
Lane	$ 255,204,883	$ 104,069,324	$ 2,601,296,095	$ 2,960,570,302	8.8%
Linn	$ 84,722,101	$ 55,424,803	$ 794,175,900	$ 934,322,804	2.8%
Marion	$1,269,221,291	$1,238,287,979	$ 2,193,334,800	$ 4,700,844,070	14.0%
Polk	$ 15,437,309	$ 27,230,661	$ 465,625,050	$ 508,293,020	1.5%
Yamhill	$ 3,011,922	$ 13,845,769	$ 834,533,100	$ 851,390,791	2.5%

Source: DOGAMI, 2020

Land Use Patterns

Region 3 has a larger percentage of private land, 57.7%, than federal land, 39.1%, with most of the federal holdings ranging up the slopes of the Cascades. However, the northern portion is dominated by agricultural activities, while the southern end has a much larger share of BLM and Forest Service timberland.

The South Willamette Region is a land of contrasts, with urban areas nestled within productive farmland, bordered by the Cascade and Coast Range timberlands. I-5 runs the length of the region, and this area’s economy is shaped by the transportation system. With 61 incorporated communities in the region, there is continued pressure on area ecosystems from population growth, land use conversion, and altered habitat, fire regimes, and floodplain development.

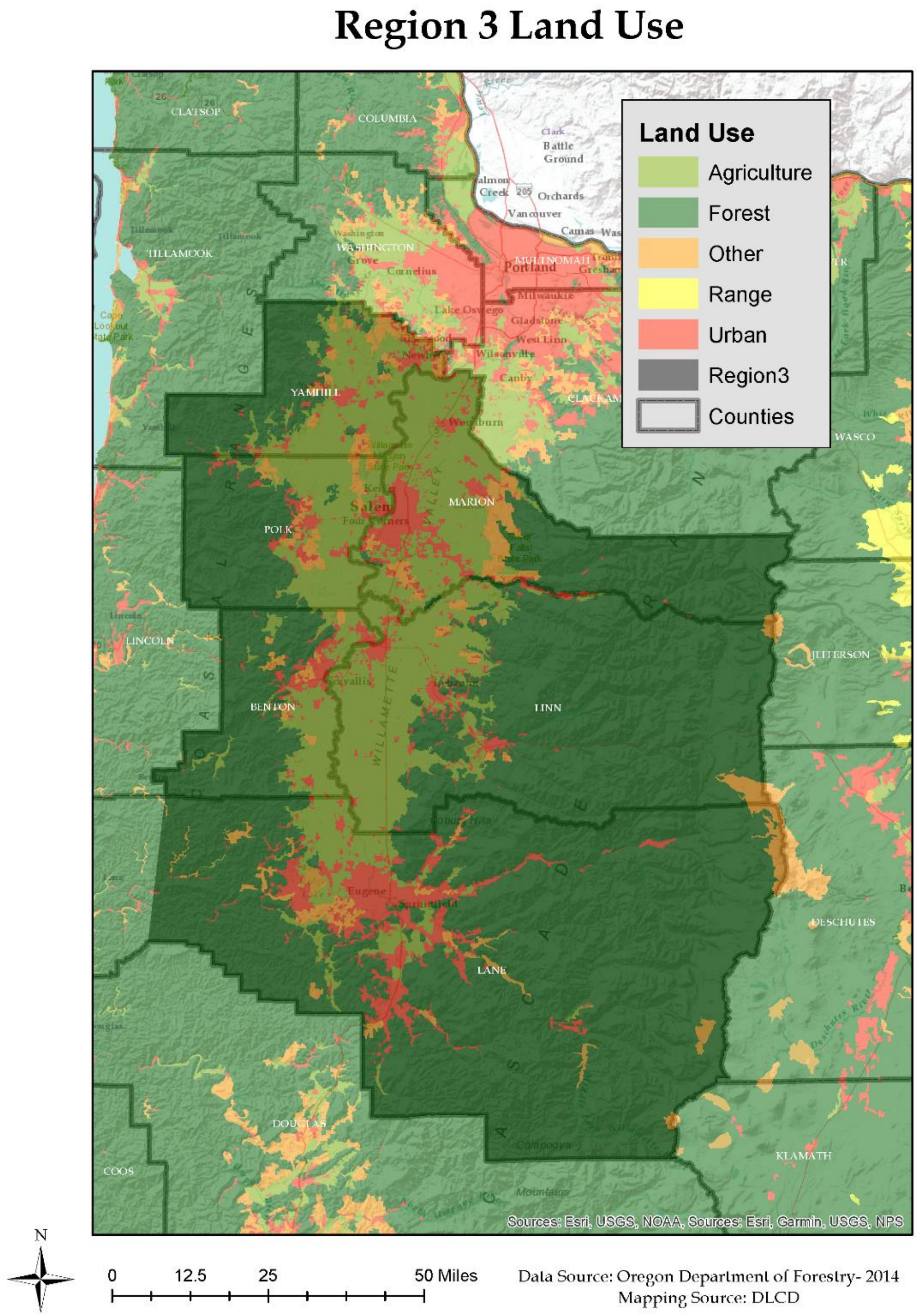
Oregon Department of Forestry data show that in the 25-year period between 1984 and 2009, approximately 147,000 acres of farm and range land in the state transitioned from land use classes more conducive to commercial farm or forest practices into more developed land classes. Almost half of all farm land conversion occurred in central Oregon, while nearly one quarter took place in the Metro area and one quarter in the general area of Region 3 (Lettman G. J., 2011).

According to the Oregon Department of Forestry's most recent land use study., "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray, Hubner, McKay, & Thompson, 2016). In Region 2, approximately 5,312 acres of resource lands were converted to more urban uses during the six-year period. **Table 2-304** shows that during the six-year period, the percentage of resource lands converted in each county in Region 3 was less than one percent of each county's total acreage. Lane County led the region in terms of total acres converted.

This region of the state is often subject to major flooding events, and communities have experienced major floods in 1861, 1890, 1945, 1956, 1964, 1996, and 2011. Generally, they have responded by keeping their flood ordinances current as well as going beyond minimum standards. For example, Corvallis, Albany, and Benton County integrate natural hazard information into their Comprehensive Plan, assuring that proper planning, such as determining if enough buildable land is available for future growth, and policies that regulate and prohibit development in natural hazard areas, will help minimize the extent of damage from future hazard events.

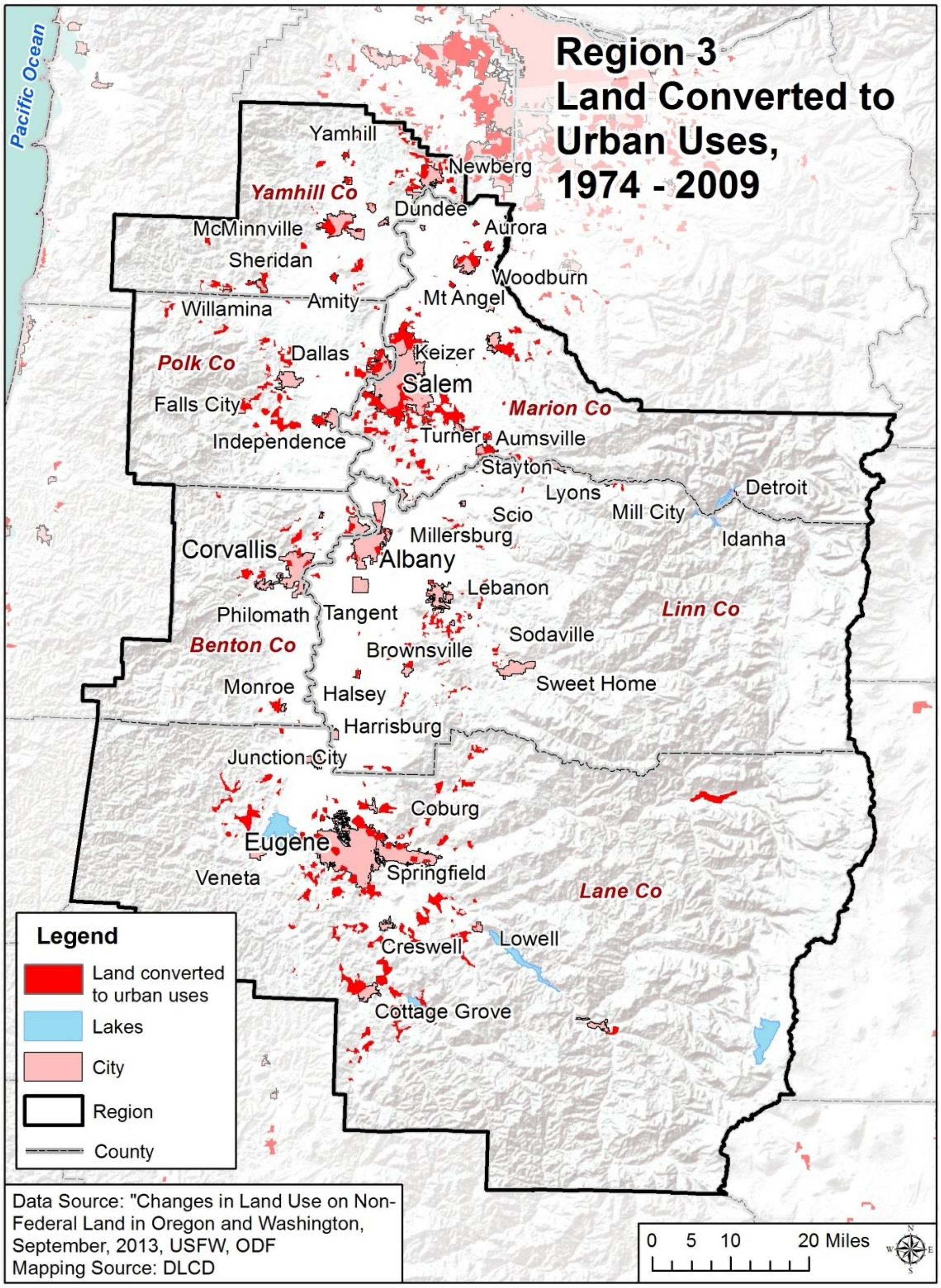
Eugene-Springfield is the third largest metropolitan area in Oregon, but expansion options are restricted by potential landslide and flood hazard areas. These communities are doing what they can to accommodate growth inside existing UGBs while minimizing encroachment into known hazard areas. One strategy they are using is to allow increased intensity of development outside of hazard areas, reducing the need to develop within them. For example, Eugene minimizes residential development on steep slopes by requiring larger lot sizes, and using floodplain areas as parks and open spaces. Overall, Eugene's average density has increased, and the mix of housing types is shifting toward more multi-family (DLCD, internal communication, 2014).

Figure 2-176. Region 3 Land Use



Source: Oregon Department of Forestry 2014

Figure 2-177. Region 3 Land Converted to Urban Uses, 1974–2009



Source: Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

Table 2-304. Region 3 Resource Lands Converted to Urban Uses, 2009-2014

	Lost Resource Lands 2009-2014		
	Total Resource Acres (2009)	**Acres Converted to Urban Use**	**Percent Converted**
Region 3	3,346,514	5,314	0.16%
Yamhill	360,084	825	0.23%
Polk	402,291	829	0.20%
Marion	447,948	998	0.22%
Linn	863,818	747	0.09%
Benton	317,707	414	0.13%
Lane	954,666	1,575	0.16%

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 3 is largely an urban county with urban development focused around the major cities along I-5. Population growth in the region was slightly below the statewide rate of growth from 2010-2018. From 2018-2030, the region is projected to continuing growing at a rate commensurate with the statewide rate of growth. Please refer to the Region 3 Risk Assessment **Demography** section for more information on population trends and forecast. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion.

In terms of housing composition and hazard risk, the region has a slightly higher percentage of manufactured homes than the state as a whole — the highest percentage being in Linn County 11.5%. Nearly 40% of housing in Linn and Lane Counties was built before 1970 and floodplain management standards. Furthermore, roughly two thirds of the region's homes were built before 1990 and seismic building standards. All of the region's FIRMs have been modernized or updated.

2.3.3.3 Hazards and Vulnerability

Droughts

Characteristics

Droughts are not common in Region 3. In 1992, the Governor declared a drought for all 36 counties in Oregon. However, since 1992, no Governor-declared droughts have occurred in Region 3 until 2015 when the Governor declared drought in Marion, Linn, and Lane counties. Federal drought declarations were given to all 36 Oregon counties in 2015. Nonetheless, a dry winter or spring can have an effect on water supplies within the Mid/Southern Willamette Valley.

Even though drought may not be declared as often in Western Oregon as in counties east of the Cascades, when drought conditions do develop in the Willamette Valley, the impacts are widespread and severe when both winter snow and spring/summer rain are low. Reasons for broad and significant impact include:

- Higher population density and growing population in the Willamette Valley;
- Dependence on surface water supplies for many municipalities, agriculture and industries from large flood control reservoirs in the Willamette river system;
- Agriculture is a major industry becoming increasingly dependent on irrigation;
- Increased frequency of toxic algal blooms in the Willamette system reservoirs, resulting in restrictions on use of water from reservoirs for drinking (i.e., for human and animals). Affected waters may not be safe for agricultural irrigation, and other uses; necessitating purchasing and transporting water from alternative sources;
- Since drought is typically accompanied by earlier onset of snowmelt (e.g., during flood control or early storage season), little or no snowmelt runoff is stored until later;
- Earlier start to growing season, before the start of the irrigation season, means that crops may not be irrigated until the irrigation season begins;
- Insufficient number of farm workers available because the growing season began before the workers were scheduled to arrive; and
- Responsibilities to recovering anadromous fish.

These are relatively recent and developing concerns, in particular on livestock and some other agricultural operations, and therefore there is no single comprehensive source or other sources for information to assess economic impacts. Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms.

Historic Drought Events

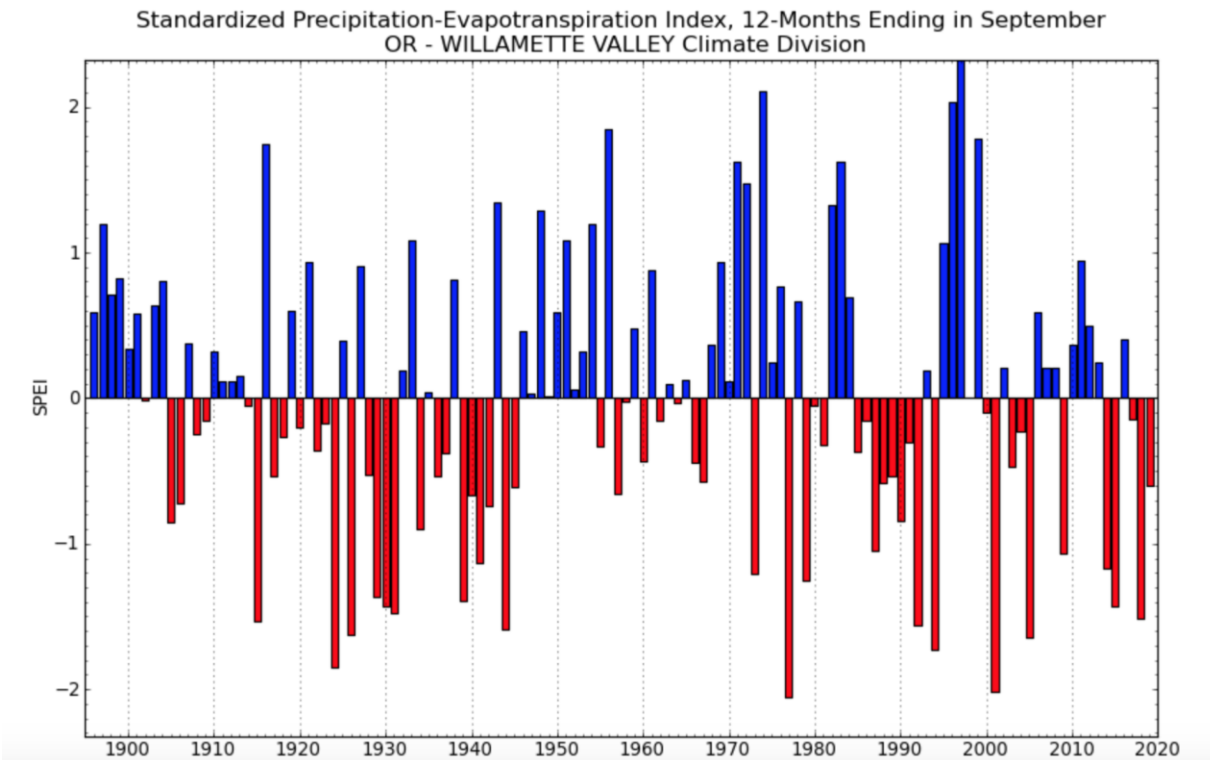
Table 2-305. Historic Droughts in Region 3

Date	Location	Description
1923-1924	statewide	prolonged statewide drought that caused major problems for agriculture
1928-1930	Regions 1–3, 5–7	moderate to severe drought affected much of the state; the worst years in Region 2 were 1928–1930, which initiated an era of many drier than normal years
1938-1939	statewide	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country; Water Year 1939 was one of the more significant drought years in during that period
1991-1992	statewide, especially Regions 1–4, 8	1992 fell toward the end of a generally dry period, which caused problems throughout the state; the 1992 drought was most intense in eastern Oregon, with severe drought occurring in Region 1
2000-2001	Regions 2–4, 6, 7	the driest water year on record in the Willamette Valley (NOAA Climate Division 2); warmer than normal temperatures combined with dry conditions
2015	statewide	Governor-declared drought in 25 counties, including Marion, Linn, and Lane, with federal declarations in all counties.

Sources: Taylor and Hatton (1999); Oregon Secretary of State's Archives Division. NOAA's Climate at a Glance. Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt. Personal Communication, Kathie Dello, Oregon Climate Service, Oregon State University.

Historical drought information can also be obtained from the West Wide Drought Tracker, which provides climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. **Figure 2-178** shows years where drought or dry conditions affected the Willamette Valley (Climate Division 2). Based on this index, Water Years 1977 and 2001 were extreme drought years for the Willamette Valley. Years with at least moderate drought have occurred 21 times during 1895–2019 (**Table 2-306**).

Figure 2-178. Standard Precipitation-Evapotranspiration Index for Region 3



Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-306. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 2 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
1931	1924	1977
1930	1994	2001
2015	2005	
1939	1926	
1929	1944	
1979	1992	
1973	1915	
2014	2018	
1941		
2009		
1987		

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Although not shown here, drought data from Climate Division 4, "the High Cascades," could also be analyzed to show a broader picture of drought impacts in Hazard Regions 2 and 3.

Probability

Table 2-307. Probability of Drought in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	VL	L	L	L	VL	VL

Source: OWRD, DLCD

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases.

A comprehensive risk analysis is needed to fully assess the probability and impact of drought to Oregon communities. Such an analysis could be completed statewide to analyze and compare the risk of drought across the state.

Benton, Polk, and Yamhill Counties have received drought declarations in only 3% of the years since 1992, Marion and Linn in 7%, and Lane in 10%. This accounts for their very low and low probability, respectively, of experiencing drought.

Climate Change

Even though drought is infrequent in the mid-southern Willamette Valley, climate models project warmer, drier summers for Oregon, including Region 3. These summer conditions coupled with projected decreases in mid-to-low elevation mountain snowpack due to warmer winter temperatures increases the likelihood that Region 3 would experience increased frequency of one or more types of drought under future climate change. In Region 3, climate change would result in increased frequency of drought due to low spring snowpack (very likely, >90%), low summer runoff (likely, >66%), and low summer precipitation and low summer soil moisture (more likely than not, >50%). In addition, Region 3, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-308. Local Assessment of Vulnerability to Drought in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	L	L	H	—	M

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-309. State Assessment of Vulnerability to Drought in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	M	H	VH	M	H

Source: OWRD, DLCD

Although long-term drought conditions are uncommon in the mid-Willamette Valley, a dry winter or spring could affect many communities and water users throughout the Basin. Recreation, particularly at the reservoirs owned and operated by the U.S. Army Corps of Engineers, contributes greatly to the valley's economy. Communities, such as Detroit in Marion County, can be economically impacted by low reservoir levels. The Willamette Valley is also home to one of the most productive and diverse agricultural regions in the United States. Drought, especially a long drought, could significantly impact agricultural production.

Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms.

Because drought impacts are relatively recent in Region 3, there is no single comprehensive source or other sources for information to assess economic impacts.

Oregon has yet to undertake a comprehensive, statewide analysis to identify which communities are most vulnerable to drought.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

Marion County's social vulnerability score is very high, Linn and Yamhill Counties' high. Lane and Polk Counties' social vulnerability score is moderate, Benton County's low. The social vulnerability score indicates the extent of impact of any natural hazard, including drought, on a county's population. Marion, Linn, and Yamhill are the communities most vulnerable to drought in Region 3.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 3 is approximately $3,107,827,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $7,490,014,000. Because drought, while uncommon in Region 3, could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, three losses totaling almost

$39,000 state facilities were recorded in Region 3 since the beginning of 2015. None were caused by drought.

Risk

Table 2-310. Risk of Drought in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Risk	L	M	H	H	M	M

Source: OWRD, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based on social vulnerability, a review of Governor-declared drought declarations since 1992, and the potential for drought to impact Region 3’s agricultural productivity and other economic drivers, Region 3 is considered to generally be at moderate to high risk from drought.

Earthquakes

Characteristics

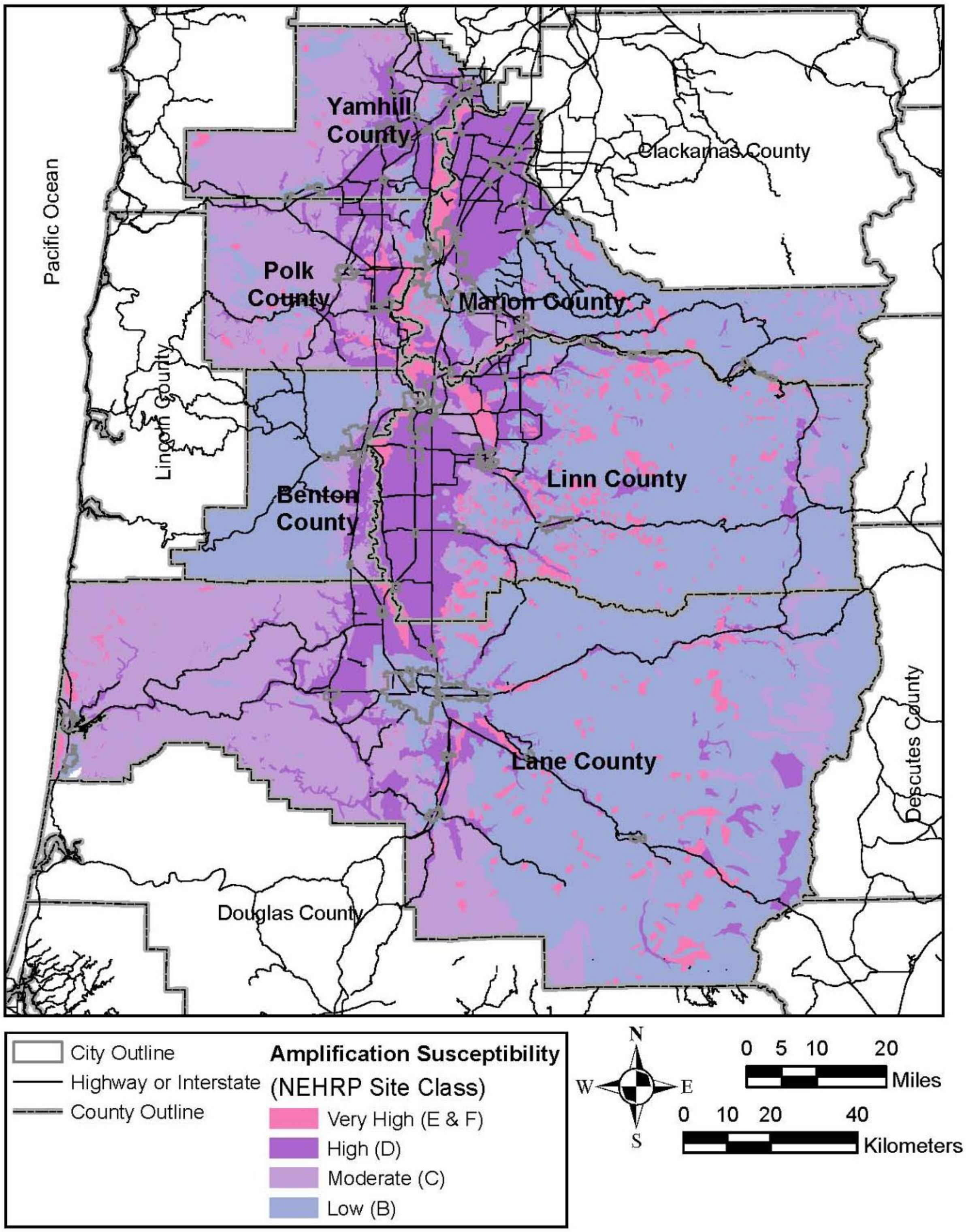
The geographic position of Region 3 makes it susceptible to earthquakes from four sources: (a) the off-shore Cascadia Fault Zone, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) shallow crustal events within the North America Plate, and (d) earthquakes associated with renewed volcanic activity.

Region 3 has experienced a few historic earthquakes centered in the region. In addition, the region has been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. All considered, there is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region and along the Cascadia Fault Zone. Deep-seated intra-plate events have been discovered by scientists in the region's historic and pre-historic record, as occurred near Olympia, Washington in 1949 and 2001, could generate magnitudes as large as M7.5.

Earthquakes produced through volcanic activity could possibly reach magnitudes of 5.5. The 1980 Mount St. Helens eruption was preceded by a magnitude 5.1 earthquake. Despite the fact that Cascade volcanoes are some distance away from the major population centers in Region 3, earthquake shaking and secondary earthquake-related hazards such as lahars could cause major damage to these centers.

Earthquake-associated hazards include severe ground shaking, liquefaction of fine-grained soils, and landsliding. The severity of these effects depends on several factors, including the distance from the earthquake source, the ability of soil and rock to conduct seismic energy, and the degree and composition of slope materials. As seismic waves travel through bedrock, some energy propagates through surface soils to the ground surface. Soil deposits can either deamplify or amplify the shaking based on the characteristics of the deposit. This phenomenon is generally referred to as ground shaking amplification (GSA). **Figure 2-179** displays the areas in Region 3 with greater and lesser ground shaking amplification hazard.

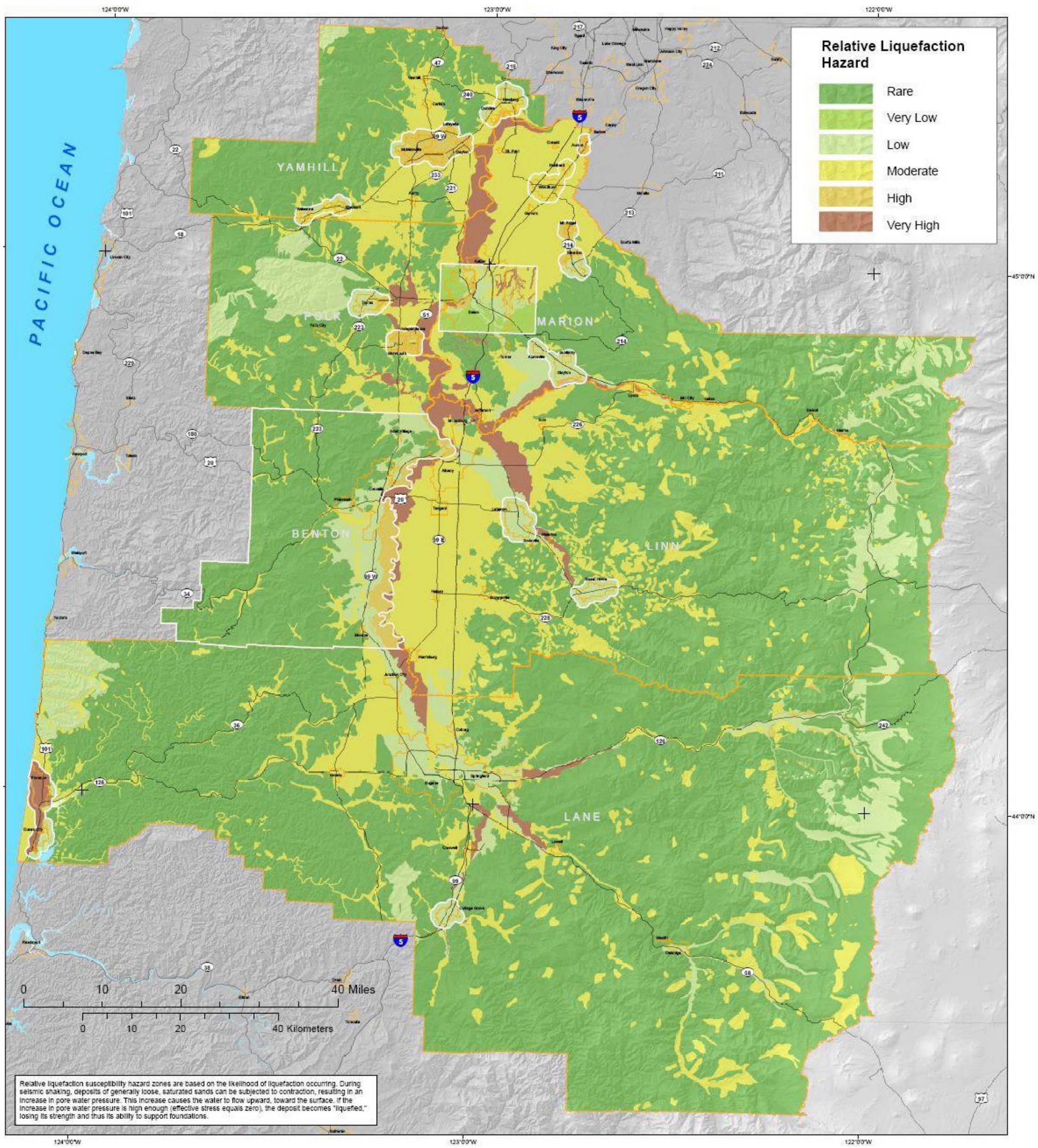
Figure 2-179. Amplification Susceptibility for Region 3



Source: Burns, et al. (2008)

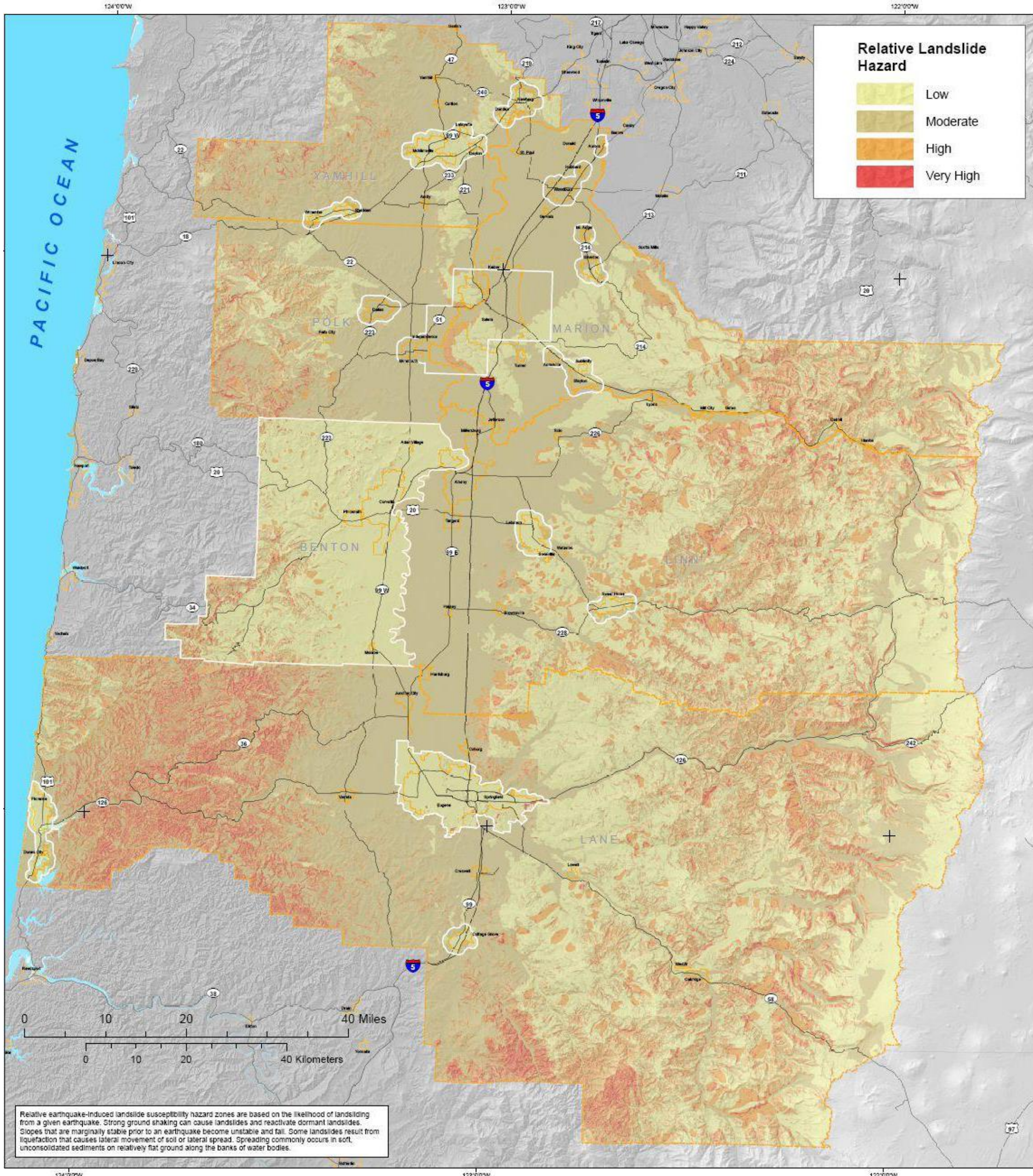
During seismic shaking, deposits of loose saturated sands can be subjected to contraction resulting in an increase in pore water pressure. If the increase in pore water pressure is high enough, the deposit becomes "liquefied," losing its strength and thus its ability to hold and support loads. **Figure 2-180** displays the areas in the region with greater and lesser liquefaction hazard.

Figure 2-180. Relative Liquefaction Hazard for Region 3



Source: Burns, et al. (2008)

Figure 2-181. Earthquake Induced Landslide Hazards for Region 3



Source: Burns, et al. (2008)

Historic Earthquake Events

Table 2-311. Significant Earthquakes Affecting Region 3

Date	Location	Magnitude (M)	Comments
Approximate Years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	offshore, Cascadia Subduction Zone	probably 8-9	mid-points of the age ranges for these six events
Jan. 1700	offshore, Cascadia Subduction Zone	about 9.0	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Apr. 1896	McMinnville, Oregon	4	also felt in Portland
July 1930	Perrydale, Oregon	4	cracked plaster
Apr. 1949	Olympia, Washington	7.1	Intraplate event. Damage: significant (Washington); minor (NW Oregon)
Aug. 1961	Albany, Oregon	4.5	damage: minor (Albany)
Nov. 1962	Portland area, Oregon	5.5	shaking up to 30 seconds; chimneys cracked; windows broken; furniture moved
Mar. 1963	Salem, Oregon	4.6	damage: minor (Salem)
Mar. 1993	Scotts Mills, Oregon	5.6	FEMA-985-DR-Oregon; center: Mt. Angel-Gales Creek fault; damage: $30 million (including Oregon State Capitol in Salem)
Feb. 2001	Nisqually, Washington	6.8	felt in the region; damage: none reported
Jul. 4, 2015	East of Springfield, OR	4.0	

*BCE: Before Common Era.

Sources: Wong & Bott (1995); Pacific Northwest Seismic Network, https://pnsn.org/

Probability

Table 2-312. Assessment of Earthquake Probability in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	H	VH	H	H	H	H

Source: DOGAMI, 2020

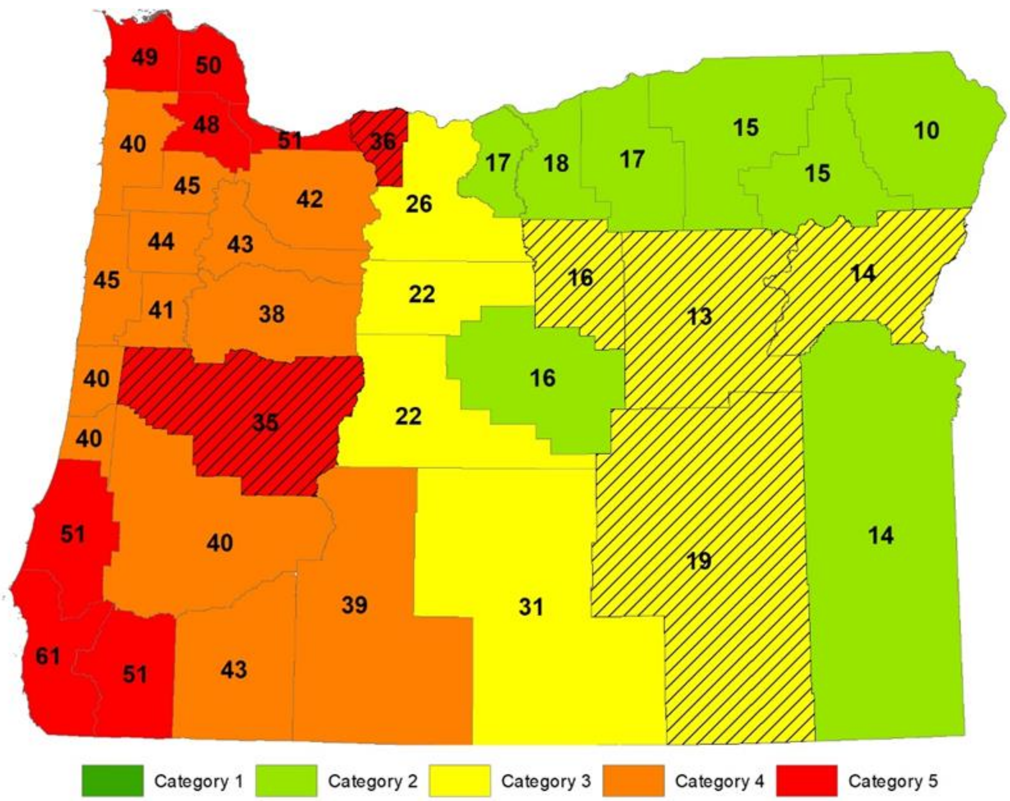
The probability of damaging earthquakes varies widely across the state. In Region 3 the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well-understood recurrence history.

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-182**.

Figure 2-182. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.
Source: DOGAMI, 2020)

The Cascadia subduction zone is responsible for most of the hazard shown in **Figure 2-182**. The paleoseismic record includes 18 magnitude 8.8–9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7 to 12%. An additional 10 to 20 smaller, magnitude 8.3–8.5, earthquakes affected only the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37–43%.

Vulnerability

Table 2-313. Local Assessment of Vulnerability to Earthquakes in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	H	M	H	H	M	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-314. State Assessment of Vulnerability to Earthquakes in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	L	VH	VH	M	VH

Source: DOGAMI and DLCD, 2020

State Assessment

Region 3 is especially vulnerable to earthquake hazards because much of the area is susceptible to earthquake-induced landslides, liquefaction, and strong ground shaking.

Of the 15 counties in the state with the highest expected damages and losses based on the 500 year model, the following counties are located in Region 3:

- Lane,
- Marion,
- Benton,
- Linn, and
- Yamhill.

The Oregon Department of Geology and Mineral Industries (DOGAMI) developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) the Cascadia Subduction Zone (CSZ), and (b) combined crustal events (500-year model). Both models use Hazus, a software program developed by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event is based on a potential M8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from such an event. The 500-year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults. Neither model takes unreinforced masonry buildings into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning and policy making purposes. Despite their limitations, the models do provide some approximate estimates of damage and are useful to understand the relative relationships between the counties.

Table 2-315, Table 2-316, Table 2-317, and Table 2-318 show estimated losses in each county, including building collapse potential and damages based on three model scenarios.

Table 2-315. Building Collapse Potential in Region 3

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Benton	13	5	22	3
Lane*	126	69	68	8
Linn	74	15	30	23
Marion	94	34	88	30
Polk	13	11	17	4
Yamhill	30	20	22	5

*Does not include the Lane County coastal communities of Deadwood, Florence, Mapleton, and Swisshome, which are addressed in the Region 1 Profile.

Source: Lewis (2007)

Table 2-316. Estimated Losses in Region 3 from a M9 CSZ and Local Crustal Event

County	Building Value (Billions)	Total Building Related Losses from an M9.0 CSZ Event (Billions)	Total Building Related Losses from a Crustal Earthquake (Billions)
Benton	$4.85	$1.1	$0.8
Lane	$21.055	$5.0	$3.4
Linn	$5.669	$1.2	$1.3
Marion	$15.86	$2.6	$3.9
Polk	$3.467	$0.6	$0.4
Yamhill	$4.597	$1.2	$1.5

Source: Burns, et al. (2008)

Table 2-317. Estimated Losses in Region 3 Associated with an M8.5-9.0 Subduction Event

Category	Benton	Lane	Linn	Marion	Polk	Yamhill
Injuries (5 pm time period)	1,356	3,945	1,049	2,492	678	1,190
Deaths (5 pm time period)	96	264	67	157	43	74
Displaced Households	2,375	7,633	2,563	5,787	1,822	3,082
Economic losses for buildings	$1,049.51 m	$4,652 m	$1,150.68 m	$2,604.95m	$624.43 m	$1198.48 m
Operational after Day 1						
Fire station	100%	100%	100%	100%	100%	100%
Police Station	100%	100%	100%	100%	100%	100%
Schools	91%	100%	100%	99%	100%	98%
Bridges	91%	84%	100%	89%	82%	85%
Economic loss to infrastructure						
Highways	$ 33.5 m	$211 m	$4.4 m	$127.7 m	$59.4 m	$60.2 m
Airports	$0 m	$13.3 m	$23.10 m	$13 m	$14 m	$21.4 m
Communications	$0 m	$0.33 m	$0.07 m	$0.03 m	$0.05 m	$0.03 m
Debris generated (thousands of tons)	0	2,000	0	1,000	0	0

Source: Burns, et al. (2008)

Table 2-318. Estimated Losses in Region 3 Associated with an Arbitrary M6.5-6.9 Crustal Event

Mitigation Factors	Benton	Lane	Linn	Marion	Polk	Yamhill
Injuries (5 pm time period)	557	1,821	993	3,249	321	1,178
Deaths (5 pm time period)	33	96	59	189	18	67
Displaced households	1,755	7,716	3,683	10,701	1,412	4,256
Economic losses from buildings	$762.25 m	$3,351.03 m	$1,315.72 m	$3979.57 m	$409.43 m	$1,525.35 m
Operational the day after the event:						
Fire station	75%	100%	77%	61%	100%	
Police Station	75%	91%	40%	65%	100%	
Schools	91%	99%	70%	74%	100%	
Bridges	100%	97%	91%	86%	93%	
Economic losses to infrastructure:						
Highways	$18.7 m	$106 m	$129.70 m	$271.5 m	$35.7 m	$71.3 m
Airports	$19.3 m	$16 m	$38.3 m	$38 m	$11 m	$43.9 m
Communications	$ 0.24 m	$0.63 m	$0.11 m	$0.18 m	$0.05 m	$0.10 m
Debris generated (in thousands of tons)	0	1,000	0	1,000	0	0

Source: Burns, et al. (2008)

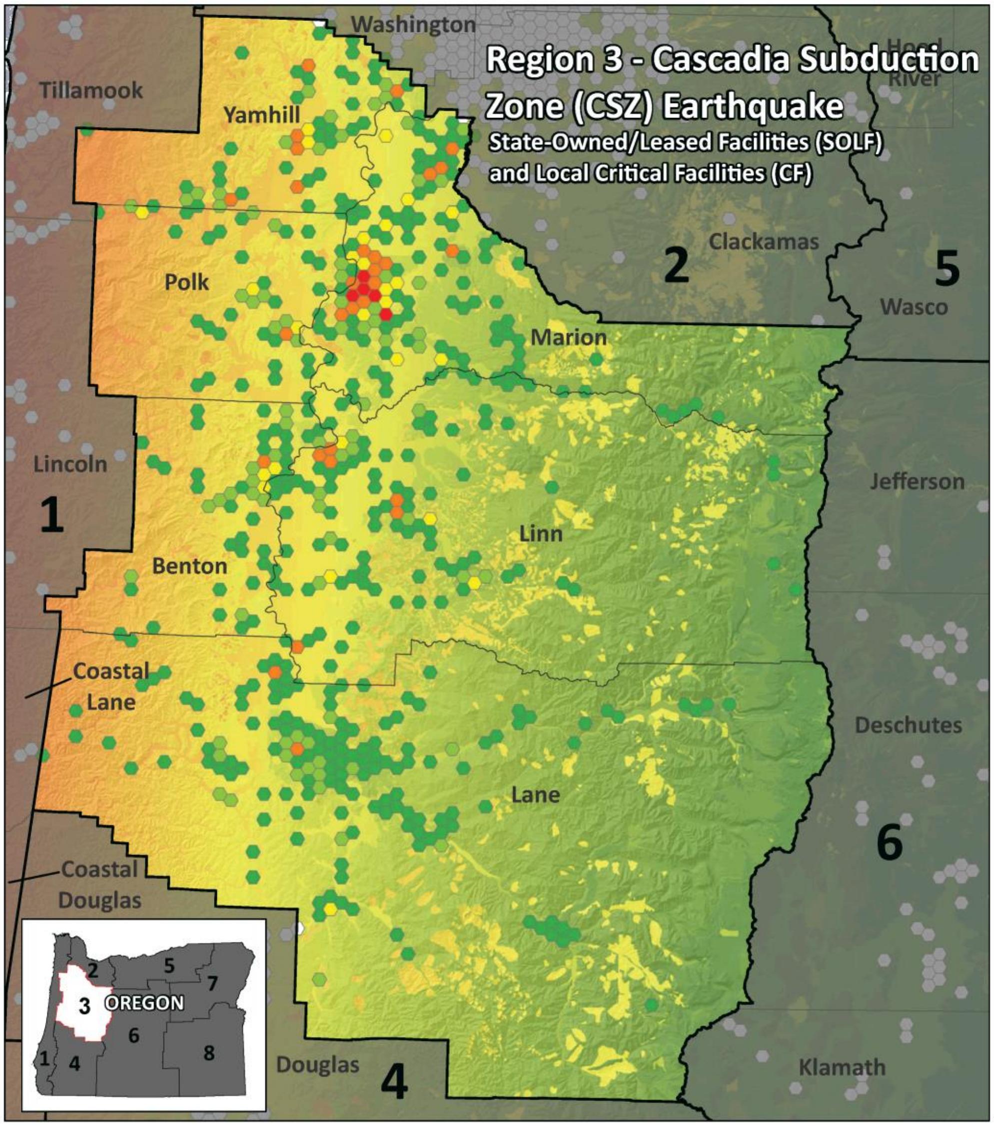
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a magnitude 9 Cascadia Subduction Zone (CSZ) event in Region 3. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 3, a CSZ event could cause a potential loss of almost $843M in state building and critical facility assets, 93% of it in Marion County alone. The potential loss in local critical facilities is somewhat greater at almost $1.2B. Again, Marion County’s potential loss is greatest at 48%. Potential losses in Lane Line, Polk, and Yamhill Counties are similar, ranging 9-14%. Benton County’s potential loss is significantly less. **Figure 2-183** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

Figure 2-183. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Cascadia Subduction Zone Earthquake Hazard Zone in Region 3.High-resolution, full-size image linked from Appendix 9.1.26.



Estimated ($) losses to hazard per cell
- Outside of region
- 1 - 1,000,000
- 1,000,001 - 5,000,000
- 5,000,001 - 10,000,000
- 10,000,001 - 50,000,000
- 50,000,001 - 477,000,000

Earthquake peak ground acceleration
(Modified Mercalli Intensity Scale)
Moderate — Severe

Administrative boundary
- Mitigation Planning Region
- County

REGION 3		Estimated Loss ($) from CSZ Earthquake						
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*	Loss Local CF	Total Loss SOLF CF and Local CF
Benton	642,420,000	2,268,000	11%	4,976,000	7,244,000	76,996,000	79,264,000
Lane	2,960,570,000	1,133,000	0%	18,348,000	19,481,000	104,898,000	106,031,000
Linn	934,323,000	11,744,000	21%	5,250,000	16,994,000	165,778,000	177,522,000
Marion	4,700,844,000	341,971,000	28%	449,154,000	791,125,000	570,657,000	912,628,000
Polk	508,293,000	1,827,000	1%	1,366,000	3,193,000	115,000,000	116,827,000
Yamhill	851,391,000	3,951,000	29%	801,000	4,752,000	148,163,000	152,114,000
Total	10,597,841,000	362,894,000	25%	479,895,000	842,789,000	1,181,492,000	1,544,386,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:750,000

Source Data:
CSZ Earthquake: Peak ground acceleration from the Oregon Resilience Plan, DOGAMI, 2013
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

0 10 20 40 Miles
N

Source: DOGAMI

Historic Resources

Of the 19,731 historic resources in Region 3, only 10% are in an area of high or very high liquefaction potential. Almost three quarters of those, 74%, are located in Linn County. Another 20% are located in Marion and Polk Counties. Many more (44%) of Region 3's historic resources are located in areas of high or very high potential for ground shaking amplification. Of those, 27% are located in Marion County. Benton, Linn, and Yamhill Counties have sizable shares of historic resources at risk of ground shaking amplification as well, ranging from 14 to 24%.

Archaeological Resources

Three thousand five hundred thirty-four archaeological resources are located in earthquake hazard areas in Region 3. Only three archaeological resources listed on the National Register of Historic Places and six eligible for listing are located in areas of high earthquake hazards. Eleven have been determined not eligible, and 200 have not been evaluated. All of the listed and eligible resources in areas of high earthquake hazards are located in Lane, Linn, and Marion Counties. Overall, the majority archaeological resources in earthquake hazard areas in Region 3 are in Lane County (55%) followed by Linn County (24%).

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in Region 3 is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well". Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Linn, Marion, and Yamhill Counties are most vulnerable, each with a very high rating. Polk County has a moderate rating and Benton and Lane Counties both have a low rating.

Seismic Lifelines

"Seismic lifelines" are the state highways ODOT has identified as most able to serve response and rescue operations, reaching the most people and best supporting economic recovery. The process, methodology, and criteria used to identify them are described in Section **2.1.6, Seismic**

Transportation Lifeline Vulnerabilities, and the full report can be accessed at Appendix **9.1.16**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification* (OSLR). According to that report, seismic lifelines in Region 3 have the following vulnerabilities.

Regional delineations for this Plan and for the OSLR are slightly different. Regions in the OSLR that correspond to Region 3 include sections of the Valley and Cascades Geographic Zones.

VALLEY GEOGRAPHIC ZONE (OLSR). The Valley Geographic Zone generally consists of two or three north-south routes through the Willamette Valley and a variety of east-west connectors between those routes. The entire area is likely to experience sustained ground shaking, with many roadways in areas subject to landslide and rockfall or liquefaction. Seismic lifeline routes that provide redundant north-south movement were designated.

The Tier 1 system in the Valley Geographic Zone consists of the following corridors:

- I-5,
- OR-99W from I-5 to OR-18 near Dayton,
- OR-18 from OR-99W near Dayton to McMinnville, and
- OR-22 from I-5 to OR-99E in Salem.

The Tier 2 system in the Valley Geographic Zone consists of the following corridors:

- US-26 from OR-47 to OR-217,
- OR-99W from McMinnville to Junction City,
- OR-99 from Junction City to I-5 in Eugene,
- OR-99E from Oregon City to I-5 in Salem, and
- OR-214 in Woodburn from I-5 to OR-99E.

The Tier 3 system in the Valley Geographic Zone consists of the following corridors:

- OR-219 from Newberg to Woodburn,
- OR-99E in Salem from I-5 to OR-22,
- OR-22 from OR-99W to Salem, and
- OR-34 from Corvallis to I-5.

Region 3 includes the central area of the Cascades Geographic Zone. These routes connect the highly seismically impacted western portion of the state to the less seismically impacted central portion of the state. The Tier 1 system in this region consists of OR-58. The Tier 2 system in the Cascades Geographic Zone in Region 3 consists of OR-22 from Salem to Santiam Junction and US-20 from Santiam Junction to Bend. There are no corridors designated as Tier 3 in the Region 3 Cascades Geographic Zone.

REGIONAL IMPACT.

- Ground shaking: In Region 3, ground shaking will be of a magnitude and duration to cause property damage, possibly severe. Unreinforced structures, roadbeds, and bridges will be damaged to varying extents, and there will be damaged areas on lifelines that will be impassable without at least temporary repairs.
- Landslides and rockfall: Many rural and some developed area roadways in Region 3 are cut into or along landslide-prone features. A major seismic event will increase

landslide and rockfall activities and may reactivate ancient slides that are currently inactive.

- Liquefaction: Structures in wetland, alluvial and other saturated areas may be subject to liquefaction damage; the total area of such impacts will vary with the extent of saturated soils at the time of the event.

Regional Loss Estimates. Highway-related losses include disconnection from supplies and replacement inventory, and the loss of tourists and other customers who must travel to do business with affected businesses.

Most Vulnerable Jurisdictions. Benton, Lane, Linn, Marion, Polk, and Yamhill Counties are generally equally vulnerable to ground shaking from a CSZ event. Each county has some steep roads in rural and developed areas that may experience landslides. All three have some transportation facilities along river beds or crossing rivers that may be vulnerable to liquefaction.

Risk

Table 2-319. Risk of Earthquake Hazards in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Risk	M	H	VH	VH	H	VH

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Linn, Marion, and Yamhill Counties are at very high risk from earthquakes; Lane and Polk are at high risk. Only Benton County has a moderate risk. Its very high probability and high vulnerability of local critical facilities are moderated by the very low vulnerability of state buildings and critical facilities as well as its low social vulnerability

Extreme Heat

Characteristics

Climate conditions in the Willamette Valley are described as Mediterranean, with rainy winters and warm dry summers. Extreme temperatures aren't as common in western Oregon compared to other parts of the state; however, Region 3 does experience days above 90°F nearly every year. Eugene has an average of about 13 days per year above 90°F. The frequency of prolonged periods of high temperatures is expected to increase.

Historic Extreme Heat Events

Table 2-320. Historic Extreme Heat Events in Region 3

Date	Location	Notes
June 24–26, 2006	Region 1–3, 5	A broad upper ridge of unusually high height coupled with a thermally induced surface trough of low pressure lingered over the Pacific Northwest for several days. This pattern resulted in persistent offshore flow, and therefore many days of record-smashing high temperatures. Portland International Airport had 101 degrees on June 26 breaking the old record at 94 degrees in 1987.
July 20-24, 2006	Region 1–3, 5, 7	An unusually strong ridge of high pressure brought several days of record breaking hot and humid weather to NW Oregon. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row. On July 21, Portland reported 104°F.
June 28–30, 2008	Region 2, 3, 5, 7	An upper level ridge and thermal trough across the Pacific Northwest produced temperatures above 100 degrees for two consecutive days breaking records in many locations. Two people died of heat-related illness.
July 1, 2014	Region 3	An upper level ridge combined with a surface thermal trough and low level offshore winds resulted in a hot day across Northwest Oregon where inland temperatures peaked in the upper 90s.
Summer 2015	Region 2, 3	A series of heat waves struck western Oregon in the summer of 2015, Oregon's hottest year on record, driven by a strong, persistent upper level ridge over the region. Heat waves occurred June 7–9, June 26–28, July 1–5, July 28–30, and August 18–19. Heat-related illnesses and deaths were markedly greater during these heat wave periods and cooling shelters were opened. High temperatures were 10–20°F above normal and overnight low temperatures were also unseasonably warm. Many locations broke both daytime high temperature records as well as warm overnight low temperature records.
June 2–5, 2016	Region 3	Excessive Heat Event: Unseasonably strong ridge of high pressure resulted in a period of early-season hot temperatures across Northwest Oregon. Temperatures of 95 to 100 in early June lead to people seeking relief at local rivers. Three drownings were reported.
August 1–4, 2017	Region 2–4, 6	Excessive Heat Event: Strong high pressure brought record breaking heat to many parts of southwest, south central, and northwest Oregon. Region 2–3: The record-breaking heat led people to seek relief at local rivers. Two people drowned while swimming.
July 12–17, 2018	Region 2, 3, 4	Region 2–3: High pressure over the region led to a stretch of hot day July 12 through July 17th. Hot temperatures led people to cool off in local rivers. There were two drownings recorded on July 16 and July 18. Temperatures on July 16th near the Sandy River in Troutdale got up to 98 degrees

Source: https://www.ncdc.noaa.gov/stormevents

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning "very low." Region 3 relative probability rankings are shown in **Table 2-321**. Most of the region is in the center quintile of extreme heat frequency meaning relative probability is moderate compared to the rest of the state. The coastal portion of Lane County is included in Region 3 for this assessment.

Table 2-321. Probability of Extreme Heat in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	M	M	M	L	M	M

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Extreme temperatures are relatively rare in Region 3, but are projected to increase under future climate change. **Table 2-322** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 3.

Table 2-322. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 3 Counties

County	Historic Baseline	2050s Future
Benton	4	25
Lane	4	24
Linn	3	22
Marion	3	20
Polk	4	23
Yamhill	5	24

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

Vulnerability

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, **Extreme Heat**. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are houseless.

Because extreme heat isn't as common in western Oregon ("moderate" probability) compared to other parts of the state, many people may not be accustomed or prepared when an extreme heat event occurs ("moderate" adaptive capacity). In Cooling Zone 1, which includes Region 3, 58% of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1–2 earned a ranking of 1 (very low); scores of 3–4 earned a ranking of 2 (low); scores of 5–6 earned a ranking of 3 (moderate); scores of 7–8 earned a ranking of 4 (high); and scores of 9–10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-323 displays the total vulnerability rankings as well as ranking for sensitivity and adaptive capacity for each county in NHMP Region 3. **Table 2-324** provides the summary descriptors of Region 3's vulnerability.

Combining sensitivity and adaptive capacity, Region 3's relative vulnerability to extreme heat is "High." With their high vulnerability ratings, Linn, Marion, and Yamhill Counties are the most vulnerable to extreme heat in Region 3.

Table 2-323. Relative Vulnerability Rankings for Region 3 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 3	**4**	**3**	**4**
Benton	2	3	3
Lane	3	3	3
Linn	4	3	4
Marion	5	3	4
Polk	3	3	3
Yamhill	4	3	4

Source: Oregon Climate Change Research Institute

Table 2-324. State Assessment of Vulnerability to Extreme Heat in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	M	H	H	H	H	H

Source: Oregon Climate Change Research Institute

Table 2-325. Local Assessment of Vulnerability to Extreme Heat in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	—	—	—	M	—	—

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Similar to drought, prolonged elevated temperatures pose risks to agriculture, involving health and welfare to farmers, farm workers, crops and livestock. Higher temperatures, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. High temperature and insufficient water stunt plant growth and cause areas of crops to wither.

Some livestock, especially dairy cattle, are sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms.

Also similar to drought, impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. Since heat waves are more recent to the Willamette Valley, appropriate data have not been collected to assess economic impacts to the state.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 3 is approximately $3,107,827,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $7,490,014,000. Because extreme heat, while relatively uncommon in Region 3, could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, three losses totaling almost $39,000 state facilities were recorded in Region 3 since the beginning of 2015. None were caused by extreme heat.

Risk

With respect to extreme heat, risk is defined as the combination of the probability of extreme heat events, sensitivity to extreme heat, and level of adaptive capacity in response to extreme heat.

The total relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total risk scores of 1–2 earned a ranking of 1 (“very low”); scores of 3–4 earned a ranking of 2 (“low”); scores of 5–6 earned a ranking of 3 (“moderate”); scores of 7–8 earned a ranking of 4 (“high”); and scores of 9–10 earned a ranking of 5 (“very high”). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-326 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 3. Table 2-327 provides the summary descriptors of Region 3's risk to extreme heat.

Combining probability and vulnerability, Region 3's relative risk to extreme heat is "Moderate." Linn and Yamhill Counties are at high risk.

Table 2-326. Risk Rankings for Region 3 Counties

County	Probability	Vulnerability	Risk
Region 3	**3**	**4**	**3**
Benton	3	3	3
Lane	3	3	3
Linn	3	4	4
Marion	2	4	3
Polk	3	3	3
Yamhill	3	4	4

Source: Oregon Climate Change Research Institute

Table 2-327. Risk of Extreme Heat in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Risk	M	M	H	M	M	H

Source: Oregon Climate Change Research Institute

Floods

Characteristics

Region 3 has a lengthy flood history. Notable floods affecting Region 3 are shown in **Table 2-328**. **Table 2-329** describes flood sources for each of the counties in the region. Additionally, sheet flooding occurs on agricultural land. Because this occurs far from a source river or stream, however, such flood areas are not depicted on federal Flood Insurance Rate Maps.

Most of the serious flooding experienced in Region 3 occurs in December and January. These events are usually associated with La Niña conditions, which result in prolonged rain and rapid snowmelt on saturated or frozen ground. This sudden influx of water causes rivers to swell, forcing tributary streams to back up and flood communities.

Region 3 is protected by several flood control dams.

A very large 1964 flood was a result of unusually intense precipitation on frozen topsoil, augmented by snowmelt in the mountains and valley. Without upstream flood control structures, the 1964 flood would have been the largest flood of the 20th century, with a peak discharge of 320,000 cubic feet per second (cfs) at the Albany gage. However, upstream dams reduced the peak discharge to 186,000 cfs.

The unincorporated areas of Region 3 are nearly all agricultural lands or timberlands. Flood damage in those areas would be limited to farm crops, farm buildings and residences, and erosion of croplands.

The Federal Emergency Management Agency (FEMA) has mapped most flood-prone streams in Oregon. The maps depict the 1% flood (100 year) upon which the National Flood Insurance Program is based. All of the Region 2 counties have Flood Insurance Rate Maps (FIRM). The FIRMs were issued at the following times:

- Benton, June 6, 2011 with some panels issued on December 8, 2016;
- Lane, June 2, 1999;
- Linn, September 29, 2010 with some panels issued on December 8, 2016;
- Marion, January 19, 2000 with some panels issued October 18, 2019;
- Polk, December 19, 2006with some panels issued October 18, 2019; and
- Yamhill, March 2, 2010.

FEMA is working through the Risk MAP process in Lane County to update the FIRMs. Preliminary FIRMs are anticipated in February 2020 to be followed with CCO meetings with local officials and eventual public review of the updated FIRMs.

The Risk MAP project for the Upper Willamette anticipates draft maps to be issued in summer 2020.

Historic Flood Events

Table 2-328. Significant Historic Floods Affecting Region 3

Date	Location	Characteristics	Type of Flood
Dec. 1861	Willamette Basin and coastal rivers	preceded by two weeks of heavy rain; every town on the Willamette was flooded or washed away; 635,000 cfs at Portland	rain on snow; snow melt
Jan. 1881	Willamette Basin	Lane, Linn, Benton, Marion, Polk, Yamhill, Clackamas, Multnomah Counties	
Feb. 1890	Willamette Basin and coastal rivers	second largest known flood in the Willamette Basin; almost every large bridge washed downstream	rain on snow
Dec. 1937	western Oregon	flooding followed heavy rains; considerable highway flooding; landslides	rain on snow
Jan. 1953	western Oregon	widespread flooding in western Oregon accompanied by windstorm	rain on snow
Dec. 1964-Jan. 1965	Willamette Basin	record flooding throughout Willamette Basin; two intense storms; near-record early season snow depths; largest flood in Oregon since dam construction on upper Willamette (1940s–50s; $34 million in damages	rain on snow
Jan. 1974	western Oregon	flooding followed heavy wet snow and freezing rain; nine counties received Disaster Declaration	rain on snow
Dec. 1978	western Oregon	intense heavy rain, snowmelt, saturated ground; one fatality in Region 3 (Benton County)	rain on snow
Feb. 1986	entire state	severe statewide flooding; rain and melting snow; numerous homes flooded and highways closed	snow melt
Feb. 1987	western Oregon	Willamette River and tributaries; mudslides; damaged highways and homes	rain on snow
Feb. 1996	entire state	deep snowpack, warm temperatures, record-breaking rains; flooding, landslides, power-outages (FEMA-1099-DR-Oregon)	rain on snow
Nov. 1996	entire state	record-breaking precipitation; local flooding/landslides (FEMA-1149-DR-Oregon)	rain on snow
Dec. 2005	Polk, Marion, Linn, Lane and Benton Counties	heavy rains causing rivers to crest above flood stage in Polk, Marion, Linn, Lane, and Benton Counties, as well as other counties in the Willamette Valley	riverine
Jan. 2006	Willamette Valley	heavy rains caused many rivers to crest above flood stage in the Willamette Valley, causing road closures and damage to agricultural lands	riverine
Dec. 2007	Yamhill	South Yamhill River flooded near McMinnville, causing damage to roads and bridges, 120 homes in Sheridan along with a few businesses and churches, and causing minor damage in Willamina; total county-wide damage estimates at $9.6 million	riverine
Dec. 2007	Polk	major flooding in Suver and other areas in Polk County; total losses equal $1 million for entire county	riverine
Jan. 2012	Polk, Marion, Yamhill, Lincoln, Benton, Linn and Lane Counties	heavy rain and wind; ice (DR-4055); flooding in the Willamette Valley; 130 homes and seven businesses were damaged in the City of Turner; 29 streets were closed in the City of Salem; the state motor pool lost 150 vehicles and thousands of gallons of fuel; Thomas Creek in the City of Scio overtopped, damaging several buildings	riverine

Date	Location	Characteristics	Type of Flood
Nov. 2012	Curry, Josephine, and Lane Counties	heavy precipitation; the Curry Coastal Pilot reported over 2 million dollars in infrastructure damage in Brookings and another 2 million in Curry County due to recent heavy rains; sinkholes and overflowing sewage facilities were also reported; according to KVAL news, Eugene Public Works has opened its emergency command center to deal with numerous flooding incidents, including two flooded intersections	riverine
Feb. 2014	Lane, Coos, Marion and Tillamook and Counties	A series of fronts resulted in a prolonged period of rain for Northwest Oregon, and minor flooding of several of the area's rivers from February 12th through February 17th. Heavy rains caused the Coquille River at Coquille to flood. The flood was categorized as a moderate flood. The Nehalem River near Foss in Tillamook County exceeded flood stage on February 18th, 2014.	riverine
Dec. 2014	Tillamook, Lincoln, Lane, Polk Clackamas, Benton Coos and Douglas Counties	A slow moving front produced heavy rain over Northwest Oregon which resulted in the flooding of eight rivers. Another impact from the rain were a couple of land/rock slides that both blocked two highways. Heavy rain brought flooding to several rivers in southwest Oregon.	riverine
Dec. 2015	Tillamook, Lincoln, Washington, Clackamas, Multnomah, Lane, Columbia, Hood River, Polk, Coos, Douglas, Jackson and Curry Counties	A moist pacific front produced heavy rainfall across Northwest Oregon which resulted in river flooding, urban flooding, small stream flooding, landslides, and a few sink holes. After a wet week (December 5 through Dec 11), several rivers were near bank full ahead of another front on December 12th. Flooding from the Nehalem River and Rock Creek in Vernonia resulted in evacuation of homes and the implementation of the Vernonia Emergency Command Center. Heavy rain resulted in a land slide that closed OR47 at mile marker 8. More than $15 million dollars in property damage reported in these counties combined.	
Nov. 2016	Columbia, Tillamook, Lincoln, Benton, Washington, Polk, and Yamhill Counties	A moist Pacific front moving slowly across the area produced heavy rainfall, resulting in flooding of several rivers across Northwest Oregon and at least two landslides.	riverine
Feb. 2017	Marion, Polk, Yamhill, Washington, Columbia, Benton, Tillamook, Lane, Coos, Curry, Klamath, Wheeler and Malheur Counties	High river flows combined with high tide to flood some areas near the southern Oregon coast. Heavy rain combined with snow melt caused flooding along the Coquille River and the Rogue River twice this month in southwest Oregon. Heavy rain combined with snow melt caused flooding along the Sprague River in south central Oregon. Flows on the John Day river reached flood levels downstream of Monument due to the breaking up of an ice jam.	riverine and coastal flooding
Oct. 2017	Tillamook, Benton, and Clackamas Counties	A very potent atmospheric river brought strong winds to the north Oregon Coast and Coast Range on October 21st. What followed was a tremendous amount of rain for some locations along the north Oregon Coast and in the Coast Range, with Lees Camp receiving upwards of 9 inches of rain. All this heavy rain brought the earliest significant Wilson River Flood on record, as well as flooding on several other rivers around the area.	riverine
June 2018	Lane County	In Lane County an upper-level trough moved across the area from the southwest, generating strong thunderstorms which produced locally heavy rainfall, lightning, hail, and gusty winds.	
April 2019	Lane, Benton, Marion, Clackamas and Linn Counties		

Sources: Taylor and Hatton (1999); National Climatic Data Center Storm Events, located at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

Table 2-329. Principal Riverine Flood Sources by County in Region 3

Benton	Lane	Linn	Marion	Polk	Yamhill
Willamette River, N. Fork Alsea, and tributaries, especially:	Willamette River and tributaries, especially:	Willamette River and tributaries, especially:	Willamette River and tributaries, especially:	Willamette River and tributaries, especially:	Willamette River and tributaries, especially:
Marys River	Amazon Creek	Calapooia River	Santiam River	S. Yamhill River	Yamhill River
Newton Creek	Berkshire Slough	Santiam (N and S)	Pudding River	Ash Creek (all forks)	Yamhill Creek
Mill Race	Blue River	Thomas Creek	Battle Creek	Agency Creek	Baker Creek
Frazier Creek	Cedar Creek	Ames Creek	Butte Creek	Ellendale Creek	Chehalem Creek
Soap Creek	Coast Fork	Oak Creek	Beaver Creek	Gibson Creek	Cozine Creek
Oak Creek	Dedrick Slough	Peters Ditch	Claggett Creek	Rickreall Creek	Hess Creek
Jackson Creek	Fall Creek	Truax Creek	Croisan Creek	Rock Creek	Palmer Creek
	Long Tom River		Gibson Creek	Rowell Creek	
	McKenzie River		Lake Labish Creek		
	Mohawk River		Mill Creek		
	Oxley Slough		Pringle Creek		
	Row River		Senecal Creek		
	Salmon Creek		Silver Creek		
	Silk Creek		Shelton Ditch		

Sources: FEMA, Benton County Flood Insurance Study (FIS), Aug. 15, 1996; FEMA, Lane County FIS, June 2, 1999; FEMA, Linn County FIS, Sept. 29, 1986; FEMA, Marion County FIS, July 13, 2001; FEMA, Polk County FIS, Dec. 19, 1995; FEMA, Yamhill County FIS, Sept. 30, 1983

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the “OEM Hazard Analysis Methodology” used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete “OEM Hazard Analysis Methodology” is located in Appendix **9.1.19**.

The purpose of the probability and vulnerability scores is to identify high-priority areas to which local and state governments can target mitigation actions.

Probability

Local Assessment

Participants in each county's Natural Hazard Mitigation Plan update process used the OEM hazard analysis methodology to analyze the probability that Region 3 will experience flooding. The resulting estimates of probability are shown in **Table 2-330**.

Table 2-330. Local Assessment of Flood Probability in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	H	H	H	H	H	H

Source: Benton County MJNHMP (2016; https://www.co.benton.or.us/sites/default/files/fileattachments/sheriff039s_office/page/6029/natural_hazard_mitigation_plan_2016.pdf), Lane County MJNHMP (2018; https://lanecounty.org/UserFiles/Servers/Server_3585797/File/Government/County%20Departments/Emergency%20Management/Hazard%20Mitigation%20Plan/20180828__MASTER_MJ-NHMPUpdate_Final.pdf), Linn County MJNHMP (2017; http://www.co.linn.or.us/Planning/HazardPlan/NHMP%202018.pdf); Marion County MJNHMP (2017; https://www.co.marion.or.us/PW/EmergencyManagement/Documents/120116_MarionNHMP_Volume%20I_Draft.pdf), Polk County MJNHMP (2017; https://cpb-us-e1.wpmucdn.com/blogs.uoregon.edu/dist/3/4943/files/2017/11/Volume-I-Polk-NHMP-Update-2f51ktm.pdf), Yamhill County Multi-Jurisdictional Hazard Mitigation Plan Update (2014; https://www.co.yamhill.or.us/sites/default/files/Yamhill_County_Natural_Hazard_Mitigation_Plan2014.pdf)

State Assessment

Using the methodology described in the Section 2.2.7.1, Floods/Probability, the state assessed the probability of flooding in the counties that comprise Region 3. The results are shown in **Table 2-331**.

Table 2-331. State Assessment of Flood Probability in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	VH	VH	VH	H	H	H

Source: DOGAMI

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Along the Willamette River and its tributaries (Regions 2, 3, and 4), the largest increases in extreme river flows are more likely to be upstream (toward Cascades headwaters), and less likely as one travels downstream. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-332. Local Assessment of Vulnerability to Flood in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	M	H	M	H	M	H

Source: Benton County MJNHMP (2016; https://www.co.benton.or.us/sites/default/files/fileattachments/sheriff039s_office/page/6029/natural_hazard_mitigation_plan_2016.pdf), Lane County MJNHMP (2018; https://lanecounty.org/UserFiles/Servers/Server_3585797/File/Government/County%20Departments/Emergency%20Management/Hazard%20Mitigation%20Plan/20180828__MASTER_MJ-NHMPUpdate_Final.pdf), Linn County MJNHMP (2017; http://www.co.linn.or.us/Planning/HazardPlan/NHMP%202018.pdf); Marion County MJNHMP (2017; https://www.co.marion.or.us/PW/EmergencyManagement/Documents/120116_MarionNHMP_Volume%20I_Draft.pdf), Polk County MJNHMP (2017; https://cpb-us-e1.wpmucdn.com/blogs.uoregon.edu/dist/3/4943/files/2017/11/Volume-I-Polk-NHMP-Update-2f51ktm.pdf), Yamhill County Multi-Jurisdictional Hazard Mitigation Plan Update (2014; https://www.co.yamhill.or.us/sites/default/files/Yamhill_County_Natural_Hazard_Mitigation_Plan2014.pdf)

Table 2-333. State Assessment of Vulnerability to Flood in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	M	H	VH	M	M

Source: DOGAMI, DLCD

Participants in the county NHMPs were consulted to evaluate critical facilities and infrastructure vulnerabilities. Most counties in Region 3 have not yet catalogued critical facilities and infrastructure and therefore have not yet analyzed the hazards to which these facilities are subject. These counties have begun to consider that analysis by establishing mitigation actions such as developing a list of hazard types to be mapped and then identifying, locating and obtaining the necessary data to plot critical facilities and infrastructure to show their location within the hazard areas. Benton County did catalogue those critical facilities located in the floodplain, but was not able to analyze whether these facilities might be damaged by flooding. Among these facilities were the wastewater/sewage treatment plants in Alsea, Corvallis, Monroe and Philomath, and Corvallis High School.

Repetitive Losses

FEMA has identified 46 Repetitive Loss buildings in Region 3, four of which are Severe Repetitive Loss properties. This region has the third most repetitive flood losses of the Oregon NHMP Natural Hazard Regions, reflecting its downstream location in or near the Willamette Valley, often flat topography, and population density.

Table 2-334. Flood Severe/Repetitive Losses and Community Rating System Communities by County in Region 3

County	RL/SRL	Number of CRS Communities per County
Benton	3	2
*Lane	30	3
** Linn	7	1
***Marion	15	2
Polk	1	1
Yamhill	5	1
Totals	**61**	**10**

*Includes non-coastal sections of Lane County.

**Albany is a CRS community located in both Benton and Linn Counties. For the purposes of this table, Albany is counted as being in Linn County.

***Salem is located in both Marion and Polk Counties. For the purposes of this table, Salem is counted as being in Marion County due to the way FEMA categorizes the City of Salem.

Source: FEMA NFIP Community Information System, https://isource.fema.gov/cis/ accessed February 2020

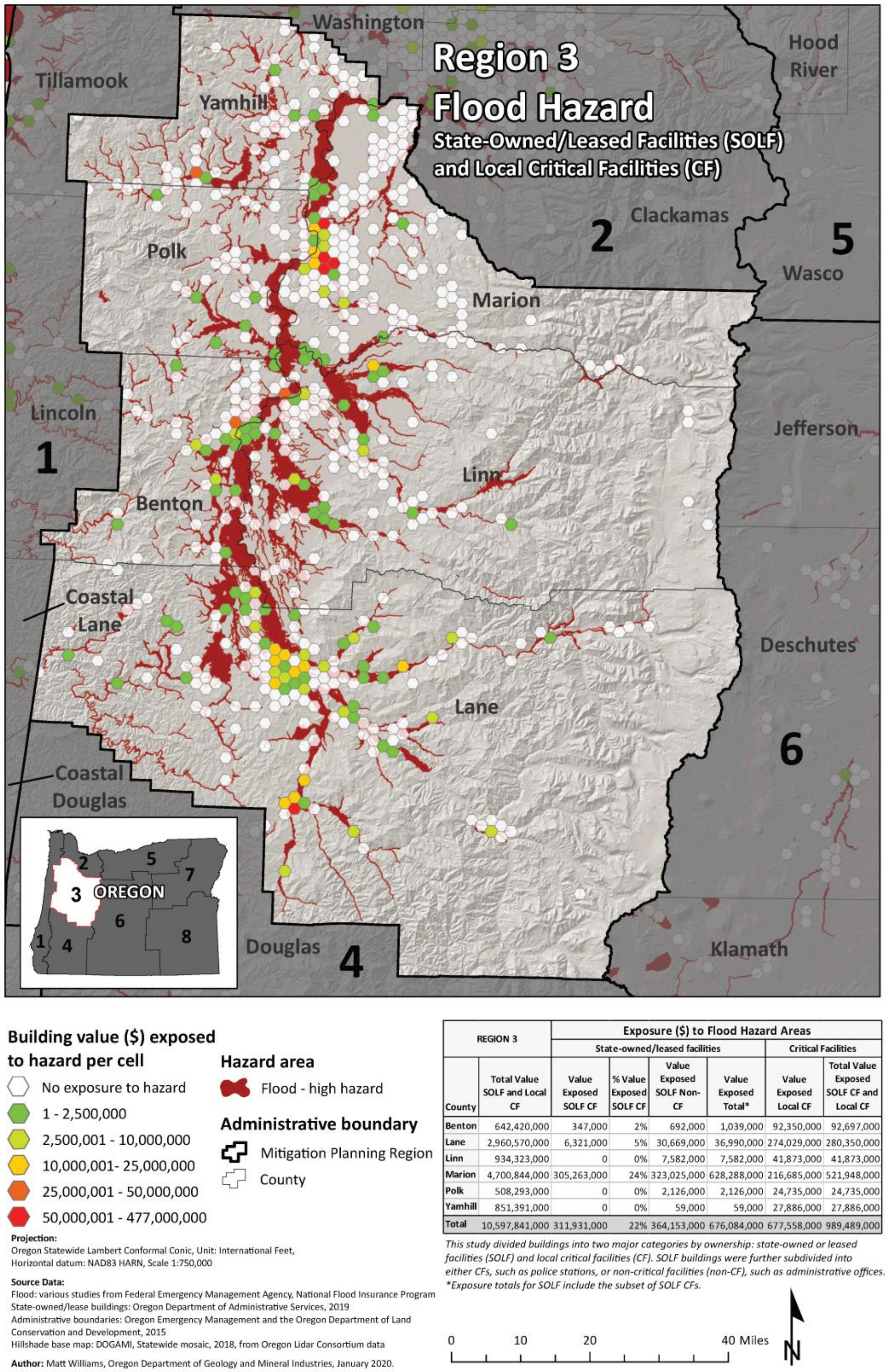
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. Benton, Lane, Marion, and Polk Counties participate in CRS, as do the cities of Albany, Corvallis, Eugene, Salem, and Sheridan.

State-Owned/Leased Facilities and Critical/Essential Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 3, there is a potential loss from flooding of over $676M in state building and critical facility assets, 93% of it in Marion County alone. The next greatest share is about $37M, only one-half percent, in Lane County. There is a similar potential loss due to flood in local critical facilities: close to $677.6M, forty percent and 32% in Lane and Marion Counties, respectively. The next greatest share, 14% is in Benton County. **Figure 2-184** illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding.

Figure 2-184. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 3.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 3		Exposure ($) to Flood Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Benton	642,420,000	347,000	2%	692,000	1,039,000	92,350,000	92,697,000
Lane	2,960,570,000	6,321,000	5%	30,669,000	36,990,000	274,029,000	280,350,000
Linn	934,323,000	0	0%	7,582,000	7,582,000	41,873,000	41,873,000
Marion	4,700,844,000	305,263,000	24%	323,025,000	628,288,000	216,685,000	521,948,000
Polk	508,293,000	0	0%	2,126,000	2,126,000	24,735,000	24,735,000
Yamhill	851,391,000	0	0%	59,000	59,000	27,886,000	27,886,000
Total	10,597,841,000	311,931,000	22%	364,153,000	676,084,000	677,558,000	989,489,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 19,731 historic resources in Region 3, two thousand three hundred seventy-seven (12%) are located in an area of high flood hazard. Of those, 1,480 (62%) are located in Lane County. The next greatest share, 17%, is in Marion County.

Archaeological Resources

Of the 854 archaeological resources located in high flood hazard areas in Region 3, fifty-two percent are located in Lane County. The next greatest share, 24% is in Linn County. Twenty-two are listed on the National Register of Historic Places and 37 are eligible for listing. Twenty have been determined not eligible and 775 have not been evaluated as to their eligibility. The listed resources are located in Lane (15), Marion (6), and Yamhill (1) Counties. Thirteen and 14 of the eligible resources are located in Lane and Marion Counties, respectively; the rest are spread throughout Region 3.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Marion County is very highly vulnerable and Linn County is highly vulnerable to the impacts of flood. Marion County's very high vulnerability score is driven by the high value of state buildings, state critical facilities, and local critical facilities in the county as well as its very high social vulnerability. Linn County's high score is driven primarily by its high social vulnerability. While Lane County has twice as many repetitive or severe repetitive loss properties, Marion County still has a significant number. Lane County has significantly more historic and archaeological resources than Marion or Linn Counties.

Most Vulnerable Jurisdictions

Marion, Lane, and Linn Counties are the most vulnerable to flood hazards in Region 3.

Risk

Table 2-335. Risk of Flood Hazards in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Risk	H	VH	VH	VH	H	H

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, all Region 3 counties are at great risk from floods; Lane, Linn, and Marion Counties face the greatest risk

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owner's property to community destruction with mass fatalities. The 1889

Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost. Oregon's first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Table 2-336. Historic Significant Dam Failures in Region 3

Year	Location	Description
1982	Mann creek dam near Sweet Home in Linn Co.	Washed out multiple forest roads
2016	Heater Reservoir near Sublimity in Marion Co.	Flooded area occupied by Christmas tree packers, flooded paved road

Source: Oregon Water Resources Department Dam Safety Program records

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 28 High Hazard dams and 38 Significant Hazard dams in Region 3.

Table 2-337. Summary: High Hazard and Significant Hazard Dams in Region 3

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 3	9	38	19
Benton	1	1	0
Lane	1	5	13
Linn	1	0	6
Marion	2	13	0
Polk	2	8	0
Yamhill	2	11	0

Source: Oregon Water Resources Department, 2019

Table 2-338. High Hazard and Significant Hazard Dams in Region 3

County	Name	Rating	Regulator
Benton	North Fork	High	State
Benton	Thompson (Benton)	Significant	State
Lane	Blue River Dam	High	Federal
Lane	Cottage Grove	High	Federal
Lane	Cougar Reservoir	High	Federal
Lane	Dexter	High	Federal
Lane	Dorena	High	Federal
Lane	Fall Creek Reservoir	High	Federal
Lane	Fern Ridge	High	Federal
Lane	Hills Creek Reservoir	High	Federal
Lane	Hult Log Storage Pond	High	Federal
Lane	Leaburg Dam	High	Federal
Lane	Lookout	High	Federal
Lane	Walterville Power Intake	High	Federal
Lane	Walterville Pumped S. Pond	High	Federal
Lane	Santa Clara	High	State
Lane	Farnam Creek Reservoir	Significant	State
Lane	Forcia And Larsen Log Pond	Significant	State
Lane	Ford Farms Reservoir	Significant	State
Lane	Schwartz Reservoir	Significant	State
Lane	Vaughn Log Pond	Significant	State
Linn	Big Cliff Dam	High	Federal
Linn	Detroit Reservoir	High	Federal
Linn	Foster Reservoir	High	Federal
Linn	Green Peter Reservoir	High	Federal
Linn	Smith River	High	Federal
Linn	Trail Bridge Reg. Reservoir	High	Federal
Linn	Foster Log Pond	High	State
Marion	Franzen	High	State
Marion	Silver Creek	High	State

County	Name	Rating	Regulator
Marion	Barnes Bros. Reservoir	Significant	State
Marion	Berger Lake	Significant	State
Marion	Fredericks Pond	Significant	State
Marion	Funrue	Significant	State
Marion	Heater Dam	Significant	State
Marion	Heater Reservoir #2	Significant	State
Marion	Koinenia Lake Dam	Significant	State
Marion	Lorence Lake	Significant	State
Marion	Neil Creek Reservoir	Significant	State
Marion	Peterson, Floyd	Significant	State
Marion	Pettit Reservoir	Significant	State
Marion	Spring Lake Estates	Significant	State
Marion	Waldo Lake	Significant	State
Polk	Croft	High	State
Polk	Mercer	High	State
Polk	Deraeve Reservoir #1 (Lower)	Significant	State
Polk	Eola Hills Reservoir	Significant	State
Polk	Fern Creek	Significant	State
Polk	Kennel Reservoir	Significant	State
Polk	Koning "E" Reservoir	Significant	State
Polk	Mt. Springs Ranch Dam	Significant	State
Polk	Olson Reservoir (Mark)	Significant	State
Polk	Shaffer Reservoir	Significant	State
Yamhill	Baker, Er	High	State
Yamhill	Mcguire	High	State
Yamhill	Amity Hills Dam	Significant	State
Yamhill	Haskins Creek Dam	Significant	State
Yamhill	Hickory Hill Farm	Significant	State
Yamhill	Jensen (Yamhill Farm)	Significant	State
Yamhill	Katz Farm	Significant	State
Yamhill	Kuehne Dam	Significant	State
Yamhill	Muhs Quarry Dam	Significant	State
Yamhill	Olson Flashboard Dam	Significant	State
Yamhill	Panther Creek Reservoir	Significant	State
Yamhill	Walker (Bryan Creek)	Significant	State
Yamhill	Yamhill Vista Dam #5	Significant	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally regulated. A dam's condition is considered public information for state-regulated dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Five of the nine state-regulated high hazard dams are in satisfactory condition and four are in fair condition.

Table 2-339. Summary: Condition of High Hazard State-Regulated Dams in Region 3

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	Fair	Poor	Unsatisfactory	Not Rated
Region 3	5	4	0	0	0
Benton	1	0	0	0	0
Lane	1	0	0	0	0
Linn	0	1	0	0	0
Marion	1	1	0	0	0
Polk	1	1	0	0	0
Yamhill	1	1	0	0	0

Source: Oregon Water Resources Department, 2019

Table 2-340. Condition of High Hazard State-Regulated Dams in Region 3

County	Dam Name	Condition
Benton	North Fork	Satisfactory
Lane	Santa Clara	Satisfactory
Linn	Foster Log Pond	Fair
Marion	Silver Creek	Fair
Marion	Franzen	Satisfactory
Polk	Mercer	Fair
Polk	Croft	Satisfactory
Yamhill	Baker, Er	Fair
Yamhill	Mcguire	Satisfactory

Source: Oregon Water Resources Department, 2019

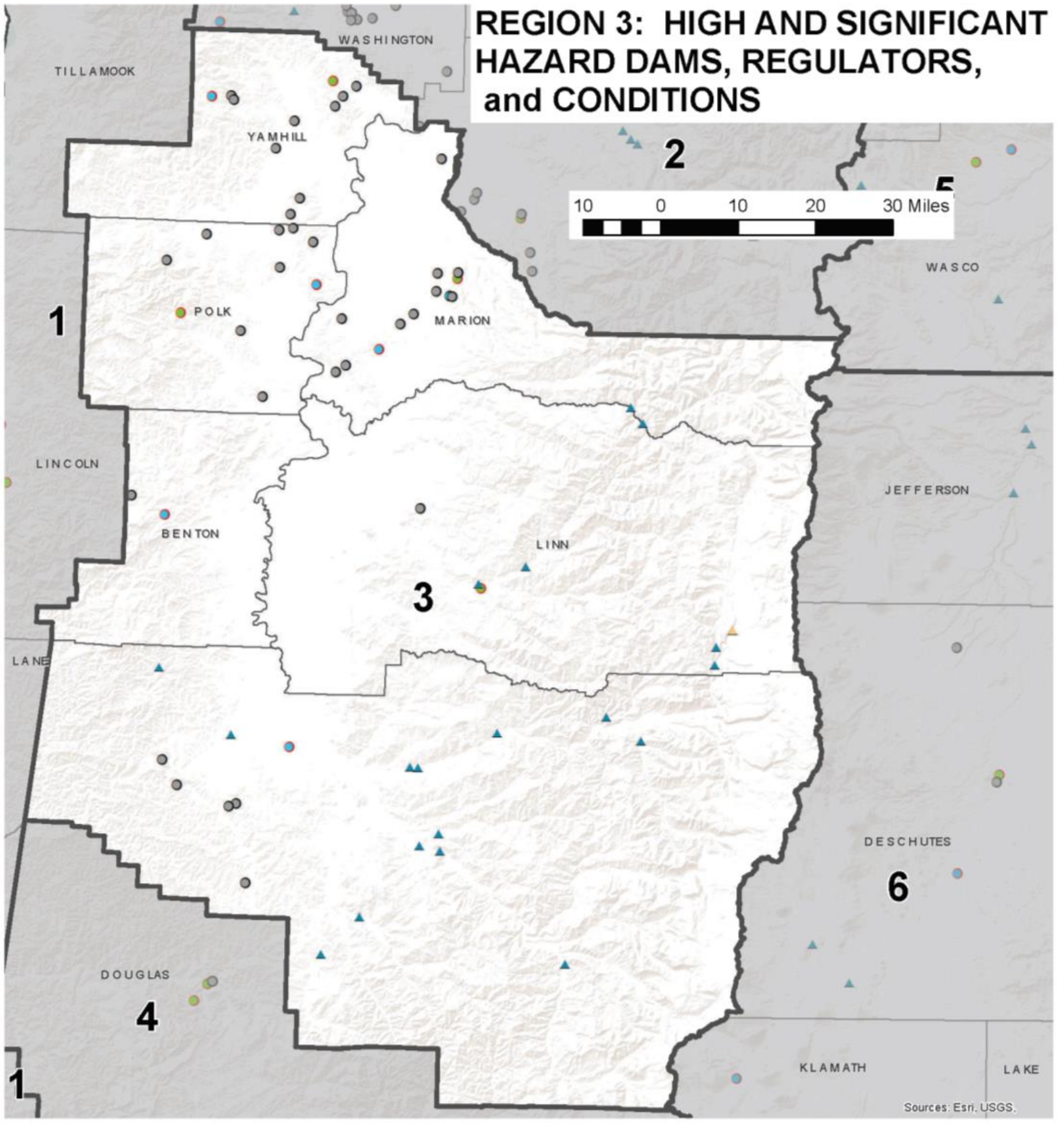
State-Regulated High Hazard Dams not Meeting Safety Standards

There are no state-regulated high hazard dams in Region 3 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Figure 2-185 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 3. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-185. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 3



	Coastal	Earthquake	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 3	0	31	*	22	3	0	0
Benton	0	2	*	0	0	0	0
Lane	0	14	*	6	1	0	0
Linn	0	3	*	6	2	0	0
Marion	0	2	*	3	0	0	0
Polk	0	3	*	1	0	0	0
Yamhill	0	7	*	6	0	0	0

* - flood risk affected by function and condition of dam, not by presence in mapped flood prone location

State regulated dams**

Condition assessment

- Poor
- Unsatisfactory
- Fair
- Satisfactory
- No assessment

Federal regulated dams

Hazard

- High
- Significant

Mitigation Planning Regions

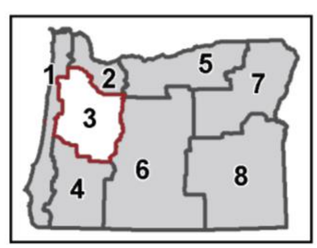
Counties

** - Significant hazard dam symbols have a black outline.
High hazard dam symbols have a red outline.

Projection:
Oregon Lambert Coordinate Reference System, Unit: International Feet, Horizontal datum: NAD83, EPSG #2992

Source Data:
State regulated dams: Oregon Water Resources Dept., July 2020
Mitigation Planning Regions: Oregon Emergency Management
Counties: U.S. Bureau of Land Management (BLM)
Base map: Esri, World Terrain Base

Author: Robert Harmon, GISP, Oregon Water Resources Dept. (July 2020)



Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

State-regulated high hazard dams in Region 3 are currently meeting safety standards.

Dams in the western portions of Region 3 can have high risks from earthquakes. Outside of valley locations, some dams have a moderately increased risk from landslide and wildfire, with some risk of large woody debris from wildfire. State-regulated dams in this region are not close to volcanic hazards; some federally regulated dams are closer.

No dams in Region 3 meet FEMA HHPD eligibility criteria.

Most Vulnerable Jurisdictions

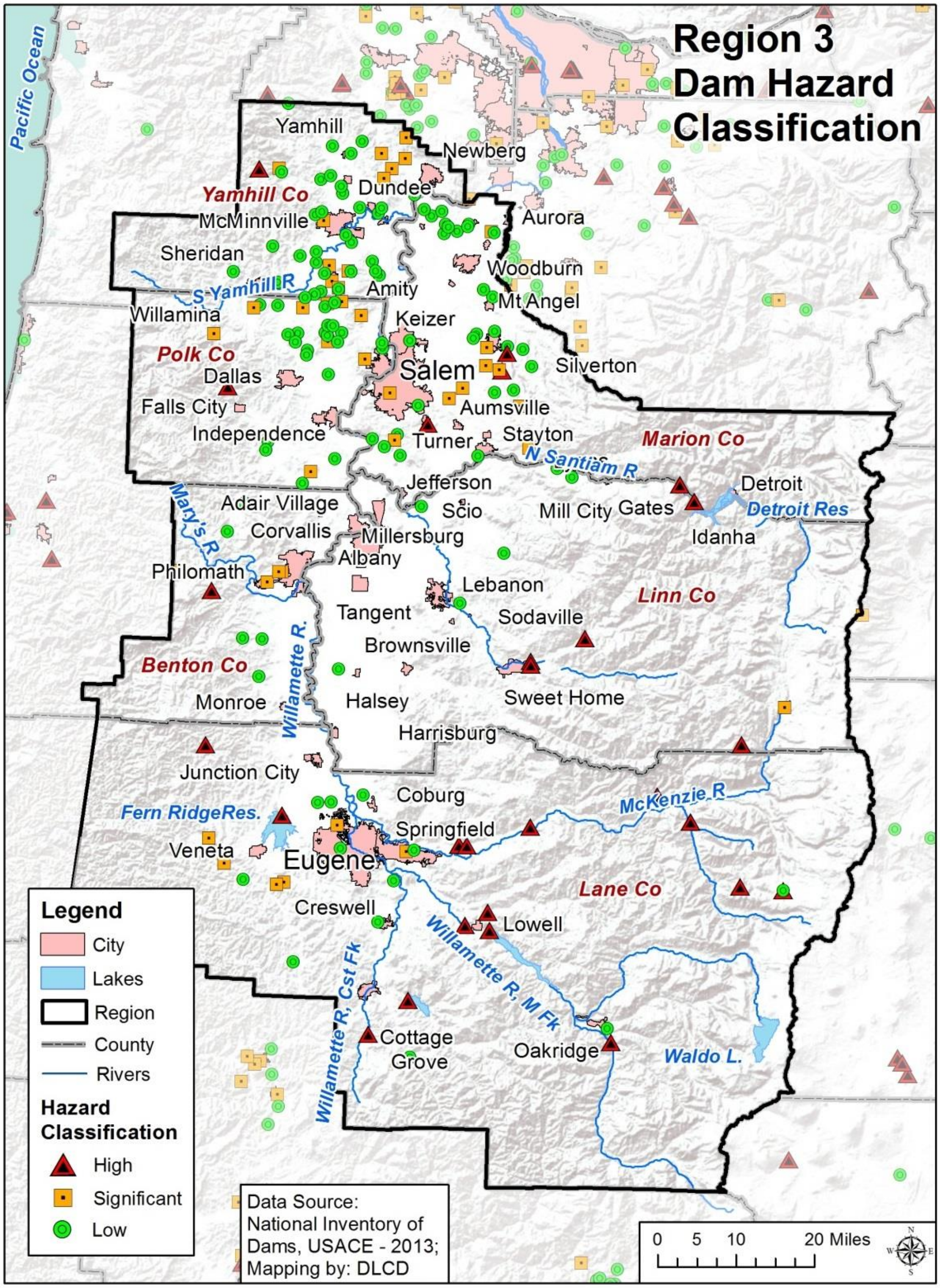
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), no Region 3 counties are considered “most vulnerable jurisdictions” because none have high hazard dams in poor or unsatisfactory condition.

As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable jurisdictions” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The counties with the most state-regulated significant hazard dams are Marion (13) and Yamhill (11).

Risk

The potential for damage to a dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-186. Region 3 Dam Hazard Classification



Source: National Inventory of Dams, USACE, 2013

Note: Federally regulated significant hazard dams are not shown.

Landslides

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the Coast Range and Cascade Mountains have a very high incidence of landslides. For example, the Vineyard Mountain area near Corvallis, which is in the Coast Range foothills, experienced at least half a dozen landslides during the January 2009 storm. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage.

Historic Landslide Events

Table 2-341. Historic Landslides in Region 3

Date	Location	Incident
Aug. 1957	near Westfir, Oregon	rock slide; fatalities: two workers
Feb. 1996		FEMA-1099-DR-Oregon; heavy rains and rapidly melting snow contributed to thousands of landslides/debris flows across the state; many on clear cuts that damaged logging roads
Nov. 1996	Benton, Lane, Lincoln, and Yamhill Counties	DR-1107; hundreds of landslides
Nov. 1996	Lane and Douglas Counties	FEMA-1149-DR-Oregon; heavy rain triggered mudslides (Lane and Douglas Counties); fatalities: eight; injuries: several (Douglas County)
Feb. 2002	Lane and Linn Counties	DR-1405, Feb 2002
Dec. 2005-Jan. 2006	Benton, Linn, Polk, and Yamhill Counties	DR-1632; several debris flows in the Oregon coast range
Dec 2006	Benton, Polk, and Yamhill Counties	DR-1683
Dec. 2007	Polk and Yamhill Counties	DR-1733; hundreds of landslides
Dec. 2008	Marion, Polk, and Yamhill Counties	DR-1824
Jan. 2012	Benton, Lane, Linn, Marion, and Polk Counties	DR-4055
Feb. 2014	Benton, Lane, and Linn Counties	DR-4169
Dec. 2015	Linn, Lane, Polk, and Yamhill Counties	DR-4258
Dec. 2016	Lane County	DR-4296; several roads closed from landslides
Feb. 2019	Lane County	DR-4432; Highway 224 closed from rockfall
Apr. 2019	Linn County	DR-4452

Sources: Taylor and Hatton (1999); Oregon Department of Transportation Emergency Operations Plan, October 7, 2002; https://www.fema.gov/disasters

Probability

Table 2-342. Assessment of Landslide Probability in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	H	VH	H	H	H	VH

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in this region in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-343. Local Assessment of Vulnerability to Landslides in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	M	—	H	L	L

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-344. State Assessment of Vulnerability to Landslides in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	M	M	H	L	M

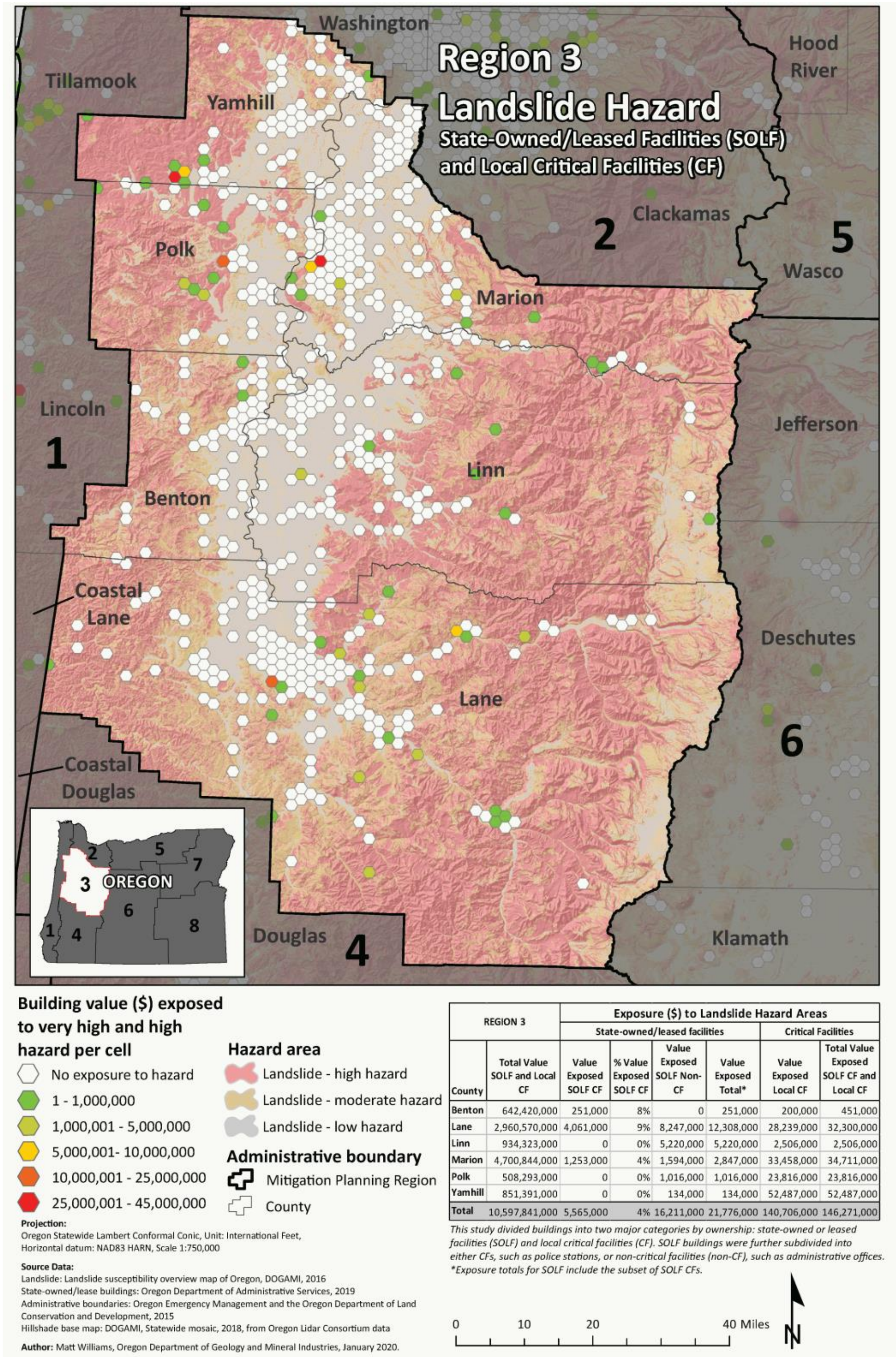
Source: DOGAMI and DLCD, 2020

Many of the communities in this region are vulnerable to landslides; for example, the cities of Salem, Corvallis, and Eugene all have moderate exposure to landslides. As previously mentioned, the Vineyard Mountain area near Corvallis had landslides during the January 2009 storm. Many of these landslides caused significant damage to homes, roads, and the environment.

State-Owned/Leased Buildings And Critical Facilities And Local Critical Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 3. More than $21.7M in value is exposed to landslide hazards in Region 3, over half of it in Lane County. The potential loss to local critical facilities is more than six times the value of state facilities at over $140.7M. Yamhill County has 37% of the value of local critical facilities followed by Polk, Lane, and Marion Counties whose shares range from 17% to 24%. **Figure 2-187** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

Figure 2-187. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 3.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 3		Exposure ($) to Landslide Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*		Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Benton	642,420,000	251,000	8%	0	251,000		200,000	451,000
Lane	2,960,570,000	4,061,000	9%	8,247,000	12,308,000		28,239,000	32,300,000
Linn	934,323,000	0	0%	5,220,000	5,220,000		2,506,000	2,506,000
Marion	4,700,844,000	1,253,000	4%	1,594,000	2,847,000		33,458,000	34,711,000
Polk	508,293,000	0	0%	1,016,000	1,016,000		23,816,000	23,816,000
Yamhill	851,391,000	0	0%	134,000	134,000		52,487,000	52,487,000
Total	10,597,841,000	5,565,000	4%	16,211,000	21,776,000		140,706,000	146,271,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 19,731 historic resources in Region 3, two hundred sixty-five or about 1.5% are in an area of very high or high landslide hazard susceptibility; 2,446 or about 12% in moderate; and 16,999 or about 86% in low. The greatest number of historic resources exposed to landslide hazards is in Lane County.

Archaeological Resources

Of the 1,854 archaeological resources located in landslide hazard areas in Region 3, seventy percent (1,293) are in high landslide hazard areas. Of those, 21 are listed on the National Register of Historic Places and 47 are eligible for listing. Thirty-two have been determined not eligible, and 1,193 have not been evaluated as to their eligibility. Fifty-seven percent of both the archaeological resources in high landslide hazard areas and those in landslide areas in Region 3 overall are located in Lane County. The resources that are listed and eligible for listing are located in all counties except Yamhill County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in Region 3 is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Marion County is the most vulnerable to landslides in Region 3.

Risk

Table 2-345. Assessment of Risk to Landslides in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Risk	M	VH	H	VH	M	VH

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 Risk Scores and DOGAMI's expert assessment, Lane, Linn, Marion, and Yamhill counties are "most vulnerable jurisdictions" with either very high or high risk ratings. All communities should be prioritized for mitigation actions.

Volcanoes

Characteristics

The eastern boundaries of Lane, Linn, and Marion Counties coincide with the crest of the Cascade Mountains. Volcanic activity in the Cascades will continue, but questions regarding how, to what extent, and when remain unanswered. Most volcano-associated hazards are local (e.g., explosions, debris, lava, and pyroclastic flows). However, lahars can travel considerable distances downstream, and wind-borne ash can blanket areas many miles from the source.

Historic Volcanic Events

Table 2-346. Historic Volcanic Events Affecting Region 3

Date	Location	Description
about 10,000 to <7,700 YBP	cones south of Mount Jefferson; Forked Butte and South Cinder Peak	lava flows
about 4,000 to 3,000 YBP	Sand Mountain, central Cascades	lava flows and cinder cones in Sand Mountain field
about 3,000 to 1,500 YBP	Belknap Volcano, central Cascades	lava flows, tephra
about 2,000 YBP	South Sister Volcano	rhyolite lava flow
about 1,300 YBP	Blue Lake Crater, central Cascades	spatter cones and tephra

Note: YBP is years before present.

Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/
Scott, et al. (2001); Walder, et al. (1999)

Probability

Table 2-347. Assessment of Volcanic Hazards Probability in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	L	M	M	M	L	L

Source: DOGAMI, 2020

Region 3 communities are closest to the Three Sisters and Mount Jefferson. Middle and South Sisters are the most active of the group. Because geologic history is fragmentary for these volcanoes, the probability of future explosive eruptions is difficult to estimate. Only two explosive episodes have occurred at the South Sister since the end of the ice age (about 12,000 years ago). Given the fragmentary record, the annual probability of the South and Middle Sister entering a new period of eruptive activity has been estimated from 1 in several thousand to 1 in 10,000 (Schilling, et al., 1997). Similar difficulties complicate predictions of future eruptions at Mount Jefferson. There have been four episodes of lava flow eruptions around Mount Jefferson since the end of the Ice Age (about 12,000 years ago). Such a frequency suggests an annual probability of lava flow eruptions of 1 in 4,000 to 1 in 3,000 Walder, et al. (1999).

Table 2-348 provides further information about probability of volcanic eruptions in Region 3.

Table 2-348. Probability of Volcano-Related Hazards in Region 3

Volcano-Related Hazards	Benton	Lane	Linn	Marion	Polk	Yamhill	Remarks
Volcanic ash (annual probability of 1 cm or more accumulation from eruptions throughout the Cascade Range)	1 in 1,000 to 1 in 5,000	1 in 1,000	1 in 1,000	1 in 1,000	1 in 1,000 to 1 in 5,000	1 in 1,000 to 1 in 5,000	Sherrod, et al. (1997)
Lahar	no risk	source: Three Sisters McKenzie River: 3 scenarios: source to Thurston	Source: Mt. Jefferson S. Santiam R. from Mt. Jefferson to Detroit	source: Mt. Jefferson, N. and S. Santiam rivers from Mt. Jefferson to Detroit	no risk	no risk	if the Detroit Lake dam is breached, lahars could reach Mill City, Lyons, and Stayton in Marion County: Walder, et al. (1999) (maps); Lane County: Scott, et al. (2001) (map)
Lava flow	no risk	source: Three Sisters immediate vicinity	Source: Mt. Jefferson Immediate vicinity	source: Mt. Jefferson immediate vicinity	no risk	no risk	Mt. Jefferson: Walder, et al. (1999) (maps); Three Sisters: Scott, et al. (2001) (maps)
Debris flow / avalanche	no risk	source: Three Sisters Proximity	Source: Mt. Jefferson Proximity	source: Mt. Jefferson proximity	no risk	no risk	Mt. Jefferson: Walder, et al. (1999) (maps); Three Sisters: Scott, et al. (2001) (maps)
Pyroclastic flow	no risk	source: Three Sisters Proximity	Source: Mt. Jefferson Pamelia and Minto Creeks	source: Mt. Jefferson Whitewater Cr and S. Fork Santiam	no risk	no risk	Mt. Jefferson: Walder, et al. (1999) (maps); Three Sisters: Scott, et al. (2001) (maps)

Sources: Sherrod, et al. (1997), Walder, et al. (1999), Scott, et al. (2001)

Vulnerability

Table 2-349. Local Assessment of Vulnerability to Volcanic Hazards in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	L	M	L	M	L

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-350. State Assessment of Vulnerability to Volcanic Hazards in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	H	H	VH	L	M

Source: DOGAMI and DLCD, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 3 (Figure 2-XX). Over $153M in value is exposed to volcanic hazards in Region 3, all of it in Marion, Lane, and Linn Counties.

Historic Resources

Of the 19,731 historic buildings in Region 3, 154 are exposed to moderate volcanic hazards, all in the same three counties. See Appendix **9.1.12** for details.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

According to the 2020 vulnerability scores, Marion County is the most vulnerable to volcanic hazards in Region 3 followed by Lane and Linn Counties. Marion County's vulnerability is driven somewhat by the presence of state and local critical facilities, but primarily by social vulnerability. Lane County's vulnerability is driven by the presence of state buildings and state and local critical facilities. Linn County's vulnerability is driven by both the presence of local critical facilities and social vulnerability. Yamhill County has a very low vulnerability score for state buildings and state and local critical facilities, but high social vulnerability accounting for its moderate vulnerability score.

Risk

Table 2-351. Assessment of Risk to Volcanic Hazards in Region 3

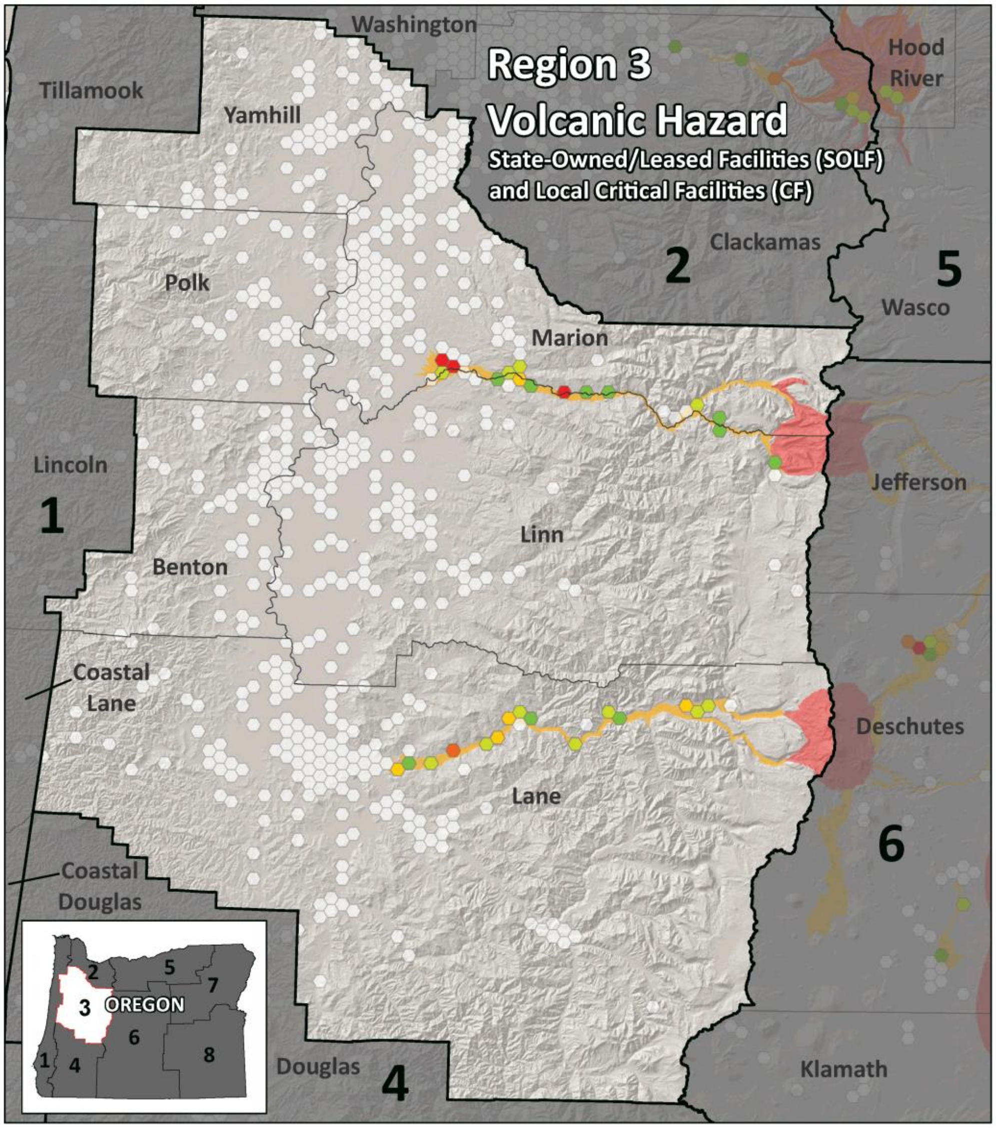
	Benton	Lane	Linn	Marion	Polk	Yamhill
Risk	VL	H	H	VH	VL	L

Source: DOGAMI and DLCD, 2020

According to the 2020 risk scores, Marion, Lane, and Linn Counties are the most at risk of volcanic hazards in Region 3 with either very high (VH) or high (H) risk ratings. These communities should be prioritized for mitigation actions. While these three counties all face moderate probability for volcanic hazards, they are more vulnerable than the other counties. Benton, Polk, and Yamhill Counties have either very low (VL) or Low (L) risk ratings.

The U.S. Geological Survey has addressed volcanic hazards at Mount Jefferson (Walder, Gardner, Conrey, Fisher, & Schilling, 1999) and the Three Sisters (Scott, Iverson, Schilling, & Fisher, 2001). These reports include maps depicting the areas at greatest risk. Lane, Linn, and Marion Counties are at risk and should consider the impact of volcano-related activity, such as lahars, on small mountain communities, dams, reservoirs, energy-generating facilities, and highways. These counties also should consider probable impacts on the local economy (e.g., wood products and recreation). There is virtually no risk from volcanoes in Benton, Polk, and Yamhill Counties, although normal prevailing winds could shift and carry ash into those areas.

Figure 2-188. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Volcanic Hazard Zone in Region 3.High-resolution, full-size image linked from Appendix 9.1.26.



Building value ($) exposed to hazard per cell

- No exposure to hazard
- 1 - 1,000,000
- 1,000,001 - 5,000,000
- 5,000,001- 10,000,000
- 10,000,001 - 25,000,000
- 25,000,001 - 44,000,000

Hazard area

- Volcanic - high hazard
- Volcanic - moderate hazard
- Volcanic - low hazard

Administrative boundary

- Mitigation Planning Region
- County

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:750,000

Source Data:
Volcanic: various studies of proximal and distal volcanic hazards from United States Geological Survey
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

REGION 3		Exposure ($) to Volcanic Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Benton	642,420,000	0	0%	0	0	0	0
Lane	2,960,570,000	1,693,000	0%	27,156,000	28,849,000	27,991,000	29,684,000
Linn	934,323,000	0	0%	153,000	153,000	35,879,000	35,879,000
Marion	4,700,844,000	2,865,000	0%	4,851,000	7,716,000	84,748,000	87,613,000
Polk	508,293,000	0	0%	0	0	0	0
Yamhill	851,391,000	0	0%	0	0	0	0
Total	10,597,841,000	4,558,000	0%	32,160,000	36,718,000	148,618,000	153,176,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

0 10 20 40 Miles

N

Source: DOGAMI

Wildfires

Characteristics

Forests in Region 3 are quite productive due to the mild temperatures, amount of precipitation, and deep, rich, fertile soils. Historically, this landscape was dominated by oak woodland and savanna with an understory consisting of grasses and forbs. These landscapes tended to burn on a regular basis with low intensity surface fires. This area was also heavily influenced by the Kalapuya Indians. The Kalapuyas frequently burned this area to make the landscape more favorable to elk and deer, which they hunted for food. As Euro-Americans moved in, native tribes moved on. Without prescribed burns, conifer trees have established and have overtopped the oak trees. The understory has changed from grasses and forbs to an understory with more woody shrubs and dead and downed wood. These forests are similar to those of the Oregon Coast Range and have historic fire return intervals of 150-300 years. These fires also tend to be large, stand-replacing fires, rather than the low-intensity, frequent fires of the oak woodland forest type.

Because wildland fires are being effectively suppressed, the patterns and characteristics of fires are changing. Vegetation that historically would have been minimized by frequent fires has become more dominant. Over time, some species have also become more susceptible to disease and insect damage, which leads to an increase in mortality. The resulting accumulation of dead wood and debris creates the types of fuels that promote intense, rapidly spreading fires

Historic Wildfire Events

Table 2-352. Historic Wildfires Affecting Region 3

Year	Name of Fire	Counties	Acres Burned	Remarks
1853	Nestucca	Tillamook/Yamhill	320,000	
1849	Siletz	Lincoln/Polk	800,000	
1865	Silverton	Marion	988,000	
1933	Tillamook	Tillamook, Yamhill	240,000	Human caused. Between 1933 and 1951, the Tillamook forest burned every 6 years. Fires followed drought conditions. Total Tillamook Burn: 350,000 acres (George Taylor, *The Oregon Weather Book*, p.202)
1972	Yamhill	Yamhill		
1977		Yamhill		west of Carlton
1987	Shady Lane	Polk		

Note: This list is representative of a lengthy wildfire history. There have been many fires, named and unnamed. Statistics differ, depending on the source. There have been no large, historic wildfires in Region 3 in recent years.

Source: Brian Ballou, August 2002, A Short History of Oregon Wildfires, Oregon Department of Forestry, unpublished; Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina.

Probability

Table 2-353. Assessment of Wildfire Probability in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	L	M	H	H	L	L

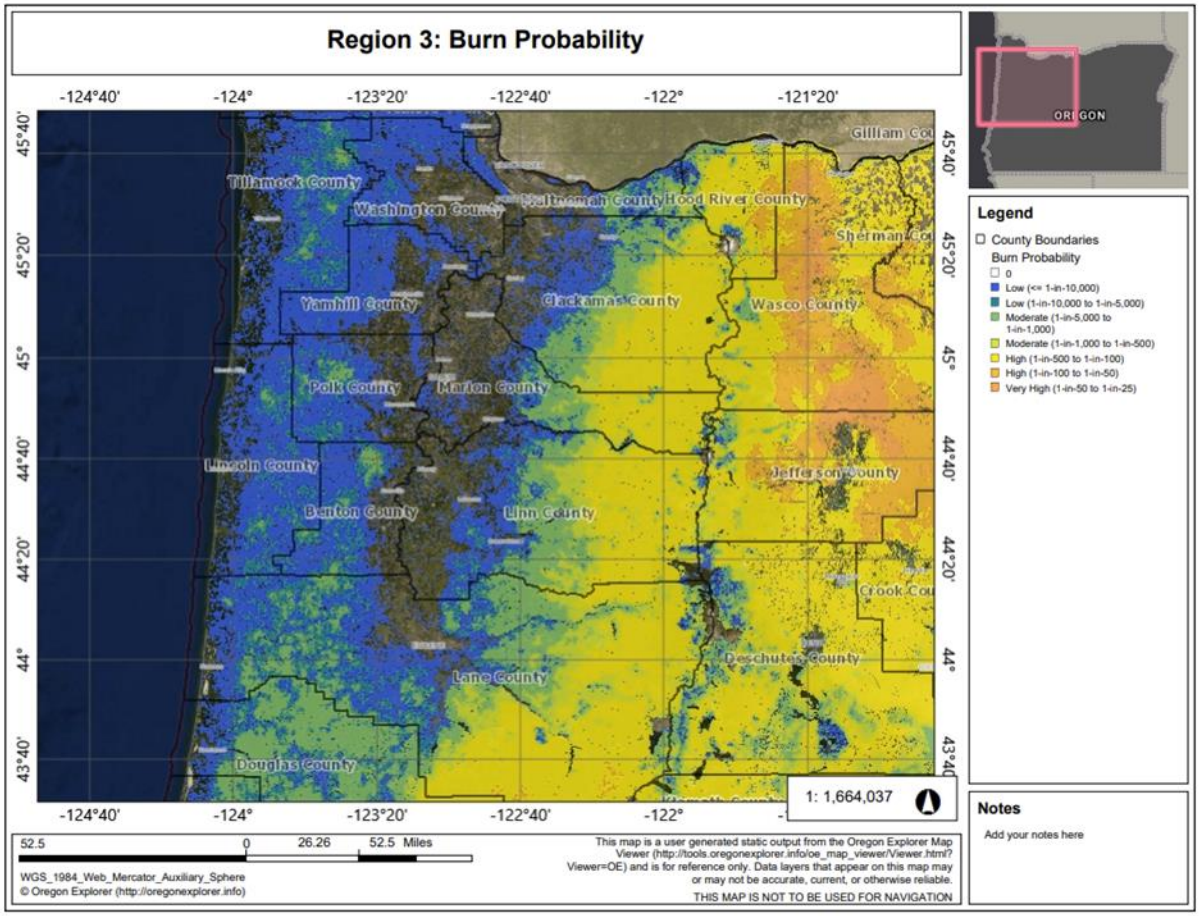
Source: PNW Quantitative Wildfire Risk Assessment and Oregon Wildfire Risk Explorer, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to assess the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-189 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

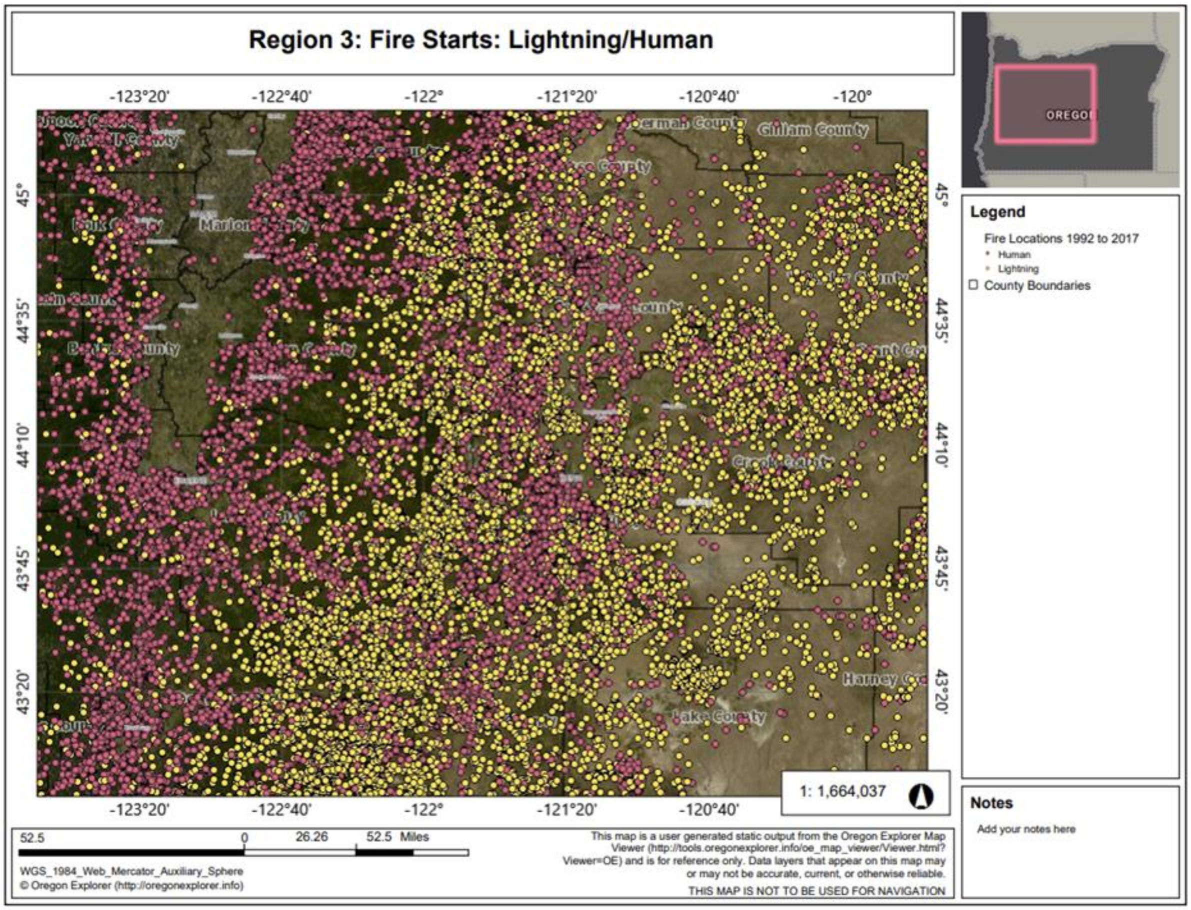
Figure 2-189. Burn Probability



Source: Oregon Wildfire Risk Explorer, March 2020

Wildfire always has been a part of the ecosystems in Oregon, sometimes with devastating effects. Some of the state's most devastating wildfires have been in counties within Region 3 (e.g., Marion, Polk, and Yamhill). Wildfire results from natural causes (e.g., lightning strikes), mechanical failure (Oxbow Fire), or human activity (unattended campfire, debris burning, or arson).

Figure 2-190. Human- and Lightning-Caused Wildfires in Region 3, 1992-2017



Source: Oregon Wildfire Risk Explorer, March 2020

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

In moisture-limited forest systems, such as those in the Coast and Cascade Ranges, warming winters will lead to more fine fuels from greater cold season growth. Hotter and drier conditions will lead to large fuel quantities, which lead to large and severe fires. It is very likely (>90%) that the Coast Range and lower elevations of the Cascade Range in Region 3 will experience increasing wildfire frequency and intensity under future climate change. Modeled projections of future fire frequency indicate more frequent fires for the Pacific Northwest, particularly west of the Cascade Mountains where fires have been infrequent historically. In coastal areas, fire frequency is projected to change from approximately every 100 years to every 60 years.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 3 counties (Table 2-354).

Table 2-354. Projected Increase in Annual Very High Fire Danger Days in Region 3 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Benton	11	30%
Lane	12	32%
Linn	12	33%
Marion	13	35%
Polk	11	31%
Yamhill	12	33%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-355. Local Assessment of Vulnerability to Wildfire in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	M	M	M	M	M	L

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-356. Assessment of Vulnerability to Wildfire in Region 3 – Communities at Risk

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	L	M	L	L	VL	L

Source: 2020 ODF Communities at Risk Report

Table 2-357. Assessment of Vulnerability to Wildfire in Region 3 – 2020 Vulnerability Assessment

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	VL	L	M	H	L	M

Source: DOGAMI and DLCD, 2020

According to ODF's assessment of Communities at Risk, wildfire vulnerability is generally low to moderate in Region 3. Jurisdictions most vulnerable to wildfire are the result of a dispersed population in close proximity to abundant vegetative fuels. These forestlands contain extensive fuels composed of flammable grasses, brush, slash and timber.

Each year a significant number of people build homes within or on the edge of the forest (wildland-urban interface), thereby increasing wildfire hazards. These communities have been designated "Wildland-Urban Interface Communities" and include those in **Table 2-358**.

Table 2-358. Wildland-Urban Interface Communities in Region 3

Benton	Lane (Non-Coastal)	Linn	Marion	Polk	Yamhill
Adair	Bohemia City	Albany	Aumsville	Airlie	Amity
Alsea	Coburg	Brownsville	Aurora	Buell	Carlton
Blodgett	Cottage Grove	Clear Lake Resort	Drakes Crossing	Dallas	Dayton
Corvallis	Creswell	Halsey	Gates	Falls City	Dundee
Dawson	Dexter	Harrisburg	Stayton	Fort Hill	Grand Ronde Agency
Hoskins	Dorena	Lebanon	Hubbard	Grand Ronde	Lafayette
Mary's River Estates	Eugene	Lost Prairie	Idanha	Independence	McMinnville
Monroe	Glenwood	Lower Willamette	Jefferson	Pedee	Midway
Philomath	Goshen	Lyons	Keizer	West Valley	Nestucca
Summit	Hazeldell	Marion Forks	Lyons		Orchard View
Vineyard Mountain	London Springs	Mill City	Marion		Sheridan
	Lorane	New Idanha	Mehama		Trask
	Lowell	Scio	Mill City		Willamina
	Lower McKenzie	South Shore	Mill Creek		Yamhill
	McKenzie	Sweet Home	Monitor		
	Mohawk	Tadmor	Mt Angel		
	Oakridge	Tangent	Orchard View		
	Pleasant Hill		Salem		
	Rainbow		Scotts Mills		
	Santa Clara, Eugene		Silverton		
	Springfield		St Paul		
	Upper McKenzie		Sublimity		
	Upper Willamette		Turner		
	Waldon		Woodburn		
	West Valley				
	Veneta				
	Walker				
	Westfir				

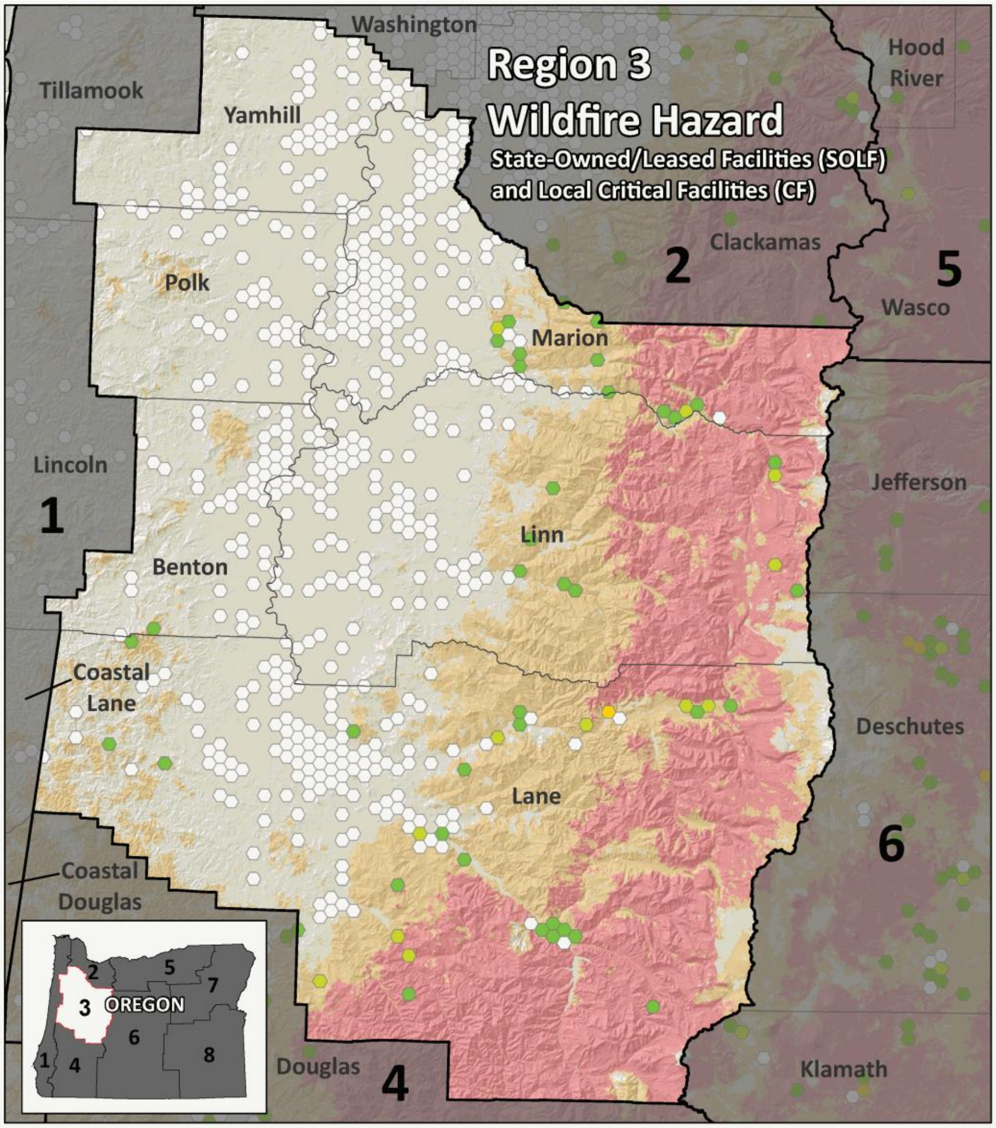
Source: Oregon Department of Forestry 2020 Communities at Risk Report

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in "High," "Moderate," and "Low" categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as "Low."

In Region 3, there is a potential loss to wildfire of about $45M in state building and critical facility assets, 65% of it in Lane County, 21% in Linn County, and 15%d in Marion County. Benton Polk, and Yamhill Counties have no state assets in wildfire hazard areas. There is a similar potential loss in local critical facilities: about $42.6M. Eighty-three percent of that value is located in Lane County, 9% in Linn County, 6% in Marion County, and 2% in Benton County. Neither Polk nor Yamhill County has local critical facilities located in a wildfire hazard area.

Figure 2-191. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 3.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 3		Exposure ($) to Wildfire Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Benton	642,420,000	0	0%	0	0	834,000	834,000
Lane	2,960,570,000	8,320,000	0%	20,869,000	29,189,000	35,186,000	43,506,000
Linn	934,323,000	5,777,000	10%	3,638,000	9,415,000	3,995,000	9,772,000
Marion	4,700,844,000	0	0%	6,630,000	6,630,000	2,627,000	2,627,000
Polk	508,293,000	0	0%	0	0	0	0
Yamhill	851,391,000	0	0%	0	0	0	0
Total	10,597,841,000	14,097,000	0%	31,137,000	45,234,000	42,642,000	56,739,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 19,731 historic resources in Region 2, eleven are located in an area of high wildfire hazard in Lane, Linn, and Marion Counties. Forty-three are located in an area of moderate wildfire hazard. Again, all are in Lane, Linn, and Marion Counties. The rest are in areas of low wildfire hazard in all the counties, with 50% in Lane County alone

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, vulnerability to wildfire varies from very low to high, but overall it is low to moderate. While the individual county scores differ, this assessment is in general agreement with the scores based on Communities at Risk. The exception is Marion County whose very high social vulnerability drove its vulnerability score higher than that of the other counties.

Marion County is the most vulnerable to wildfire in Region 3.

Risk

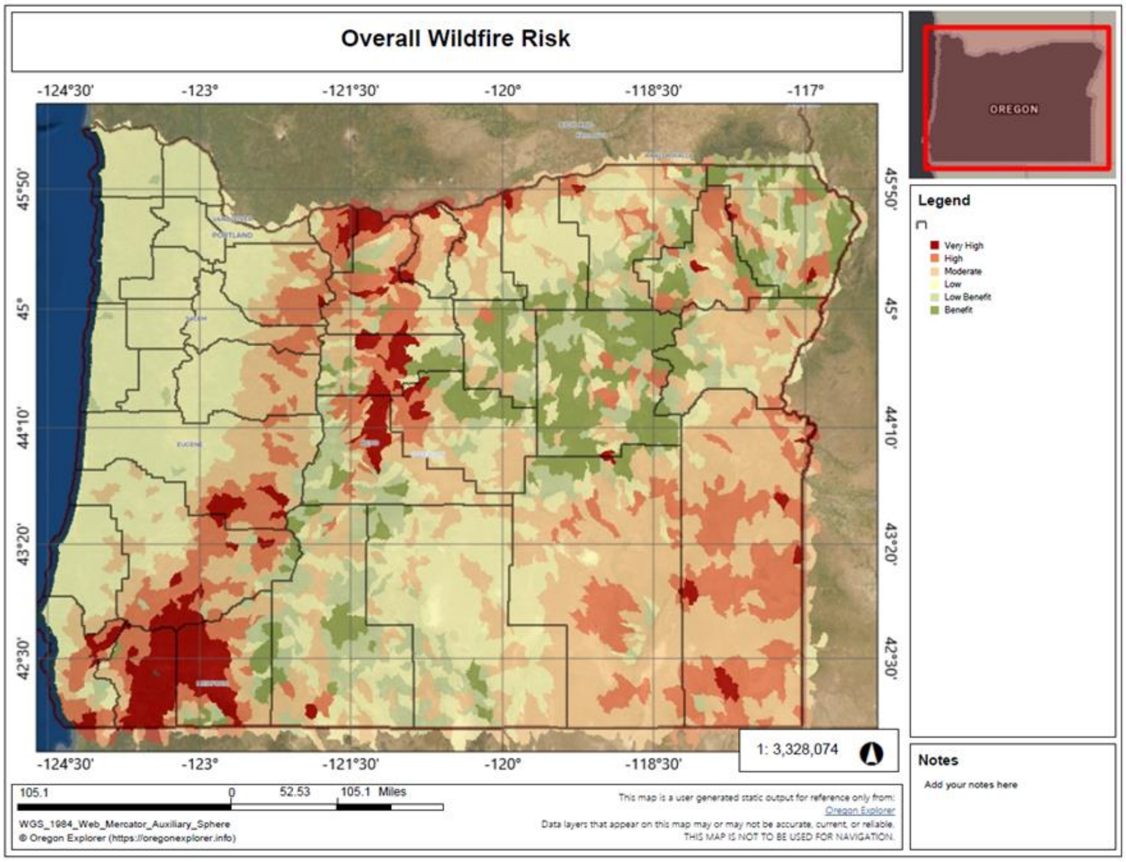
Table 2-359. Risk of Wildfire Hazards in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Risk	VL	M	M	M	VL	M

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, overall the risk from wildfire in Region three is low to moderate. In Benton and Polk Counties it is very low. Yamhill County's risk would be lower save for its high social vulnerability. These scores, then, are in agreement with ODF's assessment mapped in **Figure 2-192**. In addition, the moderate scores of the 2020 risk assessment are in general agreement with that map as the western portions of Lane, Linn, and Marion Counties are shown with low risk and the eastern portions with high or very high risk. The 2020 risk assessment is not granular enough to account for geographic differences in probability, vulnerability, or risk within a county.

Figure 2-192. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

High winds are not uncommon in the Willamette Valley. Tornados and thunderstorms are increasing in frequency in the Willamette Valley. A majority of the destructive surface winds in the region are from the southwest, similar to Region 2. The much more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they may be stronger on the coast than in the interior valleys because of the north-south orientation of the Coast Range and Cascades. These mountain ranges obstruct and slow down the westerly surface winds. The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of such a storm, and its effects were so devastating that it has become the benchmark from which other windstorms in Oregon are measured. The storm caused significant damage in Region 3.

In addition to windstorms, tornadoes have been recorded in Region 3 since 1887. The storms have occurred during all seasons, as described in **Table 2-360**. Fortunately, damage has been slight, and has mostly affected individual farm buildings, orchards, telephone poles and trees.

Historic Windstorm Events

Table 2-360. Historic Windstorms Affecting Region 3

Date	Location	Description
Apr. 1931	western Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; Wind speed 40-60 mph; gusts 75-80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 75-mph gusts; damage to buildings and utility lines
Dec. 1955	statewide	wind speeds 55-65 mph with 69-mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71-mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon’s most destructive storm to date; 116-mph winds in Willamette Valley; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Nov. 1981	most of Oregon	highest winds since Oct. 1962; wind speed 71 mph in Salem; marinas, airports, and bridges severely damaged
Jan. 1990	statewide	heavy rain with winds exceeding 75 mph; significant damage; one fatality
Dec. 1995	statewide	followed path of Columbus Day Storm; wind speeds 62 mph in Willamette Valley; damage to trees (saturated soil a factor) and homes (FEMA-1107-DR-Oregon)
Nov. 1997	western Oregon	wind speed 52 mph in Willamette Valley; trees uprooted; considerable damage to small airports
Feb. 2002	western Oregon	strongest storm to strike western Oregon in several years; many downed power lines (trees); damage to buildings; water supply problems (lack of power); estimated damage costs: $6.14 million (FEMA-1405-DR-Oregon)
July 2003	Marion County	$15,000 in property damage
Dec. 2004	Marion, Lane, and Polk Counties	$6,250 in property damage — property damage estimate includes counties outside of Region 3
Dec. 2005	Mario and Linn Counties	$3,000 in property damage
Apr. 2004	Lane County	$5,000 in property damage
Jan. 2005	Linn and Marion Counties	windstorms cause $6,000 of damage in Linn and Marion Counties; a storm total of $15,000 in damages spread out among, Linn, Marion, Clackamas, Multnomah, and Washington Counties
Jan. 2006	Yamhill, Marion, and Polk Counties	wind storm with winds up to 58 mph causes a total of $500,000 in damages spread out over all four counties and includes Clackamas, Columbia, Washington, and Multnomah Counties as well
Feb. 2006	Linn, Marion, Lane, Benton, Polk, and Yamhill Counties	windstorms with gusts up to 77 mph cause $227,000 in damages in Linn, Lane, Marion, Benton, Polk, and Yamhill Counties; storm causes damages in region 2 and region 1 as well for a total storm damage of $575,000
May 2006	Lane County	$5,000 in property damage in Eugene, approximately 13,000 customers out of power
May 2007	Marion County	hail storm causes $5,000 in damages
Mar. 2008	Marion County	heavy winds measured at 40 mph cause $15,000 in damage near Woodburn
Dec. 2015	Regions 1-4	FEMA-4258-DR: severe winter storms, straight-line winds, flooding, landslides, and mudslides
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides

Sources: Taylor and Hatton (1999); FEMA-1405-DR-OR: February 7, 2002, Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon; Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [online database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org

U.S. Department of Commerce. National Climatic Data Center. Available from http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms; https://www.fema.gov/disaster/

Table 2-361. Recorded Tornadoes in Region 3

Date	County	Damage Description
Jan. 1887	Lane	fences damaged; livestock losses; trees uprooted
Nov. 1925	Polk	buildings, barns, and fruit trees damaged
Feb. 1926	Polk	house and trees damaged
Sep. 1938	Linn	observed in Brownsville; no damage
Dec. 1951	Lane	barn destroyed
Jan. 1953	Benton	observed; no damage
Mar. 1960	Marion	several farms damaged near Aumsville; trees uprooted
May 1971	Yamhill	house and barn damaged near McMinnville
Aug. 1975	Lane	metal building destroyed near Eugene
Aug. 1978	Yamhill	minor damage near Amity
Apr. 1984	Yamhill	barn roof destroyed
May 1984	Lane	barn and shelter damaged near Junction City
Nov. 1989	Lane	telephone poles and trees uprooted near Eugene
Nov. 1991	Marion	barn damaged near Silverton
Sep. 2007	Linn	a tornado rated at F0 near Albany and Lebanon causes $20,000 in damage to buildings and $22,000 to crops
Dec. 2010	Marion	a tornado rated at F2 damaged 50 buildings in the community of Aumsville, causing a total of $1.2 million in property damage
Jun. 2013	Yamhill	McMinnville; tornado took ¼ mile path through town, some structural damage; $100K in crop damage
Apr. 2015	Lane	Eugene; EF0; $25K in property damage
Sep. 2017	Linn	Lacomb; EF1; $240K in property damage
Oct. 2017	Marion	Aurora Airport; EF0; $40K in property damage
Oct. 2018	Marion	Jefferson; EF0; $200 in property damage

Sources: Taylor and Hatton (1999), pp. 130-137); U.S. Department of Commerce. National Climatic Data Center. Available from http://www.ncdc.noaa.gov/stormevents/; https://www.ncdc.noaa.gov/stormevents/

Probability

Table 2-362. Assessment of Windstorm Probability in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	H	H	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores I

The 100-year event for a windstorm in Region 3 is 1-minute average winds of 75 mph. A 50-year event has average winds of 68 mph. A 25-year event has average winds speeds of 60 mph.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-363. Local Assessment of Vulnerability to Windstorms in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	M	H	M	L	H	M

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-364. State Assessment of Vulnerability to Windstorms in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	M	M	M	H	H	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Many buildings, utilities, and transportation systems within Region 3 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair. Benton, Lane, Marion, and Polk Counties are listed by PUC as being most vulnerable to wind damage in this region.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, uprooted or shattered trees can down power and other utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed by uprooted ancient trees growing next to a house. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establish a tree maintenance and removal program.

Bridges, which may be closed during periods of high wind, are an additional consideration.

Impacts to agriculture related to windstorms, or related to windstorms with heavy and/or freezing precipitation, include crop damage or loss (e.g., grain crops, orchards), and impacts to buildings and infrastructure important for supporting agriculture, for example, Oregon State University Extension and USDA Agricultural Research stations that provide services and support to agricultural communities and conduct valuable research on pest control, irrigation efficiency, soil health, crop research, livestock raising and health, and other topics.

Data have not yet been collected to assess the economic impacts to the state as a consequence of wind-related damage to agriculture and associated infrastructure.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties.

Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well."

Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties.

Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

Marion County's very high social vulnerability indicates that the effects of windstorms will be felt more intensely by its population than by the populations of the other Region 3 counties and will require more resources for preparation, mitigation, and response. Social vulnerability in Linn and Yamhill Counties is high. Marion, Linn, and Yamhill Counties are the most vulnerable to windstorms in Region 3.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 3 is approximately $3,107,827,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $7,490,014,000. Because windstorms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, three losses totaling almost $39,000 state facilities were recorded in Region 3 since the beginning of 2015. One with a net claim value of a little over $11,000 was caused by a windstorm.

Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

Due to their greater vulnerability, Marion, Linn, and Yamhill Counties are at greater risk from windstorms than the other counties in Region 3. Marion County is the most at risk in Region 3 and with Morrow County in the state overall.

Winter Storms

Characteristics

Severe winter weather in Region 3 is characterized by extreme cold, snow, ice, and sleet. Although such conditions may be expected in the Cascade Mountains and eastern Oregon, they are considered to be unusual in the Willamette Valley. Some Region 3 communities are unprepared, financially and otherwise, to handle severe winter storms. There are more moderate annual winter storms in the region; severe winter storms occur approximately every 4 years in the Valley. Severe weather conditions do not last long in Region 3, and winter-preparedness is a moderate priority.

Historic Winter Storm Events

Table 2-365. Severe Winter Storms in Region 3

Date	Location	Description
Dec. 1861	statewide	snowfall varied between 1 and 3 feet; did not leave Willamette Valley floor until late February
Dec. 1864	Willamette Valley and Columbia Basin	heavy snowfall; Albany (Linn County) received 16 inches in one day
Jan. 1916	statewide	two snow storms, each totaling 5 inches or more
Dec. 1919	Corvallis (Benton County	Corvallis received 22 inches of snow and set an all-time low temperature record of 14°F
Jan.- Feb. 1937	statewide	heavy snow throughout the Willamette Valley; Dallas (Polk County) had 24 inches; Salem (Marion County) had 25 inches
Jan. 1950	statewide	heaviest snowfall since 1890; many highway closures; considerable property damage
Jan. 1956	western Oregon	packed snow became ice; many automobile accidents throughout the region
Mar. 1960	statewide	snowfall: 3–12 inches, depending on location; more than 100 snow-related accidents in Marion County
Jan. 1969	statewide	Lane County surpassed old snowfall record; Eugene (Lane County) had a total snow depth of 47 inches; three to $4 million in property damage
Jan. 1980	statewide	a series of storms bringing snow, ice, wind, and freezing rain; six fatalities
Feb. 1985	statewide	western valleys received 2–4 inches of snow; massive power failures (tree limbs broke power lines)
Dec. 1985	Willamette Valley	heavy snowfall throughout valley
Mar. 1988	statewide	strong winds and heavy snow
Feb. 1989	statewide	heavy snowfall and record low temperatures; Salem (Marion County) received 9 inches
Feb. 1990	statewide	average snowfall from one storm about 4 inches (Willamette Valley)
Dec. 1992	western Oregon	heavy snow; interstate highway closed
Feb. 1993	western Oregon	record snowfall at Salem airport
Winter 1998-99	statewide	series of storms; one of the snowiest winters in Oregon history
Dec. 2003 -Jan. 2004	statewide	DR-1510. Benton, Lane, Linn, Marion, Polk, and Yamhill declared in Region 3. Wet snow blanketed highways in the Willamette Valley, causing power lines and trees to topple; Oregon 34 east of Philomath was closed for 30 hours January 5 and 6 while crews removed trees; Presidential disaster declaration for 30 of Oregon's 36 counties
Mar. 8–10, 2006	Lane, Linn, Benton, Marion, Polk, Yamhill Counties	snow fell up to a few inches at the coast and through the Willamette Valley; many school closures

Date	Location	Description
Jan.-Feb. 2008	Marion County	a series of vigorous winter storms brought record setting snow accumulation to Detroit, Oregon; three dozen Oregon National Guard personnel were called in to help with snow removal in Detroit and Idanha; the towns received over 12 feet of snow in several weeks
Dec. 9–11, 2009	Marion, Linn, Lane Counties	freezing rain covered the central valley with a coating of ice; south of Salem, numerous road closures due to accidents caused by icy roadway; I-84 from Troutdale to Hood River closed for 22 hours
Feb. 6–10, 2014	Lane, Benton, Polk, Yamhill, Linn, and Marion Counties	DR-4169. Linn, Lane, and Benton Counties declared in Region 3. A strong winter storm system affected the Pacific Northwest during the February 6–10, 2014 time period bringing a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon; a much warmer and moisture-laden storm moved across northwest Oregon after the snow and ice storm (Feb. 11-14), which produced heavy rainfall and significant rises on area rivers from rain and snowmelt runoff; during the 5-day period Feb. 6–10, 5 to 16 inches of snow fell in many valley locations and 2 to10 inches in the coastal region of northwest Oregon; freezing rain accumulations generally were 0.25 to 0.75 inches; the snowfall combined with the freezing rain had a tremendous impact on the region
Feb. 11–14, 2014	Lane, Benton, Polk, Yamhill, Linn, and Marion Counties	DR-4169 Linn, Lane, Benton and Lincoln Counties declared. Another weather system moved across northwest Oregon during the February 11–14 time frame; this storm was distinctly different from the storm that produced the snow and ice the week prior and brought abundant moisture and warm air from the sub-tropics into the region; as this storm moved across the area, 2 to 7 inches of rain fell across many counties in western Oregon; the heavy rainfall combined with warm temperatures led to snowmelt and rainfall runoff that produced rapid rises on several rivers, which included flooding on three rivers in northwest Oregon
Nov. 13, 2014	Marion, and Linn Counties (North Cascade foothills)	An early cold snap hit the Pacific Northwest before moist Pacific air moved in and resulted in one of the earliest snow, sleet, and freezing rain events in northwestern Oregon. Farther south, 1/2 of freezing rain accumulated on trees in the coast range foothills outside of Corvallis and Dallas, Oregon. Upwards of a quarter of an inch of ice fell around Dallas, Oregon. Some snow fell, but accumulations were primarily restricted to the Cascade valleys and the central Columbia River Gorge. Spotters reported around 6 to 8 inches of snow for the Cascade Foothills followed by a quarter of an inch of ice.
Dec. 6-23, 2015	Statewide storm events	DR-4258. Yamhill, Polk, Linn, and Lane Counties declared in Region 3. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Each storm system brought several inches of snow to the mountain areas. At first the snow was limited to higher elevations...but lowered with time to some of the west side valley floors. Moist onshore winds produced a steady stream of showers over the foothills of the Cascades with snow levels between 1000 and 2000 feet.
Mar. 13, 2016	Marion, Linn and Lane Counties (North Oregon Cascades and Cascades in Lane County)	A strong low pressure system generated frequent and persistent snow showers over the northern and central Oregon Cascades. Several SNOTEL stations measured 16 to 24 inches of snow over a 24 to 30 hour period above 3500 feet.
Dec. 14-15, 2016	Lane, Benton, Marion, and Linn Counties (Southern Willamette Valley, Cascade foothills in Lane County, Northern Cascade foothills)	DR-4296. Lane County declared in Region 3. Severe winter storm and flooding. East winds ahead of an approaching low pressure system brought temperatures down below freezing across the area ahead of the approaching precipitation. This lead to a mix of freezing rain, sleet, and snow across the area. While areas farther north saw more of a snow/sleet mix before a changeover to freezing rain then rain, areas in Lane County saw freezing rain for most of this event, causing power outages, damage to trees, and many car accidents around Eugene and Springfield. Snow followed by sleet and freezing rain. The freezing rain turned into a major ice storm occurred in Eugene and the vicinity with 0.5 to 1.0 inch of ice accumulation observed. There was significant damage to trees and power lines, and fairly widespread power outages across the region. 15,000 people were without power. There was a report of 0.4 inch of ice accumulation near Sodaville.

Date	Location	Description
Dec. 26-27, 2016	Linn and Marion, Counties (North Oregon Cascades)	A frontal system brought high winds to the Central Oregon Coast, heavy snow to the Cascades and a mix of ice and snow in the Columbia River Gorge and Hood River Valley. SNOTELs and other stations reported a range of 12 to 25 inches of snow in the Cascades. Some specific reports include 25 inches at Mt Hood Meadows, 22 inches at Timberline, 14 inches at Government Camp and 12 inches at McKenzie Snotel.
Jan. 7-8, 2017	Lane, Benton, Polk, Yamhill, Linn, and Marion Counties (Central and Southern Willamette Valley, North Cascades foothills)	DR-4328. No counties in Region 3 declared. Severe Winter Storms, Flooding, Landslides, And Mudslides. A broad shortwave trough brought multiple rounds of precipitation, including a wintry mix of snow and ice for many locations across Northwest Oregon. Strong easterly pressure gradients generated high winds through the Columbia River Gorge as well on January 8. General snowfall totals of 2-4 inches were reported, with the greatest total being 4.5 inches. Major ice accumulations occurred after the snow, with several locations reporting 0.50-1.00. The combination of snow and ice resulted in significant power outages and closures across the area.

Source: Taylor and Hatton (1999); unknown sources; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Probability

Table 2-366. Assessment of Winter Storms Probability in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Probability	H	H	H	H	—	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Winter storms occur annually in Region 3. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-367. Local Assessment of Vulnerability to Winter Storms in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	M	H	H	H	H	H

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-368. State Assessment of Vulnerability to Winter Storms in Region 3

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	M	H	H	H	—	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

The I-5 corridor through this region is key to intermodal transportation; severe winter storms can have an adverse impact on the economy if the interstate has to be closed for any extended period of time.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well."

Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties.

Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

Marion County's very high social vulnerability, indeed among the highest in the state, coupled with its vulnerability to closure of Interstate 5 make it the county most vulnerable to the adverse impacts of winter storms in Region 3. Linn and Yamhill's high social vulnerability make them relatively more vulnerable than the other counties in the region.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 3 is approximately $3,107,827,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $7,490,014,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, three losses totaling almost $39,000 state facilities were recorded in Region 3 since the beginning of 2015. None was caused by a winter storm.

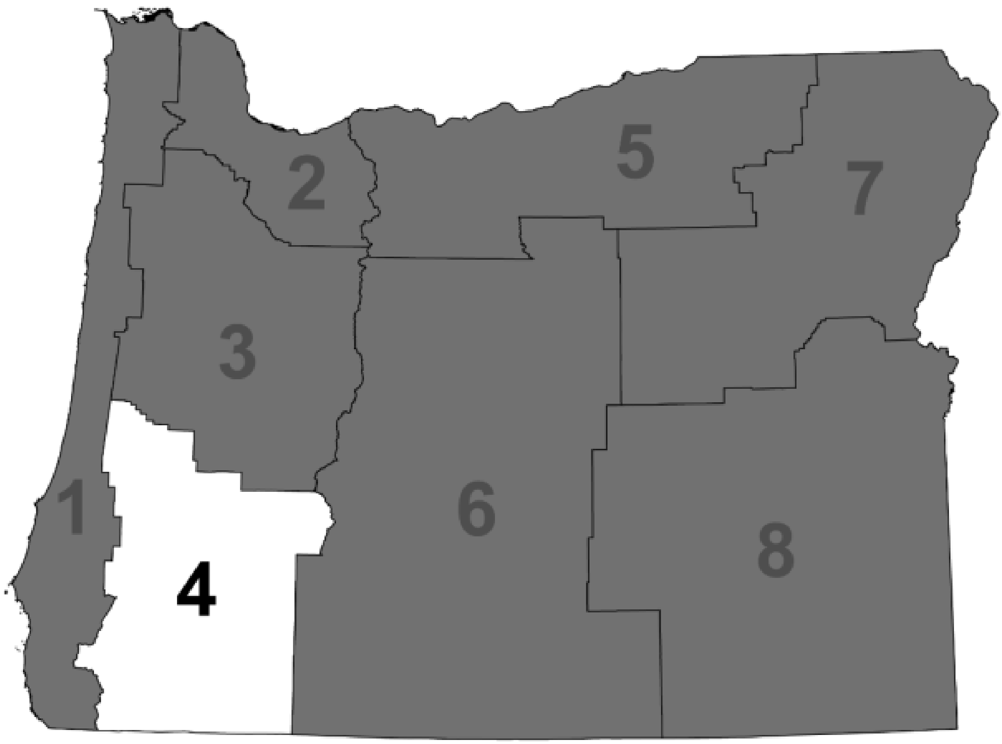
Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

Marion County is at the greatest risk from winter storms in Region 3 followed by Linn and Yamhill Counties.

2.3.4 Region 4: Southwest Oregon

*Douglas (non-coastal), Jackson, and Josephine Counties



*Note: The coastal portion of Douglas County is within Region 1. Where data are available for the coastal areas of Douglas County, the data are provided within the Region 1 profile; otherwise, countywide datasets are reported in this profile.

2.3.4.1 Summary

Profile

The region's demographic, economic, infrastructure and development patterns indicate that some populations, structures and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

Region 4 was hit particularly hard by the financial crisis that began in 2007 and continues to suffer from significantly low job recovery rates and below average wages as well as from the economic impacts of the novel coronavirus pandemic. While unemployment is relatively high in all three counties, among them Jackson County's is lowest. The region's few key industries are natural resource-based, especially vulnerable to the effects of climate change. The area is particularly vulnerable during winter months when there are fewer employment opportunities.

Transportation networks across the state are vulnerable to seismic events. Following a CSZ earthquake, access along I-5 may be limited due to bridge collapse. Energy facilities and conveyance systems in the region help support the regional economy and are vulnerable to damage and service disruptions due to natural hazard events. The region has multiple dams, hydroelectric and biomass power-generation facilities that service the state. Natural gas pipelines run through Josephine and Douglas Counties and are vulnerable to seismic activity.

Older centralized water infrastructure is vulnerable to pollution and flooding, which can have implications for public health and water quality. During high-water events, the region's drinking water is vulnerable to high levels of pollutants entering waterways through combined sewer overflows (CSOs).

Jackson and Josephine Counties' urban population is growing at about the same rate as the state's. Douglas County's rural population is growing about five times faster than Josephine and Jackson Counties' are, while overall, the state is losing rural population. Manufactured homes comprise about 15% of housing units region-wide and are inherently vulnerable to natural hazards. Roughly two thirds of homes in this region were built prior to current seismic building standards, making them especially vulnerable.

Hazards and Vulnerability

Region 4 is affected by nine of the state's 11 natural hazards. Coastal hazards and tsunamis do not directly impact this region.

Droughts: The U.S. Department of Agriculture declared Jackson and Josephine Counties as federal primary natural disaster areas due to damages and losses caused by drought in 2015, and Douglas County in 2018. Even though drought may not be declared as often in Western Oregon as in counties east of the Cascades, when drought conditions do develop, the impacts are widespread and severe. With the regional economy based in natural resource industries, droughts can affect commerce, agriculture, fisheries, and overall quality of life in all three counties. Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms.

Earthquakes: Four types of earthquakes affect Region 4 (a)shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) the offshore Cascadia Subduction Zone (CSZ) Fault, and (d) earthquakes associated with renewed volcanic activity. The CSZ is the chief earthquake hazard for Southwest Oregon. The 2020 risk assessment ranked all three counties "Very High" risk for earthquake hazards. The region is particularly vulnerable due to the large area susceptible to earthquake-induced landslide, liquefaction, and ground shaking. The state's seismic lifelines along Interstate-5 and east-west routes that connect the region to the rest of the state are highly vulnerable to seismic events. In Region 4, a CSZ event could cause a potential loss of almost $26M in state building and critical facility assets, 40% of it in Jackson County and about 30% each in Douglas and Josephine Counties. The potential loss in local critical facilities is quite a bit greater, over $361M. With 44% of the value of local critical facilities, Jackson County has the greatest potential loss followed by Douglas County with 34%.

Extreme Heat: Extreme temperatures are common and prolonged periods of high temperatures have in southern Oregon and Region 4 experiences many days above 90°F every year. Medford has an average of about 48 days per year above 90°F. Because extreme heat is common in southern Oregon, most people in Region 4 are accustomed or prepared in terms of air conditioning when an extreme heat event occurs. Region 4's relative vulnerability to extreme heat is "Moderate." Douglas County is the county most vulnerable to extreme heat in Region 4.

As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. Some livestock, especially dairy cattle, are also sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms. Impacts of drought on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. The value of state-owned and leased buildings and critical facilities in Region 4 is approximately $203,049,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $3,101,260,000.

Floods: Floods affect Southwest Oregon in the form of riverine flooding often preceded by rapid snow melt and heavy rain. According to the 2020 risk assessment, all of the region's counties are considered highly vulnerable to and at very high risk of flooding. In Region 4, there is a potential loss from flooding of over $23M in state building and critical facility assets, 74% of it in Jackson County alone. There is a much greater potential loss due to flooding in local critical facilities: over $187M, fifty-seven percent in Douglas County. The next greatest share, 34% is in Jackson County

Landslides: Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Rain-induced landslides can occur during winter months. Earthquakes can trigger landslides in the region. Vulnerability is increased in populated areas – such as in the Cities of Ashland and Medford – and in the Klamath Mountains. According to the 2020 risk assessment, all three counties are at very high risk of landslides. Almost $5M in state building and critical facility assets is exposed to landslide hazards in Region 4, over half of it in Douglas County and over a third in Jackson County. The region has almost 15 times that value in local critical facilities located in landslide hazard areas, 71% of it in Douglas County.

Volcanoes: Volcanic activity may occur within the eastern areas of the region's counties that coincide with the crest of the Cascade mountain range. Particular areas of vulnerability include Crater Lake, upper reaches of the Umpqua and Clearwater Rivers, and the OR-62 corridor. Most volcanic activity is considered local. However, lahars and ashfall can travel many miles and small mountain communities, dams, reservoirs, energy-generating facilities, and highways may be vulnerable. According to the 2020 risk assessment, Douglas and Jackson Counties are at moderate risk of volcanic hazards; Josephine County's risk is low. No state buildings, state or local critical facilities are exposed to volcanic hazards in Region 4.

Wildfires: In Southwest Oregon the combination of proximity of communities to wildland areas; high summer temperatures; rugged terrain; and likelihood of summer thunderstorm activity contribute to the region's vulnerability to wildfire. Other areas of vulnerability are within wildland-urban interface communities. Wildfires are most common during the late summer. According to the 2020 risk assessment, Douglas and Jackson Counties are at very high risk of wildfire; Josephine County is at high risk. In Region 4, there is a potential loss to wildfire of over $32M in state building and critical facility assets, 45% and 40% of it in Jackson and Douglas Counties, respectively, and 15% in Josephine County. There is a much greater potential loss in local critical facilities: over $163M. Thirty-nine and 37% are located in Douglas and Jackson Counties, respectively. Fifteen percent is located in Josephine County.

Windstorms: Windstorms can occur when Pacific Ocean winds travel inland in a northeasterly direction. These storms generally impact the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland. In December 2015, Region 4 was impacted by a severe winter storm with straight-line winds, flooding, landslides, and mudslides that merited a FEMA Presidential disaster declaration (FEMA-4258-DR). In April 2019 Douglas County was impacted by a similar event, FEMA-4452-DR. The value of state-owned and leased buildings and critical facilities in Region 4 is approximately $203,049,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $3,101,260,000.

Winter Storms: Severe winter weather in Region 4 can be characterized by extreme cold, snow, ice, and sleet. In higher elevations such as the lower Cascade Range and the Siskiyou Mountains and passes, moderate to heavy snowfall is expected on an annual basis. Some Region 4 communities are unprepared, financially and otherwise, for the impact of severe winter storms. Cold weather and high precipitation impact the region annually. Most recently, in February 2019, Douglas County was impacted by a severe winter storm warranting FEMA Presidential Disaster Declaration DR-4432. Severe winter storms can shut down the I-5 corridor passage through the Siskiyou Mountains, which can adversely impact the economy regionally and statewide. The value of state-owned and leased buildings and critical facilities in Region 4 is approximately $203,049,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $3,101,260,000.

Climate Change

The hazards faced by Region 4 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon. Coupled with projected decreases in mountain snowpack due to warmer winter temperatures, Region 4 is expected to be affected by an increased incidence of drought and wildfire. In Region 4, climate change would result in increased frequency of drought due to low spring snowpack (*very likely*, >90%), low summer runoff (*likely*, >66%), and low summer precipitation and low summer soil moisture (*more likely than not*, >50%). It is *very likely* (>90%) that Region 4 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*).

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 4, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section 2.2.1.2, **Introduction to Climate Change**.

2.3.4.2 Profile

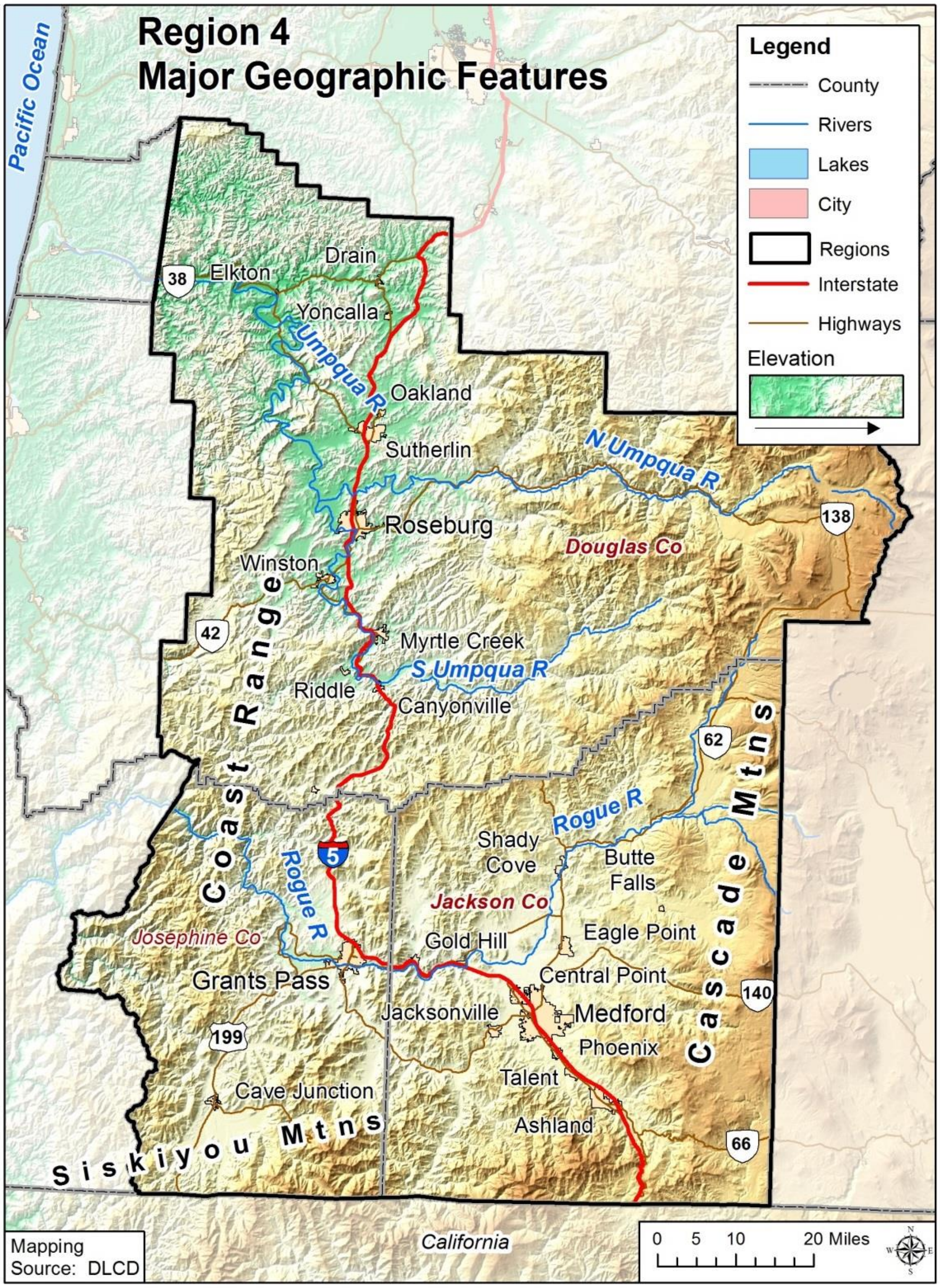
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

Southwestern Oregon is approximately 9,461 square miles in size, and includes Douglas (non-coastal), Jackson, and Josephine Counties. Mountain ranges and watersheds shape the region's topography. Region 4 begins at the Cascades in the east, and extends to the Klamath Mountains and Coast Range in the west. It extends from the Rogue-Umpqua Divide in the North to the Siskiyou Mountains at the California border in the south. Three rivers shape the region's main watersheds: the Umpqua River, the Rogue River, and the Illinois River (Downing, 2012).

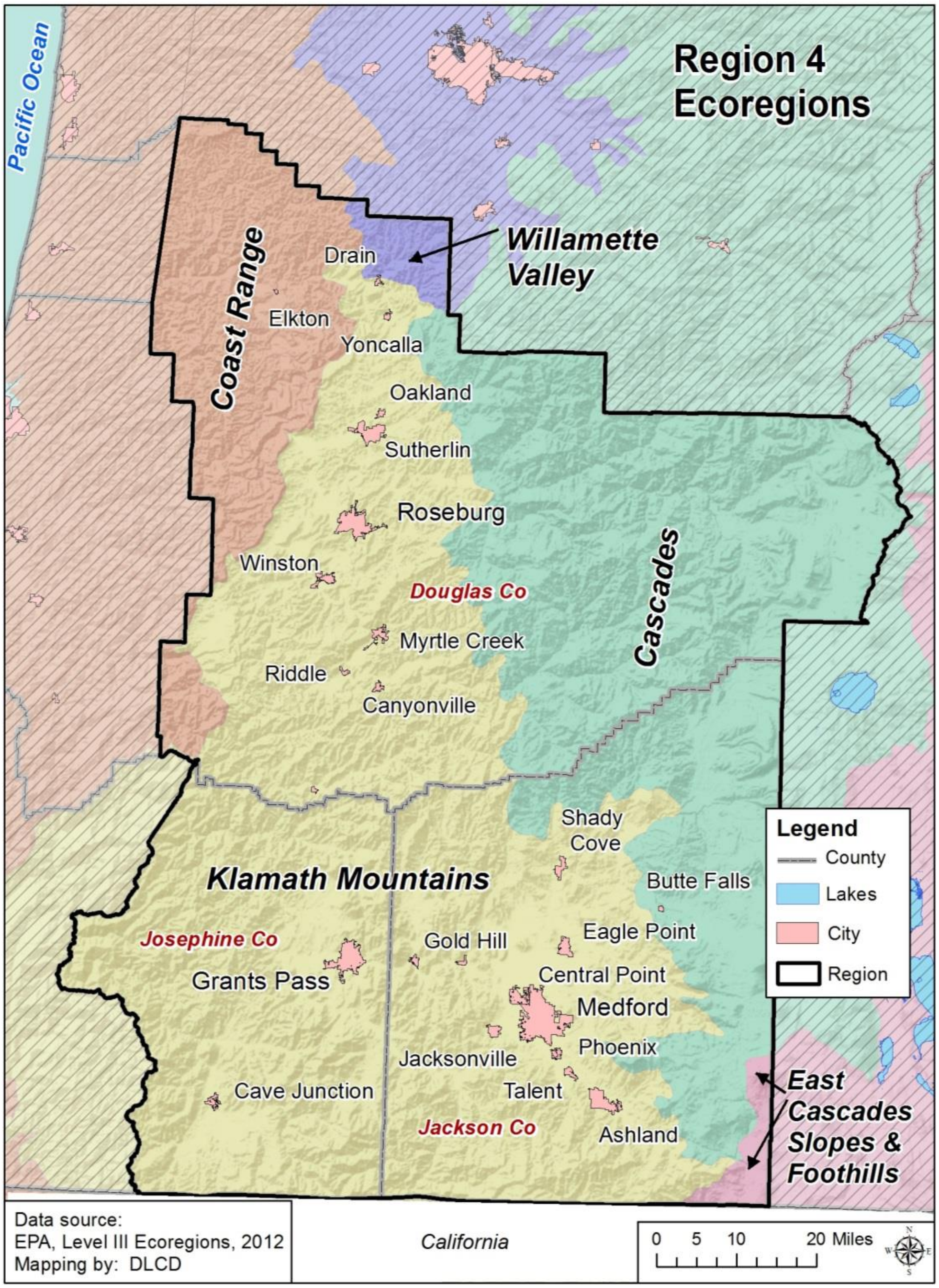
Figure 2-193. Region 4 Major Geographic Features



Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 4 is composed of three ecoregions: the Cascades, the Klamath Mountains, and the Coast Range (**Figure 2-194**).

Figure 2-194. Region 4 Ecoregions



Cascades: This ecoregion is underlain by volcanic soils. Naturally occurring mixed conifer forests have given way to predominantly Douglas fir forests that are managed for commercial logging. Logging activities have put a strain on the ecological health of streams in the area (Ecoregions of Oregon, http://www.epa.gov/wed). Waterways in the steeper valleys support threatened cold-water salmonids including Chinook salmon, steelhead, and bull trout. Streams, lakes, reservoirs, rivers, and glacial lakes at higher elevations are key sources of water (Ecoregions of Oregon, http://www.epa.gov/wed).

Coast Range: The east slope of the Coast Range is located within Region 4. Sedimentary soils in this ecoregion are prone to failure following clearcuts, which may be of concern as the commercial Douglas fir forests located here are highly productive commercial logging areas. Landslides can impact the safety of nearby infrastructure and health of the region's waterways. The ecoregion's sedimentary soils can create more concerns for stream sedimentation than areas with volcanic soils (Ecoregions of Oregon, http://www.epa.gov/wed).

Klamath Mountains: A mixture of conifer and hardwood forests covers the Klamath Mountains ecoregion. A mosaic of soil types including sedimentary, granitic, metamorphic, and extrusive rocks underlies these forests. More extensive areas of hardwood and broadleaf evergreen canopies are evident in this ecoregion than in the Cascade Mountains ecoregion. Oregon white oak savannahs and woodlands, both habitat types that have been threatened by Douglas fir encroachment and human development, are present in foothills areas. This ecoregion has a dry, Mediterranean climate, which is prone to long summer droughts. The ecoregion's water quality and habitat continue to be negatively impacted by mine tailings (Ecoregions of Oregon, http://www.epa.gov/wed).

Climate

This section covers historic climate information only. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment** for statewide projections.

Southwest Oregon's climate is characterized by warm summers—generally the warmest in the state—and cool winters—generally cooler than the rest of western Oregon. Precipitation generally occurs in the winter months accumulating a substantial snowpack in the higher elevations while the lowland valleys receive much less precipitation. The region's wet winters can lead to flood, landslide, and winter storm risks. Flooding can be a direct result of rain-on-snow events. Dry summers and years with low snowpack can lead to drought and wildfire risks. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-369** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 4 based on data from the NOAA National Centers for Environmental Information.

Table 2-369. Average Precipitation and Temperature in Region 4 Counties and Climate Divisions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Douglas County	53.75” (36.76”–86.28”)	Jan: 7.72” Jul: 0.57”	50.9F	Jan: 33.6°F /46.1°F Jul: 51.8°F /79.0°F
Jackson County	36.7” (23.13”–59.85”)	Jan: 5.1” Jul: 0.51”	50.3°F	Jan: 30.2°F /44.5°F Jul: 52.3°F /82.8°F
Josephine County	53.99” (29.93”–91.29”)	Jan: 8.53” Jul: 0.36”	50.9°F	Jan: 33.0°F /45.3°F Jul: 52.4°F /81.1°F
Climate Division 3 “Southwestern Valleys”	47.48” (30.6”–78.07”)	Jan: 6.87” Jul: 0.52”	50.6°F	Jan: 32.2°F/45.2°F Jul: 52°F/80.9°F

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 21, 2019 from https://www.ncdc.noaa.gov/cag/.

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community’s capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

Although each county within the region saw its population increase from 2010 to 2018, the region grew less quickly than the state as a whole. Jackson County experienced the largest total number of new residents and the greatest percentage increase during the period. All three counties in the region have an aging population and experienced natural decrease (more deaths than births) for the majority of the years between 2000 and 2018 (Population Research Center, Portland State University, 2019 [Douglas, Jackson, Josephine Counties]). Population growth, therefore, has largely been the product of substantial in-migration (Population Research Center, Portland State University, 2019 [Douglas, Jackson, Josephine Counties]). The region is projected to continue experiencing growth over the next decade, with the largest increases continuing in Jackson County.

Table 2-370. Population Estimate and Forecast for Region 4

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 4	393,586	417,330	6.0%	459,017	10.0%
Douglas	107,667	111,735	3.8%	119,212	6.7%
Jackson	203,206	219,200	7.9%	246,611	12.5%
Josephine	82,713	86,395	4.5%	93,194	7.9%

Source: Population Research Center, Portland State University, 2013; U.S. Census Bureau, 2010 Decennial Census. Table DP-1; Office of Economic Analysis, Long-Term Oregon State's County Population Forecast, 2010-2050, 2013

Tourists

Tourists are not counted in population statistics; and are therefore considered separately in this analysis. Three-quarters of tourism activities in Region 4 are centered on touring (traveling to experience scenic beauty, history, and culture), special events, and outdoor activities (Longwoods International, 2017d). The average travel party contains approximately three persons and 67% of their trips originate from Oregon or California. In this region, the average number of nights spent in the region was between two and three (Longwoods International, 2017d). From 2016-2018, Jackson County attracted more tourists than Douglas and Josephine Counties combined. The majority of those tourist stayed in private homes.

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

Table 2-371. Annual Visitor Estimates in Person Nights (x1000) in Region 4

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 4	9,792		9,841		9,882	
Douglas	2,485	100%	2,465	100%	2,517	100%
Hotel/Motel	600	24%	590	24%	605	24%
Private Home	1,107	45%	1,107	45%	1,131	45%
Other	777	31%	768	31%	781	31%
Jackson	5,422	100%	5,478	100%	5,476	100%
Hotel/Motel	1,790	33%	1,852	34%	1,834	33%
Private Home	2,794	52%	2,799	51%	2,801	51%
Other	838	15%	827	15%	841	15%
Josephine	1,885	100%	1,898	100%	1,889	100%
Hotel/Motel	485	26%	491	26%	477	25%
Private Home	1,096	58%	1,106	58%	1,107	59%
Other	304	16%	300	16%	305	16%

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003). A higher percentage of the population in Region 4 has a disability than statewide. The percentage with a disability is also higher in each county than in the state as a whole. In both Douglas and Josephine County, approximately one-fifth of all residents identify as having a disability. This is roughly five percentage points higher than the statewide estimate.

The percentage of younger people (<18) in the region with a disability is also higher than the statewide estimate. Each county in the region also has a higher percentage of young people with a disability than the state; however, the estimate for "under 18 with a disability" in Josephine County should be used with caution due to estimate reliability concerns. The percentage of older adults with a disability is also slightly higher in the region than in the state. Douglas County has the highest percentage of older adults with a disability while Josephine County's estimate is lower than both the region and statewide estimates.

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Table 2-372. People with a Disability by Age Group in Region 4

	With a Disability (Total Population)			Under 18 Years with a Disability			65 Years and Over with a Disability		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	14.6%	☑	0.1%	4.6%	☑	0.2%	37.1%	☑	0.4%
Region 4	18.5%	☑	0.5%	5.1%	☑	0.6%	38.1%	☑	1.0%
Douglas	21.0%	☑	0.8%	5.1%	☑	1.1%	41.2%	☑	1.6%
Jackson	16.8%	☑	0.6%	5.1%	☑	0.9%	38.1%	☑	1.6%
Josephine	19.5%	☑	1.0%	5.0%	⦿	1.6%	34.4%	☑	2.2%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau, 20013–2017 American Community Survey 5-Year Estimates, Table DP02

Homeless Population

The U.S. Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count, a biennial count of sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors.

They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing & Community Services, 2019). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing & Community Services, 2019).

According to the PIT, between 2015 and 2019 the region experienced a 16% increase in its unhoused population. Homelessness in Douglas County grew most quickly; however, Jackson and Josephine both have greater absolute numbers of people experiencing homelessness. While these two counties saw a decline in homelessness from 2015 to 2017, the 2019 numbers surpass the 2015 count for all three counties. Statewide, people of color from almost every racial group are overrepresented in the homeless population (Oregon Housing & Community Services, 2019). In all Region 4 counties, Native Americans comprise a disproportionate share of the homeless population relative to their share of the overall population.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate vulnerability conditions. Disasters that result in damage to the built environment can place additional stress on temporary shelters (Peacock, Dash, Zhang, & Van Zandt, 2017). Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-373. Homeless Population Estimate for Region 4

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 4	1,966	1,746	2,284	1,999
Douglas	404	463	542	470
Jackson	679	633	712	675
Josephine	883	650	1,030	854

Source: Oregon Housing and Community Services. 2015-2019 Oregon Point in Time Homeless Count.

Retrieved From: https://public.tableau.com/profile/oregon.housing.and.community.services#!/vizhome/2019Point-in-TimeDashboard/Story1

Biological Sex and Gender

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019). According to the survey, there are fewer males in Region 4 than females (96.04 men to every 100 women).

Jackson County has the largest discrepancy (95.10 mean to every 100 women); however, all three counties have more women than men.

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognized (Enarson, 2017). This is an area deserving of more attention as the field develops.

Age

Older adults, persons aged 65 and older, comprise a larger share of the population in Region 4 than they do in the state as a whole. Notably, the share in Douglas and Josephine Counties is approximately eight percentage points higher than the statewide estimate. Older adults require special consideration in the planning process. They are more likely to have a disability and require assistance from others to complete routine tasks. Family or neighbors who might ordinarily assist them might be unable to help during a disaster event (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Moreover, an older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

The percentage of children in the region—and in each regional county—is slightly smaller than the statewide estimate. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. Parents might lose time from work and money when their children's childcare facilities and schools are impacted by disasters (Cutter, Boruff, & Shirley, 2003).

Table 2-374. Population by Vulnerable Age Group, in Region 4

	Total Population	Under 18 Years Old			65 Years and Older		
	Estimate	Percent	CV **	MOE (+/−)	Percent	CV **	MOE (+/−)
Oregon	4,025,127	21.5%	☑	0.1%	16.3%	☑	0.1%
Region 4	404,160	20.3%	☑	0.0%	22.4%	☑	0.1%
Douglas	107,576	19.5%	☑	0.1%	24.1%	☑	0.1%
Jackson	212,070	20.9%	☑	*	20.5%	☑	0.1%
Josephine	84,514	19.6%	☑	*	24.9%	☑	0.2%

*Indicates that the estimate has been controlled to be equal to a fixed value and so it has no sampling error.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau, 2013–2017 American Community Survey 5-Year Estimates, Table DP05; https://data.census.gov/cedsci/

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to language and culturally appropriate outreach materials. Compared to the statewide estimate, a smaller portion of Region 4 residents do not speak English “very well”. Within the region, Jackson County has the largest population and the greatest share of people that might need translation services. Josephine County’s estimate should be used with caution. Communities creating outreach materials used to communicate with and plan for populations who do not speak English very well should take into consideration the language needs of these populations.

Table 2-375. English Usage in Region 4

	Speak English Less Than "Very Well"				
	Estimate	CV **	MOE (+/−)	Percent	% MOE (+/−)
Oregon	222,428	☑	4,116	5.9%	0.1%
Region 4	8,977	☑	776	2.3%	0.2%
Douglas	1,200	☑	258	1.2%	0.3%
Jackson	6,697	☑	636	3.3%	0.3%
Josephine	1,080	⊙	363	1.3%	0.5%

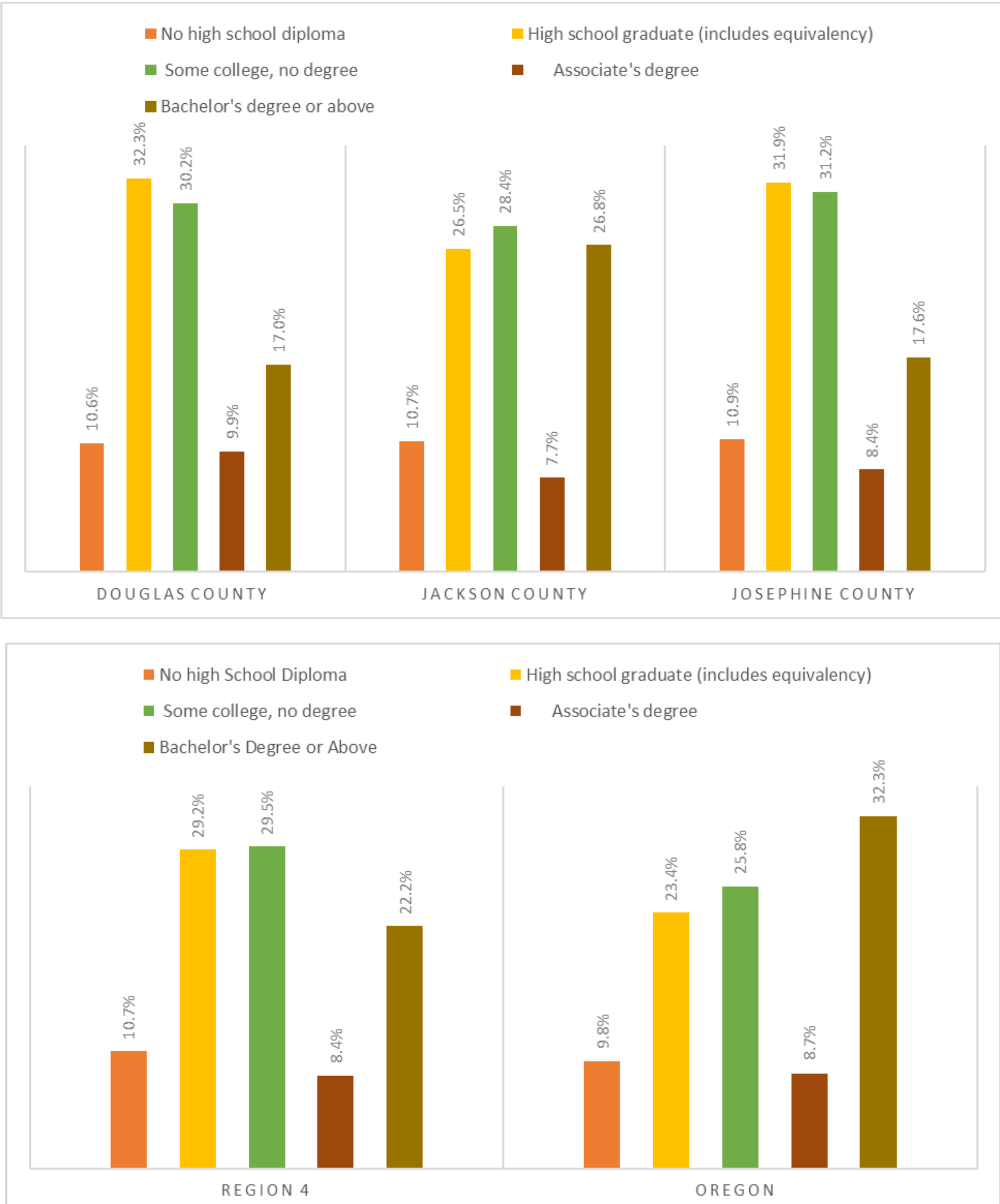
Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Education Level

Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual’s ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

While nearly 30% of Region 4 residents have some college credit, a much smaller percentage has a four-year degree vis-à-vis the state as a whole. Approximately 8% have an associate’s degree, and there is a slightly higher percentage of residents without a high school diploma compared to the share statewide. Jackson County has the highest percentage of residents with a bachelor’s degree or more. This is likely influenced by the presence of Southern Oregon University in Ashland.

Figure 2-195. Educational Attainment in Region 4: (top) by County, (bottom) Regional vs. Statewide



Source: U.S. Census Bureau (2018). Table DP02: Selected Social Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Income and Poverty

The impact of a disaster in terms of loss and the ability to recover varies among population groups. "The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event" (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public (Stahl, P., 2000). Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, are less likely to have the savings to rebuild after a disaster, and are less likely to have access to transportation and medical care.

Across the region, median household income is $12,000-$15,000 less than the statewide median. Jackson County has the highest median household income and Josephine has the lowest. From 2012 to 2017, only Jackson County experienced a statistically significant change (increase) in median household income.

Table 2-376. Median Household Income in Region 4

	2008–2012			2013–2017			
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Statistically Different*
Oregon	$53,427	☑	$338	$56,119	☑	$370	Yes
Region 4	—	—	—	—	—	—	—
Douglas	$42,927	☑	$1,174	$44,023	☑	$1,555	No
Jackson	$46,783	☑	$1,146	$48,688	☑	$1,163	Yes
Josephine	$39,284	☑	$1,474	$40,705	☑	$2,203	No

Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

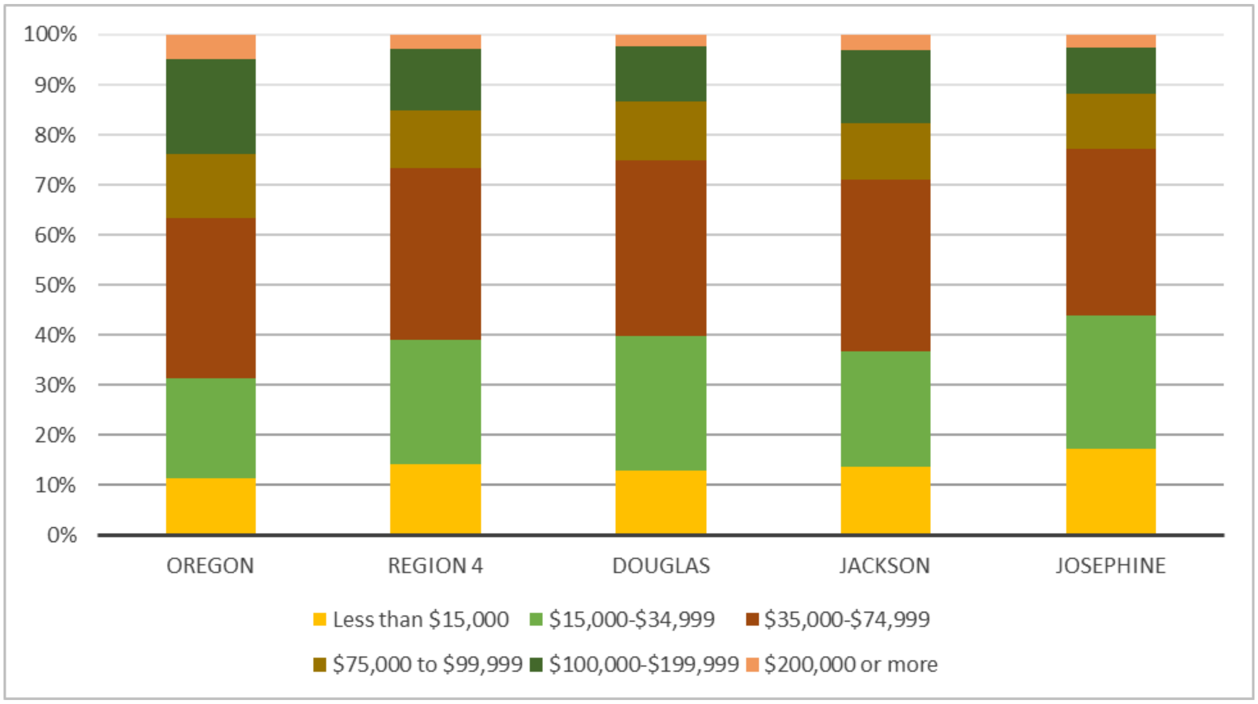
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2002 and 2013-2017. American Community Survey – 5-Year Estimates. Table CP03.

The region has a larger share of households earning less than $35,000 per year than the state as a whole. Within the region, Josephine has the highest percentage of low income earners, thirteen percentage points higher than the statewide estimate. Jackson County has the highest percentage of residents earning more than $75,000 annually, however, the share is still lower than the percentage for the state as a whole.

Figure 2-196. Median Household Income Distribution in Region 4



Source: U.S. Census Bureau (2018). Table DP03, 2013-2017 American Community Survey. Retrieved from https://data.census.gov/cedsci/

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018). A greater share of the regional population overall is living in poverty compared to the state as a whole. The same is true for all counties in the region. Josephine County has the largest percentage of people living in poverty, approximately five percentage points higher than the statewide share. Between 2012 and 2017, there were no statistically significant changes in the poverty rate within the region.

A higher percentage of children in Region 4 are living in poverty compared to the statewide share. Josephine County was the only county to experience a statistically significant change in the child poverty rate between 2012 and 2017, a decline of approximately five percentage points. Jackson County has the smallest share of children living in poverty while Douglas and Josephine have a similar share.

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources (Cutter, Boruff, & Shirley, 2003).

Table 2-377. Poverty Rates in Region 4

	Total Population in Poverty						
	2008–2012			2013–2017			Statistical Difference?*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	15.5%	☑	0.3%	14.9%	☑	0.3%	No
Region 4	17.6%	☑	0.8%	17.2%	☑	0.7%	No
Douglas	17.8%	☑	1.4%	17.0%	☑	1.4%	No
Jackson	16.6%	☑	1.0%	16.7%	☑	1.0%	No
Josephine	20.0%	☑	1.7%	18.6%	☑	1.4%	No

*Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Table 2-378. Child Poverty in Region 4

	Children Under 18 in Poverty						
	2008–2012			2013–2017			Statistical Difference?*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	20.6%	☑	0.5%	19.0%	☑	0.6%	Yes
Region 4	25.7%	☑	1.8%	23.9%	☑	1.7%	No
Douglas	27.7%	☑	3.2%	25.3%	☑	3.3%	No
Jackson	22.9%	☑	2.6%	22.6%	☑	2.5%	No
Josephine	30.8%	☑	3.9%	25.4%	☑	3.2%	Yes

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Housing Tenure

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

Each county in Region 4 has a higher home-ownership rate compared to the state overall. Douglas County has the highest percentage of owner-occupied households while Jackson County has the smallest.

Table 2-379. Housing Tenure in Region 4

		Owner-Occupied			Renter Occupied		
	Total Occupied Units	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	61.7%	✓	0.3%	38.3%	✓	0.3%
Region 4	166,637	65.0%	✓	0.8%	35.0%	✓	0.8%
Douglas	44,828	68.0%	✓	1.6%	32.0%	✓	1.6%
Jackson	86,195	62.9%	✓	1.0%	37.1%	✓	1.0%
Josephine	35,614	66.4%	✓	1.5%	33.6%	✓	1.5%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table DP04: Selected Housing Characteristics

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households. Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only.

Region 4 is predominately composed of family households. Similar to the statewide percentage, the share in each county is just under two-thirds. The region as a whole has a smaller percentage of households with children compared to the state. Josephine County has the smallest share, approximately six percentage points below the statewide estimate. In Douglas and Jackson Counties, approximately a quarter of all households have children, which is similar to the share statewide. The region as a whole as a similar share of single-parent households compared to the state. Jackson County has the highest percentage of single-parent households and Josephine has the smallest.

Table 2-380. Family vs. Non-family Households in Region 4

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	1,571,631	63.3%	✓	0.2%	36.7%	✓	0.2%	27.7%	✓	0.2%
Region 4	166,637	64.3%	✓	1.6%	35.7%	✓	1.4%	28.1%	✓	1.2%
Douglas	44,828	65.5%	✓	1.6%	34.5%	✓	1.6%	26.6%	✓	1.5%
Jackson	86,195	63.8%	✓	1.1%	36.2%	✓	1.1%	28.7%	✓	0.9%
Josephine	35,614	63.8%	✓	1.8%	36.2%	✓	1.8%	28.4%	✓	1.6%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. https://data.census.gov/cedsci/. Table DP02: Selected Social Characteristics

Table 2-381. Family Households with Children by Head of Household in Region 4

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	26.2%	☑	0.2%	8.1%	☑	0.2%
Region 4	22.9%	☑	0.7%	8.4%	☑	0.7%
Douglas	26.6%	☑	1.0%	8.0%	☑	1.1%
Jackson	25.0%	☑	0.9%	9.2%	☑	0.8%
Josephine	19.9%	☑	1.3%	6.8%	☑	1.0%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. https://data.census.gov/cedsci/. Table DP02: Selected Social Characteristics

Social and Demographic Trends

The social and demographic analysis shows that Region 4 is particularly vulnerable during a hazard event in the following categories:

- High numbers of tourists visit Jackson County.
- A higher percentage of the population in the region has a disability compared to the statewide estimate. The percentages are especially high in Josephine and Douglas Counties. Moreover, the share of people in vulnerable age—those under 18 and persons aged 65 and older—with a disability is higher across the region.
- Between 2015 and 2019, the number of people experiencing homelessness has increased in all three counties.
- The region has a higher share of older adults than the state
- A smaller percentage of the population has a college degree compared to the state, especially in Douglas and Josephine Counties.
- Median household income in each county is $12,000 to $15,000 less than the statewide median.
- The region has a larger share of households in the bottom income brackets, earning less than $35,000 annually, compared to the state as a whole.
- A greater share of the population is living in poverty compared to the state. Poverty is most severe in Josephine and Douglas Counties. All three counties have a greater share of children living in poverty compared to the share statewide.

Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses' labor, capital, suppliers, and customers are all relevant factors (Zhang, Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang, Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent

Employment and Unemployment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 4 have been steadily declining since they peaked during the Great Recession; however from 2014 to 2018 all three counties maintained higher rates than the state as a whole. Within the region, Douglas and Josephine Counties consistently have higher rates than Jackson County.

Table 2-382. Civilian Labor Force in Region 4, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 4	187,066	177,548	94.9%	9,518	5.1%
Douglas	46,374	43,869	94.6%	2,505	5.4%
Jackson	104,763	99,740	95.2%	5,023	4.8%
Josephine	35,929	33,939	94.5%	1,990	5.5%

Source: Oregon Employment Department, 2019

Table 2-383. Civilian Unemployment Rates in Region 4, 2014-2018

	2014	2015	2016	2017	2018	Change (2014-2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	-2.6%
Region 4	8.8%	7.1%	6.0%	5.0%	5.1%	-3.7%
Douglas	9.1%	7.5%	6.3%	5.3%	5.4%	-3.7%
Jackson	8.4%	6.8%	5.7%	4.7%	4.8%	-3.6%
Josephine	9.4%	7.7%	6.5%	5.4%	5.5%	-3.9%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups "economic units that have similar production processes" according to a six-digit hierarchical structure (Office of Management and Budget, n.d.). "The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry" (Office of Management and Budget, n.d.). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors (U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 4 were:

1. Trade, Transportation and Utilities
2. Education and Health Services
3. Leisure and Hospitality
4. Manufacturing
5. Local Government

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region's resiliency. A business establishment is an "economic unit… that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity" (U.S. Bureau of Labor Statistics, 2019, Sept. 4). In In Region 4, the following supersectors comprise a significant share of all business establishments.

- The Trade, Transportation, and Utilities supersector includes the highest number of establishments in Region 4, 17.4% of all businesses (QCEW, 2018).
- Other Services supersector is the second largest with 16.9% of all business establishments (QCEW, 2018).
- The Professional and Business Services supersector is third largest, with 12.4% of the regional share (QCEW, 2018).
- Education and Health Services supersector is fourth, constituting 11.0% of all establishments (QCEW, 2018).
- The Construction supersector is fifth largest, making up 10% of establishments (QCEW, 2018).

While supersectors are useful abstractions, it's important to remember that within are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event.

Table 2-384. Covered Employment by Sector in Region 4, 2019

Industry	Region 4	Douglas County		Jackson County		Josephine County	
	Percent	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	38,013	100.0%	89,743	100.0%	27,641	100.0%
Total Private Coverage	86.6%	30,755	80.9%	79,495	88.6%	24,385	88.2%
Natural Resources & Mining	3.7%	1,709	4.5%	3,228	3.6%	838	3.0%
Construction	4.9%	1,724	4.5%	4,760	5.3%	1,073	3.9%
Manufacturing	10.1%	4,862	12.8%	7,821	8.7%	2,987	10.8%
Trade, Transportation & Utilities	20.5%	6,785	17.8%	19,727	22.0%	5,337	19.3%
Information	1.1%	270	0.7%	1,191	1.3%	245	0.9%
Financial Activities	3.7%	1,046	2.8%	3,376	3.8%	1,269	4.6%
Professional & Business Services	8.7%	3,882	10.2%	7,443	8.3%	2,168	7.8%
Education & Health Services	18.0%	5,217	13.7%	16,936	18.9%	5,856	21.2%
Leisure & Hospitality	11.9%	3,448	9.1%	11,622	13.0%	3,368	12.2%
Other Services	4.1%	1,794	4.7%	3,353	3.7%	1,234	4.5%
Unclassified	0.0%	17	0.0%	39	0.0%	11	0.0%
Total All Government	13.4%	7,258	19.1%	10,247	11.4%	3,255	11.8%
Total Federal Government	2.2%	1,452	3.8%	1,765	2.0%	259	0.9%
Total State Government	1.3%	676	1.8%	964	1.1%	404	1.5%
Total Local Government	9.8%	5,130	13.5%	7,519	8.4%	2,592	9.4%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Retail businesses are concentrated in the larger cities of the region and disruption of the transportation system could sever the connectivity between people living throughout the region and these retail hubs.

Leisure and Hospitality: This sector primarily serves regional residents with disposable income and tourists. Following a natural disaster, residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Education and Health Services: The importance of Health and Social Assistance industries is underscored in Region 1 because of the significant share of older adults and individuals with a disability. Health care is a relatively stable revenue sector regionally with an abundant distribution of businesses primarily serving a local population. Following a disaster, Health and Social Assistance industries will play important roles in emergency response and recovery.

Manufacturing: This sector is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons, the manufacturing sector may be susceptible to disruptions in transportation infrastructure. However, manufacturers are frequently less dependent on local markets for sales, which may contribute to the economic resilience of this sector.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. Many of the top employment subsectors are similar across regions. For example, Food Services and Drinking Places and Educational Services are the two largest employment subsectors in Region 4. These subsectors also rank highly in other regions. Ambulatory Health Care Services—also known as outpatient services—and Hospitals are also major employers in Region 4 and across the state. Conversely, other subsectors, such as Wood Product Manufacturing, are more unique to the region.

Table 2-385. Industries with Greatest Share of Employment in Region 4, 2018

Industry	Employment Share	Employment (2018)
Food Services and Drinking Places	10%	18,480
Ambulatory Health Care Services	6%	11,601
Educational Services	6%	10,420
Administrative and Support Services	5%	9,859
Nursing and Residential Care Facilities	4%	6,684
Wood Product Manufacturing	4%	6,473
Hospitals	4%	6,386
Social Assistance	3%	6,162
Specialty Trade Contractors	3%	5,509
Food and Beverage Stores	3%	5,294

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for employment share and average employment by DLCD

Industry Concentration and Employment Change

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

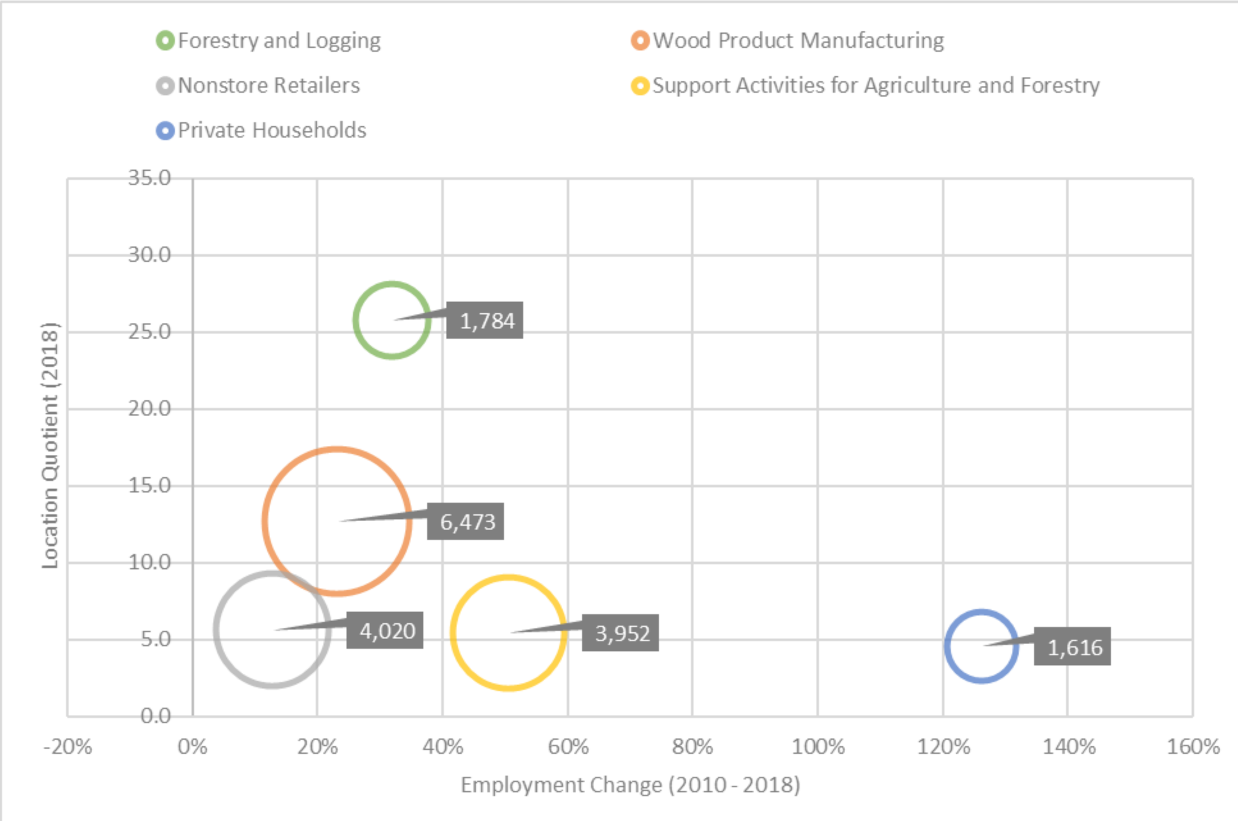
Table 2-386. Most Concentrated Industries and Employment Change in Region 4, 2018

Industry	Location Quotient	Employment (2018)	Employment Change (2010–2018)
Forestry and Logging	25.8	1,784	32%
Wood Product Manufacturing	12.7	6,473	23%
Nonstore Retailers	5.6	4,020	13%
Support Activities for Agriculture and Forestry	5.4	3,952	51%
Private Households	4.5	1,616	126%

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 4 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-197. Location Quotients, Employment Change, and Total Employment in Region 4, 2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

Three of the region's five most concentrated industries are natural resource based. Additionally, all have a location quotient higher than four—suggesting the region has a significant competitive advantage in each subsector vis-à-vis the nation. The Forestry and Logging subsector has the most significant location quotient. Employment in the region increased faster than in neighboring regions during the eight-year period but still comprises a relatively small share of overall employment. In terms of the total number jobs, more significant than harvesting trees is processing the wood into usable products. The Support Activities for Agriculture and Forestry and Wood Product Manufacturing subsectors collectively employed over ten-thousand people in 2018. In addition to natural resource based advantages, the region has employment concentrations in the Nonstore Retail—industries that sell goods using electronic methods, such as infomercials, paper or electronic catalogs, or vending machines—and the Private Households subsectors. The latter experienced significant growth during the eight-year period.

Fastest Growing and Declining Industries

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang, Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining.

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 4's fastest growing and declining industries.

Table 2-387. Fastest Growing and Declining Industries in Region 4, 2010-2018

Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Museums, Historical Sites, and Similar Institutions	315%	92	381
Private Households	126%	715	1,616
Construction of Buildings	101%	1,417	2,856
Beverage and Tobacco Product Manufacturing	100%	313	625
Justice, Public Order, and Safety Activities	99%	838	1,667
Fastest Declining			
Electrical Equipment, Appliance, and Component Manufacturing	−96%	140	6
Telecommunications	−57%	884	381
Executive, Legislative, and Other General Government Support	−41%	4,597	2,727
Wholesale Electronic Markets and Agents and Brokers	−36%	548	352
Performing Arts, Spectator Sports, and Related Industries	−32%	1,352	913

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

The Private Households industry experienced significant growth from 2010-2018. This sector employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019). The increase in employment in the Private Households industry mirrors a statewide trend (Wallis, 2019). Demand is driven in part by an aging population's need for in-home care workers (Wallis, 2019).

Beverage and Tobacco Product Manufacturing industries experienced significant increases in employment within the region. Growth in the Beverage and Tobacco Product Manufacturing industry is likely driven by Oregon's thriving craft-beer scene, which continues to grow despite a crowded market (Lehner, 2020). Although the industry has been expanding nationally, the shift-share analysis shows that the growth was driven more by regional factors.

Growth in the Construction of Buildings subsector was strong during the eight-year period, adding approximately fifteen-hundred jobs, the most of the five fastest growing industries.

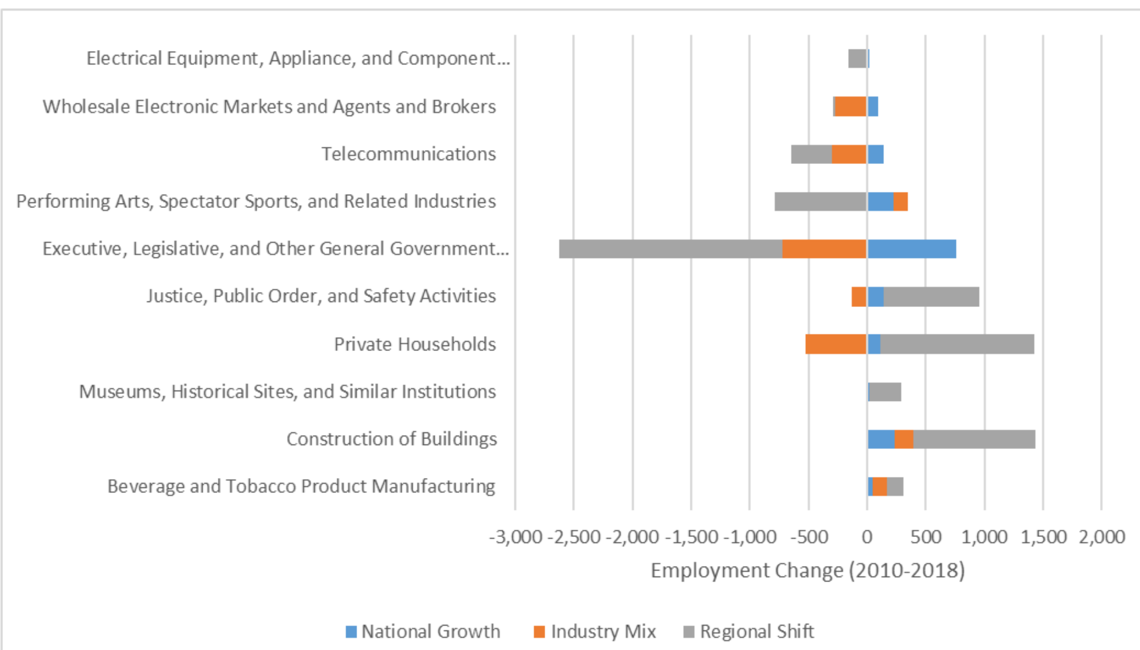
According to the shift-share analysis, the growth was mostly driven by regional factors. One reason for strong growth through the period, however, is that the subsector was severely impacted by the housing-bubble that led to the Great Recession. The decline in employment began around 2007 and was at its lowest point in 2010 (Cooke, 2019).

Museums, Historical Sites, and Similar Institutions had the highest percentage growth during the eight-year period, but the subsector comprises a very small share of employment region wide. The Justice, Public Order, and Safety subsector nearly doubled its total employment during the period. Growth in both subsectors was driven almost entirely by regional factors according to the shift-share analysis.

The Wholesale Electronic Markets and Agents and Brokers subsector—which coordinates the sale of goods owned by others, typically for a commission or fee—lost jobs during the 2010 to 2018 period. According to the shift-share analysis, the job loss was not driven by regional factors but forces impacting the industry nationwide. The subsector is part of the larger Wholesale Trade Sector, which generally saw an increase in employment in the state since the end of the Great Recession (Tauer, 2019).

Conversely, according to the shift-share analysis, losses in four of the five fastest declining subsectors can be attributed to regional factors. Those industries include: Executive, Legislative, and Other General Government subsector; the Telecommunications subsector; the Performing Arts, Spectator Sports, and Related Industries subsector; and the Electrical Equipment, Appliance, and Component Manufacturing subsector.

Figure 2-198. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 3, 2010-2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD f

Table 2-388. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 4, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Beverage and Tobacco Product Manufacturing	312	51	116	145
Construction of Buildings	1,439	233	159	1,047
Museums, Historical Sites, and Similar Institutions	289	15	−2	276
Private Households	902	117	−525	1,309
Justice, Public Order, and Safety Activities	829	138	−127	818
Fastest Declining				
Executive, Legislative, and Other General Government Support	−1,871	755	−719	−1,907
Performing Arts, Spectator Sports, and Related Industries	−439	222	128	−790
Telecommunications	−503	145	−295	−353
Wholesale Electronic Markets and Agents and Brokers	−196	90	−273	−13
Electrical Equipment, Appliance, and Component Manufacturing	−134	23	−4	−153

Economic Trends and Issues

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the following situations increase the region's level of vulnerability to natural hazard events:

- Unemployment in all three regional counties is consistently higher than the statewide average;
- Within the region, unemployment in Douglas and Josephine Counties is regularly higher than unemployment rates in Jackson County;
- The region is dependent on tourism which might increasingly be impacted by annually occurring disasters like wildfire and drought;
- Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- The regional economy has fewer opportunities for highly skilled employees, limiting the income potential of residents in Region 4.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl, et al., 2000).

Infrastructure

Transportation

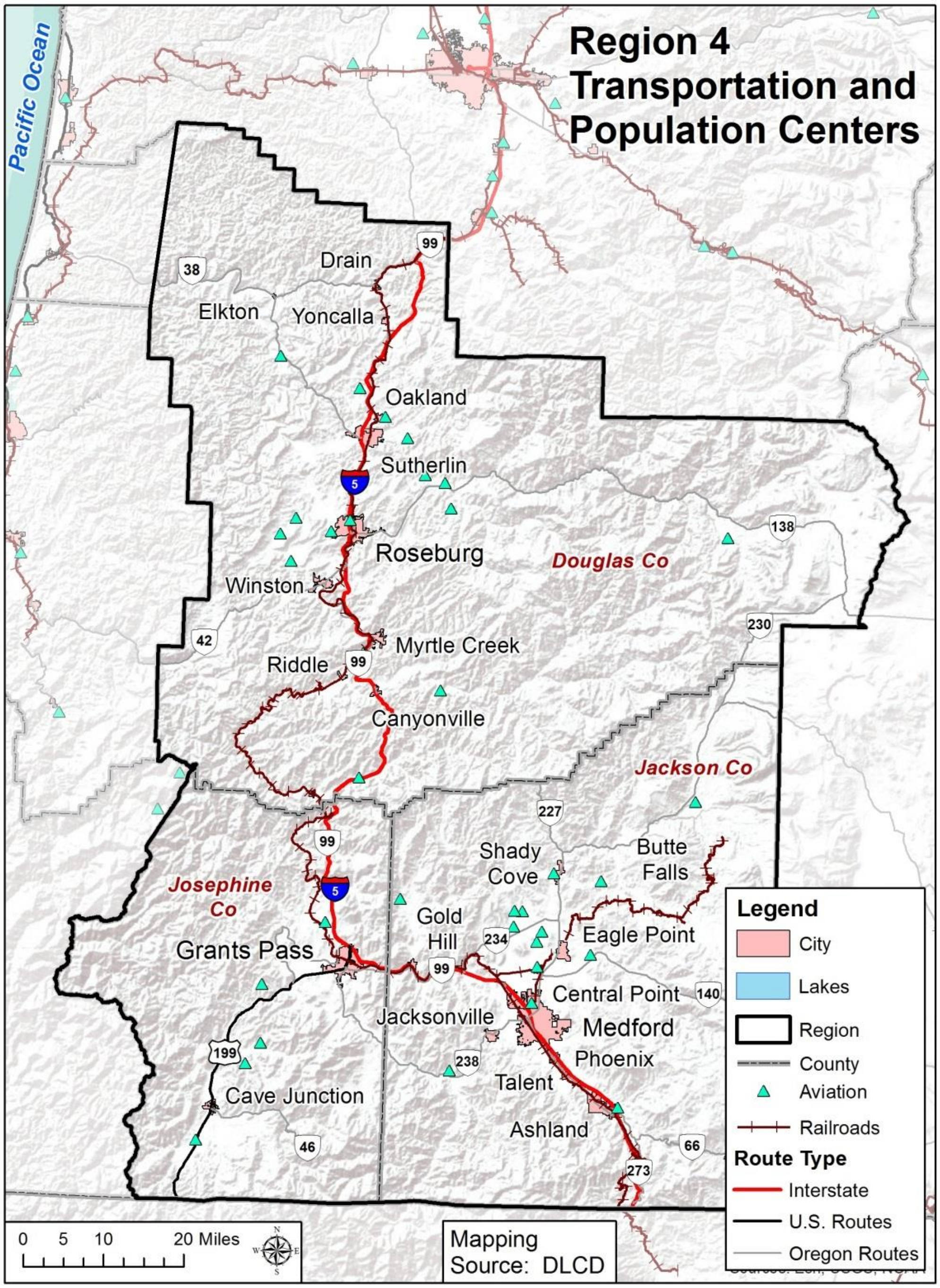
Roads

The largest population bases in Region 4 — the Cities of Ashland, Grants Pass, Medford, and Roseburg — are located along I-5. I-5 runs north-south through Region 4 and is the main passage for automobiles and trucks traveling along the West Coast.

Region 4's growing population centers bring more workers, automobiles and trucks onto roads. A high percentage of workers driving alone to work coupled with interstate and international freight movement on the I-5 corridor create additional stresses on transportation systems. Some of these include added maintenance, congestion, oversized loads, and traffic accidents. Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuation and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

According to the Oregon Department of Transportation's (2014, October) Seismic Plus Report (Appendix **9.1.13**), the region has exposure to earthquakes, especially a Cascadia Subduction Zone event. Therefore, the seismic vulnerability of the region's lifelines, including roadways and bridges, is an important issue. For information on ODOT's 2012 Seismic Lifelines Report findings for Region 4, see **Seismic Lifelines**.

Figure 2-199. Region 4 Transportation and Population Centers



Source: Oregon Department of Land Conservation and Development, 2014

Bridges

ODOT lists 953 bridges in the counties that comprise Region 4.

Because of earthquake risk in Region 4, the seismic vulnerability of the region's bridges is an important issue. Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or are part of regional and local systems that are maintained by the region's counties and cities.

Table 2-389 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. The ratings do not imply that a bridge is unsafe (ODOT, 2020). About 3% of the region's ODOT bridges are distressed, compared to 5% for the state.

Table 2-389. Bridge Inventory for Region 4

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 4	6	372	2%	20	511	4%	4	60	7%	3	10	30%	33	953	3%
Douglas	2	176	1%	16	254	6%	3	24	13%	2	6	33%	23	460	5%
Jackson	4	137	3%	2	152	1%	1	34	3%	0	0	N/A	7	323	2%
Josephine	0	59	0%	2	105	2%	0	2	0%	1	4	25%	3	170	2%

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2012, 2013)

Railroads

Railroads that run through Region 4 support cargo and trade flows. The region's rail providers are the Central Oregon & Pacific and the White City Terminal Railroad. There is no passenger rail line through the region. The Central Oregon & Pacific Line follows I-5 through the region, then runs west through Lane County and loops back into Region 4 through Reedsport. The White City Terminal Railroad is a short spur off the Central Oregon & Pacific Line in Jackson County (Loy, Allan, & Patton, 1976). Oregon's rail system is critical to the state's economy, energy, and food systems. Rail systems export lumber and wood products, pulp and paper, and other goods produced in Oregon and carry products from other states to and through Oregon by rail (Cambridge Systematics, 2014).

Rails are sensitive to icing from winter storms that can occur in Region 4. Disruptions in the rail system can result economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

Rogue Valley International-Medford Airport is the only commercial airport in the region and is the third busiest airport in Oregon (Federal Aviation Administration [FAA], 2012). The airport is owned, operated and administered by Jackson County Aviation Authority. It serves eight hubs and four air carriers with approximately 56 arriving and departing flights daily (Jackson County, Oregon, airport website, http://www.co.jackson.or.us/SectionIndex.asp?SectionID=5).

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

Table 2-390. Public and Private Airports in Region 4

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Heliport	Private Heliport	Total
Region 4	10	26	0	13	49
Douglas	4	12	0	4	20
Jackson	4	11	0	7	22
Josephine	2	3	0	2	7

Source: FAA Airport Master Record (Form 5010) (2014)

Energy

Electricity

Several power supply companies serve Region 4. The Bonneville Power Administration is the area's wholesale electricity distributor. The majority of the region is powered by PacifiCorp (Pacific Power and Light). The Coos-Curry Electric Cooperative and the Douglas Electric Cooperative serve portions of Douglas and Josephine Counties. The Umpqua Indian Utility Cooperative serves the Cow Creek Band of Umpqua Tribe of Indians, including the site of the Seven Feathers Casino Resort located in Douglas County north of Grants Pass and south of Roseburg.

Table 2-391 lists electric power-generating facilities within Region 4. The region has a total of eight power-generating facilities: three are hydroelectric power facilities, and five are categorized as "other" (primarily biomass). In total the power-generating facilities have the ability to produce up to 391 megawatts of electricity.

Table 2-391. Power Plants in Region 4

	Hydro-electric	Natural Gas	Wind	Coal	Other*	Total
Region 4	3	0	0	0	5	8
Douglas	1	0	0	0	3	4
Jackson	2	0	0	0	1	3
Josephine	0	0	0	0	1	1
Energy Production (MW)	**305**	**0**	**0**	**0**	**86**	**391**

* "Other" includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

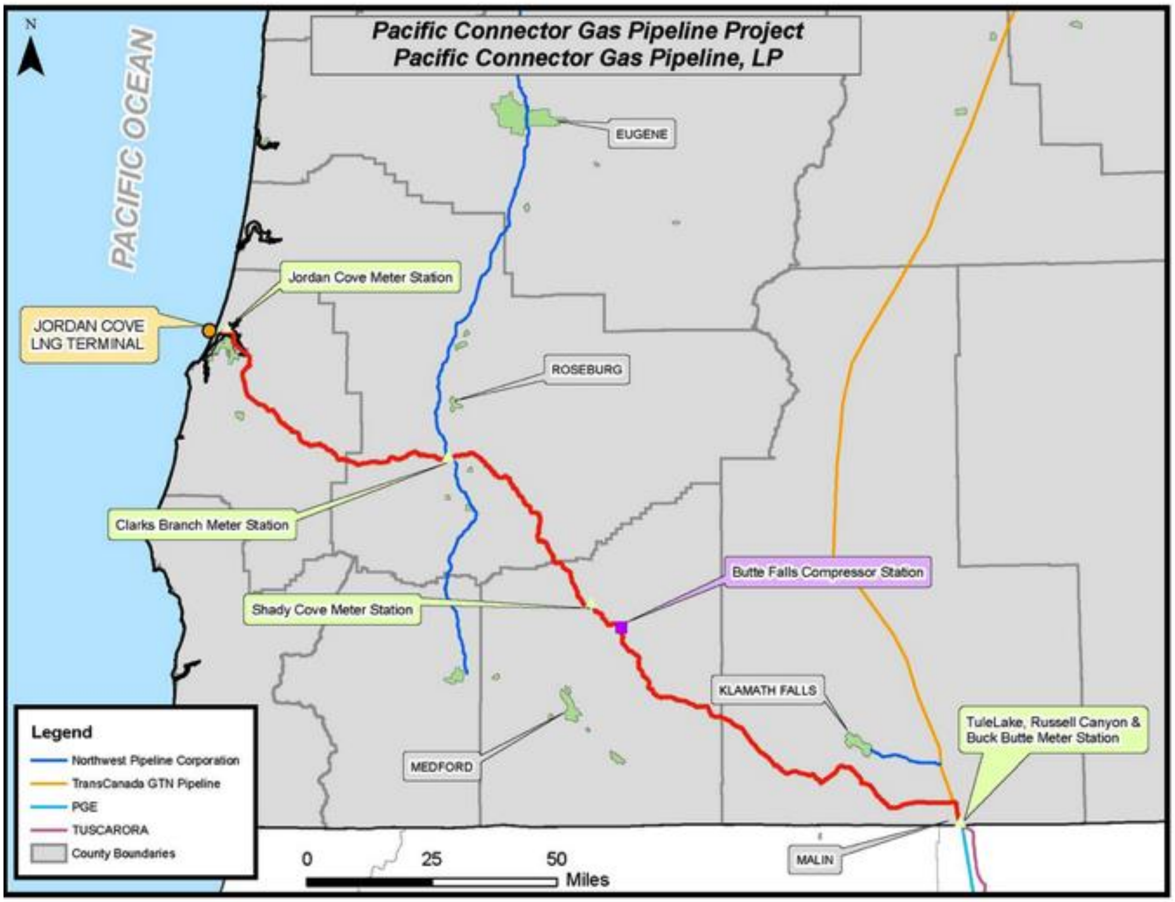
Hydropower

The majority of electrical power in Region 4 is generated through hydropower. Dams for hydropower generation are primarily situated on the Applegate, Rogue, and Umpqua Rivers. Dams operated by the Bonneville Power Administration (BPA) provide hydro-generated electricity to the state's consumer owned utilities. Major BPA dams in the region are located on the Applegate and Rogue Rivers.

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to Pacific Power's portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. Figure 2-200 shows existing LNG pipelines and the proposed Pacific Connector Gas Pipeline (in red) (Oregon Department of Environmental Quality, 2014). One pipeline, owned by the Northwest Pipeline Corporation, runs though Douglas and Josephine Counties. LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life, safety, and environmental impacts in the case of a spill.

Figure 2-200. Liquefied Natural Gas Pipelines in Region 4



Source: Oregon Department of Environmental Quality (2014)

Utility Lifelines

Southwestern Oregon primarily receives oil and gas from Alaska by way of the Puget Sound through pipelines and tankers. The region is at the southern end of this pipeline network. Oil and gas are supplied by Northern California through a separate network. The electric, oil, and gas lifelines that run through the county are both municipally and privately owned (Loy, Allan, & Patton, 1976) These utility lifelines may be vulnerable to severe, but infrequent natural hazards, such as earthquakes.

The network of electrical transmission lines running through Region 4 is operated by Pacific Power and Light and primarily facilitates local energy production and distribution (Loy, Allan, & Patton, 1976). Most of the natural gas Oregon uses originates in Alberta, Canada. Avista Utilities owns the main natural gas transmission pipeline (Loy, Allan, & Patton, 1976).

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Region 4 is part of the Southern Oregon Operational Area under The Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013), which also includes Coos, Curry, and Klamath Counties. There is a memorandum of understanding between these counties that facilitates the launching of emergency messages for counties by Jackson County. Counties in this area can launch emergency messages by contacting the Oregon Emergency Response System (OERS) which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communication capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation’s status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The local primary stations identified as emergency messengers by the Oregon State Emergency Alert System Plan are:

- KOBI-TV Channel 5, Medford; and
- Channel 49, Grants Pass.

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 4. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is becoming more readily available in the region with a greater number of providers and service types available within major communities and along major transportation corridors (I-5, US-199, etc.) (NTIA, n.d.). Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 4 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for the Southern Oregon Operational Area are (Oregon Office of Emergency Management, 2013):

- WWF-97, 162.475 MHZ, Ashland;
- WXL-85, 162.400 MHZ, Medford; and
- WXL-98, 162.550 MHZ, Roseburg.

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). Region 4 is served by ARES District 5. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency Management, n.d.). The official ham emergency station calls for Region 4 include (American Relay Radio League Oregon Chapter, www.arrloregon.org):

- Douglas County: K7AZW;
- Jackson County: K7VS; and
- Josephine County: none available at this time.

Water

Water infrastructure includes drinking water, stormwater, and wastewater systems. All of these systems possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In Region 4 the majority of the municipal drinking water supply is obtained from surface water. In Jackson and Josephine Counties, the Rogue River provides municipal water supplies to most cities. The City of Cave Junction is an exception, obtaining water from the Illinois River. In Douglas County, most cities source their water from the Umpqua River and its tributaries.

Rural residents may get water from groundwater wells or surface water. Most rural residents in Douglas County use surface water sources for potable water. The majority of rural residents in Jackson and Josephine Counties use domestic wells outside of municipal boundaries. Areas with sedimentary and volcanic soils may be subject to high levels of arsenic, hydrogen sulfide, and fecal coliform bacteria, which can impact the safety of groundwater sources.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. Non-point source pollution is a major threat to surface water quality, and may include stormwater runoff from roadways, agricultural operations, timber harvest, erosion, and sedimentation. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Landslides, flood events, and earthquakes and resulting liquefaction can cause increased erosion and sedimentation in waterways. Acid mine drainage from the Formosa mine, a U.S. Environmental Protection Agency Superfund site, is another non-point source of pollution. Acid mine drainage threatens the health of Middle Creek in southern Douglas County, a tributary to the Umpqua River.

Underground water supplies and aging or outdated infrastructure — such as reservoirs, treatment facilities, and pump stations — can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, limiting access to potable water. This can lead to unsanitary conditions that may threaten human health and limit fire suppression. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enter surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 4, most local building codes and stormwater management plans emphasize use of centralized storm sewer systems to manage stormwater. Requirements for stormwater mitigation vary in Region 4. Low impact development (LID) mitigation strategies can alleviate or lighten the burden on a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, at lower speeds, and at lower temperatures. While some jurisdictions in Region 4 refer to LID techniques in their stormwater management plans, Medford is the only city that requires LID stormwater mitigation strategies in its development code. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems, and increase a community's resilience to many types of hazard events.

Infrastructure Trends and Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

Older and structurally unsound bridges in Region 4 compromise transportation systems. The effects of bridge and road failures on the economy and health of the Region's residents could be devastating. About 18% of the region's bridges owned by the state are distressed.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. There are eight power-generating facilities in Southwest Oregon. Three are hydroelectric power facilities. The others are primarily biomass facilities. The major Bonneville Power Administration dams in the region are on the Applegate and Rogue Rivers. Of the state-owned dams in the region, 28 have High Threat Potential and 42 have Significant Threat Potential.

Buried natural gas transmission lines run through Douglas and Josephine Counties and are vulnerable to seismic activity.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services do not cover many rural areas of the region that are distant from major transportation corridors. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Water systems in the region are particularly vulnerable to hazard events because they tend to be older, centralized, and lack system redundancies Drinking water is primarily sourced from surface water. The region is at risk in case of high levels of pollutants entering waterways through CSOs during high-water events. The implementation of decentralized low impact development (LID) stormwater systems can increase the region's capacity to better manage high-precipitation events. Medford is the only city that requires LID stormwater mitigation strategies in its development code.

Built Environment

Settlement and Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program is 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD, https://www.oregon.gov/lcd/OP/Pages/Goal-7.aspx).

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people or an "urban cluster" of at least 2,500 people (but less than 50,000). Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-392** and **Table 2-393** remain from the 2010 Census.

Between 2000 and 2010 urban populations in Region 4 have grown by about 14%; more than 4 times the percent growth in rural areas. Jackson and Josephine Counties are experiencing the most urban growth in people and housing. Growth in Douglas County is more evenly distributed between urban and rural areas.

Unsurprisingly, populations tend to cluster around major road corridors and waterways. This holds true for the major cities of Ashland, Medford, Grants Pass and Roseburg. The population distribution in Region 4 is presented in **Figure 2-201**.

Table 2-392. Urban and Rural Populations in Region 4, 2010

	Urban			Rural		
	2000	**2010**	**Percent Change**	**2000**	**2010**	**Percent Change**
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	-0.1%
Region 4	238,659	271,312	13.7%	118,735	122,274	3.0%
Douglas	58,411	63,332	8.4%	41,988	44,335	5.6%
Jackson	141,112	162,458	15.1%	40,157	40,748	1.5%
Josephine	39,136	45,522	16.3%	36,590	37,191	1.6%

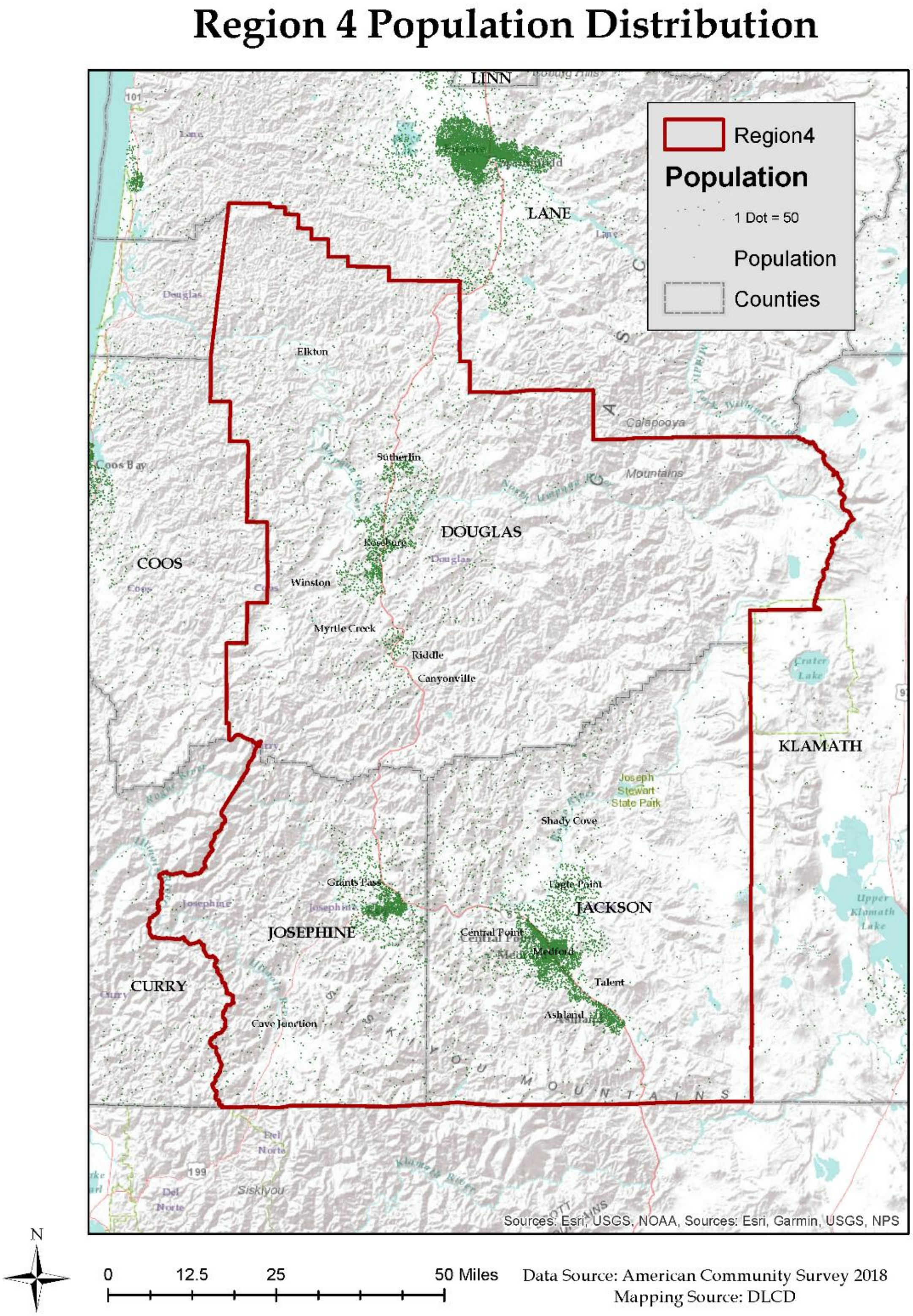
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

Table 2-393. Urban and Rural Housing Units in Region 4, 2010

	Urban			Rural		
	2000	**2010**	**Percent Change**	**2000**	**2010**	**Percent Change**
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 4	101,546	121,709	19.9%	50,714	56,144	10.7%
Douglas	25,273	28,553	13.0%	18,011	20,362	13.1%
Jackson	59,255	72,470	22.3%	16,482	18,467	12.0%
Josephine	17,018	20,686	21.6%	16,221	17,315	6.7%

Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table H002

Figure 2-201. Region 4 Population Distribution



Source: U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. **Table 2-394** provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

The majority of the region's housing stock is single-family homes. Compared to the statewide percentage, manufactured housing constitutes a significant share of the region's housing stock. Notably, in Douglas County, manufactured housing constitutes approximately one-fifth of all housing units. In natural hazard events such as earthquakes and floods, manufactured homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997).

Table 2-394. Housing Profile for Region 4

	Total Housing Units	Single Family			Multi-Family			Manufactured Homes		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	68.1%	✓	0.3%	23.5%	✓	0.3%	8.16%	✓	0.1%
Region 4	182,145	69.5%	✓	0.8%	14.5%	✓	0.7%	15.61%	✓	0.6%
Douglas	49,838	68.6%	✓	1.5%	11.6%	✓	1.3%	19.24%	✓	1.1%
Jackson	93,704	68.9%	✓	1.3%	17.3%	✓	1.0%	13.40%	✓	0.7%
Josephine	38,603	71.9%	✓	1.6%	11.6%	✓	1.4%	16.29%	✓	1.5%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Aside from location and type of housing, the year structures were built (**Table 2-396**) has implications. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally 35.8% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances. More than one third of the region's housing stock was built after 1990 and the codification of seismic building standards. A larger share of housing in Jackson and Josephine Counties was built after 1990 than does Douglas County. Additionally, as shown in **Table 2-397**, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the late 1970s or mid-1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-395. Housing Vacancy in Region 4

	Total Housing Units	Vacant^		
		Estimate	CV **	MOE (+/−)
Oregon	1,733,041	5.6%	☑	0.2%
Region 4	182,145	6.4%	☑	0.6%
Douglas	49,838	7.3%	☑	1.1%
Jackson	93,704	5.7%	☑	0.8%
Josephine	38,603	6.8%	☑	1.2%

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.

**Green, orange, and red icons indicate the reliability of each Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table B25004: Vacancy Status

Table 2-396. Age of Housing Stock in Region 4

	Total Housing Units	Pre 1970			1970 to 1989			1990 or Later		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	34.6%	☑	0.3%	30.5%	☑	0.3%	34.9%	☑	0.3%
Region 4	182,145	30.6%	☑	0.9%	33.6%	☑	0.9%	35.8%	☑	0.9%
Douglas	49,838	36.5%	☑	1.9%	33.5%	☑	1.8%	30.0%	☑	1.7%
Jackson	93,704	28.6%	☑	1.2%	31.8%	☑	1.0%	39.6%	☑	1.3%
Josephine	38,603	27.8%	☑	1.9%	38.3%	☑	2.1%	33.8%	☑	2.0%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25034: Year Structure Built, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood, damage is minimized. **Table 2-397** shows the initial and current FIRM effective dates for Region 4 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, **Flood** section.

Table 2-397. Community Flood Map History in Region 4

	Initial FIRM	Current FIRM
Douglas County	Dec. 15, 1978	Feb. 17, 2010
Canyonville	Nov. 1, 1978	Feb. 17, 2010
Drain	Aug. 1, 1979	Feb. 17, 2010
Elkton	Sept. 5, 1979	Feb. 17, 2010
Glendale	Sept. 29, 1978	Feb. 17, 2010
Myrtle Creek	Feb. 15, 1978	Feb. 17, 2010
Oakland	June 19, 1985	Feb. 17, 2010
Reedsport	Apr. 3, 1984	Feb. 17, 2010
Riddle	Aug. 1, 1979	Feb. 17, 2010
Roseburg	June 1, 1977	Feb. 17, 2010
Sutherlin	Feb. 17, 2010	Feb. 17, 2010 (M)
Winston	Dec. 31, 1974	Feb. 17, 2010
Yoncalla	Feb. 17, 2010	Feb. 17, 2010 (M)
Jackson County	Apr. 1, 1982	Jan. 19, 2018
Ashland	June 1, 1981	Apr. 5, 2017
Butte Falls	June 30, 1976	June 30, 1976 (M)
Central Point	Sept. 30, 1980	May 3, 2011
Eagle Point	Sept. 30, 1980	Jan. 19, 2018
Gold Hill	Sept. 17, 1980	May 3, 2011
Jacksonville	Dec. 4, 1979	May 3, 2011
Medford	Apr. 15, 1981	May 3, 2011
Phoenix	May 3, 1982	May 3, 2011
Rogue River	Jan. 2, 1980	May 3, 2011
Shady Cove	Sept. 30, 1980	Jan. 19, 2018
Talent	Feb. 1, 1980	May 3, 2011
Josephine County	June 1, 1982	Dec. 3, 2009
Cave Junction	June 1, 1982	Dec. 3, 2009
Grants Pass	Apr. 15, 1981	Dec. 3, 2009

(M) = no elevation determined; all Zone A, C, and X.

Source: Federal Emergency Management Agency (2019), Community Status Book Report, https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 4 can be found in Table 2-398. The region contains 9.9% of the total value of all local critical facilities and state-owned and –leased critical and non-critical facilities in the state. Cumulatively, these assets are valued at over three billion dollars.

Table 2-398. Value of State-Owned/Leased Critical and Essential Facilities in Region 4

	Value of Local and State-Owned/Leased Facilities				
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$ 2,630,306,288	$ 4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 4	$ 99,406,138	$ 103,642,420	$ 3,101,259,658	$ 3,304,308,216	9.9%
Douglas	$ 40,857,733	$ 25,436,370	$ 918,903,300	$ 985,197,403	2.9%
Jackson	$ 38,389,347	$ 42,335,010	$ 1,709,631,208	$ 1,790,355,565	5.3%
Josephine	$ 20,159,058	$ 35,871,040	$ 472,725,150	$ 528,755,248	1.6%

Source: DOGAMI, 2020

Land Use Patterns

Over half of all land in region 4 is owned by the federal government. Roughly 44.4% is owned privately and very little is owned by the state. Land use for Region 4 is dominated by forestry, with the majority of land owned by the Federal Government. Agricultural activities are the second major land use. Agricultural activities primarily entail field crops, orchards, and livestock.

Under Oregon’s land use system, each urban area is required to define an Urban Growth Boundary (UGB). Housing tracts, shopping malls, and other kinds of urban development are not allowed to sprawl past that boundary, while agricultural lands and open space outside a UGB are preserved. In Region 4, Roseburg has a significant area to the north along I-5 that can accommodate growth. Grants Pass has room to expand in several directions. Other communities, such as Medford, Central Point, and Jacksonville have little land reserved for urban expansion.

During the 25-year period between 1984 and 2009, Josephine County had a high rate of conversion of private land to developed uses. 14% of the county’s 237,000 acres of private land in forest and agricultural uses was converted to low-density residential or urban uses — most of this change occurred between 1974 and 1984. However, the rates of conversion of private land in resource land uses to low-density residential or urban uses declined in the region and almost stopped between 2000 and 2009. Strong farm and forest land protections played a role in this decline. State statutes and rules establish standards for dwellings, uses and land divisions in rural areas to limit incompatible development and land fragmentation and to ensure that newly created farm and forest parcels remain commercially viable for farm and forest use (Lettman G. J., 2011).

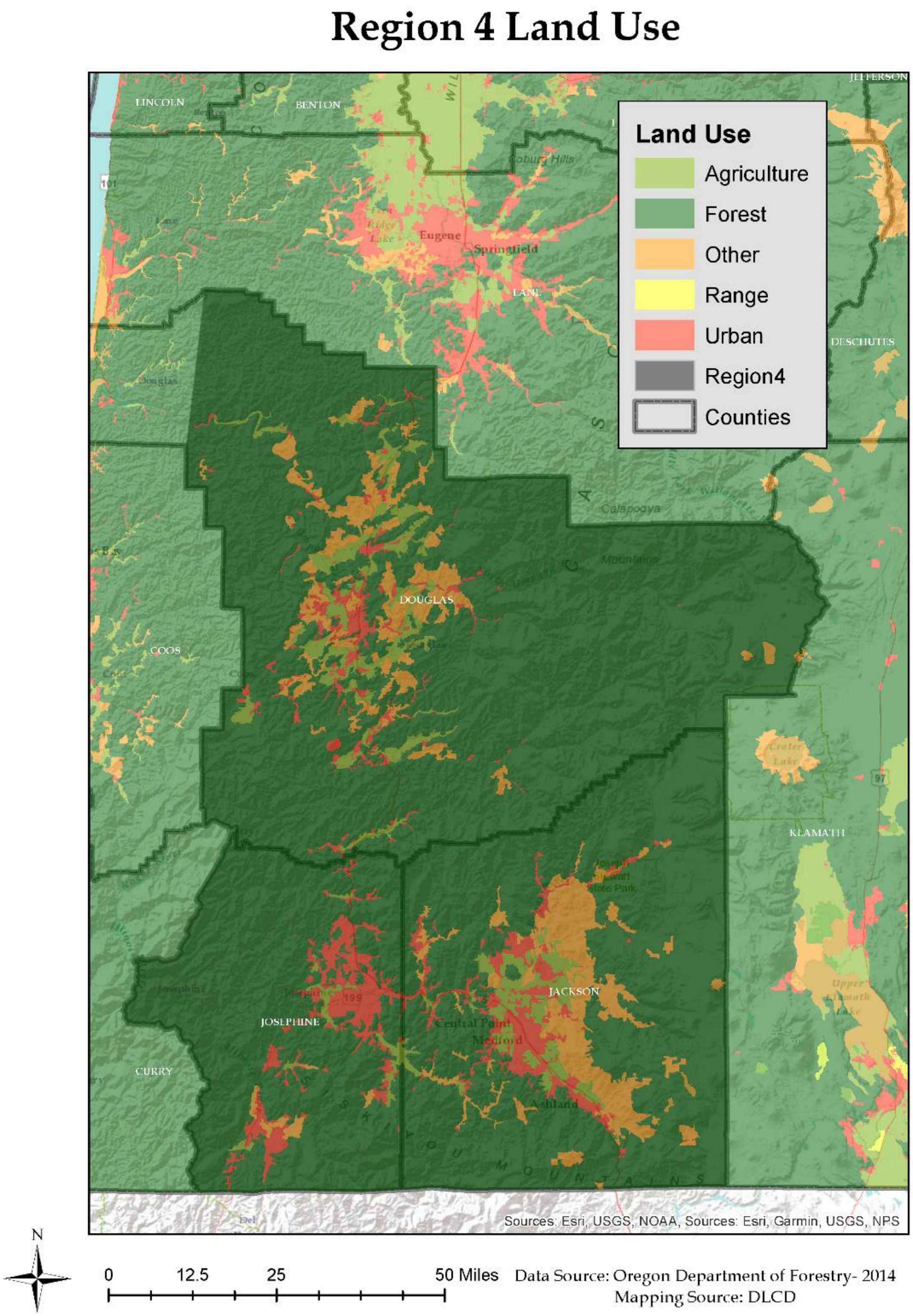
According to the Oregon Department of Forestry’s most recent land-use study, “development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of

Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray , Hubner , McKay, & Thompson , 2016). In Region 4, approximately 2,042 acres of resource lands were converted to more urban uses during the six-year period. **Table 2-372** shows that during this time, the percentage of resource lands converted in each county in Region 4 was less than one percent of each county's total acreage. Douglas County experienced the greatest total number of acres converted but the smallest share.

These changing land use development patterns and protections contribute to a slowing of the growth in the region's wildland-urban interface and other developed areas. While this does not necessarily lessen the wildfire risk in Region 4, it does provide the communities an opportunity to use tools such as the Josephine and Jackson County Integrated Fire Plans to reach vulnerable communities with wildfire risk assessment, outreach, and education.

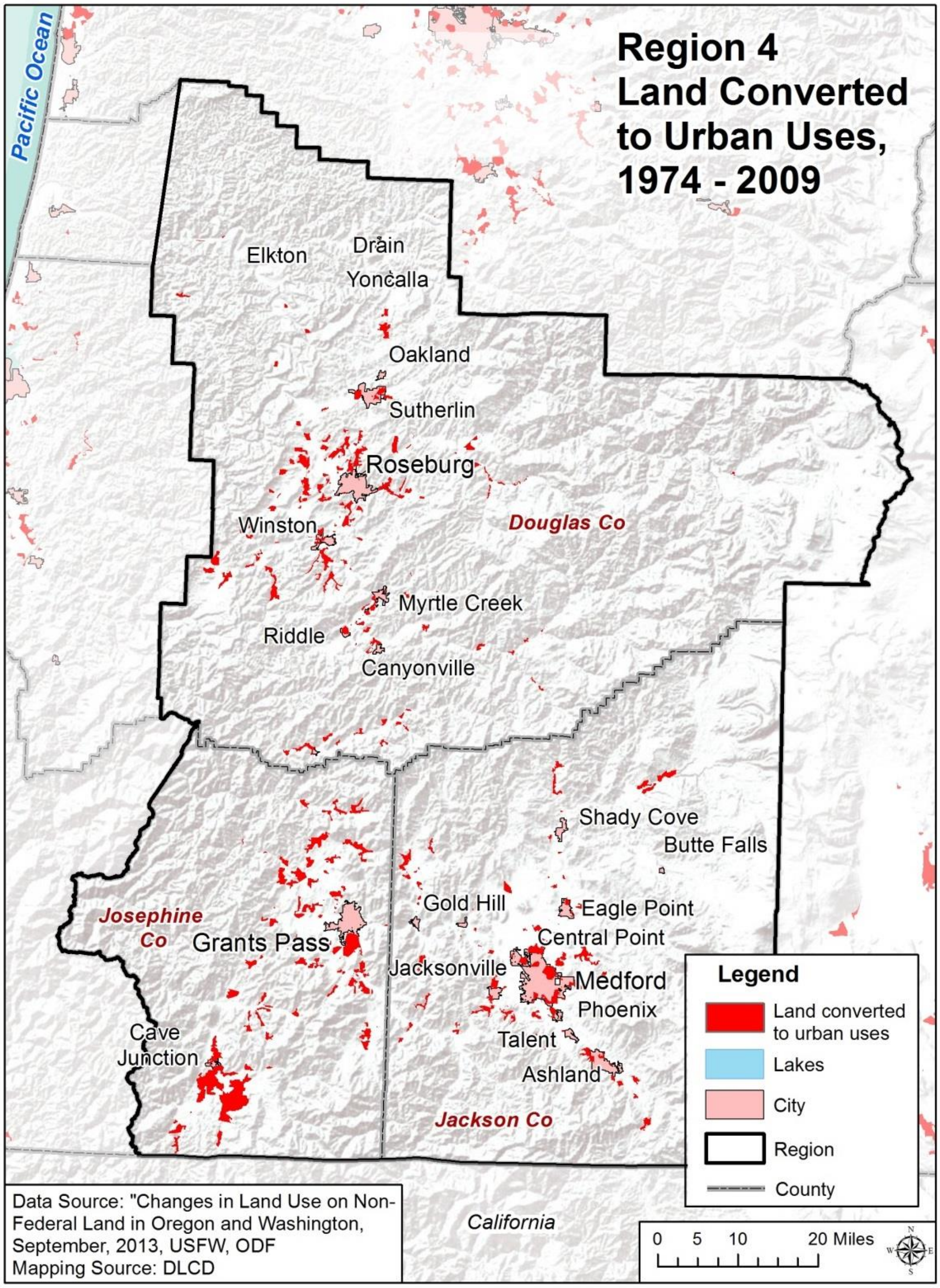
Regional problem solving activities are also addressing land use and development issues and how to guide growth. The "Greater Bear Creek Valley Regional Problem Solving Project" involves Jackson County and six cities in the Rogue Valley in guiding urban growth and development, while preserving priority farmland and floodplain.

Figure 2-202. Region 4 Land Use



Source: Oregon Department of Forestry 2014

Figure 2-203. Region 4 Land Converted to Urban Uses, 1974-2009



Source: Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

Table 2-399. Region 4 Resource Lands Converted to Urban Uses, 2009-2014

	Lost Resource Lands 2009-2014		
	Total Resource Acres (2009)	**Acres Converted to Urban Use**	**Percent Converted**
Region 4	2,381,847	2042	0.09%
Josephine	242,959	471	0.19%
Jackson	770,613	732	0.09%
Douglas	1,368,275	839	0.06%

Source: Oregon Department of Forestry, 2014; Oregon Department of Land Conservation and Development, 2020

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 3 is largely urban with development focused around the major cities along I-5 including Ashland, Medford, Grants Pass and Roseburg. Population growth in the region from 2010-2018 was commensurate with statewide growth. Jackson County saw the largest percent increase, and is project to continue growing most quickly over the next decade. Please refer to the Region 4 Risk Assessment **Demography** section for more information on population trends and forecast. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion.

The region's housing stock is largely single-family homes. The region has about twice the percentage of manufactured housing compared to the state as a whole, with Douglas County having the greatest share of manufactured units and Jackson County having the greatest number of units overall. Over 39% of homes in Jackson County were built after 1990 to current seismic building standards. All of the region's FIRMs have been modernized or updated.

2.3.4.3 Hazards and Vulnerability

Droughts

Characteristics

In Region 4, drought conditions can affect commerce, agriculture, fisheries, and overall quality of life. All three counties in Region 4 experienced drought conditions with formal drought declarations in 1992, 1994, 2001, 2002, 2015 and Douglas County again in 2018.

In August 2013, the U.S. Department of Agriculture declared Jackson and Josephine Counties, along with Klamath and Lake Counties in Region 6, as federal primary natural disaster areas due to damages and losses caused by recent drought. This also occurred in Klamath, Josephine, and Jackson Counties in 2015. The lack of snow in the basin forced the Mount Ashland Ski Resort to close the 2013-14 season early on March 13, 2014. For the first time in its 50-year history, Mount Ashland did not open for the 2014-15 season.

Even though drought may not be declared as often in Western Oregon as in counties east of the Cascades, when drought conditions do develop, the impacts are widespread and severe when both winter snow and spring/summer rain are low. Reasons for broad and significant impact include:

- Higher population density and growing population in the Willamette Valley;
- Dependence on surface water supplies for many municipalities, agriculture and industries from large flood control reservoirs in the Willamette river system;
- Agriculture is a major industry becoming increasingly dependent on irrigation;
- Increased frequency of toxic algal blooms in the Willamette system reservoirs, resulting in restrictions on use of water from reservoirs for drinking (i.e., for human and animals). Affected waters may not be safe for agricultural irrigation, and other uses; necessitating purchasing and transporting water from alternative sources;
- Since drought is typically accompanied by earlier onset of snowmelt (e.g., during flood control or early storage season), little or no snowmelt runoff is stored until later;
- Earlier start to growing season, before the start of the irrigation season, means that crops may not be irrigated until the irrigation season begins;
- Insufficient number of farm workers available because the growing season began before the workers were scheduled to arrive; and
- Responsibilities to recovering anadromous fish.

These are relatively recent and developing concerns, in particular on livestock and some other agricultural operations, and therefore there is no single comprehensive source or other sources for information to assess economic impacts. Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms.

Historic Drought Events

Table 2-400. Historic Droughts in Region 4

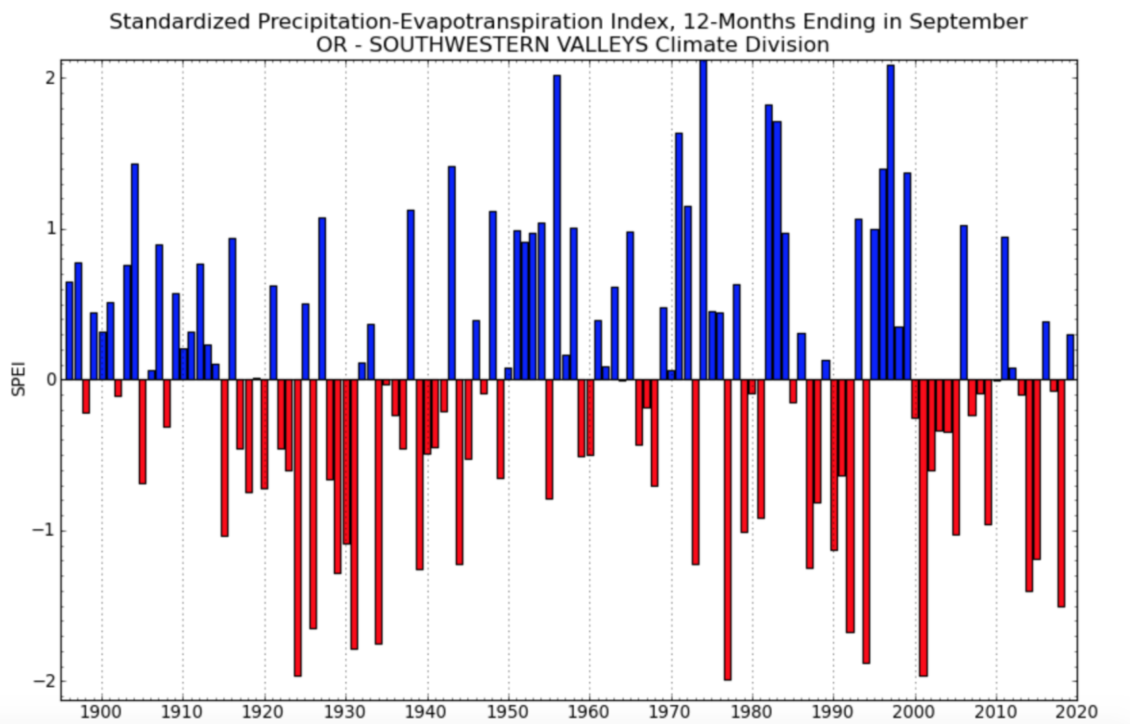
Date	Location	Description
1939	statewide	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country; water year 1939 was one of the more significant drought years in Region 4 during that period
1976-77	SW Oregon eastern Oregon	despite an insignificant PDSI value, the 1976-77 drought affected agriculture in Region 4; the water year was significantly drier than normal, but temperatures were near normal; the 1976-77 drought is included in this table because of the very large water year precipitation departures
1992	statewide	1992 fell toward the end of a generally dry period, which caused problems throughout the state
1994	SW Oregon eastern Oregon	In 1994, Governor’s drought declaration covered 11 counties located within regions 4, 5, 6, 7, and 8
2001	SW Oregon eastern Oregon	Governor-declared drought in effect for all counties in Region 4 during 2001 as well as most counties in Regions 5, 6, 7, and 8
2002	coast; SW Oregon eastern Oregon	2001 Drought Declaration still in effect; five additional counties declared
2014	Regions 4, 6, 7, 8	Governor has declared drought in 10 counties in Oregon, including Region 4’s Josephine and Jackson Counties
2015	statewide	Governor-declared drought in 25 counties, including all three Region 4 counties, with federal declarations in all counties.
2018	Regions 4-8, 1	Governor-declared drought in 11 counties, including Douglas County

Sources: Taylor and Hatton (1999); Oregon Secretary of State’s Archives Division. NOAA’s Climate at a Glance. Western Regional Climate Center’s Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt. Personal Communication, Kathie Dello, Oregon Climate Service, Oregon State University.

Region 4, which encompasses Jackson, Josephine, and Douglas Counties, is prone to frequent droughts. Historic drought information can be obtained from the West Wide Drought Tracker, which provides climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. During this record, the most extreme drought year in the southwestern valleys was 1977 followed by 1924 and 2001. The index shows moderate to severe drought on several occasions (21 years) in the 1920s and 1930s, the early 1990s, the early 2000s (**Figure 2-204**).

U.S Climate Divisions

Figure 2-204. Standard Precipitation-Evapotranspiration Index for Region 4



Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-401. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 3 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
2014	1977	
1929	1924	
1939	2001	
1987	1994	
1944	1931	
1973	1934	
2015	1992	
1990	1926	
1930	2018	
1915		
2005		
1979		

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Probability

Table 2-402. Probability of Drought in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	H	H	M

Source: OWRD, DLCD

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases.

A comprehensive risk analysis is needed to fully assess the probability and impact of drought to Oregon communities. Such an analysis should be completed statewide to analyze and compare the risk of drought across the state.

Jackson County has received drought declarations in 28% of the years since 1992, Douglas 24% and Josephine 21%. Based on this history, Jackson and Douglas County are considered to have high probability for drought; Josephine County moderate probability.

Climate Change

In southwest Oregon drought is a frequent occurrence and the region has historically been hotter and drier than the statewide average. Region 4 is at higher risk of increased drought frequency than the state overall because it is already drought-prone and future climate projections indicate an exacerbation of the already hot and dry summers. Climate models project warmer, drier summers for Oregon, including Region 4. These summer conditions coupled with projected decreases in mid-to-low elevation mountain snowpack due to warmer winter temperatures increases the likelihood that Region 4 would experience increased frequency of one or more types of drought under future climate change. In Region 4, climate change would result in increased frequency of drought due to low spring snowpack (very likely, >90%), low summer runoff (likely, >66%), and low summer precipitation and low summer soil moisture (more likely than not, >50%). In addition, Region 4, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-403. Local Assessment of Vulnerability to Drought in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	L	M	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-404. State Assessment of Vulnerability to Drought in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	H	H	H

Source: OWRD, DLCD

Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms.

Because drought impacts are relatively recent in Region 4, there is no single comprehensive source or other sources for information to assess economic impacts.

Oregon has not undertaken a comprehensive statewide analysis to identify which communities are most vulnerable to drought.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

Drought can have wide-ranging economic impacts in Region 4 and all three counties are very vulnerable to drought-induced wildfire. Further, the counties all have high social vulnerability ratings meaning that any natural hazard would significantly impact their populations. Therefore, Region 4's vulnerability to drought is considered high. All three counties are communities most vulnerable to drought.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 4 is approximately $203,049,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $3,101,260,000. Because drought could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one loss of over $33,000 to a state facility was recorded in Region 4 since the beginning of 2015. It was not caused by drought.

Risk

Table 2-405. Risk of Drought in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Risk	H	H	H

Source: OWRD, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based its history of drought declarations and high vulnerability to drought, Region 4's drought risk is considered to be high.

Earthquakes

Characteristics

The geographic position of this region makes it susceptible to earthquakes from four sources: (a) the off-shore Cascadia Fault Zone, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) shallow crustal events within the North America Plate, and (d) earthquakes associated with renewed volcanic activity.

This part of Oregon has experienced no historic earthquakes of any significance that were centered in the region. However, the region has been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. All considered, there is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region and along the Cascadia Fault Zone. The magnitude 7.3 deep-seated intraplate event centered near Brookings in 1873 was probably felt throughout Southwest Oregon. There have been no known intraplate events in the region's history or pre-history. The 1993 Klamath Falls earthquake was felt in the region, but no damage was reported.

Earthquakes produced through volcanic activity could possibly reach magnitudes of 5.5. The 1980 Mount St. Helens eruption was preceded by a magnitude 5.1 earthquake. Despite the fact that Cascade volcanoes are some distance away from the major population centers in Region 2, earthquake shaking and secondary earthquake-related hazards such as lahars could cause major damage to these centers.

Historic Earthquake Events

Table 2-406. Significant Earthquakes Affecting Region 4

Date	Location	Magnitude (M)	Remarks
Approximate Years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	offshore, Cascadia Subduction Zone	probably 8-9	based on studies of earthquake and tsunami at Willapa Bay, Washington; these are the mid-points of the age ranges for these six events
Jan. 1700	offshore, Cascadia Subduction Zone	approximately 9.0	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Nov. 1873	Brookings area	7.3	chimneys fell at Port Orford, Grants Pass, and Jacksonville; no aftershocks; origin probably Gorda block of the Juan de Fuca plate; intraplate event
Apr. 14, 1920	Fort Klamath, Oregon	5.0	three shocks felt at Fort Klamath; center: probably in the vicinity of Crater Lake
Mar. 1993	Scotts Mills	5.6	$28 million in damage; damage to homes, schools, businesses, state buildings (Salem); crustal event (FEMA-985-DR-Oregon)
Sep. 1993	Klamath Falls	5.9 to 6.0	two earthquakes causing two deaths and extensive damage; $7.5 million in damage to homes, commercial, and government buildings; crustal event (FEMA-1004-DR-Oregon)

Note: No significant earthquakes have affected Region 4 since September 1993.
*BCE: Before Common Era.
Sources: Wong & Bott (1995); Pacific Northwest Seismic Network, https://pnsn.org/

Probability

Table 2-407. Assessment of Earthquake Probability in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	H	H	VH

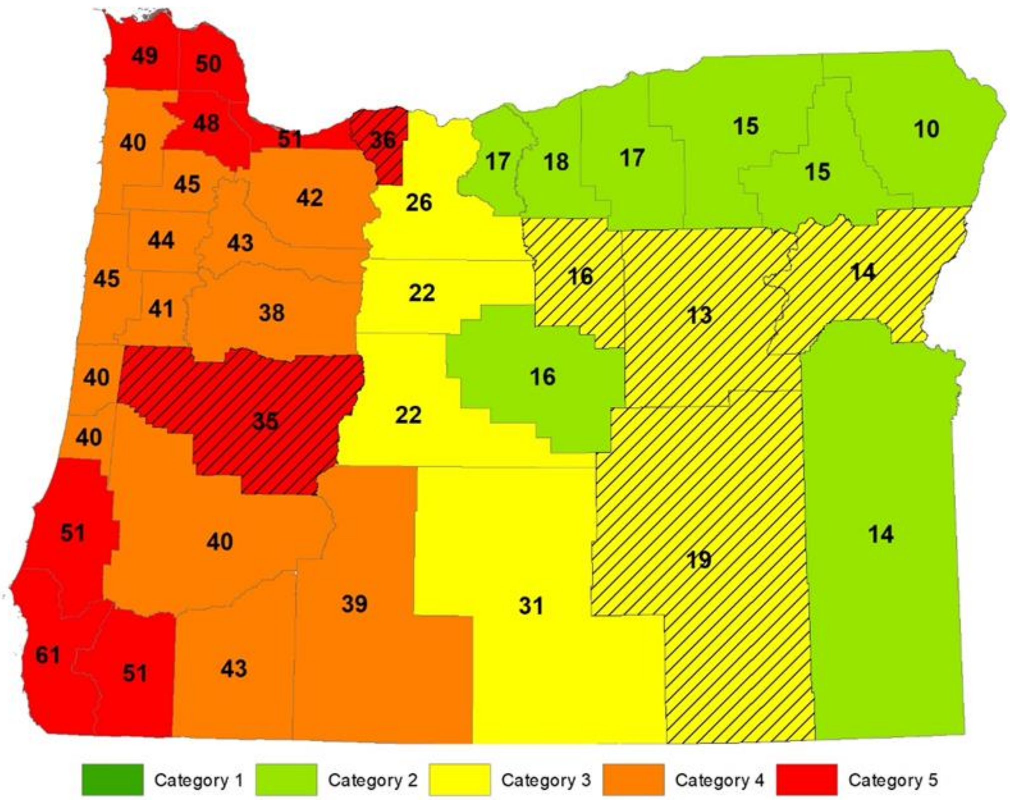
Source: DOGAMI, 2020

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-205**.

Figure 2-205. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.

Source: DOGAMI, 2020

For Oregon west of the crest of the Cascades, the CSZ is responsible for most of the hazard shown in **Figure 2-205**. The paleoseismic record includes 18 magnitude 8.8–9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7 to 12%. An additional 10–20 smaller, magnitude 8.3–8.5, earthquakes affected only the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37-43%.

Vulnerability

Table 2-408. Local Assessment of Vulnerability to Earthquakes in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	H	H	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-409. State Assessment of Vulnerability to Earthquakes in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	H	H	H

Source: DOGAMI and DLCD, 2020

In 2007, DOGAMI (Lewis, 2007) completed a rapid visual screening (RVS) of educational and emergency facilities in communities across Oregon, as directed by the Oregon Legislature in Senate Bill 2 (2005). RVS is a technique used by the Federal Emergency Management Agency (FEMA), known as FEMA 154, to identify, inventory, and rank buildings that are potentially vulnerable to seismic events. DOGAMI surveyed a total of 3,349 buildings, giving each a “low,” “moderate,” “high,” or “very high” potential of collapse in the event of an earthquake. It is important to note that these rankings represent a probability of collapse based on limited observed and analytical data and are therefore approximate rankings (Lewis, 2007). To fully assess a building’s potential of collapse, a more detailed engineering study completed by a qualified professional is required, but the RVS study can help prioritize buildings for further study. Table 2-410 shows the number of buildings surveyed in each county with their respective rankings.

Table 2-410. Building Collapse Potential in Region 4

Region 4 Counties	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Douglas*	74	45	40	10
Jackson	139	13	87	22
Josephine	37	15	16	1

*Does not include the Douglas County coastal communities of Gardiner, Reedsport, and Winchester Bay.

Source: Lewis (2007)

The Oregon Department of Geology and Mineral Industries (DOGAMI) has also developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) a Cascadia Subduction Zone (CSZ) 8.5 event, and (b) combined crustal events (using a 500-year Model). Loss and damage estimates based on these models are founds in Table 2-411 and Table 2-412. For more information on these models, see the State Risk Assessment section.

Table 2-411. Projected Dollar Losses in Region 4, Based on an M8.5 Subduction Event and a 500-Year Model

Region 4 Counties	Economic Base Loss in Thousands (1999)	Greatest Absolute Loss in Thousands (1999) from an 8.5 CSZ Event	Greatest Absolute Loss in Thousands (1999) from a 500-Year (Crustal) Event
Douglas	$4,631,000	$275,000	$546,000
Jackson	$7,829,000	$538,000	$1,191,000
Josephine	$3,240,000	$593,000	$848,000

Source: Wang & Clark (1999)

Table 2-412. Estimated Damages and Losses in Region 4 Associated with Two Earthquake Models

Damage/Loss Type	M8.5 CSZ Event			500-Year Model[1]		
	Douglas	Jackson	Josephine	Douglas	Jackson	Josephine
Injuries	151	428	418	294	930	585
Deaths	2	8	7	4	18	11
Displaced households	255	650	573	534	1,458	872
Economic losses for buildings[2]	$275 m	$538 m	$593 m	$546 m	$1.2 b	$847 m
Operational the "day after" the event[3]:						
Fire stations	66%	75%	22%	N/A	N/A	N/A
Police stations	57%	62%	45%	N/A	N/A	N/A
Schools	44%	70%	34%	N/A	N/A	N/A
Bridges	74%	84%	73%	N/A	N/A	N/A
Economic losses to:						
Highways	$43 m	$10 m	$16 m	$69 m	$34 m	$29 m
Airports	$5 m	$2 m	$5 m	$9 m	$8 m	$10 m
Communications	$7 m	$2 m	$4 m	$12 m	$9 m	$8 m
Debris generated (thousands of tons)	222	434	476	411	889	614

Notes: "b" is billion; "m" is million

[1]Every part of Oregon is subject to earthquakes. The 500-year model is an attempt to quantify the risk across the state. The estimate does not represent a single earthquake. Instead, the 500-year model includes many faults, each with a 10% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single "average" earthquake during this time. More and higher magnitude earthquakes than used in this model may occur (DOGAMI, 1999).

[2]There are numerous unreinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat" (Wang, 1998, p. 5)

[3]Because the 500-year model includes several earthquakes, the number of facilities operational the "day after" cannot be calculated.

Source: Wang & Clark (1999)

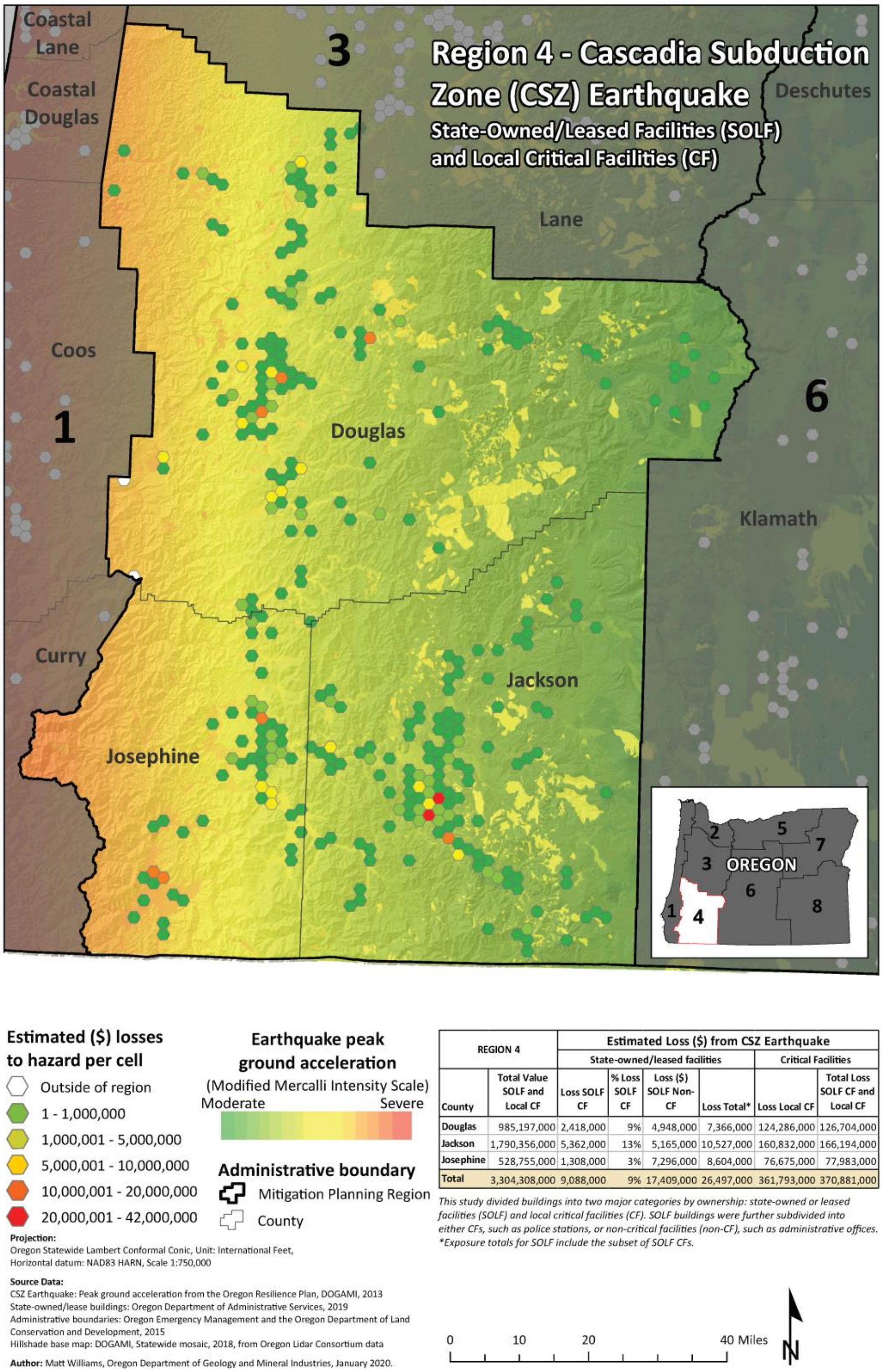
State-Owned/Leased Buildings And Critical Facilities And Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a Magnitude 9 Cascadia Subduction Zone (CSZ) event in Region 4. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 4, a CSZ event could cause a potential loss of almost $26M in state building and critical facility assets, 40% of it in Jackson County and about 30% each in Douglas and Josephine Counties. The potential loss in local critical facilities is quite a bit greater, over $361M. With 44% of the value of local critical facilities, Jackson County has the greatest potential loss followed by Douglas County with 34%. **Figure 2-206** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

Figure 2-206. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Cascadia Subduction Zone Earthquake Hazard Zone in Region 4.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 4		Estimated Loss ($) from CSZ Earthquake						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*	Loss Local CF	Total Loss SOLF CF and Local CF
Douglas	985,197,000	2,418,000	9%	4,948,000	7,366,000	124,286,000	126,704,000
Jackson	1,790,356,000	5,362,000	13%	5,165,000	10,527,000	160,832,000	166,194,000
Josephine	528,755,000	1,308,000	3%	7,296,000	8,604,000	76,675,000	77,983,000
Total	3,304,308,000	9,088,000	9%	17,409,000	26,497,000	361,793,000	370,881,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI

Historic Resources

None of the 6,265 historic resources in Region 4 are in an area of high or very high liquefaction potential. However, 42% of Region 4's historic resources are located in areas of high or very high potential for ground shaking amplification. Over three quarters of those are in Jackson County.

Archaeological Resources

Three thousand seven hundred six archaeological resources are located in earthquake hazard areas in Region 4. Only eleven are located in an area of high earthquake hazards, and none of them have been evaluated as to their eligibility for listing on the National Register of Historic Places. About 87% of Region 4's archaeological resources in earthquake hazard areas are located in Douglas and Jackson Counties.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, all three counties in Region 4 are highly vulnerable to earthquake hazards.

Seismic Lifelines

"Seismic lifelines" are the state highways ODOT has identified as most able to serve response and rescue operations, reaching the most people and best supporting economic recovery. The process, methodology, and criteria used to identify them are described in Section **2.1.6, Seismic Transportation Lifeline Vulnerabilities**, and the full report can be accessed at Appendix **9.1.16**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification* (OSLR). According to that report, seismic lifelines in Region 4 have the following vulnerabilities.

The following geographic zones identified in the OSLR are located within Region 4:

- *South I-5 Geographic Zone:* Region 4 is primarily in this geographic zone where the only recommended seismic lifeline is I-5 from Eugene to the California border. The entire area is likely to experience sustained ground shaking, with many roadways in areas subject to landslide and rockfall or liquefaction. All of I-5 in this zone was designated a Tier 1 route (highest priority roadway) due to its importance in the region and the lack of alternate corridors.

- *Cascades Geographic Zone:* Region 4 also includes the southerly portion of the Cascades Geographic Zone. The only seismic lifeline in this area is the Tier 2 route (second highest priority roadway) on OR-140 from Medford to US-97 in Klamath County, the southernmost route that can also serve as a connection from Medford to the Klamath Falls area in a seismic event. OR-140 is a mountain road that has risks related to dam failure, landslide, and rockfall and also runs through some high-water-table areas.
- *Coastal Geographic Zone:* Region 4 includes a Tier 3 lifeline (third highest priority) in the Coastal Zone: US-199 from I-5 to the Oregon-California border, connecting with US-101 near Crescent City, California. US-199 has a high risk of rockfall approaching its western end and also runs closely along a riverbed so may be vulnerable to liquefaction damage.

Regional Impact. Routes in Region 4 are vulnerable to ground shaking, landslides, rockfall, and liquefaction.

- Ground Shaking: In Region 4 ground shaking will be the most significant vulnerability in populated areas. Unreinforced structures, roadbeds, and bridges will be damaged to varying extents from either a CSZ or Klamath Falls event.
- Landslides and Rockfall: Many roadways in the foothills within and around the valley include landslide prone features. A major seismic event will increase landslide and rockfall activities and may reactivate ancient slides that are currently inactive.
- Liquefaction: Structures in wetland, alluvial and other saturated areas, including the many Umpqua and Rogue River crossings, may be subject to liquefaction damage; the total area of such impacts will vary with the extent of saturated soils at the time of the event.

Regional Loss Estimates. Economic losses caused by a CSZ event were not calculated for the specific zones of study or for specific highway facilities. The economic loss assessment statewide considered only the losses directly due to highway closures, so for example, it does not include productivity losses due to business site damage. The highway-related losses include disconnection from supplies and replacement inventory and the loss of tourists and other customers who must travel to do business with affected businesses.

Most Vulnerable Jurisdictions. Inland Douglas, Jackson, and Josephine Counties are generally equally vulnerable to ground shaking from a CSZ event. A Klamath Falls event has the potential to affect Ashland and Jackson County more that it would Josephine or Douglas County. All three counties have steep rural areas and to some extent steep developed areas that may experience landslides. All three have some transportation facilities along river beds or river crossings that may be vulnerable to liquefaction. The biggest risk is from a CSZ event with an epicenter off the southern Oregon coast.

Risk

Table 2-413. Risk of Earthquake Hazards in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Risk	VH	VH	VH

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, all three counties in Region 4 are at very high risk from earthquakes.

Extreme Heat

Characteristics

Extreme temperatures are common and prolonged periods of high temperatures have in southern Oregon and Region 4 experiences many days above 90°F every year. Medford has an average of about 48 days per year above 90°F.

Extreme heat can affect commerce, agriculture, fisheries, and overall quality of life in all three counties. Jackson and Josephine Counties were declared federal primary natural disaster areas by the U.S. Department of Agriculture in 2013.

Historic Extreme Heat Events

Table 2-414. Historic Extreme Heat Events in Region 4

Date	Location	Notes
August 1–4, 2017	Region 2–4, 6	Excessive Heat Event: Strong high pressure brought record breaking heat to many parts of southwest, south central, and northwest Oregon. Region 4: Reported high temperatures during this interval ranged from 98 to 112 degrees (Jackson), 95 to 110 degrees (Douglas), 87 to 109 degrees (Josephine, eastern Curry).
July 12–17, 2018	Region 2, 3, 4	Region 4: Strong high pressure coupled with very dry air brought very hot temperatures to the area during this interval. High temperatures ranged from 89 to 105 degrees (Jackson) and from 91 to 104 degrees (Josephine, eastern Curry).
June 11–12, 2019	Region 4 (Jackson, Douglas, Josephine, eastern Curry County)	Strong high pressure and a very dry air mass made for hot conditions over southwest Oregon during this interval. Reported high temperatures ranged from 95 to 101 degrees (Jackson), 89 to 101 degrees (Douglas), 88 to 105 degrees (Josephine, eastern Curry).
August 27-28, 2019	Region 4 (Jackson, Josephine, eastern Curry County)	Excessive Heat Event: High pressure aloft forced a thermal trough near the coast to move inland, bringing hot and dry conditions to the inland west side valleys in southwest Oregon. Reported high temperatures in this zone ranged from 99 to 106 degrees on 08/27 and from 92 to 95 degrees on 08/28. Low temperatures on the morning of 08/28 ranged from 50 to 67 degrees.

Source: https://www.ncdc.noaa.gov/stormevents

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning "very low." Region 4 relative probability rankings are shown in **Table 2-415**. Extreme heat frequency relative to the rest of the state is and will continue to be high, especially in Josephine County. The coastal portion of Douglas County is included in Region 4 for this assessment.

Table 2-415. Probability of Extreme Heat in Region 4

	Douglas	Jackson	Josephine
Probability	H	H	VH

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Southern Oregon (Region 4) experiences some of the hottest temperatures in the state and is projected to experience greater frequency of extreme temperatures under future climate change. **Table 2-416** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 4.

Table 2-416. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 4 Counties

County	Historic Baseline	2050s Future
Douglas	6	28
Jackson	9	33
Josephine	13	40

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

Vulnerability

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, **Extreme Heat**. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are house-less.

Because extreme heat is common in southern Oregon ("high" probability), most people in Region 4 are accustomed or prepared in terms of air conditioning when an extreme heat event occurs ("high" adaptive capacity). In Cooling Zone 3, which includes Jackson and Josephine counties, 91% of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1–2 earned a ranking of 1 (very low); scores of 3–4 earned a ranking of 2 (low); scores of 5–6 earned a ranking of 3 (moderate); scores of 7–8 earned a ranking of 4 (high); and scores of 9–10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-417 displays the total vulnerability rankings as well as ranking for sensitivity and adaptive capacity for each county in NHMP Region 4. **Table 2-418** provides the summary descriptors of Region 4's vulnerability.

Combining sensitivity and adaptive capacity, Region 4's relative vulnerability to extreme heat is "Moderate." Douglas County, with its high vulnerability rating, is the county most vulnerable to extreme heat in Region 4.

Table 2-417. Relative Vulnerability Rankings for Region 4 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 4	**4**	**2**	**3**
Douglas	4	3	4
Jackson	4	1	3
Josephine	4	1	3

Source: Oregon Climate Change Research Institute

Table 2-418. Vulnerability to Extreme Heat in Region 4

	Douglas	Jackson	Josephine
Vulnerability	H	M	M

Source: Oregon Climate Change Research Institute

Region 4 counties did not rank vulnerability for extreme heat.

As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. High temperature and insufficient water stunt plant growth and cause areas of crops to wither. Some livestock, especially dairy cattle, are also sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms.

Like drought, impacts of drought on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. However, the appropriate data are not available to assess impacts of heat waves on agriculture and subsequent effects on the state economy.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 4 is approximately $203,049,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $3,101,260,000. Because extreme heat could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one loss of over $33,000 to a state facility was recorded in Region 4 since the beginning of 2015. It was not caused by extreme heat.

Risk

With respect to extreme heat, risk is defined as the combination of the probability of extreme heat events, sensitivity to extreme heat, and level of adaptive capacity in response to extreme heat.

The total relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total risk scores of 1-2 earned a ranking of 1 (“very low”); scores of 3-4 earned a ranking of 2 (“low”); scores of 5-6 earned a ranking of 3 (“moderate”); scores of 7-8 earned a ranking of 4 (“high”); and scores of 9-10 earned a ranking of 5 (“very high”). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-419 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 4. Table 2-420 provides the summary descriptors of Region 4’s risk to extreme heat.

Combining probability and vulnerability, Region 4’s relative risk to extreme heat is “High.”

Table 2-419. Risk Rankings for Region 4 Counties

County	Probability	Vulnerability	Risk
Region 4	**4**	**3**	**4**
Douglas	4	4	4
Jackson	4	3	4
Josephine	5	3	4

Source: Oregon Climate Change Research Institute

Table 2-420. Risk of Extreme Heat in Region 4

	Douglas	Jackson	Josephine
Risk	H	H	H

Source: Oregon Climate Change Research Institute

Floods

Characteristics

A number of large floods have been recorded in Southwest Oregon, many of which were very destructive. Recurrence is virtually assured, since some areas at risk are rapidly urbanizing. This region has the distinction of having two major rivers—the Umpqua and Rogue Rivers—that have their origins in the Cascade Mountains and continue to flow through the Coast Range to the Pacific Ocean. Their headwaters receive an abundance of mountain snow. At lower elevations they may receive runoff from intense Pacific storms, which are not uncommon in western Oregon. A combination of rapidly melting snow and intense rain can produce disastrous flood conditions. **Table 2-421** lists some significant floods that affected southwest Oregon communities. **Table 2-422** includes tributary streams that also have produced disastrous floods.

According to the Jackson County Multi-Jurisdictional Hazard Mitigation Plan (2018) the most significant of the FEMA-determined floodplains and floodways surround the Rogue River, Bear Creek, Ashland Creek and Applegate River. Properties in and near the floodplains in the cities of Rogue River and Shady Cove are subject to frequent flooding events.

In Josephine County, the Rogue and Applegate Rivers also are sources of flooding, along with Slate Creek and the Illinois River. Rogue River flooding affects the City of Grants Pass and Illinois River flooding affects the City of Cave.

In Douglas County the highest stream flows in the Umpqua River basin usually occur during November through March as a result of heavy winter rains augmented by snowmelt. Most of the flooding occurs in the valley areas of the South Umpqua and Umpqua Rivers, although the tributary streams of Cow Creek, Calapooya Creek, and Elk Creek also have extensive flood plains. Most of the land subject to flooding along the South Umpqua River is below Days Creek. Because these valleys are the most densely populated and intensively developed in Douglas County, the principal flood problems in the county occur along the South Umpqua River. Flood potential also exists along the Umpqua River between Elkton and the confluence of the North and South Umpqua Rivers. In the Glendale-Azalea valley of Cow Creek, much bank erosion and channel shifting occurs during floods.

The physical beauty of the area has attracted a large number of people to various stream valleys, where they are placed at risk despite National Flood Insurance Program (NFIP) requirements. This is somewhat offset by Oregon’s land use program, which generally prohibits the subdivision of farm and forest land for residential purposes.

All of the Region 4 counties have digital Flood Insurance Rate Maps (FIRMs). In Douglas County a countywide update was completed in February 2009 by WEST Consultants, Inc. This update included detailed study area floodplain boundaries for portions of Newton Creek, Deer Creek using new topographic mapping with 2 ft contour intervals.

In 2018 a Physical Map Revision (PMR) was completed by STARR in Jackson County for the City of Ashland and unincorporated areas of Jackson County. The Jackson County-Neil Creek PMR incorporates revised hydraulic analysis based on new hydrologic and topographic data along Clayton and Neil Creeks.

In Josephine County a countywide update was completed in November 2009 by WEST Consultants, Inc. The 1- and 0.2-percent-annual-chance floods were re-delineated on Gilbert Creek and portions of the Rogue River using new topography with a one-foot contour interval provided by the City of Grants Pass.

The effective FIRMs for Region 4 are:

- Douglas, February 2010;
- Jackson, January 2018; and
- Josephine, December 2009.

Douglas County's FIRM has been updated but FEMA has temporarily suspended issuance of Letters of Final Determination due to COVID-19. Lidar updates in Region 4 are planned for fall and winter 2020.

Historic Flood Events

Table 2-421. Significant Historic Flood Events Affecting Region 4

Date	Location	Characteristics	Type of Flood
Mar. 1931	western Oregon	wet, mild weather; bridges and homes destroyed	rain on snow
Oct. 1950	southwest Oregon	severe flooding in Region 4; six fatalities; bridges and roads destroyed	rain on snow
Jan. 1962	western Oregon	heavy rain (3-4 inches in Rogue Valley); 84 people evacuated; great loss of farmland	rain on snow
Dec. 1964	entire state	infamous 1964 flood that has become an Oregon benchmark; record flows on Rogue and Umpqua Rivers	rain on snow
Jan. 1974	western Oregon	series of storms with mild temperatures; large snowmelt with rapid runoff	rain on snow
Jan. 1986	entire state	significant flooding in western Oregon attributable to warm, intense rain	snow melt
Jan. 1990	western Oregon	significant flooding in western Oregon	rain on snow
Nov. 1996	entire state	tropical air mass; intense rain; landslides; power outages (FEMA-1149-DR-Oregon)	rain on snow
Dec. 1996	entire state	mild weather continues; severe flooding in Ashland; FEMA declaration (FEMA-1160-DR-Oregon)	rain on snow
July 2001	Douglas, Deschutes and Lake Counties	A Flash Flood Warning was issued for East Central Douglas county. The Boulder Creek area was of special concern. A heavy slow moving thunderstorm dumped one inch of rain in one hour over Sunriver. Lakeview Police reported rock and/or mudslides on State Highway 140 at mileposts 22, 23.2, and 25.1. They also reported 0.25 inch hail up to an inch deep and 2 feet of water in spots on the same highway.	flash flood
Dec. 2005	Douglas, Jackson and Josephine Counties	$2,840,000; damage estimate includes areas outside of Region 4	riverine
June 2006	Jackson	heavy rain brought flash flooding to Jacksonville, but no reported damages	riverine
Aug. 2007	Jackson	heavy rains caused flash flooding near Ashland, no major estimated damages	riverine

Date	Location	Characteristics	Type of Flood
Jan. 2011	Clackamas, Clatsop, Crook, Douglas, Lincoln, and Tillamook Counties	severe winter storm, flooding, mudslides, landslides, and debris flows (DR-1956)	
Nov. 2012	Jackson	heavy rains resulted in at least 4 NFIP losses in the area around Central Point	riverine
Jan. 2012	Douglas	heavy rains resulted in at least two NFIP losses in the Roseburg areas	riverine
Feb. 2014	Jackson County	In Jackson County heavy rains caused a brief flood on Little Butte Creek at Eagle Point.	
Dec. 2014	Tillamook, Lincoln, Lane, Polk Clackamas, Benton Coos and Douglas Counties	A slow moving front produced heavy rain over Northwest Oregon which resulted in the flooding of eight rivers. Another impact from the rain were a couple of land/rock slides that both blocked two highways. Heavy rain brought flooding to several rivers in southwest Oregon.	riverine
Feb. 2015	Curry, Coos, Douglas, Josephine and Jackson Counties	Heavy rains caused flooding on the Rogue River at Agness and along the Coquille River at Coquille.	rain on snow
Dec. 2015	Tillamook, Lincoln, Washington, Clackamas, Multnomah, Lane, Columbia, Hood River, Polk, Coos, Douglas, Jackson and Curry Counties	A moist pacific front produced heavy rainfall across Northwest Oregon which resulted in river flooding, urban flooding, small stream flooding, landslides, and a few sink holes. After a wet week (December 5 through Dec 11), several rivers were near bank full ahead of another front on December 12th. Flooding from the Nehalem River and Rock Creek in Vernonia resulted in evacuation of homes and the implementation of the Vernonia Emergency Command Center. Heavy rain resulted in a land slide that closed OR47 at mile marker 8. More than $15 million dollars in property damage reported in these counties combined.	riverine
Jan. 2016	Jackson, Josephine, Curry and Coos Counties	Heavy rain brought flooding to some areas of southwest Oregon. Minor flooding on the Rogue at Agness and moderate flooding on the Coquille River at Coquille.	riverine
Dec. 2016	Josephine, Jackson, Douglas, Coos and Curry Counties	Heavy rain brought some areal flooding to parts of southwest Oregon.	riverine
Feb. 2019	Douglas, Coos and Curry Counties	Very heavy rain along with the melting of recent snowfall caused flooding at several locations in southern Oregon in late February. Deer Creek at Roseburg, South Fork of the Coquille at Myrtle Point, North Fork of the Coquille at Myrtle Point, the Coquille River at Coquille and the Rogue River at Agness all exceeded flood stage.	rain on snow
April 2019	Douglas, Coos and Curry Counties	Two days of very heavy rainfall (compared to April normals) combined with snowmelt led to areal flooding in southwest and south central Oregon	rain on snow

Source: Taylor and Hatton (1999); Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; 2014 BureauNet; NOAA Storm Event Database, online resource consulted January 2020; Planning for Natural Hazards: Flood TRG (Technical Resource Guide), July 2000, DLCD, Community Planning Workshop

Table 2-422. Principal Flood Sources by County in Region 4

Douglas (Non-Coastal)	Jackson	Josephine
North and South Umpqua Rivers and tributaries	Rogue River and tributaries	Rogue River and tributaries
Tributaries: Scholfield Creek Deer Creek North and South Myrtle Creeks Cow Creek Newton Creek	Tributaries: Jump Off Joe Creek Louse Creek Waters Creek Applegate River Slate Creek Murphy Creek Illinois Creek East and West Forks of the Illinois River Deer Creek	Tributaries: Lazy Creek Larson Creek Griffin Creek Pleasant Creek Foots Creek Little Butte Creek Lone Pine Creek Lassen Creek Crooked Creek Daisy Creek Evans Creek Wagner Creek Ashland Creek Colman Creek Clay Creek Bear Creek

Sources: FEMA, April 21, 1999, Douglas County Flood Insurance Study (FIS); and FEMA, May 15, 2002, Jackson County FIS; and FEMA, Sept 27, 1991, Josephine County FIS

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the “OEM Hazard Analysis Methodology” used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete “OEM Hazard Analysis Methodology” is located in Appendix **9.1.19**.

The purpose of the probability and vulnerability scores is to identify high-priority areas to which local and state governments can target mitigation actions.

Probability

Local Assessment

Participants in each county's Natural Hazard Mitigation Plan update process used the OEM hazard analysis methodology to analyze the probability that Region 4 will experience flooding. The resulting estimates of probability are shown in **Table 2-423**.

Table 2-423. Local Assessment of Flood Probability in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	H	H	H

Source: Douglas County MJNHMP (2016); Jackson County MJNHMP (2018); Josephine County MJNHMP (2017)

State Assessment

Using the methodology described in the Section 2.2.7.1, Floods/Probability, the state assessed the probability of flooding in the counties that comprise Region 4. The results are shown in **Table 2-424**:

Table 2-424. State Assessment of Flood Probability in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	VH	H	VH

Damaging floods occur approximately every 6-12 years.

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Along the Willamette River and its tributaries (Regions 2, 3, and 4), the largest increases in extreme river flows are more likely to be upstream (toward Cascades headwaters), and less likely as one travels downstream. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-425. Local Vulnerability Assessment of Flood in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	M	M	M

Source: Douglas County MJNHMP (2016); Jackson County MJNHMP (2018); Josephine County MJNHMP (2017

Table 2-426. State Vulnerability Assessment of Flood in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	H	VH	H

Source: DOGAMI, DLCD

Critical Facilities and Infrastructure

DOGAMI performed a flood loss analysis for the Upper Rogue Watershed in Jackson County. For other portions of Jackson County and both Josephine and Douglas County, participants in the county NHMPs were consulted to evaluate critical facilities and infrastructure vulnerabilities.

The DOGAMI flood loss analysis for the Upper Rogue that encompassed the cities of Eagle Creek, Shady Cove, Butte Falls and the unincorporated community of Prospect determined that 349 buildings were within the flood zone. Of these, 195 buildings are above the height of the 100-year flood. None of the remaining 154 buildings vulnerable to flooding, none are critical facilities.

They identified the following vulnerabilities. Neighborhoods in the cities of Reedsport, Roseburg, Winston, Canyonville, Drain, Elkton and Myrtle Creek were identified as particularly vulnerable to flood damage. The wastewater treatment plants in the Cities of Elkton and Riddle along with portions of the water supply system for the City of Oakland were among the at-risk critical facilities identified in Douglas County.

In Josephine County, the NHMP identified the risk of restricted access to the hospital located in Grants Pass. The City of Grants Pass is bisected by the Rogue River and connectivity of the community is vulnerable to folds that might damage the main transportation routes.

Repetitive Losses

FEMA has identified 42 Repetitive Loss properties in Region 4.

Table 2-427. Flood Severe/Repetitive Losses and Community Rating System Communities by County in Region 4

County	RL/SRL	# of CRS Communities per County
*Douglas (Myrtle Creek=8; Winston=2)	10	2
Jackson (Central Point = 2, Eagle Point = 4, Jackson Co = 11 Jacksonville = 2, Shady Grove = 3)	22	5
Josephine (Grants Pass = 2 Josephine Co = 8)	10	2
Totals	**42**	**9**

* Includes non-coastal sections of Douglas County

Source: FEMA NFIP Community Information System, https://isource.fema.gov/cis/ accessed February 2020

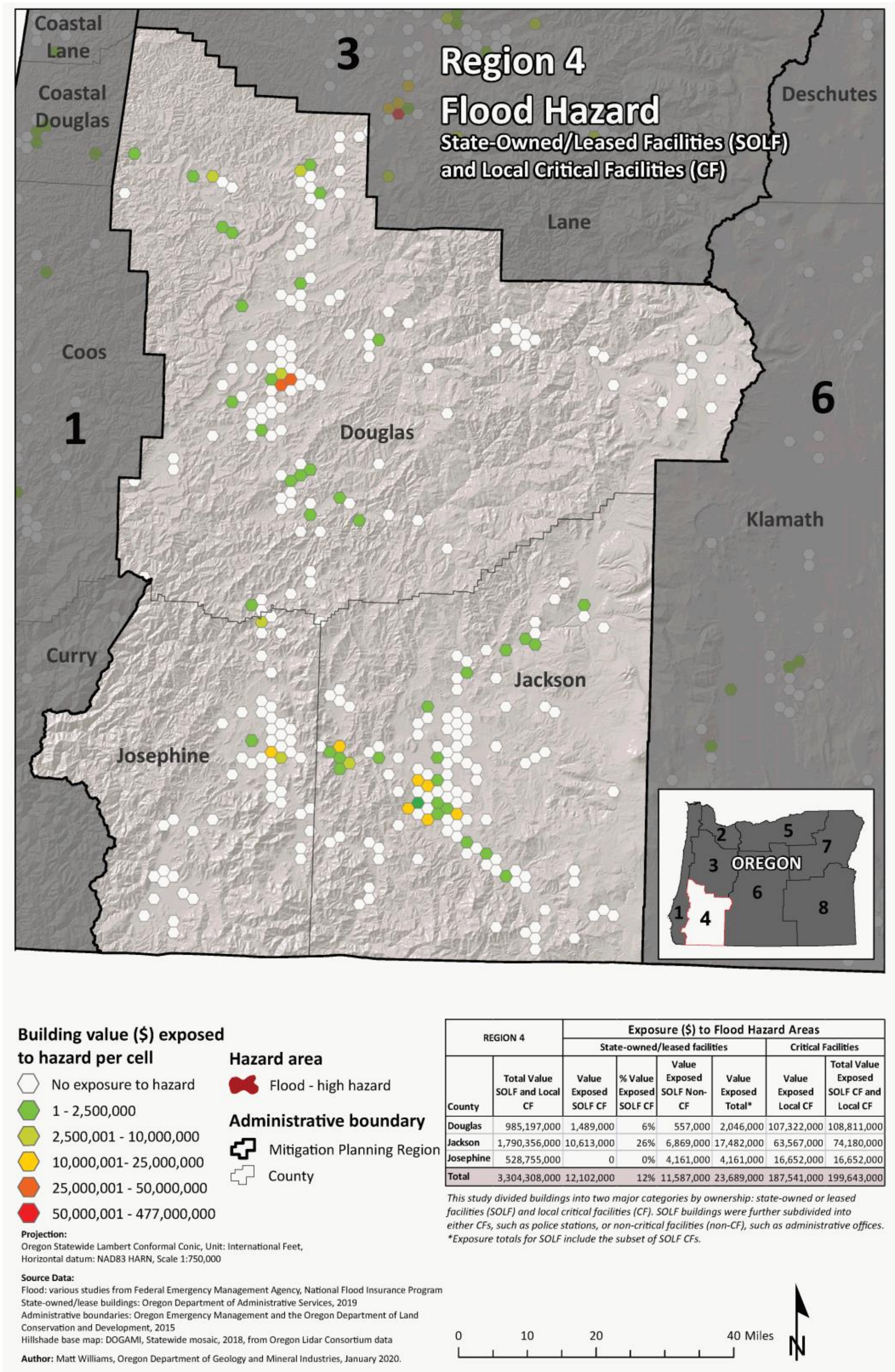
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs.

State-Owned/Leased Facilities and Critical/Essential Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 4, there is a potential loss from flooding of over $23M in state building and critical facility assets, 74% of it in Jackson County alone. There is a much greater potential loss due to flooding in local critical facilities: over $187M, fifty-seven percent in Douglas County. The next greatest share, 34% is in Jackson County. (**Figure 2-207** illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding in Region 4.

Figure 2-207. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 4.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 4		Exposure ($) to Flood Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Douglas	985,197,000	1,489,000	6%	557,000	2,046,000	107,322,000	108,811,000
Jackson	1,790,356,000	10,613,000	26%	6,869,000	17,482,000	63,567,000	74,180,000
Josephine	528,755,000	0	0%	4,161,000	4,161,000	16,652,000	16,652,000
Total	3,304,308,000	12,102,000	12%	11,587,000	23,689,000	187,541,000	199,643,000

*This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices. *Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 6,265 historic resources in Region 4, five hundred fifty-two (8%) are located in an area of high flood hazard. Of those, 290 (53%) and214 (39%) are located in Jackson and Douglas Counties, respectively.

Archaeological Resources

Of the 268 archaeological resources located in high flood hazard areas in Region 3, on hundred thirty-nine (52%) are located in Jackson County. The next greatest share, 34% is in Douglas County. Only two are listed on the National Register of Historic Places, one each in Douglas and Jackson Counties. Twenty-five are eligible for listing, 10 in Douglas County, 11 in Jackson County, and four in Josephine County. Fifteen have been determined not eligible and 226 have not been evaluated as to their eligibility.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Douglas and Josephine Counties are highly vulnerable to flood events, and Jackson County is very highly vulnerable. All the Region 4 counties have high social vulnerability. Jackson County's very high score was driven by its greater share of the value of state buildings, state critical facilities, and local critical facilities. Jackson County also has the greatest number of repetitive and severe repetitive loss properties in the Region, more than twice as many as each of the other two counties.

Most Vulnerable Jurisdictions

While all Region 4 counties are highly vulnerable to flooding, Jackson County is the most vulnerable in Region 4.

Risk

Table 2-428. Risk of Flood Hazards in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Risk	VH	VH	VH

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, all Region 4 counties are at great risk from floods.

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owner's property to community destruction with mass fatalities. The 1889

Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost. Oregon's first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Table 2-429. Historic Significant Dam Failures in Region 4

Year	Location	Description
1956	Sams Valley dam east of Gold Hill in Jackson Co.	Landslide related to reservoir filling threatened homes
1961	Woodrat Knob dam near Lake Creek in Jackson Co.	Major landslide on dam with persons evacuated, flooding prevented

Source: Oregon Water Resources Department Dam Safety Program records

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 33 High Hazard dams and 27 Significant Hazard dams in Region 4.

Table 2-430. Summary: High Hazard and Significant Hazard Dams in Region 4

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 4	20	27	13
Douglas	9	10	5
Jackson	9	16	8
Josephine	2	1	0

Source: Oregon Water Resources Department, 2019

Table 2-431. High Hazard and Significant Hazard Dams in Region 4

County	Name	Rating	Regulator
Douglas	Creekside Dam #1	High	Federal
Douglas	Creekside IWR	High	Federal
Douglas	Galesville Reservoir	High	Federal
Douglas	Lemolo Lake Dam	High	Federal
Douglas	Soda Springs Dam	High	Federal
Douglas	Bear Creek 3	High	State
Douglas	Berry Creek	High	State
Douglas	Cooper Creek (Sutherlin)	High	State
Douglas	Hayhurst Road	High	State
Douglas	Paris	High	State
Douglas	Plat I	High	State
Douglas	Updegrave	High	State
Douglas	Wageman	High	State
Douglas	Winchester	High	State
Douglas	Canyonville Reservoir	Significant	State
Douglas	Dillard Lumber Co Dike	Significant	State
Douglas	Dixonville Log Pond	Significant	State
Douglas	Dollar Mill Pond	Significant	State
Douglas	Drain Plywood Log Pond	Significant	State
Douglas	Drain Sewage Lagoon	Significant	State
Douglas	Gardiner	Significant	State
Douglas	Kinnan, Frank Reservoir	Significant	State
Douglas	Sun Studs Log Pond	Significant	State
Douglas	Sutherlin Log Pond	Significant	State
Jackson	Agate Dam	High	Federal
Jackson	Applegate Lake	High	Federal
Jackson	Emigrant	High	Federal
Jackson	Fish Lake (Jackson-USBR)	High	Federal
Jackson	Howard Prairie	High	Federal
Jackson	Hyatt Reservoir	High	Federal
Jackson	Lost Creek Reservoir (COE)	High	Federal
Jackson	Reeder Gulch Reservoir	High	Federal
Jackson	Duggan	High	State

County	Name	Rating	Regulator
Jackson	Lake Creek	High	State
Jackson	Osborne Creek	High	State
Jackson	Sams Valley	High	State
Jackson	Wade	High	State
Jackson	Walch Dam	High	State
Jackson	Willow Creek	High	State
Jackson	Woodrat Knob	High	State
Jackson	Yankee	High	State
Jackson	Bounds Reservoir	Significant	State
Jackson	Bradshaw	Significant	State
Jackson	Bradshaw 2	Significant	State
Jackson	Frog Pond #1	Significant	State
Jackson	Gardener Reservoir	Significant	State
Jackson	Hammel No. 2	Significant	State
Jackson	Harrison	Significant	State
Jackson	Hoover Pond 1	Significant	State
Jackson	Hoover Pond 2	Significant	State
Jackson	Hoover Pond 3	Significant	State
Jackson	Lester James #1	Significant	State
Jackson	Lester James Reservoir 2	Significant	State
Jackson	Lester James Reservoir 3	Significant	State
Jackson	Mccormick Reservoir	Significant	State
Jackson	Skou Reservoir	Significant	State
Jackson	Woolfolk Reservoir	Significant	State
Josephine	Mcmullen Creek	High	State
Josephine	Strong	High	State
Josephine	Sowell Dam	Significant	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally regulated. A dam's condition is considered public information for state-regulated dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.

- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Only four of the 20 state-regulated high hazard dams are in satisfactory condition and nine are in fair condition. Seven are in poor or unsatisfactory condition.

Table 2-432. Summary: Condition of High Hazard State-Regulated Dams in Region 4

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	Fair	Poor	Unsatisfactory	Not Rated
Region 4	4	9	5	2	0
Douglas	3	4	2	0	0
Jackson	1	4	3	1	0
Josephine	0	1	0	1	0

Source: Oregon Water Resources Department, 2019

Table 2-433. Condition of High Hazard State-Regulated Dams in Region 4

County	Dam Name	Condition
Douglas	Bear Creek 3	Fair
Douglas	Hayhurst Road	Fair
Douglas	Paris	Fair
Douglas	Wageman	Poor
Douglas	Winchester	Poor
Douglas	Berry Creek	Satisfactory
Douglas	Plat I	Satisfactory
Douglas	Updegrave	Satisfactory
Douglas	Cooper Creek (Sutherlin)	UDA
Jackson	Lake Creek	Fair
Jackson	Sams Valley	Fair
Jackson	Wade	Fair
Jackson	Yankee	Fair
Jackson	Duggan	Poor
Jackson	Osborne Creek	Poor
Jackson	Walch Dam	Poor
Jackson	Willow Creek	Satisfactory
Jackson	Woodrat Knob	Unsatisfactory
Josephine	Strong	Fair
Josephine	Mcmullen Creek	Unsatisfactory

Source: Oregon Water Resources Department, 2019

State-Regulated High Hazard Dams not Meeting Safety Standards

There are seven state-regulated high hazard dams in Region 4 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). These dams and the population at risk, based on a screen using the screening tool DSS-WISE, are shown in **Table 2-434**. As the dam safety program conducts analysis over time, the number of dams in less than satisfactory condition may change. Currently dams that are in poor or unsatisfactory condition are in need of rehabilitation or other action to bring them into a fully safe condition. As of December 2019, these are the dams in Region 4 that are not yet demonstrably unsafe, but that do pose unacceptable risk. When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Table 2-434. State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 4

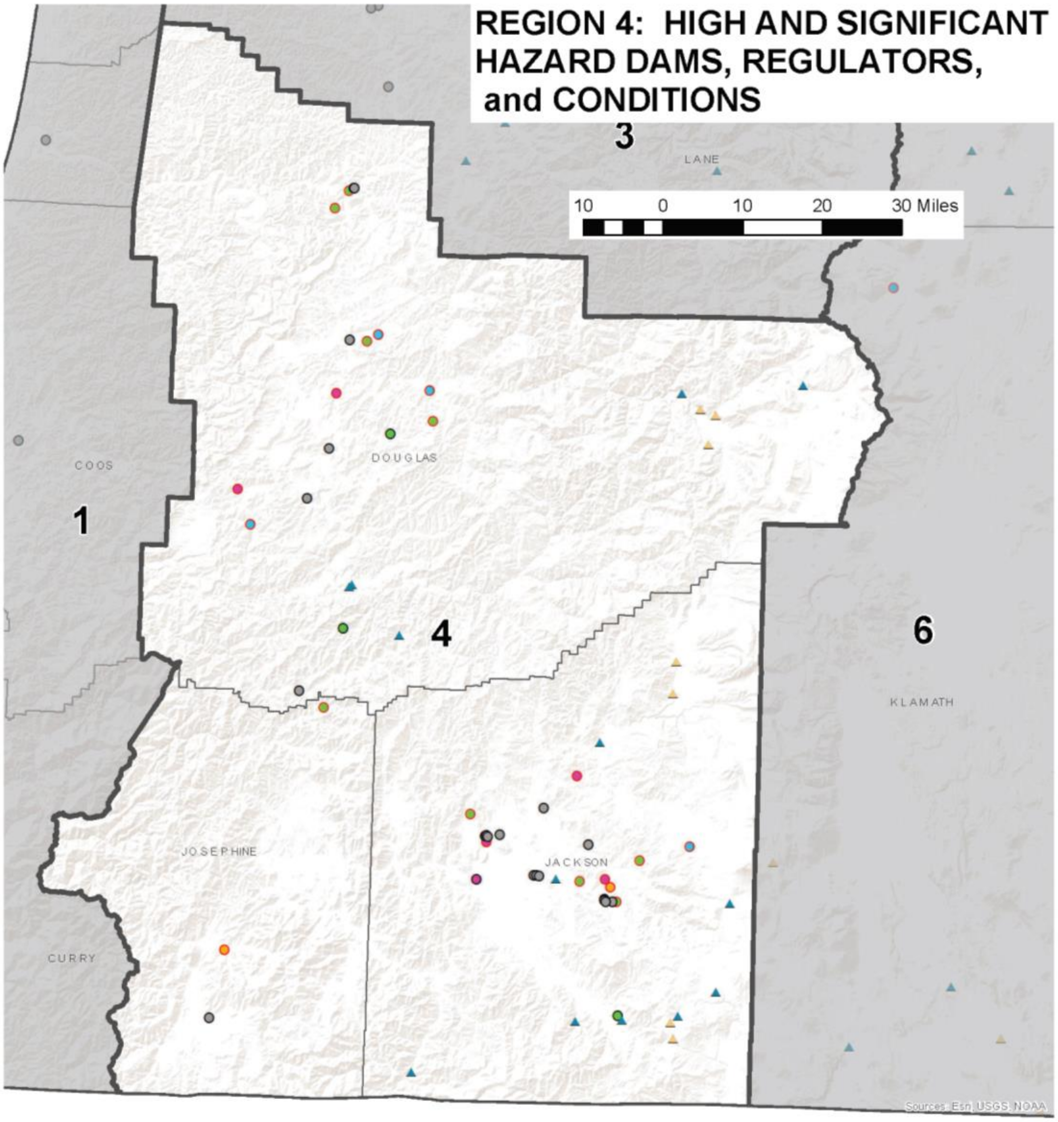
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Wageman	OR00496	POOR	6	12	Douglas
Winchester		POOR	Small	Small	Douglas
Duggan Dam	OR00475	POOR	6	11	Jackson
Osborne Creek Dam	OR00401	POOR	227	500	Jackson
Walch Dam		POOR	Small	Small	Jackson
Woodrat Knob	OR00357	UNSAT	123	229	Jackson
McMullen Creek	OR00513	UNSAT	85	243	Josephine

Note: "PAR" is number of "Persons At Risk" in the dam failure inundation zone based on a conservative estimate using DSS-Wise dam breach estimator. It includes all persons that normally could be in the inundation area. Actual impacts depend on the velocity and depth of water and will be determined as part of Oregon's HHPD grant tasks.

Source: DSS-Wise output

Figure 2-208 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 4. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-208. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 4



	Coastal	Earthquake	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 4	0	23	*	17	0	0	34
Douglas	0	7	*	7	0	0	5
Jackson	0	14	*	10	0	0	26
Josephine	0	2	*	0	0	0	3

* - flood risk affected by function and condition of dam, not by presence in mapped flood prone location

State regulated dams**

Condition assessment

- Poor
- Unsatisfactory
- Fair
- Satisfactory
- No assessment

** - Significant hazard dam symbols have a black outline.
High hazard dam symbols have a red outline.

Federal regulated dams

Hazard

- High
- Significant

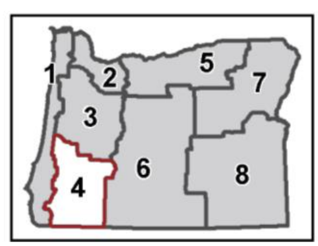
Mitigation Planning Regions

Counties

Projection:
Oregon Lambert Coordinate Reference System, Unit: International Feet, Horizontal datum: NAD83, EPSG #2992

Source Data:
State regulated dams: Oregon Water Resources Dept., July 2020
Mitigation Planning Regions: Oregon Emergency Management
Counties: U.S. Bureau of Land Management (BLM)
Base map: Esri, World Terrain Base

Author: Robert Harmon, GISP, Oregon Water Resources Dept. (July 2020)



Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

Table 2-434, State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 4, indicates the number of people currently anticipated to be impacted by potential failure of the state-regulated high hazard dams in poor or unsatisfactory condition. OWRD plans to do more analysis to determine the number and value of structures that may be impacted as well.

Dams in the western portions of Region 4 can have high risks from earthquakes There is one state-regulated dam in this region known to have high seismic vulnerability. Dams have a moderately increased risk from landslide and wildfire, with risk of large woody debris from wildfire. State-regulated dams in this region are not close to volcanic hazards; some federally regulated dams are closer.

Five dams in Region 4 meet FEMA HHPD eligibility criteria. There are lifeline highways in the dam breach inundation area of three of these dams, including one highway providing essential coastal access.

Most Vulnerable Jurisdictions

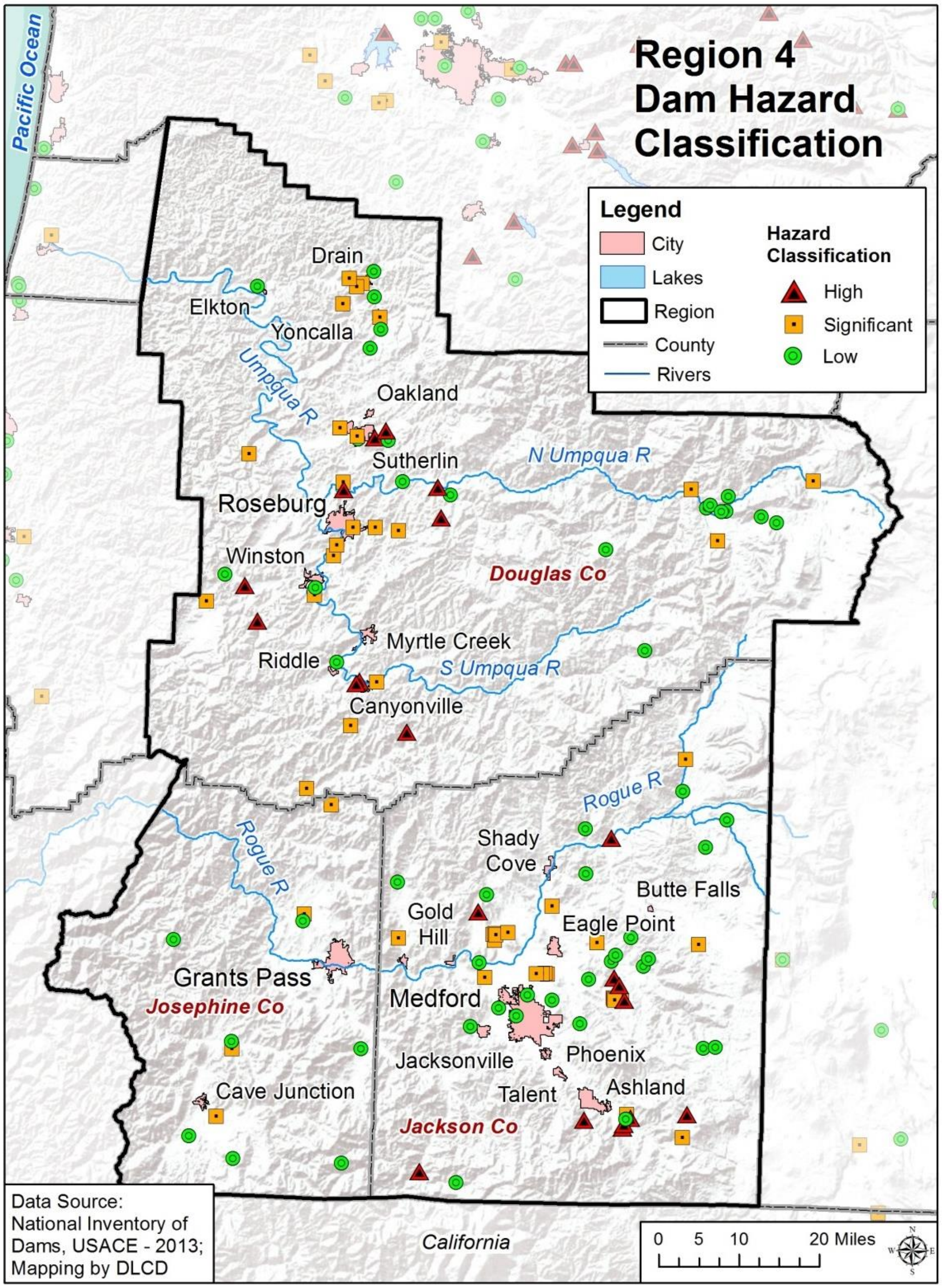
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), all the counties in Region 4 have high hazard dams in poor or unsatisfactory condition are therefore considered most vulnerable. Of those, the greatest number of people in potentially dangerous locations if a dam were to fail are in Jackson County followed by Josephine County.

As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable jurisdictions” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The county with the most state-regulated significant hazard dams is Jackson County (16).

Risk

With FEMA and State funding, OWRD will be completing risk assessments for five of Region 4’s state-regulated high hazard dams in poor or unsatisfactory condition over the next several years. For now, the potential for damage to the dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-209. Region 4 Dam Hazard Classification



Source: National Inventory of Dams, USACE, 2013

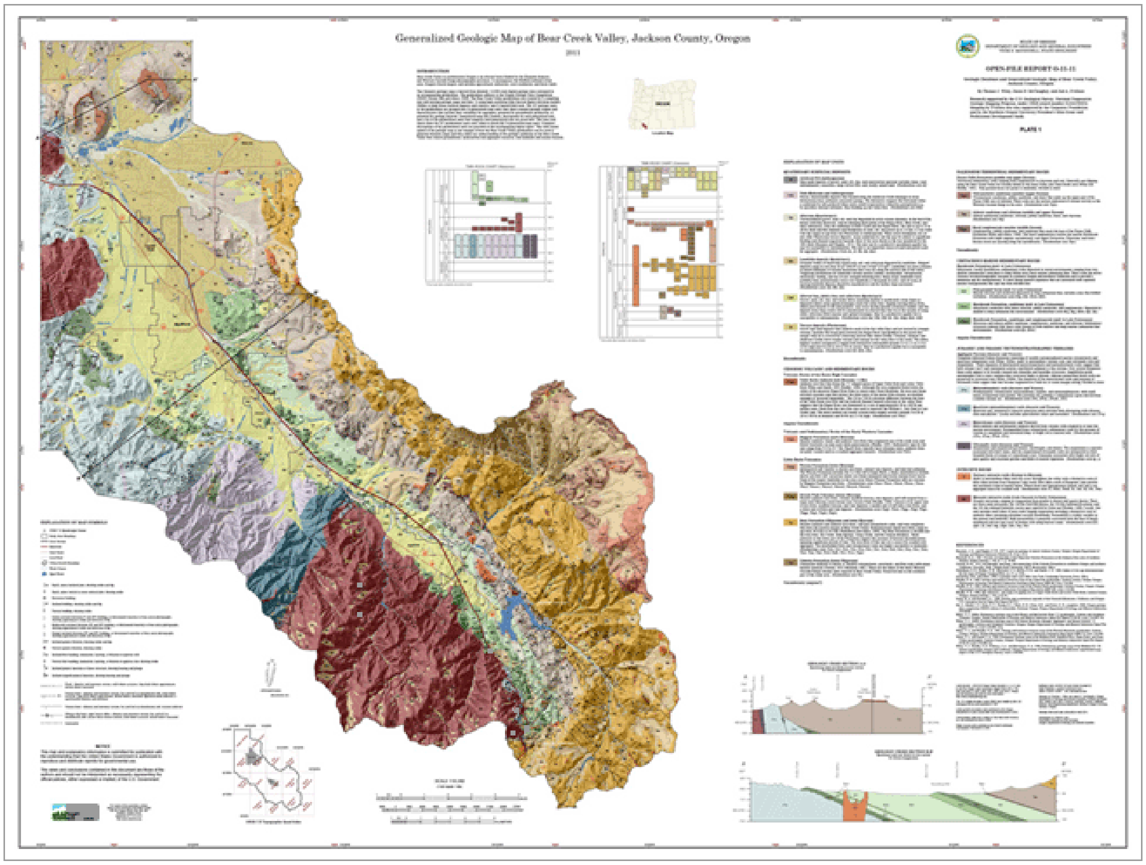
Note: Federally regulated significant hazard dams are not shown.

Landslides

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the Klamath Mountains have a high incidence of landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage. For example, new geologic mapping of the Medford area found 1,734 landslide, debris fan, and colluvium deposits indicating a high level of hazard in this small area (**Figure 2-210**).

Figure 2-210. Generalized Geologic Map of Bear Creek Valley, Jackson County, Oregon



Source: Wiley, et al. (2011)

Historic Landslide Events

Table 2-435. Historic Landslide Events in Region 4

Date	Location	Incident
Jan. 1974	near Canyonville, Oregon	nine employees working in a telephone building were killed when the building was pushed by a mudslide into Canyon Creek
Feb. 1996		heavy rains and rapidly melting snow contributed to hundreds of landslides / debris flows across the state; many occurred on clear cuts that damaged logging roads
Nov. 1996	Lane and Douglas Counties	heavy rain triggered mudslides (Lane and Douglas Counties); eight fatalities and several injuries (Douglas County)
Dec. 1996-Jan. 1997	Douglas, Jackson, and Josephine Counties	DR-1160 – Two significant storms caused hundreds of landslides damaging houses and infrastructure
Dec. 2003-Jan. 2004	Douglas	DR-1510
Dec. 2005-Jan. 2006	Douglas, Jackson, and Josephine Counties	DR-1632
Jan. 2011	Douglas	DR-1956
Jan. 2012	Douglas	DR-4055
Dec. 2015	Douglas	DR-4258 – many landslides. Closed roads including Stagecoach Rd (east of Mapleton)
Dec. 2016	Josephine	DR-4296
Jan. 2017	Josephine	DR-4328 – many landslides. Closed roads including OR-36, OR-58, and OR-103
Feb. 2019	Douglas	DR-4432
Apr. 2019	Douglas	DR-4452 – many landslides. Closed roads including OR-58

Source: Taylor and Hatton (1999); https://www.fema.gov/disasters

Probability

Table 2-436. Assessment of Landslide Probability in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	VH	VH	VH

Source: DOGAMI, 2020

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in this region in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is more likely than not (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-437. Local Assessment of Vulnerability to Landslides in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	L	L	L

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-438. State Assessment of Vulnerability to Landslides in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	H	H	M

Source: Oregon Office of Emergency Management, November 2013, County Hazard Analysis Scores

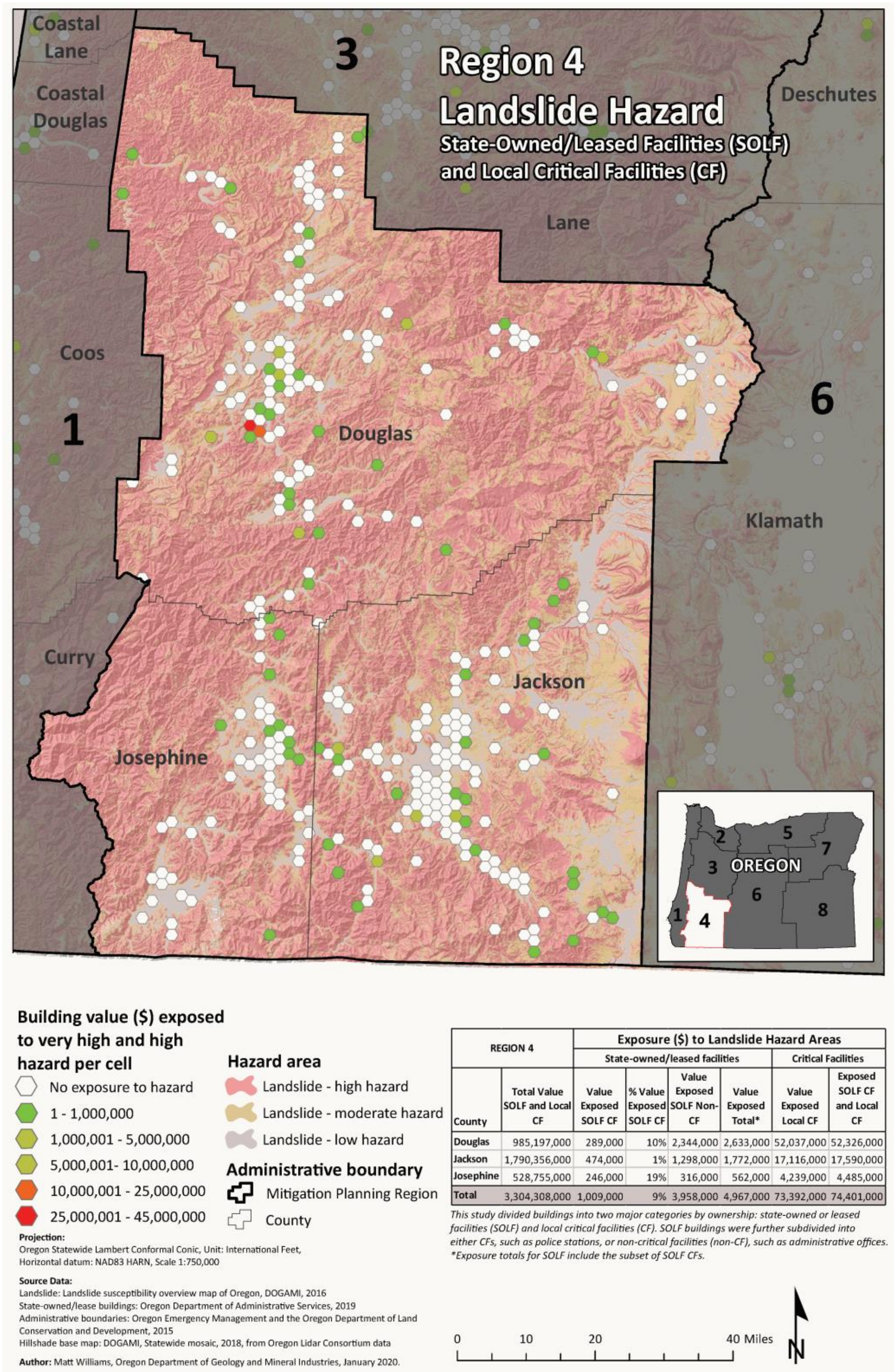
Many of the communities in this region are vulnerable to landslides; for example, the cities of Medford and Ashland have a moderate exposure to landslides.

According to the 2020 risk assessment, the vulnerability scores are driven by high social vulnerability in all three counties. Josephine County's moderate vulnerability rating owes to having fewer state buildings, state and local critical facilities exposed to landslides.

State-Owned/Leased Facilities and Critical and Essential Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 4. Almost $5M in state building and critical facility assets is exposed to landslide hazards in Region 4, over half of it in Douglas County and over a third in Jackson County. The region has almost 15 times that value in local critical facilities located in landslide hazard areas, 71% of it in Douglas County. **Figure 2-211** illustrates the potential loss to state buildings and critical facilities and local critical facilities from landslide hazards.

Figure 2-211. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 4.High-resolution, full-size image linked from Appendix [9.1.26](#).



REGION 4		Exposure ($) to Landslide Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Exposed SOLF CF and Local CF	
Douglas	985,197,000	289,000	10%	2,344,000	2,633,000	52,037,000	52,326,000	
Jackson	1,790,356,000	474,000	1%	1,298,000	1,772,000	17,116,000	17,590,000	
Josephine	528,755,000	246,000	19%	316,000	562,000	4,239,000	4,485,000	
Total	3,304,308,000	1,009,000	9%	3,958,000	4,967,000	73,392,000	74,401,000	

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI**, 2020**

Historic Resources

Of the 6,265 historic resources in Region 4, 265 or about 4% are in areas of very high or high landslide hazard susceptibility; 1,595 are in moderate; and 4,405 in low. Over half of those in high landslide hazard areas are located in Douglas County. However, 67% of all historic resources in landslide hazard areas in Region 4 are located in Jackson County.

Archaeological Resources

Of the 1,988 archaeological resources located in landslide hazard areas in Region 4, eighty-two percent (1,625) are in high landslide hazard areas. Of those, seven are listed on the National Register of Historic Places and 142 are eligible for listing. Two hundred twenty-five have been determined not eligible, and 1,251 have not been evaluated as to their eligibility. Fifty-three percent of the archaeological resources in high landslide hazard areas are located in Douglas County and 51% of all archaeological resources in landslide hazard areas in Region 4 are located in Douglas County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Douglas and Jackson Counties are the most vulnerable to landslides in Region 4.

Risk

Table 2-439. Assessment of Risk to Landslides in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Risk	H	H	M

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 Risk Scores and DOGAMI's expert assessment, all three of the counties are "most vulnerable jurisdictions" with very high risk ratings. All communities should be prioritized for mitigation actions.

Volcanoes

Characteristics

The eastern boundaries of Douglas and Jackson Counties coincide with the crest of the Cascade Mountains, a volcanic range. The Cascade Mountains are still active as has been demonstrated by Mount St. Helens in Washington State. Volcanic activity in the Cascades will continue, but questions regarding how, to what extent, and when, remain. Both Douglas and Jackson Counties are at some risk from volcano-associated hazards however remote. Josephine County is west of the Cascade Mountains and is not subject to the same risks.

Southwest Oregon communities are close to several prominent volcanic peaks, one of which is a national park (Crater Lake). The other peaks include Mount Bailey (elevation 8,363 ft), Mount Thielsen (9,182 ft), and Mount McLaughlin (9,495 ft). Of the three, Crater Lake (6,178 ft) may pose the greatest risk. It is a caldera and the remnant of a mountain (Mount Mazama) that probably had an elevation between 10,800 and 12,000 ft. The massive eruption, which produced the caldera, took place about 7,700 years ago. The long history at Mount Mazama strongly suggests that this volcanic center will be active in the future (Bacon, Mastin, Scott, & Nathenson, 1997). The presence of the lake means that any future eruption likely will be violent; there are many examples of explosive activity brought about by magma coming into contact with water.

Douglas and Jackson Counties should consider the impact of volcano-related activity on small mountain communities, tourist attractions (e.g., Crater Lake) dams, reservoirs, and highways. These counties also should consider probable impacts on the local economy (e.g., wood products, tourism, and recreation).

Historic Volcanic Events

Table 2-440. Historic Volcanic Events in Region 4

Date	Location	Description
about 7,780 to 15,000 YBP	Cinnamon Butte, southern Cascades	basaltic scoria cone and lava flows
about 7,700 YBP	Crater Lake Caldera	formation of Crater Lake caldera, pyroclastic flows, widespread ashfall

Note: YBP is years before present.

Sources: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/; Bacon, et al. (1997)

Probability

Table 2-441. Assessment of Volcanic Hazards Probability in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	M	M	VL

Source: DOGAMI, 2020

There is virtually no risk from volcanoes in Josephine County, other than the possibility of ashfall. Ashfall could come from several sources in the Cascade Range, including Mount Shasta in California or Crater Lake in Oregon. The probability of ashfall totaling 1 cm or more in Josephine County, from any Cascade volcano, is about 1 in 10,000.

Douglas and Jackson Counties are at greater risk of volcanic hazards. The probability of a 1 cm or greater ashfall varies from 1 in 5,000 to 1 in 10,000 (Sherrod, Mastin, Scott, & Schilling, 1997).

Based on the total number of eruptive episodes in the past 100,000 years, the average recurrence interval in the Crater Lake area is about 10,000 years. The annual probability of an eruption then, is about 1 in 10,000; the 30-year probability is about 1 in 330 (Bacon, Mastin, Scott, & Nathenson, 1997). The probability of an event is summarized in **Table 2-442** for each of the counties in Region 4.

Table 2-442. Probability of Volcano-Related Hazards in Region 4

Volcano-Related Hazard	Douglas	Josephine	Jackson	Remarks
Volcanic ash (annual probability of 1 cm or more accumulation from eruptions throughout the Cascade Range)	1 in 5,000 to 1 in 10,000	1 in 10,000	1 in 5,000 to 1 in 10,000	Sherrod, et al. (1997)
Lahar	Source: Crater Lake	no risk	Source: Crater Lake	Bacon, et al. (1997)
Lava flow	no risk	no risk	no risk	Bacon, et al. (1997)
Debris flow / avalanche	no risk	no risk	Source: Crater Lake	Bacon, et al. (1997)
Pyroclastic flow	Source: Crater Lake	no data available	Source: Crater Lake	Bacon, et al. (1997)

Sources: Sherrod, et al. (1997); Bacon, et al. (1997).

Vulnerability

Table 2-443. Local Assessment of Vulnerability to Volcanic Hazards in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	—	L	L

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-444. State Assessment of Vulnerability to Volcanic Hazards in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	M	M	M

Source: DOGAMI and DLCD, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 4. No state buildings, state or local critical facilities are exposed to volcanic hazards in Region 4.

Historic Resources

None of the 6,265 historic buildings in Region 4 are exposed to volcanic hazards. See Appendix **9.1.12** for details.

[Insert archaeological vulnerability here.]

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

According to the 2020 vulnerability scores, all three counties in Region 4 are moderately vulnerable to volcanic hazards. The vulnerability scores are driven primarily by high social vulnerability in all three counties along with low to moderate probability of a volcanic hazard event.

Risk

Table 2-445. Assessment of Risk to Volcanic Hazards in Region 4

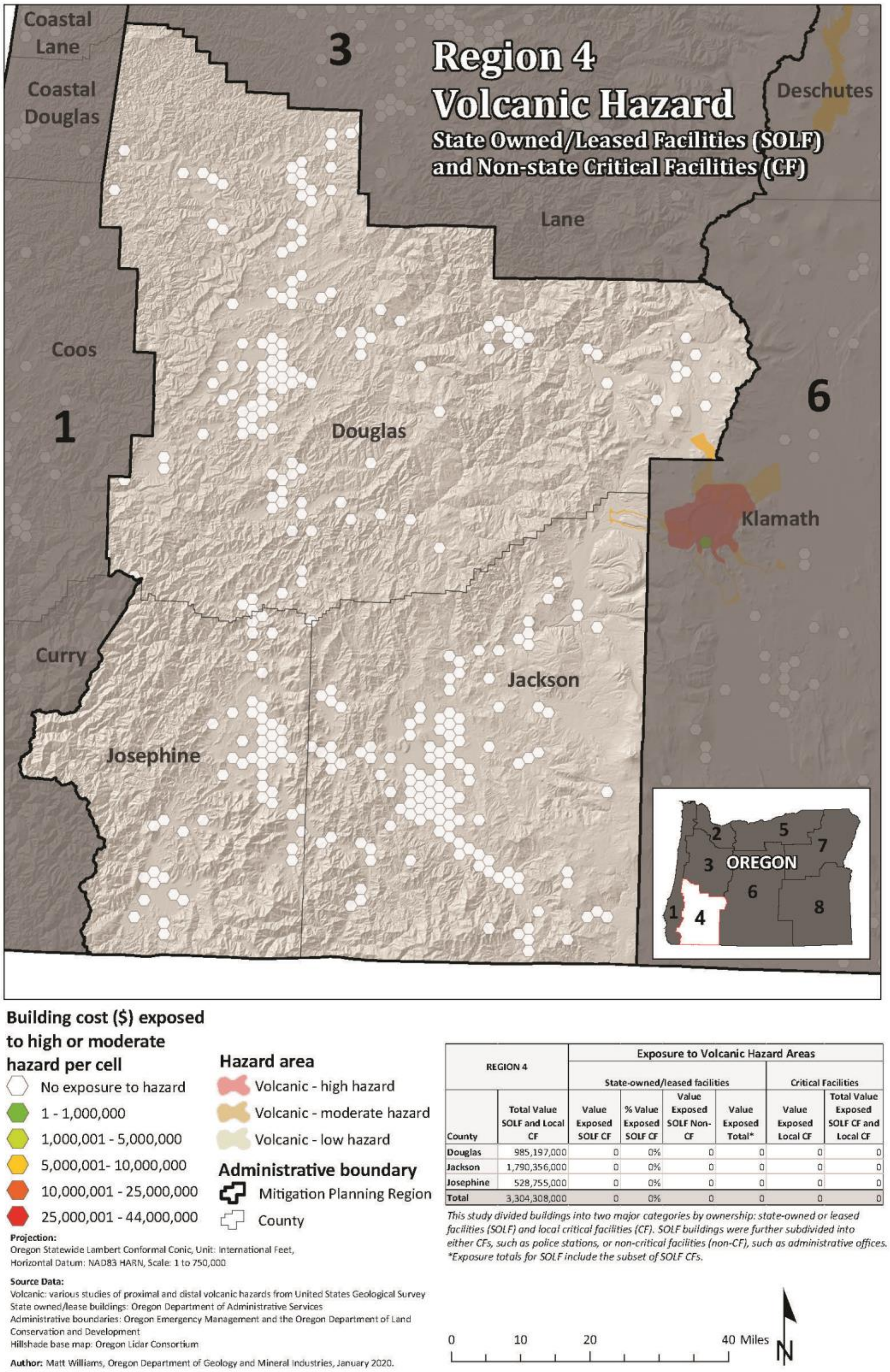
	Douglas (Non-Coastal)	Jackson	Josephine
Risk	M	M	L

Source: DOGAMI and DLCD, 2020

According to the 2020 Risk Scores, Douglas and Jackson Counties are Region 4's "most vulnerable jurisdictions" with moderate (M) risk ratings. All three counties' vulnerability scores are driven by their social vulnerability. Douglas and Jackson Counties should be prioritized for mitigation actions. Josephine County has a Low (L) risk rating.

The U.S. Geological Survey has addressed volcanic hazards in the Crater Lake region (Bacon, Mastin, Scott, & Nathenson, 1997). This report includes maps depicting the areas at greatest risk. The park itself is in the greatest risk category. In Douglas County, the upper reaches of the Umpqua and Clearwater rivers are subject to volcano-associated hazards, as is the OR-62 corridor in Jackson County (Bacon, Mastin, Scott, & Nathenson, 1997); http://pubs.usgs.gov/of/1997/0487/). There is virtually no risk from volcanoes in Josephine County, other than the possibility of ashfall.

Figure 2-212. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Volcanic Hazard Zone in Region 4. High-resolution, full-size image linked from Appendix 9.1.26.



REGION 4		Exposure to Volcanic Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Douglas	985,197,000	0	0%	0	0	0	0
Jackson	1,790,356,000	0	0%	0	0	0	0
Josephine	528,755,000	0	0%	0	0	0	0
Total	3,304,308,000	0	0%	0	0	0	0

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Wildfires

Characteristics

While the residents in Region 4 enjoy moderate winters, during the summer residents can expect long drought periods, low humidity with temperatures that sometimes exceed 100°F, and frequent lightning storms. Some landscapes are affected by autumn east winds that occur when stable air pushes across a mountain range and then descends on the leeward side. The air becomes warmer and drier as it descends and can lead to increased, sometimes extreme, fire behavior in lower lee-side locations.

Summers in Region 4 bring perfect weather conditions for extreme wildfires. Lightning strikes are frequent during the summer months, and the numerous strikes have the potential to ignite numerous fires.

Fire exclusion in Region 4 has created vegetation and fuel conditions for large and catastrophic fires that are more difficult to suppress than smaller fires. Throughout the watersheds, forests present a continuous fuel supply both vertically, in small, thin trees and dead branches (ladder fuels), and horizontally, in an abundance of dead and downed material. When a fire gets started in such a forest, the dead branches, sticks, twigs, and other material increase fire intensity and, with ladder fuels present, provide great opportunity for the fire to reach the forest canopy, resulting in a stand-killing crown fire. These conditions also affect the means in which prescribed fire and fuels treatment are applied to the landscape.

Current climate conditions, especially in drought years, influence the frequency, intensity, duration, and extent of fire. Summers are dry and lightning prone because a Pacific coast high-pressure system typically blocks precipitation for much of the season. In the upper elevations, where temperatures are low and rainfall is high, fires are less frequent than in the valleys. Larger climatic factors such as long-term global variations related to El Niño or to sunspot cycles also influence fire regimes, but this influence is confounded by local climatic variations, recent land management activities, and burns.

Historic Wildfire Events

Table 2-446 describes some of the more noteworthy wildfires in Region 4's history.

Table 2-446. Historic Wildfires Affecting Region 4

Year	Name of Fire	County	Acres Burned	Remarks
1951	Hubbard Creek, Russell Creek, Vincent Creek Fires	Douglas	16,094	the Hubbard Creek Fire burned 15,774 acres and destroyed 18 homes; the Russell Creek Fire burned 350 acres and killed one person; the Vincent Creek Fire burned 23,000 acres near Scottsburg
1966	Oxbow Fire	Douglas	43,368	the Oxbow Fire killed one person
1987	Bland Mountain	Douglas	10,300	near Canyonville; 14 structures lost, 2 people killed
1992	E. Evans Creek	Jackson	10,135	four structures lost
1994	Hull Mountain	Jackson	8,000	one life and 44 structures were lost; the fire was an act of arson
1994	Sprignett Butte	Jackson	1,631	arson
2000	Antioch road	Jackson	376	
2002	Squires Peak/Wall Creek	Jackson	3,125	
2002	Timbered Rock	Jackson	27,111	
2002	Biscuit	Curry, Josephine	500,000	estimated to be one of Oregon's largest in recorded history, the Biscuit Fire encompassed most of the Kalmiopsis Wilderness
2003	Cove Road	Jackson	700	3 miles east of Ashland
2004	Bland Mtn. #2	Douglas	4,700	two homes lost
2008	Doubleday	Jackson	1,244	threatened Butte Falls
2010	Oak Knoll Fire	Jackson County	< 100	Oak Knoll Fire in Ashland destroyed 11 homes in less than 45 minutes
2013	Douglas Complex	Douglas, Josephine, Wasco, Grant	48,324	combined with fires in Region 5, 6, and 7, the most acres burned in since 1951 on lands protected by the Oregon Department of Forestry
2013	Brimstone	Josephine	2,377	part of southern Oregon fire storm that included the Douglas Complex above
2013	Big Windy	Josephine	26,725	part of southern Oregon fire storm that included Brimstone and Douglas Complex; one firefighter death
2018	Klondike	Josephine	175,258	eventually merged into the Taylor Creek Fire that had burned 52,839 acres
2018	Miles	Jackson, Douglas	54,134	combination of merged fires: Sugar Pine, South Umpqua Complex, and the Miles fire
2018	Taylor Creek	Josephine	52,839	started by a lightning strike

Source: 2013 Fire Statistics, Oregon Department of Forestry; ODF, 2020

Probability

Table 2-447. Assessment of Wildfire Probability in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	H	H	H

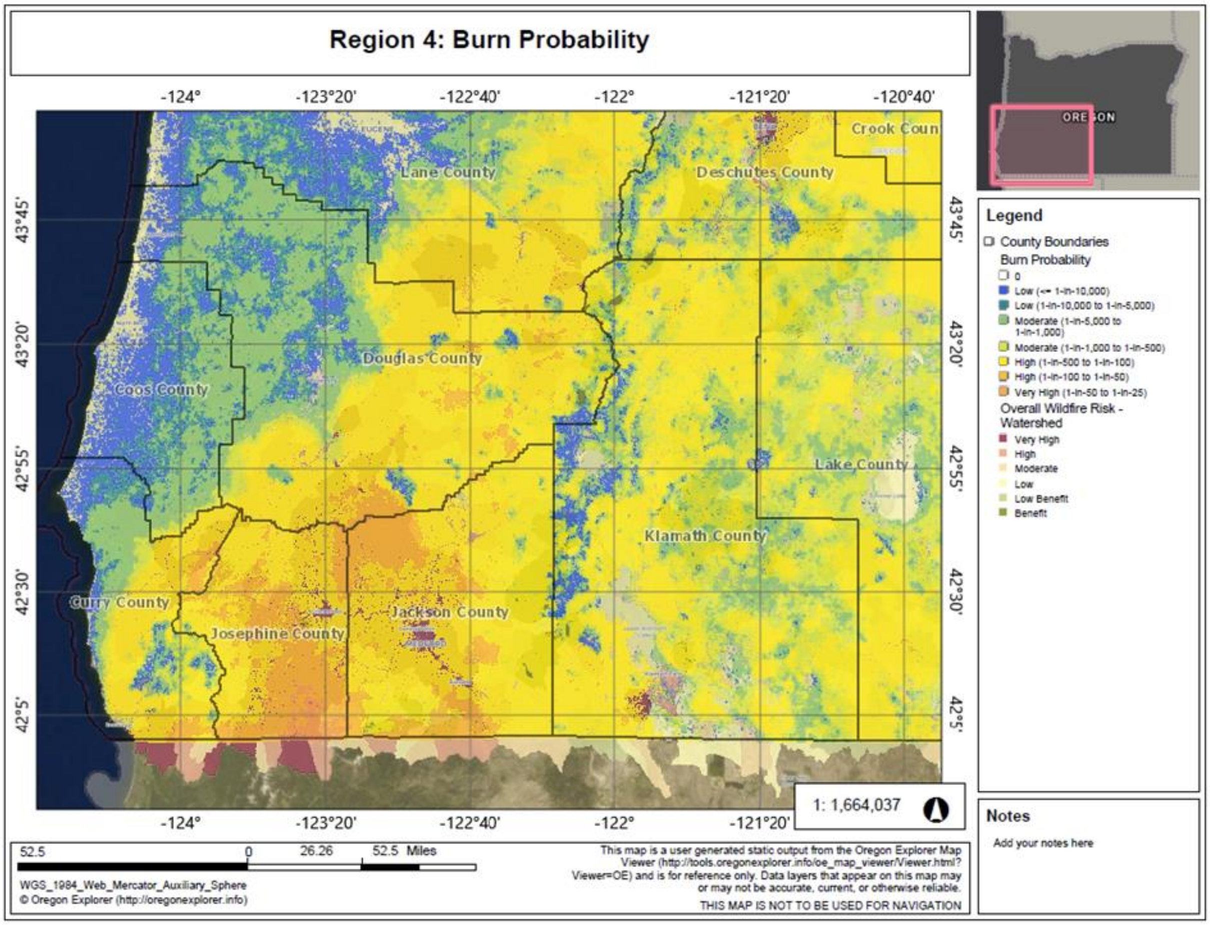
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to assess the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-213 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

Figure 2-213. Burn Probability

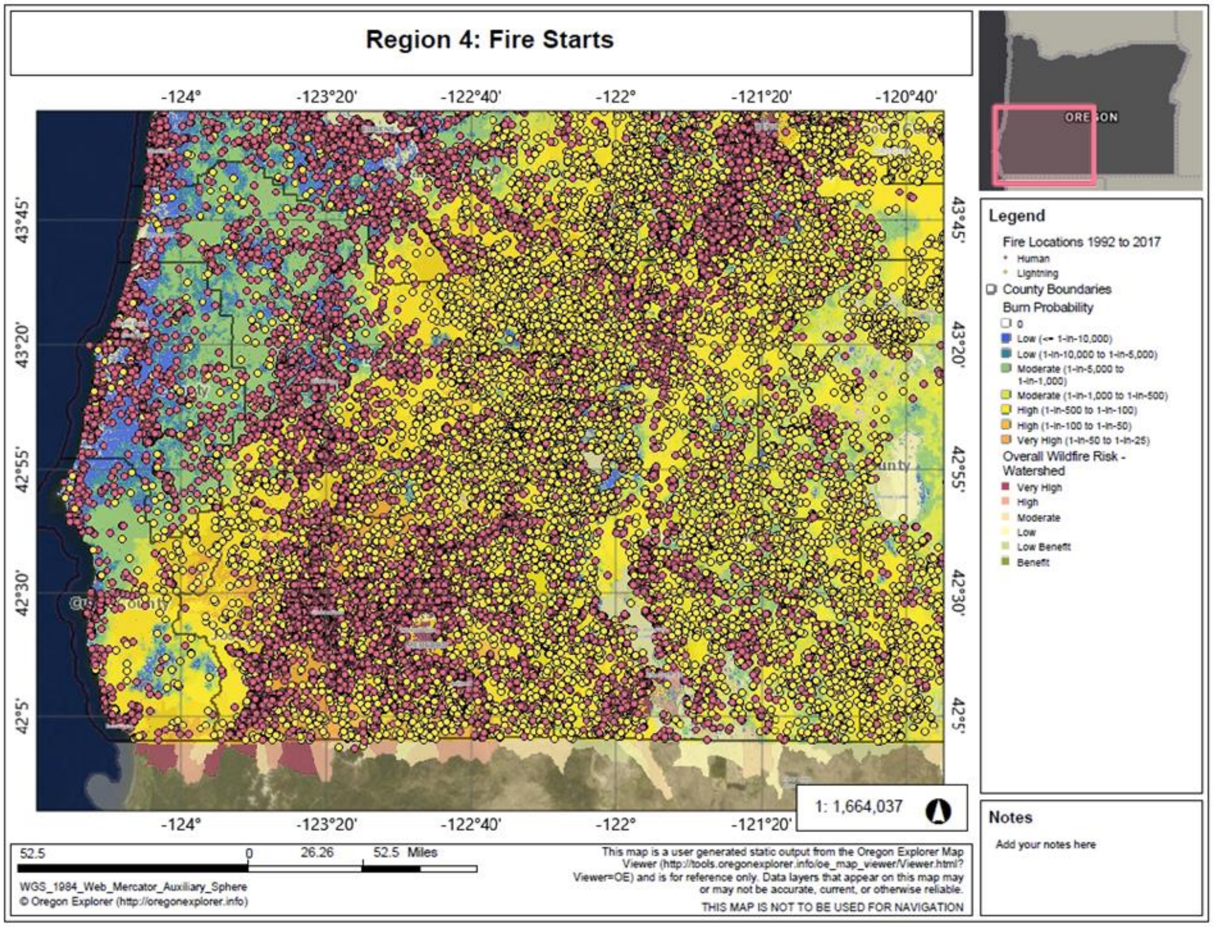


Source: Oregon Wildfire Risk Explorer, March 2020

Wildfire is defined as an uncontrolled burning of forest, brush, or grassland. Wildfires have always been a part of these ecosystems, sometimes with devastating effects. Wildfire may result from natural causes (e.g., lightning strikes), a mechanical failure (Oxbow Fire), or human causes (unattended campfire, debris burning, or arson). Most wildfires can be linked to human carelessness.

Hot and dry summers combined with frequent lightning events, rugged terrain, and an abundance of fuels makes Region 4 a hotbed of fire activity. Historically, some of Region 4's largest fires have been caused by human activity.

Figure 2-214. Human- and Lightning-Caused Wildfires in Region 4, 1992-2017



Source: Oregon Wildfire Risk Explorer, March 2020

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

In ignition-limited forest systems, such as those in the southern portions of the state, a long history of fire suppression has resulted in high fuel loads and, forests that have closer canopies and experience greater water competition. These forests experience long, dry fire seasons and are frequently at high fire danger and have a very high potential to burn if exposed to an ignition source. Winter warming will lead to more fine fuels due to greater growth during the cold season; hotter and drier conditions combined with a suppression management regime will lead to large quantity of fuel and closer canopies. Large and severe fires ("unsuppressable megafires") are a result of this large fire debt and climate change combined. It is very likely (>90%) that Region 4 will experience increasing wildfire frequency and intensity under future climate change.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 4 counties (Table 2-459).

Table 2-448. Projected Increase in Annual Very High Fire Danger Days in Region 4 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Douglas	12	34%
Josephine	13	35%
Jackson	13	37%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-449. Local Assessment of Vulnerability to Wildfire in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	H	M	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-450. Assessment of Vulnerability to Wildfire in Region 4 – Communities at Risk

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	VH	VH	H

Source: ODF Communities at Risk Report, 2020

Table 2-451. Assessment of Vulnerability to Wildfire in Region 4 – 2020 Vulnerability Assessment

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	H	M	M

Source: DOGAMI and DLCD

According to ODF's assessment of Communities at Risk, Region 4 is one of the state's regions most susceptible to wildfire. It has a high percentage of wildland acres subject to Fire Risk, Wildland Development Areas, Fire Effects, or Fire Threat, making them especially vulnerable.

Douglas, Josephine, and Jackson Counties are made up of several smaller communities that lie within the wildland-urban interface and have a distinct vulnerability to wildfire given their proximity to forestland, high summer temperatures, rugged terrain, and likelihood of summer thunderstorm activity. The human element is a factor as well with several populations intermixed in wildland areas. Arson continues to be a concern in this part of the state as well as the high number of fires caused by debris burning and equipment use.

Each year a significant number of people build homes within or on the edge of the forest (wildland-urban interface), thereby increasing wildfire hazards. These communities have been designated "Wildland-Urban Interface Communities" and include those in **Table 2-463**.

Table 2-452. Region 4 Wildland-Urban Interface Communities

Douglas		Jackson	Josephine
Azalea	Riddle	Antelope Creek	Cave
Camas Valley	Roseburg	Applegate	Galice
Canyonville	South Umpqua	Ashland	Murphy
Cavitt Creek	Steamboat	Butte Falls	Sunny Valley
Cow Creek	Susan Creek	Central Point	Wilderville
Curtin	Sutherlin	Colestin	Junction
Days Creek	Tenmile	Crowfoot Falls	Grants Pass
Dillard	Tiller	Eagle Point	Kerby
Dixonville	Toketee	Elk Creek	Merlin
Drain	Kellogg	Gold Hill	Selma
Drew	Loon Lake	Green Springs	Williams
Dry Creek	Myrtle Creek	Jackson	Wolf Creek
Elkton	Rice Hill	Jacksonville	
Fair Oaks	Riddle Canyonville	Lake Creek	
Fortune Branch Cow Creek	Tri-City	Medford	
Freezeout Creek	Winston	Pioneer Village	
Gardiner	Diamond Lake	Medford	
Glenbrook	North Umpqua	Prospect	
Glendale	Oakland	Rogue River	
Glide	Reedsport	Ruch	
Green Acres	Scottsburg	Sams Valley	
Lemolo	Winchester Bay	Shady Cove	
Lemolo Lake	Yoncalla	Trail	
Little River	Union Gap	Whetstone	
Lookingglass	Wilber	Union Creek	
Milo	Wolf Creek	Phoenix	
Myrtle Creek		White City	
North Umpqua		Wimer	
Oakland Village			

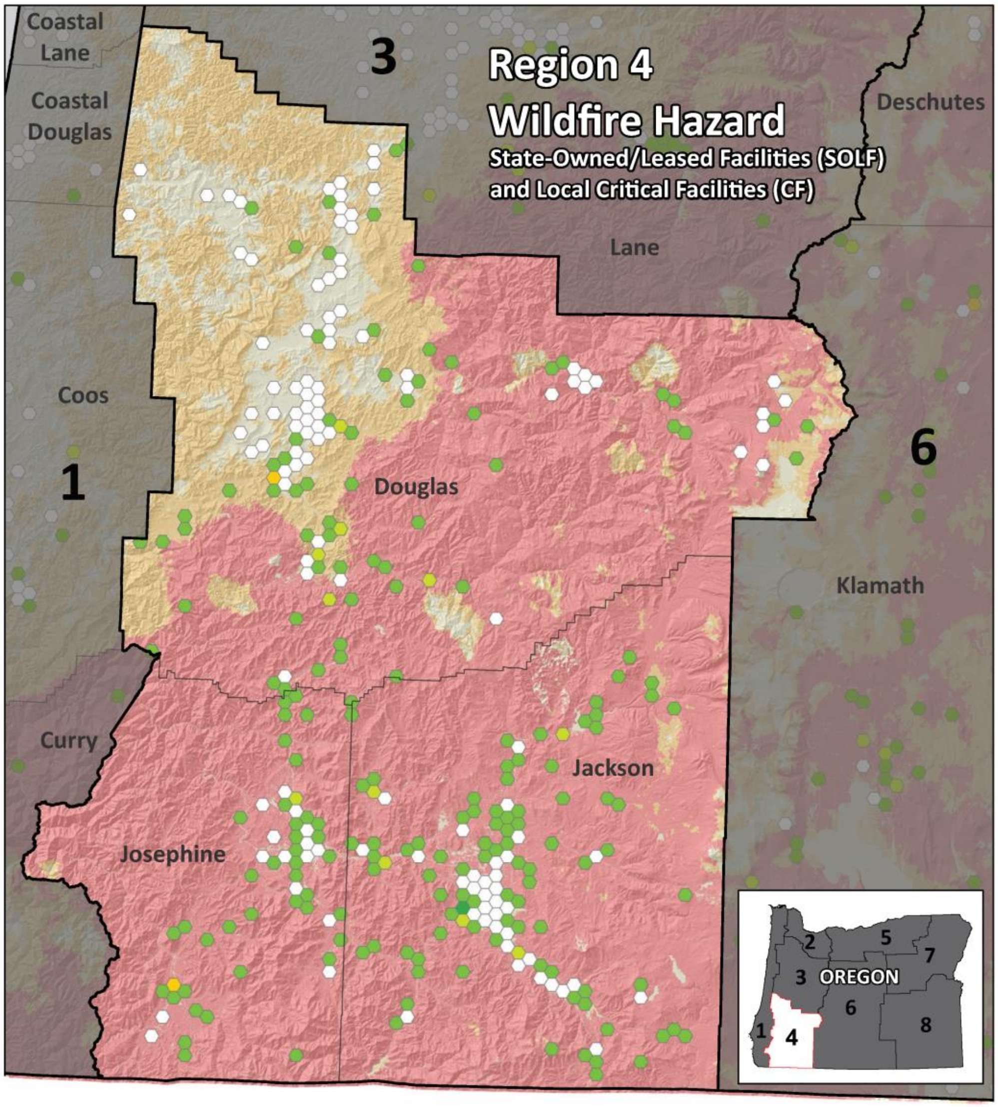
Source: ODF Communities at Risk Report, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in "High," "Moderate," and "Low" categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as "Low."

In Region 4, there is a potential loss to wildfire of over $32M in state building and critical facility assets, 45% and 40% of it in Jackson and Douglas Counties, respectively, and 15% in Josephine County. There is a much greater potential loss in local critical facilities: over $163M. Thirty-nine and 37% are located in Douglas and Jackson Counties, respectively. Fifteen percent is located in Josephine County.

Figure 2-215. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 4.High-resolution, full-size image linked from Appendix 9.1.26.



Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:750,000

Source Data:
Wildfire: Burn probability data, Oregon Department of Forestry, 2018
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

REGION 4		Exposure ($) to Wildfire Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Douglas	985,197,000	2,090,000	4%	10,996,000	13,086,000	63,550,000	65,640,000
Jackson	1,790,356,000	405,000	0%	14,071,000	14,476,000	61,072,000	61,477,000
Josephine	528,755,000	235,000	0%	4,679,000	4,914,000	38,722,000	38,957,000
Total	3,304,308,000	2,730,000	1%	29,746,000	32,476,000	163,344,000	166,074,000

*This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices. *Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 6,265 historic resources in Region 4, six-hundred ninety-two (11%) are located in an area of high wildfire hazard. Of those, 52% are located in Jackson County. Of the 194 (3%) located in a moderate wildfire hazard area, 194 (80%) are located in Douglas County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Douglas County's vulnerability to wildfire is high; Jackson County and Josephine County are moderately vulnerable. This is not consistent with the Communities at Risk assessment.

All three counties in Region 4 are most vulnerable to wildfire.

Risk

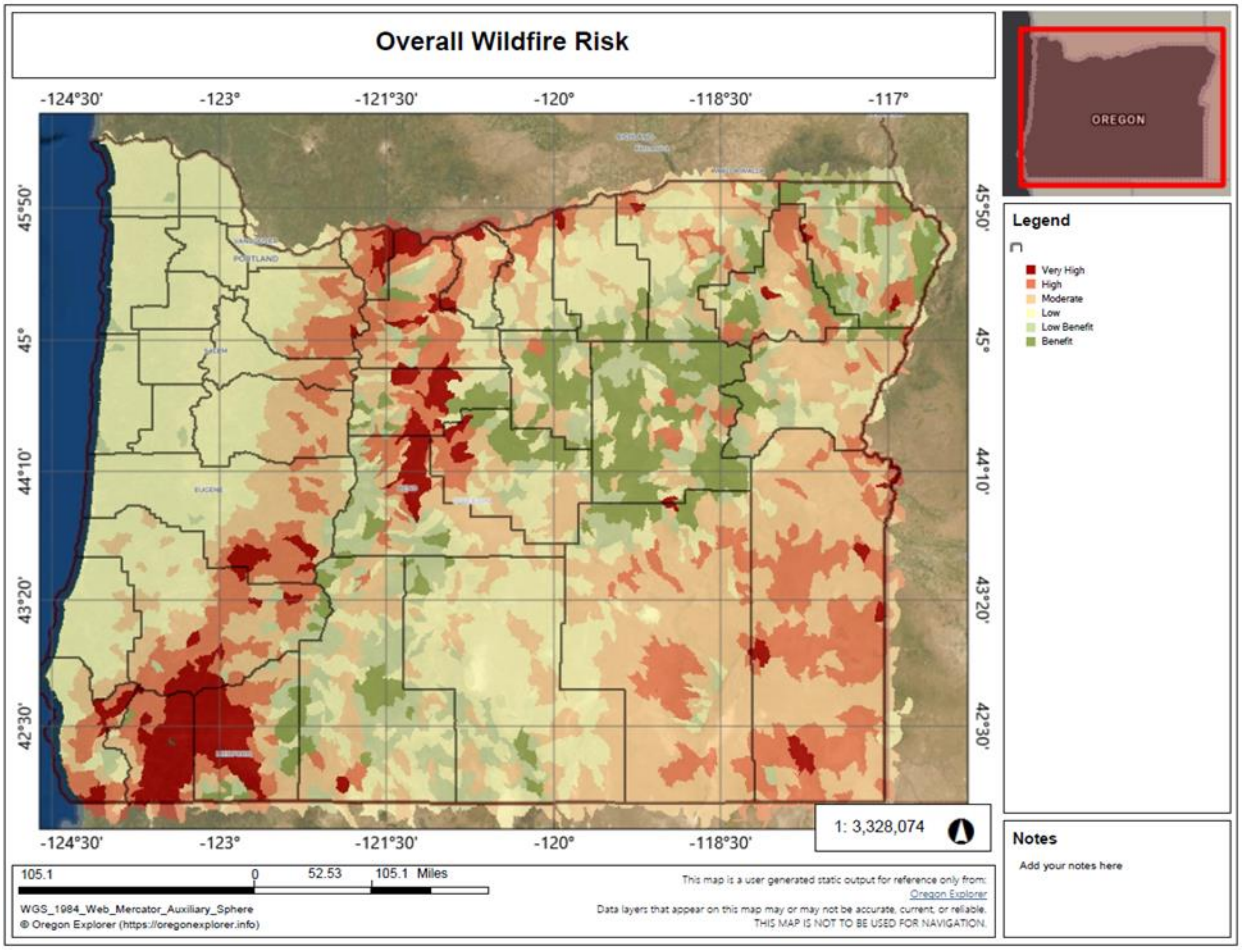
Table 2-453. Risk of Wildfire Hazards in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Risk	VH	VH	H

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Douglas and Jackson Counties are at very high risk from wildfire; Josephine at high risk. This is fairly consistent with ODF's assessment for the eastern portion of Douglas County, the central and western portions of Jackson County, and all of Josephine County mapped in **Figure 2-216**. The 2020 risk assessment is not granular enough to account for geographic differences in probability, vulnerability, or risk within a county.

Figure 2-216. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

Extreme winds (other than tornadoes) are experienced in all of Oregon's eight regions. A majority of the destructive surface winds in Oregon are from the southwest. Under certain conditions, very strong east winds may occur, but these usually are limited to small areas in the vicinity of the Columbia River Gorge or other low mountain passes. The much more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they may be stronger on the coast than in the interior valleys because of the north-south orientation of the Coast Range and Cascades. These mountain ranges obstruct and slow down the westerly surface winds. The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of such a storm, and its effects were so devastating that it has become the benchmark from which other windstorms in Oregon are measured. The storm caused significant damage in Region 4.

There were no documented tornadoes in Jackson, Josephine, or central Douglas Counties until 2013. An EF0 tornado occurred near Roseburg in Douglas County on June 18, 2013. Winds were 65-85 mph and property damage was estimated at $1,000.

Historic Windstorm Events

Table 2-454. Historic Windstorms in Region 4

Date	Affected Area	Characteristics
Apr. 1931	western Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; wind speed 40–60 mph; gusts 75–80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 75-mph gusts; damage to buildings and utility lines
Dec. 1955	statewide	wind speeds 55–65 mph with 69-mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71-mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon’s most destructive storm to date; 116 mph winds in Willamette Valley; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Nov. 1981	most of Oregon	highest winds since Oct. 1962; wind speed 71-mph in Salem; marinas, airports, and bridges severely damaged
Jan. 1990	statewide	heavy rain with winds exceeding 75 mph; significant damage; one fatality
Dec. 1995	statewide	followed path of Columbus Day Storm; wind speeds 62 mph in Willamette Valley; damage to trees (saturated soil a factor) and homes
Nov. 1997	western Oregon	wind speed 52 mph in Willamette Valley; trees uprooted; considerable damage to small airports
Feb. 2002	western Oregon	strongest storm to strike western Oregon in several years; many downed power lines (trees); damage to buildings; water supply problems (lack of power); estimated damage costs: $6.14 million
Feb. 2004	Jackson County	heavy winds caused $4,000 in damages in Jackson County
Dec. 2006	Douglas and Josephine Counties	high winds up to 90 mph caused $150,000 in damages in Douglas and Josephine; the storm also impacted Coos and Curry Counties for a storm damage total of $300,000
Jul. 2007	Josephine and Jackson Counties	severe thunderstorms with winds up to 60 mph down numerous trees damaging vehicles and trailers; $100,000 in damage in Jackson County; lightning struck the steeple of a church in Josephine County, causing $60,000 in damages
Jun. 2013	Douglas County	Winchester; tornado; EF0; $1K in property damage
Dec. 2015	Regions 1-4	FEMA-4258-DR: severe winter storms, straight-line winds, flooding, landslides, and mudslides
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides

Sources: Taylor and Hatton (1999); Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon, February 7, 2002 (FEMA-1405-DR-OR); Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; National Climatic Data Center, Storm Events, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms; https://www.ncdc.noaa.gov/stormevents/

Probability

Table 2-455. Assessment of Windstorm Probability in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	H	H	H

Source: Oregon Office of Emergency Management, 2013, County Hazard Analysis Scores

The 100-year event in Region 4 consists of 1-minute average winds of 80 mph. A 50-year event is 70 mph. A 25-year event has average winds of 60 mph.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-456. Local Assessment of Vulnerability to Windstorms in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	M	M	M

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-457. State Assessment of Vulnerability to Windstorms in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	M	H	H

Source: Oregon Office of Emergency Management, November 2013, County Hazard Analysis Scores

Many buildings, utilities, and transportation systems within Region 4 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome. They can block roads and rails for long periods and can affect emergency operations. In addition, uprooted or shattered trees can down power and/or utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed by uprooted ancient trees growing next to a house. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establish a tree maintenance and removal program.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

All the counties in Region 4 are most vulnerable to windstorms.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 4 is approximately $203,049,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $3,101,260,000. Because windstorms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one loss of over $33,000 to a state facility was recorded in Region 4 since the beginning of 2015. It was indeed caused by a windstorm.

Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

All the counties in Region 4 are at risk of windstorms.

Winter Storms

Characteristics

Severe winter weather in Region 4 can be characterized by extreme cold, snow, ice, and sleet. In higher elevations such as the lower Cascade Range and the Siskiyou Mountains and passes, moderate to heavy snowfall is expected on an annual basis. Some Region 4 communities are unprepared, financially and otherwise, for the impact of severe winter storms. An historical summary of extreme winter conditions in this region is shown in Table 2-458.

Historic Winter Storm Events

Table 2-458. Severe Winter Storms in Region 4

Date	Location	Characteristics
Dec. 1861	statewide	snow covered entire Pacific Northwest 1–3 feet
Jan. 1916	statewide	two snow storms, each totaling 5 inches or more
Jan. 1932	SW Oregon mountains	Crater Lake record snowfall: 879 inches
Jan.- Feb. 1937	statewide	heavy snow throughout state
Jan. 1950	statewide	heaviest snowfall since 1890; highway closures; considerable property damage
Jan. 1951	Crater Lake, Oregon	new annual record snowfall at Crater Lake
Jan. 1956	western Oregon	packed snow became ice; automobile accidents throughout region
Mar. 1960	statewide	snowfall: 3–12 inches; over 100 accidents in Marion County
Jan. 1969	statewide	Lane County surpassed old snowfall record; 47 inches in Eugene; $3 to $4 million in property damage
Jan. 1980	statewide	a series of storms bringing snow, ice, wind, and freezing rain; six fatalities
Feb. 1985	statewide	2-4 inches of snow in western valleys; massive power failures (tree limbs broke power lines)
Feb. 1986	Cascades, Oregon	heavy snowfall
Mar. 1988	statewide	strong winds and heavy snow
Feb. 1989	statewide	heavy snowfall and record low temperatures
Nov. 1989	Siskiyou, Oregon	unusually heavy snowfall
Dec. 1992	western Oregon	heavy snow; interstate highway closed
Feb. 1993	western Oregon	record snowfall at Salem airport
Winter 1998-1999	statewide	series of storms; one of the snowiest winters in Oregon history
Dec. 28, 2003-Jan. 9, 2004	statewide	most significant winter storm in several years brought snowfall to most of Oregon; largest snowstorm in the Siskiyou Pass (Jackson County) in a quarter century; shut down I-5

Date	Location	Characteristics
Dec. 6-23, 2015	Statewide storm events	DR-4258. Douglas County declared in Region 4. Severe winter storms, straight-line winds, flooding, landslides, and mudslides. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Each storm system brought several inches of snow to the mountain areas. Another in a long series of storms brought heavy snow to portions of south central Oregon. Also on the 21st a series of storms made for a long lasting winter storm over southwest and south central Oregon. At first the snow was limited to higher elevations...but lowered with time to some of the west side valley floors. Moist onshore winds produced a steady stream of showers over the foothills of the Cascades with snow levels between 1000 and 2000 feet. This resulted in heavy snow for the Northern Oregon Cascades and Coast Range.
Dec. 14-15, 2016	Josephine County	DR-4296. Josephine County declared in Region 4. Severe winter storm and flooding. East winds ahead of an approaching low pressure system brought temperatures down below freezing across the area ahead of the approaching precipitation. This lead to a mix of freezing rain, sleet, and snow across the area. There was significant damage to trees and power lines, and fairly widespread power outages across the region. 15,000 people were without power.
Jan. 7-8, 2017	Josephine County	DR-4328. Josephine County declared in Region 4. Severe Winter Storms, Flooding, Landslides, And Mudslides. A broad shortwave trough brought multiple rounds of precipitation, including a wintry mix of snow and ice. General snowfall totals of 2-4 inches were reported, with the greatest total being 4.5 inches. Major ice accumulations occurred after the snow, with several locations reporting 0.50-1.00. The combination of snow and ice resulted in significant power outages and closures across the area.
Feb. 22-26, 2019	Douglas County	DR-4432. Douglas County declared in Region 4. Severe Winter Storms, Flooding, Landslides, And Mudslides. Persistent troughing off the coast of the Pacific Northwest focused a stream of mid-level moisture over the Inland Northwest resulting in a long duration snow event as the plume drifted north and south several times between the 22nd and 27th of February. Snowfall rates were greatly enhanced over central Oregon with the proximity of a nearly stationary surface boundary where snowfall rates were in excess of 1 inch per hour.

Source: Taylor and Hatton (1999); Oregon Department of Transportation, 2008; State Natural Hazards Mitigation Plan, Winter Storm chapter; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents.

Probability

Table 2-459. Assessment of Winter Storms Probability in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Probability	H	H	H

Source: Oregon Office of Emergency Management, November 2013, County Hazard Analysis Scores

Winter storms occur annually in Region 4. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time. Higher elevations through the Siskiyou Mountains and the Cascade Range are expected to have higher annual snowfall amounts and this is planned for at the state and local level.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-460. Local Assessment of Vulnerability to Winter Storms in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	M	M	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-461. State Assessment of Vulnerability to Winter Storms in Region 4

	Douglas (Non-Coastal)	Jackson	Josephine
Vulnerability	H	H	H

Source: Oregon Office of Emergency Management, November 2013, County Hazard Analysis Scores

All three counties in Region 4 are impacted by severe winter storms. The I-5 corridor passes through the Siskiyou Mountains in this region facilitating commodity flow between Oregon and California. Similarly, US-199 connects Oregon with California from I-5 at Grants Pass to US-101 at Crescent City on the northern California coast. Severe winter storms can shut down these vital links for extended periods and can have a direct adverse impact on Oregon's economy.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, vulnerability is similarly high across all three counties in Region 4. Each county's high vulnerability is driven by moderately high scores across the CDC index. Jackson County ranks in the top half of counties for 11 of the 15 index variables. Notably, it is in the 80th percentile for its share of single-parent households and in the 70th percentile for its share of residents that speak English less than "well." Josephine County is in the 80th percentile for its share of residents 65 and older, its unemployment rate, and the share of persons living in poverty. Douglas County has a higher unemployment rate than 80 percent of all counties and ranks in the 60th percentile for 7 of the 15 variables included in the CDC index.

All of the counties in Region 4 are vulnerable to the adverse impacts of winter storms, not only because of their high social vulnerabilities, but also because of the important commodity transport routes connecting Oregon with California and the economic costs associated with road closures.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 4 is approximately $203,049,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $3,101,260,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, only one loss of over $33,000 to a state facility was recorded in Region 4 since the beginning of 2015. It was not caused by a winter storm.

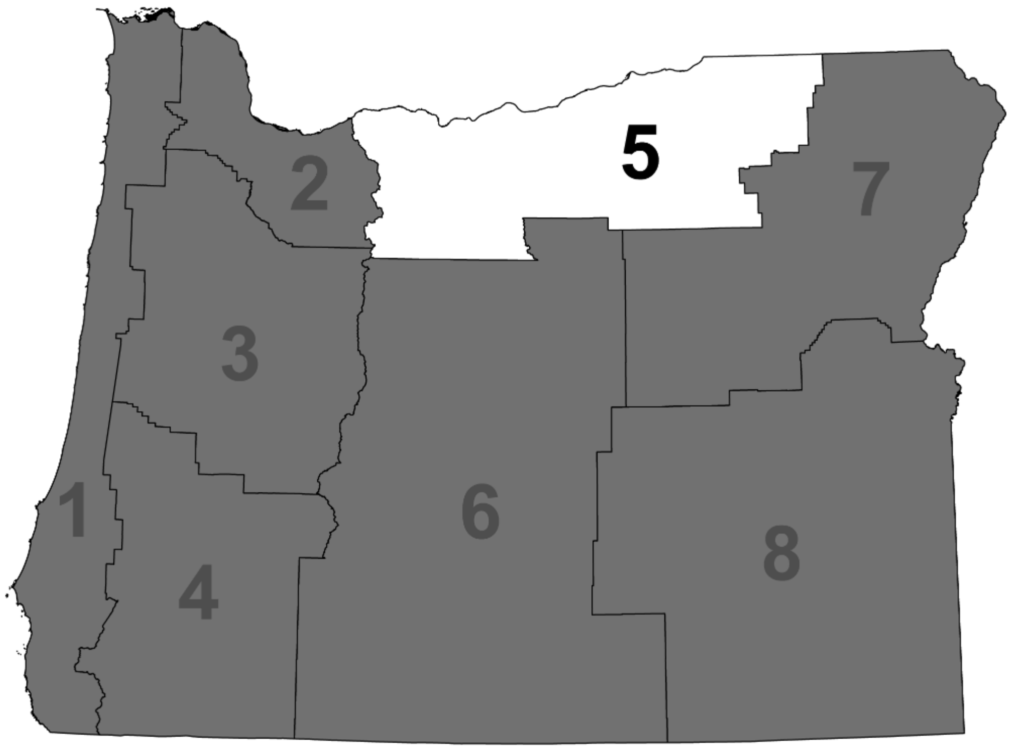
Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

All of the counties in Region 4 are similar risk from winter storms.

2.3.5 Region 5: Mid-Columbia

Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties



2.3.5.1 Summary

Profile

The region's demographic, economic, infrastructure and development patterns indicate that some populations, structures and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

Across the region, social vulnerability is driven by fewer college degrees and high numbers of housing rentals and vacancies. Children, persons aged under 18, also represent a vulnerable segment of the population. Region 5 has a higher percentage of children than the state as a whole. In Region 5, the share of people who do not speak English "Very Well" is higher than the statewide estimate—especially for Morrow, Hood River, and Umatilla Counties.

At the county level a notably high percentage of residents in Gilliam County have a disability, approximately one-fifth of all residents. According to the US Department of Housing and Urban Development's Point In Time count, between 2015 and 2019 the region reported a 65% increase in the number of people experiencing homelessness. Total number of homeless people is low, but the percentage increase is notable. Gilliam, Sherman, and Wasco Counties all have higher percentages of older adults than the statewide estimate. Within the region, Umatilla and Hood River Counties have the highest share of children. Overall, Region 5 has been rebounding from the financial crisis that began in 2007. Economic vulnerability is driven by high unemployment rates in Morrow and Umatilla Counties and low wages in Morrow and Hood River Counties.

Interstate-84, two rail yards, Amtrak lines, three ports, and one commercial airport support the economy and daily operations in Region 5. These integral transportation systems are susceptible to many natural hazards. Damage or interruption to the services these systems provide could be devastating to the region and state.

There are 31 power-generating facilities in the Mid-Columbia Region, including hydroelectric, natural gas, wind, and coal facilities. Liquid natural gas pipelines run through Gilliam, Morrow, and Umatilla Counties. Four additional wind facilities are proposed for the region. The diverse energy and drinking water systems here help reduce the area's vulnerability to damage and disruptions in service that can happen during a natural hazard event.

Surface water, wells, and springs supply local drinking water. These systems are vulnerable to non-point source pollution, erosion, and sedimentation that can adversely impact water quality. Rigid, buried infrastructure is vulnerable to seismic activity.

Region 5 is largely rural, with urban development occurring in communities along I-84 in Hood River County. Manufactured homes, which are inherently more vulnerable to natural hazards, make up a significant share of the region's housing units. Over 80% of homes in Gilliam and Sherman Counties were built before 1990 and current seismic building standards. With the exception of Morrow and Umatilla Counties where FIRMs were updated in 2007 and 2010 respectively, the region's FIRMs date from the 1980's. A FEMA Risk MAP project is underway to update the Middle Columbia Hood watershed flood maps in Hood River, Sherman and Wasco Counties.

Hazards and Vulnerability

Region 5 is affected by nine of the 11 natural hazards that affect Oregon communities. Coastal hazards and tsunamis do not directly impact this region.

Droughts: Droughts are common in Region 5, particularly within Gilliam, Morrow, and Sherman Counties. Agricultural industries in the region are vulnerable to scarcity of water supplies during drought events. The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $1,080,652,000. Because drought could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought.

Earthquakes: Overall, the region is moderately vulnerable to three types of earthquakes: (a) shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, and (c) the offshore Cascadia Subduction Zone (CSZ) Fault. Primary vulnerabilities are due to shallow crustal and intraplate earthquakes that cause earthquake-induced landslides in the Cascades, ground shaking, and liquefaction. A CSZ event will affect markets to east upon which communities in Region 5. In Region 5, a 2500-year probabilistic earthquake scenario could cause a potential loss of over $17.5M in state building and critical facility assets, 77% of it in Umatilla County alone. The potential loss in local critical facilities is about double, over $34M. Almost half (46%) of the potential loss in local critical facilities is in Umatilla County, and 33% in Hood River County.

Extreme Heat: Extreme temperatures are common in Region 5 and the frequency of prolonged periods of high temperatures has increased. Pendleton has an average of about 31 days per year above 90°F. Extreme heat can affect commerce, agriculture, fisheries, and overall quality of life. As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. Like drought, impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $1,080,652,000.

Floods: Rain-on-snow events during unseasonably warm winters create disastrous riverine flooding events in the Mid-Columbia Region. Flash floods associated with summer thunderstorms are also exceptionally damaging. All of the region's counties are considered moderately vulnerable to flooding. In Region 5, there is a potential loss from flooding of over $9M in state building and critical facility assets, approximately 34% of it in each of Wasco and Umatilla Counties and 16% in Sherman County. There is a three times greater potential loss due to flood in local critical facilities: over $28M, of this forty percent and 36% in Umatilla and Morrow Counties, respectively.

Landslides: Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Rain-induced landslides can occur during winter months. Earthquakes can trigger landslides at any time. For example, the geology map of the Hood River area and the Mount Hood Multi-Hazard and Risk study both found hundreds of landslides in this area. In February 2014, a large rock slide in Hood River closed I-84 for almost a week. Vulnerability is increased in populated areas within the Columbia River Gorge, along the I-84 corridor and in the Cascade Mountains. Over $32M in value of state facilities is exposed to landslide hazards in Region 5, more than half in Wasco County followed by 40% in Hood River County. The value of local critical facilities is over $18.6M, 72% also in Wasco County.

Volcanoes: There are several active and potentially active volcanoes in the Cascade Range along the western border of the Mid-Columbia Region. Areas particularly vulnerable to volcanic activity include the Cities of Parkdale and Hood River near Mount Hood, and communities along the White River in Wasco County. Though most volcanic activity is considered local, lahars and ashfall can travel many miles, impacting small mountain communities, dams, reservoirs, energy-generating facilities, and highways. DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 5. Just under $11.2M in value is exposed to volcanic hazards in Region 5, all of it in Hood River and Wasco Counties.

Wildfires: This region has unique geographic features, weather characteristics, a history of unmanaged fuels, and an expanding wildland-urban interface that contribute to the region's susceptibility to wildfire. The majority of the forestlands in Region 5 are historically prone to wildfire. Summer weather patterns can produce lightning storms that start many fires. Based on data from the 2013 West Wide Wildfire Risk Assessment, in Region 5, Umatilla and Wasco Counties have high percentages of wildland acres subject to Fire Risk, Wildland Development Areas, Fire Effects, or Fire Threat, making them especially vulnerable. Other areas of vulnerability are within wildland-urban interface communities. In Region 5, there is a potential loss to wildfire of almost $105M in state building and critical facility assets, almost 60% of it in Wasco County and 30% in Umatilla County. Seven percent is located in Hood River County and the remaining three percent in Sherman, Morrow, and Gilliam Counties. There is a slightly greater potential loss in local critical facilities: about $15.6M. Around 25% is located in each of Hood River and Morrow Counties, about 20% in Umatilla County.

Windstorms: High winds within Region 5 in the Columbia River Gorge are legendary, sometimes reaching 80 miles per hour. Windstorms generally impact the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland. Special building codes in this region require tie downs for manufactured homes within 30 miles of the Columbia River. The most vulnerable jurisdictions are those near the Columbia Gorge within Gilliam, Hood River, Morro, and Sherman Counties. The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $1,080,652,000.

Winter Storms: Frigid air emanating from the Wallowa Mountains and traveling through the Columbia River Gorge bring winter storms to this region annually. Though winter storms have the potential to affect the entire region, particularly along the I-84 corridor, the area is known for cold winters so residents and visitors are usually prepared for these storms. The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $1,080,652,000.

Climate Change

The hazards faced by Region 5 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon, including Region 5, which could lead to greater drought conditions. However, projected increases in spring precipitation may counteract some of the effects of warming and result in increases in summer soil moisture and runoff (*low confidence*). It is *very likely* (>90%) that Region 5 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*).

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 5, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section 2.2.1.2, **Introduction to Climate Change**.

2.3.5.2 Profile

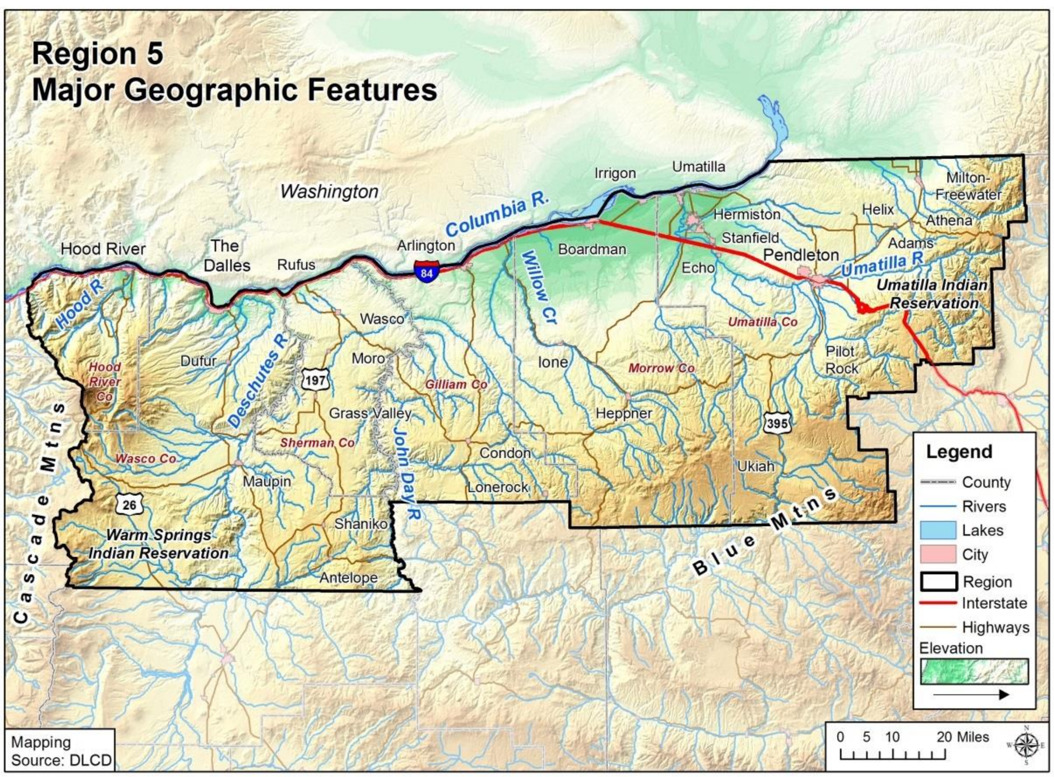
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

Oregon's Mid-Columbia Region is approximately 10,178 square miles in size and includes Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties. The Columbia River and the eastern slope of the Cascades shape the region's topography. Region 5 begins at the Cascades crest in the west and extends east to the Idaho border. The region's northern border is the Columbia River and extends to the northern ridges of the Blue Mountains in the south. The region's major watershed is the Columbia River with all smaller water bodies feeding it as it flows west into the Pacific Ocean. The region supports crop farming as well as livestock grazing.

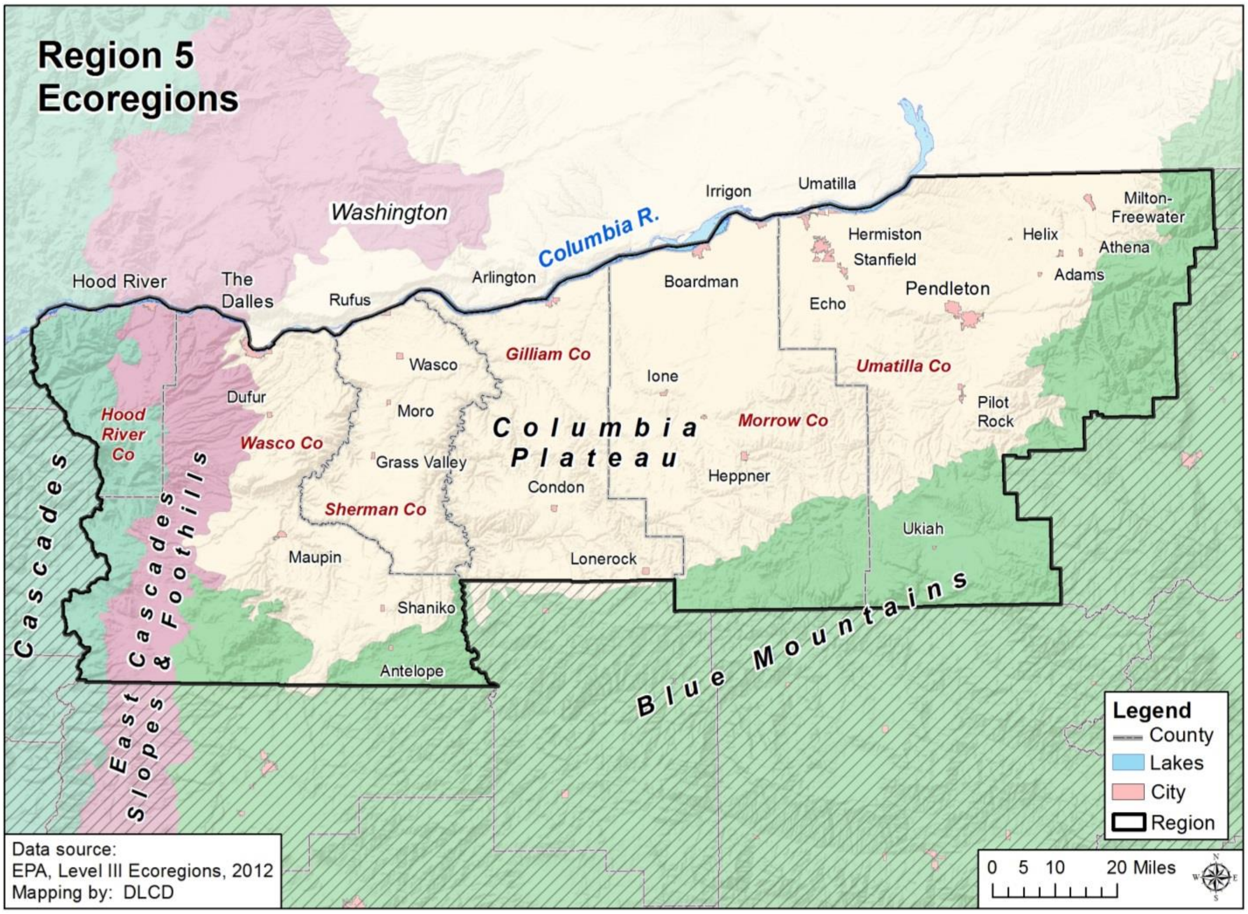
Figure 2-217. Region 5 Major Geographic Features



Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 5 is composed of four ecoregions: the Cascades, the Eastern Cascades Slope and Foothills, the Blue Mountains and, predominantly, the Columbia Plateau (Figure 2-218).

Figure 2-218. Region 5 Ecoregions



Blue Mountains: This ecoregion is complex and diverse, with many sub-ecoregions with unique conditions. In general, the Blue Mountains areas of Region 5 have a dry continental climate with marine intrusions because of proximity to the Columbia Gorge. While much of the Blue Mountains are underlain with volcanic rock, land in the Wallowa and Elkhorn Mountain ranges is composed of granitic intrusives, deep sea sediments, and metamorphic rocks. Grazing, logging, and fire suppression regimes have altered land cover throughout the region where juniper woodlands have given way to sagebrush grasslands and grand fir forests have given way to spruce fir forests. Other forests in the region predominantly have either a Douglas fir or ponderosa pine canopy. Ponderosa forests tend toward sparsely vegetated understories. The ecoregion's Douglas fir forests tend toward dense shrub understories, making them more difficult to log. Some high meadows also exist within the Blue Mountains in Region 5 and unchannelized streams tend toward a meandering nature within wide floodplains, moving dynamically through the landscape. Riparian areas of the region have a diverse palette of understory shrubs with black cottonwoods, grand firs, and alders in the canopy layer (Thorson, et al., 2003).

Cascades: This ecoregion is underlain by volcanic soils. Naturally occurring mixed conifer forests have given way to predominantly Douglas fir forests that are managed for commercial logging. Logging activities have put a strain on the ecological health of streams in the area (Thorson, et al., 2003). Waterways in the steeper valleys support threatened cold-water salmonids including Chinook salmon, steelhead, and bull trout. Streams, lakes, reservoirs, rivers, and glacial lakes at higher elevations are key sources of water. Large volcanic peaks, glaciers and year-round snowfields punctuate the alpine and subalpine areas of the ecoregion (Thorson, et al., 2003).

Columbia Plateau: The Columbia River has shaped this arid, sagebrush steppe. This ecoregion is underlain by basaltic bedrock up to two miles deep. Naturally occurring wheatgrass, sagebrush, sage grass and other drought-tolerant plants have given way to crop farming and grazing. Higher elevation areas support Douglas fir and ponderosa pine forests while narrow canyons provide habitat for riparian species such as white alders and mock orange. Deep loess soil deposits cover some areas, making them more agriculturally productive than areas with spare soils (Thorson, et al., 2003).

Eastern Cascades Slope and Foothills: The Region 5 section of this ecoregion is dominated by grand fir mixed forests in the uplands and mixed oak/conifer forests in the foothills. The Columbia River Gorge influences lower elevations with marine weather systems while the uplands are moister with richer soils. Because of its location in the rain shadow of the Cascades, the ecoregion often experiences dramatic temperature extremes and native plants are adapted to dry climates and frequent wildfires. Logging and recreation are common land uses throughout and rural residential development and agricultural uses can be found in the foothills (Thorson, et al., 2003).

Climate

This section covers historic climate information. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment** for statewide projections.

The Mid-Columbia region is characterized by a semi-arid high elevation climate, in which summers and winters can be extreme. The Columbia Plateau's arid climate supports Oregon's major wheat producing area. The region is subject to droughts and wildfires, particularly during dry summers and years with low snowpack. Despite its relative dryness, the region is also subject to floods and landslides. Flooding can be a direct result of rain-on-snow events. Localized variations in temperature and precipitation exist across the region's microclimates. Table 2-462 displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 5 based on data from the NOAA National Centers for Environmental Information.

Table 2-462. Average Precipitation and Temperature in Region 5 Counties and Climate Divisions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Gilliam County	11.71" (7.18"–17.53")	Jan: 1.43" Jul: 0.32"	50.3F	Jan: 27.6°F /40.4°F Jul: 54.3°F /85.5°F
Hood River County	58.89" (40.98"–91.5")	Jan: 9.06" Jul: 0.66"	45.4°F	Jan: 27.3°F /36.9°F Jul: 50.1°F /73.7°F
Morrow County	14.52" (9.59"–20.89")	Jan: 1.67" Jul: 0.39"	49.6°F	Jan: 27.1°F /40.4°F Jul: 53.6°F /84.5°F
Sherman County	13.63" (8.70"–21.22")	Jan: 1.79" Jul: 0.3"	49.9F	Jan: 27.4°F /39.7°F Jul: 54.1°F /84.8°F
Umatilla County	20.8" (14.28"–27.03")	Jan: 2.48" Jul: 0.51"	48.7°F	Jan: 26.4°F /39.4°F Jul: 52.5°F /83.4°F
Wasco County	20.8" (14.42"–33.99")	Jan: 3.13" Jul: 0.38"	48.2°F	Jan: 26.6°F /39.3°F Jul: 51.6°F /82°F
Climate Division 6 "North Central"	18.68" (13.65"–27.79")	Jan: 2.52" Jul: 0.39"	49.5°F	Jan: 27.3°F/40.1°F Jul: 53.3°F/83.9°F

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 21, 2019 from https://www.ncdc.noaa.gov/cag/.

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community's capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

Morrow County has experienced slow population growth since 2010. Similar to most areas in the state, the population is aging. Natural increase has been the primary driver of population growth; however, net-out migration has slowed in recent years and in-migration is expected to be the primary driver moving forward (Population Research Center, Portland State University, 2019 [Morrow County]). Umatilla County experienced steady population growth, largely driven by natural increase but net in-migration has also contributed; in the near term, in-migration will play a larger role in population growth because of waning natural increase. The population in Sherman and Gilliam Counties decreased from 2010 to 2018. In both counties, deaths outpaced births in most years and migration patterns have been sporadic; however, since 2010, in-migration has helped to offset natural decrease (Population Research Center, Portland State University, 2019 [GIlliam and Sherman Counties]). Growth in Hood River County has been driven by both natural increase and net in-migration; however, natural increase has been steadily declining since 2010; over the next decade, the county is expected to continue to grow at a modest pace, tempered by the demand and shortage of additional housing (Population Research Center, Portland State University, 2020 [Hood River]). Wasco County has grown at a modest pace since 2010, with net in-migration outweighing natural decrease; the population is expected to continuing growing slowly over the next decade, driven mostly by in-migration (Population Research Center, Portland State University, 2020 [Wasco]).

Table 2-463. Population Estimate and Forecast for Region 5

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 5	138,257	148,930	7.7%	158,131	6.2%
Gilliam	1,871	1,985	6.1%	1,763	−11.2%
Hood River	22,346	25,310	13.3%	29,014	14.6%
Morrow	11,173	11,885	6.4%	12,960	9.0%
Sherman	1,765	1,785	1.1%	1,653	−7.4%
Umatilla	75,889	80,765	6.4%	82,943	2.7%
Wasco	25,213	27,200	7.9%	29,798	9.6%

Source: Population Research Center, Portland State University (2018), Certified Population Estimates; Population Research Center, Portland State University (2019), Current Forecast Summaries for All Areas & Oregon Final Forecast Table by Age (2019); U.S. Census Bureau, 2010 Decennial Census. Table DP-1

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 5 are largely centered on outdoor activities (hiking/backpacking, visiting national/state parks etc.), touring (traveling to experience scenic beauty, history and culture), and special events (such as fairs, festivals or sporting events) (Longwoods International, 2017e). Approximately two-thirds of trips to the region occur between April and September (Longwoods International, 2017e). The average travel party contains approximately three persons and the on average visitors spend two nights in the region (Longwoods International, 2017e). The majority of tourist stay in Umatilla, Wasco, and Hood River Counties.

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

Table 2-464. Annual Visitor Estimates in Person Nights (x1000) in Region 5

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 5	4,187		4,354		4,393	
Gilliam	68	100%	69	100%	69	100%
Hotel/Motel	16	23.5%	17	25%	17	25%
Private Home	19	27.9%	19	28%	19	28%
Other	33	48.5%	33	48%	34	49%
Hood River	970	100%	1,021	100%	1,015	100%
Hotel/Motel	480	49%	531	52%	526	52%
Private Home	303	31%	306	30%	301	30%
Other	187	19%	185	18%	188	19%
Morrow	265	100%	267	100%	269	100%
Hotel/Motel	85	32%	89	33%	90	33%
Private Home	113	43%	113	42%	113	42%
Other	66	25%	66	25%	67	25%
Sherman	84	100%	85	100%	86	100%
Hotel/Motel	30	36%	31	36%	31	36%
Private Home	17	20%	18	21%	18	21%
Other	37	44%	36	42%	37	43%
Umatilla	1,651	100%	1,735	100%	1,778	100%
Hotel/Motel	636	39%	693	40%	730	41%
Private Home	757	46%	785	45%	787	44%
Other	259	16%	257	15%	260	15%
Wasco	1,149	100%	1,177	100%	1,176	100%
Hotel/Motel	488	42%	517	44%	515	44%
Private Home	266	23%	268	23%	263	22%
Other	395	34%	392	33%	397	34%

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003).

As a whole, the percentage of residents in Region 5 with a disability is similar, but slightly higher than the statewide estimate. A notably high percentage of residents in Gilliam County have a disability, approximately one-fifth of all residents. The share of residents in Sherman and Wasco is also high, just under 20%. Conversely, the share of residents with a disability in Hood River County is smaller than both the region and statewide estimates. The region also has a disproportionate share of older adults (≥ 65) with a disability; however, it should be noted that the margin of error for each county is significant, potentially resulting in a much higher or lower estimate than what's included below. Similarly, accurately measuring the number of children with a disability is challenging, especially in counties with a smaller overall population. Consequently, the estimate of young people (< 18) with a disability for each county should be used with caution or not used at all.

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Table 2-465. People with a Disability by Age Group in Region 5

	With a Disability (Total Population)			Under 18 Years with a Disability			65 Years and Over with a Disability		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	14.6%	☑	0.10%	4.6%	☑	0.2%	37.1%	☑	0.4%
Region 5	15.3%	☑	0.58%	3.9%	☑	0.7%	43.0%	☑	2.3%
Gilliam	21.2%	☑	3.70%	6.6%	⊗	5.2%	47.5%	☑	7.6%
Hood River	9.9%	☑	1.10%	1.6%	⊗	0.9%	37.8%	☑	5.1%
Morrow	14.1%	☑	1.80%	3.6%	⊗	2.3%	44.8%	☑	7.5%
Sherman	19.2%	☑	3.20%	4.5%	⊗	3.1%	30.0%	☑	6.3%
Umatilla	15.8%	☑	0.80%	4.0%	⊙	1.0%	44.6%	☑	3.1%
Wasco	18.6%	☑	1.50%	5.9%	⊙	1.9%	43.3%	☑	5.1%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP05: ACS Demographics and Housing Estimates, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Homeless Population

The U.S. Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count (PIT), a biennial count of both sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors. They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing and Community Services, 2019). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing and Community Services, 2019).

According to the PIT, between 2015 and 2019 the region reported a 65% increase in the number of people experiencing homelessness. Sherman and Morrow Counties both reported significant percent increases, but started with a count of zero and continue to have a small total numbers of unhoused people. Wasco, Umatilla, and Hood River Counties all reported similar rates of increase during the period and have a similar numbers of unhoused individuals.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate their vulnerability. Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-466. Homeless Population Estimate for Region 5

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 5	191	321	315	276
Gilliam	0	0	0	0
Hood River	69	70	90	76
Morrow	0	0	2	1
Sherman	0	1	12	4
Umatilla	75	55	124	85
Wasco	47	195	87	110

Source: Oregon Housing and Community Services (n.d.). Oregon Point in Time Homeless Counts. Retrieved from https://public.tableau.com/profile/oregon.housing.and.community.services#!/vizhome/2019Point-in-TimeDashboard/Story1

Biological Sex and Gender

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019). According to the survey, there are more men than women in Region 5 (104.99 men to every 100 women) (U.S. Census Bureau, 2019). Within the region, Umatilla County has more men than women (109 men to every 100 women) (U.S. Census Bureau, 2019). Sherman County also has more men than women (118.7 men to every 100 women); however, the margin of error is significant (+/-12%) (U.S. Census Bureau, 2019). Conversely, Gilliam County has more women than men (91.7 men to every 100 women); however, the margin of error is significant for this estimate as well (+/-9.6%) (U.S. Census Bureau, 2019).

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognized (Enarson, 2017). This is an area deserving of more attention as the field develops.

Age

Older adults, those aged 65 and up, comprise a slightly smaller share of the population in Region 5 than they do in the state as a whole. This is also true for Umatilla, Hood River, and Morrow Counties. Conversely, Gilliam, Sherman, and Wasco Counties all have higher percentages of older adults than the statewide estimate. An older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

Children, persons aged under 18, also represent a vulnerable segment of the population. Region 5 has a higher percentage of children than the state as a whole. Within the region, Umatilla and Hood River Counties have the highest share of children and Sherman County has the smallest share. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. In addition, parents might lose time and money when their children’s childcare facilities and schools are impacted by disasters.

Table 2-467. Population by Vulnerable Age Group, in Region 5

	Total Population	Under 18 Years Old			65 and Older		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	4,025,127	21.5%	☑	0.1%	16.3%	☑	0.1%
Region 5	140,059	25.0%	☑	0.1%	15.8%	☑	0.2%
Gilliam	1,910	22.3%	☑	2.5%	25.1%	☑	3.2%
Hood River	22,938	24.7%	☑	0.1%	14.6%	☑	0.6%
Morrow	11,153	27.6%	☑	0.4%	15.3%	☑	1.0%
Sherman	1,635	14.9%	☑	2.6%	25.7%	☑	3.2%
Umatilla	76,736	25.7%	☑	0.1%	14.6%	☑	0.1%
Wasco	25,687	22.6%	☑	0.1%	19.4%	☑	0.4%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP05: ACS Demographics and Housing Estimates, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to developing language and culturally appropriate outreach materials. In Region 5, the share of people who do not speak English “Very Well” is higher than the statewide estimate—especially for Morrow, Hood River, and Umatilla Counties. The estimates for Gilliam and Sherman County should not be used, as the estimates are unreliable. Communities creating outreach materials used to communicate with and plan for populations who do not speak English very well should take into consideration the language needs of these populations.

Table 2-468. English Usage in Region 5

	Speak English Less Than "Very Well"				
	Estimate	CV **	MOE (+/−)	Percent	% MOE (+/−)
Oregon	222,428	☑	4,116	5.9%	0.1%
Region 5	14,117	☑	751	10.8%	0.6%
Gilliam	38	⊗	47	2.1%	2.6%
Hood River	3,395	☑	375	15.8%	1.8%
Morrow	1,633	☑	214	15.8%	2.1%
Sherman	13	⊗	15	0.8%	1.0%
Umatilla	7,518	☑	563	10.5%	0.8%
Wasco	1,520	☑	242	6.3%	1.0%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

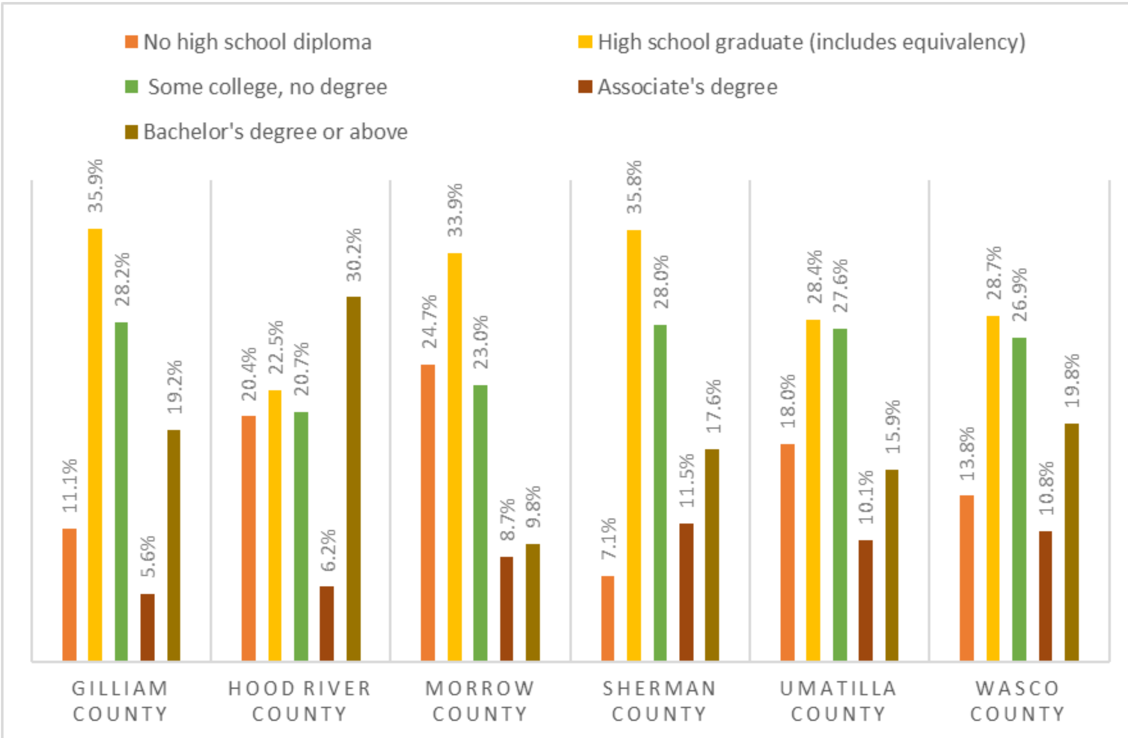
Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

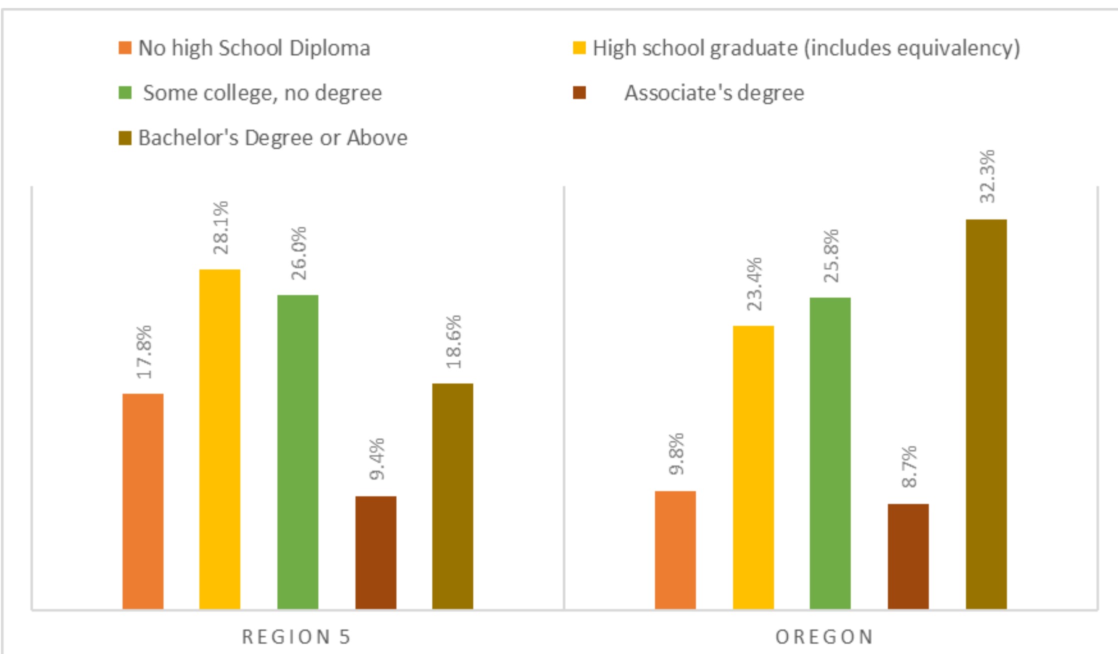
Education Level

Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual's ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

Approximately 19% of residents in Region 5 have a bachelor's degree or higher, which is roughly thirteen percentage points lower than the share statewide. A slightly higher percentage of residents have an associate's degree compared to the state, however, the share of the population without a high school diploma is considerably higher than the statewide estimate. The percentage of people with some college education is similar to the estimate statewide. Within the region, Hood River has the highest percentage of residents with a bachelor's degree or higher; however, the share is still below the statewide estimate. Gilliam and Hood River Counties have smaller shares of residents with an associate's degree compared to the state as a whole, but at least one-fifth of residents in each county have some college credit. The share of residents without a high school diploma is highest in Morrow and Hood River Counties. Except for Sherman County, all counties in the region have a higher share of residents without a high school diploma compared to the state as a whole.

Figure 2-219. Educational Attainment in Region 5: (top) by County, (bottom) Regional vs. Statewide





Source: U.S. Census Bureau (2018). Table DP02: Selected Social Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Income and Poverty

The impact of a disaster in terms of loss and the ability to recover varies among population groups. “The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event” (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public (Stahl, P., 2000). Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, are less likely to have the savings to rebuild after a disaster, and are less likely to have access to transportation and medical care.

Except for Hood River County, median household income in each county is $1,000 – $16,000 below the statewide median. Gilliam County has the highest disparity; however, the margin of error (+/– $8,471) indicates the estimate could be closer to the median or further away. Between 2012 and 2017, there was no statistically significant change in median household income in any county in the region.

Table 2-469. Median Household Income in Region 5

	2008-2012			2013-2017			Statistically Different*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	$53,427	☑	$338	$56,119	☑	$370	Yes
Region 5	—	—	—	—	—	—	—
Gilliam	$49,024	☑	$8,149	$39,831	☑	$8,471	No
Hood River	$60,745	☑	$3,986	$57,269	☑	$3,838	No
Morrow	$51,826	☑	$4,052	$54,386	☑	$3,538	No
Sherman	$47,687	☑	$8,944	$42,074	☑	$7,268	No
Umatilla	$51,888	☑	$2,596	$50,071	☑	$1,555	No
Wasco	$46,590	☑	$1,622	$48,510	☑	$2,079	No

Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

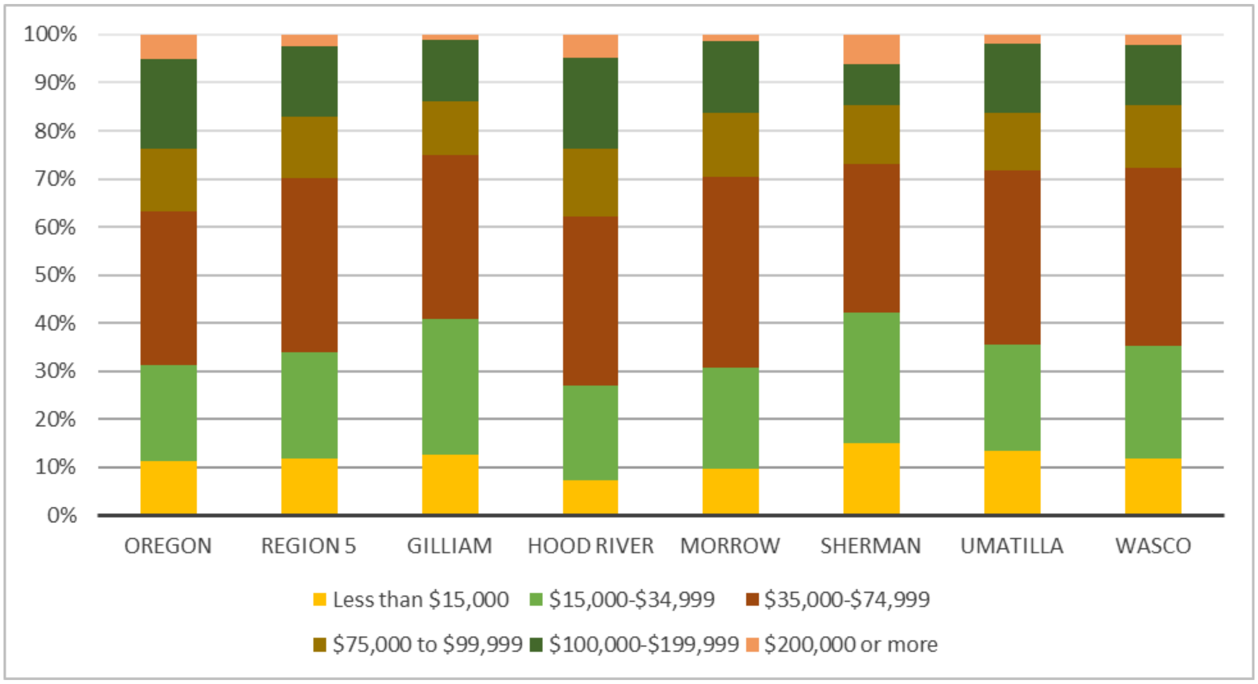
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018), CP03: Comparative Economic Characteristics, American Community Survey - 5 year estimates, Retrieved from: Data.census.gov.

Region 5 has a slightly higher percentage of households earning less than $35,000 annually vis-à-vis the state. Within the region, Sherman County has the highest percentage of households (42.2 %) earning less than $35,000 per year, while Hood River County has the highest percentage of households (37.9 %) earning more than $75,000 per year. Just over one third of the region’s households earn between $35,000 and $75,000 per year.

Figure 2-220. Median Household Income Distribution in Region 5



Source: U.S. Census Bureau. Table DP03: Selected Economic Characteristics, American Community Survey, 2013-2017 American Community Survey 5-Year Estimates

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018). The poverty rate in Umatilla County is approximately three percentage points higher than the statewide estimate. For all other counties in the region, the share is slightly smaller than the statewide estimate; however, due to sampling error, the estimates for Gilliam and Hood River Counties should be used with caution.

A higher percentage of children in Region 5 are living in poverty compared to the statewide share; however, due to sampling error, estimates of child poverty for individual counties vary in reliability and should be used with caution. Notably, estimates for Gilliam, Hood River, and Sherman Counties should be used with extreme caution.

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources (Cutter, Boruff, & Shirley, 2003).

Table 2-470. Poverty Rates in Region 5

	Total Population in Poverty						
	2008-2012			2013-2017			Statistically Different*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	15.5%	☑	0.3	14.9%	☑	0.3%	No
Region 5	15.4%	☑	1.2	15.7%	☑	1.2%	No
Gilliam	12.6%	⊙	3.5	9.9%	⊙	3.5%	No
Hood River	10.1%	⊙	2.6	12.1%	⊙	3.3%	No
Morrow	15.5%	☑	3.4	14.7%	☑	3.4%	No
Sherman	22.4%	☑	4.2	13.7%	☑	3.0%	Yes
Umatilla	15.5%	☑	1.7	17.8%	☑	1.7%	No
Wasco	19.3%	☑	2.6	13.7%	☑	1.8%	Yes

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Table 2-471. Child Poverty in Region 5

	Children Under 18 in Poverty						
	2008-2012			2013-2017			Statistically Different*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	20.6%	☑	0.5	19.0%	☑	0.6%	Yes
Region 5	21.2%	☑	2.6	22.0%	☑	2.8%	No
Gilliam	11.6%	⊗	8.0	2.3%	⊗	3.4%	Yes
Hood River	12.0%	⊙	5.3	18.2%	⊗	9.9%	No
Morrow	22.9%	⊙	6.5	20.2%	⊙	6.7%	No
Sherman	44.1%	⊙	3.7	13.8%	⊗	8.5%	Yes
Umatilla	22.4%	☑	3.7	25.8%	☑	3.8%	No
Wasco	24.6%	⊙	7.0	15.5%	☑	3.4%	Yes

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Housing Tenure

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

Each county in Region 5 has a higher home-ownership rate compared to the state overall. Morrow County has the highest percentage of owner occupied households while Umatilla has the lowest.

Table 2-472. Housing Tenure in Region 5

	Total Occupied Units	Owner-Occupied			Renter-Occupied		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	61.7%	☑	0.3%	38.3%	☑	0.3%
Region 5	51,174	63.9%	☑	1.2%	36.1%	☑	1.4%
Gilliam	805	64.0%	☑	6.0%	36.0%	☑	6.0%
Hood River	8,543	63.8%	☑	3.3%	36.2%	☑	3.3%
Morrow	3,936	70.9%	☑	3.6%	29.1%	☑	3.6%
Sherman	779	63.8%	☑	5.8%	36.2%	☑	5.8%
Umatilla	26,976	62.9%	☑	1.7%	37.1%	☑	1.7%
Wasco	10,135	64.1%	☑	2.3%	35.9%	☑	2.3%

U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table DP04: Selected Housing Characteristics

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households. Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only.

Region 5 is predominately composed of family households. Morrow County has the highest share and Sherman County has the smallest. Sherman and Gilliam Counties also have higher percentages of single-person households; however, the margin of error for each estimate indicates the percentage could be much closer to (or further from) the statewide share. The region has a higher percentage of households with children compared to the state as a whole. Morrow County has the highest share and Sherman has the smallest. Region 5 has a slightly higher share of single-parent households compared to the state. Umatilla County has the highest share, three percentage points above the statewide estimate.

Table 2-473. Family vs. Non-family Households in Region 5

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	63.3%	☑	0.2%	36.7%	☑	0.2%	27.7%	☑	0.2%
Region 5	51,174	67.1%	☑	1.5%	32.9%	☑	1.4%	26.4%	☑	1.3%
Gilliam	805	63.6%	☑	6.0%	36.4%	☑	6.0%	31.2%	☑	5.6%
Hood River	8,543	64.7%	☑	3.6%	35.3%	☑	3.6%	26.4%	☑	3.1%
Morrow	3,936	75.3%	☑	4.0%	24.7%	☑	4.0%	20.7%	☑	3.4%
Sherman	779	59.1%	☑	5.4%	40.9%	☑	5.4%	32.5%	☑	5.0%
Umatilla	26,976	67.8%	☑	1.9%	32.2%	☑	1.9%	26.0%	☑	1.9%
Wasco	10,135	65.0%	☑	2.4%	35.0%	☑	2.4%	28.7%	☑	2.2%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-474. Family Households with Children by Head of Household in Region 5

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	26.2%	☑	0.2%	8.1%	☑	0.2%
Region 5	29.3%	☑	1.2%	9.3%	☑	0.9%
Gilliam	18.1%	☑	4.1%	5.3%	⊙	2.6%
Hood River	25.0%	☑	3.2%	5.7%	⊙	1.9%
Morrow	33.0%	☑	3.8%	7.6%	⊙	2.4%
Sherman	13.5%	☑	2.9%	2.0%	⊗	2.0%
Umatilla	31.8%	☑	1.5%	11.3%	☑	1.5%
Wasco	27.1%	☑	2.1%	1.6%	☑	1.6%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Social and Demographic Trends

The social and demographic analysis shows that Region 5 is particularly vulnerable during a hazard event in the following ways:

- A notably high percentage of residents in Gilliam County have a disability, approximately one-fifth of all residents. The share of residents in Sherman and Wasco is also high, just under 20%.
- According to the PIT, between 2015 and 2019 the region reported a 65% increase in the number of people experiencing homelessness.
- Region 5 has a higher percentage of children than the state as a whole.
- The share of people who do not speak English "Very Well" is higher than the statewide estimate—especially for Morrow, Hood River, and Umatilla Counties.
- Approximately 19% of residents in Region 5 have a bachelor's degree or higher, which is roughly thirteen percentage points lower than the share statewide. Moreover, except for Sherman County, all counties in the region have a higher share of residents without a high school diploma compared to the state as a whole.
- Except for Hood River County, median household income in each county is $1,000 – $16,000 below the statewide median.
- Sherman and Gilliam Counties have higher percentages of single-person households compared to the state as a whole.

Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses' labor, capital, suppliers, and customers are all relevant factors (Zhang, Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang, Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent.

Employment and Unemployment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 5 have been steadily declining since peaking during the Great Recession. In 2018, Umatilla County, which has the largest labor force, also had the highest unemployment rate. From 2014 to 2018, Hood River County consistently had the lowest unemployment rate.

Table 2-475. Civilian Labor Force in Region 5, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 5	72,204	69,004	95.6%	3,200	4.4%
Gilliam	844	811	96.1%	33	3.9%
Hood River	14,533	14,048	96.7%	485	3.3%
Morrow	5,732	5,484	95.7%	248	4.3%
Sherman	898	861	95.9%	37	4.1%
Umatilla	36,813	34,994	95.1%	1,819	4.9%
Wasco	13,384	12,806	95.7%	578	4.3%

Source: Oregon Employment Department, 2019

Table 2-476. Civilian Unemployment Rates in Region 5, 2014-2018

	2014	2015	2016	2017	2018	Change (2014-2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	−2.6%
Region 5	7.0%	5.8%	4.9%	4.4%	4.4%	−2.6%
Gilliam	8.0%	6.4%	5.8%	4.2%	3.9%	−4.1%
Hood River	5.4%	4.7%	4.1%	3.6%	3.3%	−2.1%
Morrow	6.9%	5.7%	4.8%	4.4%	4.3%	−2.6%
Sherman	7.5%	6.1%	4.6%	4.7%	4.1%	−3.4%
Umatilla	7.7%	6.4%	5.3%	4.8%	4.9%	−2.8%
Wasco	6.6%	5.6%	4.8%	4.2%	4.3%	−2.3%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups “economic units that have similar production processes” according to a six-digit hierarchical structure (Office of Management and Budget, n.d.). “The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry” (Office of Management and Budget, n.d.). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors

(U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 5 were:

1. Trade, Transportation and Utilities
2. Natural Resources and Mining
3. Local Government
4. Education and Health Services
5. Manufacturing

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region's resiliency. In Region 5, the following supersectors comprise a significant share of all business establishments.

- The Trade, Transportation, and Utilities supersector includes the highest number of establishments in Region 5, 17.2% of all businesses (QCEW, 2018).
- Other Services is second largest, with 16.0% of all business establishments (QCEW, 2018).
- Natural Resources and Mining is third largest supersector by total establishments, with 15.1% of all regional share (QCEW, 2018).
- Professional and Business Services is fourth, with 10% of all business establishments (QCEW, 2018).
- The Education and Health Services and Leisure and Hospitality both have the same number of establishments, each comprising 9.1% of the total (QCEW, 2018).

While supersectors are useful abstractions, it's important to remember that within each supersector are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event.

Table 2-477. Covered Employment by Sector in Region 5, 2019

Industry	Region 5	Gilliam County		Hood River County		Morrow County	
	Percent	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	815	100.0%	14,248	100.0%	6,175	100.0%
Total Private Coverage	82.0%	574	70.4%	12,980	91.1%	5,201	84.2%
Natural Resources & Mining	13.7%	45	5.5%	2,491	17.5%	1,344	21.8%
Construction	3.4%	23	2.8%	492	3.5%	113	1.8%
Manufacturing	11.8%	(c)	(c)	1,758	12.3%	1,809	29.3%
Trade, Transportation & Utilities	17.8%	133	16.3%	2,126	14.9%	687	11.1%
Information	1.6%	(c)	(c)	141	1.0%	513	8.3%
Financial Activities	2.0%	17	2.1%	252	1.8%	72	1.2%
Professional & Business Services	5.6%	219	26.9%	1,168	8.2%	158	2.6%
Education & Health Services	12.4%	52	6.4%	1,700	11.9%	251	4.1%
Leisure & Hospitality	10.3%	37	4.5%	2,388	16.8%	188	3.0%
Other Services	3.2%	20	2.5%	453	3.2%	66	1.1%
Unclassified	0.5%	(c)	(c)	13	0.1%	(c)	(c)
Total All Government	17.8%	241	29.6%	1,268	8.9%	973	15.8%
Total Federal Government	1.7%	13	1.6%	116	0.8%	58	0.9%
Total Government	2.9%	6	0.7%	86	0.6%	65	1.1%
Total Government	13.5%	222	27.2%	1,067	7.5%	850	13.8%

Industry	Region 5	Sherman County		Umatilla County		Wasco County	
	Percent	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	856	100.0%	30,721	100.0%	11,647	100.0%
Total Private Coverage	82.0%	535	62.5%	23,798	77.5%	9,739	83.6%
Natural Resources & Mining	13.7%	22	2.6%	3,393	11.0%	1,526	13.1%
Construction	3.4%	64	7.5%	1,175	3.8%	353	3.0%
Manufacturing	11.8%	(c)	(c)	3,416	11.1%	637	5.5%
Trade, Transportation & Utilities	17.8%	229	26.8%	6,323	20.6%	1,990	17.1%
Information	1.6%	(c)	(c)	175	0.6%	178	1.5%
Financial Activities	2.0%	(c)	(c)	696	2.3%	262	2.2%
Professional & Business Services	5.6%	28	3.3%	1,403	4.6%	624	5.4%
Education & Health Services	12.4%	36	4.2%	3,622	11.8%	2,343	20.1%
Leisure & Hospitality	10.3%	122	14.3%	2,578	8.4%	1,327	11.4%
Other Services	3.2%	21	2.5%	1,014	3.3%	495	4.3%
Unclassified	0.5%	321	37.5%	(c)	(c)	4	0.0%
Total All Government	17.8%	130	15.2%	6,924	22.5%	1,908	16.4%
Total Federal Government	1.7%	130	15.2%	485	1.6%	290	2.5%
Total State Government	2.9%	42	4.9%	1,391	4.5%	250	2.1%
Total Local Government	13.5%	148	17.3%	5,047	16.4%	1,369	11.8%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system.

Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region.

Natural Resources and Mining: The primary industries within this sector regionally are largely crop and animal production. These industries tend to fluctuate seasonally and are vulnerable to a variety of natural hazards (winter storms, floods, etc.). In addition to the loss of farm production, wages could be lost due to natural disasters. In addition, these industries are dependent upon transportation systems that are vulnerable to disasters.

Education and Health Services: The industries in these sectors play important roles in emergency response in the event of a disaster. Health care is a relatively stable revenue sector regionally with an increasing distribution of businesses primarily serving a local and aging population.

Manufacturing: This sector is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons the manufacturing sector may be susceptible to disruptions in transportation infrastructure. However, manufacturers are not dependent on local markets for sales, which may contribute to the economic resilience of this sector.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. Many of the top employment subsectors are similar across regions. For example, Food Services and Drinking Places and Educational Services are the two largest employment subsectors in Region 6. These subsectors also rank highly in other regions. Ambulatory Health Care Services—also known as outpatient services—and Hospitals are also major employers in Region 6 and across the state. Conversely, other subsectors, such as Crop Production and Food Manufacturing, are more unique to the region.

Table 2-478. Industries with Greatest Share of Employment in Region 5, 2018

Industry	Employment Share	Employment (2018)
Crop Production	13%	10,085
Food Services and Drinking Places	8%	5,794
Educational Services	6%	4,626
Food Manufacturing	6%	4,556
Support Activities for Agriculture and Forestry	5%	3,922
Accommodation	4%	2,672
Ambulatory Health Care Services	3%	2,487
Professional, Scientific, and Technical Services	3%	2,134
Nursing and Residential Care Facilities	3%	2,111
Executive, Legislative, and Other General Government Support	3%	2,032

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for employment share and average employment by DLCD

Industry Concentration and Employment Change

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

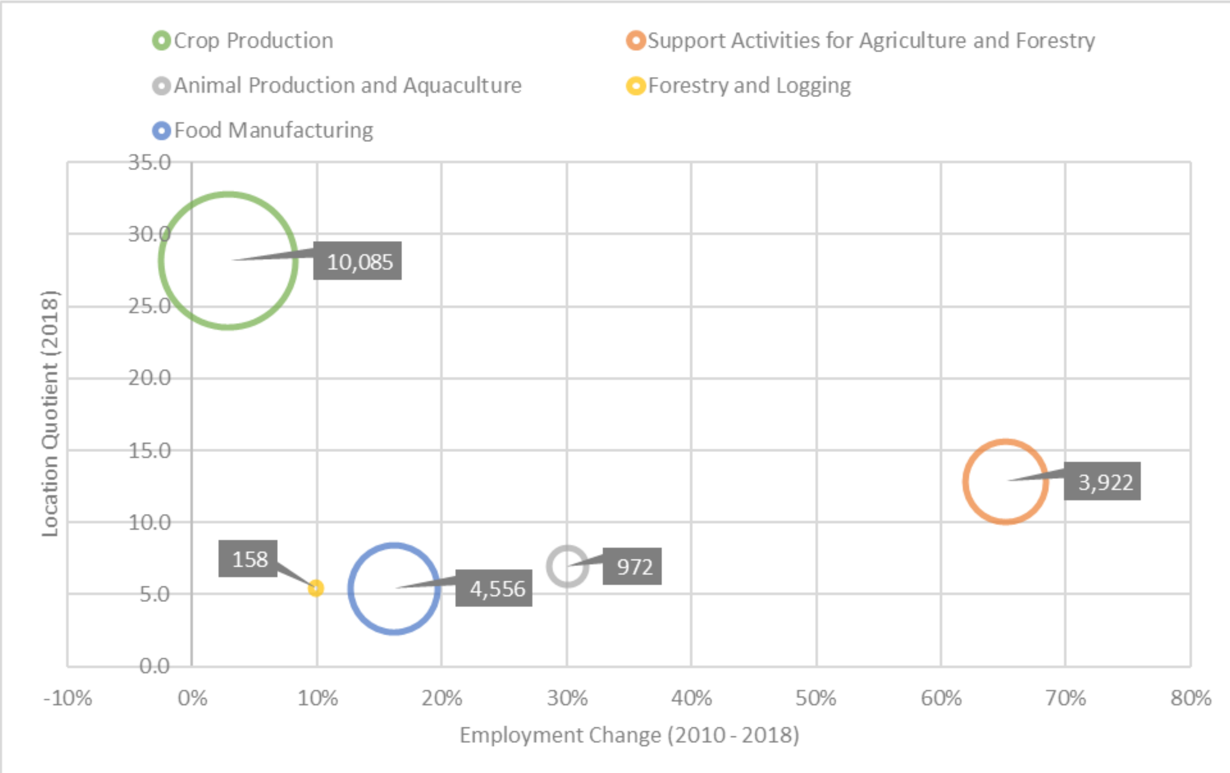
Table 2-479. Most Concentrated Industries and Employment Change in Region 4, 2018

Industry	Location Quotient	Employment (2018)	Employment Change (2010–2018)
Crop Production	28.2	10,085	3%
Support Activities for Agriculture and Forestry	12.9	3,922	65%
Animal Production and Aquaculture	7.0	972	30%
Forestry and Logging	5.4	158	10%
Food Manufacturing	5.4	4,556	16%

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 5 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-221. Location Quotients, Employment Change, and Total Employment in Region 5, 2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

All five of the region's most concentrated industries are either natural resource based or directly dependent on natural resource industries. Looking at the five most concentrated subsectors as a whole, it's clear that the region has a competitive advantage in growing and processing food products. Although the subsector experienced modest growth from 2010-2018, Crop Production has the highest location quotient within the region and employs over ten-thousand induvial. The region has less of an advantage in Food Manufacturing but the sector grew more quickly than Crop Production and is one of the largest subsectors by employment. Support Activities for Agriculture and Forestry is also one of the region's largest employers and grew most quickly among the five most concentrated industries—adding approximately fifteen-hundred jobs from 2010-2018.

Fastest Growing and Declining Industries

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang, Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining.

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 5's fastest growing and declining industries

Table 2-480. Fastest Growing and Declining Industries in Region 5, 2010-2018

Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Private Households	590%	72	499
Beverage and Tobacco Product Manufacturing	157%	268	688
Performing Arts, Spectator Sports, and Related Industries	147%	57	140
Museums, Historical Sites, and Similar Institutions	108%	53	111
Plastics and Rubber Products Manufacturing	81%	95	172
Fastest Declining			
Furniture and Related Product Manufacturing	−100%	12	0
Nonmetallic Mineral Product Manufacturing	−68%	301	96
Waste Management and Remediation Services	−55%	888	399
Textile Product Mills	−44%	22	13
Motion Picture and Sound Recording Industries	−39%	91	56

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

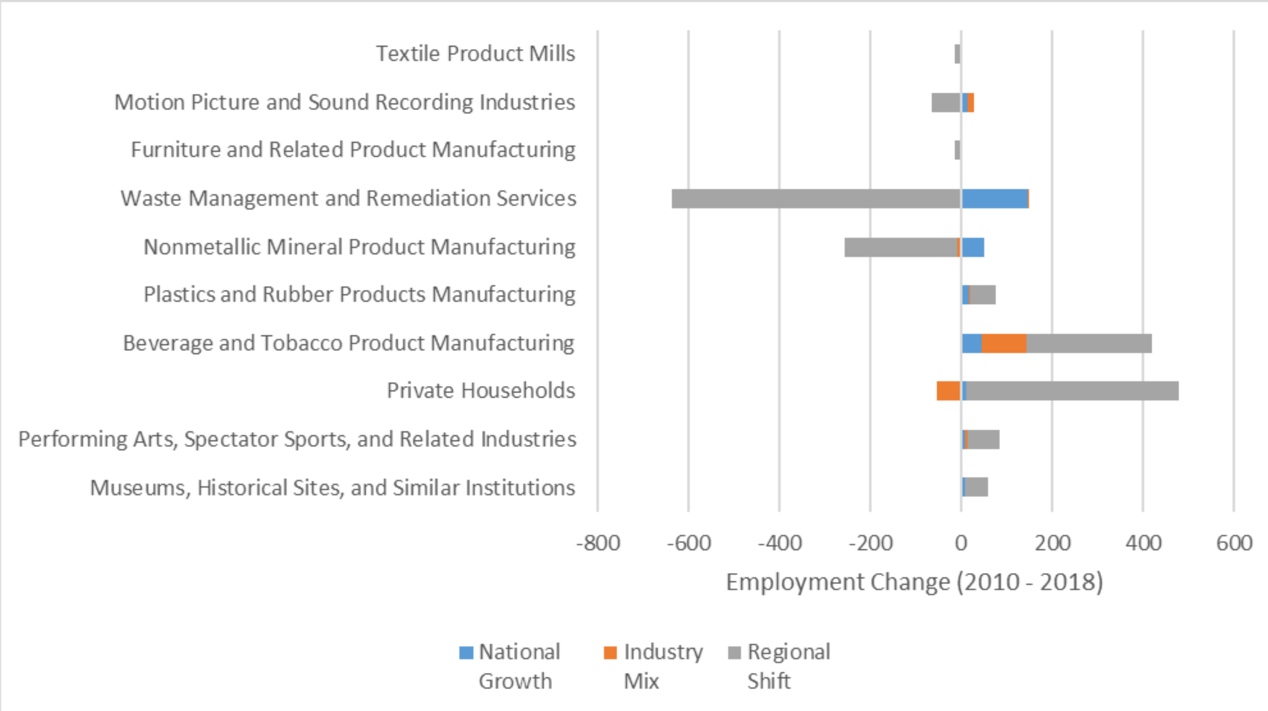
The Private Households industry experienced significant growth from 2010-2018. This sector employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019). The increase in employment in the Private Households industry mirrors a statewide trend (Wallis, 2019). Demand is driven in part by an aging population's need for in-home care workers (Wallis, 2019).

Beverage and Tobacco Product Manufacturing subsector also grew in employment within the region. Growth in the Beverage and Tobacco Product Manufacturing industry is likely driven by Oregon's thriving craft-beer scene, which continues to grow despite a crowded market (Lehner, 2020). Although the industry has been expanding nationally, the shift-share analysis shows that the growth was driven more by regional factors.

Additionally, the region experienced significant growth—but smaller actual numbers—in the Performing Arts, Spectator Sports, and Related Industries subsector; Museums, Historical Sites, and Similar Institutions subsector; and the Plastics and Rubber Products Manufacturing subsector. According to this shift-share analysis, growth in these industries was also caused by local factors rather than industry trends at the national level.

According to the shift-share analysis, losses in all five of the fastest declining subsectors can also be attributed to regional factors. While the industry experienced slight growth nationally, in Region 5 Waste Management and Remediation Services shed nearly five hundred positions from 2010-2018. The Nonmetallic Mineral Product Manufacturing sector also shed a meaningful number of jobs during this period—approximately two hundred.

Figure 2-222. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 5, 2010-2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Table 2-481. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 5, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Museums, Historical Sites, and Similar Institutions	58	9	−1	50
Performing Arts, Spectator Sports, and Related Industries	84	9	5	69
Private Households	426	12	−53	467
Beverage and Tobacco Product Manufacturing	420	44	99	277
Plastics and Rubber Products Manufacturing	77	16	3	58
Fastest Declining				
Nonmetallic Mineral Product Manufacturing	−205	50	−8	−247
Waste Management and Remediation Services	−490	146	2	−637
Furniture and Related Product Manufacturing	−12	2	0	−13
Motion Picture and Sound Recording Industries	−35	15	14	−64
Textile Product Mills	−10	4	−4	−9

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Economic Trends and Issues

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the following situations increase the regional communities' level of vulnerability to natural hazard events:

- Unemployment in Umatilla County is consistently higher than the statewide average;
- Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- The region lost employment in many of its manufacturing subsectors from 2010-2018;
- The region lacks a diversity of traded sector industries.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl, et al., 2000).

Infrastructure

Transportation

Roads

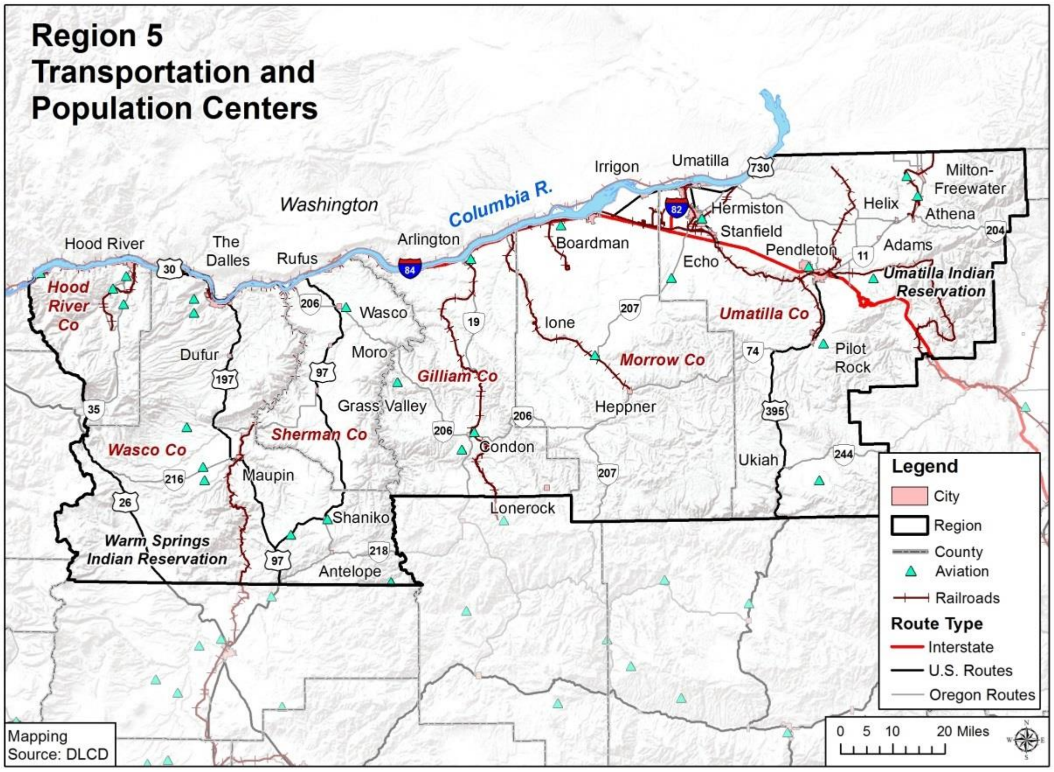
The largest population bases in Region 5 are located along the region's major freeways, I-84. I 84 is the main east-west passage for automobiles and trucks traveling between the northwest and states to the east.

Region 5's growing population centers bring more workers, automobiles and trucks onto roads. A high percentage of workers driving alone to work coupled with interstate and international freight movement on the I-84 corridor create additional stresses on transportation systems. Some of these stresses are added maintenance, congestion, oversized loads, and traffic accidents.

Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuation and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

According to the Oregon Department of Transportation's (2014, October) Seismic Plus Report (Appendix **9.1.13**), ground shaking from a CSZ event is not expected to cause damage to the region's major highways. The region has relatively low vulnerability to ground shaking from a CSZ event. However, connections to markets and services will likely be disrupted. For information on ODOT's 2012 Seismic Lifelines Report findings for Region 5 5, see **Seismic Lifelines**.

Figure 2-223. Region 5 Transportation and Population Centers



Source: Oregon Department of Transportation (2014, October)

Bridges

ODOT lists 644 bridges in the counties that comprise Region 5.

Because of earthquake risk in Region 5, the seismic vulnerability of the region's bridges is an important issue. Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or that are part of regional and local systems that are maintained by the region's counties and cities.

Table 2-482 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. The ratings do not imply that a bridge is unsafe (ODOT, 2020). The region has about the same percentage of bridges that are distressed or deficient (5%) as does the state.

Table 2-482. Bridge Inventory for Region 5

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 5	4	293	1%	26	303	9%	3	40	8%	0	8	0%	33	644	5%
Gilliam	0	19	0%	2	15	13%	0	1	0%	0	0	N/A	2	35	6%
Hood River	1	45	2%	1	15	7%	0	0	N/A	0	2	0%	2	62	3%
Morrow	0	24	0%	3	32	9%	1	11	9%	0	3	0%	4	70	6%
Sherman	0	35	0%	1	11	9%	0	1	0%	0	0	N/A	1	47	2%
Umatilla	2	118	2%	12	165	7%	2	22	9%	0	1	0%	16	306	5%
Wasco	1	52	2%	7	65	11%	0	5	0%	0	2	0%	8	124	6%

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2020)

Railroads

Railroads that run through Region 5 support cargo and trade flows. The region's major freight rail providers are the Union Pacific (UP) and the Burlington Northern-Santa Fe (BNSF) railroads. There are two major rail yards in the region — in The Dalles and Hinkle — operated by UP (Cambridge Systematics, 2014). The Hinkle Yard serves as UP's system yard and locomotive service and repair yard for Oregon and the greater northwest area (Cambridge Systematics, 2014).

Amtrak provides passenger rail service along the Columbia Gorge and eastward via the Empire Builder line.

Rails are sensitive to icing from winter storms that can occur in Region 5. Disruptions in the rail system can result economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

The Eastern Oregon Regional Airport is the only commercial airport in the region (City of Pendleton website, http://www.pendleton.or.us/pendleton-airport). It serves one passenger airline, SeaPort Airlines, providing service to Portland and North Bend (Portland International Airport, 2014).

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

Table 2-483. Public and Private Airports in Region 5

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Helipad	Private Helipad	Total
Region 5	9	18	0	8	35
Gilliam	2	2	0	0	4
Hood River	2	2	0	1	5
Morrow	2	0	0	1	3
Sherman	1	0	0	0	1
Umatilla	2	6	0	5	13
Wasco	0	8	0	1	9

Source: FAA Airport Master Record (Form 5010), 2014

Ports

Oregon's ports have historically been used for timber transport, and commercial and recreational fishing. With the decline in the timber industry, ports have evolved to embrace economic development and tourism by offering industrial land and river, rail, road, and air infrastructure. There are three ports within Region 5: The Port of Cascade Locks, The Port of The Dalles, and the Port of Hood River. The Port of Cascade Locks includes industrial land, a marine park, and the Bridge of the Gods, and promotes recreation tourism (Port of Cascade Locks website, http://portofcascadelocks.org/). The Port of Hood River encompasses industrial land, business parks, an expo center, the Hood River Marina and waterfront area, Hood River Airport, and the Hood River – White Salmon Bridge (Portland Hood River website, http://www.portofhoodriver.com/). The Port of The Dalles is approximately 425,000 square acres and covers the northern third of Wasco County. It contains industrial land and The Dalles Marina (Port of The Dalles website, http://www.portofthedalles.com/).

Energy

Electricity

The region is served by several investor-owned, public, cooperative, and municipal utilities. The Bonneville Power Administration is the area's wholesale electricity distributor. Pacific Power and Light (Pacific Power) is the primary investor-owned utility company serving portions of Gilliam, Hood River, Morrow, Sherman, and Umatilla Counties. The region's electric cooperatives are: the Hood River Electric Cooperative (Hood River County), Wasco Electric Cooperative (Gilliam, Hood River, Sherman, Wasco), Columbia Basin Cooperative (Gilliam, Morrow, Umatilla), Umatilla Cooperative (Umatilla), Columbia Power Cooperative (Umatilla) and Central Electric Cooperative (Wasco). Two utility districts serve the region: City of Cascade Locks (Hood River) and Milton-Freewater (Umatilla). In addition, the Northern Wasco People's Utility District (Wasco) serves portions of the region.

The region has a total of 31 power-generating facilities: 4 hydroelectric power facilities, 3 natural gas power facilities, 23 wind power facilities, and 1 coal power facility. In total, the power-generating facilities have the ability to produce up to 11,227 megawatts (MW) of electricity. The region also includes four wind power facilities that are approved but not constructed. The wind power facilities will have the capacity to generate up to 1,205 MW of electricity (Oregon Department of Energy).

Table 2-484. Power Plants in Region 5

	Hydro-electric	Natural Gas	Wind	Coal	Other*	Total
Region 5	4	3	23	1	0	31
Gilliam	0	0	8**	0	0	8
Hood River	1	0	0	0	0	1
Morrow	0	1	3**	1	0	5
Sherman	1	0	7	0	0	8
Umatilla	1	2	5	0	0	8
Wasco	1	0	0	0	0	1
Energy Production (MW)	**6,458**	**1,265**	**3,044**	**460**	**0**	**11,227**

*"Other" includes biomass, geothermal, landfill gas, solar, petroleum, and waste

**There are four wind power facilities that are located in both Gilliam and Morrow Counties, this table places half of each facility in each county.

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

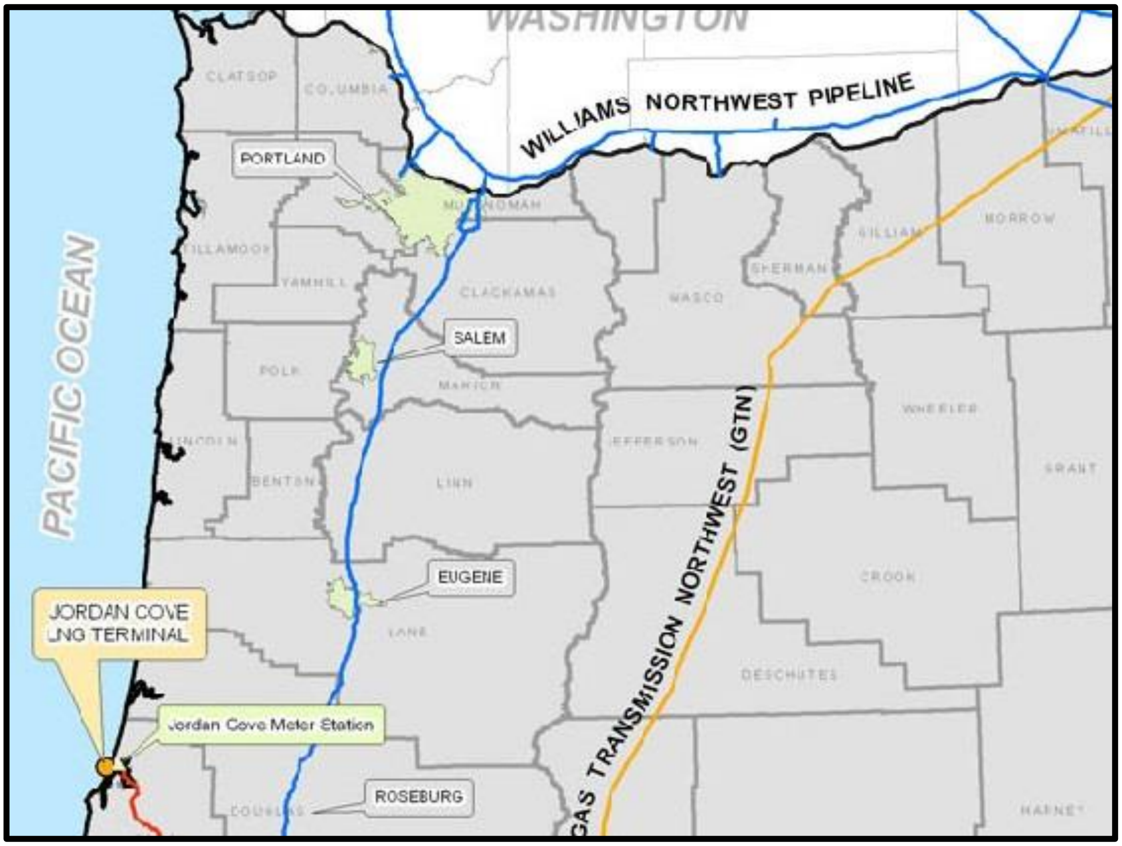
Hydropower

The Bonneville Power Administration (BPA) provides hydro-generated electricity to the state's consumer-owned utilities. The major BPA dams in the region are located on the Columbia River in communities of The Dalles, John Day, and McNary

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to the region's energy portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-224** shows the Gas Transmission Northwest (GTN) line, which runs through Gilliam, Morrow, and Umatilla Counties (in green) (Pipelines International, 2009). LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

Figure 2-224. Liquefied Natural Gas Pipelines in Region 5



Source: Oregon Department of Environmental Quality

Utility Lifelines

The Mid-Columbia region is an important thoroughfare for oil and gas pipelines and electrical transmission lines. The region is also a major producer of hydropower. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe, but infrequent natural hazards, such as earthquakes.

Communities in this region primarily receive oil and gas from Alaska by way of the Puget Sound through pipelines and tankers. The region is at the southern end of this pipeline network. Oil and gas are supplied by Northern California via a separate network. The electric, oil, and gas lifelines that run through the region are both municipally and privately owned (Loy, Allan, & Patton, 1976).

The network of electrical transmission lines running through Region 5 is operated primarily by Pacific Power, regional electrical cooperatives, and Bonneville Power Administration (Loy, et al., 1976). Most of the natural gas Oregon uses originates in Alberta, Canada. Avista Utilities owns the main natural gas transmission pipeline (Loy, Allan, & Patton, 1976).

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Region 5 is part of the Columbia Gorge Operational Area (Hood River, Wasco, Sherman, Gilliam), Central Oregon Operational Area (Wheeler, Southern Wasco), and Eastern Oregon Operational Area (Morrow, Umatilla) under The Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013). There is a memorandum of understanding between these counties that facilitates the launching of emergency messages. Counties in these areas can launch emergency messages by contacting the Oregon Emergency Response System (OERS), which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communications capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation’s status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The Oregon State Emergency Alert System Plan does not identify a local primary station for emergency messages.

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 5. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is readily available throughout most parts the region with a smaller number of providers and service types available in the southern parts of the region (south of I-84) (NTIA, n.d.) Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 5 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for the Columbia Gorge Operational Area are (Oregon Office of Emergency Management, 2013):

- KMSW-FM, 92.7 MHZ, The Dalles, 102.9 MHZ, Hood River;
- KHRV-FM, 90.1 MHZ, Hood River, OPB Radio Network; and
- KOTD, 89.7 MHZ, The Dalles, OPB Radio Network.

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). Region 5 is served by ARES Districts 2 and 3. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency Management, n.d.). The official ham emergency station calls for Region 5 include (American Relay Radio League Oregon Chapter, n.d., www.arrloregon.org):

- Gilliam County: W7ILD;
- Hood River County: K7VEW;
- Morrow County: N7ZHG;
- Sherman County: WB7PPK;
- Umatilla County: N7ZHG; and
- Wasco County: KF7LN.

Water

Water infrastructure includes drinking water, stormwater, and wastewater systems. All of these systems possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

The drinking water supply in Region 5 is drawn from a combination of surface, well, and spring sources. Surface water is drawn from rivers and smaller tributaries. In the eastern and western portions of the region these surface water sources are often backed up by groundwater that is drawn from an aquifer when surface water levels get low, especially in summer months. However, in the region's central counties municipal wells drawing from the aquifer are primary sources with springs used as a backup where they are available. In this central part of the region water shortages in wells are increasing although flow levels tend to stay consistent throughout the year. Water quality in the region's municipal supply is high. Chemical and fuel spills are a concern when surface waterways intersect with or parallel major roadways. Water quality could be threatened as older or damaged well infrastructure may not filter coliform and other bacteria as effectively as newer infrastructure.

Rural residents draw water from surface water, groundwater wells, or springs. Surface water is usually used for irrigation, and wells are used as backup source. Groundwater wells serve residential needs. In rural areas storage ponds or small dams are sometimes created on private land to provide additional on-site drinking water storage. Water quality for rural residents is primarily affected by nitrates from agricultural activities and by low flow levels, which can increase the density of pollutants.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. An example of non-point source pollution is stormwater runoff from roadways, agricultural operations, timber harvest, erosion, and sedimentation. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Landslides, flood events, earthquakes, and liquefaction can cause increased erosion and sedimentation in waterways.

Underground water supplies and aging or outdated infrastructure — such as reservoirs, treatment facilities, and pump stations — can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, limiting access to potable water. This can lead to unsanitary conditions that may threaten human health and limit fire suppression. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures, adversely affecting habitat health. Furthermore, fast-moving large volumes of stormwater entering surface waterways can cause flooding and erosion.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 5, most municipal building codes and stormwater management plans (city and county) emphasize use of centralized storm sewer systems to manage stormwater. Requirements for stormwater mitigation vary in Region 5. Low impact development (LID) mitigation strategies can alleviate or lighten the burden on a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, at lower speed, and at lower temperatures. The four largest municipalities in the region, Hood River, Hermiston, The Dalles and Pendleton, do not require LID strategies in their building codes. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems and could increase a community's resilience to many types of hazard events.

Infrastructure Trends and Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

The effects of road, bridge, rail, and port failures could be devastating to the economy and public health in the Mid-Columbia Region. I-84 supports the main east-west passenger and freight transport and is subject to winter storms and windstorms. Rail systems are vulnerable to icy conditions in the Gorge. In Region 5, there are two rail yards that service the state and greater Northwest region. Amtrak provides passenger service through the Columbia River Gorge. Three ports and one commercial airport are economic engines for the region, providing for tourism and recreation and supporting business and industrial parks.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. A diverse energy portfolio helps increase the area's ability to communicate and transport goods and emergency services after a hazard event. There are 31 power-generating facilities: four hydroelectric, three natural gas, 23 wind, and one coal facility. Four additional wind facilities have been proposed for this region. Three of BPA's large dams and hydroelectric projects are here on the Columbia River. LNG pipelines run through Gilliam, Morrow, and Umatilla Counties.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services may not cover rural areas of the region that are distant from I-84. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Drinking water is sourced from surface water, wells, and springs. Water quality can be threatened by non-point source pollution from stormwater runoff and agricultural activities in the area. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Erosion and sedimentation caused by natural hazard events could also threaten the water quality. In addition, outdated, damaged, or rigid buried water infrastructure is vulnerable to seismic activity. Though low impact development (LID) stormwater systems can increase the region's capacity to better manage high-precipitation events, no communities in this region require LID practices.

Built Environment

Settlement and Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program is 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD, https://www.oregon.gov/lcd/OP/Pages/Goal-7.aspx).

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people, or an "urban cluster" of at least 2,500 people (but less than 50,000). Gilliam and Sherman Counties do not meet either definition; therefore even though both counties contain incorporated cities, they are considered 100% rural. Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-485** and **Table 2-486** remain from the 2010 Census.

Between 2000 and 2010, growth in the region's urban areas has been about 10% less than urban growth statewide. While Umatilla County has the greatest number of people and housing in urban areas, urban populations, and homes in Hood River County have grown considerably, by roughly 22% and 32%, respectively. Gilliam and Sherman Counties do not have urban populations and are also losing the greatest share of their rural populations. Rural homes have increased by almost 10% in Gilliam and Wasco Counties.

The region's population is clustered around the I-84 corridor and the cities of Hood River, Pendleton, and The Dalles. The population distribution in Region 5 is presented in Figure 2-225.

Table 2-485. Urban and Rural Populations in Region 5, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	−0.1%
Region 5	79,500	87,442	10.0%	50,094	50,815	1.4%
Gilliam	0	0	—	1,915	1,871	−2.3%
Hood River	8,727	10,687	22.5%	11,684	11,659	−0.2%
Morrow	5,790	6,048	4.5%	5,205	5,125	−1.5%
Sherman	0	0	—	1,934	1,765	−8.7%
Umatilla	49,253	53,831	9.3%	21,295	22,058	3.6%
Wasco	15,730	16,876	7.3%	8,061	8,337	3.4%

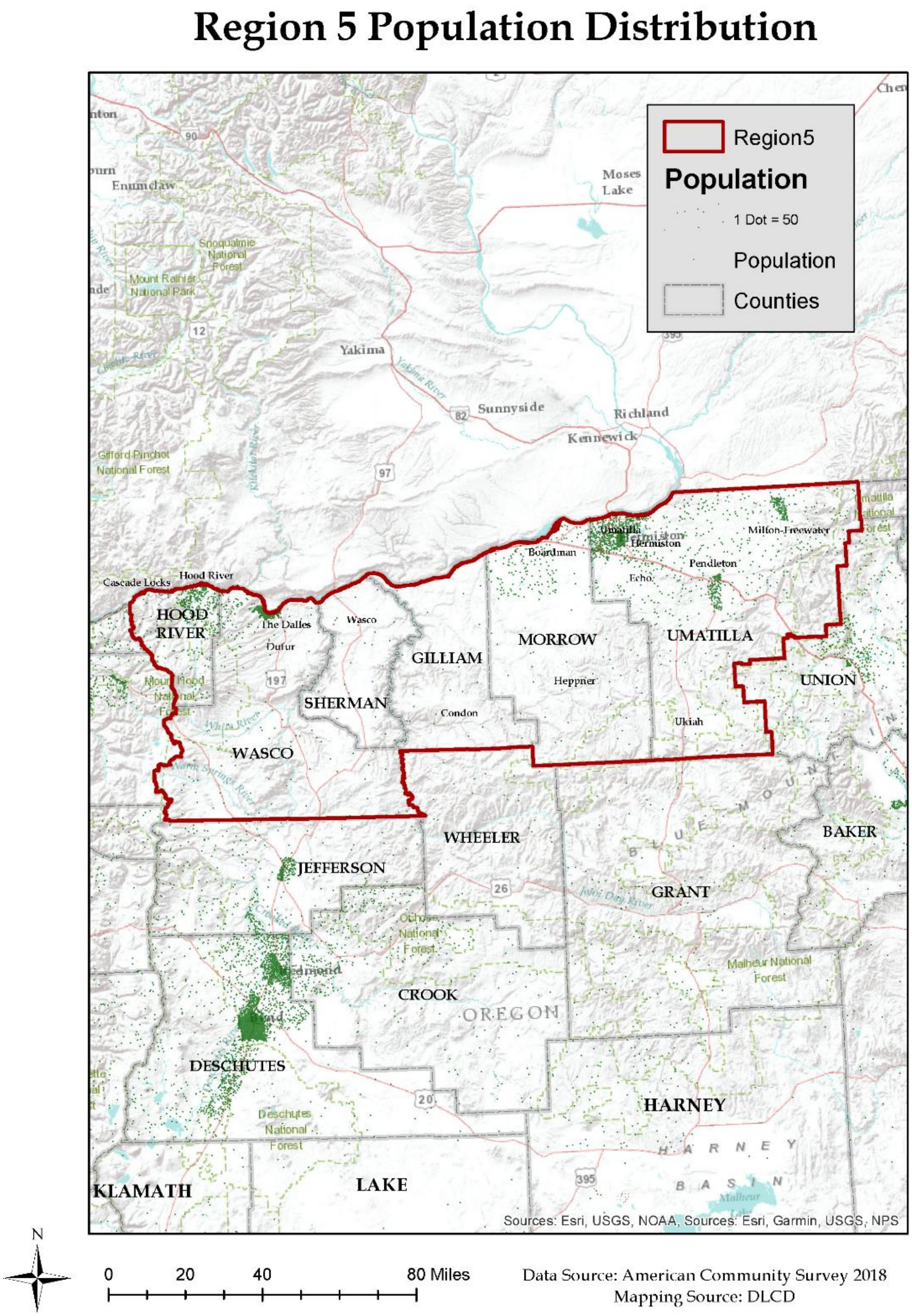
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

Table 2-486. Urban and Rural Housing Units in Region 5, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 5	31,453	34,811	10.7%	20,946	22,156	5.8%
Gilliam	0	0	—	1,043	1,156	10.8%
Hood River	3,681	4,870	32.3%	4,137	4,401	6.4%
Morrow	1,957	2,010	2.7%	2,319	2,432	4.9%
Sherman	0	0	—	935	918	−1.8%
Umatilla	19,124	20,755	8.5%	8,552	8,938	4.5%
Wasco	6,691	7,176	7.2%	3,960	4,311	8.9%

Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table H002

Figure 2-225. Region 5 Population Distribution



Source: U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. **Table 2-487** provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

The data show that the majority (68.2%) of the region's housing stock is single-family homes. Multi-family housing represents a smaller portion (15.7%) of housing within the region. Umatilla County has over half of the region's supply of multi-family units (5,297). Manufactured homes make up 15.8% of Region 5's housing. Umatilla County has the highest number of manufactured homes, while almost one third of the total housing units in Morrow County are manufactured homes. In natural hazard events such as earthquakes and floods, manufactured homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997).

Table 2-487. Housing Profile for Region 5

	Total Housing Units	Single Family			Multi-Family			Manufactured Homes		
		Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	1,733,041	68.1%	✓	0.3%	23.5%	✓	0.3%	8.2%	✓	0.1%
Region 5	58,040	68.2%	✓	1.3%	15.7%	✓	1.3%	15.8%	✓	0.9%
Gilliam	1,070	81.3%	✓	6.1%	5.0%	⊗	2.8%	13.6%	⊙	4.4%
Hood River	9,697	72.1%	✓	3.9%	15.8%	✓	3.8%	12.1%	✓	2.7%
Morrow	4,558	61.3%	✓	3.6%	7.7%	⊙	2.2%	30.5%	✓	3.4%
Sherman	943	70.9%	✓	5.1%	5.2%	⊙	2.2%	21.4%	✓	3.3%
Umatilla	30,172	67.1%	✓	1.8%	17.6%	✓	1.9%	15.0%	✓	1.3%
Wasco	11,600	68.9%	✓	2.2%	16.0%	✓	2.2%	14.7%	✓	1.6%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-488. Housing Vacancy in Region 5

		Vacant^		
	Total Housing Units	**Estimate**	**CV ****	**MOE (+/−)**
Oregon	1,733,041	5.6%	☑	0.2%
Region 5	58,040	7.0%	☑	0.9%
Gilliam	1,070	14.0%	⊙	4.2%
Hood River	9,697	5.7%	⊙	2.1%
Morrow	4,558	6.6%	⊙	2.6%
Sherman	943	13.0%	⊙	5.1%
Umatilla	30,172	7.7%	☑	1.3%
Wasco	11,600	6.1%	⊙	1.5%

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.
**Green, orange, and red icons indicate the reliability of each Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red “x” icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table B25004: Vacancy Status

Aside from location and type of housing, the year structures were built has implications (**Table 2-489**). Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as a part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally, 42.2% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances (about 60% within both Gilliam and Sherman Counties). Also regionally, approximately 72% of the housing stock was built before 1990 and the codification of seismic building standards. Further, as shown in **Table 2-490**, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the mid to late 1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-489. Age of Housing Stock in Region 5

	Total Housing Units	Pre 1970			1970 to 1989			1990 or Later		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	34.6%	☑	0.3%	30.5%	☑	0.3%	34.9%	☑	0.3%
Region 5	58,040	42.2%	☑	1.7%	29.0%	☑	1.4%	28.8%	☑	1.4%
Gilliam	1,070	59.1%	☑	7.5%	13.7%	⊙	3.8%	27.2%	☑	5.2%
Hood River	9,697	38.7%	☑	4.7%	27.1%	☑	3.6%	34.2%	☑	4.2%
Morrow	4,558	28.5%	☑	3.9%	32.6%	☑	3.9%	38.9%	☑	5.0%
Sherman	943	62.4%	☑	7.7%	19.8%	⊙	5.1%	17.8%	☑	4.1%
Umatilla	30,172	43.3%	☑	2.6%	30.3%	☑	2.1%	26.5%	☑	2.0%
Wasco	11,600	44.4%	☑	3.3%	28.1%	☑	2.3%	27.5%	☑	2.6%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25034: Year Structure Built, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood, damage is minimized. **Table 2-490** shows the initial and current FIRM effective dates for Region 5 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, **Flood** section.

Table 2-490. Community Flood Map History in Region 5

	Initial FIRM	Current FIRM
Gilliam County	Sept. 24, 1984	Sept. 24, 1984 (M)
Arlington	Sept. 24, 1984	Sept. 24, 1984 (M)
Condon	Sept. 24, 1984	Sept. 24, 1984 (M)
Hood River	Sept. 24, 1984	Sept. 24, 1984 (M)
Cascade Locks	Sept. 24, 1984	Sept. 24, 1984 (M)
City of Hood River	Sept. 24, 1984	Sept. 24, 1984 (M)
Morrow County	Apr. 1, 1981	Dec. 18, 2007
Boardman	Dec. 18, 2007	Dec. 18, 2007 (M)
Heppner	Apr. 1, 1981	Dec. 18, 2007
Ione	Apr. 1, 1981	Dec. 18, 2007
Irrigon	Dec. 18, 2007	Dec. 18, 2007
Lexington	Apr. 1, 1981	Dec. 18, 2007
Sherman County	Sept. 24, 1984	Sept. 24, 1984 (M)
Grass Valley	Sept. 24, 1984	Sept. 24, 1984 (M)
Rufus	Sept. 24, 1984	Sept. 24, 1984 (M)
City of Wasco	Sept. 15, 1989	Sept. 15, 1989
Umatilla County	June 15, 1978	Sept. 3, 2010
Adams	May 15, 1984	Sept. 3, 2010
Athena	July 16, 1984	Sept. 3, 2010
Echo	May 15, 1984	Sept. 3, 2010
Helix	June 1, 1984	Sept. 3, 2010
Hermiston	Oct. 28, 1977	Sept. 3, 2010
Milton-Freewater	Sept. 12, 1978	Sept. 3, 2010
Pendleton	Nov. 3, 1978	Sept. 3, 2010
Pilot Rock	Aug. 4, 1988	Sept. 3, 2010
Stanfield	Aug. 15, 1984	Sept. 3, 2010
Ukiah	Sept. 24, 1984	Sept. 3, 2010 (M)
City of Umatilla	Sept. 24, 1984	Sept. 3, 2010 (M)
Weston	Sept. 18, 1987	Sept. 3, 2010
Umatilla Indian Reservation	Sept. 3, 2010	Sept. 3, 2010
Wasco County	Sept. 24, 1984	Sept. 24, 1984 (M)
Dufur	Sept. 24, 1984	Sept. 24, 1984 (M)
Maupin	Sept. 24, 1984	Sept. 24, 1984 (M)
Mosier	Feb. 17, 1989	Feb. 17, 1989
The Dalles	Sept. 24, 1984	Sept. 24, 1984 (M)
Warm Springs Reservation	See Jefferson County	See Jefferson County

(M) = no elevation determined; all Zone A, C, and X.

Note: The Umatilla and Warm Springs Indian reservation information is provided for reference only. The State of Oregon has no jurisdiction over tribal lands.

Source: Federal Emergency Management Agency (2019), Community Status Book Report, https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 5 are shown in **Table 2-491**. The region contains 5.9% of the total value of all local critical facilities and state-owned and –leased critical and non-critical facilities in the state. Cumulatively, these assets are valued at just under two billion dollars.

Table 2-491. Value of State-Owned/Leased Critical and Essential Facilities in Region 5

	Value of Local and State-Owned/Leased Facilities				
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$ 2,630,306,288	$ 4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 5	$ 156,875,214	$ 738,485,535	$ 1,080,651,747	$ 1,976,012,496	5.9%
Gilliam	$ 726,796	$ 2,787,213	$ 38,430,450	$ 41,944,459	0.1%
Hood River	$ 20,147,398	$ 12,295,428	$ 156,277,749	$ 188,720,575	0.6%
Morrow	$ 3,295,908	$ 4,665,416	$ 111,486,000	$ 119,447,324	0.4%
Sherman	$ 2,296,321	$ 2,675,485	$ 25,910,268	$ 30,882,074	0.1%
Umatilla	$ 35,092,950	$ 692,104,032	$ 513,048,000	$ 1,240,244,982	3.7%
Wasco	$ 95,315,841	$ 23,957,961	$ 235,499,280	$ 354,773,082	1.1%

Source: DOGAMI, 2020

Land Use Patterns

Region 5 includes the Columbia River Plateau, where land uses have traditionally been dominated by agriculture and beef cattle. The vast majority of land in the region, approximately 71%, is held privately. Another quarter is owned by the federal government. Very little is owned by the state, roughly 1%, and the remainder is held by other public entities.

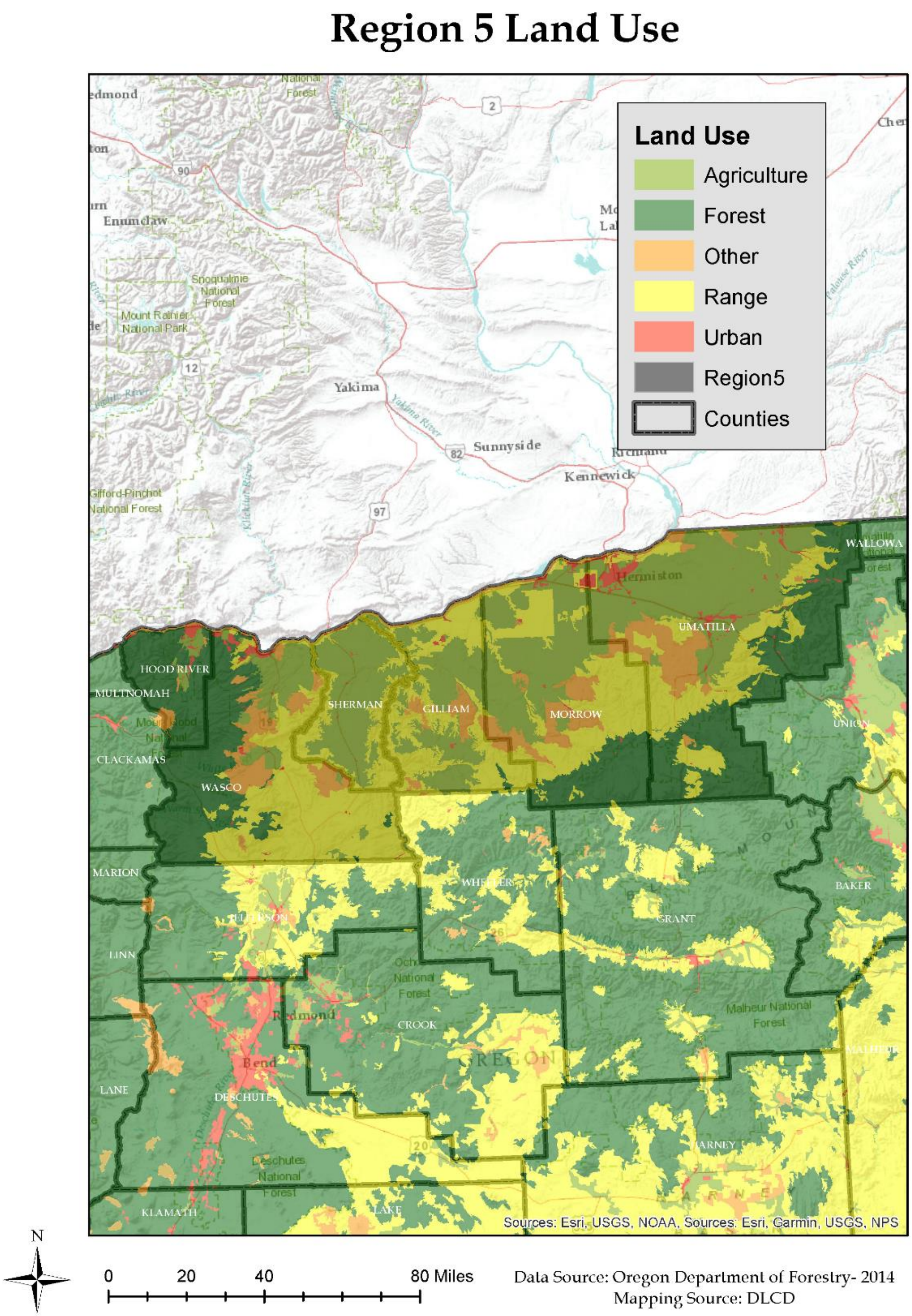
Over the past 40 years — since all counties and incorporated municipalities were required to prepare comprehensive land use plans in accordance with 19 statewide planning goals (the Land Conservation and Development Act in 1973) — little has changed in this region's land use. According to a study by the Department of Forestry, between 1974 and 2009 very little loss in the area of private land in forest, agricultural, and range uses occurred in Wasco, Gilliam, Sherman Counties. The study does note an exception in Morrow County between 1974 and 1984, where private owners converted an estimated 33,000 acres of land in wildland range use to agricultural use (Lettman G. J., 2011).

According to the Oregon Department of Forestry's most recent land-use study, "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray , Hubner , McKay, & Thompson , 2016). In Region 5, approximately 1,703 acres of resource lands were converted to more urban uses during the six-year period. **Table 2-492** shows that during this time, the percentage of resource lands converted in each county in Region 5 was less than one percent of each county's total acreage. The highest percentage of resource land conversion occurred in Hood River County, while the highest total number of acres converted to more urban uses occurred in Umatilla County.

The community of Arlington (Gilliam County) has maintained a steady growth rate, and the Port of Morrow, 25 miles to the east in Umatilla County, remains the second busiest port in Oregon. Development can be limited in Region 5 along the Columbia River partly due to the geography. For example, buildable land in the community of Hood River is partly constrained by floodplains.

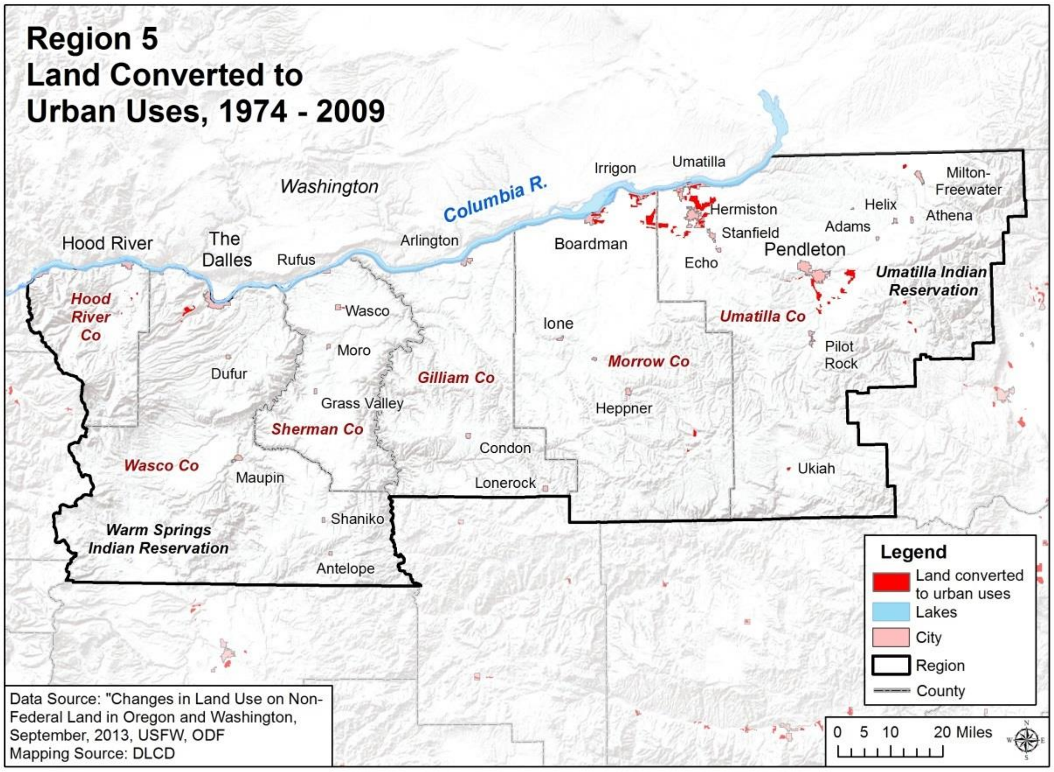
Caithness Shepherds Flat Wind Farm—located in both Morrow and Gilliam Counties—officially opened in 2012 and is one of the largest land-based wind farms in the world. Built entirely on private land, it "deploy[s] 338 wind turbines across 32,100 acres to generate 845 megawatts of clean energy..." (https://caithnessshepherdsflat.com/project-overview-2/, August 2020).

Figure 2-226. Region 5 Land Use



Source: Oregon Department of Forestry 2014

Figure 2-227. Region 5 Land Converted to Urban Uses, 1974–2009



Source: Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

Table 2-492. Region 5 Resource Lands Converted to Urban Uses, 2009-2014

	Lost Resource Lands 2009-2014		
	Total Resource Acres (2009)	Acres Converted to Urban Use	Percent Converted
Region 5	4,678,992	1,703	0.04%
Hood River	113,400	307	0.27%
Wasco	894,879	15	0.00%
Sherman	470,876	17	0.00%
Morrow	1,082,026	239	0.02%
Umatilla	1,409,018	684	0.05%
Gilliam	708,793	441	0.06%

Source: Oregon Department of Forestry, 2014; Oregon Department of Land Conservation and Development, 2020

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 5 is largely rural with urban development focused along I-84 and around the population centers of Hood River, The Dalles and Pendleton. Hood River County has the fastest growing urban population in the region, while Gilliam and Sherman Counties are entirely rural. Over the next decade, Gilliam and Sherman Counties are expected to experience population decline. Please refer to the Region 5 Risk Assessment **Demography** section for more information on population trends and forecast. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion.

The region's housing stock is largely single-family homes. However, there is nearly double the state's percentage of manufactured homes. The region's housing stock is also older than that of the state's. Although the estimates should be used with caution, it is clear that a significant share of homes in Gilliam and Sherman Counties were built before 1990 and current seismic building standards. With the exception of Morrow and Umatilla Counties, none of the region's FIRMs have been modernized or updated, leaving this region's flood maps less up to date than those of other regions.

2.3.5.3 Hazards and Vulnerability

Droughts

Characteristics

Region 5 has experienced drought conditions on several occasions. Most recently, Gilliam and Morrow County had drought emergencies declared by the Governor in 2018. Region 5 is susceptible to drought impacts, particularly since this region is predominantly supported by an agriculturally based economy.

Agricultural industries in the region are vulnerable to scarcity of water supplies during drought events. In addition, high temperatures and low precipitation associated with drought conditions reduce soil moisture, dry vegetation, and tend to enhance winds. These conditions increase the amount of soil entrained in high winds, particularly in semi-arid regions where temperatures are increasing and precipitation is decreasing, and where areas of substantial land disturbance and/or development is occurring. Thus, during extended dry and drought conditions, productive soils are vulnerable to loss, further impacting agriculture.

Historic Drought Events

Table 2-493. Historic Droughts in Region 5

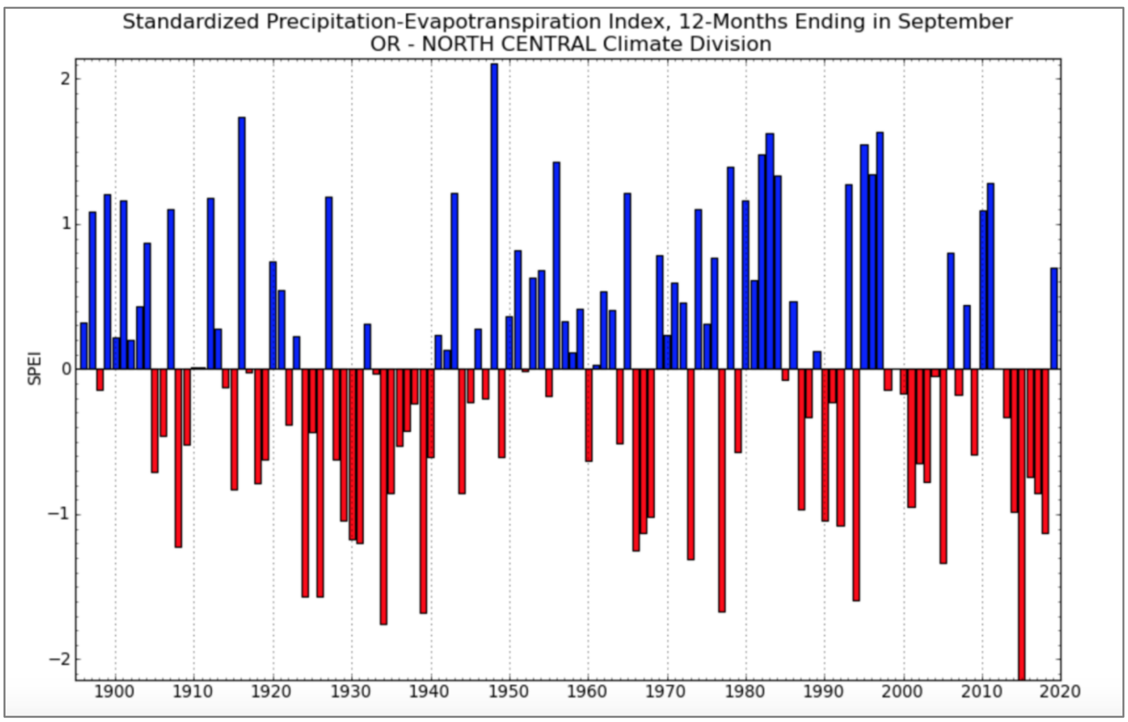
Water Year	Location	Description
1939	statewide 1938-1939, extreme drought in Region 5 in 1939-1940	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country
1977	Regions 4–8	the 1976-1977 drought was the most severe drought in the region with significant agricultural impacts
1994	Regions 4–8	in 1994 the Governor's drought declaration covered 11 counties located within regions 4, 5, 6, 7, and 8
2001	Regions 4–8 (18 counties)	Governor declared drought in Hood River, Wasco, Sherman, Gilliam, and Morrow Counties
2002	Regions 1 and 4–8	2001 drought declaration still in effect; Governor declares 5 additional counties, including Umatilla County
2003	Regions 5–8	eight counties declared; for Region 5, this included Sherman County; Hood River, Wasco, Gilliam, Morrow, and Umatilla County drought declarations from 2001 and 2002 were in effect through June 23, 2003; other counties outside of Region 5 under a drought declaration included Wheeler and Crook County from Region 6; Baker, Union, and Wallowa from Region 7; and Malheur and Harney County from Region 8; the Klamath County (Region 6) 2001 drought declaration remained in effect through December 31, 2003
2004	eastern Oregon	Governor declared drought for Morrow County in Region 5; three other counties also declared in neighboring regions
2005	Regions 5–7	all six counties within Region 5 declared drought by the Governor, along with five counties in Region 6, and two counties in Region 7
2008	Region 5 only	Governor issued a drought declaration for Sherman and Gilliam Counties in September
2013	Regions 5–8	five counties affected statewide; for Region 5: Gilliam and Morrow; Region 6: Klamath County, Region 7: Baker County, and Region 8: Malheur County
2015	statewide	All 36 Oregon Counties receive federal drought declarations, including 25 under Governor's drought declaration
2018	Regions 1, 4–8	Gilliam and Morrow County receive Governor's drought declarations, including 9 other counties in 5 other regions

Sources: Taylor Hatton (1999); Oregon Secretary of State's Archives Division; NOAA's Climate at a Glance; Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt; personal communication, Kathie Dello, Oregon Climate Service, Oregon State University

Historical drought information can also be obtained from the West Wide Drought Tracker, which provides climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. **Figure 2-228** shows years where drought or dry conditions affected the Hazard Region 5, the north central area of Oregon (Climate Division 6).

Based on this index, 2015 was the most extreme drought year. During the 1930s, there were many moderate and severe drought years. 1977 and 1994 were other severe drought years. 2018 was a moderate drought year. Years with at least moderate drought have occurred 19 times during 1895–2019 in Region 5 (Climate Divisin 6) (**Table 2-494**).

Figure 2-228. Standard Precipitation-Evapotranspiration Index for Region 5



Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-494. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 6 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
2003	1934	2015
1973	1939	
1966	1977	
1908	1994	
1931	1924	
1930	1926	
1967		
2018		
1992		
1929		
1990		
1968		

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Probability

Table 2-495. Probability of Drought in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	M	H	H	M	M

Source: OWRD, DLCD

A comprehensive risk analysis is needed to fully assess the probability and impact of drought on Oregon communities. Such an analysis should be completed statewide to analyze and compare the risk of drought across the state.

Gilliam and Morrow Counties have received drought declarations in 31% of the years since 1992 and Sherman in 28%. Umatilla has received drought declarations in 21% of the years since 1992, Hood River and Wasco 17%. These differences account for their High and Moderate probability ratings.

Climate Change

Climate models project warmer, drier summers for Oregon, including Region 5. With less confidence, climate models project increases in summer runoff and summer soil moisture for lowland parts of eastern Oregon, including Region 5. Increases in summer soil moisture are the result of increased precipitation in the spring, which dominates the effects of warming temperatures (Gergel, et al., 2017). However, Region 5, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-496. Local Assessment of Vulnerability to Drought in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	—	H	—	H

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-497. State Assessment of Vulnerability to Drought in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	M	VH	VL	VH	VH

Source: OWRD, DLCD

Oregon has not undertaken a comprehensive statewide analysis to identify which communities are most vulnerable to drought.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5. Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income. Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger. Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters. Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma. Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

Region 5's economy is based in agriculture which is very vulnerable to the impacts of drought. Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms. There is no single comprehensive source or other sources for information to assess economic impacts.

Morrow, Umatilla, and Wasco Counties all have very high social vulnerability ratings meaning that any natural hazard would have a significant impact on their populations. Hood River County's social vulnerability rating is moderate; Gilliam and Sherman Counties' social vulnerability ratings are very low. Morrow, Umatilla, and Wasco Counties are considered those most vulnerable to drought in Region 5.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $1,080,652,000. Because drought could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 5 since the beginning of 2015. Nevertheless, none of the recorded losses was due to drought.

Risk

Table 2-498. Risk of Drought in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	L	M	VH	L	H	H

Source: OWRD, DLCD

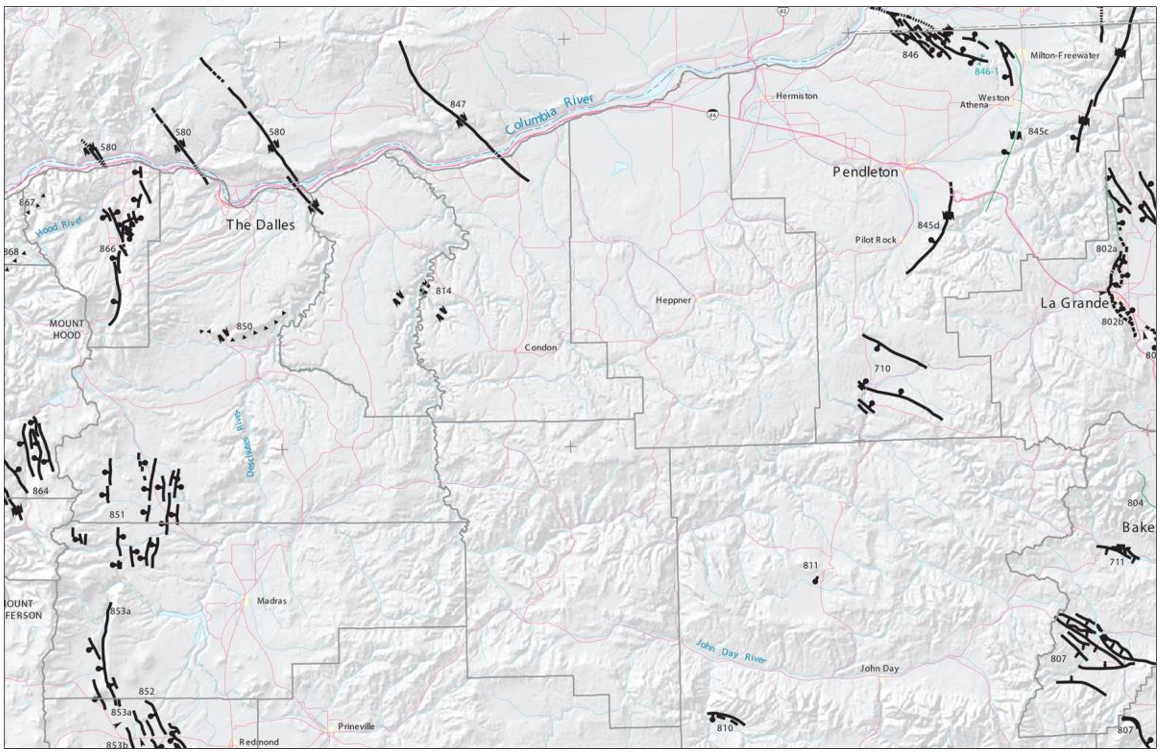
With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based the history of drought declarations, the counties' social vulnerability ratings, and the potential for drought to impact the agricultural economy, Morrow County is considered to be at very high risk from drought, and Umatilla and Wasco Counties at high risk. Hood River is considered to be at moderate risk, Gilliam and Sherman Counties at low risk.

Earthquakes

Characteristics

The geographic position of this region makes it susceptible to earthquakes from three sources: subduction zone, intraplate, and crustal events. The map below shows the location of the known crustal faults which could affect the region. Because only certain faults have been studied in detail and determined to be active, there may be many more crustal faults in the region capable of producing earthquakes which have not yet been identified. **Figure 2-229** shows the locations of faults in Region 5.

Figure 2-229. Quaternary Faults and Folds in Region 5

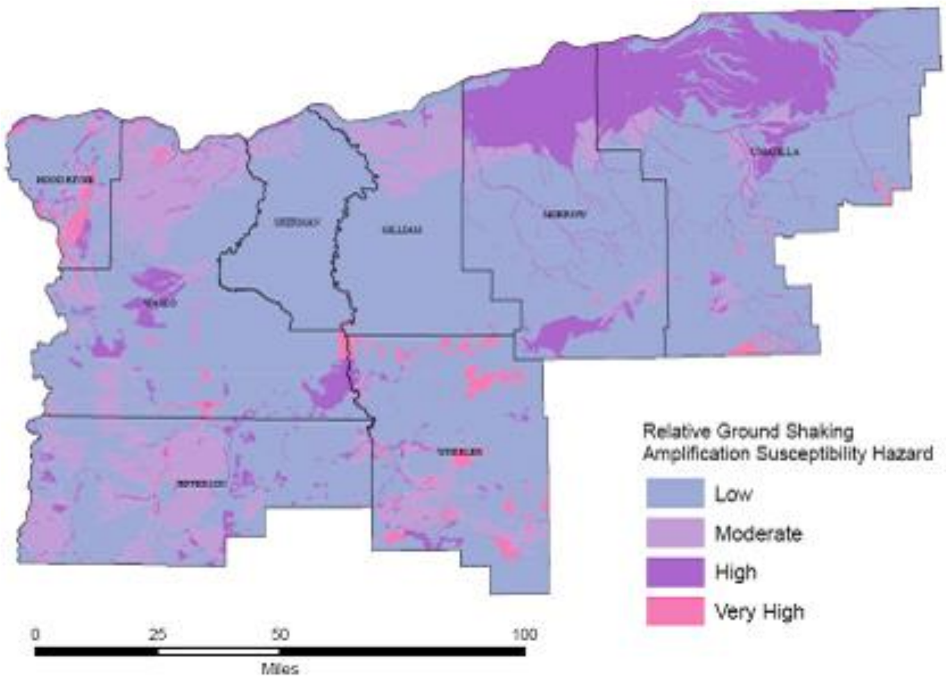


Source: Modified from Personius, et al. (2003)

When all of these earthquake sources are added together, the general earthquake hazard in the region can be displayed as a whole and is reflected in the USGS national seismic hazard maps. When compared to the rest of the United States, most of the region is within a relatively moderate seismicity area, except for Hood River and Wasco Counties which are mostly within relatively moderate to high zones.

[Figure 2-230](#) displays the relative ground shaking amplification hazard throughout Region 5.

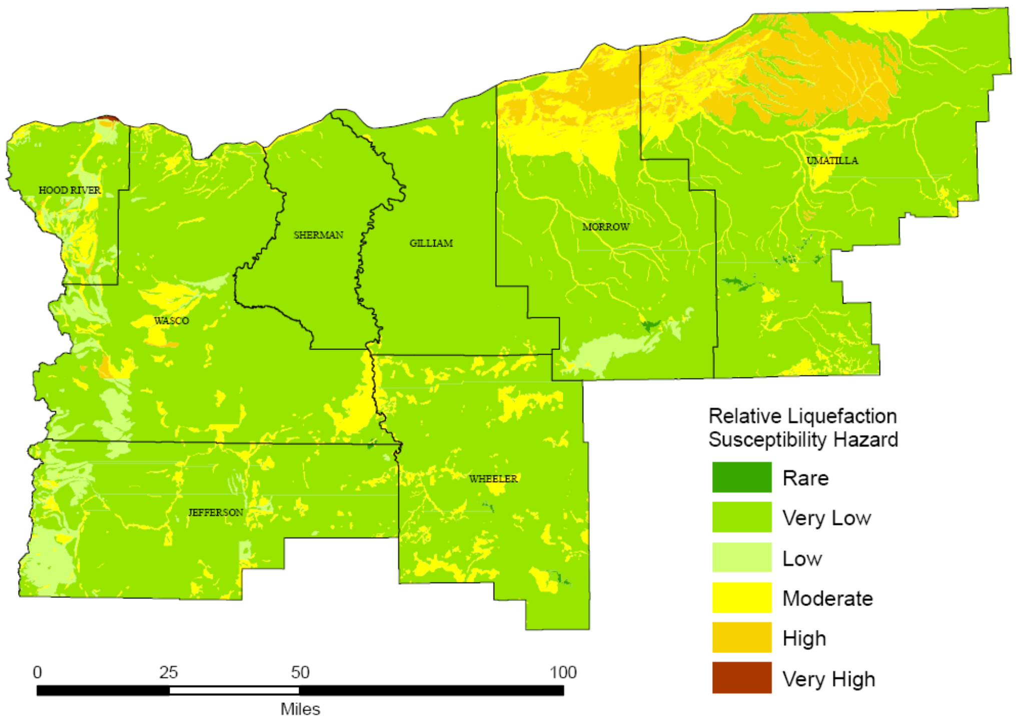
Figure 2-230. Relative Ground Shaking Amplification Hazard in Region 5



Source: Burns, 2007

During seismic shaking, deposits of loose saturated sands can be subjected to contraction resulting in an increase in pore water pressure. If the increase in pore water pressure is high enough, the deposit becomes "liquefied," losing its strength and its ability to support loads. Figure 2-231 displays the relative liquefaction hazard throughout Region 5.

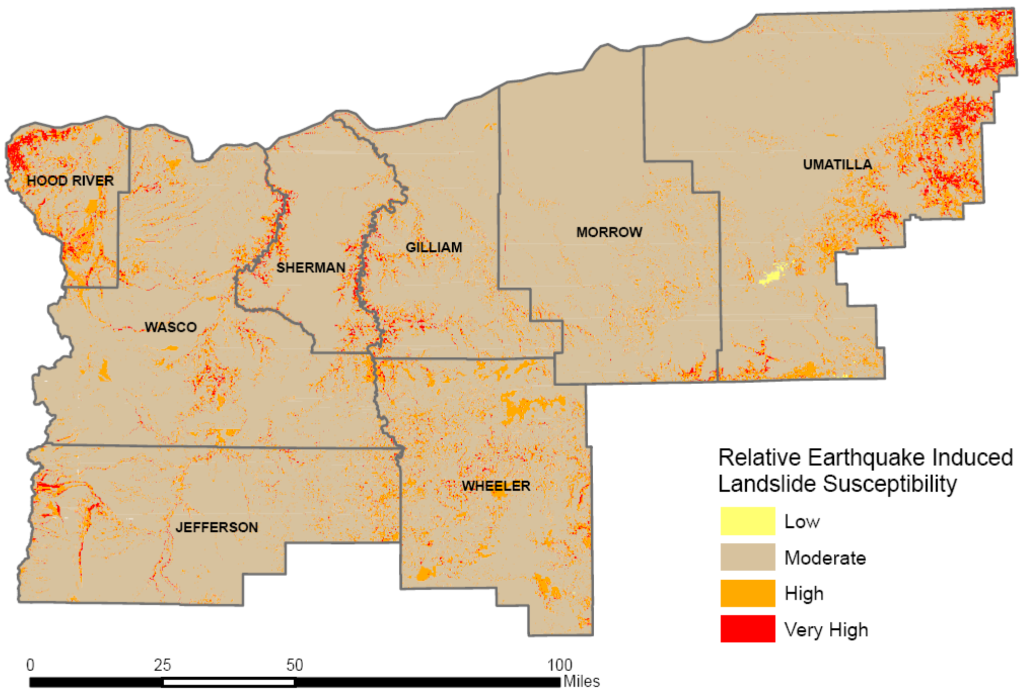
Figure 2-231. Relative Liquefaction Susceptibility Hazard in Region 5



Source: Burns, 2007

Strong ground shaking can also cause landslides and reactivate dormant landslides. Commonly, slopes that are marginally stable prior to an earthquake become unstable and fail. Some landslides result from liquefaction that causes lateral movement of soil, or lateral spread. Figure 2-232 displays the relative earthquake induced landslide hazard throughout Region 5.

Figure 2-232. Relative Earthquake-Induced Landslide Susceptibility Hazard in Region 5

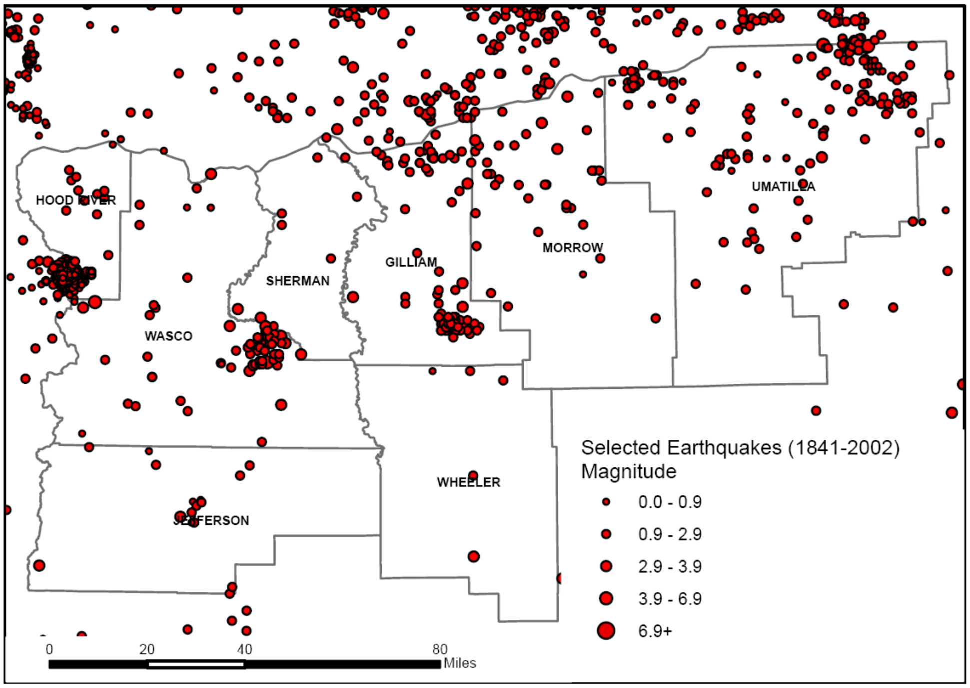


Source: Burns, 2007

Region 5 has experienced many earthquakes as shown in Figure 2-233 and Table 2-499. Three historic earthquakes of significance that were centered in the region are the 1893 Umatilla, 1936 Milton-Freewater (M6), 1951 Hermiston, and 1976 Maupin area (M4.8), all shallow crustal earthquakes. There are faults in the region that have been active in the last 20,000 years. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area.

The map displays over 1,000 earthquakes that have been recorded in the region during the last century. Because the instrument network in the region was very sparse until the mid-2000s, it is likely that thousands of earthquakes have occurred in the region but were not recorded and thus do not appear on this map.

Figure 2-233. Selected Earthquakes in Region 5, 1841–2002



Source: Niewendorp and Neuhaus (2003)

Historic Earthquake Events

Table 2-499. Significant Earthquakes Affecting Region 5

Date	Location	Magnitude (M)	Comments
Approximate years: 1400 BCE, 1050 BCE, 600 BCE, 400, 750, 900	offshore, Cascadia subduction zone	probably 8-9	these are the midpoints of the age ranges for these six events
Jan. 26, 1700	offshore, Cascadia Subduction zone	about 9	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Nov. 23, 1873	near Brookings, Oregon, at the Oregon-California border	6.8	may have been an intraplate event because of lack of aftershocks; felt as far away as Portland and San Francisco
Mar. 1893	Umatilla, Oregon	VI-VII (Modified Mercalli Intensity)	damage: unknown
July 15, 1936	Milton-Freewater, Oregon	6.4	two foreshocks and many aftershocks felt; damage: $100,000 (in 1936 dollars)
Apr. 13, 1949	Olympia, Washington	7.1	fatalities: eight; damage: $25 million (in 1949 dollars); cracked plaster, other minor damage in northwest Oregon
Jan. 1951	Hermiston, Oregon	V (Modified Mercalli Intensity)	damage: unknown
Nov. 5, 1962	Portland, Oregon and Vancouver, Washington	5.5	shaking up to 30 seconds; chimneys cracked, windows broke, furniture moved
May- June 1968	Adel	5.1	Increased flow at a hot spring
Apr. 12, 1976	near Maupin, Oregon	4.8	sounds described as distant thunder, sonic booms, and strong wind
Apr. 25, 1992	Cape Mendocino, California	7.0	subduction earthquake at the triple-junction of the Cascadia subduction zone and the San Andreas and Mendocino faults
Mar. 25, 1993	Scotts Mill	5.6	center: Mount Angel-Gates Creek fault; damage: $30 million, including Molalla High School and Mount Angel church
Sep. 20, 1993	Klamath Falls	5.9 and 6.0	fatalities: two; damage: $10 million, including county courthouse; rockfalls

Note: No significant earthquakes have affected Region 5 since September 1993.

*BCE: Before Common Era.

Sources: Wong, et al. (1995); Pacific Northwest Seismic Network, https://pnsn.org/

Probability

Table 2-500. Local Probability Assessment of Earthquakes in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	L	VH	L	L	L	M

Source: DOGAMI, 2020

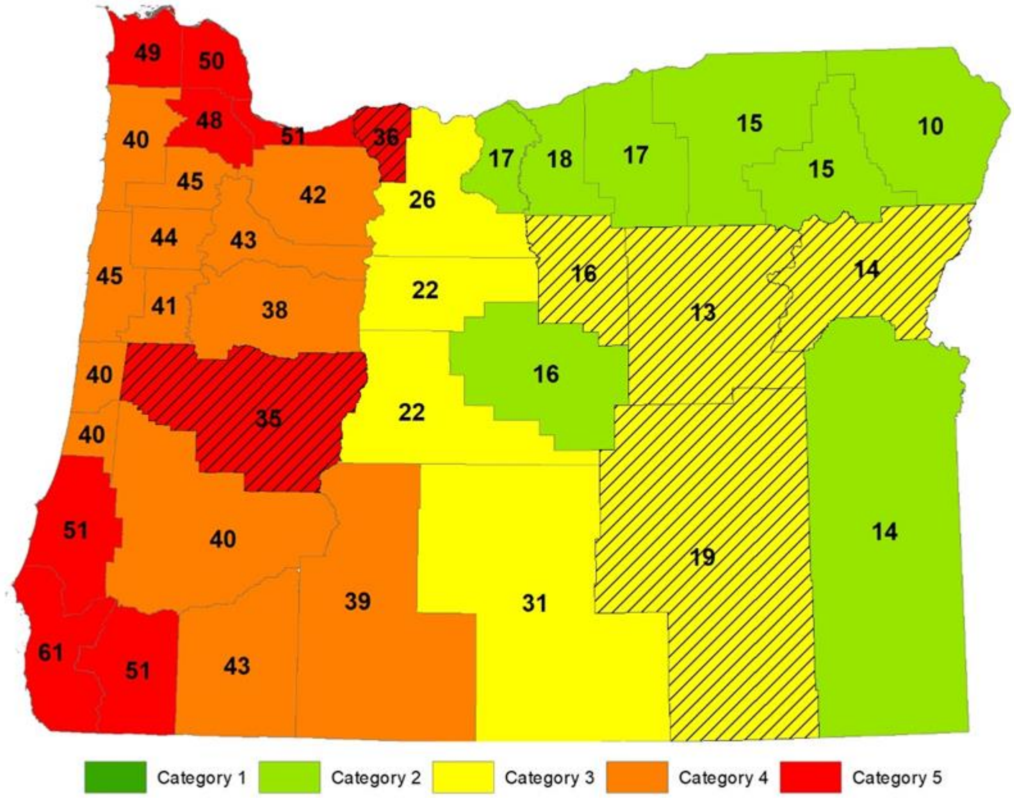
The probability of damaging earthquakes varies widely across the state. In Region 5, the hazard is dominated by local faults and background seismicity.

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-234**.

Figure 2-234. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.

Source: DOGAMI, 2020

Vulnerability

Table 2-501. Local Assessment of Vulnerability to Earthquakes in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	M	L	M	M

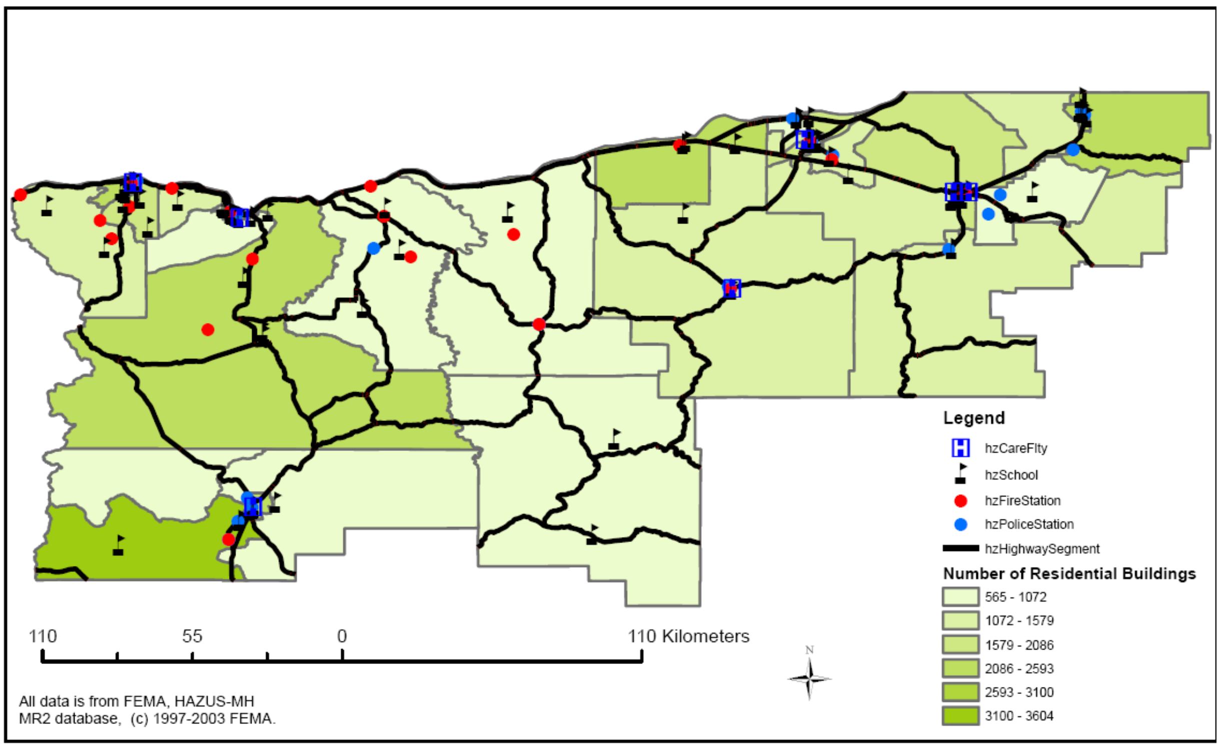
Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-502. State Assessment of Vulnerability to Earthquakes in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	VH	VH	VL	VH	H

Source: DOGAMI and DLCD, 2020

Figure 2-235. Region 5 Generalized Earthquake Hazard Exposure



Data are from Hazus-MH MR2 database.

Source: Burns (2007)

Most of the people and infrastructure are along the I-84 corridor, which runs along the northern portion of the region. This multimodal transportation corridor is vital to Oregon's economy and includes a major interstate highway (I-84); two transcontinental rail lines, Union Pacific and Burlington Northern Santa Fe; the Columbia River inland water navigation; major electric power and gas lines; and communication conduits. Roughly $14 billion worth of goods are carried through the corridor each year (Wang & Chaker, 2004). **Figure 2-236** displays the general exposure of the region.

The geographic size of the region is roughly 13,700 square miles and contains 36 census tracts. There are over 54,000 households in the region and it has a total population of over 150,000 people (FEMA, 2006). There are an estimated 52,000 buildings in the region with a total building replacement value (excluding contents) of $8.5 billion. Approximately 99% of the buildings (and 84% of the building value) are associated with residential housing. The replacement values of the transportation system and utility lifeline systems are estimated to be approximately $16.5 billion and $4.8 billion, respectively.

Table 2-503 shows the number of school and emergency response buildings surveyed in each county and their respective rankings.

Table 2-503. School and Emergency Response Buildings Collapse Potential in Region 5

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Gilliam	4	2	5	4
Hood River	18	14	7	13
Morrow	11	10	7	5
Sherman	5	4	3	—
Umatilla	40	24	46	16
Wasco	23	7	10	—

Source: DOGAMI 2007. Open-File Report 07-02, Statewide Seismic Needs Assessment Using Rapid Visual Assessment.

As mentioned in the State Risk Assessment, DOGAMI developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) a M6.5 Arbitrary Crustal event and (b) a 2,500 year mean return period probabilistic earthquake scenario (2,500-year Model). Both models are based on Hazus-MH, a computer program currently used by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The arbitrary crustal event is based on a potential M6.5 earthquake generated from an arbitrarily chosen fault using the Hazus software, and assuming a worst-case scenario. The 2,500-year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults, each with a 2% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single “average” earthquake during this time.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models do provide some approximate estimates of damage. Results are found in **Table 2-504**, **Table 2-505**, and **Table 2-506.**

Table 2-504. Total Building, Transportation, and Utility Exposure and Potential Losses in Region 5 from a 2,500-Year-Return Interval Ground Motion

Region 5 Counties	**Building Exposure**	**Transportation Exposure**	**Utility Exposure**	**Total Exposure**	
Gilliam	$148,000,000	$1,777,000,000	$153,000,000	$2,078,000,000	
Hood River	$1,282,000,000	$1,413,000,000	$702,000,000	$3,397,000,000	
Jefferson	$1,009,000,000	$1,185,800,000	$405,910,000	$2,600,710,000	
Morrow	$517,000,000	$1,592,600,000	$740,040,000	$2,849,640,000	
Sherman	$124,000,000	$1,299,700,000	$117,520,000	$1,541,220,000	
Umatilla	$3,837,000,000	$4,956,900,000	$1,390,340,000	$10,184,240,000	
Wasco	$1,513,000,000	$3,305,400,000	$1,162,950,000	$5,981,350,000	
Region Total	**$8,430,000,000**	**$15,530,400,000**	**$4,671,760,000**	**$28,632,160,000**	
	Building Losses	Transportation Losses	Utility Losses	Total Losses	Loss % of Total
Gilliam	$6,300,000	$12,700,000	$6,040,000	$25,040,000	1.2%
Hood River	$153,510,000	$85,900,000	$102,990,000	$342,400,000	10.1%
Jefferson	$54,580,000	$15,600,000	$16,790,000	$86,970,000	3.3%
Morrow	$178,540,000	$49,300,000	$106,800,000	$334,640,000	11.7%
Sherman	$5,600,000	$45,300,000	$5,810,000	$56,710,000	3.7%
Umatilla	$736,640,000	$200,600,000	$135,480,000	$1,072,720,000	10.5%
Wasco	$191,010,000	$82,400,000	$116,890,000	$390,300,000	6.5%
Region Total	**$1,326,180,000**	**$491,800,000**	**$490,800,000**	**$2,308,780,000**	**8.0%**

Source: W. J. Burns, 2007, unpublished report: Hazards, Earthquake and Landslide Hazard Maps, and Future Earthquake Damage and Loss Estimates for Seven Counties in the Mid-Columbia River Gorge Region Including Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Jefferson, and Wheeler

Table 2-505. Estimated Losses in Region 5 Associated with an Arbitrary M6.5 Crustal Event

	Region 5 Counties					
	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Injuries (5 pm time frame)	3	120	126	4	208	220
Deaths (5 pm time frame)	0	6	7	0	10	13
Displaced households	3	419	521	6	1,048	720
Economic Losses for buildings	$9.21 mil	$189.96 mil	$109.9 mil	$8.4 mil	$248.68 mil	$307.09 mil
Operational the day after the event: Fire stations Police stations Schools Bridges	 100% 100% 100% 100%	 60% 0% 21% 100%	 50% 100% 43% 100%	 0% 0% 33% 88%	 75% 79% 88% 99%	 50% 0% 27% 98%
Economic losses to infrastructure: Highways Airports Communications	 $0.1 mil $3.2 mil 0	 $37.2 mil $7.3 mil $0.08 mil	 $43.5 mil $1.7 mil 0	$33.1 mil $2 mil 0	 $77 mil $16.5 mil $0.05 mil	 $35.5 mil $13.3 mil $0.08 mil
Debris generated (million tons)	0	0	0	0	0	0

Source: W. J. Burns, 2007, DOGAMI unpublished report: Geologic hazards, earthquake and landslide hazard maps, and future earthquake damage and loss estimates for seven counties in the Mid-Columbia River Gorge Region including Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Jefferson, and Wheeler

Table 2-506. Estimated Losses in Region 5 Associated with a 2,500-Year Probable M6.5 Driving Scenario

	Region 5 Counties					
	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Injuries (5 pm time frame)	2	111	164	2	623	136
Deaths (5 pm time frame)	0	6	8	0	32	8
Displaced households	0	303	768	1	2,957	373
Economic Losses for buildings	$6.3 mil	$153.51 mil	$178.54 mil	$5.68 mil	$736.64 mil	$191.01 mil
Operational the day after the event:						
Fire stations	100%	20%	0%	66%	25%	75%
Police stations	100%	100%	50%	100%	21%	67%
Schools	100%	14%	14%	100%	28%	33%
Bridges	100%	82%	100%	76%	93%	96%
Economic losses to infrastructure:						
Highways	$6.3 mil	$71.9 mil	$36.4 mil	$42.2 mil	$173.8 mil	$63.1 mil
Airports	$5.7 mil	$7.6 mil	$5.2 mil	$1.8 mil	$19.7 mil	$15.8 mil
Communications	$0	$0.05 mil	$0	$0	$ 0.24 mil	$0.05 mil
Debris generated (million tons)	0	0	0	0	0	0

Source: W. J. Burns, 2007, DOGAMI unpublished report: Geologic hazards, earthquake and landslide hazard maps, and future earthquake damage and loss estimates for seven counties in the Mid-Columbia River Gorge Region including Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Jefferson, and Wheeler

State-Owned/Leased Buildings And Critical Facilities And Local Critical Facilities

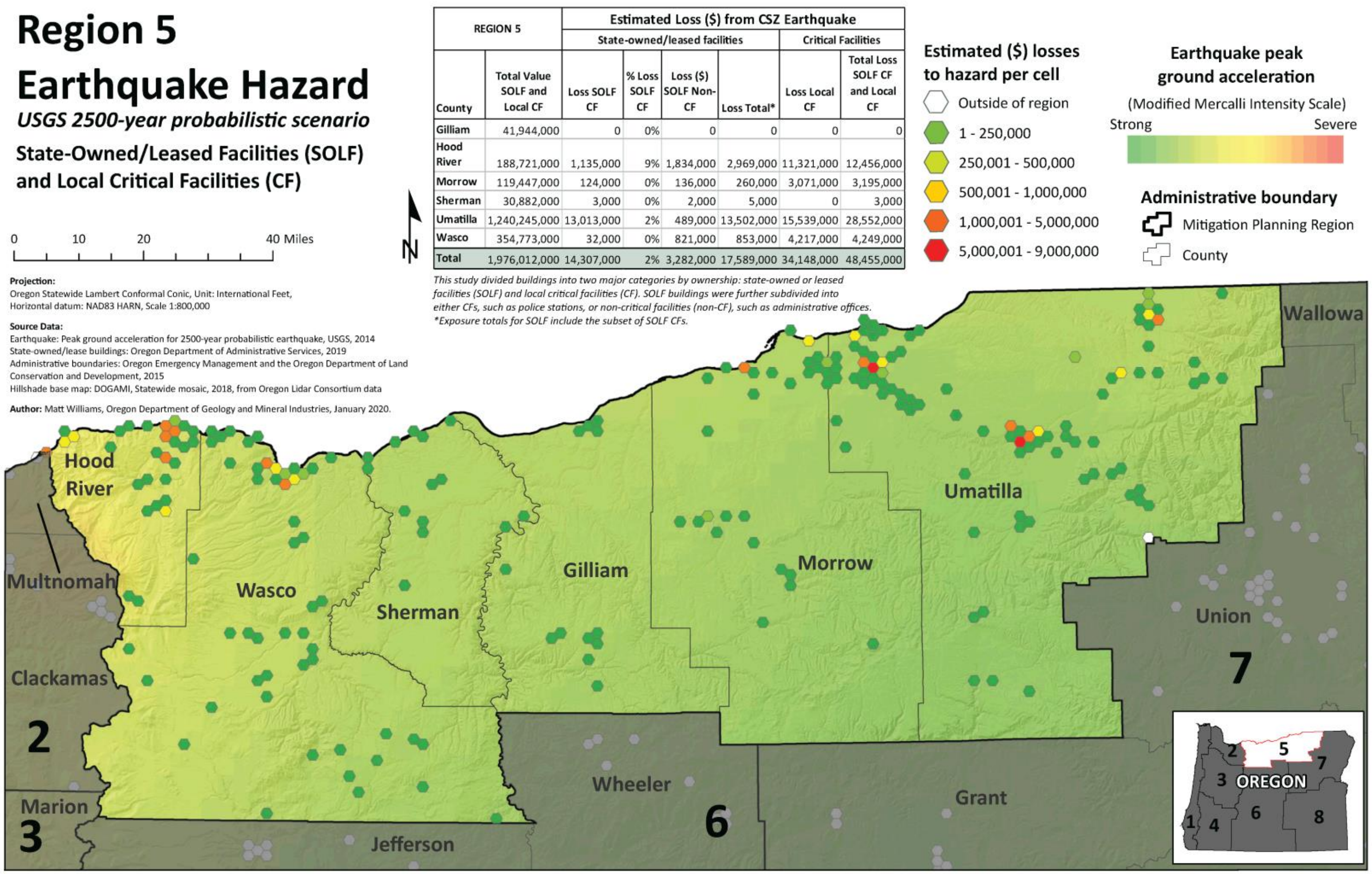
For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a 2500-year probabilistic earthquake scenario in Region 5. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 5, a 2500-year probabilistic earthquake scenario could cause a potential loss of over $17.5M in state building and critical facility assets, 77% of it in Umatilla County alone. The potential loss in local critical facilities is about double, over $34M. Almost half (46%) of the potential loss in local critical facilities is in Umatilla County, and 33% in Hood River County.

Figure 2-236 illustrates the potential loss to state buildings and critical facilities and local critical facilities from a 2500-year probabilistic earthquake scenario.

Figure 2-236. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in an Earthquake Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Estimated Loss ($) from CSZ Earthquake						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*	Loss Local CF	Total Loss SOLF CF and Local CF
Gilliam	41,944,000	0	0%	0	0	0	0
Hood River	188,721,000	1,135,000	9%	1,834,000	2,969,000	11,321,000	12,456,000
Morrow	119,447,000	124,000	0%	136,000	260,000	3,071,000	3,195,000
Sherman	30,882,000	3,000	0%	2,000	5,000	0	3,000
Umatilla	1,240,245,000	13,013,000	2%	489,000	13,502,000	15,539,000	28,552,000
Wasco	354,773,000	32,000	0%	821,000	853,000	4,217,000	4,249,000
Total	1,976,012,000	14,307,000	2%	3,282,000	17,589,000	34,148,000	48,455,000

Source: DOGAMI

Historic Resources

Of the 2, 456 historic resources in Region 5, only 72 are in an area of high or very high liquefaction potential. Seventy of the 72 are in Umatilla County. However, 1,764 (72%) of Region 5's historic resources are located in areas of high or very high potential for ground shaking amplification. Most of those are located Hood River County followed by Umatilla County.

Archaeological Resources

Two thousand five hundred twenty archaeological resources are located in earthquake hazard areas in Region 5. Only 13 are located in an area of high earthquake hazards, and only one of them is listed on the National Register of Historic Places. The other twelve have not been evaluated as to their potential for listing. Most archaeological resources in earthquake hazard areas in Region 5 are located in Wasco County, followed by Umatilla and Gilliam Counties.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5. Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income. Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger. Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters. Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma. Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Hood River, Morrow, and Umatilla Counties are very highly vulnerable to earthquake hazards. Wasco County is highly vulnerable. Gilliam and Sherman Counties have very low vulnerability.

Seismic Lifelines

"Seismic lifelines" are the state highways ODOT has identified as most able to serve response and rescue operations, reaching the most people and best supporting economic recovery. The process, methodology, and criteria used to identify them are described in Section **2.1.6, Seismic**

Transportation Lifeline Vulnerabilities, and the full report can be accessed at Appendix **9.1.16**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification* (OSLR). According to that report, seismic lifelines in Region 5 have the following vulnerabilities.

The following geographic zones identified in the OSLR are located within Region 5:

- Cascades Geographic Zone: OEM Mitigation Planning Region 5 is located in part within the OSLR Cascades Geographic Zone. Two crossings of the Cascades from western to central Oregon are partly within this zone and connect the highly seismically impacted western portion of the state to the less seismically impacted central portion of the state. The area contains one Tier 1 route: I-84. It also contains part of the Tier 2 route: OR-212 and US-26.
- Central Geographic Zone: Region 5 also encompasses the northerly part of the Central Geographic Zone, which contains Tier 1 routes I-84 from The Dalles to Biggs Junction and US-97. These roadways are subject to rockfall risks in several areas. There are no Tier 2 routes in this region, and one Tier 3 corridor: the north end of US-197.

REGIONAL IMPACT.

- Ground shaking: Ground shaking damage from a CSZ event is not expected to be significant in Region 5.
- Landslides and rockfall: Landslide and rockfall damage are not anticipated to be activated by a CSZ event in Region 5.
- Liquefaction: Structures in wetland, alluvial, and other saturated areas may be subject to liquefaction damage, particularly in areas associated with the Columbia River near the western end of Region 5.
- Other: Damage to shipping channels and shore facilities, and failure of Columbia River bridges west of Region 5 may have long-term impacts on freight shipments into and out of Region 5.

REGIONAL LOSS ESTIMATES. The highway-related losses include disconnection from supplies and replacement inventory, and the loss of tourists and other customers who must travel to do business with affected businesses.

MOST VULNERABLE JURISDICTIONS. Gilliam, Hood River, Morrow, Sherman, Umatilla and Wasco Counties have similar, relatively low vulnerability to ground shaking from a CSZ event. However, connections to markets and services will likely be disrupted due to the vulnerability of river transportation, ports, and surface routes to freight intermodal connections in the Portland Metro area.

Risk

Table 2-507. Assessment of Earthquake Risk in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	VL	VH	H	VL	H	H

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Hood River is at greatest risk from earthquakes in Region 5 followed by Morrow, Umatilla, and Wasco Counties.

Extreme Heat

Characteristics

Extreme temperatures are common in Region 5 and the frequency of prolonged periods of high temperatures has increased. Pendleton has an average of about 31 days per year above 90°F. Extreme heat can affect commerce, agriculture, fisheries, and overall quality of life.

Historic Extreme Heat Events

Table 2-508. Historic Extreme Heat Events in Region 5

Date	Location	Notes
July 10–14, 2002	Region 5–7	A record breaking heat wave shattered many daily record high temperatures across the state, with a few locations breaking all-time records.
June 24–26, 2006	Region 1–3, 5	A broad upper ridge of unusually high height coupled with a thermally induced surface trough of low pressure lingered over the Pacific Northwest for several days. This pattern resulted in persistent offshore flow, and therefore many days of record-smashing high temperatures. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row.
July 20-24, 2006	Region 1–3, 5, 7	An unusually strong ridge of high pressure brought several days of record breaking hot and humid weather to NW Oregon. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row. Many daily maximums were between 10 and 20 degrees above normal. A few sites reported record high minimum temperatures during this very humid event; a couple broke all-time record high minimums as well. 4500 homes lost power during this event. In north central and eastern Oregon, daily maximum temperatures between 100 and 113 degrees were observed at lower elevations, with temperatures 90 to 100 degrees at elevations up to 4000 feet. Several people were treated for heat related illness.
June 28–30, 2008	Region 2, 3, 5, 7	An upper level ridge and thermal trough across the Pacific Northwest produced temperatures above 100 degrees for two consecutive days breaking records in many locations. Two people died of heat-related illness.
August 15–17, 2008	Region 5–7	Excessive Heat Event: An upper level ridge and dry air brought excessive heat into eastern Oregon. Many locations experienced multiple days of at least 100 degree temperatures.
July 25–26, 2010	Region 5, 7	Excessive Heat Event: Temperatures topped 100 degrees for two successive days in Hermiston, Pendleton, 5 miles northeast of Pendleton, Ione, Echo, Arlington, and Umatilla.
August 1, 2011	Region 5	A dry weak westerly flow aloft under a broad upper level high pressure system combined with a surface thermal trough to bring several days of temperatures in the 90s.

Source: https://www.ncdc.noaa.gov/stormevents

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning "very low." Region 5 relative probability rankings are shown in **Table 2-509**. Extreme heat frequency relative to the rest of the state is very high, highest in the state. Hood River County is an exception here in that it is climatically similar to Region 2.

Table 2-509. Probability of Extreme Heat in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	VH	VL	VH	VH	VH	VH

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Region 5 experiences some of the hottest temperatures in the state and is projected to experience greater frequency of extreme temperatures under future climate change. **Table 2-510** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 5.

Table 2-510. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 5 Counties

County	Historic Baseline	2050s Future
Gilliam	14	43
Hood River	2	12
Morrow	12	38
Sherman	13	42
Umatilla	10	35
Wasco	9	34

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

Vulnerability

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, Extreme Heat. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are houseless.

Because extreme heat is common in Region 5 ("high" probability), many people are accustomed or prepared in terms of air conditioning when an extreme heat event occurs ("high" adaptive capacity). In Cooling Zone 3, which includes Wasco and Umatilla counties, 91% of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf). In Cooling Zones 1 and 2, which includes Hood River, Sherman, Gilliam, and Morrow counties, just over half of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1–2 earned a ranking of 1 (very low); scores of 3–4 earned a ranking of 2 (low); scores of 5–6 earned a ranking of 3 (moderate); scores of 7–8 earned a ranking of 4 (high); and scores of 9–10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-511 displays the total vulnerability rankings as well as ranking for sensitivity and adaptive capacity for each county in NHMP Region 5. **Table 2-512** provides the summary descriptors of Region 5's vulnerability.

Combining sensitivity and adaptive capacity, Region 5's relative vulnerability to extreme heat is "Moderate". With high relative vulnerability, Morrow County is the most vulnerable to extreme heat in Region 5.

Table 2-511. Relative Vulnerability Rankings for Region 5 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 5	**3**	**2**	**3**
Gilliam	1	3	2
Hood River	3	3	3
Morrow	5	3	4
Sherman	1	3	2
Umatilla	5	1	3
Wasco	5	1	3

Source: Oregon Climate Change Research Institute

Table 2-512. State Assessment of Vulnerability to Extreme Heat in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	L	M	H	L	M	M

Source: Oregon Climate Change Research Institute

Region 5 counties did not rank vulnerability to extreme heat.

As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. High temperature and insufficient water stunt plant growth and cause areas of crops to wither. Some livestock, especially dairy cattle, are also sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms.

Like drought, impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. However, the appropriate data are not available to assess impacts of heat waves on agriculture and subsequent effects on the state economy.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $1,080,652,000. Because extreme heat could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 5 since the beginning of 2015. Nevertheless, none of the recorded losses was due to extreme heat.

Risk

With respect to extreme heat, risk is defined as the combination of the probability of extreme heat events, sensitivity to extreme heat, and level of adaptive capacity in response to extreme heat.

The total relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total risk scores of 1–2 earned a ranking of 1 (“very low”); scores of 3–4 earned a ranking of 2 (“low”); scores of 5–6 earned a ranking of 3 (“moderate”); scores of 7–8 earned a ranking of 4 (“high”); and scores of 9–10 earned a ranking of 5 (“very high”). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-513 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 5. Table 2-514 provides the summary descriptors of Region 5’s risk to extreme heat.

Combining probability and vulnerability, Region 5’s relative risk to extreme heat is “High.” Morrow County’s relative risk is “Very High.”

Table 2-513. Risk Rankings for Region 5 Counties

County	Probability	Vulnerability	Risk
Region 5	**4**	**3**	**4**
Gilliam	5	2	4
Hood River	1	3	2
Morrow	5	4	5
Sherman	5	2	4
Umatilla	5	3	4
Wasco	5	3	4

Source: Oregon Climate Change Research Institute

Table 2-514. Risk of Extreme Heat in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	H	L	VH	H	H	H

Source: Oregon Climate Change Research Institute

Floods

Characteristics

Region 5 is subject to a variety of flood conditions. The most common type of flooding is associated with unseasonably warm weather during the winter months, which can quickly melt snow. This condition has produced devastating floods throughout the region. Flash floods, another type of flooding experienced in the region, are almost always a summer phenomenon associated with intense local thunderstorms. The flash flood of June 1903 in the City of Heppner (Morrow County) is a benchmark event. No flood in Oregon has been more lethal: 247 fatalities. Heppner's vulnerability to flash flood hazards has since been reduced through the construction of the Willow Creek Dam. The region's other flood events are linked to normal seasonal snowmelt and runoff from agricultural fields.

There are several rivers in the region that produce natural extreme flood conditions. Surprisingly, the Columbia is not one of them, nor is the lower Deschutes or the John Day. The Columbia is regulated by up-stream dams. A swollen Columbia River, however, can back up tributary streams to the point where they constitute a significant hazard. This has occurred on a number of occasions. The lower Deschutes and John Day are confined to fairly deep canyons with small floodplains. Consequently, they do not present the flood problems associated with smaller rivers, such as the Umatilla, the Walla Walla, and their tributaries.

The Federal Emergency Management Agency (FEMA) has mapped most flood-prone streams in Oregon. The maps depict the 1% flood (100-year) upon which the National Flood Insurance Program is based. All of the Region 5 counties have Flood Insurance Rate Maps (FIRM); however, some of the maps are old and could be outdated. The FIRM maps were issued at the following times:

- Gilliam, September 24, 1984;
- Hood River, September 24, 1984;
- Morrow, December 18, 2007;
- Sherman, September 24, 1984;
- Umatilla, September 2010; and
- Wasco, September 24, 1984.

Updates to FIRMS using high definition LiDAR are underway for Wasco, Sherman and Hood River counties through the Middle Columbia Hood Watershed Risk MAP project.

Historic Flood Events

Table 2-515. Significant Historic Floods Affecting Region 5

Date	Location	Description	Type of Flood
June 1894	main stem Columbia River (Region 5 communities)	largest flood observed on the Columbia River (1,200,000 cfs); City of Umatilla inundated; widespread damage	snow melt
June 1903	Morrow County (Willow Creek)	very devastating flash flood; 40-ft wall of water in City of Heppner; 247 fatalities; 141 homes destroyed	flash flood
Jan. 1923	Mid-Columbia region	widespread flooding; unusually warm weather, intense rain	rain on snow

Date	Location	Description	Type of Flood
Jan. 1933	Mid-Columbia region	widespread flooding; heavy mountain snowpack followed by rain and mild temperatures	rain on snow
Dec. 1955	Mid-Columbia region	mild temperatures and rain; farms, highways flooded	rain on snow
Dec. 1964	entire state	record-breaking floods throughout state; heavy snow in mountains followed by intense rain; considerable flood damage	rain on snow
July 1965	Lane/Spears Canyons (Umatilla County)	thunderstorm; 8–10 ft wall of water from canyon; considerable damage; one fatality; several people injured	flash flood
Dec. 1980	Polallie Creek (Hood River County)	debris flow from vicinity of Mount Hood; debris dam formed a small lake that was later breeched; damage to highways and utilities	debris flow
Feb. 1985	Umatilla County	warm rain on snow at higher elevations; flooding throughout county	rain on snow
Feb. 1986	entire state	warm rain on snow; widespread flooding; considerable damage	rain on snow
May 1998	central and eastern Oregon	widespread flooding; rain melting mountain snow	rain on snow
Aug. 2003	Gilliam County	$7,000 in property damage	
Aug. 2003	Sherman County	Flash flood (Gerking Canyon) *excerpted from State Plan, 2006	flash flood
Apr. 2005	Morrow County	$2,000 in property damage	
Apr. 2005	Umatilla County	$170,000 in property damage	
Mar. 2006	Morrow County	flash flood from a collapsed irrigation dike embankment floods the south side of I-84 near Boardman, closing down the road	flash flood
Nov. 2006	Hood River County	Hood River near the City of Hood River caused extensive damage on OR-35 closing the highway for a month; moderate damage done to irrigation works; total $30 million in damage	riverine
May/June 2011	Morrow County	intense rainfall in the Heppner and Lexington areas resulting in damage to roads, bridges, and the Morrow County Fairgrounds; total of $164,000 in damage	flash flood
June 2011	Heppner	persistent showers with heavy rainfall of 1 to 2 inches produced flooding on Willow and Hinton Creeks; flash flooding on Hinton and Willow Creeks damaged roads, bridges, and the Morrow County Fairgrounds; the Heppner elementary school was evacuated as a precaution	flash flood

Date	Location	Description	Type of Flood
Jan. 2012	Columbia, Hood River, Tillamook, Polk, Marion, Yamhill, Lincoln, Benton, Linn, Lane, Douglas, Coos, and Curry Counties	heavy rain and wind; ice (DR-4055); flooding in the Willamette Valley; 130 homes and seven businesses were damaged in the City of Turner; 21 streets were closed in the City of Salem; the state Motor Pool lost 150 vehicles and thousands of gallons of fuel; Thomas Creek in the City of Scio overtopped, damaging several buildings	winter storm
March 2014	Union, Umatilla, and Grant Counties	Heavy rain fell across much of the northern Blue Mountains and Wallowa County throughout the first week of March. March 9th received very heavy rain with snow levels around 6000ft. This allowed for a significant increase in runoff, which lead to a quick rise in rivers for the period	rain on snow
Dec. 2015	Tillamook, Lincoln, Washington, Clackamas, Multnomah, Lane, Columbia, Hood River, Polk, Coos, Douglas, Jackson and Curry Counties	A moist pacific front produced heavy rainfall across Northwest Oregon which resulted in river flooding, urban flooding, small stream flooding, landslides, and a few sink holes. After a wet week (December 5 through Dec 11), several rivers were near bank full ahead of another front on December 12th. Flooding from the Nehalem River and Rock Creek in Vernonia resulted in evacuation of homes and the implementation of the Vernonia Emergency Command Center. Heavy rain resulted in a land slide that closed OR47 at mile marker 8. More than $15 million dollars in property damage reported in these counties combined.	winter storm
March 2017	Malheur, Harney, Wallowa, Umatilla and Wheeler Counties	An extended period of snow melt, combined with a period of heavy rain, caused an extended period of flooding along portions of the John Day River, the Umatilla and the Silvies Rivers. Flooding occurred on the Snake River near Ontario.	rain on snow
June 2017	Umatilla County	In Pendleton, the heavy rain caused several small debris flows along Airport Road and several intersections were flooding with water about 5 to 6 inches deep. Rainfall amounts include 1.54 inches of rain at the NWS office at the Pendleton Airport, with 0.88 inch falling in 30 minutes.	riverine
Feb. 2018	Umatilla County	Two to three inches of rain fell along the west slopes of the Blue Mountains from February 1st through 4th. The increased runoff caused high water levels and minor flooding along the Umatilla and Walla Walla Rivers.	Feb. 2018
Oct. 2018	Morrow County	Moist upslope flow into the Blue Mountains produced heavy rain with rainfall rates of up to one inch per hour and storm total accumulations between one and three inches. Localized flooding was reported near the town of Heppner where water inside a residence forced an evacuation.	riverine
April 2019	Union, Grant, Umatilla, Wallowa and Wheeler Counties	DR-4452. Grant, Umatilla, and Wheeler Counties declared. Snow water equivalents near 200% of normal in the Blue Mountains coupled with warm temperatures and near record rainfall totals for April produced significant river flooding across eastern Oregon.	rain on snow
Aug. 2019	Crook and Wasco Counties	A powerful upper storm system combined with modest low and mid-level moisture to yield scattered strong to severe storms and flash flooding. Storms developed first across the higher terrain of central Oregon nearer the Cascades and adjacent Ochoco mountains. Storms then built northward with hail and damaging winds along the way.	flash flooding
Feb. 2020	Umatilla, Union, Wallowa	DR-4519: severe storms, flooding, landslides, and mudslides	

Sources: Taylor and Hatton (1999); Hazards and Vulnerability Research Institute (2007); The Spatial Hazard Events and Losses Database for the United States, version 5.1 [online database]. Columbia, SC: University of South Carolina, available from http://www.sheldus.org; State Interagency Hazard Mitigation Team (2006). National Climatic Data Center, Storm Events, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

Table 2-516. Principal Flood Sources by County in Region 5

Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Columbia River Thirty Mile Creek	Columbia River Hood River Indian Creek	Columbia River Hinton Creek Little Blackhorse Canyon Creek Shobe Creek Willow Creek Rhea Creek	Columbia River	Columbia River Birch Creek McKay Creek Mill Creek Patawa Creek Stage Gulch Tutuilla Creek Umatilla River Walla Walla River Waterman Gulch Pine Creek Greasewood Creek	Columbia River Spanish Hollow Creek Fifteen Mile Creek Mosier Creek

Source: FEMA Flood Insurance Studies for Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the "OEM Hazard Analysis Methodology" used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in Appendix **9.1.19**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers during the development of recent county NHMPs, the probability as estimated by participants in these county NHMPs that Region 5 will experience flooding is shown in **Table 2-517**.

Table 2-517. Local Assessment of Flood Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	M	M	H	L	M	M

Source: Gilliam County MJNHMP (2018) p. 2-30; Hood River MJNHMP (2018) p. 2-23; Morrow County MJNHMP (2016); Pt.1, p. 34; Sherman County MJNHMP (2018) p.3-28; Umatilla County NHMP (2014) p.102; Wasco County MJNHMP (2018 p. 2-25

State Assessment

Using the methodology described in the Section 2.2.7.1, Floods/Probability, the state assessed the probability of flooding in the counties that comprise Region 3. The results are shown in Table xx.

Table 2-518. State Assessment of Flood Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	H	H	H	H	H

Source: DOGAMI

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-519. Local Assessment of Vulnerability to Flood in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	L	M	M	M	M

Source: Oregon Gilliam County MJNHMP (2018) p. 2-37; Hood River MJNHMP (2018) p. 2-23; Morrow County MJNHMP (2016); Pt.1, p. 34; Sherman County MJNHMP (2018) p.3-43; Umatilla County NHMP (2014) p.102; Wasco County MJNHMP (2018 p. 2-25

Table 2-520. State Assessment of Vulnerability to Flood in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	L	VH	L	H	H

Source: Oregon Gilliam County MJNHMP (2018) p. 2-37; Hood River MJNHMP (2018) p. 2-23; Morrow County MJNHMP (2016); Pt.1, p. 34; Sherman County MJNHMP (2018) p.3-43; Umatilla County NHMP (2014) p.102; Wasco County MJNHMP (2018 p. 2-25

A flood loss analysis was performed by DOGAMI in Wasco County by overlaying building locations on the 100-year flood extent. This analysis showed that of 18,481 buildings, 1,999 buildings are at risk of flood loss in Wasco County potentially displacing 2,115 people.

Digitized FIRM data was not available for the other counties in the region and therefore, did not allow meaningful flood loss analysis. DOGAMI has utilized more detailed flood mapping data to develop depth grids for other flood zones in the state. In combination with detailed information on structure elevation, this data allows the calculation of potential flood losses, and also an estimate of the number of residents that might not have access to evacuation routes due to surrounding water.

Critical facilities

The DOGAMI Risk Assessment and flood loss analysis for Wasco County found that 5 critical facilities in that county are at risk of flood damage.

Absent a flood loss analysis performed using depth grids in the Special Flood Hazard Area, vulnerability of critical infrastructure was assessed by local NHMP steering committees. Steering committee members catalogued critical facilities in Sherman, Umatilla, Gilliam, Hood River and Morrow Counties and rated the anticipated risk to each critical facility posed by the range of hazards considered in the NHMPs.

In Sherman County during the 2018 NHMP update, the steering committee catalogued 42 critical facilities, 19 of which are vulnerable to flooding. These include Sherman Elementary School, Sherman Jr/High School, John Day Dam, Sherman County Medical Clinic, Sherman County Ambulance Sherman County Emergency Management office, City of Grass Valley City Hall and city water supply infrastructure, South Sherman Fire Dept and the City of Moro Fire Department, North Sherman Rufus Fire Station, and Moro Rural Fire Department, Moro, Wasco and Rufus Wastewater Treatment plants, Rufus City Hall and Fire Station, Wasco Water Supply and the Wasco State Airport.

In Umatilla County, 7 critical facilities were named as being at risk of impact from flooding. These include the McKay Reservoir, McNary Dam and Three Mill Dam, Stanfield Sewer Facility, the County Road Department and the Port of Umatilla docks.

In Gilliam County 27 critical facilities were listed by participants in the NHMP, 11 of which were believed to be at risk of flood damage These include a number of bridges, the Union Pacific Rail line, I-84, route 206, and 97, Arlington Medical Clinic, Condon and Arlington wastewater treatment facilities and Water system, the Lonerock Community Hall, Fire station/outpost and the water system.

In Hood River County, the NHMP Steering Committee catalogued vulnerabilities in the areas of population, economy, land development and environment. A number of vulnerable assets were identified in this manner including the Odell Creek chemical storage facility on Odell Highway, the Waste water facilities near Odell and Columbia River, and local, state and national park lands. Cascade Locks the Fire Station is located in the floodplain.

In Morrow County, the City of Heppner Annex notes that the Elementary School was evacuated during the May 2011 flood event and that the Lexington City Hall was relocated with FEMA funds prior to the update. No other critical facilities were mentioned in the 2016 Morrow County NHMP.

Region 5 is exposed to flood hazards, but is less vulnerable to flood damage than other regions.

Among the most vulnerable assets of Region 5 are elements of the transportation and utility infrastructure. Most of the people and infrastructure are along the I-84 corridor, which runs along the northern portion of the region. This multimodal transportation corridor is vital to Oregon's economy and includes a major interstate highway (I-84); two transcontinental rail lines, Union Pacific and Burlington Northern Santa Fe; the Columbia River inland water navigation; major electric power and gas lines; and communication conduits. Roughly $14 billion worth of goods are carried through the corridor each year (Wang & Chaker, 2004).

The vulnerability from the hazard can be examined through the spatial relationship of the percent of a city's total area versus the percent of the city's area within the 100 year flood zone. Four of the top 10 cities in Oregon examined using this metric are located in Region 5: Helix, Ione, Adams, and Athena. This indicates that damaging floods are indeed possible in developed areas of the Region, but lower than average vulnerability is due to low populations in those cities. Nevertheless, floods can devastate these small cities.

Repetitive Losses

FEMA has identified no Repetitive Loss properties in Region 5 (FEMA NFIP BureauNet, http://bsa.nfipstat.fema.gov/, accessed 12/1/2014).

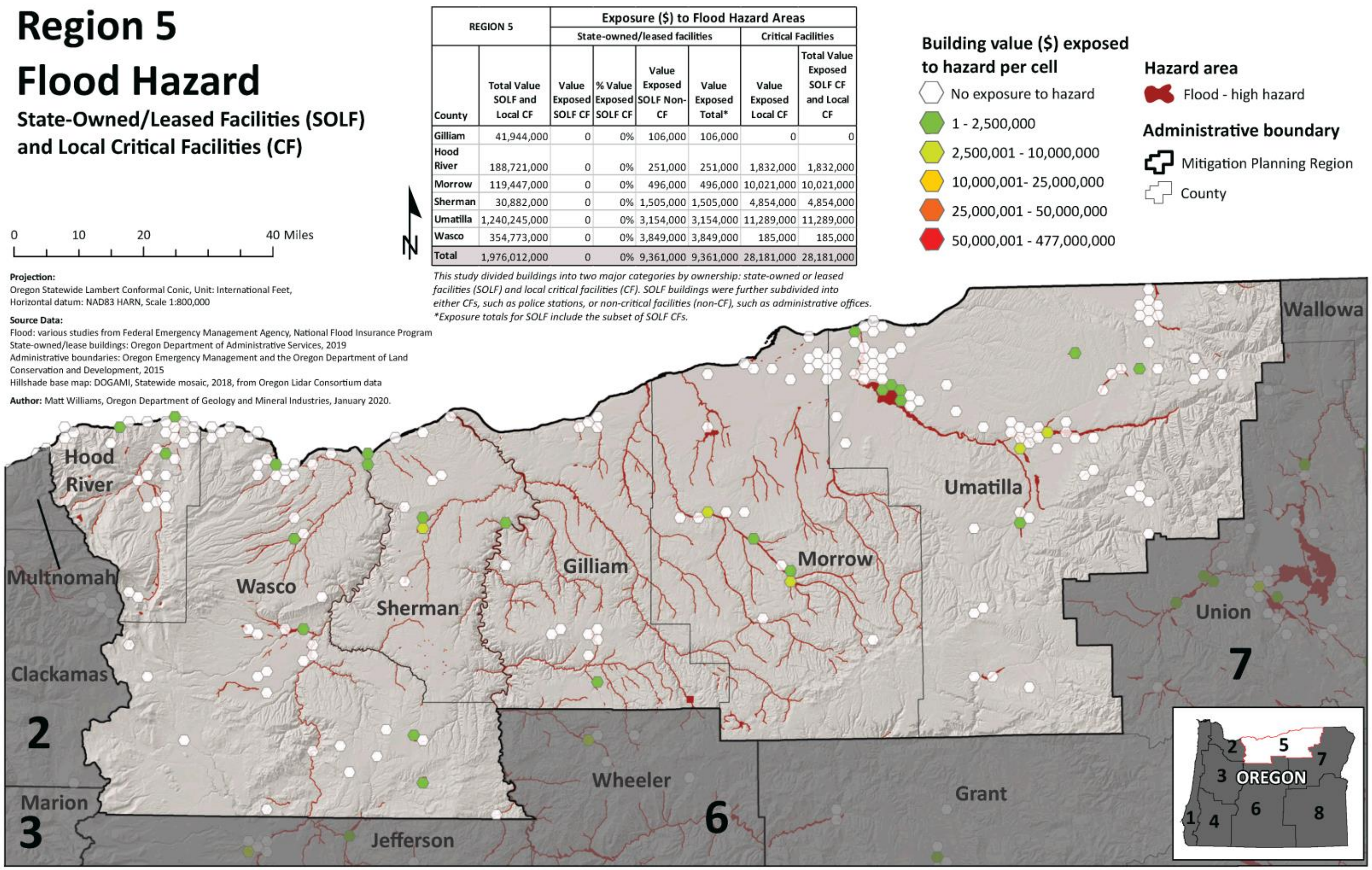
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. The city of Heppner belongs to CRS with a current rating of 9.

State-Owned/Leased Facilities and Critical/Essential Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 5, there is a potential loss from flooding of over $9M in state building and critical facility assets, approximately 34% of it in each of Wasco and Umatilla Counties and 16% in Sherman County. There is a three times greater potential loss due to flood in local critical facilities: over $28M. Forty percent and 36% in Umatilla and Morrow Counties, respectively. Figure 2-176 illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding.

Figure 2-237. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Exposure ($) to Flood Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Gilliam	41,944,000	0	0%	106,000	106,000	0	0
Hood River	188,721,000	0	0%	251,000	251,000	1,832,000	1,832,000
Morrow	119,447,000	0	0%	496,000	496,000	10,021,000	10,021,000
Sherman	30,882,000	0	0%	1,505,000	1,505,000	4,854,000	4,854,000
Umatilla	1,240,245,000	0	0%	3,154,000	3,154,000	11,289,000	11,289,000
Wasco	354,773,000	0	0%	3,849,000	3,849,000	185,000	185,000
Total	1,976,012,000	0	0%	9,361,000	9,361,000	28,181,000	28,181,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 2,456 historic resources in Region 5, three hundred thirteen (13%) are located in an area of high flood hazard. Of those, 215 (69%) are located in Umatilla County. The rest are spread throughout Region 5.

Archaeological Resources

Of the 340 archaeological resources located in high flood hazard areas in Region 5, one hundred sixteen (34%) are located in Gilliam County. Only 4 are listed on the National Register of Historic Places and 20 are eligible for listing. Sixteen have been determined not eligible and 300 have not been evaluated as to their eligibility. The listed resources are located in Umatilla and Wasco Counties. The eligible resources are located in all Region 5 counties except Umatilla.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma. Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes.

Gilliam County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Morrow County is very highly vulnerable to the impacts of flooding; Umatilla and Wasco

Counties are highly vulnerable. In all three cases, their vulnerability scores are driven primarily by their very high social vulnerability. Morrow County's score is also due in part to somewhat greater values of state buildings and local critical facilities in the County.

Most Vulnerable Jurisdictions

Morrow, Umatilla, and Wasco Counties are the most vulnerable to flood hazards in Region 3.

Risk

Table 2-521. Risk of Flood Hazards in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	VL	M	VH	M	VH	VH

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Morrow, Umatilla, and Wasco Counties are at greatest risk from flooding in Region 5.

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owner's property to community destruction with mass fatalities. The 1889 Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost.

Oregon's first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Table 2-522. Historic Significant Dam Failures in Region 5

Year	Location	Description
1959	Currant Creek dam east of Antelope in Wasco Co.	Property damaged
2005	Simplot Lagoon south of Hermiston in Umatilla Co.	Washed out State Highway, major irrigation ditch and made 1 home unrepairable

Source: Oregon Water Resources Department Dam Safety Program records

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 17 High Hazard dams and 6 Significant Hazard dams in the region.

Table 2-523. Summary: High Hazard and Significant Hazard Dams in Region 5

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 5	7	6	10
Gilliam	0	0	0
Hood River	0	2	1
Morrow	0	2	1
Sherman	0	0	1
Umatilla	0	2	4
Wasco	7	0	3

Source: Oregon Water Resources Department, 2019

Table 2-524. High Hazard and Significant Hazard Dams in Region 5

County	Name	Rating	Regulator
Hood River	Clear Branch Creek Dam	High	Federal
Hood River	Green Point-Lower (No. 1)	Significant	State
Hood River	Green Point-Upper (No. 2)	Significant	State
Morrow	Willow Creek (Morrow)	High	Federal
Morrow	Carty Reservoir	Significant	State
Morrow	Sand Dunes Wastewater Lagoon Dam	Significant	State
Sherman	John Day Dam	High	Federal
Umatilla	Cold Springs Reservoir (USBR)	High	Federal
Umatilla	Indian Lake Dam	High	Federal
Umatilla	Mckay Reservoir (USBR)	High	Federal
Umatilla	Mcnary Dam	High	Federal
Umatilla	Meacham Lake Dam	Significant	State
Umatilla	Simplot Waste Lagoon #1	Significant	State
Wasco	Happy Canyon	High	Federal
Wasco	The Dalles Dam	High	Federal
Wasco	Wasco Dam	High	Federal
Wasco	Crow Creek	High	State
Wasco	Currant Creek	High	State
Wasco	Pine Hollow	High	State
Wasco	Rock Creek (Wasco)	High	State
Wasco	Younglife Waste A (Lower)	High	State
Wasco	Younglife Waste B (Middle)	High	State
Wasco	Younglife Waste C (Upper)	High	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally regulated. A dam's condition is considered public information for state-regulated

dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Four of the seven state-regulated high hazard dams in Region 5 are in satisfactory condition and three are in fair condition.

Table 2-525. Summary: Condition of High Hazard State-Regulated Dams in Region 5

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	**Fair**	**Poor**	**Unsatisfactory**	**Not Rated**
Region 5	4	3	0	0	0
Gilliam	0	0	0	0	0
Hood River	0	0	0	0	0
Morrow	0	0	0	0	0
Sherman	0	0	0	0	0
Umatilla	0	0	0	0	0
Wasco	4	3	0	0	0

Source: Oregon Water Resources Department, 2019

Table 2-526. Condition of High Hazard State-Regulated Dams in Region 5

County	Dam Name	Condition
Wasco	Crow Creek	Fair
Wasco	Currant Creek	Fair
Wasco	Rock Creek (Wasco)	Fair
Wasco	Pine Hollow	Satisfactory
Wasco	Younglife Waste A (Lower)	Satisfactory
Wasco	Younglife Waste B (Middle)	Satisfactory
Wasco	Younglife Waste C (Upper)	Satisfactory

Source: Oregon Water Resources Department, 2019

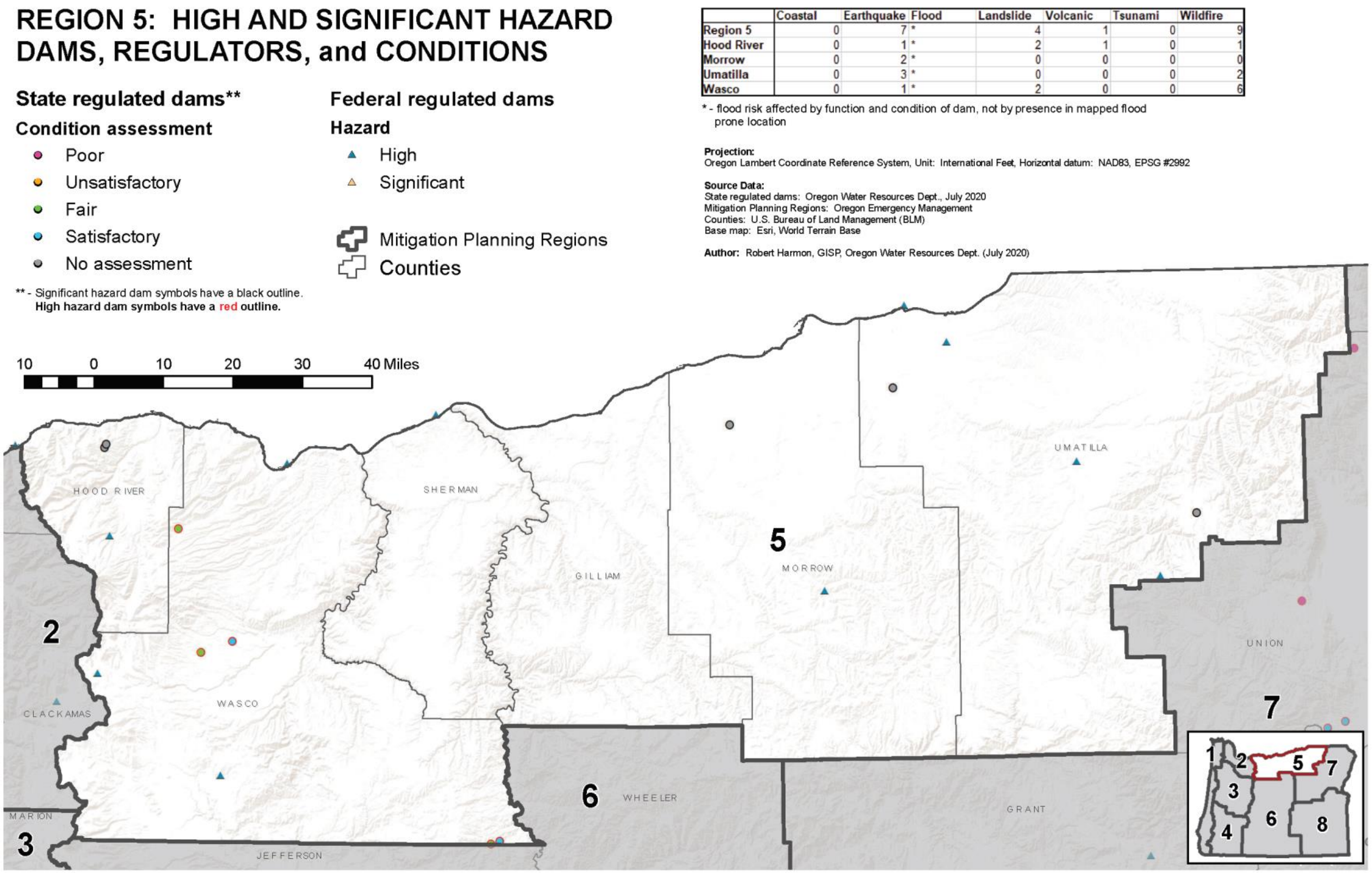
State-Regulated High Hazard Dams not Meeting Safety Standards

There are no state-regulated high hazard dams in Region 5 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Figure 2-238 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 5. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-238. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 5



	Coastal	Earthquake	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 5	0	7	*	4	1	0	9
Hood River	0	1	*	2	1	0	1
Morrow	0	2	*	0	0	0	0
Umatilla	0	3	*	0	0	0	2
Wasco	0	1	*	2	0	0	6

Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

State-regulated high hazard dams in Region 5 are currently meeting safety standards.

Dams in Region 5 tend to have lower risk from natural hazards, except in Hood River County where natural hazards pose risks more like those of Region 2: potential for high risks from earthquakes and moderately increased risk from landslide and wildfire, with some risk of large woody debris from wildfire. State-regulated dams in this region are less likely than federally regulated dams to be subject to volcanic hazards.

There are no dams meeting FEMA HHPD eligibility criteria in Region 5.

Most Vulnerable Jurisdictions

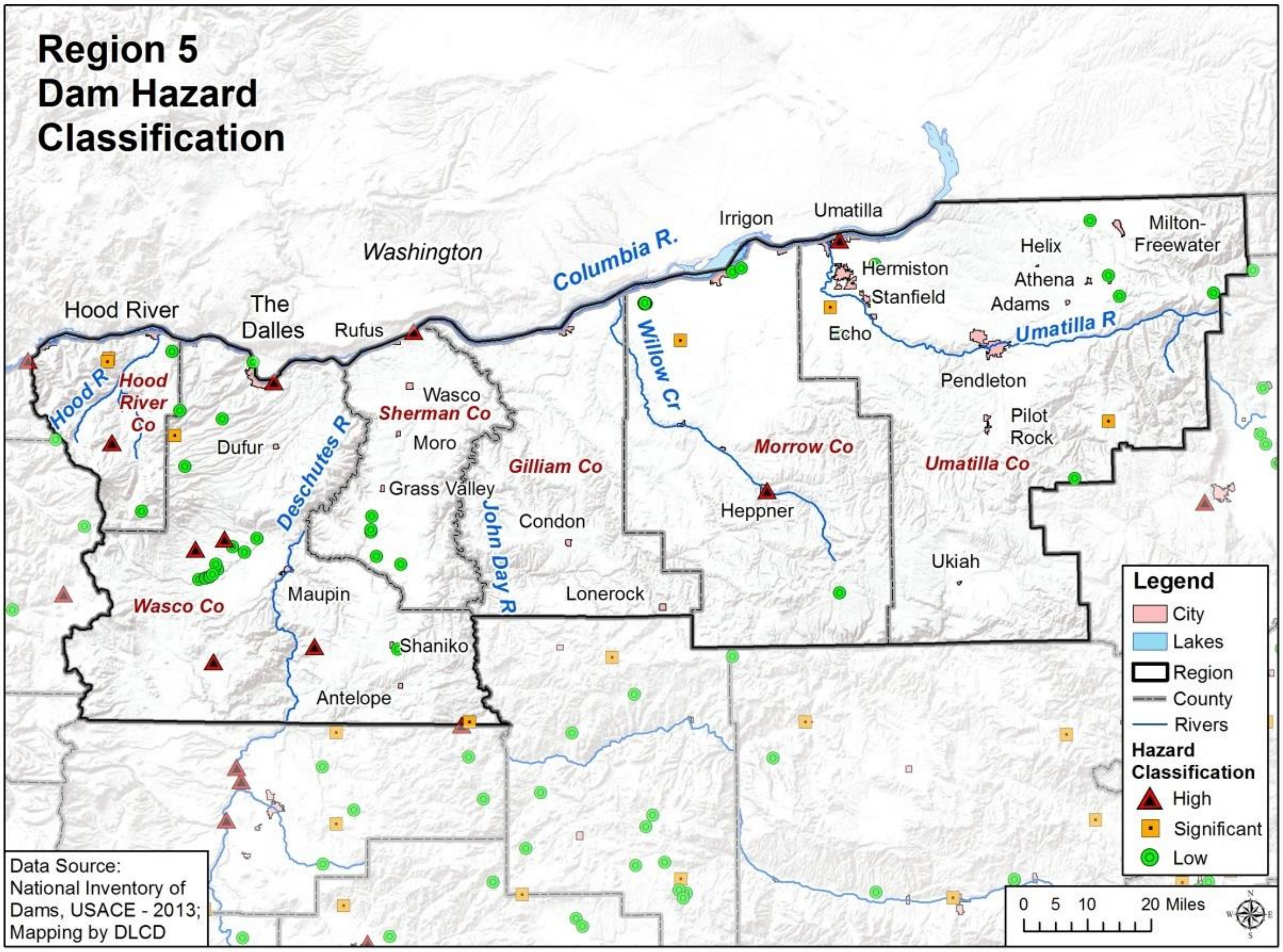
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), no Region 5 counties are considered "most vulnerable jurisdictions" because none have high hazard dams in poor or unsatisfactory condition.

As with high hazard dams, whether counties with significant hazard dams are actually "most vulnerable jurisdictions" depends on the conditions of those dams. Since the dams' conditions have not yet been rated, we cannot determine the counties' vulnerability with respect to significant hazard dams. Hood River, Morrow, and Umatilla Counties each have two state-regulated significant hazard dams.

Risk

The potential for damage to a dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-239. Region 5 Dam Hazard Classification



Source: National Inventory of Dams, USACE, 2013

Note: Federally regulated significant hazard dams are not shown.

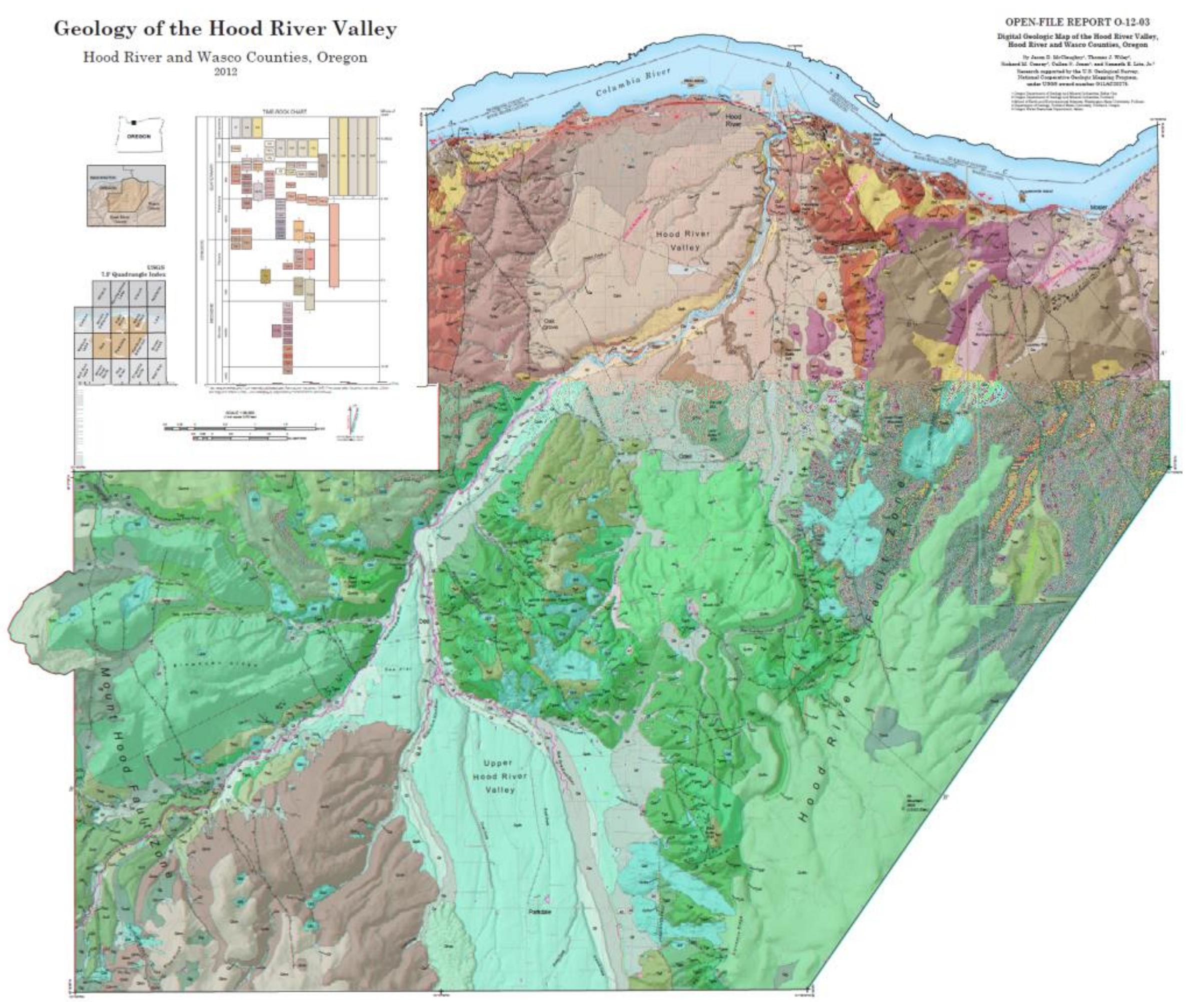
Landslides

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the Cascade Mountains and the Columbia River Gorge have very high incidence of landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage.

For example, the geology map of the Hood River area and the Mount Hood Multi-Hazard and Risk study both found hundreds of landslides in this area (McClaughry, Wiley, Conrey, Jones, & Lite, 2012) (Burns W. J., et al., 2011c). In February 2014, a large rock slide in Hood River closed I-84 for almost a week.

Figure 2-240. Geology of the Hood River Valley



Source: McClaughry, et al. (2012).

Historic Landslide Events

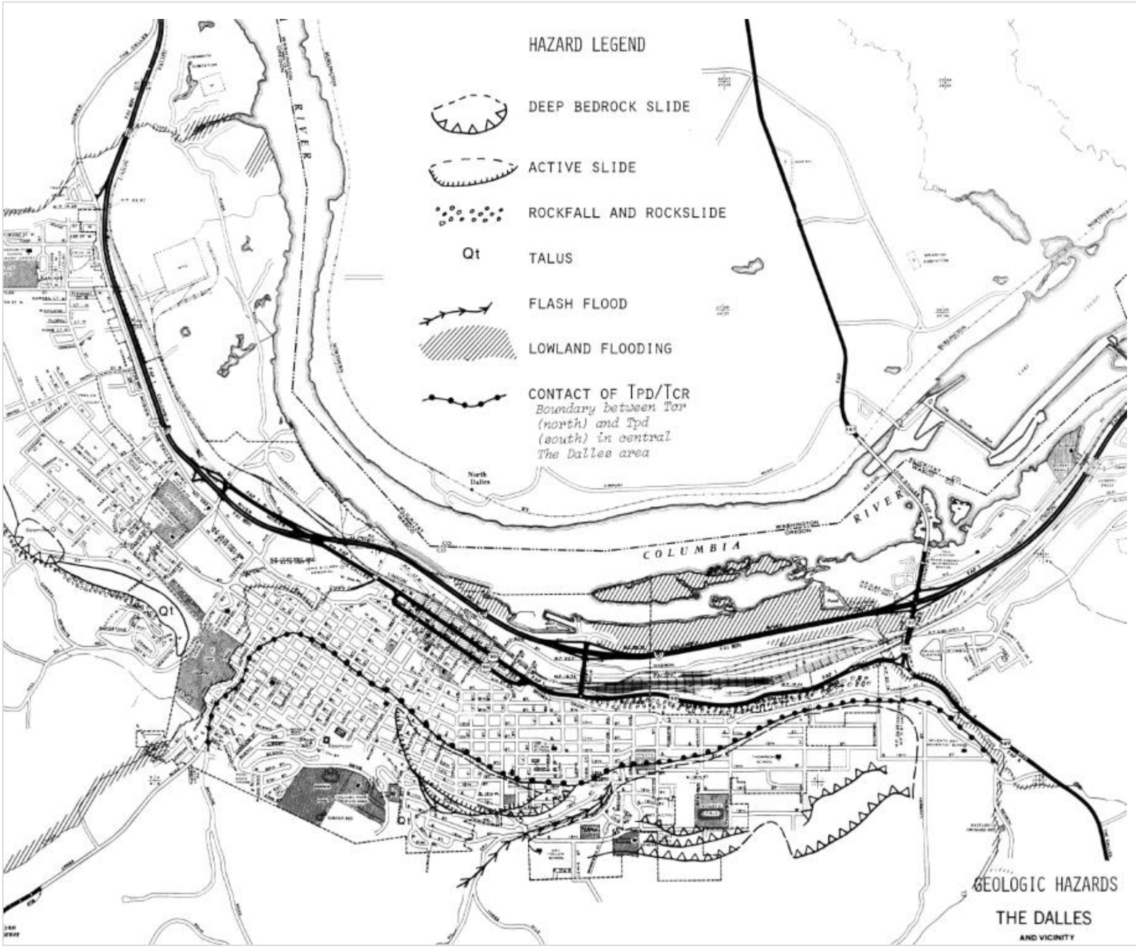
Table 2-527. Historic Landslides in Region 5

Date	Location	Description
Unknown	The Dalles	affected significant portions of the city
Dec. 1964	Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties	DR-184
Jan. 1974	Hood River and Wasco Counties	DR-413
Jul. 1995	Wasco County	DR-1061
Feb. 1996	Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties	DR-1099; hundreds of landslides
Dec. 1996-Jan. 1997	Gilliam, Morrow, and Umatilla Counties	DR-1160; hundreds of landslides
Dec. 2003-Jan. 2004	Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties	DR-1510
2005	Sherman and Wasco Counties	property damage: $35,000 (includes Jefferson County)
Dec. 2005-Jan. 2006	Sherman and Gilliam Counties	DR-1632
Nov. 2006	Hood River County	DR-1672; massive debris flows on Mt Hood caused $50M in damage to Highway 35 alone; many other landslides.
Dec. 2006	Wasco County	DR-1683
Dec. 2008	Hood River County	DR-1824
2009	Hood River County	property damage: $78,571
Jan. 2012	Hood River County	DR-4055
2014	Hood River County	rock slide on I-84; interstate closed for days
Jan. 2017	Hood River County	DR-4328
Apr. 2019	Umatilla County	DR-4452

Source: Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; https://www.fema.gov/disasters

Another existing landslide area affecting significant portions of the City of The Dalles was mapped in DOGAMI Bulletin 91 (**Figure 2-241**). The date of movement is unknown.

Figure 2-241. Landslides in the The Dalles, Oregon Area



Source: Beaulieu (1977)

Probability

Table 2-528. Assessment of Landslide Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	VH	L	M	M	H

Source: DOGAMI, 2020

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in this region in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or a future earthquake.

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-529. Local Assessment of Vulnerability to Landslides in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	—	M	L	L	—	L

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-530. State Assessment of Vulnerability to Landslides in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	M	H	VL	H	VH

Source: DOGAMI and DLCD, 2020

Most of the people and infrastructure in the Mid-Columbia Region are located along the I-84 corridor which runs along the northern portion of the region. This multimodal transportation corridor is vital to Oregon's economy and includes a major interstate highway (I-84); two transcontinental rail lines, Union Pacific and Burlington Northern Santa Fe; the Columbia River inland water navigation; major electric power and gas lines; and communication conduits. Roughly $14 billion worth of goods are carried through the corridor each year (Wang & Chaker, 2004). Many of the communities in this region are vulnerable to landslide hazard; for example, the cities of Hood River and The Dalles have a moderate to high exposure to landslides.

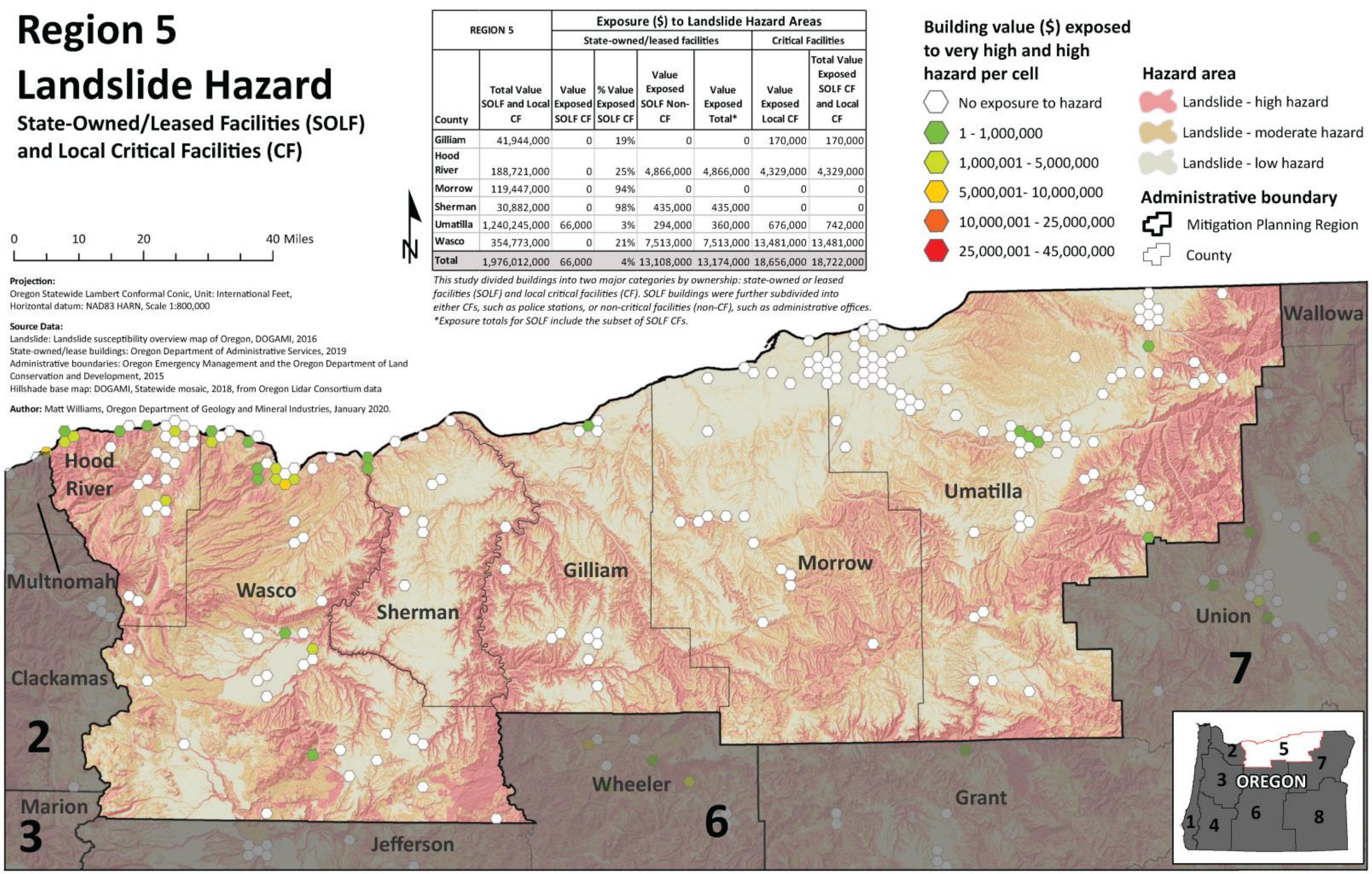
DOGAMI has recently published numerous earthquake and natural hazard reports. **Open-File Report O-11-16, Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon** (Burns W. J., et al., 2011b) provides details about the landslide hazard and risk in Hood River County.

According to the 2020 risk assessment, Morrow and Umatilla Counties are highly vulnerable to landslides, and Wasco County is very highly vulnerable. All three counties' scores are driven by very high social vulnerability, and Wasco's score is driven even higher by the dollar value of its local critical facilities located in landslide hazard areas.

State-Owned/Leased Facilities and Critical and Essential Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 5. Over $32M in value of state facilities is exposed to landslide hazards in Region 5, more than half in Wasco County followed by 40% in Hood River County. The value of local critical facilities is over $18.6M, 72% also in Wasco County. Figure 2-242 illustrates the potential loss to state buildings and critical facilities and local critical facilities from landslide hazards.

Figure 2-242. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Exposure ($) to Landslide Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF	
Gilliam	41,944,000	0	19%	0	0	170,000	170,000	
Hood River	188,721,000	0	25%	4,866,000	4,866,000	4,329,000	4,329,000	
Morrow	119,447,000	0	94%	0	0	0	0	
Sherman	30,882,000	0	98%	435,000	435,000	0	0	
Umatilla	1,240,245,000	66,000	3%	294,000	360,000	676,000	742,000	
Wasco	354,773,000	0	21%	7,513,000	7,513,000	13,481,000	13,481,000	
Total	1,976,012,000	66,000	4%	13,108,000	13,174,000	18,656,000	18,722,000	

Source: DOGAMI, 2020

Historic Resources

Of the 2,456 historic resources in Region 5, all but one are exposed to landslide hazards: 177 are in an area of very high or high landslide hazard susceptibility; 807 in moderate; and 1,471 in low. The greatest numbers of historic resources exposed to landslide hazards are in Hood River and Umatilla Counties with 952 and 899, respectively.

Archaeological Resources

Of the 1,291 archaeological resources located in landslide hazard areas in Region 5, sixty-nine percent (887) are in high landslide hazard areas. Of those, three are listed on the National Register of Historic Places and 48 are eligible for listing. Forty-two have been determined not eligible, and 794 have not been evaluated as to their eligibility. Wasco County has the most archaeological resources in high landslide hazard areas followed by Gilliam and Sherman Counties. Wasco County also has the most archaeological resources in landslide hazard areas in Region 5 overall, 734 (57%).

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau’s American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than “well,” the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger. Wasco County’s high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than “well,” and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than “well,” and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Wasco County is the most vulnerable to landslides in Region 5 followed by Morrow and Umatilla Counties. All three counties' scores are driven by very high social vulnerability, and Wasco's score is driven even higher by the dollar value of its local critical facilities located in landslide hazard areas.

Risk

Table 2-531. Assessment of Risk to Landslides in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	VL	VH	M	VL	H	VH

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 Risk Scores and DOGAMI's expert assessment, Hood River, Umatilla, and Wasco Counties are "most vulnerable jurisdictions" with either very high or high risk ratings. All communities should be prioritized for mitigation

Volcanoes

Characteristics

The western boundary of Region 5 coincides with the Cascade Range, which are mountains derived from volcanic activity. Within this range of mountains are several active and potentially active volcanoes. Mount Hood, Mount Jefferson, and Mount Adams are all potentially active volcanoes close to Region 5 that can impact these communities.

Volcanic activity can produce many types of hazardous events including landslides, ashfall, lahars, pyroclastic flows, and lava flows (Scott, Iverson, Schilling, & Fisher, 2001). Pyroclastic flows are fluid mixtures of hot rock fragments, ash, and gases that can move down the flanks of volcanoes at speeds of 50 to more than 150 kilometers per hour (30 to 90 miles per hour) (Scott, Iverson, Schilling, & Fisher, 2001). Lahars or volcanic debris flows are water-saturated mixtures of soil and rock fragments that can travel very long distances (over 100 km) as fast as 80 kilometers per hour (50 miles per hour) in steep channels close to a volcano (Scott, et al., 1997a). Lahars can be very localized (only meters across) or can affect areas hundreds of kilometers away (Walder, Gardner, Conrey, Fisher, & Schilling, 1999).

Mount Hood’s eruptive history can be traced to late Pleistocene times (15,000–30,000 years ago) and will no doubt continue. But the central question remains: When? The most recent series of events (1760–1810) consisted of small lahars and debris avalanches; steam explosions and minor tephra falls occurred between 1859 and 1865. Mount Hood’s recent history also includes ashfalls, dome building, lahars, pyroclastic flows, and steam explosions.

Historic Volcanic Events

Table 2-532. Historic Volcanic Activity Affecting Region 5

Date	Location	Description
about 20,000 to 13,000 YBP	Polallie Eruptive episode, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
about 7,700 YBP	Parkdale, north-central Oregon	eruption of Parkdale lava flow
about 1,500 YBP	Timberline eruptive period, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
1760–1810	Crater Rock/Old Maid Flat on Mount Hood	pyroclastic flows in upper White River; lahars in Old Maid Flat; dome building at Crater Rock
1859–1865	Crater Rock on Mount Hood	steam explosions and tephra falls
1907 (?)	Crater Rock on Mount Hood	steam explosions

Note: YBP is years before present.

Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/; Scott, et al. (1997a)

Probability

Table 2-533. Assessment of Volcanic Hazards Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	L	M	L	L	L	M

Source: DOGAMI, 2020

Mount St. Helens remains a probable source of ashfall. It has repeatedly produced voluminous amounts of this material and has erupted much more frequently in recent historical time than any other Cascade volcano. It blanketed Yakima and Spokane, Washington during the 1980 eruption and continues to be of concern. The location, size, and shape of the area affected by ashfall are determined by the vigor and duration of the eruption and the wind direction. Because wind direction and velocity vary with both time and altitude, it is impossible to predict the direction and speed of ash transport more than a few hours in advance.

Geoscientists have provided some estimates of future activity in the vicinity of Crater Rock, a well-known feature on Mount Hood. They estimate a 1 in 300 chance that some dome activity will take place in a 30-year period (1996–2026). For comparison, the 30-year probability of a house being damaged by fire in the United States is about 1 in 90.

The probability of 1 cm or more of ashfall from eruptions anywhere in the Cascade Range, include:

- Gilliam County: 1 in 1,000;
- Hood River County: Between 1 in 500 and 1 in 1,000;
- Morrow County: 1 in 1,000;
- Sherman County: 1 in 1,000;
- Umatilla County: Between 1 in 1,000 and 1 in 5,000; and
- Wasco County: Between 1 in 500 and 1 in 1,000.

Vulnerability

Table 2-534. Local Assessment of Vulnerability to Volcanic Hazards in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	L	L	—	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-535. State Assessment of Vulnerability to Volcanic Hazards in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	VH	H	VL	H	H

Source: DOGAMI and DLCD, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 5 (**Figure 2-243**). Just under $11.2M in value is exposed to volcanic hazards in Region 5, all of it in Hood River and Wasco Counties.

Historic Resources

Of the 2,456 historic buildings in Region 5, 114 are exposed to volcanic hazards, all in Hood River County. Four are located in a high hazard area; 36 in a moderate hazard area; and 74 in a low hazard area. See Appendix **9.1.12** for details.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5. Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income. Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger. Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters. Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma. Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

According to the 2020 vulnerability scores, Hood River County is the most vulnerable to volcanic hazards in Region 4 followed by Morrow, Umatilla, and Wasco Counties. Hood River's vulnerability score is driven largely by the presence of state and local critical facilities with a moderate social vulnerability rating, while Morrow, Wasco and Umatilla Counties' high vulnerability scores are driven primarily by very high social vulnerability. Wasco County's high vulnerability rating is also influenced by the presence of state buildings.

Risk

Table 2-536. Assessment of Risk to Volcanic Hazards in Region 5

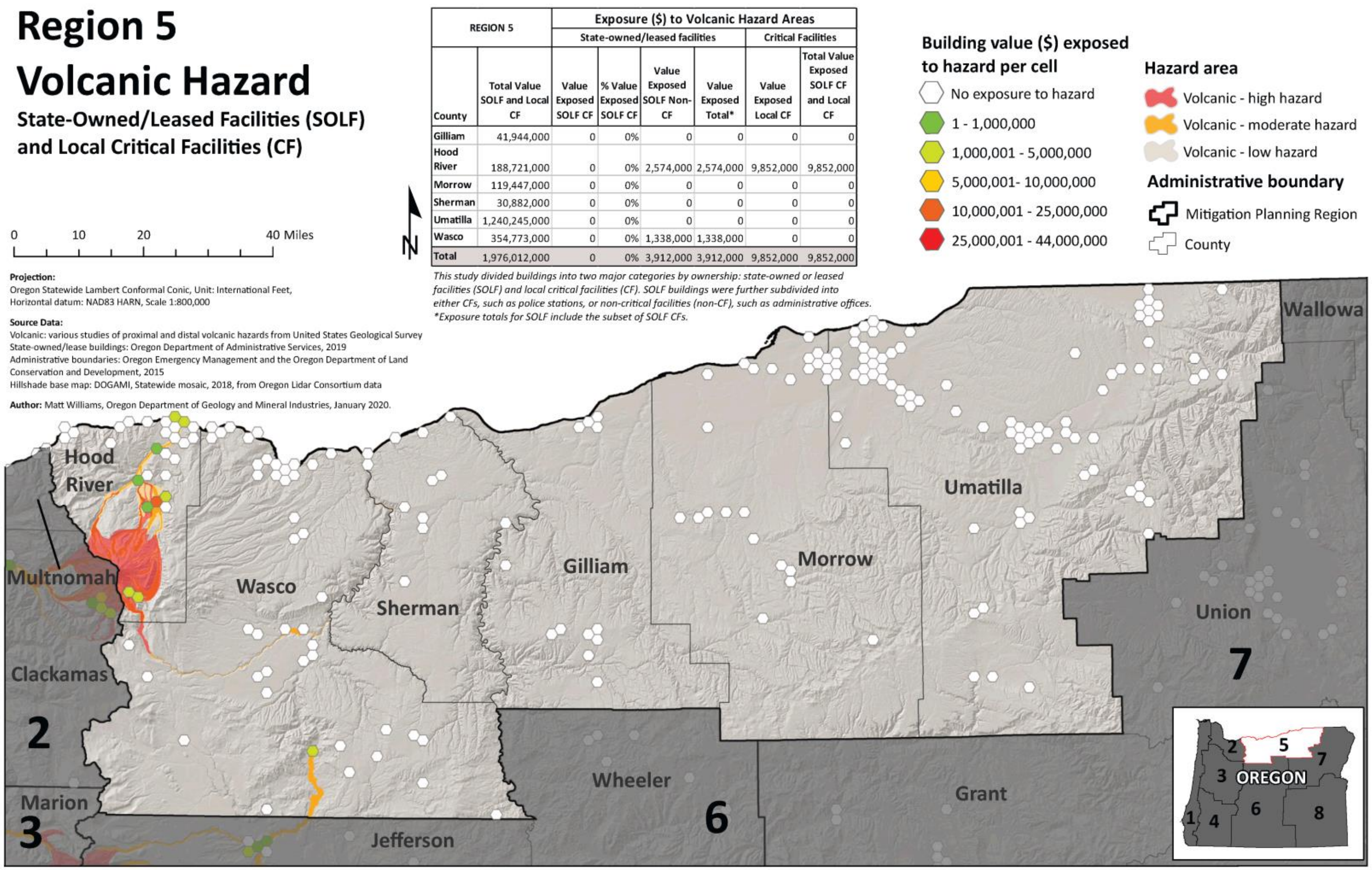
	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	VL	VH	M	VL	M	H

Source: DOGAMI and DLCD, 2020

According to the 2020 Risk Scores, Hood River and Wasco Counties in Region 5 are "most vulnerable jurisdictions" with very high and high risk ratings, respectively. Morrow and Umatilla Counties have moderate risk ratings. These communities should be prioritized for mitigation actions. Gilliam and Sherman Counties, in Region 5 have very low risk ratings.

The U.S. Geological Survey has addressed volcanic hazards at Mount Hood (Scott, et al., 1997a). This report includes maps depicting the areas at greatest risk. The communities which are closer to Mount Hood, such as the Parkdale and the City of Hood River in Hood River County, are at risk from proximal as well as the distal hazards, such as lahars and ashfall. In Wasco County, communities situated along the White River may be at risk from pyroclastic flows and far-reaching lahars. Counties in Region 5, farther east of Mount Hood, are only at risk from the distal hazards such as ashfall.

Figure 2-243. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Volcanic Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Exposure ($) to Volcanic Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Gilliam	41,944,000	0	0%	0	0	0	0
Hood River	188,721,000	0	0%	2,574,000	2,574,000	9,852,000	9,852,000
Morrow	119,447,000	0	0%	0	0	0	0
Sherman	30,882,000	0	0%	0	0	0	0
Umatilla	1,240,245,000	0	0%	0	0	0	0
Wasco	354,773,000	0	0%	1,338,000	1,338,000	0	0
Total	1,976,012,000	0	0%	3,912,000	3,912,000	9,852,000	9,852,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI

Wildfires

Characteristics

In Region 5, wildfires burn primarily in vegetative fuels outside the urban areas, and can generally be categorized as agricultural, forest, range, or wildland-urban interface fires.

Region 5 has unique geographic features, weather characteristics, a history of unmanaged fuels, and an expanding urban interface. Douglas fir, grand fir, and western hemlock (fire interval 150–400 years) dominate in the wetter forests of the western Columbia River Gorge, while ponderosa pine, Oregon white oak brush, and grass are more characteristic toward the east (15 year fire intervals). Historically, the region consisted of pine forests. More recently, due to decay in forest health and changes in forest practices, ponderosa pine has given way to brush and mixed conifer (Douglas fir, grand fir, and subalpine fir) at higher elevations. North and east facing slopes are typically forested while south and westerly aspects are generally open and grass covered.

This region is subject to weather patterns that can contribute significantly to extreme fire behavior. Annual precipitation levels vary from 8 to 10 inches along the Columbia River, to as high as 60 inches in the higher elevations of the Blue Mountains. Wind in the gorge is a constant variable. Wind at the east end of the gorge tends to be minimal; however, the west portion experiences 20–30 mph winds daily and, at times, winds exceed 40 mph. Significant drying occurs as sustained winds, coupled with high daytime temperatures and drier air from the desert, pushes toward the coast.

OEM Weather Statement

Extreme winds are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge. The Columbia River Gorge is the most significant east-west gap in the mountains between California and Canada. It serves as a funnel for east and west winds, where direction depends solely on the pressure gradient. Once set in motion, the winds can attain speeds of 80 mph, halt truck traffic, and damage a variety of structures and facilities. The average wind speed at Hood River is 13 mph.

Land ownership and resultant management and suppression capabilities and protocols in this area also affect the potential for wildfires. In region 5, the most significant land ownership falls to federal agencies, and includes forested and wilderness areas. Federal lands in this area are characterized by dense stands, heavy underbrush, and ladder fuels, increasing the potential for wildfires. County, state, and private lands contribute to the remainder. These lands have a variety of management practices resulting in a mix of stand conditions and resultant fire potential.

Regardless of ownership, the majority of the forestlands in Region 5 are historically prone to wildfire. As the number of dwellings extends into these areas the potential for ignition and losses increases. Many of these communities in the wildland-urban interface fall just outside of any agency's primary protection coverage, which reduces their likelihood of surviving a wildfire.

Historic Wildfire Events

Table 2-537. Historic Wildfires in Region 5

Year	Name of Fire	Location	Acres Burned	Remarks
1977		Wasco		
1979	Pine Grove/Juniper Flat			
1983	Moro	Sherman		
1985	Maupin	Wasco		
1988		Wasco		
1991	Falls		1,100	fire along the Columbia Gorge
1994	Smith Canyon			
1998	Rowena	Wasco	2,208	
1998	Reith Barnhart/Coombs Canyon	Umatilla	45,000	
2000	Willow Creek	Morrow and Gilliam	27,000	
2000	Antelope	Wasco		
2001	Two Rivers	Umatilla	7,011	
2001	Bridge Creek	Umatilla	9,230	
2002	Sheldon Ridge	Wasco	12,681	
2003	Herman Creek	Wasco	300	3 structures were lost in this fire that affected Cascade Locks
2003		Umatilla County		$40,000 in property damage, $200,000 in crop damage
2003		Umatilla County		$15,000 in property damage, $500 in crop damage
2004		Gilliam, Morrow and Umatilla Counties		$6,000 in property damage
2005		Sherman and Wasco Counties		$1,000 in property damage *damage estimate includes Jefferson County
2005		Morrow and Umatilla Counties		$2,500 in property damage and $11,500 in crop damage
Mar. 2005		Gilliam, Morrow and Umatilla Counties		$113,900 in crop damage
July 2005		Umatilla and Morrow Counties		$5,000 in property damage, $23,000 in crop damage
May 2006		Gilliam, Morrow and Umatilla Counties		$10,000 in property damage
June 2006		Gilliam, Morrow and Umatilla Counties		$500,000 in property damage
2009	Microwave Fire	Wasco County		fire threatened Maupin, burned 2 residences
2011	High Cascade Complex	Wasco County	101,292	fire burned into Warm Springs
2013	Government Flats Complex	Wasco County	11,450	fire burned four homes in The Dalles; fire suppression costs more than $15 million
2018	Boxcar	Wasco County	100,207	started due to lightning
2018	Substation	Wasco County	78,425	moved over 18 miles in just days

Source: Oregon Department of Forestry, 2020

Probability

Table 2-538. Assessment of Wildfire Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	H	H	H	H	H

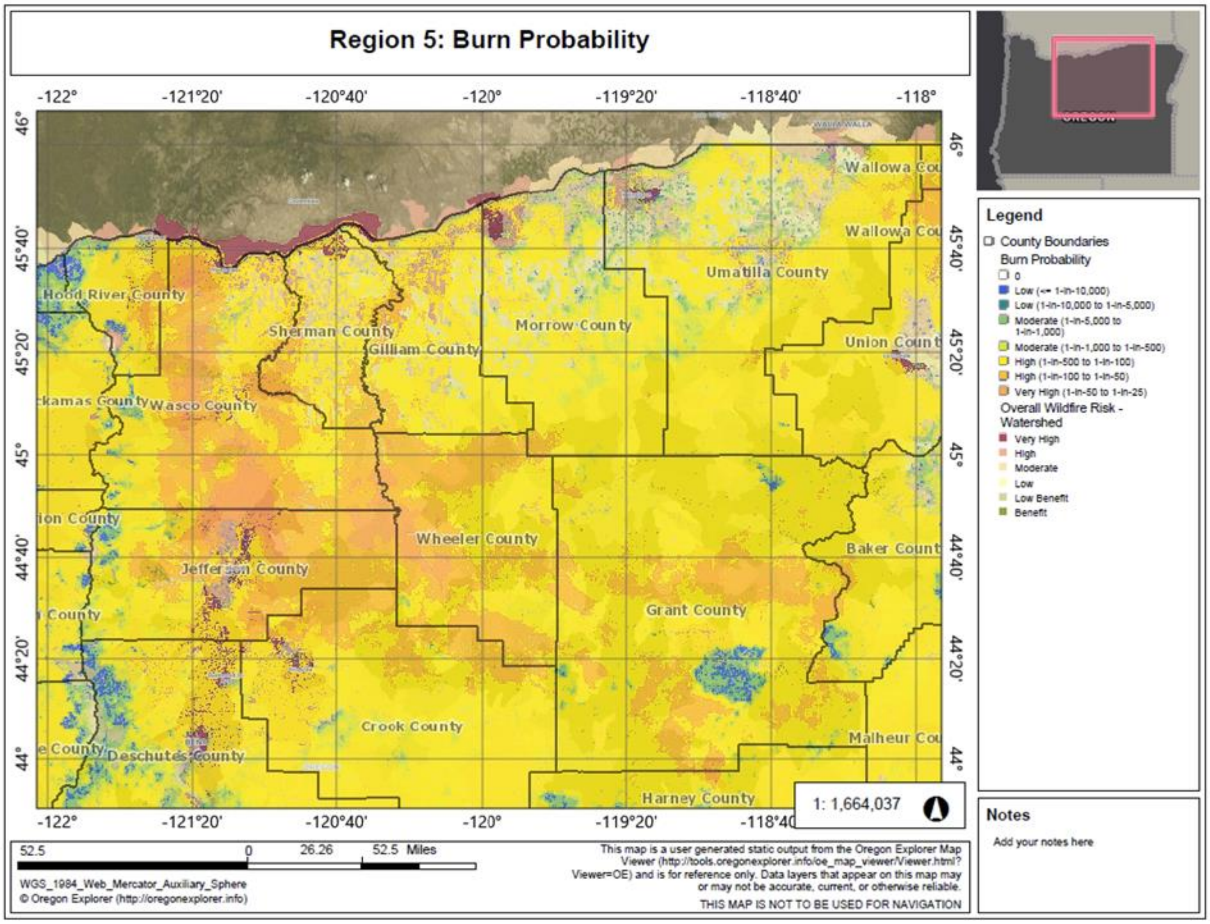
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to look at the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-244 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

Figure 2-244. Burn Probability



Source: Oregon Wildfire Risk Explorer, March 2020

In Region 5, weather patterns can produce summer lightning storms that start many fires. These multiple starts can put a strain on the wildland firefighting resources spread across the county. With the drying of fuels over time and the low relative humidity factored in, the probability for large fires can significantly increase during these lightning events. The number of days per season that forest fuels are capable of producing a significant fire event is also important to consider. Oregon Department of Forestry has determined that eastern Oregon is at the highest hazard rating for weather. This value was assigned through an analysis of daily wildfire danger rating indices in each regulated use area of the state.

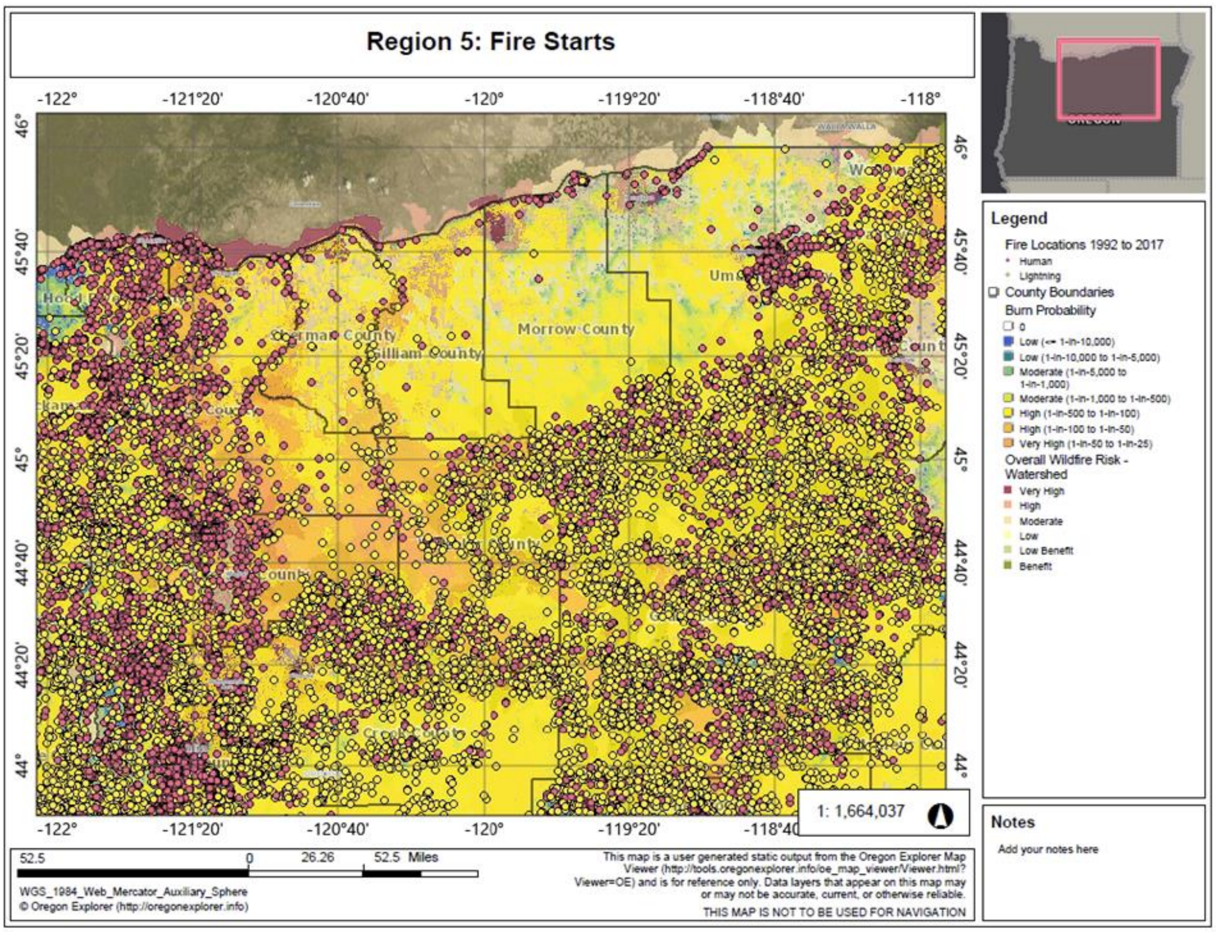
The west side of the region includes the heavily wooded hills and mountains of the Cascades; the east side is lined with hills that are also wooded but drier, along with significantly more oak and grasses; the west end of the heavily wooded region is pinched between the Columbia River and the near vertical sides of the river gorge.

A healthy forest across this region is never free of insects, disease, or other disturbances, and infestations can increase the likelihood of ignition and fire spread. The potential for extreme fire behavior is of concern for any valued property, whether it be a structure or scenic vista at the top of a bluff, hill, or canyon that has enough fuel to sustain a fire. The more fuels on a bluff, hill, or canyon, the more active the fire will become. As the percentage of slope increases more preheating of fuels preceding the fire front will occur. The fire front will proceed up the hill at a faster rate and the fire will burn more intensely. Coupled with high winds and low humidity, this region has the potential for a severe wildfire.

This region is susceptible to wildfire when favorable east wind conditions prevail. Fires have the potential to spread from Washington State across the river into Oregon via long-range spotting.

Sources of human-caused ignition include discarded cigarettes, motor cars and trucks, railroads, mowing, acts of nature, and fire emanating from adjoining land. Most fires adjacent to the freeway start in fine grasses and can rapidly progress into conifers that line the safety zone for almost the entire breadth of the region's west end.

Figure 2-245. Human- and Lightning-Caused Wildfires in Region 5, 1992-2017



Source: Oregon Wildfire Risk Explorer, March 2020

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

In ignition-limited forest systems, found on the east side of the state, a long history of fire suppression has resulted in high fuel loads and, forests that have closer canopies and experience greater water competition. These forests experience long, dry fire seasons and are frequently at high fire danger and have a very high potential to burn if exposed to an ignition source. Winter warming will lead to more fine fuels due to greater growth during the cold season; hotter and drier conditions combined with a suppression management regime will lead to large quantity of fuel and closer canopies. Large and severe fires ("unsuppressable megafires") are a result of this large fire debt and climate change combined. Fuel-limited systems, such as those in eastern and southeastern Oregon, have non-contiguous fuels including sagebrush and bunchgrasses. As invasive annual grasses increase (e.g., Cheatgrass), fuels become contiguous since invasive grasses regrow quickly outcompeting other vegetation. Warming winters will lead to more fine fuels from greater cold season growth. Also, conditions conducive to conversion to invasive grasses can lead to frequent fires and conversion to invasive-dominated systems as climate changes, including reduction in habitat for sage grouse. It is likely (>66%) that Region 5 will experience increasing wildfire frequency and intensity under future climate change.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 5 counties (**Table 2-539**).

Table 2-539. Projected Increase in Annual Very High Fire Danger Days in Region 5 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Gilliam	15	41%
Hood River	15	40%
Morrow	15	42%
Sherman	15	40%
Umatilla	15	40%
Wasco	14	38%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-540. Local Assessment of Vulnerability to Wildfire in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	M	H	M	M

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-541. Assessment of Vulnerability to Wildfire in Region 5 – Communities at Risk

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	H	M	H	VH

Source: ODF Communities at Risk Report, 2020

Table 2-542. Assessment of Vulnerability to Wildfire in Region 5 – 2020 Vulnerability Assessment

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	H	VH	L	H	VH

Source: DOGAMI and DLCD, 2020

According to ODF's assessment of Communities at Risk, Umatilla, Morrow, and Wasco Counties have a high percentage of wildland acres subject to Fire Risk, Wildland Development Areas, Fire Effects, or Fire Threat, making them especially vulnerable.

In addition, each year a significant number of people build homes within or on the edge of the forest (urban-wildland interface), thereby increasing vulnerability. These communities have been designated "Wildland-Urban Interface Communities" and listed in **Table 2-543**.

There is also critical infrastructure beyond the wildland-urban interface that is vulnerable to wildfire. Disruption to the municipal water supply and irrigation water supply from wildfires would negatively impact all of the residents and agricultural operators that depend on this resource by reducing water quality and availability. Roads, bridges, and evacuation routes could be compromised, limiting the ability of firefighters to reach the fire as well as inhibiting evacuation procedures. Utilities including Bonneville Power Administration power lines, Portland General Electric and Northwest Natural Gas electrical and gas distribution lines and communication infrastructure are also at risk.

The economic stability of the Region is dependent on a major interstate highway (I-84). This highway runs east-west, paralleling the Columbia River from MP 35 to MP 69. This four lane highway is considered part of the "National Defense Highway System" and as such some federal entities are sensitive to highway closures that impede or stop the flow of traffic. Most frequently, closures or restrictions are for motor vehicle accidents; however, closures can also be expected in the face of low or no visibility secondary to wildfire or inclement winter weather. Additional economic sectors that could be affected by wildfire are agriculture, forest products, tourism, manufacturing, recreation, and power generation. Community values and natural resources at risk of wildfire include agriculture and livestock, wildlife and salmonids, and historic buildings.

Table 2-543. Wildland-Urban Interface Communities in Region 5

Gillam	Hood River	Morrow	Sherman	Umatilla	Wasco
Arlington	Cascade Locks	Black Mountain	Grass Valley	Adams	Antelope
Condon	Dee	Boardman	Moro	Athena	Big Muddy Ranch
Gilliam	Hood River	Cutsforth Park	Rufus	Battle Mountain	Chenoweth
Lonerock	Odell	Heppner	Sherman	Dry Creek	Dufur
	Parkdale	Ione	Wasco	Echo	Juniper Flat
	Pine Grove	Irrigon		Helix	Maupin
	West Side	Lake Penland		Hermiston	Mid-Columbia
		Lexington		Lehman Hot Springs	Mosier
		Morrow CO OHV Park		McKay Creek	Pine Grove
				Milton-Freewater	Pine Hollow
				Mission	Rail Hollow
				Pendleton	Shaniko
				Pilot Rock	The Dalles
				Rieth	Tygh Valley
				Riverside	Wamic
				Stanfield	Warm Springs
				Tollgate Spout Springs	Wasco
				Ukiah	White River
				Umapine	
				Umatilla	
				Walla Walla River Corridor	
				Weston Mountain	

Source: ODF Communities at Risk Report, 2020

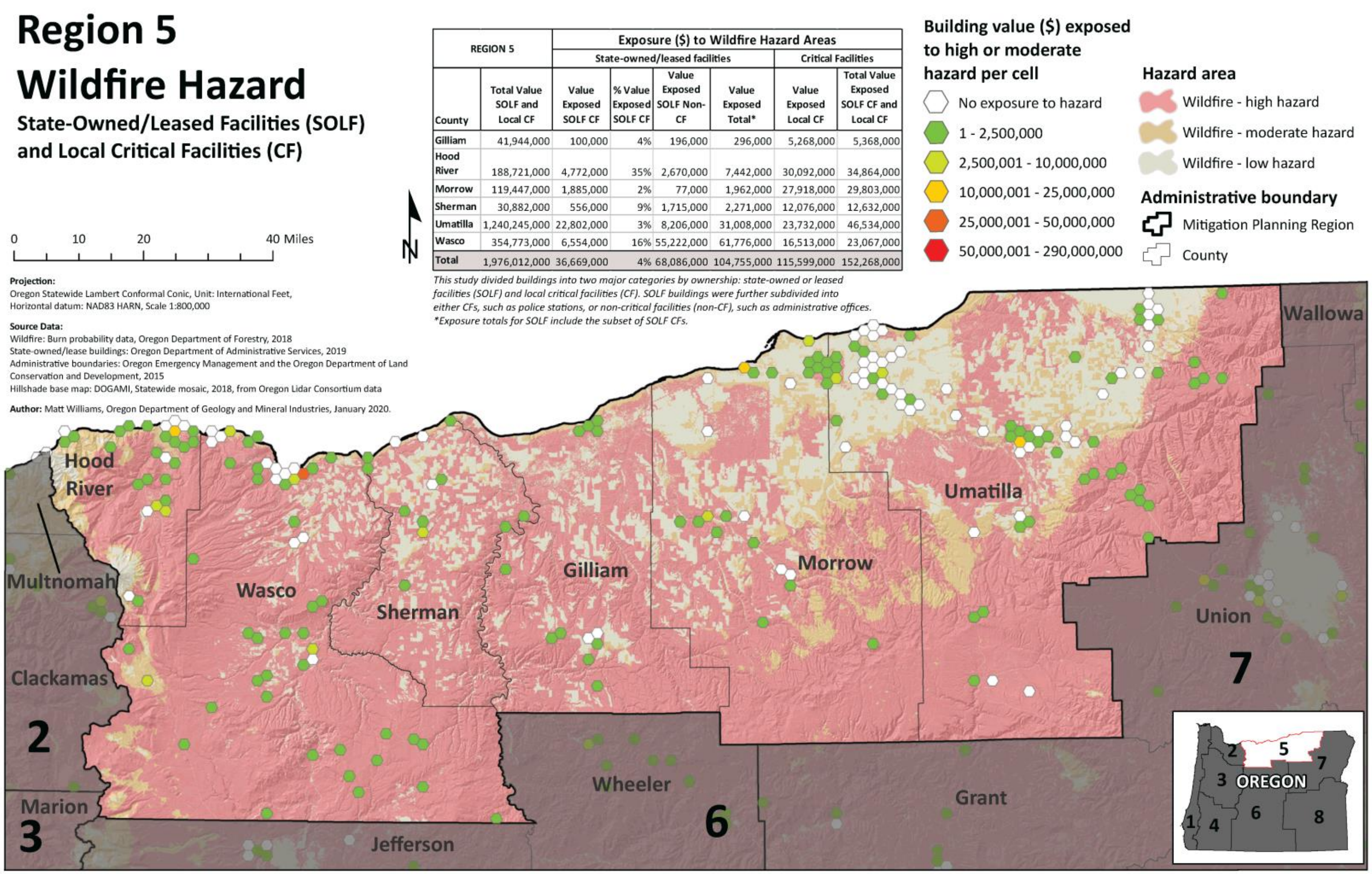
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in “High,” “Moderate,” and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as “Low.”

In Region 5, there is a potential loss to wildfire of almost $105M in state building and critical facility assets, almost 60% of it in Wasco County and 30% in Umatilla County. Seven percent is located in Hood River County and the remaining three percent in Sherman, Morrow, and Gilliam Counties. There is a slightly greater potential loss in local critical facilities: about $15.6M. Around 25% is located in each of Hood River and Morrow Counties, about 20% in Umatilla County.

Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, there has been one reported loss to a state asset caused by a wildfire since the beginning of 2015. It was located in the Columbia River Gorge; whether in Region 5 or Region 2 is not clear. The net claim paid was under $2,000.

Figure 2-246. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Exposure ($) to Wildfire Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Gilliam	41,944,000	100,000	4%	196,000	296,000	5,268,000	5,368,000
Hood River	188,721,000	4,772,000	35%	2,670,000	7,442,000	30,092,000	34,864,000
Morrow	119,447,000	1,885,000	2%	77,000	1,962,000	27,918,000	29,803,000
Sherman	30,882,000	556,000	9%	1,715,000	2,271,000	12,076,000	12,632,000
Umatilla	1,240,245,000	22,802,000	3%	8,206,000	31,008,000	23,732,000	46,534,000
Wasco	354,773,000	6,554,000	16%	55,222,000	61,776,000	16,513,000	23,067,000
Total	1,976,012,000	36,669,000	4%	68,086,000	104,755,000	115,599,000	152,268,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 2,456 historic resources in Region 5, sixty-six (3%) are located in an area of high wildfire hazard. Of those, 42% are located in Wasco County. Of the 87 (4%) located in a moderate wildfire hazard area, 53% are located in Umatilla County and 39% in Hood River County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Morrow County and Wasco County are very highly vulnerable to wildfire; Hood River and Umatilla Counties highly vulnerable. Sherman County's vulnerability is low and Gilliam County's very low. This assessment is consistent with the Communities at Risk assessment for Umatilla and Wasco Counties, and close for Morrow County, but inconsistent for the other counties. This is indicative of the different criteria used for these assessments.

Wasco, Umatilla, and Morrow Counties are most vulnerable to wildfire in Region 5.

Risk

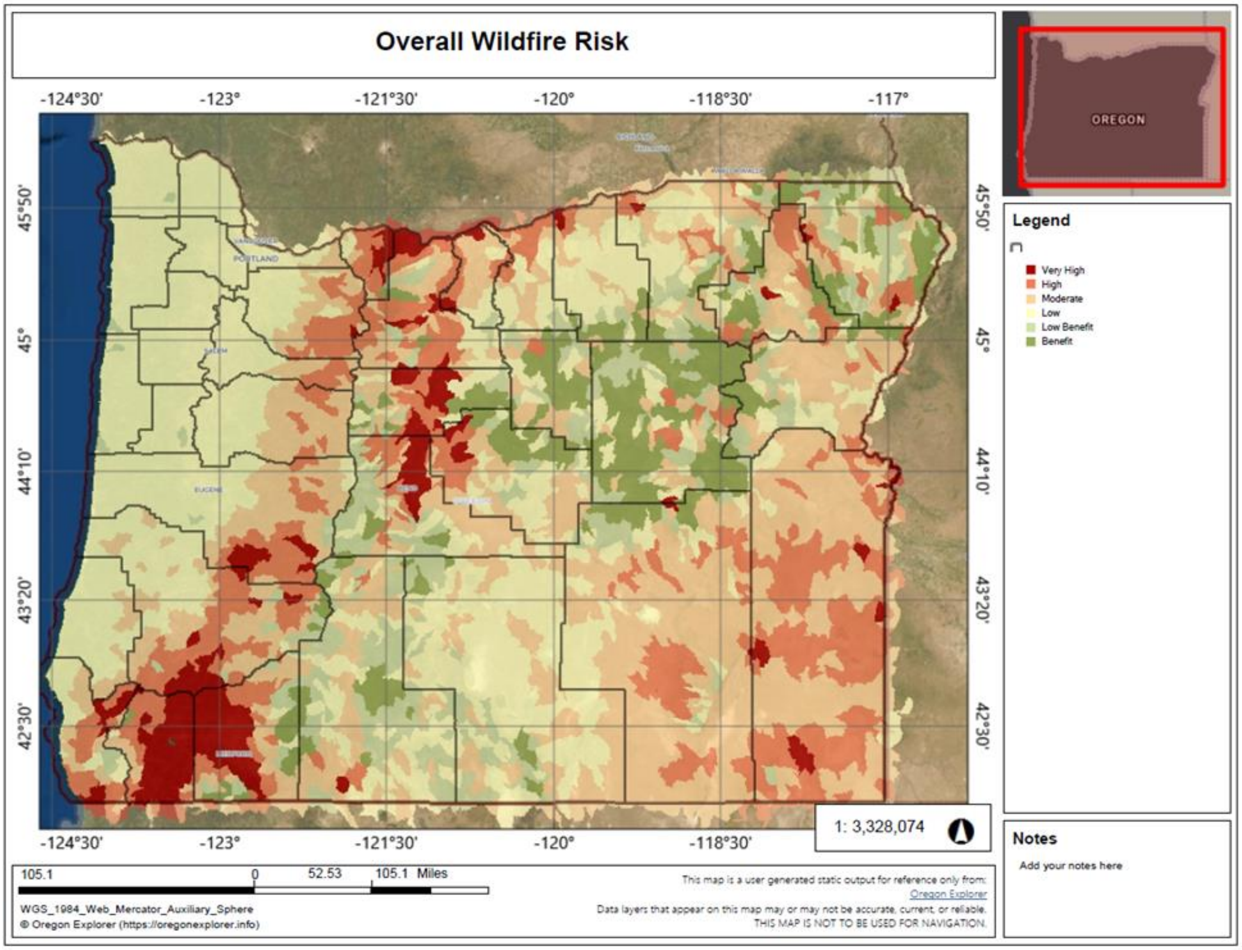
Table 2-544. Risk of Wildfire Hazards in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	VL	H	VH	M	VH	VH

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Morrow, Umatilla, and Wasco Counties are at very high risk from wildfire and Hood River is at high risk. This is only partially consistent with ODF's assessment, mapped in **Figure 2-247**. The map shows that primarily the areas of Umatilla and Morrow Counties in the Columbia River Gorge are at very high risk from wildfire, while most of Wasco and Hood River Counties are at very high risk. The 2020 risk assessment is not granular enough to account for geographic differences in probability, vulnerability, or risk within a county.

Figure 2-247. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

Extreme winds are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge, so much so that these areas have special building code standards. All manufactured homes in Region 5 that are within 30 miles of the Columbia River must meet special anchoring standards. High winds in this area of Oregon are legendary. The Columbia Gorge is the most significant east-west gap in the mountains between California and Canada. It serves as a funnel for east and west winds, where direction depends solely on the pressure gradient. Once set in motion, the winds can attain speeds of 80 mph, halt truck traffic, and damage a variety of structures and facilities. The average wind speed at Hood River is 13 mph, not much less than the notoriously windy Texas and Kansas plains whose wind speeds average 15 mph (Taylor & Hatton, 1999).

Though their occurrence is somewhat less frequent, Region 5 has also experienced tornadoes. For the most part, these tornadoes have not resulted in major damages **Table 2-546** lists historic tornadoes in the region.

Historic Winter Storm Events

Table 2-545. Historic Windstorms Affecting Region 5

Date	Affected Area	Characteristics
Apr. 1931	N. Central Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Dec. 1935	W. Columbia Gorge, Oregon	damage to automobiles; wind gusts at 120 mph
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; wind speed 40–60 mph; gusts 75–80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 75 mph gusts; damage to buildings and utility lines
Dec. 1955	statewide	wind speeds 55–65 mph with 69 mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71 mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon's most destructive storm to date; 116 mph winds in Willamette Valley.; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Nov. 1981	statewide	severe wind storm
Dec. 1987	Umatilla County	damaging wind storm; two fatalities
Mar. 1991	Mid-Columbia / NE Oregon	severe wind storm
Dec. 1991	N. central Oregon	severe wind storm; blowing dust
Jan. 1993	northern Oregon	severe wind storm; damage to utilities
Dec. 1995	statewide	severe wind storm; widespread damage
Oct. 2003	Umatilla County	$1,000 in property damage
Jan. 2004	Morrow and Umatilla Counties	$2,500 in property damage
Feb. 2004	Umatilla County	$3,000 in property damage *damage estimate includes Jefferson County

Date	Affected Area	Characteristics
Apr. 2004	Hood River County	$25,000 in property damage
Apr. 2004	Wasco County	$1,000 in property damage
Oct. 2004	Gilliam, Morrow and Umatilla Counties	$333.33 in property damage
Dec. 2004	Gilliam, Morrow and Umatilla Counties	$166.66 in property damage
Dec. 2004	Sherman and Wasco Counties	$3,333.33 * damage estimate includes Jefferson County
Feb. 2005	Gilliam, Morrow and Umatilla Counties	$3,000 in property damage
Mar. 2005	Sherman and Wasco Counties	$2,500 in property damage *damage estimate includes Jefferson County
Nov. 2005	Umatilla County	$400 in property damage
Apr. 2006	Umatilla County	$10,000 in property damage in Hermiston
May 2006	Morrow County	$500,000 in property damage with a high wind gust measured at 117 mph; $1 million in crop damage
May 2006	Sherman County	$50,000 in property damage in Grass Valley; winds ranged from 70 to 80 mph
Nov. 2006	Morrow and Umatilla Counties	$35,000 in property damage from 80 mph winds; property damage also occurred in Union and Wallowa Counties, for a total storm damage of $70,000
Jan. 2007	Gilliam, Morrow, Sherman, Wasco and Umatilla Counties	$5,000 in property damage from 64 mph winds; damage estimate includes Jefferson County
June 2008	Umatilla County	powerful windstorm with wind speeds at 58 mph caused $10,000 in damage to buildings in Pendleton
June 2008	Morrow and Umatilla Counties	wind damage downed several trees and power lines, caused $250,000 in property damage and $100,000 crop damage in Morrow County, and $108,000 in property damage in Umatilla County
July 2010	Umatilla County	64 mph winds caused $40,000 in property damage in the Hermiston area
Nov. 2012	Wasco, Sherman, Umatilla, Gilliam, Morrow, Union and Wallowa Counties	74 mph winds $120,000 in damage *includes Jefferson County
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides
Feb. 2020	Regions 5 and 7: Umatilla, Union, Wallowa Counties	FEMA-4519-DR: Severe storms, tornadoes, straight-line winds and flooding
Jan. 2004	Morrow and Umatilla Counties	$2,500 in property damage
Feb. 2004	Umatilla County	$3,000 in property damage *damage estimate includes Jefferson County

Sources: Taylor and Hatton (1999); FEMA-1405-DR-OR, February 7, 2002, Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon. and Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org and U.S. Department of Commerce. National Climatic Data Center. Available from http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms; https://www.fema.gov/disaster/

Table 2-546. Historic Tornadoes in Region 5

Date	Location	Result
June 1888	Morrow County (Lexington, Sand Hill, Pine City)	30 buildings, including two schools destroyed; six people killed (including two children); four people injured
Apr. 1925	Gilliam County	warehouse and automobiles destroyed in Condon; about $10,000 in damages
Apr. 1957	Gilliam and Morrow Counties	minor damage (rangeland)
Apr. 1970	Wasco County	observed; no damage
May 1991	Umatilla County	some damage to wheat fields
July 1995	Umatilla County	some damage to wheat fields
May 2006	Morrow County	$20,000 in property damage, F1 intensity
May 2009	Umatilla County	$50,000 in property damage, F1 intensity
April 2011	Morrow County (Lexington)	damage to pump house

Note: No tornadoes reported since April 2011 **(**https://www.ncdc.noaa.gov/stormevents/)

Sources: Taylor and Hatton (1999); U.S. Department of Commerce. National Climatic Data Center. Available from http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Probability

Table 2-547. Assessment of Windstorm Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	H	M	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

High winds occur yearly in the Columbia River Gorge. The 100-year event in this region consists of 1-minute average winds of 90 mph. A 50 year event has average winds of 80 mph. A 25-year event has average winds of 75 mph.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-548. Local Assessment of Vulnerability to Windstorms in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	M	M	H	H

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-549. State Assessment of Vulnerability to Windstorms in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	L	H	M	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Many buildings, utilities, and transportation systems within Region 5 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, uprooted or shattered trees can down power and/or utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Uprooted trees growing next to a house have destroyed roofs when they fall as a result of windstorms. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establish a tree maintenance and removal program.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

Gilliam, Hood River, Morrow, Sherman and Wasco Counties are the most vulnerable to windstorms because of their proximity to the Columbia River. Social vulnerability in Morrow and Wasco Counties is very high. In. Hood River it is moderate, and in Gilliam and Sherman Counties very low. Therefore, Morrow and Wasco Counties are considered the most vulnerable to windstorms in Region 5.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $1,080,652,000. Because windstorms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 5 since the beginning of 2015. Eight losses were due to windstorms statewide. Of those, it is possible that one or two may have been located in the eastern portion of Region 5. One claim was for approximately $6,200 and the other has not been settled.

Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

All the counties in Region 5 are at risk of windstorms, particularly on their northern boundaries along the Columbia River. Morrow County is the most at risk in Region 8 and with Marion County in the state overall.

Winter Storms

Characteristics

Severe winter weather in Region 5 can be characterized by extreme cold, snow, ice, and sleet. Winter storm events are an annual occurrence in Region 5; most communities are prepared for them. This is particularly true through the Columbia River Gorge where frigid air sometimes moves westward out of the Wallowa Mountains. During these periods, it is not unusual to receive snow or ice storms. Severe weather conditions do not last long in Region 5; consequently, winter-preparedness is a moderate priority. This is advantageous in at least one respect: in general, the region is prepared, and those visiting the region during the winter usually come prepared. However, there are occasions when preparation cannot meet the challenge.

Historic Winter Storm Events

Table 2-550. Historic Winter Storms Affecting Region 5

Date	Location	Remarks
Dec. 1861	entire state	storm produced 1–3 feet of snow throughout Oregon
Dec. 1884	Columbia Basin, Oregon	heavy snowfall; 29.5 inches in The Dalles in one day
Dec. 1885	Wasco County, Oregon	most snow recorded (6–10 feet); trains had difficulty reaching Portland
Dec. 1892	northern counties, Oregon	15–30 inches of snow throughout northern counties
Jan. 1916	entire state	two storms; very heavy snowfall, especially in mountainous areas
Jan. and Feb. 1937	entire state	deep snow drifts
Jan. 1950	entire state	record snowfalls; property damage throughout state
Mar. 1960	entire state	many automobile accidents; two fatalities
Jan. 1969	entire state	heavy snow throughout state
Jan. 1980	entire state	series of storms across state; injuries and power outages
Feb. 1985	entire state	2 feet of snow in northeast mountains; downed power lines; fatalities
Feb. 1986	central/eastern Oregon	Heavy snow in Deschutes Basin; traffic accidents; broken power lines
Mar. 1988	entire state	strong winds; heavy snow
Feb. 1990	entire state	heavy snow throughout state
Nov. 1993	Cascade Mountains, Oregon	heavy snow throughout region
Mar. 1994	Cascade Mountains, Oregon	heavy snow throughout region
Winter 1998-99	entire state	one of the snowiest winters in Oregon history (snowfall at Crater Lake: 586 inches)
Dec.28, 2003–Jan. 9, 2004	statewide storm	DR-1510. Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties declared in Region 5. The most significant winter storm in several years brought snowfall to most of Oregon. ODOT closed I-84 through the Columbia Gorge twice, for almost 70 hours total. Freight trucks and passenger cars had to detour over Mount Hood where, ironically, road conditions were better than they were in downtown Portland where all vehicles were required to chain up. A frigid arctic air mass, heavy snow, sleet and freezing rain, strong east winds and blizzard conditions through and near the Columbia River Gorge snarled travel, forced school and business closures, and resulted in widespread power outages and properly damage in Northwestern Oregon. Blizzard conditions in the Columbia River Gorge: • closed I-84 between Troutdale and Hood River • closed Washington State Route 14 between Washougal, and White Salmon, Washington • Halted east-west travel through the Gorge and stranded hundreds of trucks at both ends of the Gorge
Jan. 2005	Gilliam, Morrow, and Umatilla Counties	33 injuries
Nov. 2006	Hood River County	heavy freezing rain along I-84, closed the highway near Hood River
Dec. 2006	Hood River County	freezing rain and sleet caused ice conditions from Cascade Locks to Hood River; black ice on I-84
Jan. 2008	Hood River, Wasco, Sherman, Gilliam, Morrow, and Umatilla Counties	heavy freezing rain from Bonneville westward through Columbia Gorge causing accidents on I-84; one fatality

Date	Location	Remarks
Nov. 29-30, 2010	Hood River and Wasco Counties	4-5 inches of snow reported in Cascade Locks and Hood River; 1/2 inch of ice in Corbett
Jan. 12–18, 2012	Hood River, and Wasco Counties	4.5 inches of new snow reported in Hood River; I-84 closed due to ice and snow east of Troutdale
Feb. 6–10, 2014	Hood River County	a strong winter storm system affected the Pacific Northwest during the February 6–10, 2014 time period bringing a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon.
Feb. 11–14, 2014	Hood River County	Another weather system moved across northwest Oregon during the February 11–14 time frame; this storm was distinctly different from the storm that produced the snow and ice the week prior and brought abundant moisture and warm air from the sub-tropics into the region; as this storm moved across the area, 2 to 7 inches of rain fell across many counties in western Oregon; the heavy rainfall combined with warm temperatures led to snowmelt and rainfall runoff that produced rapid rises on several rivers, which included flooding on three rivers in northwest Oregon
March 2, 2014	Hood River County, Upper Hood River Valley, Central Columbia River Gorge	East winds brought very cold air from east of the Cascades through the Columbia River Gorge as a moist front pushed in from the Pacific. The combination of the cold air mass and frontal precipitation resulted in snow and ice for the Gorge. There were numerous reports of snow and ice in the Central Columbia River Gorge with generally 6 to 8 inches of snow. There was a quarter of an inch of ice on top of the snow in Hood River and White Salmon, and as much as 0.4 to 0.5 inch of ice in Parkdale where the cold air held on the longest.
Nov. 13, 2014	Hood River County (Western Columbia River Gorge)	An early cold snap hit the Pacific Northwest before moist Pacific air moved in and resulted in one of the earliest snow, sleet, and freezing rain events in northwestern Oregon. Sleet and freezing rain in particular created hazardous commutes for tens of thousands in the western and eastern suburbs of Portland. Snow accumulations were primarily restricted to the Cascade valleys and the central Columbia River Gorge. Spotters reported around 6 to 8 inches of snow for the Cascade Foothills followed by a quarter of an inch of ice. A combination of heavy snow and ice resulted in slick driving conditions for the Western Columbia River Gorge. Areas in the gorge measured a quarter of an inch of ice whereas other areas had 5 to 8 inches of snow.
Dec. 6-23, 2015	Statewide storm events	DR-4258 Clatsop, Columbia, Multnomah, Clackamas, Washington, Tillamook, Yamhill, Polk, Lincoln, Linn, Lane, Douglas, Coos, and Curry Counties declared. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Each storm system brought several inches of snow to the mountain areas.
Dec. 8, 2016	Hood River County (Western Columbia River Gorge)	A strong frontal system brought strong east winds to the North Willamette Valley and a mix of snow, sleet, and freezing rain down to the Valley Floor. Ice accumulations were higher in the West Hills and near the Columbia River Gorge.

Date	Location	Remarks
Dec. 19, 2016	Hood River County (Upper Hood River Valley and Central Columbia River Gorge)	A warmer low pressure system moved into to Northwest Oregon, bringing high winds along the North and Central Oregon Coast. Cold east winds through the Columbia River Gorge continued for the first part of the event, leading to light accumulations of snow and sleet in portions of far northwest Oregon and higher accumulations in the Columbia River Gorge and Hood River Valley. Estimate the Columbia Gorge had around 0.2 to 0.5 inch of ice accumulation as temperatures in the lower 30s with reports of snow and freezing rain in Hood River. A frontal system brought high winds to the Central Oregon Coast, heavy snow to the Cascades and a mix of ice and snow in the Columbia River Gorge and Hood River Valley. SNOTELs and other stations reported a range of 12 to 25 inches of snow. Some specific reports include 25 inches at Mt Hood Meadows, 22 inches at Timberline, 14 inches at Government Camp and 12 inches at McKenzie Snotel.
Jan. 7-8, 2017	Hood River County (Western and Central Columbia Gorge, Upper Hood River Valley)	DR-4328 Columbia, Hood River, Deschutes and Josephine Counties declared. A broad shortwave trough brought multiple rounds of precipitation, including a wintry mix of snow and ice for many locations across Northwest Oregon. Strong easterly pressure gradients generated high winds through the Columbia River Gorge as well on January 8. General snowfall totals of 2-4 inches were reported, with the greatest total being 4.5 inches. Major ice accumulations occurred after the snow, with several locations reporting 0.50-1.00. The combination of snow and ice resulted in significant power outages and closures across the area.
Feb. 3-4, 2017	Hood River County (Western and Central Columbia River Gorge, Upper Hood River Valley)	Fronts associated with a low pressure system passing north into the Olympic Peninsula brought heavy snow and ice to the Columbia Gorge. The Hood River area reported 4 to 6 inches of snow turning to ice in the western-most part of this zone.
Feb. 8-9, 2017	Wasco, Sherman, Gilliam, (Eastern Columbia River Gorge)	A strong Pacific storm system brought snow, sleet and freezing rain to many areas of the Interior Northwest February 7th through 9th. Winter storm produced a total snow accumulation of 5.25 inches with an ice accumulation of 0.25 inches on top of the snow. Occurred 5 miles SSW of Chenoweth in Wasco county.
Dec. 24, 2017	Hood River County (Western Columbia River Gorge	Low pressure system moving into the Pacific Northwest pulled cold air from the Columbia Basin west into the Willamette Valley, through the Columbia River Gorge. As this system started to bring moisture and precipitation into NW Oregon, temperatures were around or below freezing, allowing for a mix of snow and ice to fall all the way to the Valley Floor around the Portland Metro, in the Columbia River Gorge, and the Hood River Valley. Local Broadcast Meteorologist reported getting 2.5 inches of snow and 0.2 inch of ice in Corbett. Also, a Skywarn Spotter in Cascade Locks reported getting 4.8 inches of snow.
Feb. 22-26, 2019	Wasco, Sherman, Gilliam, Morrow, and Umatilla, Counties (Eastern Columbia River Gorge)	Persistent troughing off the coast of the Pacific Northwest focused a stream of mid-level moisture over the Inland Northwest resulting in a long duration snow event as the plume drifted north and south several times between the 22nd and 27th of February.

Date	Location	Remarks
Jan. 15-16, 2020	Hood River County (Western and Central Columbia River Gorge)	A low pressure zone located near 45N/130W along with an attendant warm front moved into the southern Oregon Coast and overran a cold air mass originating from the Columbia River Gorge. This resulted in snow that gradually transitioned to freezing rain in the Gorge on Wednesday night into Thursday. The amounts of snow and ice varied greatly across the Columbia River Gorge, with heaviest amounts in the Central Columbia River Gorge zone. The combination of snow, ice, and wind resulted in the closure of I-84 between Troutdale and Cascade Locks. Based on ODOT and spotter reports, 4 to 10 inches fell in the stretch from Corbett to Cascade Locks, followed by a few hours of light freezing rain. Additionally, east winds gusted to 56 mph at Corbett, with higher gusts at Crown Point.

Taylor and Hatton (1999); Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Probability

Table 2-551. Assessment of Winter Storms Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	H	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Winter storms occur annually in Region 5. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-552. Local Assessment of Vulnerability to Winter Storms in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	H	H	H	H	H	H

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-553. State Assessment of Vulnerability to Winter Storms in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	H	H	H	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Within the State of Oregon, Region 5 communities are known for cold winter conditions. This region is the commodity flow route to Eastern Oregon. With long road closures the communities suffer from the loss of traffic and revenue. Drifting, blowing snow has brought highway traffic to a standstill. Also, windy and icy conditions have closed Oregon's principal east-west transportation route, I-84, for hours. In these situations, travelers must seek accommodations — sometimes in communities where lodging is very limited. For local residents, heating, food, and the care of livestock and farm animals are everyday concerns. Access to farms and ranches can be extremely difficult and present a serious challenge to local emergency managers.

Winter storms, particularly east of the Cascades where snow storms are typically more intense, bring larger amounts of snow and last longer. They can strand livestock in pastures, leaving them without food and water and exposed to extreme cold for long periods of time. As a consequence, substantial losses in livestock from starvation, dehydration and freezing, significantly impact producers, and state and local economies. In addition, water quality and health hazards develop when dead livestock are not retrieved until roads are cleared and vehicles can be used to remove the carcasses. Livestock buried under snow may not be found until the snow melts. The snowmelt may carry the carcasses to streams and wash them downstream.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

All the counties in Region 5 are vulnerable to the adverse economic impacts of winter storms. Morrow, Umatilla, and Wasco Counties are among those with the greatest social vulnerability in Oregon. Their very high social vulnerability indicates that the effects of winter storms will be felt more intensely by their populations than by those of other counties and will require more resources for preparation, mitigation, and response. Considered in combination with the importance of large truck commodity transport through this region and the costs associated with road closures, Morrow, Umatilla, and Wasco Counties are the counties most vulnerable to winter storms in Region 5.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $1,080,652,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 5 since the beginning of 2015. Thirteen losses were due to winter storms statewide. Of those, it is possible that up to four may have been located in the eastern portion of Region 5. These claims totaled a little over $72,000.

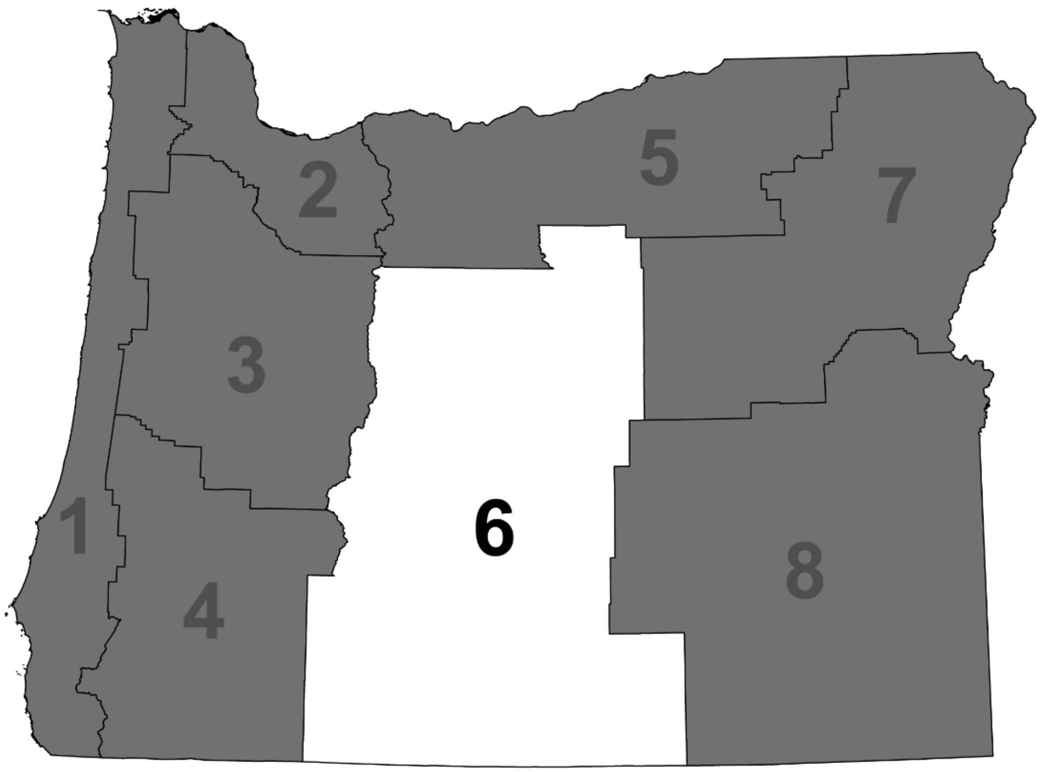
Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

While the risk of winter storms for all counties in Region 5 is great, Morrow, Umatilla, and Wasco Counties' elevated vulnerabilities put them at greater risk than the others.

2.3.6 Region 6: Central Oregon

Crook, Deschutes, Jefferson, Klamath, Lake, and Wheeler Counties



2.3.6.1 Summary

Profile

The region's demographic, economic, infrastructure, and development patterns suggest that some populations, structures and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

Regionally, social vulnerability is driven by high percentages of individuals with a disability and low median household incomes. At the county level, vulnerability is driven by a high share of senior citizens in Crook, Lake, and Wheeler Counties; increases in child poverty in Douglas and Deschutes Counties; vacant homes in Deschutes, Lake and Klamath Counties; and single-parent households in Klamath County.

Higher than average unemployment rates and low wages illustrate the region's slow recovery since the financial crisis that began in 2007 and continued vulnerability following the 2020 pandemic. All counties, except Deschutes County, have a lower median household income compared to the state as a whole. Notably, the median estimates in Wheeler and Lake Counties are substantially lower than the other counties.

Road, bridge, rail and port infrastructure across the state are vulnerable to damage and disruption caused by icy conditions, flooding, or seismic events. The Redmond Regional Airport is of particular importance in this region because it has been identified as a primary airport for the state following a catastrophic Cascadia Subduction Zone (CSZ) earthquake.

Older centralized water infrastructure is vulnerable to pollution and flooding, which can have implications for human health and water quality.

Energy facilities and infrastructure in Central Oregon support the regional economy and are vulnerable to damage and service disruptions due to natural hazard events. Liquified natural gas pipelines run through Klamath, Deschutes, Crook, and Jefferson Counties. The region's diverse energy portfolio — including hydroelectric, natural gas, biomass, and solar voltaic systems — helps boosts its ability to withstand system disruptions.

Region 6 is mostly rural, with the majority of development occurring in communities along I-97. Manufactured homes are inherently vulnerable to natural hazard events, and there are a significant number of manufactured homes in Jefferson, Lake, and Wheeler Counties. Roughly half the homes in Klamath, Lake, and Wheeler Counties were built before 1970 and floodplain management and seismic building standards, making them especially vulnerable. With the exception of Crook and Deschutes Counties, the region's Flood Insurance Rate Maps (FIRMs) are not as up to date as those of other areas of the state.

Hazards and Vulnerability

Region 6 is affected by nine of the 11 natural hazards that affect Oregon communities. Coastal hazards and tsunamis do not directly impact this region.

Droughts: Droughts are common throughout Region 6. When droughts occur they can be problematic, impacting community water supplies, wildlife refuges, fisheries, and recreation. Klamath and Lake Counties are especially vulnerable. Considering that several drought declarations have occurred during the last 10 years, is it reasonable to assume that there is a high probability that Region 6 will experience drought in the near future. Klamath County has received drought declarations in 48% of the years since 1992, the most in the state. Lake County has received 34%, Crook and Wheeler Counties 28%, Deschutes 24%, and Jefferson 17%. These statistics account for the differences in their probability ratings.

Earthquakes: Four types of earthquakes affect Region 6: (a) shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) the offshore Cascadia Subduction Zone (CSZ) Fault, and (d) earthquakes associated with volcanic activity. Shallow crustal and intraplate earthquakes are the primary earthquake risks. In a CSZ event, most of the region's impact will be secondary, due to disruptions to markets to the west. The region's seismic lifelines have low vulnerability to a CSZ event, unless a Klamath Falls event is triggered. Region 6 is vulnerable to earthquake-induced landslides, liquefaction, and strong ground shaking. Klamath County ranks among the top 15 in the state with the highest expected earthquake related damages and losses. In Region 6, a 2500-year probabilistic earthquake scenario could generate a potential loss of over $10M in state building and critical facility assets. Over half that value is in Klamath and Lake Counties. Wheeler County has no state assets at risk of earthquakes. The potential loss in local critical facilities is more than double, over $22.5M. Lake and Deschutes Counties have the greatest potential losses, followed by Klamath and Crook Counties.

Extreme Heat: Extreme temperatures are moderately common in Region 6 and the frequency of prolonged periods of high temperatures has increased. Redmond has an average of about 24 days per year above 90°F. As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. Like drought, impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. The value of state-owned and leased buildings and critical facilities in Region 6 is approximately $616,270,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $2,014,056,000.

Floods: Flooding affects Central Oregon in a variety of ways, including (a) spring runoff from melting snow, (b) intense warm rain during the winter months, (c) ice-jam flooding (Deschutes County), (d) local flash flooding, (e) lake flooding associated with high winds (Klamath Lake), and (f) flooding associated with the breeching of natural debris dams (Deschutes County). East of the Cascades there have also been rain-on-snow floods associated with La Niña events. All of the region's counties are considered moderately vulnerable to the flood hazard. In Region 6, there is a potential loss from flooding of almost $5M in state building and critical facility assets, between 25% and 30% each in Lake, Crook, and Jefferson Counties. There are no state assets in flood hazard areas in Deschutes County. There is a far greater potential loss – almost 25 times as much - due to flood in local critical facilities: over $120M. Fifty-seven percent of that value is in Crook County and 33% in Jefferson County.

Landslides: Landslide events can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Rain-induced landslides can occur during winter months. Earthquakes can trigger landslides. Most landslides in this region have taken place in the Klamath and Cascade Mountains, along the US-26 corridor near Prineville and Mitchell, and along US-97 just north of Klamath Falls. DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 6. Over $15M in value of state assets is exposed to landslide hazards in Region 6, most of it in Crook County followed by Jefferson and Klamath Counties. The value of local critical facilities is over $24M, more than two-thirds of it in Wheeler and Klamath Counties.

Volcanoes: Western areas of the region's counties that coincide with the crest of the Cascade mountain range may be impacted by volcanic activity. Most volcanic activity is considered local, however, some activity (lahars and ashfall) can travel many miles. Due to proximity to potential volcanic activity, small mountain communities, dams, reservoirs, energy-generating facilities, and highways merit special attention. Communities closer to the main volcanoes — Bend, Sisters, La Pine, and Klamath Falls — are at the greatest risk for inundation by lava flows, pyroclastic flows, lahars, or ashfall. Communities on the eastern side of the region may be subject to ashfall from Cascade volcanoes. DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 6. Over $72.3M in value is exposed to volcanic hazards in Region 6, all of it in Deschutes, Jefferson, and Klamath Counties.

Wildfires: Central Oregon is especially vulnerable to wildfires because homes are widely dispersed among ladder fuels and overstocked pine, sage, grassy areas and invasive weeds. Fire risk is highest in late summer and fall when fuel conditions are dry. Based on data from the 2013 West Wide Wildfire Risk Assessment, in Region 6, Deschutes, Jefferson and Klamath and Wasco Counties have high percentages of wildland acres subject to Fire Risk, Wildland Development Areas, Fire Effects, or Fire Threat, making them especially vulnerable. Other areas of vulnerability are within wildland-urban interface communities. In Region 6, there is a potential loss to wildfire of almost $346.5M in state building and critical facility assets, 67% of it in Jefferson County alone. Deschutes County contains the next greatest value of state building and critical facility assets at 13%, followed by Crook and Klamath Counties, each with 8%, then Lake and Wheeler Counties. There is a similar potential loss in local critical facilities: about $322M. Fifty-eight percent is located in Deschutes County, 20% in Klamath County, and 10% in Lake County.

Windstorms: Windstorms are common in the inter-mountain areas of the region, and can reach speeds of 70-90 miles per hour. Most vulnerable to windstorms are insufficiently anchored manufactured homes and buildings needing roof repair. Overturned trees pose problems as they can block roads and emergency routes and can damage buildings and utility lines. The value of state-owned and leased buildings and critical facilities in Region 6 is approximately $616,270,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $2,014,056,000.

Winter Storms: Annual winter storms bring colder weather and higher precipitation. Communities are typically prepared for light to moderate storms, but are less prepared for severe winter storms that occur less frequently. Winter storms have the potential to affect the entire region, particularly transportation corridors along US-97 and mountain passes to the west. The value of state-owned and leased buildings and critical facilities in Region 6 is approximately $616,270,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $2,014,056,000.

Climate Change

The hazards faced by Region 6 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon. Coupled with projected decreases in mountain snowpack due to warmer winter temperatures, Region 6 is expected to be affected by an increased incidence of drought and wildfire. In Region 6, climate change would result in increased frequency of drought due to low spring snowpack (*very likely*, >90%). It is *very likely* (>90%) that Region 6 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*).

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 6, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section 2.2.1.2, **Introduction to Climate Change**.

2.3.6.3 Profile

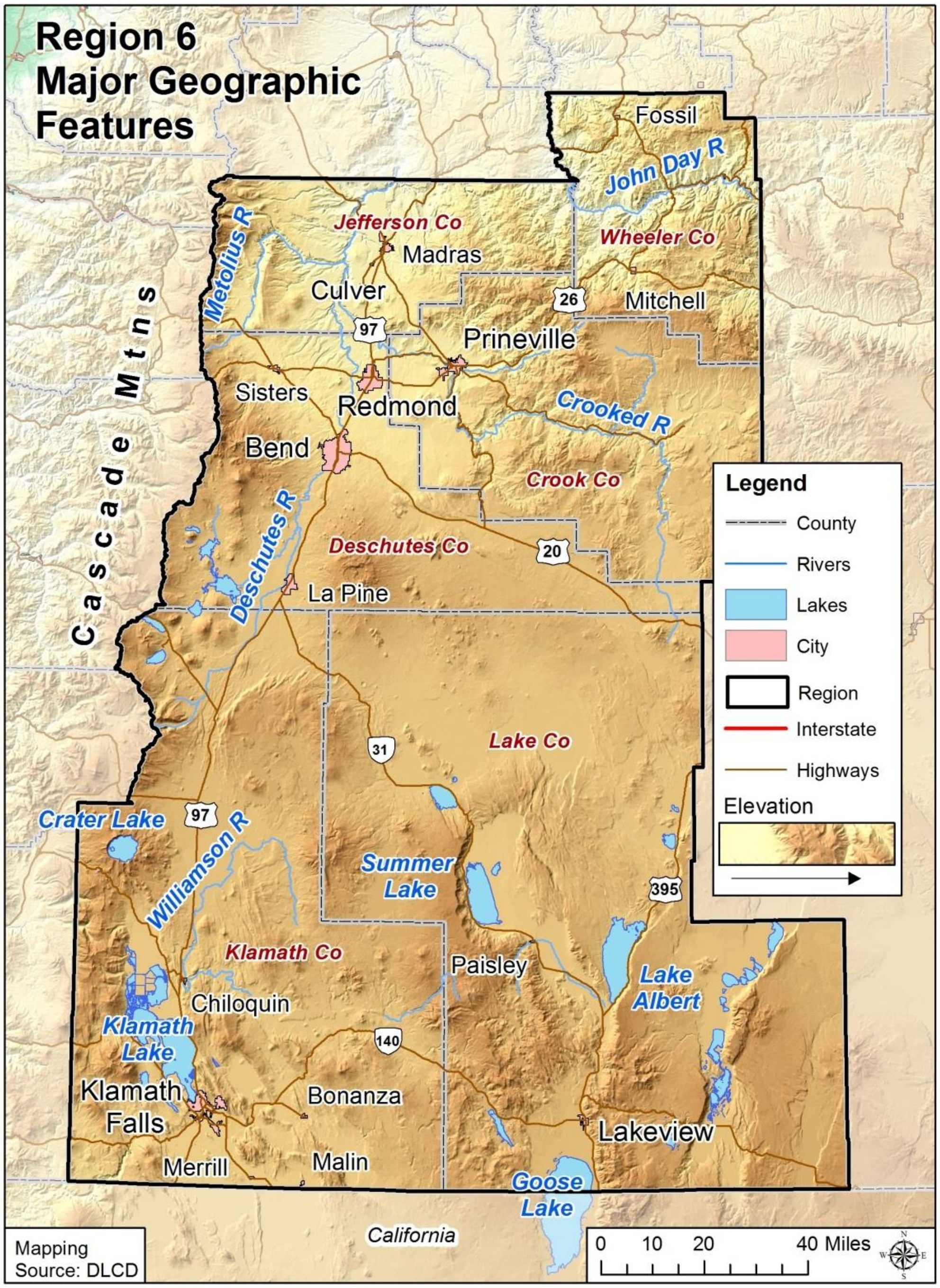
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

Central Oregon is approximately 24,144 square miles in size and includes Crook, Deschutes, Jefferson, Klamath, Lake, and Wheeler Counties. The Cascades crest to the west, Blue Mountains in the north and the California border to the south define the region. Region 6 has a diverse variety of ecological zones and is not shaped by any particular watershed, although the Deschutes, John Day, and Crooked Rivers are major watersheds to the north. Large lakes are common in the southern portions of Region 6.

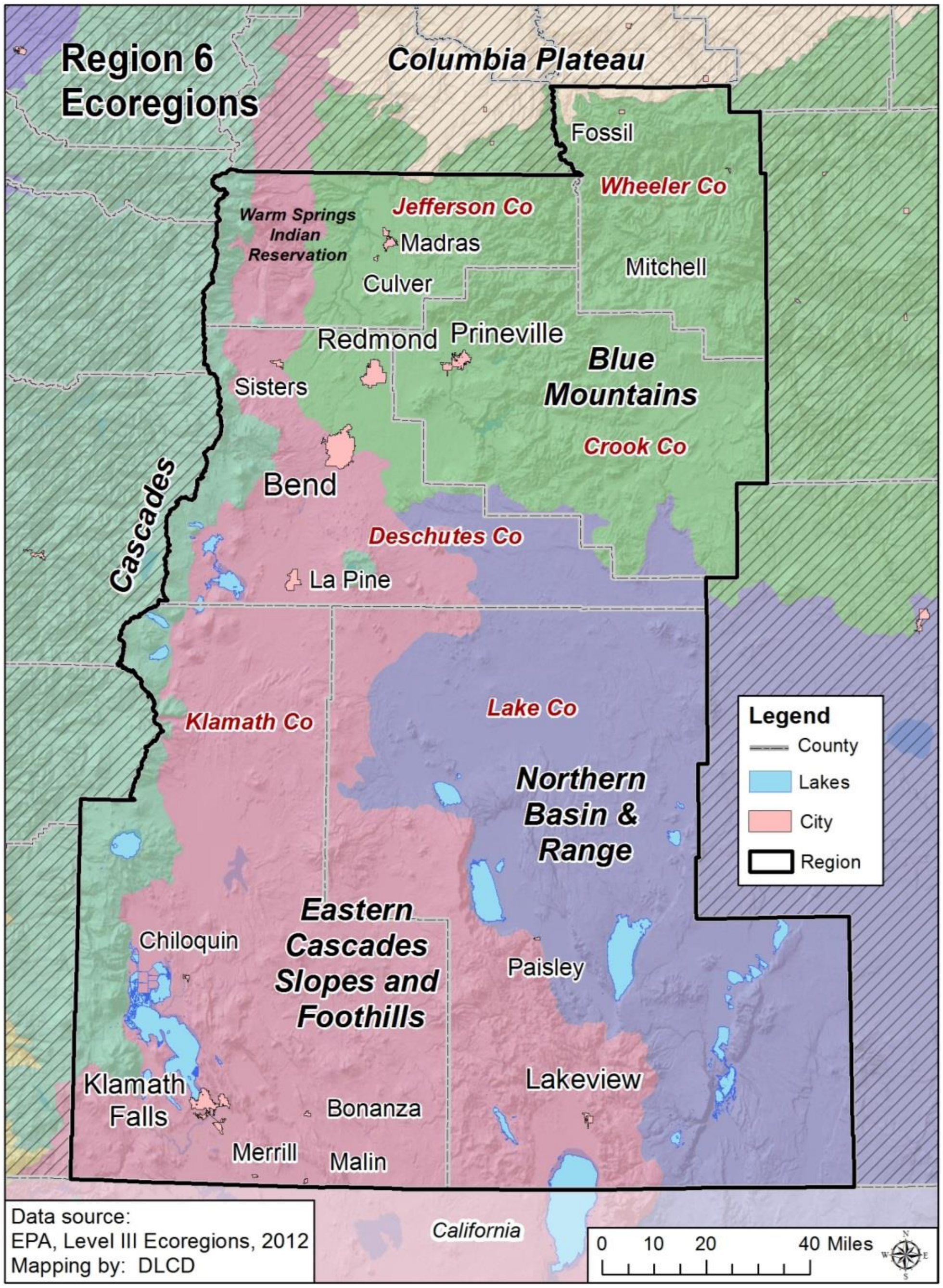
Figure 2-248. Region 6 Major Geographic Features



Source: Department of Land Conservation and Development

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 6 is composed of four ecoregions: the Blue Mountains, the Cascades, the Eastern Cascades Slope and Foothills, and the Northern Basin and Range (**Figure 2-249**).

Figure 2-249. Region 6 Ecoregions



Blue Mountains: This ecoregion is complex and diverse with many sub-ecoregions with unique conditions. While much of the Blue Mountains are flat with arid climates, the highly dissected John Day / Clarno Highlands contain the John Day and Crooked Rivers that provide more abundant water than other parts of the Blue Mountains ecoregion, which leads to higher levels of human settlement in proximity to the rivers. Grazing, logging, and fire suppression regimes have altered land cover throughout the region where juniper woodlands have given way to sagebrush grasslands and grand fir forests have given way to spruce fir forests. Other forests in the region predominantly have either a Douglas fir or ponderosa pine canopy. Ponderosa forests tend toward sparsely vegetated understories the ecoregion's Douglas fir forests tend toward dense shrub understories, making them more difficult to log. Some wet, high meadows also exist within Cold Basins of the Blue Mountains in Region 6 and unchannelized streams tend toward a meandering nature within wide floodplains, moving dynamically through the landscape. Riparian areas of the region have a diverse palette of understory shrubs with black cottonwoods, grand firs, and alders in the canopy layer (Thorson, et al., 2003).

Cascades: This ecoregion is underlain by volcanic soils and naturally occurring mixed conifer forests have given way to predominantly Douglas fir forests that are managed for commercial logging. Logging activities have strained the ecological health of streams in the area (Thorson, et al., 2003). Waterways in the steeper valleys support threatened cold-water salmonids including Chinook salmon, steelhead, and bull trout. Streams, lakes, reservoirs, rivers, and glacial lakes at higher elevations are key sources of water. Large volcanic peaks, glaciers, and year-round snowfields punctuate the alpine and subalpine areas of the ecoregion (Thorson, et al., 2003).

Eastern Cascades Slope and Foothills: The Region 6 section of this ecoregion is an ecological mosaic. Wooded areas may be dominated by ponderosa pines or mixed fir canopies while rangelands are dominated by sagebrush, bitterbrush, and bunchgrasses. Most historically wet meadows have been drained to accommodate agricultural uses; however, marshland wildlife refuges have been established to preserve biodiversity, particularly for avian populations. Because of its location in the rain shadow of the Cascades, the ecoregion often experiences dramatic temperature extremes and native plants are adapted to dry climates and frequent wildfires. Much of this ecoregion is underlain by highly permeable volcanic pumice soils, which contribute to the effects of drought in the ecoregion. Logging, livestock grazing, agriculture and recreation are common land uses throughout (Thorson, et al., 2003).

Northern Basin and Range: The Region 6 section of this ecoregion contains seasonally wet lake basins, high desert wetlands, high shrub- and grass-covered plains, scattered hills, mountains and buttes, playas, and dunes. Lake levels and salinity in the region can fluctuate seasonally and yearly, with several years passing before some lake beds are filled with water. The majority of this ecoregion is dominated by shrub- and grass-covered rangeland, lending itself primarily to wildlife habitat, recreation, and limited cropland farming and livestock grazing.

Climate

This section covers historic climate information. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment** for statewide projections.

The climate of Central Oregon is semi-arid supporting primarily livestock grazing. The region is subject to droughts and wildfires, particularly during dry summers and years with low snowpack. Despite its relative dryness, the region is also subject to floods and landslides. Flooding can be a direct result of rain-on-snow events. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-554** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 6 based on data from the NOAA National Centers for Environmental Information.

Table 2-554. Average Precipitation and Temperature in Region 6 Counties and Climate Divisions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Crook County	14.87" (8.64"–23.35")	Jan: 1.7" Jul: 0.61"	45.5°F	Jan: 22.1°F /38.5°F Jul: 47.5°F /81.9°F
Deschutes County	23.87" (15.27"–38.03")	Jan: 3.28" Jul: 0.63"	44.1°F	Jan: 22°F /38.2°F Jul: 45.2°F /79.5°F
Jefferson County	19.1" (12.5"–31.51")	Jan: 2.72" Jul: 0.5"	47.2°F	Jan: 25.6°F /39.8°F Jul: 49.0°F /82.3°F
Klamath County	27.42" (19.67"–43.28")	Jan: 3.84" Jul: 0.51"	44.2°F	Jan: 21.2°F /38.3°F Jul: 45.4°F /80.2°F
Lake County	14.96" (9.14"–23.36")	Jan: 1.6" Jul: 0.49"	45.0°F	Jan: 21.3°F /38.9°F Jul: 47.4°F /82.2°F
Wheeler County	16.34" (10.65"–24.24")	Jan: 1.84" Jul: 0.56"	47.2°F	Jan: 24.9°F /39.7°F Jul: 50.3°F /82.2°F
Climate Division 5 "High Plateau"	26.47" (18.7"–41.42")	Jan: 3.62" Jul: 0.57"	43.5°F	Jan: 20.7°F/37.9°F Jul: 44.5°F/79.6°F
Climate Division 7 "South Central"	16.16" (10.02"–24.98")	Jan: 1.89" Jul: 0.49"	45.7°F	Jan: 21.5°F/38.4°F Jul: 48.6°F/82.6°F

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 21, 2019 from https://www.ncdc.noaa.gov/cag/.

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community's capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

The population in Crook County has grown slightly slower than the state as a whole. Net in-migration has been sporadic but ultimately driven population growth as deaths began outpacing births in 2010. This trend is expected to continue over the next decade. Deschutes County experienced rapid population growth since 2000, driven largely by in-migration but also by natural increase, a trend that continued through 2018. While steady in-migration continues, natural increase has declined. The population is projected to continue growing at a fast pace over the next decade (Population Research Center, Portland State University, 2018 [Deschutes

County]). Jefferson County has grown as fast as the state since 2010. Growth has occurred through natural increase and net in-migration, although the former has been declining and the latter growing (Population Research Center, Portland State University, 2018 [Jefferson County]). Klamath County has experienced slow population growth since 2010, driven by both natural increase and net in-migration. Over the next decade, the population is projected to continue to grow, but in-migration is expected to play a bigger role as natural increase is expected to decline (Population Research Center, Portland State University, 2018 [Klamath County]). Lake County experienced slow population growth since 2010. The growth has been driven entirely by sporadic net in-migration and has been undercut by natural decrease. This growth trend is forecast to continue over the next (Population Research Center, Portland State University, 2018 [Lake County]). The population in Wheeler County has remained relatively constant since 2010. The minimal change was a result of sporadic net in-migration. Over the next decade, the population is projected to decline at a faster pace, driven largely by natural decrease outpacing net in-migration (Population Research Center, Portland State University, 2019 [Wheeler County]).

Table 2-555. Population Estimate and Forecast for Region 6

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 6	276,147	312,775	13.3%	376,222	20.3%
Crook	20,978	22,710	8.3%	26,565	17.0%
Deschutes	157,733	188,980	19.8%	244,018	29.1%
Jefferson	21,720	23,560	8.5%	26,375	11.9%
Klamath	66,380	67,960	2.4%	69,545	2.3%
Lake	7,895	8,115	2.8%	8,420	3.8%
Wheeler	1,441	1,450	0.6%	1,299	−10.4%

Source: Population Research Center, Portland State University (2018), Certified Population Estimates; Population Research Center, Portland State University (2019), Current Forecast Summaries for All Areas & Oregon Final Forecast Table by Age (2019); U.S. Census Bureau, 2010 Decennial Census. Table DP-1

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 6 are largely centered on outdoor activities (hiking and backpacking, visiting national and state parks etc.), touring (traveling to experience scenic beauty, history and culture), and special events (such as fairs, festivals or sporting events) (Longwoods International, 2017f). Note that the Longwoods Travel Report includes Crook, Deschutes, Jefferson, and Wheeler Counties within the Central Region (which also includes parts of Gilliam, Sherman, and Wasco Counties). Klamath and Lake Counties are included within the Southern region (which also includes Douglas, Jackson, and Josephine Counties); see Region 4 for the results of this study area. The majority of trips to the region occur between April and September, and the average travel party contains approximately three persons (Longwoods International, 2017f). The average number of nights spent in Central Oregon is between two and three (Longwoods International, 2017f). Deschutes County has more overnight visitors annually than all the other counties in the region combined. Many of these visitors are as likely to stay in a hotel as a private home.

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population

Table 2-556. Annual Visitor Estimates in Person Nights (X1000) in Region 6

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 6	10,874	—	11,008	—	11,171	—
Crook	687	100%	690	100%	708	100%
Hotel/Motel	194	28.2%	195	28.3%	205	29.0%
Private Home	228	33.2%	231	33.5%	236	33.3%
Other	265	38.6%	264	38.3%	267	37.7%
Deschutes	6,846	100%	6,910	100%	7,037	100%
Hotel/Motel	2,527	36.9%	2,538	36.7%	2,627	37.3%
Private Home	2,359	34.5%	2,387	34.5%	2,434	34.6%
Other	1,960	28.6%	1,984	28.7%	1,976	28.1%
Jefferson	907	100%	911	100%	927	100%
Hotel/Motel	125	13.8%	126	13.8%	132	14.2%
Private Home	232	25.6%	237	26.0%	243	26.2%
Other	549	60.5%	548	60.2%	553	59.7%
Klamath	2,100	100%	2,162	100%	2,161	100%
Hotel/Motel	670	31.9%	716	33.1%	713	33.0%
Private Home	849	40.4%	869	40.2%	863	39.9%
Other	581	27.7%	577	26.7%	585	27.1%
Lake	262	100%	263	100%	265	100%
Hotel/Motel	58	22%	59	22%	59	22%
Private Home	78	30%	79	30%	79	30%
Other	126	48%	125	48%	127	48%
Wheeler	72	100%	72	100%	73	100%
Hotel/Motel	9	13%	9	13%	10	14%
Private Home	13	18%	14	19%	14	19%
Other	50	69%	49	68%	50	68%

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003). Region 6 has a slightly higher percentage of people with a disability vis-à-vis the state. Except for Deschutes County, the share of residents with a disability is also higher in each county than in the state as a whole. In Lake, Wheeler, and Crook Counties, approximately one-fifth of all residents identify as having a disability—roughly five percentage points higher than the statewide estimate.

The percentage of younger people (<18) in the region with a disability is similar to statewide share. However, estimates for “under 18 with a disability” are subject to sampling error and should be used with caution.

The percentage of older adults with a disability in the region is smaller than the share statewide. Within the region, estimates are reliable; however, the margins of error for Lake and Wheeler Counties are significant.

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Table 2-557. People with a Disability by Age Group in Region 6

	With a Disability			**Under 18 Years with a Disability**			**65 Years and Over with a Disability**		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	14.6%	☑	0.1%	4.6%	☑	0.2%	37.1%	☑	0.4%
Region 6	15.6%	☑	0.6%	4.2%	☑	0.9%	35.2%	☑	1.3%
Crook	21.6%	☑	2.2%	8.4%	⊙	3.0%	40.9%	☑	4.5%
Deschutes	13.0%	☑	0.8%	3.9%	⊙	1.3%	31.7%	☑	1.9%
Jefferson	16.2%	☑	1.6%	2.6%	⊙	1.3%	35.8%	☑	4.5%
Klamath	19.4%	☑	1.1%	4.2%	⊙	1.4%	40.1%	☑	2.4%
Lake	22.0%	☑	3.0%	4.6%	⊗	3.4%	45.2%	☑	7.0%
Wheeler	21.9%	☑	3.7%	2.7%	⊗	2.4%	38.4%	☑	7.4%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Homeless Population

The U.S. Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count, a biennial count of sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors. They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing & Community Services, 2019). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing & Community Services, 2019).

According to the PIT, between 2015 and 2019 the region reported a 22% increase in the number of persons experiencing homelessness. Within the region, Deschutes County has the highest number of people experiencing homelessness. There are significantly fewer people in Klamath County experiencing homelessness, but still a relatively large number. Lake and Wheeler Counties reported fewer than ten people without a home during the period. Crook County experienced the greatest percent increase according to the data.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate vulnerability conditions. Disasters that result in damage to the built environment can place additional stress on temporary shelters (Peacock, Dash, Zhang, & Van Zandt, 2017). Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-558. Homeless Population Estimate for Region 6

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 6	852	983	1045	960
Crook	36	43	79	53
Deschutes	503	701	700	635
Jefferson	55	34	58	49
Klamath	252	192	207	217
Lake	6	12	0	6
Wheeler	0	1	1	1

Oregon Housing and Community Services (n.d.). Oregon Point In Time Homeless Counts. Retrieved from https://public.tableau.com/profile/oregon.housing.and.community.services#!/vizhome/2019Point-in-TimeDashboard/Story1

Biological Sex and Gender

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019). According to the survey, there are fewer men than women in the region (99.1 men to every 100 women) (U.S. Census Bureau, 2019). Within the region, Crook, Deschutes, and Klamath Counties mirror the regional trend, more women than men. Conversely, Lake, Jefferson, and Wheeler Counties all have more men than women, with Lake County having the largest imbalance (114.8 men to every 100 women).

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognized (Enarson, 2017). This is an area deserving of more attention as the field develops.

Age

Older adults, those 65 and older, comprise a larger share of the population in Region 6 than they do in the state as a whole. This is true for all counties in the region as well. Notably, Wheeler County has the highest percentage, approximately double the statewide share. An older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

Children also represent a vulnerable segment of the population. The share of children in Region 6 is approximately the same as in the state as a whole. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. In addition, parents might lose time and money when their children's childcare facilities and schools are impacted by disasters.

Table 2-559. Population by Vulnerable Age Group, in Region 6

	Total Population	Under 18 Years Old			65 and Older		
	Estimate	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	4,025,127	21.5%	☑	0.1%	16.3%	☑	0.1%
Region 6	294,985	21.3%	☑	0.1%	19.4%	☑	0.1%
Crook	21,717	19.5%	☑	0.5%	24.2%	☑	0.3%
Deschutes	175,321	21.2%	☑	0.1%	18.5%	☑	0.1%
Jefferson	22,707	23.9%	☑	0.3%	18.2%	☑	0.4%
Klamath	66,018	21.7%	☑	0.1%	19.7%	☑	0.1%
Lake	7,807	18.8%	☑	0.2%	23.7%	☑	0.6%
Wheeler	1,415	15.8%	⊙	3.3%	33.5%	☑	3.6%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

U.S. Census Bureau (2018). Table DP05: ACS Demographics and Housing Estimates, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to language and culturally appropriate outreach materials. Language barrier in Region 6 are not a large concern. The share of residents that do not speak English “very well” is much smaller in the region compared to the state. Due to sampling techniques employed by the American Community Survey, some estimates for Region 6 should be used with caution. Communities creating outreach materials used to communicate with and plan for populations who do not speak English very well should take into consideration the language needs of these populations.

Table 2-560. English Usage in Region 6

	Speak English Less Than "Very Well"				
	Estimate	CV **	MOE (+/−)	Percent	% MOE (+/−)
Oregon	222,428	☑	4,116	5.9%	0.1%
Region 6	6,878	☑	787	2.5%	0.3%
Crook	242	⊗	190	1.2%	0.9%
Deschutes	3,460	☑	635	2.1%	0.4%
Jefferson	1,077	⊙	312	5.1%	1.5%
Klamath	1,966	☑	277	3.2%	0.4%
Lake	132	⊗	81	1.8%	1.1%
Wheeler	1	⊗	2	0.1%	0.2%

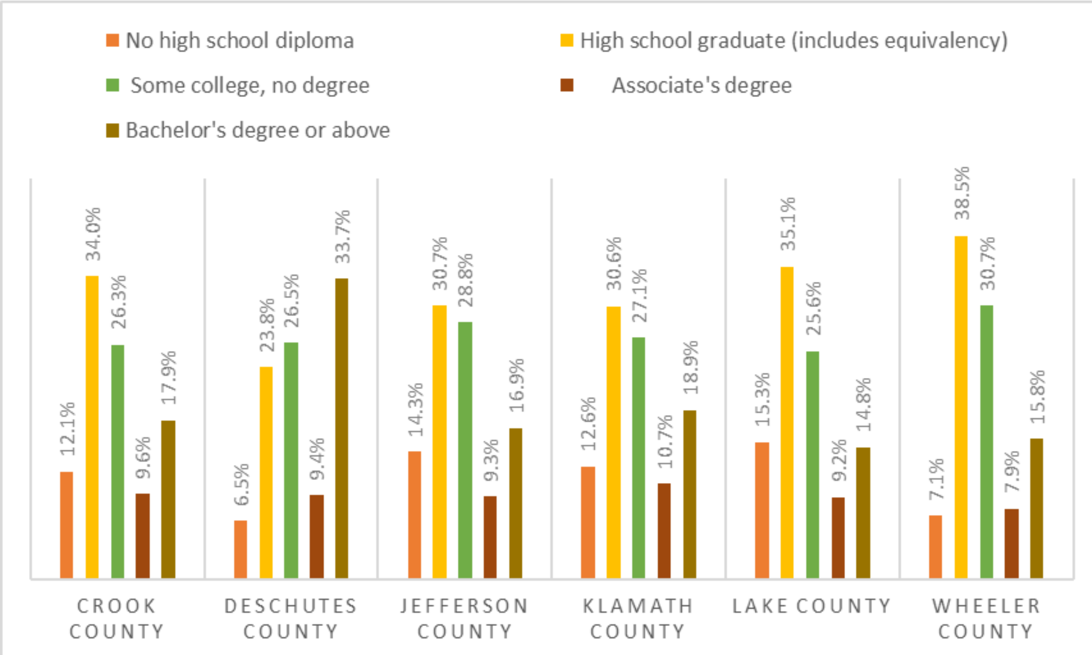
**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Education Level

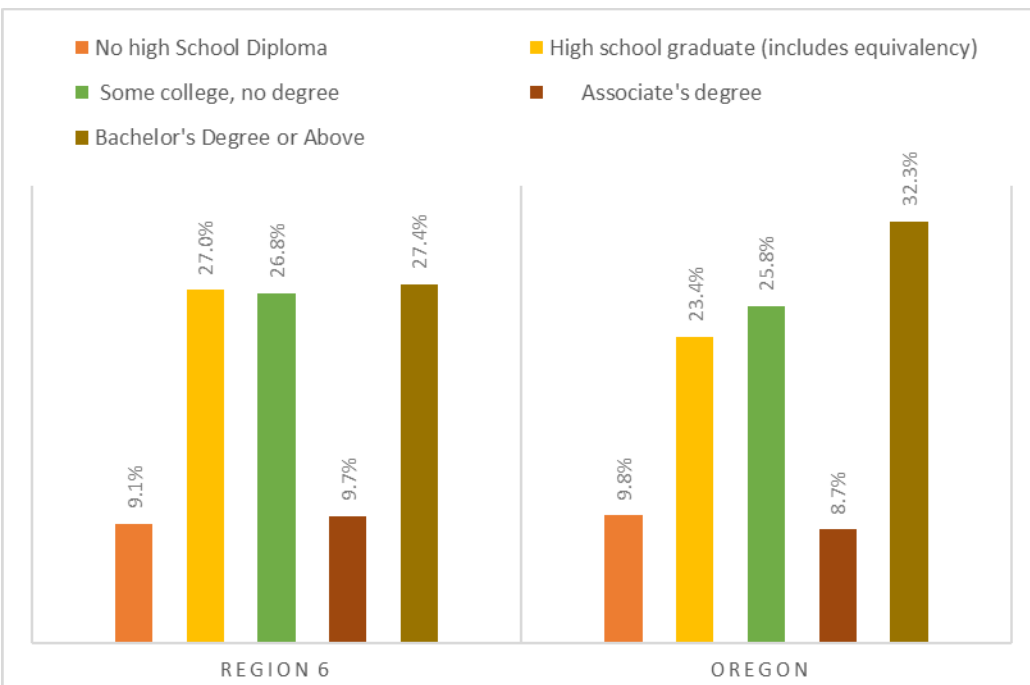
Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual’s ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

Approximately 27% of residents in Region 6 have a bachelor’s degree or higher, which is about five percentage points below the statewide share. The portion of the population with an associate’s degree is slightly higher vis-à-vis the state, as is the share of people with some college credit and a high school diploma. Educational attainment within the region varies considerably. Deschutes County has the highest share of college graduates, slightly higher than the statewide share. Notably, the share of college graduates in all other counties is between 15%-20%. Approximately a quarter of residents in each regional county have some college credit; and similar to the state, approximately 8%-10% in each county have an associate’s degree. All counties in the region, except Deschutes County, have a higher percentage of residents that did not graduate high school vis-à-vis the state.

Figure 2-250. Educational Attainment in Region 6: (top) by County, (bottom) Regional vs. Statewide



Source: U.S. Census Bureau (2018). Table DP02: Selected Social Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/



Source: U.S. Census Bureau (2018). Table DP02: Selected Social Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Income and Poverty

The impact of a disaster in terms of loss and the ability to recover varies among population groups. "The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event" (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public (Stahl, P., 2000). Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, and less likely to have the savings to rebuild after a disaster. They are also less likely to have access to transportation and medical care.

Median household income varies across the region. All counties, except Deschutes County, have a lower median household income compared to the state as a whole. The estimate for Klamath, Crook, and Jefferson Counties is $7,000-$15,000 below the statewide number. Notably, the median estimates in Wheeler and Lake Counties are substantially lower than the others—approximately $23,000 less than the statewide median. Moreover, both counties experienced a statistically significant decrease in median household income from 2012 to 2017. Conversely, Deschutes County's estimate increased by a statistically significant amount between 2012 and 2017 and is approximately $3,000 higher than the statewide number.

Table 2-561. Median Household Income in Region 6

	2008–2012			2013–2017			Statistically Different*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	$53,427	☑	$338	$56,119	☑	$370	Yes
Region 6	—	—	—	—	—	—	—
Crook	$42,968	☑	$2,379	$41,777	☑	$3,308	No
Deschutes	$55,289	☑	$1,909	$59,152	☑	$2,132	Yes
Jefferson	$46,308	☑	$2,221	$48,464	☑	$3,467	No
Klamath	$44,090	☑	$2,482	$42,531	☑	$1,905	No
Lake	$42,643	☑	$5,348	$32,769	☑	$3,649	Yes
Wheeler	$38,889	☑	$2,744	$33,563	☑	$3,911	Yes

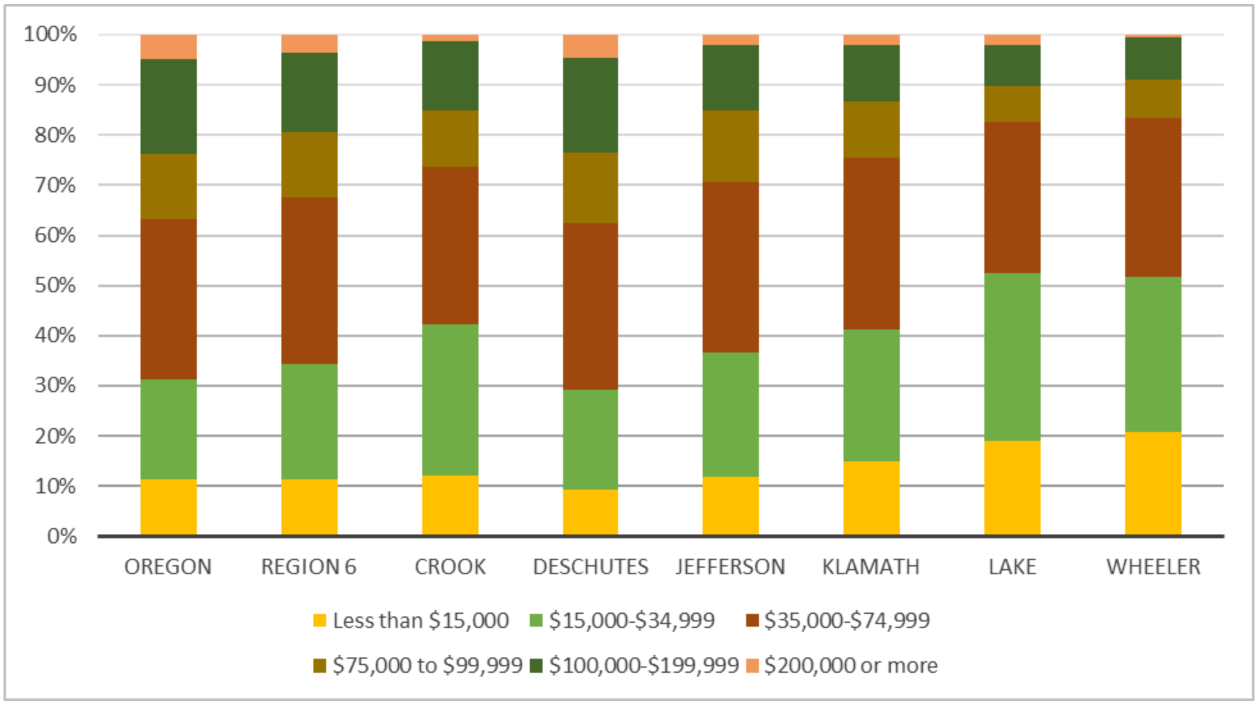
Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Compared to statewide numbers, the region has a smaller percentage of households earning more than $75,000 and a larger earning under $35,000 annually. Deschutes County is the only county within the region that has a higher percentage of residents compared to the state earning above $75,000 annually. Just under one-third of the region's households earn between $35,000 and $75,000 per year, similar to the statewide share. Just over half of all residents in Lake and Wheeler Counties earn less than $35,000 annually.

Figure 2-251. Median Household Income Distribution in Region 6



Source: U.S. Census Bureau. Table DP03: Selected Economic Characteristics, American Community Survey, 2013-2017 American Community Survey 5-Year Estimates

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018). A similar share of the regional population is living in poverty compared to the state as a whole. However, poverty rates vary across the region. Approximately one-fifth of residents in Wheeler, Lake, and Jefferson Counties are living in poverty, although the margins of error should be noted—especially for Lake and Wheeler Counties.

A similar share of children are living in poverty in the region compared to the statewide share. The percentage is driven largely by conditions in Deschutes County, which has the largest population in the region. Child poverty in all other counties is more common than in the state as a whole. More than one-third of all children in Wheeler and Jefferson Counties live in poverty; however, the margins of error should be noted. Although the change might not be as drastic as the estimates suggest, the increase in child poverty between 2012 and 2017 in Wheeler County is statistically significant—the only statistically significant change in the region.

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources.

Table 2-562. Poverty Rates in Region 6

	Total Population in Poverty						
	2008-2012			2013-2017			Statistical Difference?*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	15.5%	☑	0.3	14.9%	☑	0.3%	No
Region 6	15.3%	☑	0.9	14.7%	☑	0.8%	No
Crook	17.4%	☑	2.7	15.3%	☑	2.8%	No
Deschutes	13.1%	☑	1.3	12.1%	☑	1.1%	No
Jefferson	19.2%	☑	3.5	20.9%	☑	2.8%	No
Klamath	18.7%	☑	1.7	18.7%	☑	1.5%	No
Lake	17.2%	☑	3.7	20.0%	☑	4.2%	No
Wheeler	12.0%	⊙	3.2	20.6%	☑	4.6%	Yes

Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Table 2-563. Child Poverty in Region 6

	Children Under 18 in Poverty						
	2008-2012			2013-2017			Statistical Difference?*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	20.6%	☑	0.5%	19.0%	☑	0.6%	Yes
Region 6	21.5%	☑	2.1%	19.5%	☑	0.0%	No
Crook	26.1%	☑	6.3%	23.1%	⊙	7.5%	No
Deschutes	18.3%	☑	3.0%	15.2%	☑	2.6%	No
Jefferson	30.0%	⊙	7.6%	30.3%	☑	6.6%	No
Klamath	24.6%	☑	3.3%	24.7%	☑	3.5%	No
Lake	23.7%	⊙	11.7%	25.6%	⊙	8.1%	No
Wheeler	12.0%	⊗	8.3%	37.4%	⊙	13.7%	Yes

Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Housing Tenure

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more manufactured and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

Region 6 has a higher percentage of owner-occupied households than the state as a whole. This is true for all counties in the region, except Lake County. However, the margin of error for Lake County indicates the share of owner-occupied housing might be closer to or above the statewide estimate. Even considering the margin of error, the high percentage of owner-occupied housing in Wheeler County is notable.

Table 2-564. Housing Tenure in Region 6

	Total Occupied Units	Owner-Occupied			Renter-Occupied		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	61.7%	☑	0.3%	38.3%	☑	0.3%
Region 6	117,959	65.5%	☑	1.0%	34.5%	☑	1.1%
Crook	9,330	67.4%	☑	3.3%	32.6%	☑	3.3%
Deschutes	69,631	65.3%	☑	1.4%	34.7%	☑	1.4%
Jefferson	7,628	68.7%	☑	2.6%	31.3%	☑	2.6%
Klamath	27,171	65.0%	☑	1.8%	35.0%	☑	1.8%
Lake	3,522	59.5%	☑	4.9%	40.5%	☑	4.9%
Wheeler	677	74.0%	☑	5.7%	26.0%	☑	5.7%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP04: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households. Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only. A greater share of households in Region 6 are family households compared to the statewide share; however, the percentage varies within the region. Lake and Wheeler Counties are the only counties with a larger share of non-family households. These two counties, along with Crook County, also have a higher percentage of single-person households than the state as a whole. Approximately one-quarter of households have children in the region, similar to the state as a whole. Within the region, at least one-fifth of households have children in each county, except for Wheeler County. The region has a similar share of single-parent households compared to the state as a whole. Jefferson County has the highest percentage, although the margin of error should be considered.

Table 2-565. Family vs. Non-family Households in Region 6

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	63.3%	☑	0.2%	36.7%	☑	2.7%	27.7%	☑	0.2%
Region 6	117,959	66.5%	☑	0.2%	33.5%	☑	1.0%	25.7%	☑	0.9%
Crook	9,330	65.1%	☑	0.3%	34.9%	☑	2.7%	28.6%	☑	2.9%
Deschutes	69,631	67.3%	☑	0.2%	32.7%	☑	3.2%	24.5%	☑	1.1%
Jefferson	7,628	70.8%	☑	0.1%	29.2%	☑	3.2%	23.5%	☑	3.2%
Klamath	27,171	64.7%	☑	0.1%	35.3%	☑	1.6%	26.9%	☑	1.6%
Lake	3,522	60.5%	☑	0.2%	39.5%	☑	4.8%	34.8%	☑	4.6%
Wheeler	677	59.7%	☑	0.1%	40.3%	☑	5.6%	35.3%	☑	5.7%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-566 shows household structures for families with children in Region 6.

Table 2-566. Family Households with Children by Head of Household in Region 6

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	26.2%	☑	0.2%	8.1%	☑	0.2%
Region 6	24.9%	☑	0.8%	8.0%	☑	0.7%
Crook	22.1%	☑	2.6%	6.6%	⦿	1.7%
Deschutes	25.6%	☑	1.1%	7.8%	☑	0.9%
Jefferson	24.3%	☑	2.8%	11.2%	☑	2.7%
Klamath	24.7%	☑	1.4%	8.0%	☑	1.1%
Lake	22.1%	☑	3.2%	3.2%	⦿	3.3%
Wheeler	13.1%	⦿	3.7%	3.2%	⊗	2.2%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Social and Demographic Trends

This analysis shows that Region 6 has a greater number of people than the state average who are predisposed to be particularly vulnerable during a hazard event, in the following categories:

- In Lake, Wheeler, and Crook Counties, approximately one-fifth of all residents identify as having a disability—roughly five percentage points higher than the statewide estimate.
- According to the PIT, between 2015 and 2019 the region reported a 22% increase in the number of persons experiencing homelessness.
- Older adults, those 65 and older, comprise a larger share of the population in Region 6 than they do in the state as a whole.
- Excluding Deschutes County, the share of residents with a four-year degree in each county is between twelve and seventeen percentage points below the statewide share. Moreover, all counties in the region, except Deschutes County, have a higher percentage of residents that did not graduate high school vis-à-vis the state.
- All counties, except Deschutes County, have a lower median household income compared to the state as a whole. The median household income in Wheeler and Lake Counties is approximately $23,000 less than the statewide median. Moreover, Compared to statewide numbers, the region has a smaller percentage of households earning more than $75,000 and a larger earning under $35,000 annually.
- Approximately one-fifth of residents in Wheeler, Lake, and Jefferson Counties are living in poverty. Child poverty is more common in all counties (except Deschutes County) compared to the statewide share.
- Lake, Wheeler, and Crook Counties have a higher percentage of single-person households than the state as a whole.

Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses' labor, capital, suppliers, and customers are all relevant factors (Zhang, Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang, Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent.

Employment and Unemployment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 6 have been steadily declining since they peaked during the Great Recession. Deschutes County has most of the region's population and consequently most of the employment. From 2014 to 2018, with the exception of Wheeler County—and Deschutes County in 2018—unemployment rates across the region were higher than in the state as a whole.

Table 2-567. Civilian Labor Force in Region 6, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 6	148,790	141,523	95.1%	7,267	4.9%
Crook	9,464	8,898	94.0%	566	6.0%
Deschutes	95,367	91,347	95.8%	4,020	4.2%
Jefferson	10,241	9,682	94.5%	559	5.5%
Klamath	29,499	27,602	93.6%	1,897	6.4%
Lake	3,496	3,296	94.3%	200	5.7%
Wheeler	723	698	96.5%	25	3.5%

Source: Oregon Employment Department, 2019

Table 2-568. Civilian Unemployment Rates in Region 6, 2014-2018

	2014	2015	2016	2017	2018	Change (2014-2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	-2.6%
Region 6	8.3%	6.6%	5.5%	4.8%	4.9%	-3.5%
Crook	9.8%	8.4%	6.9%	6.3%	6.0%	-3.8%
Deschutes	7.7%	5.9%	4.9%	4.2%	4.2%	-3.5%
Jefferson	8.9%	7.3%	6.6%	5.6%	5.5%	-3.4%
Klamath	9.3%	7.8%	6.8%	5.9%	6.4%	-2.9%
Lake	9.6%	7.7%	6.4%	5.7%	5.7%	-3.9%
Wheeler	6.2%	5.2%	4.2%	4.0%	3.5%	-2.7%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups "economic units that have similar production processes" according to a six-digit hierarchical structure (Office of Management and Budget, n.d.). "The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry" (Office of Management and Budget, n.d.). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors

(U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 6 were:

1. Trade, Transportation, and Utilities
2. Education and Health Services
3. Leisure and Hospitality
4. Local Government
5. Professional and Business Services

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region's resiliency. In Region 6, the following supersectors comprise a significant share of all business establishments.

- The Trade, Transportation, and Utilities supersector includes the highest number of establishments in Region 6, 16.4% of all businesses (QCEW, 2018).
- Professional and Business Services is second largest, with 15.9% of all business establishments (QCEW, 2018).
- Other Services is third largest with 13.7% of the regional business establishments (QCEW, 2018).
- The Construction supersector comprises 12.5% of all business, making it the fourth largest supersector by number of establishments (QCEW, 2018).
- Education and Health Services supersector is fifth largest by number of establishments, with 9.2% of all businesses (QCEW, 2018).

While supersectors are useful abstractions, it's important to remember that within are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event

Table 2-569. Covered Employment by Sector in Region 6, 2019

Industry	Region 6	Crook County		Deschutes County		Jefferson County	
	Percent	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	5,896	100.0%	83,170	100.0%	6,939	100.0%
Total Private Coverage	84.8%	4,726	80.2%	73,959	88.9%	4,636	66.8%
Natural Resources & Mining	2.2%	185	3.1%	756	0.9%	460	6.6%
Construction	6.7%	332	5.6%	6,708	8.1%	120	1.7%
Manufacturing	7.8%	673	11.4%	5,692	6.8%	1,204	17.4%
Trade, Trans. & Utilities	18.3%	1,080	18.3%	15,743	18.9%	870	12.5%
Information	1.8%	191	3.2%	1,864	2.2%	33	0.5%
Financial Activities	3.5%	165	2.8%	3,258	3.9%	96	1.4%
Prof. & Business Serv.	10.7%	358	6.1%	10,068	12.1%	282	4.1%
Edu. & Health Serv.	15.6%	724	12.3%	13,479	16.2%	668	9.6%
Leisure & Hospitality	14.1%	731	12.4%	12,990	15.6%	643	9.3%
Other Services	4.2%	288	4.9%	3,345	4.0%	252	3.6%
Unclassified	0.1%	(c)	(c)	56	0.1%	7	0.1%
Total All Government	15.1%	1,169	19.8%	9,211	11.1%	2,303	33.2%
Total Federal Govt	2.0%	279	4.7%	946	1.1%	126	1.8%
Total State Govt	1.6%	130	2.2%	869	1.0%	294	4.2%
Total Local Govt	11.6%	760	12.9%	7,396	8.9%	1,883	27.1%

Industry	Region 6	Klamath County		Lake County		Wheeler County	
	Percent	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	23,282	100.0%	2,551	100.0%	316	100.0%
Total Private Coverage	84.8%	18,593	79.9%	1,446	56.7%	202	63.9%
Natural Resources & Mining	2.2%	924	4.0%	372	14.6%	36	11.4%
Construction	6.7%	902	3.9%	66	2.6%	8	2.5%
Manufacturing	7.8%	1,814	7.8%	192	7.5%	4	1.3%
Trade, Trans. & Utilities	18.3%	4,248	18.2%	330	12.9%	39	12.3%
Information	1.8%	136	0.6%	18	0.7%	(c)	(c)
Financial Activities	3.5%	713	3.1%	37	1.5%	(c)	(c)
Prof. & Business Serv.	10.7%	2,182	9.4%	70	2.7%	58	18.4%
Edu. & Health Serv.	15.6%	4,019	17.3%	98	3.8%	30	9.5%
Leisure & Hospitality	14.1%	2,636	11.3%	189	7.4%	15	4.7%
Other Services	4.2%	1,012	4.3%	72	2.8%	114	36.1%
Unclassified	0.1%	8	0.0%	(c)	(c)	6	1.9%
Total All Government	15.1%	4,689	20.1%	1,105	43.3%	5	1.6%
Total Federal Govt	2.0%	866	3.7%	252	9.9%	6	1.9%
Total State Govt	1.6%	459	2.0%	174	6.8%	0	0.0%
Total Local Govt	11.6%	3,365	14.5%	679	26.6%	108	34.2%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region.

Education and Health Services: The industries in these sectors play important roles in emergency response in the event of a disaster. Health care is a relatively stable revenue sector regionally with an increasing distribution of businesses primarily serving a local and aging population.

Leisure and Hospitality: This sector primarily serves regional residents with disposable income and tourists. The behavior of both of these social groups would be disrupted by a natural disaster. Regional residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Professional and Business Services: This sector is composed of professional service providing industries including scientific and technical, management professionals and administrative and support services (e.g., engineering, law, headquarters, temp help, etc.). In general this sector has low vulnerability to natural disasters. Vulnerability is increased if suppliers are affected and/or physical infrastructure is damaged (buildings, roads, telecommunications, water systems, etc.). Mitigation efforts for this sector should include preparing business recovery and continuity plans.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. Many of the top employment subsectors are similar across regions. For example, Food Services and Drinking Places and Educational Services are the two largest employment subsectors in Region 6. These subsectors also rank highly in other regions. Ambulatory Health Care Services—also known as outpatient services—and Hospitals are also major employers in Region 6 and across the state. Conversely, other subsectors, such as Amusement, Gambling, and Recreational Industries, are more unique to the region.

Table 2-570. Industries with Greatest Share of Employment in Region 6, 2018

Industry	Employment Share	Employment (2018)
Food Services and Drinking Places	11%	14,570
Educational Services	7%	8,851
Administrative and Support Services	6%	8,754
Ambulatory Health Care Services	6%	7,639
Specialty Trade Contractors	5%	6,209
Professional, Scientific, and Technical Services	5%	6,201
Accommodation	3%	4,737
Amusement, Gambling, and Recreation Industries	3%	4,141
Food and Beverage Stores	3%	3,923
Hospitals	3%	3,756

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for employment share and average employment by DLCD

Industry Concentration and Employment Change

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

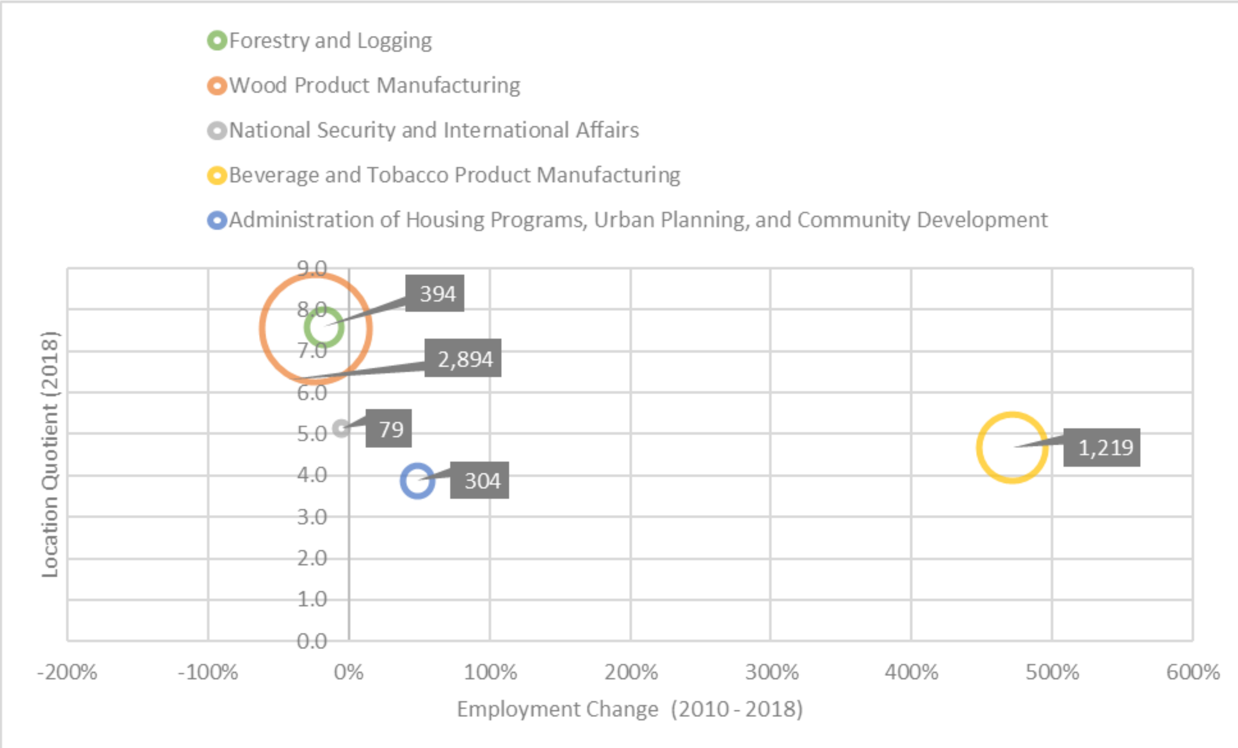
Table 2-571. Most Concentrated Industries and Employment Change in Region 6, 2018

Industry	Location Quotient	Employment (2018)	Employment Change (2010–2018)
Forestry and Logging	7.6	394	−18%
Wood Product Manufacturing	7.6	2,894	−24%
National Security and International Affairs	5.1	79	−5%
Beverage and Tobacco Product Manufacturing	4.7	1,219	472%
Administration of Housing Programs, Urban Planning, and Community Development	3.9	304	49%

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 6 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-252. Location Quotients, Employment Change, and Total Employment in Region 6, 2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

Similar to other regions, Region 6 has significant employment concentrations in timber related industries. Forestry and Logging and Wood Product Manufacturing both have a location quotient over six. Put differently, employment is five-hundred times higher than would be expected—suggesting the industries are rather unique within the United States. Despite this competitive advantage, both industries lost employment from 2010-2018. Notably, the region also has a competitive advantage and experienced significant growth in the Beverage and Tobacco Product Manufacturing subsector. This growth is reflective of strong growth in the craft beer industry in Deschutes County. Additionally, the region has employment concentrations in National Security and International Affairs and Administration of Housing Programs, Urban Planning, and Community Development; however, total employment in both industries is negligible.

Fastest Growing and Declining Industries

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang, Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining.

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 6's fastest growing and declining industries.

Table 2-572. Fastest Growing and Declining Industries in Region 6, 2010-2018

Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Beverage and Tobacco Product Manufacturing	472%	213	1,219
Data Processing, Hosting, and Related Services	217%	80	252
Couriers and Messengers	164%	226	596
Private Households	160%	351	914
Chemical Manufacturing	148%	116	288
Fastest Declining			
Electrical Equipment, Appliance, and Component Manufacturing	−83%	235	41
Executive, Legislative, and Other General Gov. Support	−44%	3,204	1,789
Mining (except Oil and Gas)	−33%	150	100
Wood Product Manufacturing	−24%	3,785	2,894
Forestry and Logging	−18%	478	394

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

The Private Households industry experienced significant growth from 2010-2018. This sector employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019). The increase in employment in the Private Households industry mirrors a statewide trend (Wallis, 2019). Demand is driven in part by an aging population's need for in-home care workers (Wallis, 2019).

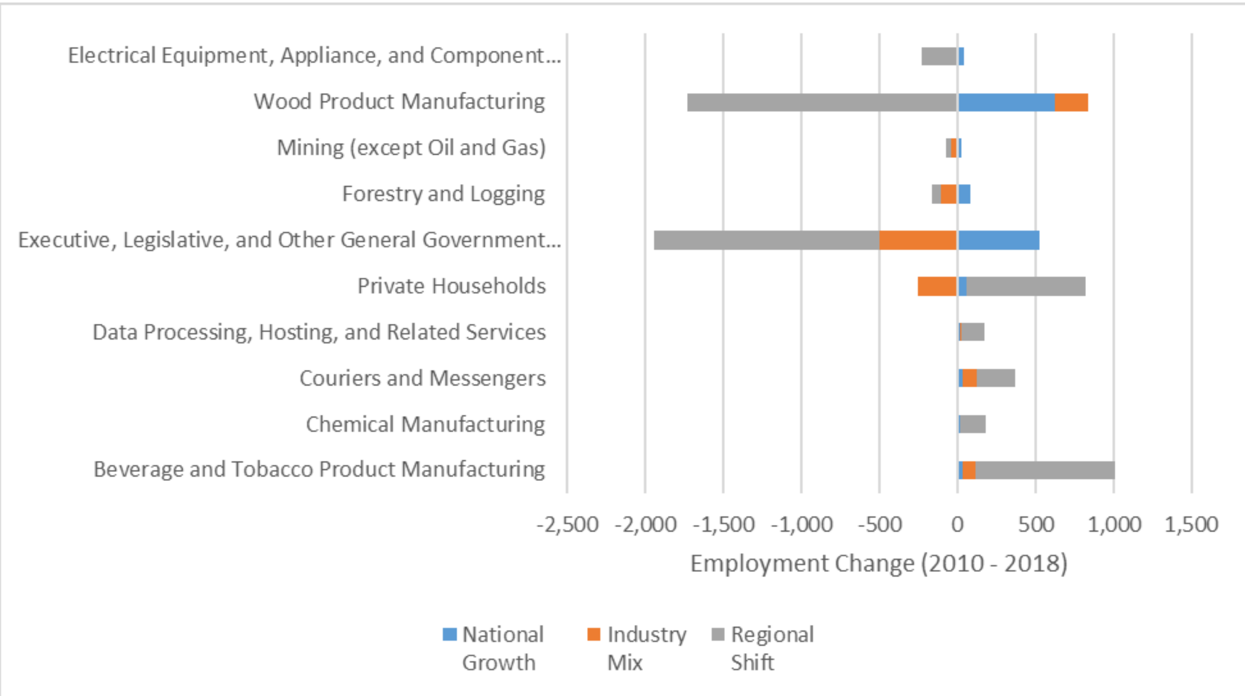
Beverage and Tobacco Product Manufacturing subsector also grew in employment within the region. Growth in the Beverage and Tobacco Product Manufacturing industry is likely driven by Oregon's thriving craft-beer scene, which continues to grow despite a crowded market (Lehner, 2020). Although the industry has been expanding nationally, the shift-share analysis shows that the growth was driven primarily by regional factors.

Employment in the Couriers and Messengers subsector is likely a reflection of the global revolution in retail sales. With an increased share of retail shopping occurring online, growth in transportation, storage, and distribution infrastructure and employment has been increasing nationally. Although the character of work is quite different, new employment in this in the subsector has helped to offset job loss in traditional "Brick and Mortar" retail (Lehner, Oregon's Shifting Retail Landscape, 2017). Companies employing couriers include names like Federal Express, FedEx Ground, and United Parcel Service (Wallis, 2018)

While the employment growth in the Data Processing, Hosting, and Related Services was smaller in terms of the total number of jobs added, the growth was definitely drive by regional factors—namely, the climate. Oregon's high-desert creates an ideal environment the massive data centers owned by industry giants like Facebook (Metz, 2011). In addition, the Chemical Manufacturing subsector—also a smaller subsector—more than doubled its employed from 2010-2018.

Although Wood Product Manufacturing Industry grew nationally from 2010-2018, the subsector shed approximately 900 jobs in Region 6 during the eight-year period. According to the shift-share analysis, this jobs loss was driven by regional factors. Significant losses, also driven by regional factors, also occurred in the Executive, Legislative, and Other General Government Services subsector. During the eight-year period, the subsector shed approximately fourteen-hundred positions. Losses also occurred in the Mining (except oil and gas), Forestry and Logging, and Electrical Equipment, Appliance, and Component Manufacturing subsectors. Whole Forestry and Logging was driven by trends in the industry at the national level, job loss in the other two sectors resulted from regional factors.

Figure 2-253. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 6, 2010-2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Table 2-573. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 6, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Beverage and Tobacco Product Manufacturing	1,006	35	79	892
Chemical Manufacturing	172	19	−11	164
Couriers and Messengers	370	37	84	249
Data Processing, Hosting, and Related Services	172	13	16	143
Private Households	563	58	−258	763
Fastest Declining				
Executive, Legislative, and Other General Gov. Support	−1,415	526	−501	−1,440
Forestry and Logging	−84	78	−107	−55
Mining (except Oil and Gas)	−50	25	−37	−37
Wood Product Manufacturing	−891	621	217	−1,729
Electrical Equipment, Appliance, and Component Manufacturing	−195	39	−7	−227

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Economic Trends and Issues

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the following situations increase the region's level of vulnerability to natural hazard events:

- The region generally lacks a diversity of traded sector industries. Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- Two of the region's most competitive subsectors—Wood Product Manufacturing and Forestry and logging—experienced declining employment from 2010-2018;
- Except for Wheeler County—and Deschutes County in 2018—unemployment rates across the region were higher than in the state as a whole from 2014 to 2018;

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl, et al., 2000).

Infrastructure

Transportation

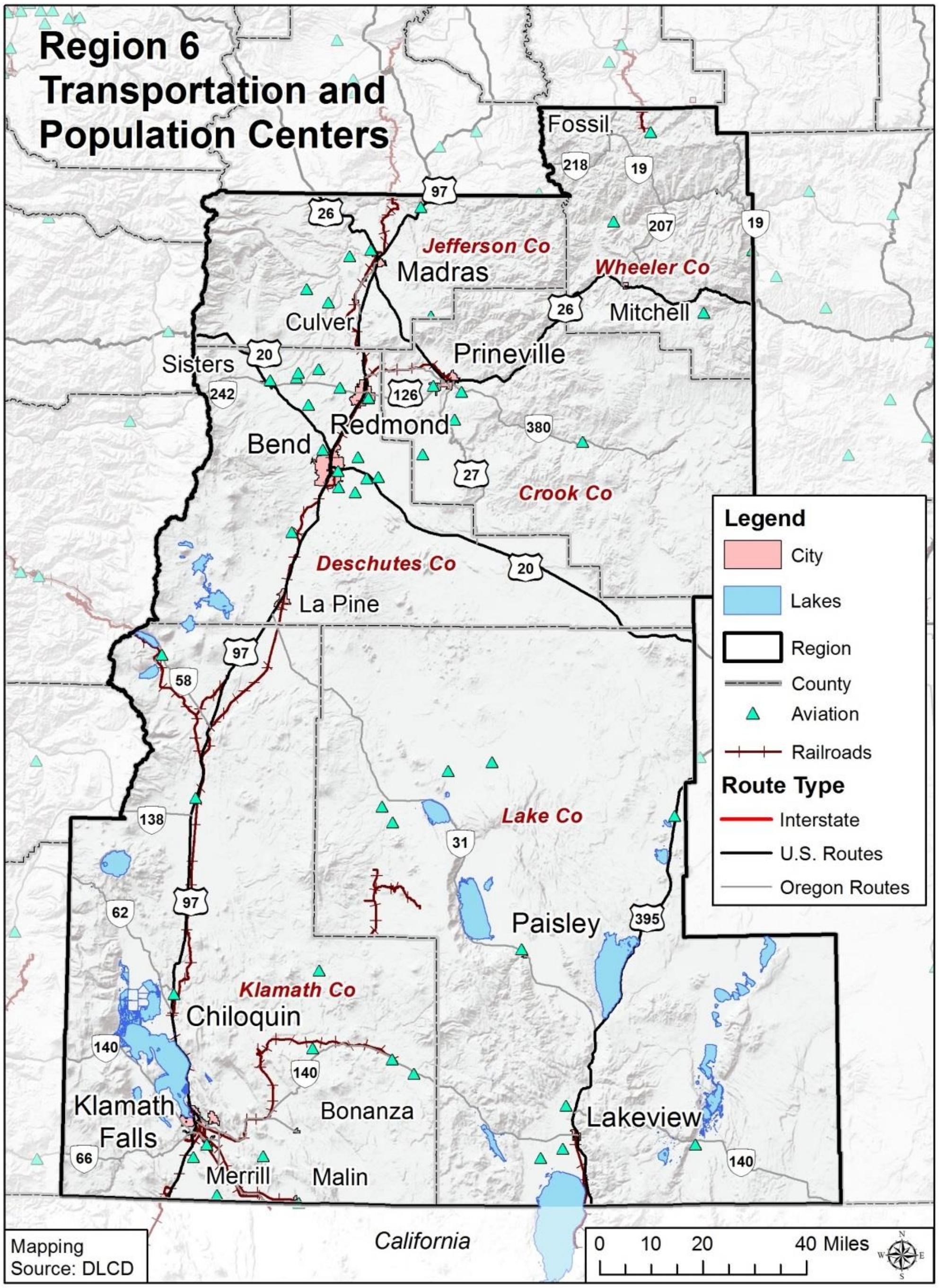
Roads

The largest population bases in Region 6 are located along the region's major highways. Growing population centers bring more workers, automobiles, and trucks onto roads. A high percentage of workers driving alone to work coupled with interstate and international freight movement create additional stresses on transportation systems. Some of these are added maintenance, congestion, oversized loads, and traffic accidents.

Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuation and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

According to the Oregon Department of Transportation's (2014, October) Seismic Plus Report (Appendix **9.1.13**), ground shaking from a CSZ event is not expected to cause damage in the region's major highways. However, either a local event or possibly one triggered by a CSZ event, can cause extensive damage and disrupt roadway connections to services. For information on ODOT's 2012 Seismic Lifelines Report findings for Region 6, see **Seismic Lifelines**.

Figure 2-254. Region 6 Transportation and Population Centers



Source: Oregon Department of Transportation (2014, October)

Bridges

ODOT lists 551 bridges in the counties that comprise Region 6.

Because of earthquake risk in Region 6, the seismic vulnerability of the region's bridges is an important issue. Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or that are part of regional and local systems that are maintained by the region's counties and cities. For information on ODOT's Seismic Lifeline Report findings for Region 6, see Seismic Lifelines.

Table 2-574 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. The ratings do not imply that a bridge is unsafe (ODOT, 2020). The table shows that the region has a lower percentage of bridges that are distressed and/or deficient (2%), than does the state (5%).

Table 2-574. Bridge Inventory for Region 6

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 6	0	190	0%	10	288	3%	0	64	0%	2	9	22%	12	551	2%
Crook	0	28	0%	2	24	8%	0	6	0%	0	0	N/A	2	58	3%
Deschutes	0	46	0%	2	49	4%	0	39	0%	0	4	0%	2	138	1%
Jefferson	0	13	0%	3	36	8%	0	6	0%	1	1	100%	4	56	7%
Klamath	0	55	0%	3	135	2%	0	12	0%	1	4	25%	4	206	2%
Lake	0	25	0%	0	38	0%	0	1	0%	0	0	N/A	0	64	0%
Wheeler	0	23	0%	0	6	0%	0	0	N/A	0	0	N/A	0	29	0%

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2020)

Railroads

Railroads that run through Region 6 support cargo and trade flows. The region's major (Class I) freight rail providers are the Union Pacific (UP) and the Burlington Northern-Santa Fe (BNSF) railroads. There is one major rail yard in the region (in Klamath Falls, Klamath County) operated by BNSF and UP (Cambridge Systematics, 2014). The Klamath Falls Yard, actually two adjacent yards, is used for switching, storing rail cars, and for locomotive repair (Cambridge Systematics, 2014).

Amtrak provides passenger rail service from the Willamette Valley south through Region 6 and southward to Los Angeles, California (with stops in Chemult and Klamath Falls) via the Coast Starlight line.

Rails are sensitive to icing from winter storms that can occur in Region 6. Disruptions in the rail system can result economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

The Redmond Regional Airport is the only commercial airport in the region (Redmond Airport website, http://www.flyrdm.com). The airport serves four passenger airlines (American Airlines, Alaska Air, Delta Air, United/United Express) providing direct service to Denver, Los Angeles, Portland, San Francisco, Salt Lake City, and Seattle (Redmond Airport website, http://www.flyrdm.com). This airport has been identified to become a primary airport following a Cascadia Subduction Zone (CSZ) seismic event.

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

Table 2-575. Public and Private Airports in Region 6

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Helipad	Private Helipad	Total
Region 6	17	37	0	11	65
Crook	1	5	0	3	9
Deschutes	4	12	0	3	19
Jefferson	2	4	0	2	8
Klamath	5	7	0	2	14
Lake	5	5	0	1	11
Wheeler	0	4	0	0	4

Source: FAA Airport Master Record (Form 5010), 2014

Energy

Electricity

The region is served by several investor-owned, public, cooperative, and municipal utilities. The Bonneville Power Administration is the area's wholesale electricity distributor. Pacific Power and Light (Pacific Power) is the primary investor-owned utility company serving portions of Crook, Deschutes, Jefferson, Klamath, and Lake Counties. The region's electric cooperatives include: Central Electric Cooperative (Crook, Deschutes, Jefferson, Lake), Columbia Basin Cooperative (Wheeler), Columbia Power Cooperative (Wheeler), Harney Electric Cooperative (Crook, Deschutes, Harney, Lake), Midstate Electric Cooperative (Deschutes, Klamath, Lake), Surprise Valley Electric Cooperative (Klamath, Lake), and Wasco Electric Cooperative (Jefferson, Wheeler).

Table 2-576 lists electric power-generating facilities that are within Region 6. The region has a total of eight power-generating facilities: three are hydroelectric power facilities, two are natural gas power facilities, and three are categorized as "other" (biomass or solar voltaic). In total the power-generating facilities have the ability to produce up to 1,109 megawatts (MW) of electricity. The region also includes one natural gas power facility (Klamath County) that is approved but not constructed. It will have the capacity to generate up to 500 MW of electricity (Oregon Department of Energy, n.d.a).

Table 2-576. Power Plants in Region 6

	Hydroelectric	Natural Gas	Wind	Coal	Other*	Total
Region 6	3	2	0	0	3	**8**
Crook	0	0	0	0	0	**0**
Deschutes	0	0	0	0	0	**0**
Jefferson	2	0	0	0	1	**3**
Klamath	1	2	0	0	0	**3**
Lake	0	0	0	0	2	**2**
Wheeler	0	0	0	0	0	**0**
Energy Production (MW)	**461**	**636**	**0**	**0**	**12**	**1,109**

* "Other" includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

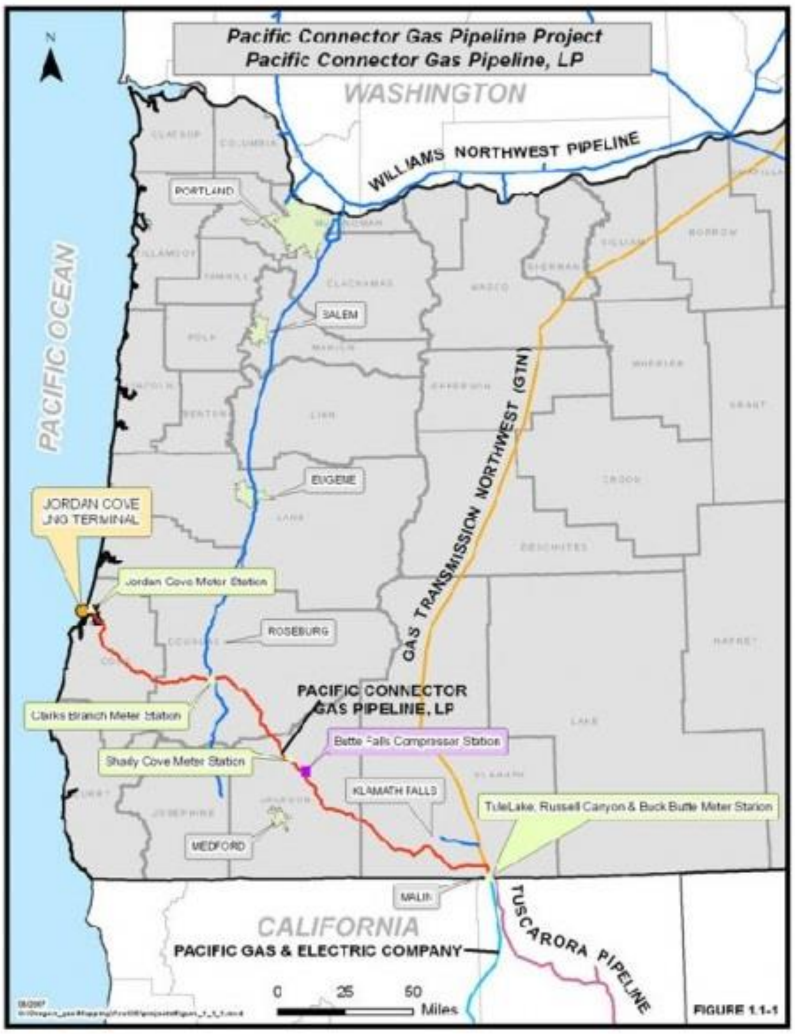
Hydropower

The Bonneville Power Administration (BPA) operates dams that provide hydro-generated electricity to the state's consumer-owned utilities. The major BPA dams in the region are located on the Deschutes River (Pelton and Round Butte).

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to the region's energy portfolio. Cascade Natural Gas Corporation is the major supplier of natural gas in Central Oregon. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-255** shows the Gas Transmission Northwest (GTN) line, which runs through Klamath, Deschutes, Crook, and Jefferson Counties (in green) and the proposed Pacific Connector that would connect to the GTN line in Klamath County (red) (Pipelines International, 2009). LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

Figure 2-255. Liquefied Natural Gas Pipelines in Region 6



Source: Retrieved from http://gs-press.com.au/images/news_articles/cache/Pacific_Connector_Gas_Pipeline_Route-0x600.jpg

Utility Lifelines

Central Oregon is an important throughway for oil and gas pipelines and electrical transmission lines, connecting Oregon to California and Washington. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe but infrequent natural hazards such as earthquakes.

Region 6 primarily receives oil and gas from Alaska by way of the Puget Sound through pipelines and tankers. The region is at the southern end of this pipeline network. Oil and gas are supplied by Northern California via a separate network. The electric, oil, and gas lifelines that run through the County are both municipally and privately owned (Loy, Allan, & Patton, 1976).

The network of electrical transmission lines running through Region 6 is operated primarily by Pacific Power and regional electrical cooperatives (and Bonneville Power Administration) and primarily facilitates local energy production and distribution (Loy, et al., 1976b). Most of the natural gas Oregon uses originates in Alberta, Canada. Avista Utilities owns the main natural gas transmission pipeline in southern Oregon while Cascade Natural Gas supplies the greater part of Central Oregon (Loy, Allan, & Patton, 1976).

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Region 6 is part of the Central Oregon Operational Area (Crook, Deschutes, Jefferson, Wheeler), the Lake-Harney Operational Area (Lake), and the Southern Oregon Operational Area (Klamath) under The Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013). There is a memorandum of understanding between these counties that facilitates the launching of emergency messages. Counties in these areas can launch emergency messages by contacting the Oregon Emergency Response System (OERS), which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communications capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation’s status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The Oregon State Emergency Alert System Plan does not identify a local primary station for emergency messages. Messages are provided via the three state primary networks: Oregon Public Broadcasting (Portland), KOBI TV (Medford), and KWAX-FM (Eugene).

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 6. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is readily available throughout most parts the region with a smaller number of providers and service types available in the more remote parts of the region (NTIA, n.d.). Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 6 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for the Central Oregon Operational Area are:

- KOAB-FM, 91.3 MHZ, Bend; and
- KWRX-FM, 88.5 MHZ, Redmond (KWAX-FM Network).

The radio transmitter for the Lake-Harney Operational Area is:

- KOAP-FM, 88.7 MHZ, Lakeview.

The radio transmitter for the Southern Oregon Operational Area is:

- KOTI-TV, Ch. 13, Klamath Falls.

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). ARES Districts 2 (Crook, Deschutes, Jefferson), 3 (Wheeler), and 4 (Klamath, Lake) provide service to Region 6. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency Management, n.d.). The official ham emergency station calls for Region 6 include (American Relay Radio League Oregon Chapter, n.d., www.arrloregon.org):

- Crook County: W7KFO;
- Deschutes County: KE7TMU;
- Jefferson County: K1GER;
- Klamath County: WA7YPR;
- Lake County: KE7QP; and
- Wheeler County: W7ILD.

Water

Water infrastructure includes drinking water, stormwater, and wastewater systems. All of these systems possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In Region 6 municipal drinking water supply is obtained from both surface and ground sources. In Crook, Deschutes, Jefferson, and Klamath Counties rural areas draw water from surface water sources. In the upper basin of Klamath County rural drinking water is drawn from springs, while the lower basin draws water from Klamath Lake for drinking water and irrigation. In rural areas of Lake County drinking water is primarily drawn from wells. Rural drinking water and irrigation water is primarily drawn from surface water sources and may be delivered by localized irrigation districts or may be drawn directly by landowners with water rights. The region's cities primarily draw drinking water from groundwater wells with the exception of the City of Bend, which draws water from Bridge Creek, a spring-fed waterway. A small portion of the City of Lakeview's drinking water is drawn from springs.

Region 6 is impacted by several threats to water quality and quantity. Low levels of snowpack and rain can lead to water shortages in a region that is often subject to annual shortages. Water rights in the region are fully appropriated in the summer season, which may impact opportunities for new development of urban and farm lands in the region. Above-ground storage in reservoirs is a tool used throughout the region to help prepare for potential water shortages. Aging wells in the region may also contribute to shortages because of decreased efficiency in water delivery. However, the age and maintenance level of wells is mostly a concern because older equipment may not filter minerals and bacteria as effectively as well maintained infrastructure.

Water quality in Crook, Deschutes, and Jefferson Counties is generally high, partially due to the volcanic nature of the area's soil and bedrock, which lacks high levels of sedimentation. However, concerns regarding water quality do exist. Sedimentation could be caused by river bank erosion due to freeze-thaw cycles in the winter and weed growth lowering channel capacity. A decrease in channel capacity may in turn contribute to turbidity and sedimentation. Throughout the region, complaints about hydrogen sulfide causing unpleasant odors to the water occasionally occur; however, the unpleasant odor is not indicative of any health concerns. In Lake County, minerals including arsenic and boron are of concern and monitored regularly. In the area surrounding the City of Lakeview tailings and runoff from abandoned mines are a concern for the area's water quality. In Klamath County, the shallow, slow-moving nature of waterways causes high water temperatures, which threatens water quality. Throughout the region, bacterial coliform levels are monitored to ensure that waterborne diseases do not threaten the quality of drinking water.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. Non-point source pollution is a major threat to surface water quality, and may include stormwater runoff from roadways, agricultural operations, timber harvest, erosion and sedimentation. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Landslides, flood events, and earthquakes and resulting liquefaction can cause increased erosion and sedimentation in waterways

Underground water supplies and aging or outdated infrastructure — such as reservoirs, treatment facilities, and pump stations — can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, limiting access to potable water and fire suppression. This can lead to unsanitary conditions that may threaten human health. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enter surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 6, county and municipal building codes and stormwater management plans (city and county) emphasize use of centralized storm sewer systems to manage stormwater. Low impact development (LID) mitigation strategies can alleviate or lighten the burden on a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, at lower speed, and at lower temperatures. The largest municipalities in the region (Fossil, Madras, Prineville, Redmond, Bend, La Pine, Klamath Falls, and Lakeview) do not require use LID strategies in their building codes. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems, and increase a community's resilience to many types of hazard events.

Infrastructure Trends/Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

Damage or service interruption to roads, bridges, rail systems, and ports can have devastating effects the region's economy. Icy winter conditions may disrupt the flow of cargo and trade by rail as well as Amtrak's passenger service. The Redmond Regional Airport will become a primary airport for the state following a catastrophic Cascadia Subduction Zone (CSZ) earthquake event.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. The region has a diverse energy portfolio that boosts its ability to withstand system disruptions due to natural hazard events. This includes eight power-generating facilities: three hydroelectric, two natural gas, and three biomass or solar voltaic facilities. The region has two large dams and hydroelectric projects on the Deschutes River. LNG is transported through the region via the Gas Transmission Northwest (GTN) pipeline that runs through Klamath, Deschutes, Crook, and Jefferson Counties. A natural gas power plant has been proposed for Klamath County. In addition, there is an emerging solar photovoltaic energy infrastructure in Central Oregon.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services may not cover rural areas of the region that are distant from US-97. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Water systems in the region are particularly vulnerable to hazard events because they tend to be older, centralized, and lacking system redundancies. Furthermore, because most drinking water is sourced from surface water or wells, the region is at risk of high levels of pollutants entering waterways through stormwater runoff and combined sewer overflows (CSOs) during high-water events. The implementation of decentralized LID stormwater systems can increase the region's capacity to better manage high precipitation events.

Built Environment

Settlement and Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program is 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD, https://www.oregon.gov/lcd/OP/Pages/Goal-7.aspx).

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people or an "urban cluster" of at least 2,500 people (but less than 50,000). Wheeler County does not meet either definition; therefore all of its population is considered rural even though the county has incorporated cities. Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-570** and **Table 2-571** remain from the 2010 Census.

The region's percent urban growth between 2000 and 2010 is double that of the state. Deschutes County has the highest population in urban and rural areas and has experienced roughly 57% urban growth. Overall, the region's urban areas are growing about 4 times faster than rural areas. Rural populations have grown significantly, between 10 and 18%, in all counties except Deschutes and Wheeler. Wheeler is the only county that does not have an urban population, even though it contains incorporated cities, and it is also the only county in the region that is losing rural population.

Urban housing is growing at twice the rate of rural housing in the region. Deschutes County gained the most urban housing units (approximately 21,150), growing by 69%. Notably, rural housing has increased by about 30% in Crook and Klamath Counties.

The region's population is clustered around the US-97 corridor and the cities of Bend, Klamath Falls, Madras, and Redmond. The population distribution in Region 6 presented in **Figure 2-256**.

Table 2-577. Urban and Rural Populations in Region 6, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	-0.1%
Region 6	134,438	177,374	31.9%	91,864	98,773	7.5%
Crook	10,290	10,905	6.0%	8,892	10,073	13.3%
Deschutes	72,554	114,130	57.3%	42,813	43,603	1.8%
Jefferson	7,252	8,010	10.5%	11,757	13,710	16.6%
Klamath	41,153	41,434	0.7%	22,622	24,946	10.3%
Lake	3,189	2,895	-9.2%	4,233	5,000	18.1%
Wheeler	0	0	—	1,547	1,441	-6.9%

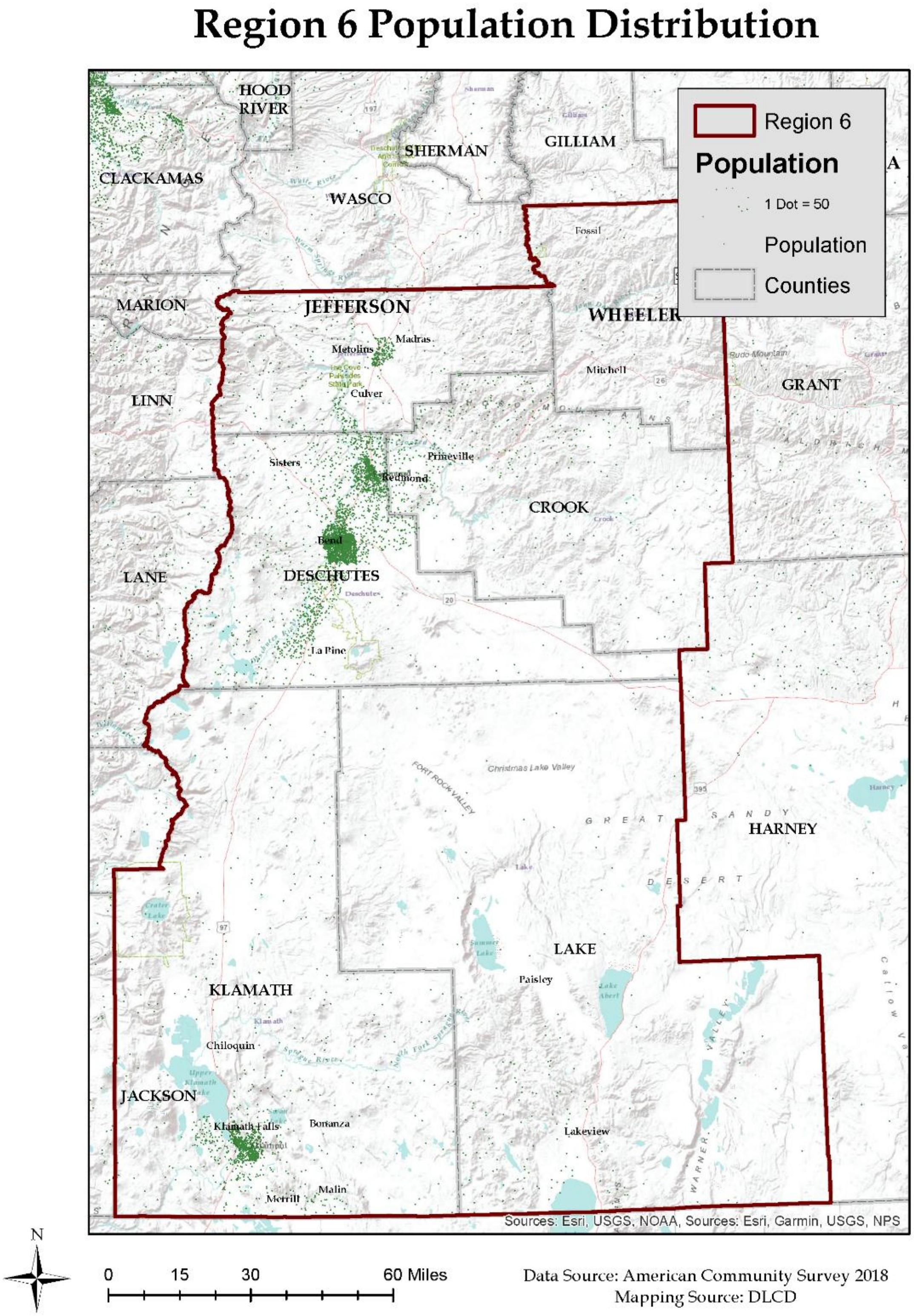
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

Table 2-578. Urban and Rural Housing Units in Region 6, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 6	57,098	80,325	40.7%	47,792	57,939	21.2%
Crook	4,190	4,884	16.6%	4,074	5,318	30.5%
Deschutes	30,684	51,844	69.0%	23,899	28,295	18.4%
Jefferson	2,735	3,382	23.7%	5,584	6,433	15.2%
Klamath	17,950	18,684	4.1%	10,933	14,090	28.9%
Lake	1,539	1,531	-0.5%	2,460	2,908	18.2%
Wheeler	0	0	-	842	895	6.3%

Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table H002

Figure 2-256. Region 6 Population Distribution



Source: U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. **Table 2-579** provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

Almost three-quarters of the region's housing stock is single-family homes. Manufactured homes account for 11.4% of Region 6's housing, and roughly 70% of all manufactured homes are located in Deschutes and Klamath Counties. In natural hazard events such as earthquakes and floods, manufactured homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997).

Table 2-579. Housing Profile for Region 6

	Total Housing Units	Single Family			Multi-Family			Manufactured Homes		
		Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	1,733,041	68.1%	☑	0.3%	23.5%	☑	0.3%	8.2%	☑	0.1%
Region 6	144,321	75.0%	☑	0.9%	13.3%	☑	0.8%	11.4%	☑	0.6%
Crook	10,569	72.5%	☑	3.0%	11.1%	☑	2.6%	14.7%	☑	2.0%
Deschutes	85,012	77.4%	☑	1.4%	15.5%	☑	1.2%	6.9%	☑	0.7%
Jefferson	9,951	70.0%	☑	3.0%	8.5%	☑	1.9%	21.4%	☑	2.5%
Klamath	33,302	71.7%	☑	1.6%	11.1%	☑	1.2%	17.2%	☑	1.3%
Lake	4,503	69.0%	☑	3.7%	5.7%	☑	1.7%	23.4%	☑	3.5%
Wheeler	984	79.0%	☑	4.8%	2.8%	⊗	3.1%	18.2%	☑	3.8%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-580. Housing Vacancy in Region 6

		Vacant^		
	Total Housing Units	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	5.6%	✓	0.2%
Region 6	144,321	6.6%	✓	0.2%
Crook	10,569	4.9%	⦿	1.7%
Deschutes	85,012	4.6%	✓	0.1%
Jefferson	9,951	8.6%	✓	0.8%
Klamath	33,302	10.5%	✓	0.4%
Lake	4,503	13.9%	✓	1.6%
Wheeler	984	9.9%	✓	0.7%

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.
**Green, orange, and red icons indicate the reliability of each Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table B25004: Vacancy Status

Aside from location and type of housing, the year structures were built (**Table 2-581**) has implications. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally, about one fifth of the housing stock was built prior to 1970 — including roughly half of the residences in Lake and Wheeler Counties — before the implementation of floodplain management ordinances. Also regionally, roughly half of the housing stock was built before 1990 and the codification of seismic building standards. Further, as shown in **Table 2-582**, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the 1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-581. Age of Housing Stock in Region 6

	Total Housing Units	Pre 1970			1970 to 1989			1990 or later		
		Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)	Estimate	CV**	MOE (+/−)
	1,733,041	34.6%	☑	0.3%	30.5%	☑	0.3%	34.9%	☑	0.3%
	144,321	20.2%	☑	0.8%	30.6%	☑	1.0%	49.2%	☑	1.2%
Oregon	10,569	23.9%	☑	3.3%	28.0%	☑	3.5%	48.1%	☑	4.5%
Region 6	85,012	10.0%	☑	0.8%	31.5%	☑	1.4%	58.5%	☑	1.7%
Crook	9,951	22.3%	☑	3.0%	31.4%	☑	3.0%	46.2%	☑	3.8%
Deschutes	33,302	39.7%	☑	2.0%	30.1%	☑	1.7%	30.2%	☑	1.8%
Jefferson	4,503	47.6%	☑	6.0%	23.3%	☑	3.7%	29.1%	☑	4.8%
Klamath	984	50.1%	☑	6.5%	22.7%	☑	4.9%	27.2%	☑	4.3%
Lake	1,733,041	34.6%	☑	0.3%	30.5%	☑	0.3%	34.9%	☑	0.3%
Wheeler	144,321	20.2%	☑	0.8%	30.6%	☑	1.0%	49.2%	☑	1.2%

Source: U.S. Census Bureau. 2008–2012, American Community Survey 5-Year Estimates, Table B25034

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood, damage is minimized. **Table 2-582** shows the initial and current FIRM effective dates for Region 6 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, **Flood** section.

Table 2-582. Community Flood Map History in Region 6

	Initial FIRM	Current FIRM
Crook County	July 17, 1989	Feb. 12, 2012
Prineville	July 17, 1989	Feb. 12, 2012
Deschutes County	Aug. 16, 1988	Sept. 28, 2007
Bend	Sept. 4, 1987	Sept. 28, 2007
La Pine	Sept. 28, 2007	Sept. 28, 2007
Sisters	Sept. 29, 1986	Sept. 28, 2007
Jefferson County	July 17, 1989	July 17, 1989
Culver	Sept. 4, 1987	Sept. 4, 1987
Madras	July 17, 1989	July 17, 1989
Klamath	Dec. 18, 1984	Dec. 18, 1984
Bonanza	June 1, 1983	June 1, 1983 (M)
Chiloquin	Aug. 15, 1984	Aug. 15, 1984
Klamath Falls	June 5, 1985	June 5, 1985
Lake	Dec. 5, 1989	Dec. 5, 1989
Lakeview	Nov. 16, 1982	Sept. 5, 1990
Paisley	Sept. 15, 1989	Sept. 15, 1989
Wheeler County	July 17, 1989	July 17, 1989
Fossil	May 4, 1989	May 4, 1989
Mitchell	Apr. 17, 1989	Apr. 17, 1989

(M) = no elevation determined; all Zone A, C and X.

Source: Federal Emergency Management Agency (2019), Community Status Book Report, https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 6 can be found in **Table 2-583**. The region contains 7.8% of the total value of all local critical facilities and state-owned and –leased critical and non-critical facilities in the state. These assets have a combined value over two and one-half billion dollars.

Table 2-583. Value of State-Owned/Leased Critical and Essential Facilities in Region 6

Value of Local and State-Owned/Leased Facilities					
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$ 2,630,306,288	$ 4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 6	$ 97,935,431	$ 518,334,447	$ 2,014,056,450	$ 2,630,326,328	7.8%
Crook	$ 13,469,060	$ 30,269,883	$ 145,184,250	$ 188,923,193	0.6%
Deschutes	$ 25,977,373	$ 92,478,992	$ 1,060,552,500	$ 1,179,008,865	3.5%
Jefferson	$ 6,424,430	$ 252,435,472	$ 165,797,550	$ 424,657,452	1.3%
Klamath	$ 34,263,232	$ 96,116,561	$ 460,839,750	$ 591,219,543	1.8%
Lake	$ 15,812,322	$ 42,753,230	$ 158,353,050	$ 216,918,602	0.6%
Wheeler	$ 1,989,014	$ 4,280,309	$ 23,329,350	$ 29,598,673	0.1%

Source: DOGAMI, 2020

Land Use Patterns

Land ownership and geography tend to drive the land use patterns in Region 6. Federal ownership (61%) is made up primarily of the U.S. Forest Service in the western portion ranging up the Cascade crest, and BLM has holdings generally ranging from southeast of Redmond and increasing until dominating the area of Lake County. The majority of land ownership is private holdings (35.6%) from the north Jefferson County and Madras area through the Prineville/Redmond/Sisters/Bend areas. The Warm Springs Indian Reservation dominates the northeast portion.

Development pressure has been high in the Bend, Sisters, and Redmond areas in the past few decades. Between 1974 and 2009, the Bend area lost 13% of its land in resource land uses to more developed uses. However, since 1984 that rate has declined; annual average rates of conversion of land in resource land uses to low-density or urban uses in Deschutes County was 88% less in the 2005–2009 period when compared to the 1974–1984 period. Similar trends, although less pronounced, are seen in Klamath County (Lettman G. J., 2011).

According to the Oregon Department of Forestry's most recent land-use study, "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray , Hubner , McKay, & Thompson , 2016). In Region 6, approximately 3,030 acres of resource lands were converted to more urban uses during the six-year period. **Table 2-584** shows that during the six-year period, the percentage of resource lands converted in each county in Region 6 was less than one percent of each county's total acreage. The majority of conversion during this period occurred in Crook and Deschutes Counties.

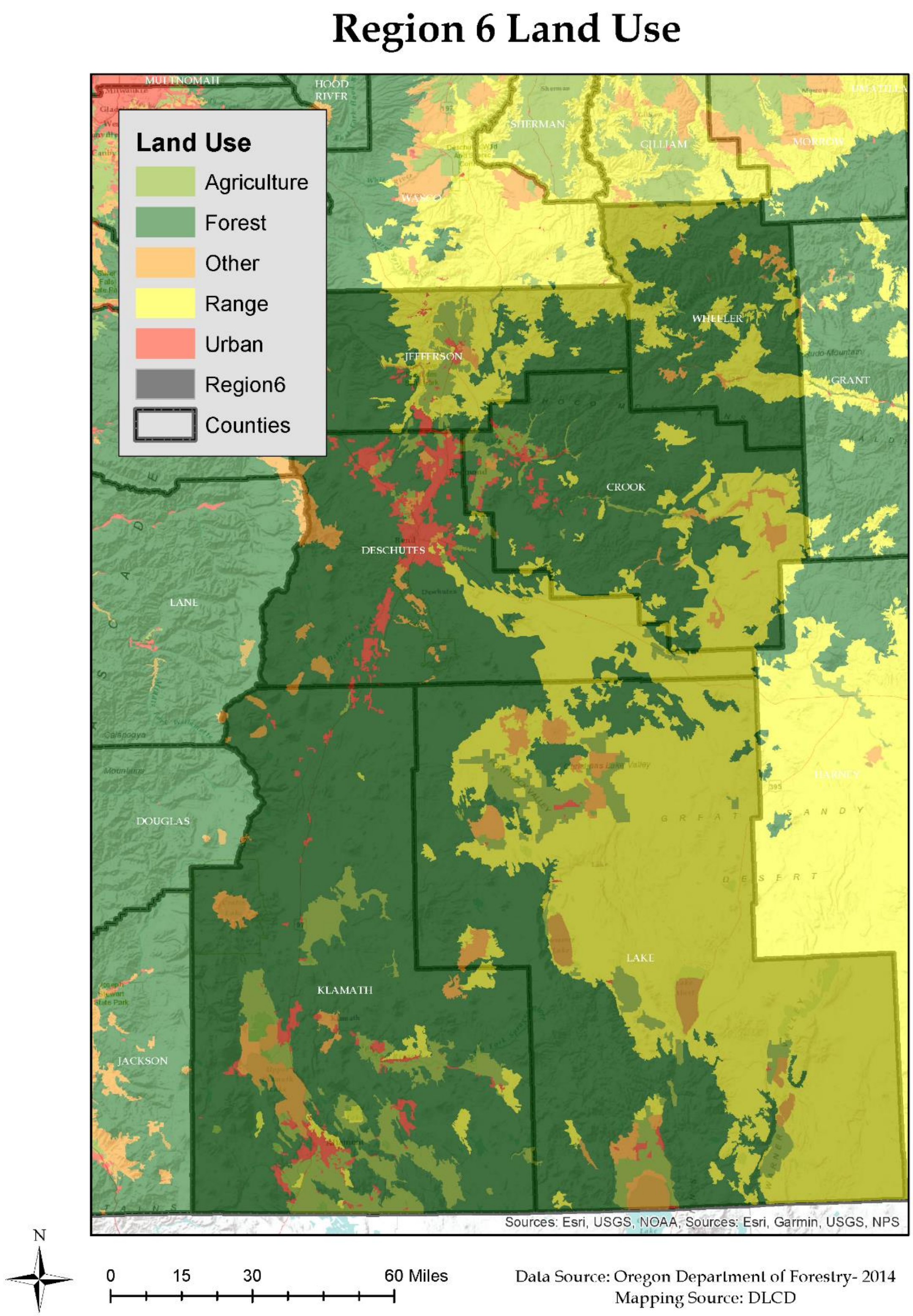
Responding to rapid growth and changing demographics, in 2011 Deschutes County completed a multi-year effort to establish "Plan 2030." This new plan incorporates updated goals and policies, community plans, and new projects like the South County Plan, destination resort remapping, a 2030 Transportation System Plan, and a South County Local Wetland Inventory.

Increasing federal efforts to protect sage grouse habitat affect large portions of Deschutes, Crook, and Lake County's resource lands devoted to farm, ranch, or forest uses. Land use threats to habitat have been identified as conversion to agriculture, energy development, mining, infrastructure, and urbanization. Counties have been addressing some of these issues through their land use planning programs.

While periodic flooding is a challenge in the northern portion of the Region, the wildland-urban interface areas are a constant concern for community planners and emergency managers. The Oregon Forestland-Urban Interface Fire Protection Act — often referred to as Senate Bill 360 — enlists the aid of property owners toward the goal of turning fire-vulnerable urban and suburban properties into less volatile zones where firefighters may more safely and effectively defend homes from wildfires. All Region 6 counties implemented this in 2013.

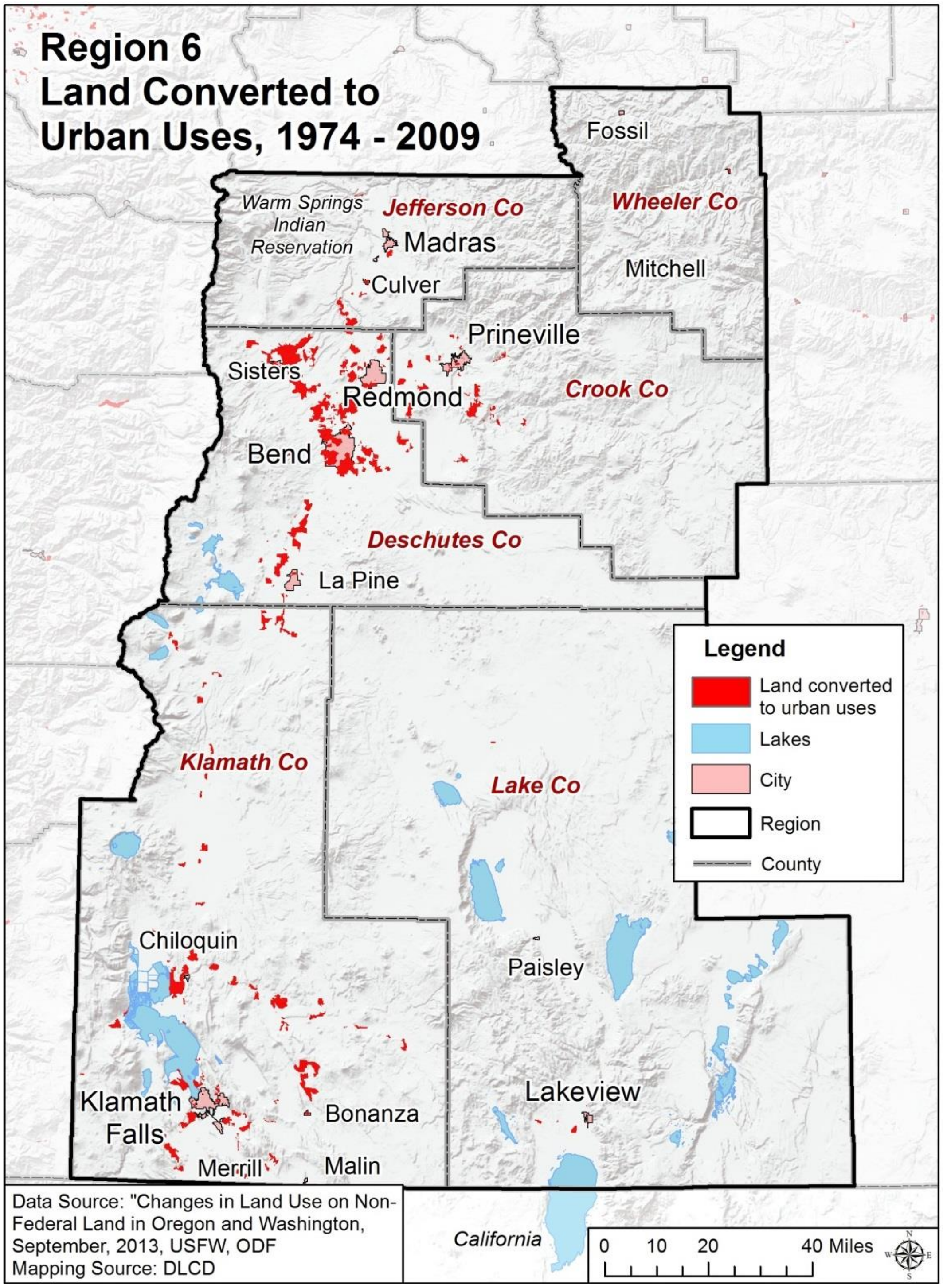
The City of Madras integrated portions of its Natural Hazards Mitigation Plan with its Comprehensive Plan; this serves as a model for other local governments.

Figure 2-257. Region 6 Land Use



Source: Oregon Department of Forestry 2014

Figure 2-258. Region 6 Land Converted to Urban Uses, 1974-2009



Source: Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

Table 2-584. Region 6 Resource Lands Converted to Urban Uses, 2009-2014

	Lost Resource Lands 2009-2014		
	Total Resource Acres (2009)	Acres Converted to Urban Use	Percent Converted
Region 6	5,591,401	3,030	0.05%
Jefferson	548,650	120	0.02%
Deschutes	318,784	1,025	0.32%
Klamath	1,582,089	482	0.03%
Crook	929,989	1,200	0.08%
Lake	1,428,687	195	0.01%
Wheeler	783,202	8	0.00%

Source: Oregon Department of Forestry, 2014; Oregon Department of Land Conservation and Development, 2020

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 6 is largely a rural county with urban development focused along US-97, around the population centers of Bend, Klamath Falls, Prineville, and Redmond. Deschutes County has the fastest growing urban population in the region while Wheeler County is entirely rural and the population remained relatively constant from 2010-2018; the population in Wheeler county is expected to decline over the next decade. Please refer to the Region 6 Risk Assessment **Demography** section for more information on population trends and forecast. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion.

The region's housing stock is largely single-family homes, though Jefferson, Lake, and Wheeler Counties have approximately triple the state's percentage of manufactured housing. Roughly half the homes in Lake and Wheeler Counties, and approximately 40% of homes in Klamath County were built before 1970, before modern flood ordinances were adopted. With the exception of Crook and Deschutes Counties, none of the region's FIRMs have been modernized or updated, leaving this region's flood maps less up to date than those of other regions.

2.3.6.4 Hazards and Vulnerability

Droughts

Characteristics

Every county in Central Oregon has experienced drought conditions at some point since 1977, with Klamath County receiving the most Governor-declared declarations. A summary of Governor-declared droughts since 1994 is given in **Table 2-585**. The U.S. Department of Agriculture can also designate a county as a "natural disaster area" due to damages or losses caused by a drought. In 2007, Lake County was declared a natural disaster area and Klamath County received the same designation in 2010. In 2013, Klamath and Lake Counties were declared natural disaster areas. In 2015, all counties in region 6 were declared natural disaster areas.

When droughts occur they can be problematic, impacting community water supplies, wildlife refuges, fisheries, and recreation. High temperatures and low precipitation associated with drought conditions reduce soil moisture; dry vegetation, and tend to enhance winds. These conditions can increase the amount of soil entrained in high winds, particularly in semi-arid regions like Region 6 where temperatures are increasing and precipitation is decreasing, and substantial land disturbance and development are occurring. Therefore, during extended dry and drought conditions, productive soils are vulnerable to loss, further impacting agriculture.

Historic Drought Events

Table 2-585. Historic Droughts in Region 6

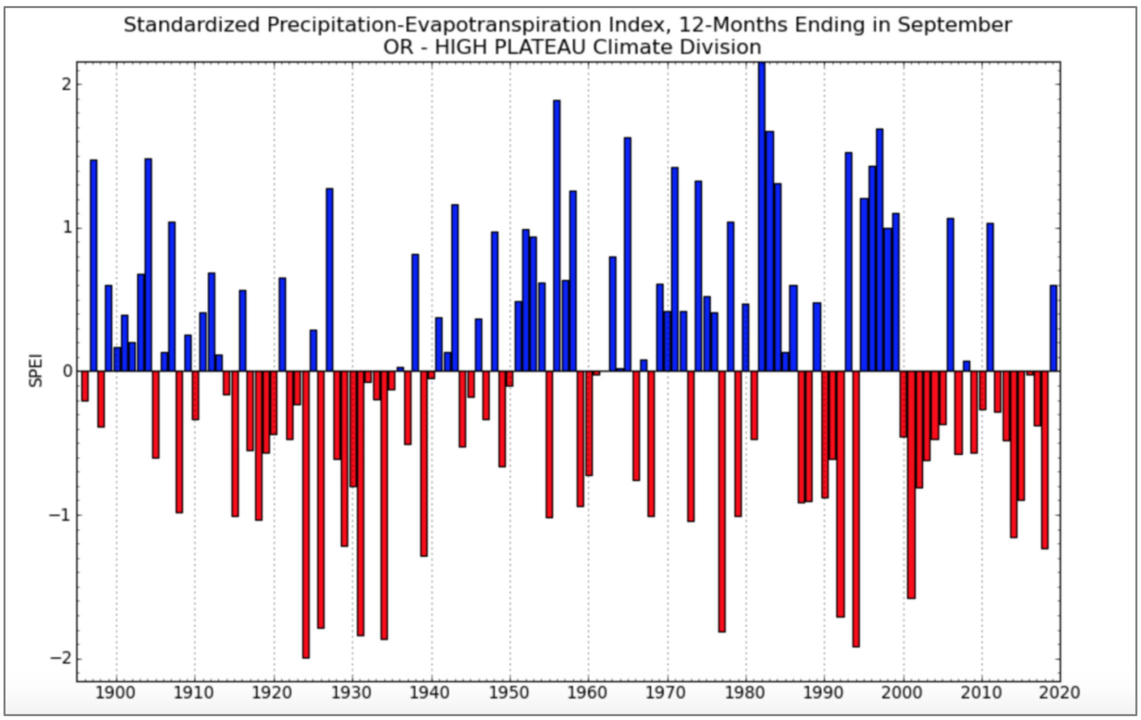
Date	Location	Description
1929–1931	Region 1–3, 5–7 (1929-1930); Region 6 and 7 (1930-1931) (extreme drought)	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country; moderate to severe drought affected much of the state
1939	statewide	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country
1977	N. & S. central and eastern Oregon	the water year was significantly drier than normal, but temperatures were near normal
1994	Regions 4–8	in 1994, Governor's drought declaration covered 11 counties located within Regions 4–8
2001	southern, eastern OR	Jefferson, Wheeler, Crook, Deschutes, Klamath, and Lake Counties under a Governor-declared drought; in 2001, 18 counties were declared statewide
2002	southern, eastern Oregon	counties declared in 2001 remained in effect; Governor added five additional counties in 2002, bringing the total to 23 counties
2003	southern, eastern Oregon	Jefferson, Deschutes, and Lake Counties' drought declarations expired June 23, 2003; Governor issued new drought declarations for Wheeler and Crook Counties and extended Klamath drought order through December 2003
2004	eastern Oregon	Klamath County under a Governor drought declaration; three other counties declared in neighboring regions
2005	Regions 5–7	Governor declared drought in Wheeler, Crook, Deschutes, Klamath, and Lake Counties; all Region 5 counties declared as well as two counties in Region 7
2007	Regions 6–8	Governor declared drought in Lake County, along with five other counties in Regions 6 and 7
2010	Region 6	Governor declared drought for Klamath County and "contiguous counties"
2012	Region 6	Governor declared drought for Lost River Basin only, located within Klamath and Lake Counties
2013	Regions 5-8	Governor declared drought for Klamath County along with four other counties
2014	Regions 4, 6–8	Governor declared drought in 10 counties including Crook, Wheeler, Klamath, Lake
2015	statewide	All 36 Oregon Counties receive federal drought declarations, including 25 under Governor's drought declaration
2018	Regions 1, 4-8	Klamath, Lake, and Wheeler County receive Governor's drought declarations, including 8 other counties in 5 other regions

Sources: Taylor and Hatton (1999); Oregon Secretary of State's Archives Division (Governor's Executive Orders); NOAA's Climate at a Glance; Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt; personal communication, Kathie Dello, Oregon Climate Service, Oregon State University.

Historical drought information can also be obtained from the West Wide Drought Tracker, which provides historical climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. **Figure 2-259** shows years where drought or dry conditions affected the high plateau region of Oregon, which comprises much of Klamath County and smaller portions of Lake and Deschutes Counties (Climate Division 5).

Based on this index, 1924 was an extreme drought year in Climate Division 5, the driest year in this record. There were several years with moderate to severe drought in the late 1920s and 1930s. 1977, 1992, 1994, and 2001 were severe drought years, followed by moderate drought years in 2014 and 2018 in Climate Division 5.

Figure 2-259. Standard Precipitation-Evapotranspiration Index for Region 6



Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-586. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 5 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
1939	1994	1924
2018	1934	1934
1929	1931	
2014	1977	
1973	1926	
1918	1992	
1955	2001	
1915		
1968		
1979		

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-587. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 7 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
1926	1924	1934
1990	1994	
1966	1931	
2007	1992	
1988	1977	
1918	1939	
2014		
2018		
2002		
1973		
2015		
1968		

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

The SPEI for Climate Division 7 (south central Oregon), which includes Deschutes, Jefferson, Crook, Wheeler, portions of Lake County, and the southern portion of Klamath County, along with Harney County (a "Region 7" county for hazard planning) had similar dry years to Climate Division 5. Seven out of the top 8 driest years were the same except for 2001 which was not a drought year in Division 7, though 2002 was (**Table 2-587**). Water Year 1934, for example, was an extreme drought year in Division 7 and a severe drought year in Division 5. Vice versa for year 1924. Water Years 1990, 1966, 2007, 1988, 2002, and 2015 showed up as moderate drought years in climate division 7 whereas those years did not show up as at least moderate drought years in climate division 5. Similarly, water years 2001, 1929, 1955, 1915, and 1979 showed up as at least moderate drought years in climate division 5, but were not at least moderate drought years in climate division 7.

Probability

Table 2-588. Probability of Drought in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	H	H	M	VH	VH	H

Source: OWRD, DLCD

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases.

Oregon has yet to undertake a statewide comprehensive risk analysis for drought to determine probability or vulnerability for a given community. Considering that several drought declarations have occurred during the last 10 years, is it reasonable to assume that there is a high probability that Region 6 will experience drought in the near future. Klamath County has received drought declarations in 48% of the years since 1992, the most in the state. Lake County has received 34%, Crook and Wheeler Counties 28%, Deschutes 24%, and Jefferson 17%. These statistics account for the differences in their probability ratings.

Climate Change

Drought is common in central Oregon. Climate models project warmer, drier summers for Oregon, including Region 6. These summer conditions coupled with projected decreases in mid-to-low elevation mountain snowpack due to warmer winter temperatures increases the likelihood that Region 6 would experience increased frequency of one or more types of drought under future climate change. In Region 6, climate change would result in increased frequency of drought due to low spring snowpack (very likely, >90%). In addition, Region 6, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-589. Local Assessment of Vulnerability to Drought in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	—	L	H	H	H	H

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-590. State Assessment of Vulnerability to Drought in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	H	VH	VH	H	L

Source: OWRD, DLCD

Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms. There is no single comprehensive source or other sources for information to assess economic impacts.

Oregon has not undertaken a comprehensive statewide analysis to identify which communities are most vulnerable to drought.

In 2013, the Klamath Falls area experienced the second driest January through March period on record with precipitation measuring below average throughout the Klamath Basin. According to the U.S. Bureau of Reclamation, Klamath Basin Project irrigators have not received a full supply of water in nine out of the last thirteen irrigation seasons during dry or drought years, national wildlife refuges in the Klamath Basin received smaller water deliveries as well. These refuges are important nesting and feeding grounds for birds migrating along the Pacific Flyway. Reduced river flows, especially during the summer months, can negatively impact fisheries, recreation, and other uses as well.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6. Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households. Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median. Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters. Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment. Deschutes County has low social vulnerability.

Klamath County's social vulnerability rating is very high, as is Jefferson County's. Lake County's is high. Crook County's is moderate, and Deschutes and Wheeler Counties' are low. Any natural hazard, including drought, would have a significant impact on populations in counties with high or very high ratings. Deschutes County's vulnerability to wildfire as a result of drought is taken into account in this rating. Klamath, Lake, Jefferson, and Deschutes Counties are the most vulnerable to drought in Region 6.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 6 is approximately $616,270,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $2,014,056,000. Because drought could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 6 since the beginning of 2015. Nevertheless, none of the recorded losses was due to drought.

Risk

Table 2-591. Risk of Drought in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Risk	H	H	H	VH	VH	M

Source: OWRD, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based on the high probability of drought in Region 6 and its high vulnerability – very high in Klamath and Lake Counties – risk of drought in Region 6 is considered high in general, and very high in Klamath and Lake Counties.

Earthquakes

Characteristics

The geographic position of this region makes it susceptible to earthquakes from four sources: (a) the off-shore Cascadia Fault Zone, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) shallow crustal events within the North America Plate, and (d) earthquakes associated with volcanic activity.

Central Oregon includes portions of five physiographic provinces (High Cascades, Blue Mountains, Basin and Range, High Lava Plains, and Deschutes-Columbia Plateau). Consequently, its geology and earthquake susceptibility varies considerably. There have been several significant earthquakes that have been centered in the region, all in Klamath County: 1920 Crater Lake, and the 1993 Klamath County earthquakes (M5.9 and 6). There are also numerous identified faults in the region (mostly Klamath County) that have been active in the last 20,000 years. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. Earthquakes produced through volcanic activity could possibly reach magnitudes of 5.5. The 1980 Mount St. Helens eruption was preceded by a magnitude 5.1 earthquake. Despite the fact that the Cascade volcanoes are some distance away from the major population centers in Region 6, earthquake shaking and secondary earthquake-related hazards such as lahars could cause major damage to these centers.

Most of the region is within a relative moderate seismicity area, except for portions of Klamath County, which is within a relative high zone as shown in **Figure 2-260**.

There have been several significant earthquakes that have been centered in the region, all in Lake County: 1906 north of Lakeview, 1923 Lakeview area, 1958 Adel (M4.5), and 1968 Adel swarm (M4.7–5.1). There are also numerous identified faults in the region (mostly in Lake County) that have been active in the last 20,000 years. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. All considered, there is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region.

Historic Earthquake Events

Table 2-592. Significant Earthquakes Affecting Region 6

Date	Location	Magnitude (M)	Remarks
Approximate Years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	Offshore, Cascadia Subduction Zone	probably 8-9	these are the mid-points of the age ranges for these six events
Jan. 1700	Offshore, Cascadia Subduction Zone	about 9.0	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Apr. 1906	North of Lakeview, Oregon	V	three felt aftershocks
Apr. 1920	Crater Lake, Oregon	V	one of three shocks
Jan. 1923	Lakeview, Oregon	VI	
1968	Adel, Oregon	5.1	swarm lasted May through July, decreasing in intensity; increased flow at a hot spring
Sep, 1993	Klamath Falls, Oregon	5.9 and 6.0	series of earthquakes, largest: M6.0; damage: considerable (in and around Klamath Falls); fatalities: two (one rock fall on highway and one heart attack)
Apr. 28, 1999	Christmas Valley, Oregon	3.8	damage: unknown
Apr. 1999	Christmas Valley, Oregon	1.9–3.0	at least six earthquakes occurred in the area
June 30, 2004	SE of Lakeview, Oregon	4.4	damage: unknown
June 2004	SE of Lakeview, Oregon	1.9–3.9	at least 20 earthquakes occurred in the area

Note: No significant earthquakes have affected Region 6 since June 2004.

*BCE: Before Common Era.

Sources: Wong & Bott (1995); Pacific Northwest Seismic Network, https://pnsn.org/

Probability

Table 2-593. Assessment of Earthquake Probability in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	L	M	M	H	M	M

Source: DOGAMI, 2020

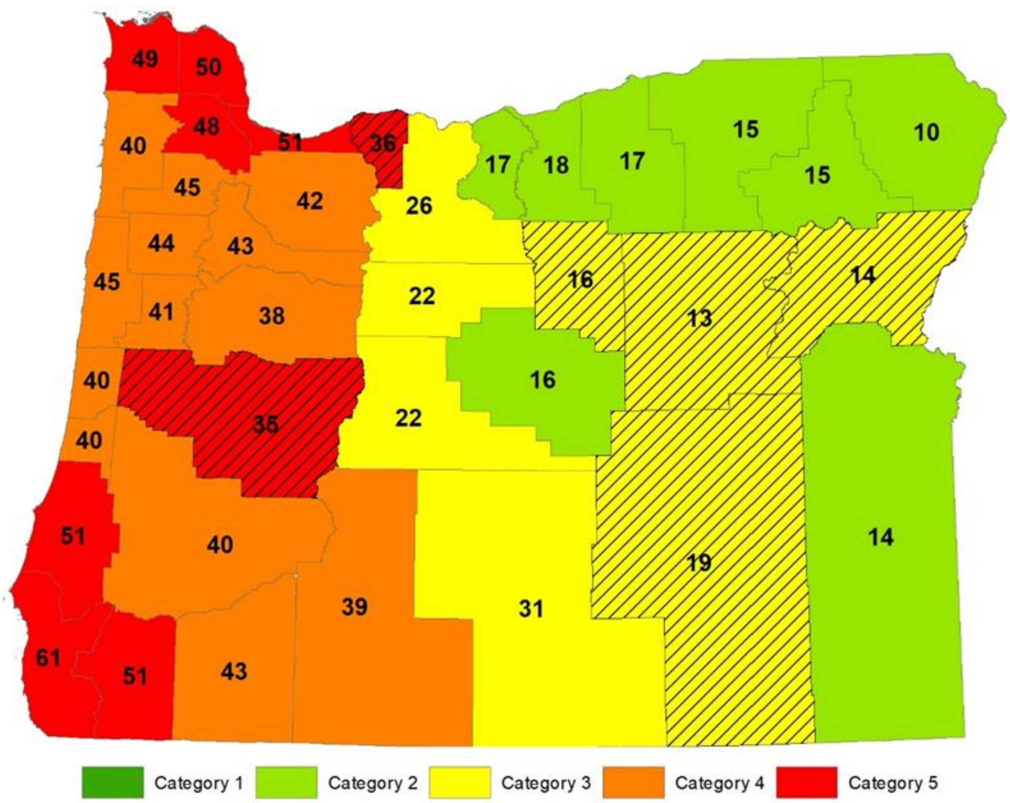
The probability of damaging earthquakes varies widely across the state. In Region 6, the hazard is dominated by local faults and background seismicity.

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-260**.

Figure 2-260. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.

Source: DOGAMI, 2020

Vulnerability

Table 2-594. Local Assessment of Vulnerability to Earthquakes in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	H	HL	L	H	H	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-595. State Vulnerability Assessment of Earthquakes in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	VL	H	VH	VH	VL

Source: DOGAMI and DLCD, 2020

The Oregon Department of Geology and Mineral Industries (DOGAMI) has developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) the Cascadia Subduction Zone (CSZ), and (b) combined crustal events (500-year model). Both models are based on Hazus, a computerized program, currently used by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event is based on a potential 8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from the event. The 500-year crustal model does not look at a single earthquake (as in the CSZ model). Rather, it encompasses many faults, each with a 10% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single "average" earthquake during this time. Neither model takes unreinforced masonry buildings into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models do provide some approximate estimates of damage.

Region 6 is vulnerable to earthquake-induced landslides, liquefaction, and strong ground shaking. Based on the 500 year model, Klamath County is one of the top 15 counties expected to have highest loss and most damage statewide. Results are found in Table 2-596 and Table 2-597.

Table 2-596. Building Collapse Potential in Region 6

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Crook	7	7	3	13
Deschutes	55	35	41	9
Jefferson	11	1	12	11
Klamath	15	10	37	18
Lake	13	1	4	10
Wheeler	5	1	6	3

Source: Lewis (2007)

Table 2-597. Projected Dollar Losses in Region 6, Based on an M8.5 Subduction Event and a 500-Year Model

County	Economic Base in Thousands (1999)	Greatest Absolute Loss In Thousands (1999) from a M8.5 CSZ Event	Greatest Absolute Loss In Thousands (1999) from a 500-Year Event
Crook	$733,000	less than $1,000	$6,000
Deschutes	$4,673,000	$5,000	$71,000
Jefferson	$707,000	less than $1,000	$14,000
Klamath	$3,134,000	$41,000	$939,000

Note: New Hazus data were developed for Jefferson County using Hazus-MH. The data are available through W. J. Burns, unpublished report (2007): Geologic Hazards, Earthquake and Landslide Hazard Maps, and Future Earthquake Damage and Loss Estimates for Seven Counties in the Mid-Columbia River Gorge Region Including Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Jefferson, and Wheeler.

Source: Wang & Clark (1999)

Table 2-598. Estimated Losses in Region 6 Associated with an M8.5 Subduction Event

	Crook	Deschutes	Jefferson	Klamath
Injuries	0	1	0	14
Deaths	0	0	0	0
Displaced households	0	0	0	37
Economic losses for buildings	$156,000	$5 m	$764,000	$41 m
Operational the day after the event:				
Fire stations	96%	100%	100%	99%
Police stations	96%	99%	100%	99%
Schools	97%	99%	99%	97%
Bridges	100%	100%	100%	98%
Economic losses to infrastructure:				
Highways	$6,000	$17,000	$9,000	$339,000
Airports	0	$40,000	0	$642,000
Communications	$8,000	$2,000	0	$141,000
Debris generated (thousands of tons)	0	3	1	28

Notes: “m” is million

Source: Wang & Clark (1999)

Table 2-599. Estimated Losses in Region 6 Associated with a 500-Year Model

	Crook	Deschutes	Jefferson	Klamath
Injuries	1	17	7	630
Deaths	0	0	0	12
Displaced households	0	5	12	1,409
Economic losses for buildings[2]	5.5 mil	$71 mil	$14 mil	$939 mil
Operational the “day after” the event[3]:				
Fire stations	N/A	N/A	N/A	N/A
Police stations	N/A	N/A	N/A	N/A
Schools	N/A	N/A	N/A	N/A
Bridges	N/a	N/A	N/A	N/A
Economic losses to infrastructure:				
Highways	$879,000	$572,000	$698,000	$28 mil
Airports	$316,000	$2 mil	$395,000	$15 mil
Communications	$18 mil	$1 mil	$104,000	$14 mil
Debris generated (thousands of tons)	0	47	10	610

Note: Every part of Oregon is subject to earthquakes. The 500-year model is an attempt to quantify the risk across the state. The estimate does not represent a single earthquake. Instead, the 500-year model includes many faults. More and higher magnitude earthquakes than used in this model may occur (DOGAMI, 1999).

[2]“…there are numerous unreinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat” (Wang, 1998, p. 5)

[3]Because the 500-year model includes several earthquakes, the number of facilities operational the “day after” cannot be calculated

Source: Wang & Clark (1999)

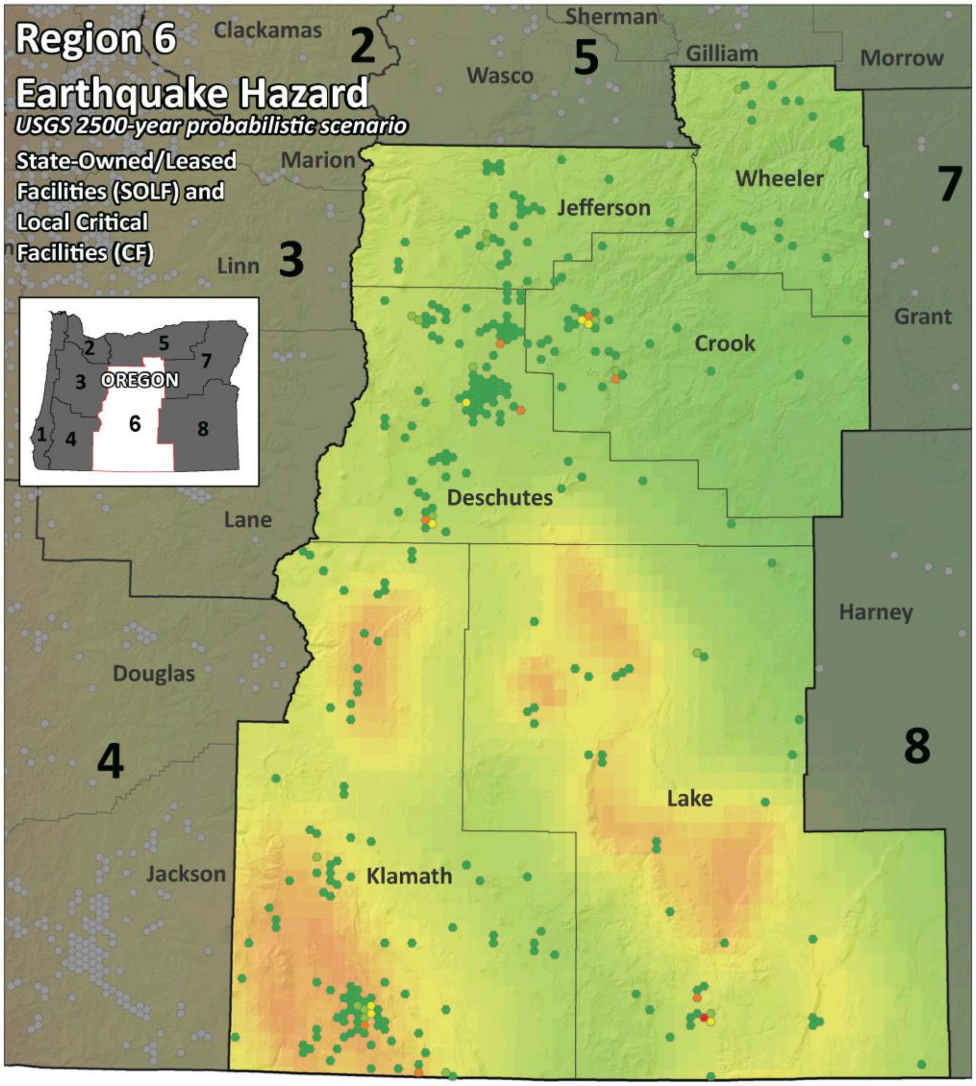
State-Owned/Leased Buildings And Critical Facilities And Local Critical Facilities

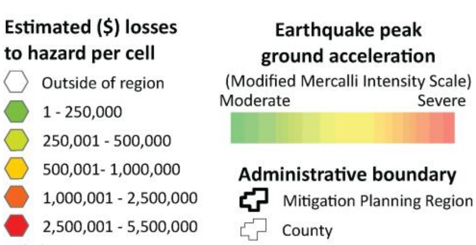
For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a 2,500-year probabilistic earthquake scenario in Region 6. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 6, a 2500-year probabilistic earthquake scenario could generate a potential loss of over $10M in state building and critical facility assets. Over half that value is in Klamath and Lake Counties. Wheeler County has no state assets at risk of earthquakes. The potential loss in local critical facilities is more than double, over $22.5M. Lake and Deschutes Counties have the greatest potential losses, followed by Klamath and Crook Counties. Figure 2-261 illustrates the potential loss to state buildings and critical facilities and local critical facilities from a 2500-year probabilistic earthquake scenario.

Figure 2-261. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in an Earthquake Hazard Zone in Region 6.High-resolution, full-size image linked from Appendix 9.1.26.





Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet, Horizontal datum: NAD83 HARN, Scale 1:1,200,000

Source Data:
Earthquake: Peak ground acceleration for 2500-year probabilistic earthquake, USGS, 2014
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

REGION 6		Estimated Loss ($) from CSZ Earthquake					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*	Loss Local CF	Total Loss SOLF CF and Local CF
Crook	188,923,000	190,000	0%	1,712,000	1,902,000	3,409,000	3,599,000
Deschutes	1,179,009,000	1,559,000	2%	305,000	1,864,000	6,685,000	8,244,000
Jefferson	424,657,000	5,000	0%	806,000	811,000	49,000	54,000
Klamath	591,220,000	2,330,000	2%	676,000	3,006,000	4,464,000	6,794,000
Lake	216,919,000	2,185,000	5%	748,000	2,933,000	7,323,000	9,508,000
Wheeler	29,599,000	0	0%	0	0	574,000	574,000
Total	2,630,327,000	6,269,000	1%	4,247,000	10,516,000	22,504,000	28,773,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

0 15 30 60 Miles

N

Source: DOGAMI

Historic Resources

Of the 2,111 historic resources in Region 6, only 4 are in an area of high or very high liquefaction potential, all of them in Klamath County. However, 726 (34%) of Region 6's historic resources are located in areas of high or very high potential for ground shaking amplification. Most of those are located Deschutes, Klamath, and Lake Counties.

Archaeological Resources

Seventeen thousand three hundred fifty-three archaeological resources are located in earthquake hazard areas in Region 6. Of those, 260 are located in an area of high earthquake hazards. Only two of them are listed on the National Register of Historic Places and ten are eligible for listing. Sixteen have been determined not eligible and 232 have not been evaluated as to their potential for listing. Most archaeological resources in earthquake hazard areas in Region 6 are located in Klamath and Lake Counties, followed by Deschutes then Crook Counties.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6. Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households. Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median. Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters. Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment. Deschutes County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Klamath and Lake Counties are very highly vulnerable to earthquake hazards, followed by Jefferson County.

Seismic Lifelines

"Seismic lifelines" are the state highways ODOT has identified as most able to serve response and rescue operations, reaching the most people and best supporting economic recovery. The process, methodology, and criteria used to identify them are described in Section **2.1.6, Seismic Transportation Lifeline Vulnerabilities**, and the full report can be accessed at Appendix **9.1.16**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification* (OSLR). According to that report, seismic lifelines in Region 6 have the following vulnerabilities.

Regional delineations for this Plan and for the OSLR are slightly different. Regions in the OSLR that correspond to Region 6 include sections of the OSLR Cascades and Central Geographic Zones, as follows:

- *Cascades Geographic Zone:* The Cascades Geographic Zone consists of five crossings of the Cascades from western to central Oregon. These routes connect the highly seismically impacted western portion of the state to the less seismically impacted central portion of the state. In addition, the southernmost route can serve as a connection from Medford to the Klamath Falls area should a seismic event occur in the Klamath Falls area.

  OR-58 is the only Tier 1 transportation lifeline in the Cascades Geographic Zone. The Tier 2 system in the Cascades Geographic Zone consists of OR-22 from Salem to Santiam Junction, US-20 from Santiam Junction to Bend, and OR-140 from Medford to Klamath Falls. There are no corridors designated as Tier 3 in this region.

- *Central Geographic Zone:* Region 6 contains only the southerly portion of the Central Geographic zone. The only Tier 1 system in this area is US-97.

REGIONAL IMPACT.

- Ground Shaking: In Region 6, ground shaking from a CSZ event is not expected to cause damage. However, a Klamath Falls event, either a local event or possibly one triggered by a CSZ event, can cause extensive damage. Unreinforced structures, roadbeds and bridges will be damaged to varying extents. Unreinforced bridges on lifeline corridors may be damaged and require clearing or temporary repairs to remain in service.
- Landslides and Rockfall: The east-west routes in this region are cut into or along landslide prone features. A major seismic event may increase landslide and rockfall activities and may reactivate ancient slides.
- Liquefaction: Structures in wetland, alluvial and other saturated areas will be subject to liquefaction damage; the total area of such impacts will vary with the extent of saturated soils at the time of the event. The Klamath Basin is the one area in this region with extensive wetland and otherwise saturated soil areas.

REGIONAL LOSS ESTIMATES. Economic losses caused by a CSZ event were not calculated for the specific zones of study or for specific highway facilities. The economic loss assessment statewide considered only the losses directly due to highway closures, so, for example, it does not include productivity losses due to business site damage. The highway-related losses include disconnection from supplies and replacement inventory, and the loss of tourists and other customers who must travel to do business with affected businesses. Losses in this region are expected to be low locally. Economic disruption from major losses in the larger markets of the state will affect the economy in this region.

MOST VULNERABLE JURISDICTIONS. Crook, Deschutes, Jefferson, Wheeler, Lake and Klamath have similar, relatively low vulnerability to ground shaking from a CSZ event and resulting landslides and rockfall. Relative to the western regions of the state, fewer roadways in this region are sited in landslide prone areas, but those that are may be easily damaged.

Klamath County is the Region 6 county most vulnerable to a local surface fault earthquake, with ground shaking for over 50 miles noted for relatively small earthquakes. A Klamath Falls earthquake could cause damage in Lake and Jackson Counties, as well.

Risk

Table 2-600. Assessment of Earthquake Risk in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Risk	M	VL	H	VH	VH	VL

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Klamath and Lake Counties are at greatest risk from earthquakes in Region 6 followed by Jefferson County.

Extreme Heat

Characteristics

Extreme temperatures are moderately common in Region 6 and the frequency of prolonged periods of high temperatures has increased. Redmond has an average of about 24 days per year above 90°F.

Historic Extreme Heat Events

Table 2-601. Historic Extreme Heat Events in Region 6

Date	Location	Notes
July 10–14, 2002	Region 5–7	A record breaking heat wave shattered many daily record high temperatures across the state, with a few locations breaking all-time records.
August 15–17, 2008	Region 5–7	Excessive Heat Event: An upper level ridge and dry air brought excessive heat into eastern Oregon. Many locations experienced multiple days of at least 100 degree temperatures.
August 1–4, 2017	Region 2–4, 6	Excessive Heat Event: Strong high pressure brought record breaking heat to many parts of southwest, south central, and northwest Oregon. Region 6: Reported high temperatures during this interval ranged from 82 to 102 degrees.

Source: https://www.ncdc.noaa.gov/stormevents

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning "very low." Region 6 relative probability rankings are shown in **Table 2-602**.

Table 2-602. Probability of Extreme Heat in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	H	L	H	L	M	H

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Region 6 experiences some extreme high temperatures and is projected to experience greater frequency of extreme temperatures under future climate change. **Table 2-603** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 6.

Table 2-603. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 6 Counties

County	Historic Baseline	2050s Future
Crook	4	26
Deschutes	3	21
Jefferson	9	33
Klamath	2	20
Lake	3	24
Wheeler	7	28

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

Vulnerability

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, Extreme Heat. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6.

Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households.

Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median.

Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters.

Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment. Deschutes County has low social vulnerability.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are house-less.

Although extreme heat is moderately common in Region 6 (“moderate” probability), many people may not be accustomed or prepared in terms of air conditioning when an extreme heat event occurs ("moderate" adaptive capacity). In Cooling Zones 1 and 2, which include Region 6 counties, just over half of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1–2 earned a ranking of 1 (very low); scores of 3–4 earned a ranking of 2 (low); scores of 5–6 earned a ranking of 3 (moderate); scores of 7–8 earned a ranking of 4 (high); and scores of 9–10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-604 displays the total vulnerability rankings as well as ranking for sensitivity and adaptive capacity for each county in NHMP Region 6. Table 2-605 provides the summary descriptors of Region 6's vulnerability.

Combining sensitivity and adaptive capacity, Region 6's overall relative vulnerability to extreme heat is "Moderate." With high ratings, Jefferson, Klamath, and Lake Counties are the most vulnerable jurisdictions to extreme heat in Region 6.

Table 2-604. Relative Vulnerability Rankings for Region 6 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 6	**3**	**3**	**3**
Crook	3	3	3
Deschutes	1	3	2
Jefferson	5	3	4
Klamath	5	3	4
Lake	4	3	4
Wheeler	1	3	2

Source: Oregon Climate Change Research Institute

Table 2-605. Vulnerability to Extreme Heat in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	L	H	H	H	L

Source: Oregon Climate Change Research Institute

Region 6 counties did not rank vulnerability to extreme heat.

As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. High temperature and insufficient water stunt plant growth and cause areas of crops to wither. Some livestock, especially dairy cattle, are also sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms.

Like drought, impacts of drought on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. However, the appropriate data are not available to assess impacts of heat waves on agriculture and subsequent effects on the state economy.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 6 is approximately $616,270,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $2,014,056,000. Because extreme heat could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 6 since the beginning of 2015. Nevertheless, none of the recorded losses was due to extreme heat.

Risk

With respect to extreme heat, risk is defined as the combination of exposure to extreme heat events (probability), sensitivity to extreme heat, and level of adaptive capacity in response to extreme heat.

The total relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for exposure (probability) and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1-2 earned a ranking of 1 ("very low"); scores of 3-4 earned a ranking of 2 ("low"); scores of 5-6 earned a ranking of 3 ("moderate"); scores of 7-8 earned a ranking of 4 ("high"); and scores of 9-10 earned a ranking of 5 ("very high"). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-606 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 6. Table 2-607 provides the summary descriptors of Region 6's risk to extreme heat.

Combining probability and vulnerability, Region 6's overall relative risk to extreme heat is "Moderate." The risk for Crook, Jefferson, and Lake Counties is "High."

Table 2-606. Risk Rankings for Region 6 Counties

County	Probability	Vulnerability	Risk
Region 6	**3**	**3**	**3**
Crook	4	3	4
Deschutes	2	2	2
Jefferson	4	4	4
Klamath	2	4	3

County	Probability	Vulnerability	Risk
Lake	3	4	4
Wheeler	4	2	3

Source: Oregon Climate Change Research Institute

Table 2-607. Risk of Extreme Heat in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Risk	H	L	H	M	H	M

Source: Oregon Climate Change Research Institute

Floods

Characteristics

Central Oregon is subject to a variety of flood conditions, including:

- Spring runoff from melting snow;
- Intense warm rain during the winter months;
- Ice-jam flooding;
- Local flash flooding;
- Lake flooding associated with high winds (e.g., Klamath Lake); and
- Flooding associated with the breeching of natural debris dams.

Although not as notable as flash floods, the most common flood condition in Central Oregon is associated with warm winter rain on snow.

Rain-on-snow floods, so common in western Oregon, also occur east of the Cascades. The weather pattern that produces these floods occurs during the winter months and has come to be associated with La Niña events, 3- to 7-year cycles of cool, wet weather. Brief cool, moist weather conditions are followed by a system of warm, moist air from tropical latitudes. The intense warm rain associated with this system quickly melts foothill and mountain snow. Above-freezing temperatures may occur well above pass levels in the Cascade Mountains (4,000–5,000 feet). Some of Oregon's most devastating floods are associated with these events (Taylor, 1999).

Although flooding occurs throughout central Oregon, local geology and the relatively low population of the six-county area lessen its effects. Volcanic rocks, some of which have a large capacity for water storage, underlie much of the region. Consequently, the discharge rates for some streams (e.g., Deschutes River) are very low considering the size of their basins (June 8, 1998, Deschutes County Flood Insurance Study). In addition, there are some large reservoirs in the upper watersheds that can contain considerable quantities of runoff. Potential flood losses also are mitigated through land use standards; all Region 6 communities participate in the National Flood Insurance Program.

The Flood Insurance Studies (FIS) for each of the Region 6 counties provide some insights associated with ice jam flooding (Deschutes County), lake level differentials produced by local wind conditions (Klamath County), and possible flooding caused by the failure of natural debris dams (Deschutes County). Although these phenomena have not and would not produce devastation like historical flash floods in Jefferson County, they certainly warrant the consideration of local emergency managers.

All of the Region 6 counties have Flood Insurance Rate Maps (FIRMs); however, some of the maps are old and could be outdated. The FIRMs were issued at the following times:

- Crook, February 2012;
- Deschutes, September 2007;
- Jefferson, July 17, 1989;
- Klamath, December 18, 1984;
- Lake, December 5, 1989; and
- Wheeler, July 17, 1989.

Updates to these maps in the near future include the following:

- Klamath County is due to provide opportunities for public comment at a Consultation Coordination Officer (CCO) meeting in May or June 2020;
- LiDAR is due to be produced for the John Day watershed within Crook and Wheeler Counties in 2020.

Notable floods affecting Region 6 are shown in **Table 2-608**.

Historic Flood Events

Table 2-608. Significant Historic Floods Affecting Region 6

Date	Location	Description	Type of Flood
June 1884	Wheeler County (Painted Hills)	mother and three children perished	flash flood
June 1900	Wheeler County (Mitchell)	large area of county devastated	flash flood
Dec, 1964	entire state	severe flooding in central Oregon	rain on snow
Aug. 1976	Jefferson County (Ashwood)	severe flooding; damaged buildings	flash flood
Feb, 1986	entire state	severe flooding	rain on snow
Aug. 1991	Crook County (Aspen Valley)	severe flooding; one fatality	flash flood
Mar. 1993	Wheeler County	severe flooding	rain on snow
May 1998	Crook County (Prineville)	Federal disaster declaration (FEMA-DR 1221-Oregon); Ochoco Dam threatened	rain on snow
Apr. 2001	Wheeler	A slow moving thunderstorm produced an estimated 1 inch of rain over mountainous terrain in southeastern Wheeler County.	
July 2001	Douglas, Deschutes and Lake Counties	A Flash Flood Warning was issued for East Central Douglas county. The Boulder Creek area was of special concern. A heavy slow moving thunderstorm dumped one inch of rain in one hour over Sunriver. Lakeview Police reported rock and/or mudslides on State Highway 140 at mileposts 22, 23.2, and 25.1. They also reported 0.25 inch hail up to an inch deep and 2 feet of water in spots on the same highway.	flash flood
Dec. 2005	Crook, Deschutes Counties	$1,000,000 in property damage	
Dec. 2005	Klamath and Lake Counties	$500,000 in property damage	
June 2006	Klamath County	a dike on Upper Klamath Lake failed, inundating agricultural fields, the Running Y Golf Resort, and OR-140	flash flood

Date	Location	Description	Type of Flood
Feb. 2017	Marion, Polk, Yamhill, Washington, Columbia, Benton, Tillamook, Lane, Coos, Curry, Klamath, Wheeler and Malheur Counties	High river flows combined with high tide to flood some areas near the southern Oregon coast. Heavy rain combined with snow melt caused flooding along the Coquille River and the Rogue River twice this month in southwest Oregon. Heavy rain combined with snow melt caused flooding along the Sprague River in south central Oregon. Flows on the John Day river reached flood levels downstream of Monument due to the breaking up of an ice jam.	rain on snow
March 2017	Malheur, Harney, Wallowa, Umatilla and Wheeler Counties	An extended period of snow melt, combined with a period of heavy rain, caused an extended period of flooding along portions of the John Day River, the Umatilla and the Silvies Rivers. Flooding occurred on the Snake River near Ontario.	rain on snow
April 2019	Union, Grant, Umatilla, Wallowa and Wheeler Counties	DR-4452. Grant, Umatilla, and Wheeler Counties declared. Snow water equivalents near 200% of normal in the Blue Mountains coupled with warm temperatures and near record rainfall totals for April produced significant river flooding across eastern Oregon.	rain on snow
April 2019	Wheeler County	Total rainfall of 1.67 inches was recorded just east of Mitchell. This heavy rain over a short period of time triggered a flash flood through Huddleston Heights and Nelson Street, and off of High Street and Rosenbaum with mud and debris blocking roads in and around the town of Mitchell.	flash flood
July 2019	Deschutes County	Slow moving thunderstorms produced localized flooding and minor mud flows around the Tumalo area during the evening of July 1st.	
Aug. 2019	Crook and Wasco Counties	A powerful upper storm system combined with modest low and mid-level moisture to yield scattered strong to severe storms and flash flooding. Storms developed first across the higher terrain of central Oregon nearer the Cascades and adjacent Ochoco mountains. Storms then built northward with hail and damaging winds along the way.	

Source: Taylor and Hatton (1999); Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; NOAA Storm Event Database, online resource consulted January 2020; Planning for Natural Hazards: Flood TRG (Technical Resource Guide), July 2000, DLCD, Community Planning Workshop

Table 2-609 describes flood sources for each of the counties in the region.

Table 2-609. Principal Riverine Flood Sources by County Affecting Region 6

Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Crooked River Ochoco River	Deschutes River Little Deschutes River Whychus Creek Paulina Creek Spring River	Willow Creek unnamed stream north of Culver Muddy Creek	Sprague River Williamson River Klamath River Williamson River Link River Four Mile Creek Varney Creek Upper Klamath Lake	Chewaucan River N. Goose Lake Basin	Bridge Creek Keyes Creek

Sources: FEMA, Crook County Flood Insurance Study (FIS) 07/17/89; FEMA, Deschutes County FIS, 06/08/98; FEMA, Jefferson County FIS, 07/17/89; FEMA, Klamath County FIS, 06/18/84; FEMA

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the "OEM Hazard Analysis Methodology" used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in Appendix **9.1.19**.

Probability

Local Assessment

Participants in each county's Natural Hazard Mitigation Plan update process used the OEM hazard analysis methodology to analyze the probability that Region6 will experience flooding. The resulting estimates of probability are shown in **Table 2-610**.

Table 2-610. Local Assessment of Flood Probability in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	H	H	H	M	H	H

Source: Crook County NHMP update (2018); Deschutes County NHMP update (2015); Jefferson County NHMP update (2013), Klamath County NHMP update (2017); Lake County NHMP draft update; Wheeler County NHMP (2019)

State Assessment

Using the methodology described in the Section 2.2.7.1, Floods/Probability, the state assessed the probability of flooding in the counties that comprise Region 6. The results are shown in **Table 2-611**.

Table 2-611. State Assessment of Flood Probability in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	L	L	L	L	L	H

Source: DOGAMI

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-612. Local Assessment of Vulnerability to Flood in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	H	L	M	M	H	H

Vulnerability to flooding in Madras was rated as High, whereas the vulnerability to this hazard at the county level was rated as moderate.

Source: Crook County NHMP update (2018); Deschutes County NHMP update (2015); Jefferson County NHMP update (2013), Klamath County NHMP update (2017); Lake County NHMP draft update; Wheeler County NHMP (2019)

Table 2-613. State Assessment of Vulnerability to Flood in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	VL	VH	H	M	VL

Vulnerability to flooding in Madras was rated as High, whereas the vulnerability to this hazard at the county level was rated as moderate.

Source: DOGAMI, DLCD

The exposure of critical infrastructure and facilities was addressed in the NHMP update process.

The Crook County NHMP has a number of foster care facilities and nursing homes located within its floodplains. Other critical facilities at risk of damage by natural hazards are not listed in the plan. Developing a database of these is a mitigation action to be taken.

The Deschutes County NHMP identified critical and essential facilities in each of the jurisdictions covered in the plan and developed a mitigation action to identify those public infrastructure and critical facilities that are at risk from natural hazards.

The Jefferson County NHMP identified the need to update existing data on critical facilities for the next plan update. Specific mitigation actions addressed the need to ensure adequate heating and cooling of schools, develop mitigation strategies for critical facilities and infrastructure located in the floodplain, and to ensure that sufficient back up sources of energy exist for all critical facilities.

The Klamath County NHMP identified the critical facilities in the county. None of these are located in the floodplain. The plan identifies a mitigation action aimed at identifying schools and child care facilities to determine which facilities are vulnerable to natural hazards and to identify mitigation projects to reduce risk. DOGAMI conducted a Seismic Needs Assessment and identified 79 building in the county at moderate, high or very high risk of collapse.

In Lake County, the participants in the NHMP update process catalogued 55 critical facilities and infrastructure. Of those 16 were identified as being at risk of damage from flooding. These include the Lake County Airport, Lake District Hospital, Lake County Emergency Services Dispatch Building/Courthouse/Sheriff's Office, Lake County Sheriff Search and Rescue, Lake County Public Health Department, the Town of Lakeview Municipal water system and wastewater treatment plant and all the critical facilities named in the City of Paisley.

In Wheeler County, the participants in the NHMP update process catalogued 25 critical facilities and infrastructure. Of those 21 were identified as being at risk of damage from flooding. These include the bridges over Bridge Creek, the Fossil water supply infrastructure, Fossil City Hall, Fossil Volunteer Fire Department, the Wheeler County Courthouse, Wheeler High School, Spray City Hall and Spray School.

Repetitive Losses

FEMA has identified six Repetitive Loss properties in Region 6, three in Jefferson County and three in Lake County (FEMA NFIP Community Information System, https://isource.fema.gov/cis/ accessed 02/11/2020).

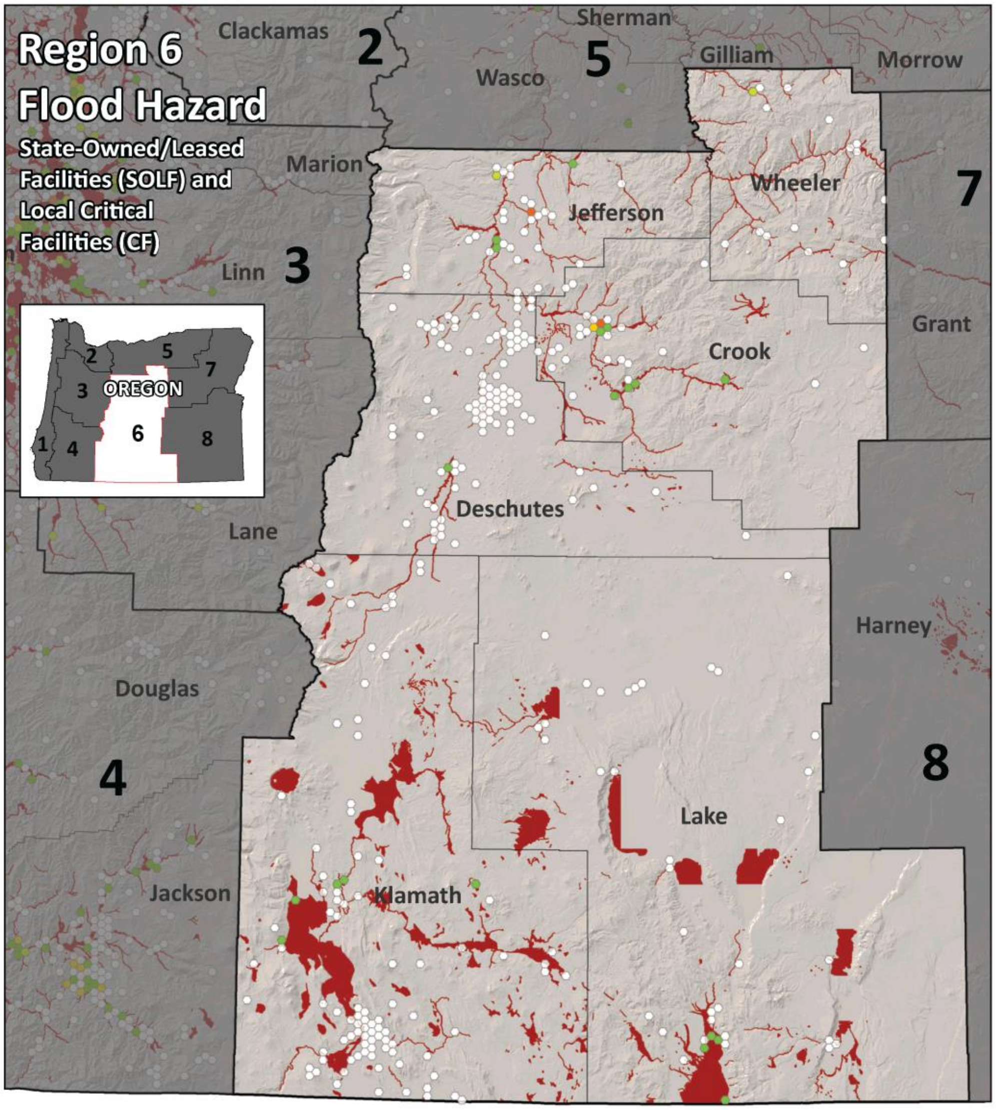
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS) Program, which results in reduced flood insurance costs. No Region 6 communities participate in the CRS Program.

State-Owned/Leased Facilities and Critical/Essential Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

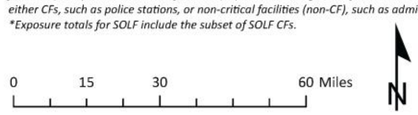
In Region 6, there is a potential loss from flooding of almost $5M in state building and critical facility assets, between 25% and 30% each in Lake, Crook, and Jefferson Counties. There are no state assets in flood hazard areas in Deschutes County. There is a far greater potential loss – almost 25 times as much - due to flood in local critical facilities: over $120M. Fifty-seven percent of that value is in Crook County and 33% in Jefferson County. **Figure 2-262** illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding in Region 6.

Figure 2-262. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 6.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 6		Exposure ($) to Flood Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Crook	188,923,000	0	0%	1,421,000	1,421,000	68,468,000	68,468,000
Deschutes	1,179,009,000	0	0%	0	0	369,000	369,000
Jefferson	424,657,000	0	0%	1,227,000	1,227,000	40,062,000	40,062,000
Klamath	591,220,000	0	0%	654,000	654,000	1,616,000	1,616,000
Lake	216,919,000	0	0%	1,516,000	1,516,000	4,795,000	4,795,000
Wheeler	29,599,000	0	0%	28,000	28,000	5,287,000	5,287,000
Total	2,630,327,000	0	0%	4,846,000	4,846,000	120,597,000	120,597,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*



Source: DOGAMI, 2020

Historic Resources

Of the 2,111 historic resources in Region 6, sixty-four (3%) are located in an area of high flood hazard. Of those, 33 (52%) are located in Crook County. The rest are found throughout Region 6.

Archaeological Resources

Of the 1,021 archaeological resources located in high flood hazard areas in Region 6, forty-three percent are located in Klamath County and 22% in Lake County. Only four are listed on the National Register of Historic Places while 85 are eligible for listing. Forty-eight have been determined not eligible and 884 have not been evaluated as to their eligibility. The listed resources are located in Deschutes, Jefferson, and Lake Counties. About half the eligible resources are found in those counties as well; the other half are located in Klamath County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6.

Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households. Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median.

Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters.

Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment.

Deschutes County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Jefferson County is very highly vulnerable to the impacts of flooding and Klamath County is highly vulnerable. Both Jefferson County's and Klamath County's high scores are driven by their very high social vulnerability, while Jefferson County's is also driven by the value of local critical facilities there. Further, Jefferson County is also home to three of the six Repetitive Loss properties in Region 6. Many archaeological resources are vulnerable to flooding in Klamath County.

Most Vulnerable Jurisdictions

Jefferson and Klamath Counties are the most vulnerable to flood hazards in Region 6.

Risk

Table 2-614. Risk of Flood Hazards in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Risk	M	VL	H	M	M	M

Vulnerability to flooding in Madras was rated as High, whereas the vulnerability to this hazard at the county level was rated as moderate.

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, only Jefferson County is at high risk from flooding in Region 6.

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owners property to community destruction with mass fatalities. The 1889 Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost. Oregon's

first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Table 2-615. Historic Significant Dam Failures in Region 6

Year	Location	Description
1920	Bonneyview dam east of Prineville in Crook Co.	Property damaged
1927	Cottonwood creek dam northwest of Lakeview in Lake Co.	Property damaged

Source: Oregon Water Resources Department Dam Safety Program records

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 19 High Hazard dams and 17 Significant Hazard dams in Region 6.

Table 2-616. Summary: High Hazard and Significant Hazard Dams in Region 6

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 6	8	17	11
Crook	3	7	2
Deschutes	1	2	2
Jefferson	0	3	4
Klamath	1	0	3
Lake	3	5	0
Wheeler	0	0	0

Source: Oregon Water Resources Department, 2019

Table 2-617. High Hazard and Significant Hazard Dams in Region 6

County	Name	Rating	Regulator
Crook	Ochoco Reservoir	High	Federal
Crook	Prineville Reservoir (Bowman)	High	Federal
Crook	Barnes Butte	High	State
Crook	Joe Fisher	High	State
Crook	Johnson Creek (Crook)	High	State
Crook	Bear Creek (Crook)	Significant	State
Crook	Bonnie View Dam	Significant	State
Crook	Dick Dam	Significant	State
Crook	Mainline 1	Significant	State
Crook	Mainline 2	Significant	State
Crook	Mainline 3	Significant	State
Crook	Wampler-Werth	Significant	State
Deschutes	Crane Prairie	High	Federal
Deschutes	Wickiup Reservoir (USBR)	High	Federal
Deschutes	North Canal Diversion	High	State
Deschutes	Bend Hydro (Mirrorpond)	Significant	State
Deschutes	Mckenzie Canyon Dam	Significant	State
Jefferson	Haystack Equalizing Pond	High	Federal
Jefferson	Pelton Dam	High	Federal
Jefferson	Pelton Regulating Dam	High	Federal
Jefferson	Round Butte Dam	High	Federal
Jefferson	Brewer Reservoir (Jefferson)	Significant	State
Jefferson	Fuston Ranch Dam	Significant	State
Jefferson	Gillworth Reservoir	Significant	State
Klamath	Gerber Reservoir	High	Federal
Klamath	JC Boyle Dam	High	Federal
Klamath	Upper Klamath Lake	High	Federal
Klamath	Crescent Lake	High	State
Lake	Bullard Creek F.R.S. (Lake)	High	State
Lake	Cottonwood	High	State
Lake	Drews	High	State
Lake	Cottonwood Meadows	Significant	State
Lake	Micke	Significant	State
Lake	Muddy Creek Reservoir	Significant	State
Lake	Thompson Valley Diversion (Slid)	Significant	State
Lake	Thompson Valley Reservoir	Significant	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally regulated. A dam's condition is considered public information for state-regulated

dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Seven of the eight state-regulated high hazard dams are in satisfactory or fair condition; only one is in poor condition.

Table 2-618. Summary: Condition of High Hazard State-Regulated Dams in Region 6

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	**Fair**	**Poor**	**Unsatisfactory**	**Not Rated**
Region 6	4	3	1	0	0
Crook	1	1	1	0	0
Deschutes	0	1	0	0	0
Jefferson	0	0	0	0	0
Klamath	1	0	0	0	0
Lake	2	1	0	0	0
Wheeler	0	0	0	0	0

Source: Oregon Water Resources Department, 2019

Table 2-619. Condition of High Hazard State-Regulated Dams in Region 6

County	Dam Name	Condition
Crook	Johnson Creek (Crook)	Fair
Crook	Barnes Butte	Poor
Crook	Joe Fisher	Satisfactory
Deschutes	North Canal Diversion	Fair
Klamath	Crescent Lake	Satisfactory
Lake	Drews	Fair
Lake	Bullard Creek F.R.S. (Lake)	Satisfactory
Lake	Cottonwood	Satisfactory

Source: Oregon Water Resources Department, 2019

State-Regulated High Hazard Dams not Meeting Safety Standards

There is one state-regulated high hazard dam in Region 6 that is currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). This dam and the population at risk, based on a screen using the screening tool DSS-WISE, is shown in **Table 2-620**. As the dam safety program conducts analysis over time, the number of dams in less than satisfactory condition may change. Currently dams that are in poor or unsatisfactory condition are in need of rehabilitation or other action to bring them into a fully safe condition. As of December 2019, this is the dam in Region 6 that is not yet demonstrably unsafe, but that does pose unacceptable risk. When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Table 2-620. State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 6

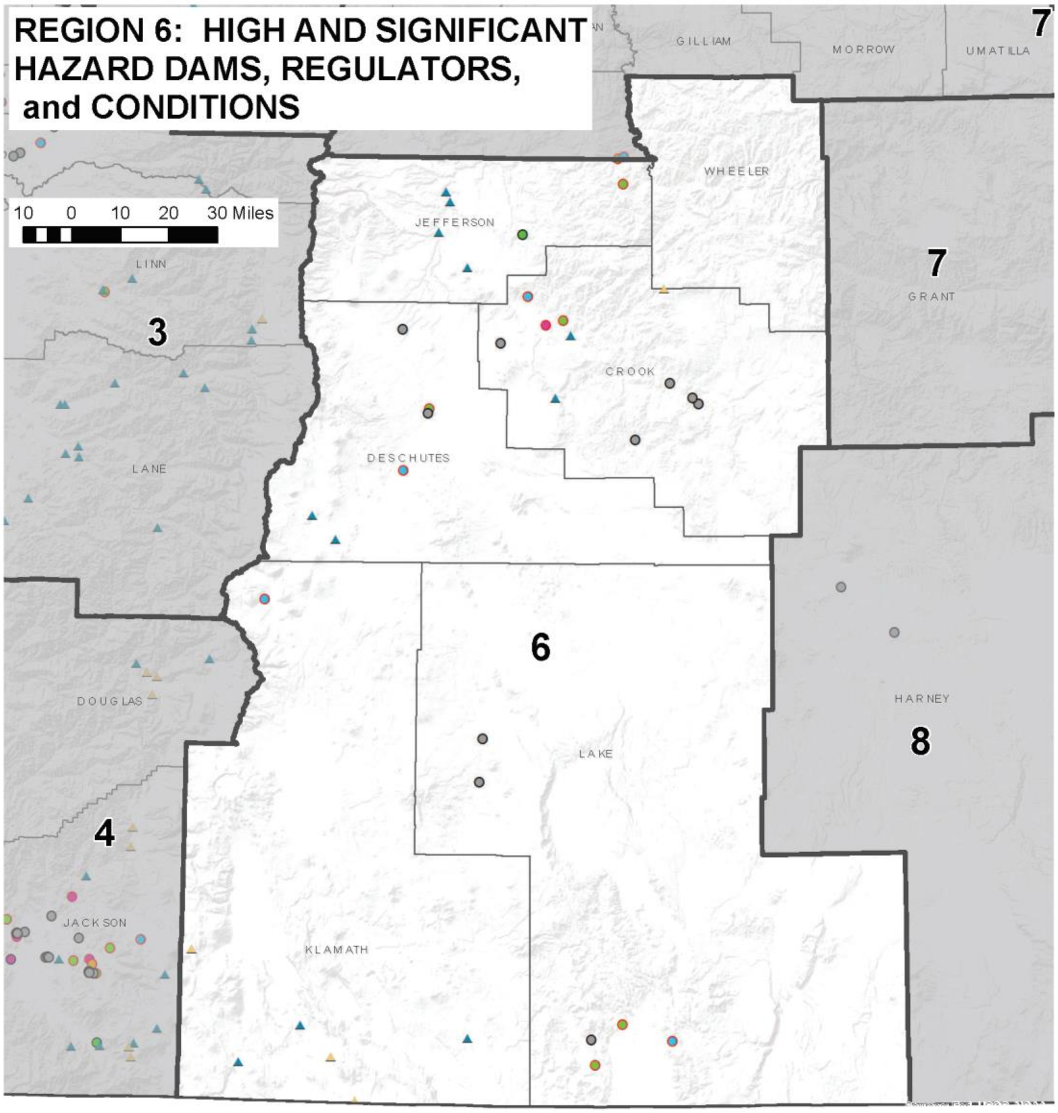
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Barnes Butte Reservoir	OR00284	POOR	1,787	1,648	Crook

Note: "PAR" is number of "Persons At Risk" in the dam failure inundation zone based on a conservative estimate using DSS-Wise dam breach estimator. It includes all persons that normally could be in the inundation area. Actual impacts depend on the velocity and depth of water and will be determined as part of Oregon's HHPD grant tasks.

Source: DSS-Wise output

Figure 2-263 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 6. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-263. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 6



	Coastal	Earthquake	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 6	0	17	*	11	4	0	16
Crook	0	7	*	3	0	0	7
Deschutes	0	2	*	1	1	0	2
Jefferson	0	4	*	3	3	0	3
Klamath	0	3	*	4	0	0	0
Lake	0	1	*	0	0	0	4

* - flood risk affected by function and condition of dam, not by presence in mapped flood prone location

State regulated dams**

Condition assessment

- Poor
- Unsatisfactory
- Fair
- Satisfactory
- No assessment

Federal regulated dams

Hazard

- High
- Significant

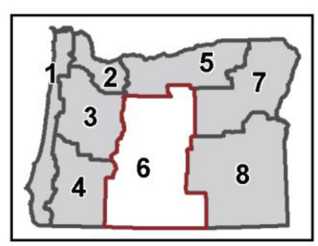
- Mitigation Planning Regions
- Counties

** - Significant hazard dam symbols have a black outline.
High hazard dam symbols have a red outline.

Projection:
Oregon Lambert Coordinate Reference System, Unit: International Feet, Horizontal datum: NAD83, EPSG #2992

Source Data:
State regulated dams: Oregon Water Resources Dept., July 2020
Mitigation Planning Regions: Oregon Emergency Management
Counties: U.S. Bureau of Land Management (BLM)
Base map: Esri, World Terrain Base

Author: Robert Harmon, GISP, Oregon Water Resources Dept. (July 2020)



Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

Table 2-620, State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 6, indicates the number of people currently anticipated to be impacted by potential failure of the state-regulated high hazard dam in poor or unsatisfactory condition. OWRD plans to do more analysis to determine the number and value of structures that may be impacted as well.

There is a higher seismic risk, but no state regulated high hazard dams in Klamath County. Landslide risk is generally lower, and risk of debris and flash flooding from wildfire areas can be fairly high.

One dam in Region 6 meets FEMA HHPD eligibility criteria. There is a major highway in the inundation area below this dam.

Most Vulnerable Jurisdictions

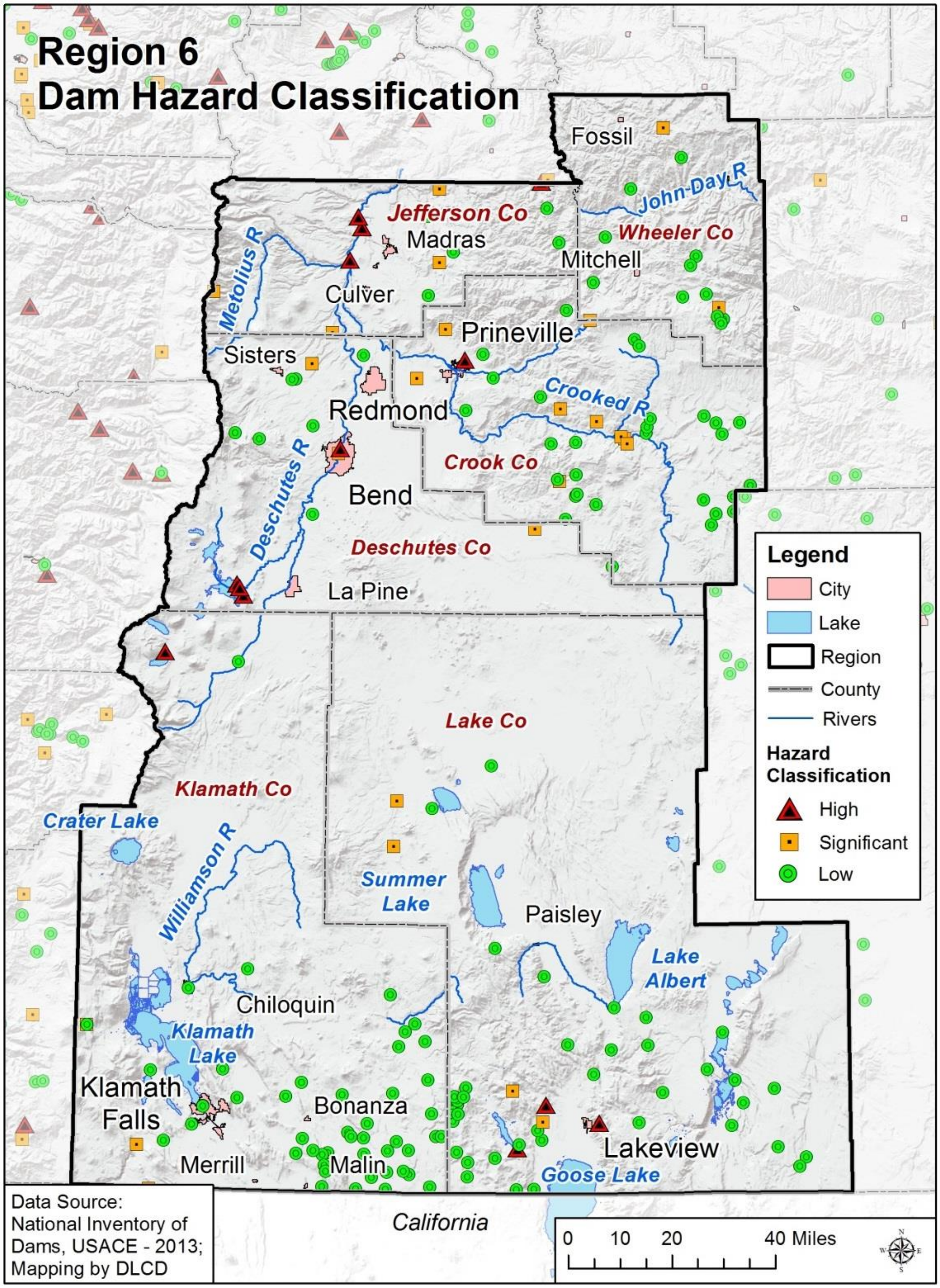
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), only Crook County in Region 6 has a high hazard dam in poor or unsatisfactory condition and is therefore considered most vulnerable.

As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable jurisdictions” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The county with the most state-regulated significant hazard dams is Crook County (7).

Risk

With FEMA and State funding, OWRD will be completing a risk assessment for Region 6’s state-regulated high hazard dam in poor or unsatisfactory condition over the next several years. For now, the potential for damage to the dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-264. Region 6 Dam Hazard Classification



Source: National Inventory of dams, USACE, 2013

Note: Federally regulated significant hazard dams are not shown.

Landslides

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the Cascade Mountain Range and the Klamath Mountains have a high incidence of landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage.

Most landslides in Region 6 occur within the US-26 corridor (Prineville-Mitchell). US-97 just north of Klamath Falls has a history of rock falls. One person was killed by a rockslide in this area during the 1993 Klamath Falls earthquake.

Historic Landslide Events

Table 2-621. Significant Landslides in Region 6

Date	Location	Description
Dec. 1964	Crook, Deschutes, Jefferson, Klamath, Lake, and Wheeler Counties	DR-184
Sep. 1993	Klamath County	Rockslide resulting from earthquake; One life lost.
Dec. 1996-Jan. 1997	Lake and Wheeler Counties	DR-1160
May-Jun. 1998	Crook County	DR-1221
Dec. 2003-Jan. 2004	Crook, Deschutes, Jefferson, Lake, and Wheeler Counties	DR-1510
Dec. 2005	Jefferson County	damage: $11,666.67 * (includes Sherman and Wasco Counties)
Dec. 2005-Jan. 2006	Crook, Jefferson, and Wheeler Counties	DR-1632
Dec. 2006	Wheeler County	DR-1683
Jan. 2011	Crook County	DR-1956
Jan. 2017	Deschutes County	DR-4328
Feb. 2019	Jefferson County	DR-4432

Source: Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; FEMA, https://www.fema.gov/disasters

Probability

Table 2-622. Assessment of Landslide Probability in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	M	L	H	L	L	VH

Source: DOGAMI, 2020

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in this region in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-623. Local Assessment of Vulnerability to Landslides in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	L	L	L	L	L	M

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-624. State Assessment of Vulnerability to Landslides in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	VL	H	H	M	L

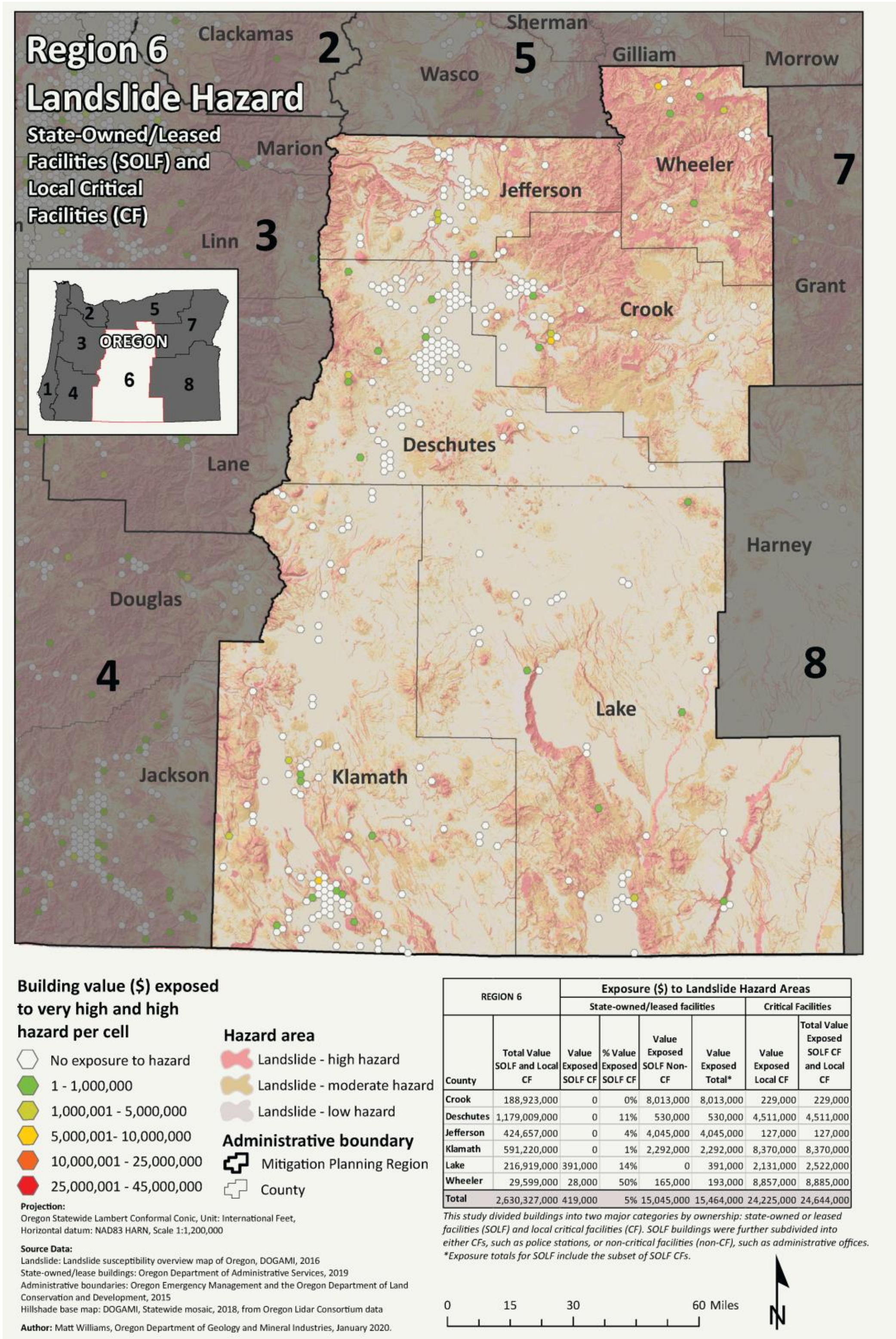
Source: DOGAMI and DLCD, 2020

Many of the historic landslides occur along the highways in this region and the areas along the Cascade Mountains (Burns, et al., 2012).

State-Owned/Leased Facilities and Critical and Essential Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 6. Over $15M in value of state assets is exposed to landslide hazards in Region 6, most of it in Crook County followed by Jefferson and Klamath Counties. The value of local critical facilities is over $24M, more than two-thirds of it in Wheeler and Klamath Counties. **Figure 2-265** illustrates the potential loss to state buildings and critical facilities and local critical facilities from landslide hazards.

Figure 2-265. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 6.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 6	Exposure ($) to Landslide Hazard Areas						
	State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Crook	188,923,000	0	0%	8,013,000	8,013,000	229,000	229,000
Deschutes	1,179,009,000	0	11%	530,000	530,000	4,511,000	4,511,000
Jefferson	424,657,000	0	4%	4,045,000	4,045,000	127,000	127,000
Klamath	591,220,000	0	1%	2,292,000	2,292,000	8,370,000	8,370,000
Lake	216,919,000	391,000	14%	0	391,000	2,131,000	2,522,000
Wheeler	29,599,000	28,000	50%	165,000	193,000	8,857,000	8,885,000
Total	2,630,327,000	419,000	5%	15,045,000	15,464,000	24,225,000	24,644,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Archaeological Resources

Of the 8,803 archaeological resources located in landslide hazard areas in Region 6, forty-three percent (3,749) are in high landslide hazard areas. Of those, 33 are listed on the National Register of Historic Places and 415 are eligible for listing. Eighty-seven have been determined not eligible, and 3,214 have not been evaluated as to their eligibility. Sixty-two percent of the archaeological resources in high landslide hazard areas are located in Klamath and Lake Counties and 61% of all archaeological resources in landslide hazard areas in Region 6 are located in those two counties as well.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6. Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households.

Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median.

Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters.

Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment. Deschutes County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Jefferson and Klamath Counties are the most vulnerable to landslides in Region 6. Jefferson and Klamath Counties' high vulnerability rating is driven by their very high social vulnerability.

Risk

Table 2-625. Assessment of Risk to Landslides in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Risk	M	VL	VH	M	M	H

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 Risk Scores and DOGAMI's expert assessment, Jefferson and Wheeler Counties are "most vulnerable jurisdictions" with very high and high ratings, respectively. While Jefferson and Klamath Counties both have very high social vulnerability scores, Jefferson and Wheeler Counties have greater probability scores than Klamath County and Wheeler County faces greater potential for loss of state buildings, state critical facilities, and especially local critical facilities. All three communities should be prioritized for mitigation actions.

Volcanoes

Characteristics

The western boundaries of Jefferson, Deschutes, and Klamath Counties coincide with the Cascade Mountains. Volcanic activity in the Cascades will continue, but questions regarding how, to what extent, and when, remain. Most volcano-associated hazards are local (e.g., explosions, debris, lava, and pyroclastic flows). However, lahars can travel considerable distances through stream valleys and wind-borne ash can blanket areas many miles from the source.

There is virtually no risk from lahars, debris, or pyroclastic flows in Wheeler and Crook Counties, although normal prevailing winds could carry ash into those areas. Jefferson, Deschutes, and Klamath Counties are at risk, however, and should consider the impact of volcano-related activity on small mountain communities, natural debris dams (e.g., South Sister, Broken Top), dams creating reservoirs, tourist destinations (e.g., Crater Lake), highways and railroads. These counties also should consider probable impacts on the local economy (e.g., wood products and recreation) should a volcano-related hazard occur.

The history of volcanic activity in the Cascade Range is contained in its geologic record, and the ages of the volcanoes vary considerably. Some lava flows on Washington’s Mount Rainier are thought to be older than 840,000 years; Mount St. Helens erupted in May 1980, and continues to be active. In short, all of the Cascade volcanoes are characterized by long periods of quiescence with intermittent activity, making predictions, recurrence intervals, or probability very difficult to attain.

Several Region 6 communities are within a few miles of prominent volcanoes. Mt. Jefferson, the Three Sisters, Broken Top, and Mt. Bachelor dominate the skyline between Redmond and Bend (Deschutes County). A less imposing, but nonetheless important volcano, Newberry Crater, is within 15 miles of La Pine (Deschutes County) and less than 25 miles from the City of Bend. The string of volcanoes continues south with Mount Thielsen, Mount Scott (Crater Lake), and Mount McLaughlin dominating the horizon. The composition, eruptive behavior, and history of these volcanoes are not the same, which probably has a bearing on any future activity.

Historic Volcanic Events

Table 2-626. Historic Volcanic Events in Region 6

Date	Location	Description
about 18,000 to 7,700 YBP	Mount Bachelor, central Cascades	cinder cones, lava flows
about 13,000 YBP	Lava Mountain, south-central Oregon	Lava Mountain field, lava flows
about 13,000 YBP	Devils Garden, south-central Oregon	Devils Garden field, lava flows
about 13,000 YBP	Four Craters, south-central Oregon	Four Craters field, lava flows
about 7,700 YBP	Crater Lake Caldera	formation of Crater Lake caldera, pyroclastic flows, widespread ashfall
< 7,700 YBP; 5,300 to 5,600 YBP	Davis Lake, southern Cascades	lava flows and scoria cones in Davis Lake field
about 10,000 to <7,700 YBP	Cones south of Mount Jefferson; Forked Butte and South Cinder Peak	lava flows
about 2,000 YBP	South Sister Volcano	rhyolite lava flow
about 1,300 YBP	Newberry Volcano, central Oregon	eruption of Big Obsidian flow
about 1,300 YBP	Blue Lake Crater, central Cascades	spatter cones and tephra

Note: YBP is years before present.

Sources: Sherrod, et al. (1997); Bacon, et al. (1997); Walder, et al. (1999); Scott, et al. (2001); and U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/

Probability

Table 2-627. Assessment of Volcanic Hazards Probability in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	VL	M	M	M	L	L

Source: DOGAMI, 2020

According to the 2020 Risk Scores, Deschutes, Jefferson, and Klamath Counties have moderate probability of volcanic hazards, and Crook, Lake, and Wheeler have very low probability.

The probability of volcanic activity can be very difficult to predict, unless there are obvious precursors. The precursors might include increased seismic activity, temperature, and chemical changes in groundwater, etc. Probability is especially difficult when the volcano has been inactive for many thousands of years and lacks a clear geologic record of past events. Also, the knowledge of volcanoes is too limited to know how long a dormant period at any volcano can last (Walder, Gardner, Conrey, Fisher, & Schilling, 1999) and this probably is the case for most Cascade volcanoes. Eruption probabilities generated by the U.S. Geological Survey for the Oregon Cascades are largely based on the position of volcanic rocks in the geologic record. There is a considerable opportunity for error. **Table 2-628** describes the probability of volcano-related hazards in Region 6.

Table 2-628. Probability of Volcano-Related Hazards in Region 6

Volcano-Related Hazards	Jefferson	Deschutes	Klamath	Crook	Remarks
Volcanic ash (annual probability of 1 cm or more accumulation from eruptions throughout the Cascade Range)	1 in 5,000	1 in 5,000	1 in 5,000	1 in 5,000	Sherrod, et al. (1997)
Lahar	Source: Mt. Jefferson	Source: Newberry Crater and Three Sisters	Source: Crater Lake	no risk	if the Detroit Lake dam is breached, lahars could reach Mill City, Lyons, and Stayton in Marion County Sources: Walder, et al. (1999); Lane County: Scott, et al. (2001)
Lahar	Source: Mt. Jefferson	Source: Newberry Crater and Three Sisters	Source: Crater Lake	no risk	if the Detroit Lake dam is breached, lahars could reach Mill City, Lyons, and Stayton in Marion County. Walder, et al. (1999); Lane County: Scott, et al. (2001)
Lava flow	Source: Mt. Jefferson	Source: Newberry Crater and Three Sisters	Source: Crater Lake	no risk	Mount Jefferson: Walder, et al. (1999); Three Sisters: Scott, et al. (2001)
Debris flow / avalanche	Source: Mt. Jefferson	Source: Three Sisters	Source: Crater Lake	no risk	Mt. Jefferson: Walder, et al. (1999); Three Sisters: Scott, et al. (2001)
Pyroclastic flow	Source: Mt. Jefferson	Source: Newberry Crater and Three Sisters	Source: Crater Lake and Newberry Crater	no risk	Mt. Jefferson: Walder, et al. (1999); Three Sisters: Scott, et al. (2001)

Source: Sherrod, et al. (1997); Walder, et al. (1999); Scott, et al. (2001)

Vulnerability

Table 2-629. Local Assessment of Vulnerability to Volcanic Hazards in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	H	HL	H	M	H	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-630. State Assessment of Vulnerability to Volcanic Hazards in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	L	M	VH	H	M	VL

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 6 (**Figure 2-266**). Over $72.3M in value is exposed to volcanic hazards in Region 3, all of it in Deschutes, Jefferson, and Klamath Counties.

Historic Resources

Of the 2,111 historic buildings in Region 6, 228 are exposed to volcanic hazards, all in Deschutes and Klamath Counties. In Deschutes County, one historic building is in a high hazard area and 202 are in a moderate hazard area. In Klamath County, 24 are in a high hazard area and one is in a moderate hazard area. See Appendix **9.1.12** for details.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6. Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households. Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median. Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters. Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment. Deschutes County has low social vulnerability.

According to the 2020 vulnerability scores, Jefferson County is the most vulnerable to volcanic hazards in Region 6 followed by Klamath and Deschutes Counties. Jefferson County's very high vulnerability score is driven somewhat by the presence of state buildings local critical facilities, but primarily by its social vulnerability. Klamath County's high score is driven solely by its social vulnerability, while Deschutes County's moderate score is driven solely by the presence of state buildings and state and local critical facilities.

Risk

Table 2-631. Assessment of Risk to Volcanic Hazards in Region 6

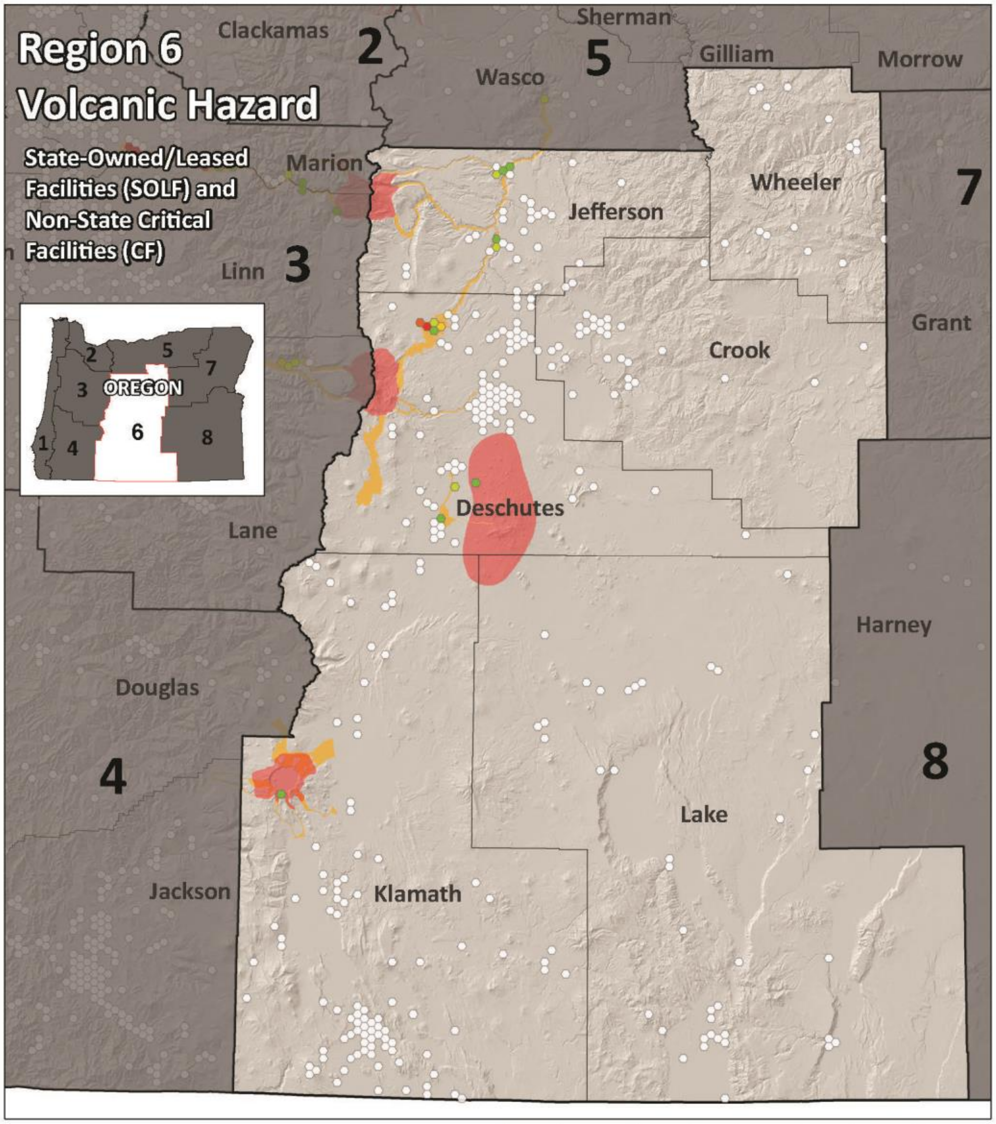
	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Risk	VL	M	VH	H	L	VL

Source: DOGAMI and DLCD, 2020

According to the 2020 risk scores, Jefferson and Klamath Counties in Region 6 are at the greatest risk of volcanic hazards in Region 6 with very high and high risk ratings respectively, while Deschutes County has a moderate risk rating. These communities should be prioritized for mitigation actions. Crook, Lake, and Wheeler Counties, in Region 6 have low or very low risk ratings.

The U.S. Geological Survey has addressed volcanic hazards at Mount Jefferson (Walder, Gardner, Conrey, Fisher, & Schilling, 1999), the Three Sisters (Scott, Iverson, Schilling, & Fisher, 2001), Newberry Volcano (Sherrod, Mastin, Scott, & Schilling, 1997), and Crater Lake (Bacon, Mastin, Scott, & Nathenson, 1997). These reports include maps depicting the areas at greatest risk. Communities which are closer to the main volcanoes such as Bend, Sisters, La Pine, and Klamath Falls are at the greatest risk for inundation by lava flows, pyroclastic flows, lahars, or ashfall. Counties on the eastern side of Region 6 may be subject to ashfall from Cascade volcanoes.

Figure 2-266. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Volcanic Hazard Zone in Region 6.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 6		Exposure ($) to Volcanic Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Crook	188,923,000	0	0%	0	0	0	0
Deschutes	1,179,009,000	3,812,000	4%	2,591,000	6,403,000	62,662,000	66,474,000
Jefferson	424,657,000	0	0%	2,489,000	2,489,000	5,378,000	5,378,000
Klamath	591,220,000	0	0%	0	0	524,000	524,000
Lake	216,919,000	0	0%	0	0	0	0
Wheeler	29,599,000	0	0%	0	0	0	0
Total	2,630,327,000	3,812,000	1%	5,080,000	8,892,000	68,564,000	72,376,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI

Wildfires

Characteristics

Region 6 has had significant growth of the wildland-urban interface. This growth seems to occur in areas dominated by juniper, sage, and grass. As populations increase, so do the number of wildland fires. Homes are widely dispersed in these pine-fringe areas, putting them at a greater risk of a high-intensity wildfire.

The hazard of wildland fire is high in Region 6 due to ladder fuels and overstocked ponderosa pine stands, juniper invasion into sagebrush and grasslands, and the pervasiveness of invasive weeds such as cheat grass and Medusahead grass. Fire risk is extreme during the late summer and fall months when grasses and weeds are dry. These flashy fuels are easily ignited, burn rapidly, and resist suppression. Many structures are at risk because owners do not follow Firewise guidelines for protection.

Historic Wildfire Events

Table 2-632. Significant Wildfires in Region 6

Year	Name of Fire	Location	Acres Burned	Remarks
1981	Redmond			State Conflagration Act Fire
1984	Crooked River Ranch			State Conflagration Act Fire
1985	Crooked River Ranch			State Conflagration Act Fire
1990	Delicious	Deschutes	1704	
1990	Awbrey Hall	Deschutes	3,400	this fire was an act of arson that affected the western fringe of Bend
1992	Hanes Butte	Deschutes	348	
1992	Sage Flat	Deschutes	995	
1992	Round Lake	Klamath	490	
1992	Lone Pine	Klamath	30,320	
1994	LaClair	Jefferson		
1995	Day Road	Deschutes		
1996	Little Cabin	Jefferson	2,438	
1996	Smith Rock	Deschutes	500	one structure destroyed
1996	Simnasho	Jefferson		
1996	Skeleton	Deschutes	17,700	19 structures destroyed, impacting the eastern fringe of Bend
1996	Ashwood/ Donnybrook	Central Oregon	118,000	this fire burned in areas of the state not protected from fire
1996	Wheeler Point	Wheeler	21,980	
1999	McCoin Road	Deschutes	99	Prineville
2002	Eyerly	Jefferson	23,573	37 structures destroyed
2002	Winter	Lake County	35,779	
2002	Cache Mountain	Deschutes	4,200	2 structures destroyed
2003	Booth	Crook	90,800 (acreage also includes BandB fire)	13 structures destroyed
2003	Davis	Deschutes	16,000	
2005		Jefferson		$333.33 in property damage *Damage estimate includes Sherman and Wasco Counties for a total of $1000 in damages
2007		Klamath		$100,000 in property damage
2007	GW	Deschutes	7,357	
2008	Summit Springs Complex	Deschutes	1,973	
2013	Sunnyside Turnoff	Jefferson	51,480	started by a firecracker that was thrown into vegetation; grew to 51,480 acres on the Warm Springs Indian Reservation.
2015	County Line 2	Jefferson	>67,000	

Source: Oregon Department of Forestry, 2020

Probability

Table 2-633. Assessment of Wildfire Probability in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	H	H	H	H	H	H

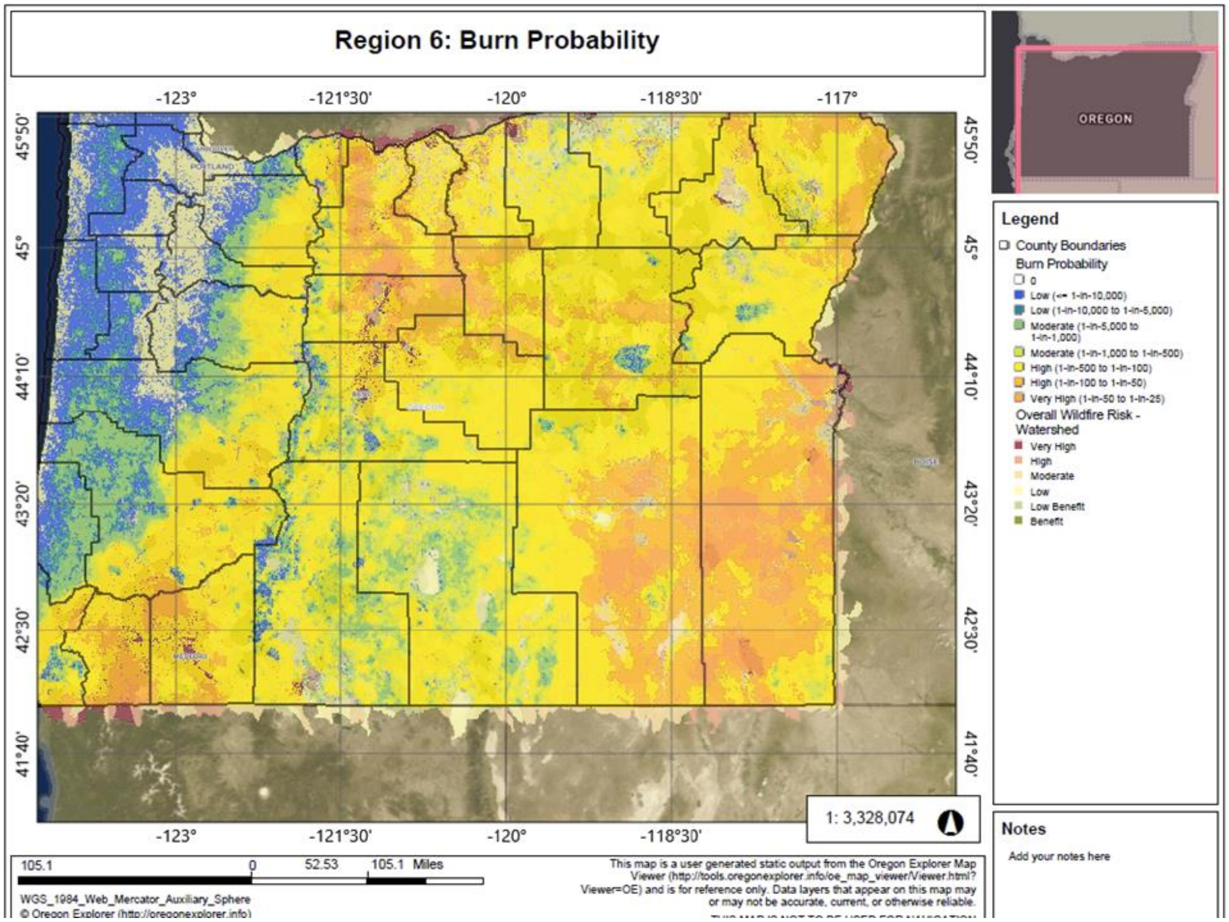
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to look at the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-267 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

Figure 2-267. Burn Probability



Source: Oregon Wildfire Risk Explorer, March 2020

The lightning potential in Region 6 is very high. For example, in Lake County only about 5% of the fires were human ignited, while 95% were lightning caused. There is very little that can be done in terms of ignition prevention from lightning.

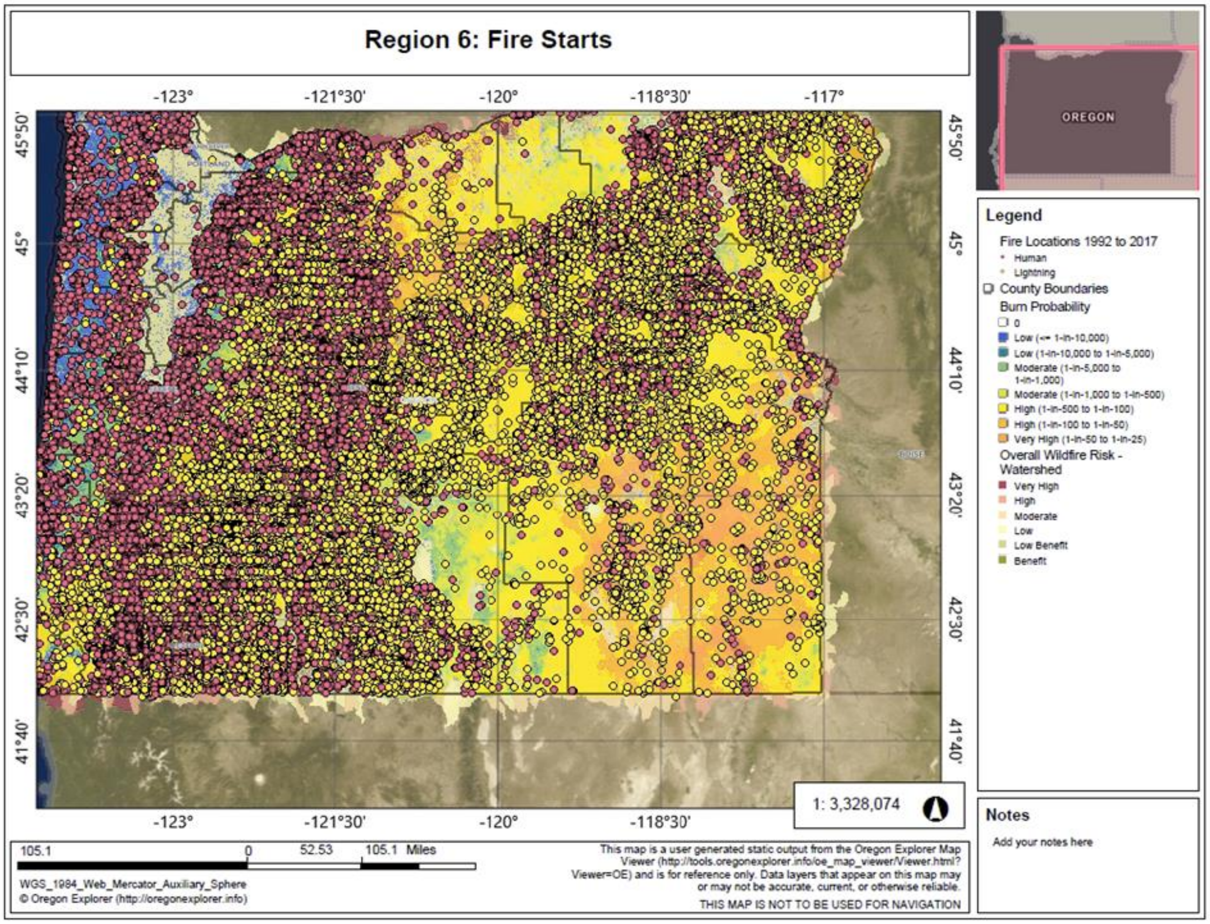
Due to many years of fire suppression, logging, and other human activities, the forests and rangelands of Region 6 have changed significantly. Areas that historically experienced frequent, low-severity wildfires now burn with much greater intensity due to the build-up of understory brush and trees. This region's fires are larger and more severe, killing the trees and vegetation at all levels. The combination of steep slope, canyons, open rangeland, and fuel type have a history and potential for fast-moving and fast-spreading wildfires. The area is highly vulnerable to wind-driven fires, whose embers could ignite grasses and weeds, and cause spot fires in more populated areas. Typical summer conditions could prove to be problematic due to a fire moving uphill from a structure fire on a lower slope, or from a wildland fire pushing upslope through the trees on a windy day, endangering multiple homes simultaneously in a very short period of time. Residents would have very short notice of an approaching fire.

Fire protection districts are created and staffed to deal with the fire emergency needs of the property within the district. Wildland fires that threaten multiple homes simultaneously can quickly overwhelm the available fire-fighting resources. The areas protected by these fire districts are typically large, with few stations, which causes longer response time for additional fire forces. This could prove to be a negative factor for early fire control. When a wildland fire is threatening structures, additional resources are ordered, but may be several hours away. A wildland fire can easily travel into and through a wildland-urban interface (WUI) community before additional responding resources can arrive. There simply are not enough fire engines to protect all threatened homes. Ultimately, the homes that are less vulnerable to ignition are most likely to survive. A home that is extremely vulnerable may not be able to be protected regardless of protection resources on the scene. Under dry, windy conditions, an advanced house fire could extend within the area, or a rapidly approaching wildland fire could have the potential to overwhelm local firefighters before additional outside resources could arrive.

In more populated areas like Klamath County, historic wildfire occurrence shows that most of the large and damaging wildfires that threatened communities or other improvements were caused by humans.

Recreation is a main attraction for people currently living in and moving to Central Oregon. There are popular recreation destinations for hunting, fishing, camping and water sports, such as Lake Billy Chinook, the Middle Deschutes River, Lake of the Woods, Crescent, Odele, Crater Lake, and Haystack Reservoir. This area swells with visitors on any given weekend in the summer during fire season. Most fires are concentrated near recreation areas and reservoirs. Concerns in this region not only include potential evacuation in the event of an emergency, but also the potential for recreationists to inadvertently start wildfires through improper campfire use, smoking, or use of all-terrain vehicles.

Figure 2-268. Human- and Lightning-Caused Wildfires in Region 6, 1992-2017



Source: Oregon Wildfire Risk Explorer, March 2020

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

In ignition-limited forest systems, found on the east side and southern portions of the state, a long history of fire suppression has resulted in high fuel loads and, forests that have closer canopies and experience greater water competition. These forests experience long, dry fire seasons and are frequently at high fire danger and have a very high potential to burn if exposed to an ignition source. Winter warming will lead to more fine fuels due to greater growth during the cold season; hotter and drier conditions combined with a suppression management regime will lead to large quantity of fuel and closer canopies. Large and severe fires ("unsuppressable megafires") are a result of this large fire debt and climate change combined. Fuel-limited systems, such as those in eastern and southeastern Oregon, have non-contiguous fuels including sagebrush and bunchgrasses. As invasive annual grasses increase (e.g., Cheatgrass), fuels become contiguous since invasive grasses regrow quickly outcompeting other vegetation. Warming winters will lead to more fine fuels from greater cold season growth. Also, conditions conducive to conversion to invasive grasses can lead to frequent fires and conversion to invasive-dominated systems as climate changes, including reduction in habitat for sage grouse. It is likely (>66%) that Region 6 will experience increasing wildfire frequency and intensity under future climate change.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 6 counties (**Table 2-634**).

Table 2-634. Projected Increase in Annual Very High Fire Danger Days in Region 6 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Crook	14	39%
Deschutes	14	37%
Jefferson	14	38%
Klamath	13	36%
Lake	14	38%
Wheeler	14	39%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-635. Local Assessment of Vulnerability to Wildfire in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	HL	H	H	H	H

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-636. Assessment of Vulnerability to Wildfire in Region 6 – Communities at Risk

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	H	H	VH	M	M	H

Source: ODF Communities at Risk Report, 2020

Table 2-637. Assessment of Vulnerability to Wildfire in Region 6 – 2020 Vulnerability Assessment

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	H	L	VH	VH	H	H

Source: DOGAMI and DLCD, 2020

According to ODF's assessment of Communities at Risk, Jefferson, Wheeler, Crook and Deschutes have highest vulnerabilities subject to Fire Risk, Wildland Development Areas, Fire Effects, and Fire Threat.

In addition, each year a significant number of people build homes within or on the edge of the forest (urban-wildland interface area), thereby increasing vulnerability. These communities have been designated "Wildland-Urban Interface Communities" and are shown in **Table 2-638**.

The checkerboard pattern of land ownership in Region 6 means that many residences are dispersed on small, scattered private parcels of land. Narrow roads, dead end roads, and long steep driveways are prevalent. Access and egress could be cumbersome with evacuees and fire forces operating in the area at the same time. Evacuation and fire suppression could be problematic due to bottle necking.

Many people choose to live in Central Oregon for its cultural interest and historic values, creating an imperative to protect key homestead, Native American, and other historic sites.

The northwest corner of Region 6 belongs to the Confederated Tribes of the Warm Springs Reservation. The Warm Springs community is an historic community with heavy home densities and infrastructure, and is protected by a structural fire department. Homes are all distributed within Trust and restricted title lands of the Confederated Tribes of Warm Springs.

Economic values at risk include businesses, private forests, farmland, ranchland, grazing land, hunting, and other recreational land. Wildfires have the potential to change the vegetative landscape, which would have a significant effect on the natural resource industries that are the economic staple of this region. Critical infrastructure (communication sites, electrical transmission lines and substations, gas lines, water sources, highways, bridges, and railroad lines) are also vulnerable to wildfires and could be out of service for extended periods of time. Many of the communities that depend on this infrastructure are very remote and could be very adversely impacted while it is out of service.

There are extensive areas of private land within the county that receive no wildland or structural fire protection. Rural areas have general issues including the absence of formal fire protection and extended response times, dense vegetation capable of causing flame lengths greater than four feet, insufficient water supply, insufficient ingress/egress, and combustible structures.

Table 2-638. Wildland-Urban Interface Communities by County in Region 6

Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Allen Creek	Alfalfa	Ashwood	Beaty	Adel	Camp Hancock
Jasper Canyon	Bend	Camp Sherman	Beaver Marsh	Christmas Valley	Fossil
Paulina	Black Butte	Crooked River Ranch	Bly	Drew's Gap	Kinzua Golf Course
Post	Brothers	Culver	Bly Mountain	Drews Reservoir	Mitchell
Prineville	Elk Lake	Grandview	Bonanza	Lakeview	Richmond
	Greater La Pine	Juniper Butte	Chemult	New Pine Creek	Spray
	Green	Madras	Chiloquin	Paisley	Twickenham
	Hampton	Metolius	Crater Lake National Park	Plush	Winlock
	La Pine	Montgomery Shores	Crescent	Silver Lake	
	Redmond	Round Butte	Dairy	Summer Lake	
	Sisters	Trout Creek	Diamond Lake Junction	South Drews	
	Sunriver	Upper Metolius	Gilchrist	Valley Falls/ Chandler	
	Terrebonne	Warm Springs	Harriman		
	Tumalo		Illinois Valley		
	Upper Deschutes River		Keno		
			Klamath Falls		
			Lake of the Woods		
			Little River		
			Malin		
			Merrill		
			Meadows		
			Odell Lake		
			Powers		
			Rocky Point		
			Rosedale		
			Running Y		
			Sand Creek		
			Seven Basins		
			Spraque River Valley		
			Sycan Estates		
			Walker Range		

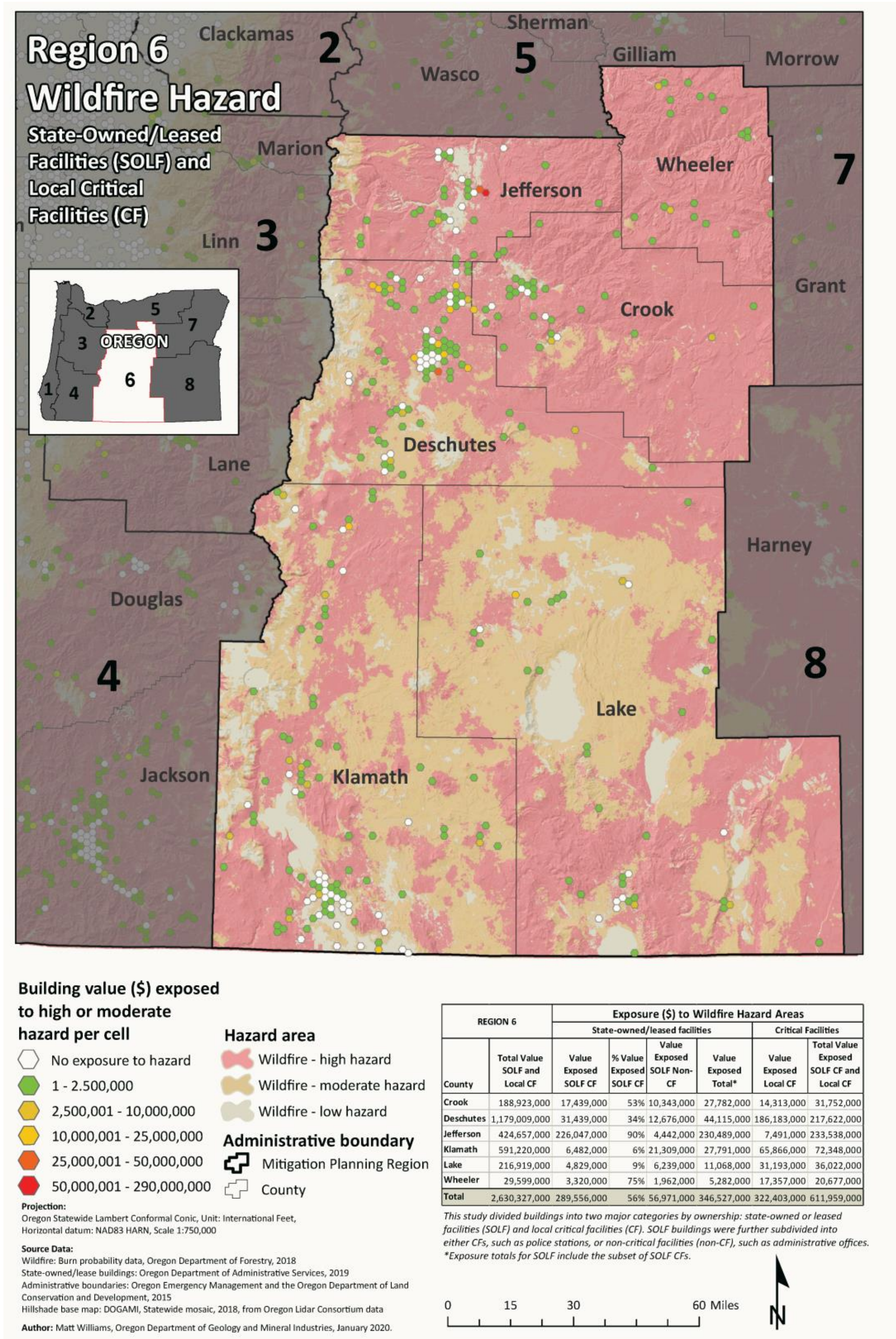
Source: ODF Communities at Risk Report, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in “High,” “Moderate,” and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as “Low.”

In Region 6, there is a potential loss to wildfire of almost $346.5M in state building and critical facility assets, 67% of it in Jefferson County alone. Deschutes County contains the next greatest value of state building and critical facility assets at 13%, followed by Crook and Klamath Counties, each with 8%, then Lake and Wheeler Counties. There is a similar potential loss in local critical facilities: about $322M. Fifty-eight percent is located in Deschutes County, 20% in Klamath County, and 10% in Lake County.

Figure 2-269. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 6.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 6		Exposure ($) to Wildfire Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Crook	188,923,000	17,439,000	53%	10,343,000	27,782,000	14,313,000	31,752,000
Deschutes	1,179,009,000	31,439,000	34%	12,676,000	44,115,000	186,183,000	217,622,000
Jefferson	424,657,000	226,047,000	90%	4,442,000	230,489,000	7,491,000	233,538,000
Klamath	591,220,000	6,482,000	6%	21,309,000	27,791,000	65,866,000	72,348,000
Lake	216,919,000	4,829,000	9%	6,239,000	11,068,000	31,193,000	36,022,000
Wheeler	29,599,000	3,320,000	75%	1,962,000	5,282,000	17,357,000	20,677,000
Total	2,630,327,000	289,556,000	56%	56,971,000	346,527,000	322,403,000	611,959,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 2,111 historic resources in Region 6, one hundred forty-two (7%) are located in an area of high wildfire hazard. Of those, 65% are located in Deschutes and Crook Counties. Of the 153 (8%) located in a moderate wildfire hazard area, 67% are located in Deschutes County. Sixty-five percent of the historic resources located in low wildfire hazard areas in Region 6 are also in Deschutes County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau’s American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6.

Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households. Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median.

Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters.

Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment.

Deschutes County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Jefferson and Klamath Counties’ vulnerability to wildfire is very high; Crook, Lake, and Wheeler Counties’ is high. This assessment is consistent with the Communities at Risk assessment for Crook, Jefferson, and Wheeler Counties, but not for Deschutes, Klamath, or Lake Counties. This is indicative of the different criteria used for these assessments.

All the counties in Region 6 are highly vulnerable to wildfire. Jefferson County is most vulnerable, followed by Klamath, Crook, Wheeler, Lake, and Deschutes Counties.

Risk

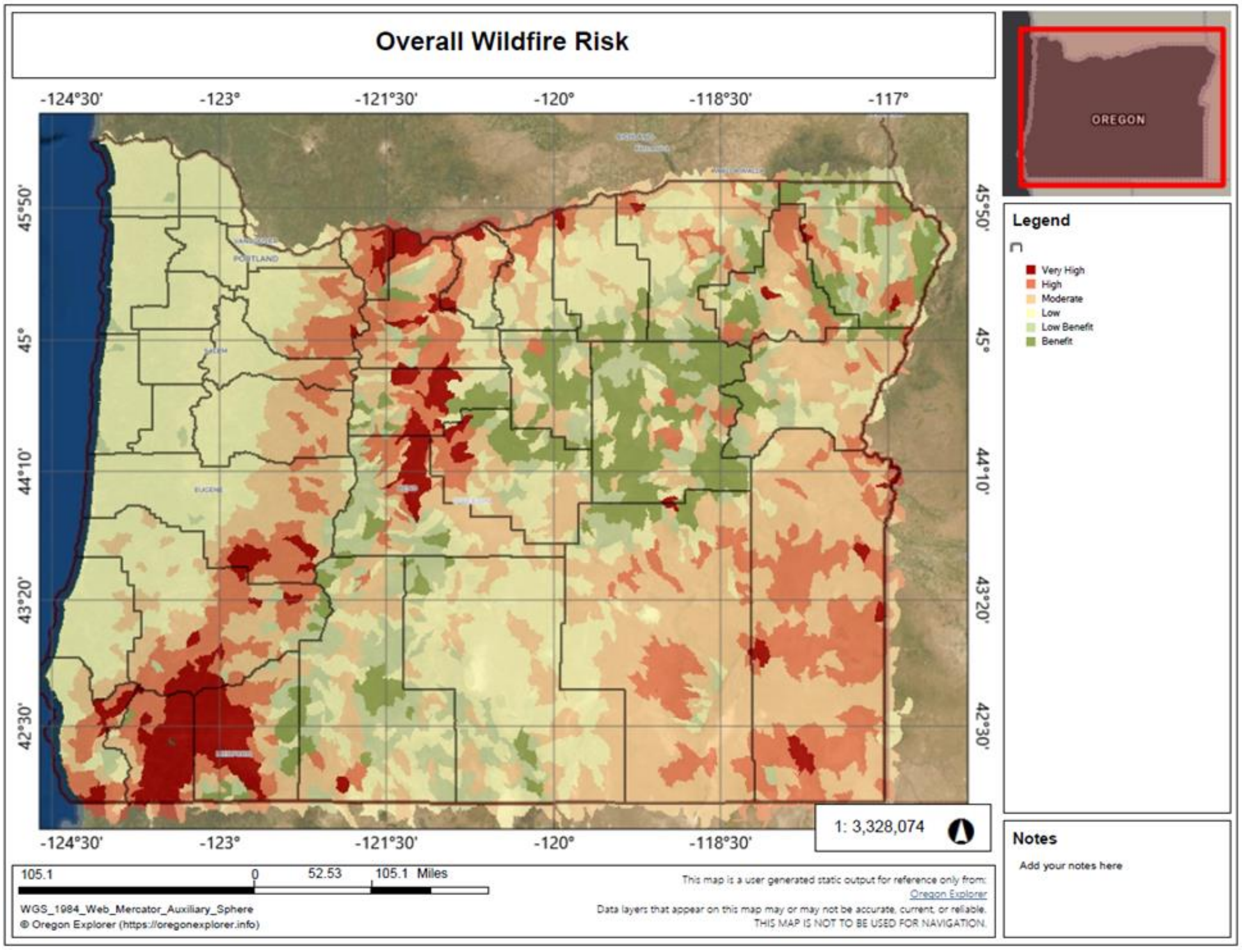
Table 2-639. Risk of Wildfire Hazards in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	VH	M	VH	VH	H	VH

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Crook, Jefferson, Klamath, and Wheeler Counties are at very high risk from wildfire, Lake County is at high risk, and Deschutes at moderate risk. This is only partially consistent with ODF's assessment, mapped in **Figure 2-270**. The map shows Jefferson, Deschutes, and about two-thirds of Crook Counties at very high risk, and portions of Wheeler, Klamath and Lake Counties at high risk. This is indicative of the different criteria used for these assessments and that the 2020 risk assessment is not granular enough to account for geographic differences in probability, vulnerability, or risk within a county.

Figure 2-270. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

High winds in inter-mountain areas in Central Oregon are not uncommon. For example, stiff winds from the Ochoco Mountains often occur in the City of Prineville (Crook County). These areas experience thunderstorms, which are sometimes accompanied by strong outflow and surface winds. Fallen trees and structural damage from windstorms are not uncommon in these areas. The prominent Cascade Range can act as a buffer to strong storms that mostly affect western Oregon. However, the interior counties in this region may experience strong down sloping winds off the lee side of the mountains.

Historic Windstorm Events

Table 2-640. Historic Windstorms in Region 6

Date	Affected Area	Characteristics
Apr. 1931	N. central Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; wind speed 40-60 mph; gusts 75–80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 75-mph gusts; damage to buildings and utility lines
Dec. 1955	statewide	wind speeds 55–65 mph with 69-mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71-mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon’s most destructive storm to date; 116 mph winds in Willamette Valley; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Nov. 1981	statewide	severe wind storm
Dec. 1991	N. central Oregon	severe wind storm; blowing dust; damage reported in Bend (Deschutes County)
Dec. 1995	statewide	severe wind storm
Apr. 2003	Deschutes County	$10,000 in property damage
Aug. 2003	Wheeler County	$1,000
Nov. 2003	Deschutes County	$2,000 in property damage
Jan. 2004	Jefferson County	$3,000 in property damage
June 2004	Crook and Jefferson Counties	$1,000 in property damage
Aug. 2004	Crook Count	$100 in property damage
Dec. 2004	Jefferson County	$3,333.33 in property damage *damage estimate includes Sherman and Wasco Counties
Mar. 2005	Jefferson County	$2,000 in property damage *damage estimate includes Sherman and Wasco Counties
Mar. 2005	Crook, Deschutes Counties	$9,000 in property damage
Aug.2005	Klamath County	hail storm caused $1,000 in damage
Oct. 2005	Crook and Deschutes Counties	$50,000 in property damage

Date	Affected Area	Characteristics
Nov. 2005	Crook and Deschutes Counties	$40,000 in property damage
June 2006	Jefferson, Deschutes and Crook Counties	strong winds and hail caused $10,000 in damages to grass and alfalfa crops in Jefferson County, $7 million in insurance claims for damage to automobiles and homes in Deschutes County, $20 million in insurance claims for damage to automobiles and homes in Crook County
July 2006	Deschutes County	lightning from a severe storm hit an electrical transmission line, knocking out power to 31,500 people
Aug. 2006	Klamath County	severe windstorm with winds up to 66 mph downed several trees and power lines between Klamath Falls and Chiloquin
July 2007	Klamath County	extensive wind, rain, and hail damage to Malin and Yonna Valleys, and several power lines downed due to falling trees
Oct. 2007	Crook and Deschutes Counties	$1000 in total damage from high wind storm
Oct. 2007	Crook and Deschutes Counties	$50,000 in total damage from high wind storm
Aug. 2009	Jefferson County	high winds broke boat docks off the shore at Pelton Park Reservoir; $50,000 in total damages
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides

Sources: Taylor and Hatton (1999); FEMA-1405-DR-OR, February 7, 2002, Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon; Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; U.S. Department of Commerce. National Climatic Data Center. Available from http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms; https://www.fema.gov/disaster/

Table 2-641. Tornadoes Recorded in Region 6

County	Date	Location	Damage
Lake	Dec. 1973	County	no reported damage
Lake	Aug. 2005	Christmas Valley, OR	no reported damage
Klamath	Apr. 2007	Keno	no reported damage
Wheeler	Jun. 2016	Waterman	no reported damage
Deschutes	Apr. 2017	Bend	no reported damage
Klamath	May 2019	Sprague River	no reported damage

Source: Taylor and Hatton (1999); https://www.ncdc.noaa.gov/stormevents/

Probability

Table 2-642. Assessment of Windstorm Probability in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	H	H	—	—	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

In this region, a 100-year event is considered to have one-minute average winds of 90 mph. A 50-year event has average winds of 80 mph. A 25-year event has average winds 70 mph.

Based on the historic windstorm events and tornadoes in Table 2-640 and Table 2-641, Jefferson and Klamath Counties are considered to have roughly the same probability of windstorm events as the other counties in Region 6.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-643. Local Assessment of Vulnerability to Windstorms in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	M	L	—	H	M

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-644. State Assessment of Vulnerability to Windstorms in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	L	—	—	M	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Many buildings, utilities, and transportation systems within Region 6 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome. They can block roads and rails for long periods of time, impacting emergency operations. In addition, uprooted or shattered trees can down power or utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed by uprooted trees felled by high winds. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establish a tree maintenance and removal program.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6.

Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households.

Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median. Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters.

Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment. Deschutes County has low social vulnerability.

Based on the information about historic windstorm events and tornadoes listed in in **Table 2-640** and **Table 2-641**, Jefferson County is considered to have moderate vulnerability to windstorms and Klamath County is considered to have low vulnerability. While these two counties are the most socially vulnerable overall in Region 6, Wheeler County's very high percentages of senior residents and residents with a disability increase its vulnerability. Crook, Jefferson, Klamath, Lake, and Wheeler are considered the counties most vulnerable to windstorms in Region 6.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 6 is approximately $616,270,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $2,014,056,000. Because windstorms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 6 since the beginning of 2015. Eight losses were due to windstorms statewide. Of those, it is possible that one or two may have been located in Region 6. One claim was for approximately $6,200 and the other has not been settled.

Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

With similar vulnerability to damages from windstorms but greater social vulnerabilities, Jefferson, Klamath, and Wheeler Counties are at the greatest risk from windstorms in Region 6.

Winter Storms

Characteristics

Severe winter weather in Region 6 can be characterized by extreme cold, snow, ice, and sleet. While there are annual winter storm events in Region 6 with an average of 24 inches of snow annually, most communities are prepared for them. Severe winter storms are considered to be unusual. Light to moderate snowfall is prepared for and expected on an annual basis in this central region. Heavier snowfall is expected and planned for in the areas on the west side of the region into the Cascades as elevation increases.

Historic Winter Storm Events

Table 2-645. Significant Winter Storms in Region 6

Date	Location	Remarks
Dec. 1861	entire state	storm produced 1–3 feet of snow
Dec. 1892	northern counties, Oregon	15–30 inches of snow fell throughout the northern counties
Jan. 1916	entire state	two storms; heavy snowfall, especially in mountain areas
Jan. and Feb. 1937	entire state	deep snow drifts
Jan. 1950	entire state	record snowfalls; property damage throughout state
Mar. 1960	entire state	many automobile accidents; two fatalities
Jan. 1969	entire state	heavy snow throughout state
Jan. 1980	entire state	series of string storms across state; many injuries and power outages
Feb. 1985	entire state	2 feet of snow in northeast mountains; downed power lines; fatalities
Feb. 1986	central/eastern Oregon	heavy snow in Deschutes Basin; traffic accidents; broken power lines
Mar. 1988	entire state	strong winds; heavy snow
Feb. 1990	entire state	heavy snow throughout state
Nov. 1993	Cascade Mountains, Oregon	heavy snow throughout region
Mar. 1994	Cascade Mountains, Oregon	heavy snow throughout region
Winter 1998-99	entire state	one of the snowiest winters in Oregon history (snowfall at Crater Lake: 586 inches)
Dec. 2003–Jan. 2004	entire state	the most significant winter storm in several years brought snowfall to most of Oregon in late December 2003; according to the state climatologist, a combination of cold air near the surface and overrunning moist air from a Pacific weather system was responsible for the storm
Mar. 8–10, 2006	Jefferson County	snow fell up to 2–4 feet in the Coast Range, Cascades, and Cascade Foothills; many school closures
Jan. 2–Feb. 9, 2008	Jefferson, Deschutes, and Crook Counties in Region 6	heavy snow and freezing rain across eastern Oregon

Date	Location	Remarks
Dec. 6-23, 2015	Statewide storm events	Several pacific storm systems moved across the region over the Dec 12-13 weekend. Each storm system brought several inches of snow to the mountain areas. Snowfall amounts in inches include: 21.0 10 miles west of La Pine, 14.0 at Tollgate, Another in a long series of storms brought heavy snow to portions of south central Oregon. The cooperative observer at Chemult reported 17 inches of snow in 24 hours ending Dec. 17th. Snowfall amounts are as followed: 14" recorded at the Milk Shakes Snotel and 10" in 24 hours 5 miles north northwest of La Pine. Also on the 21st a series of storms made for a long lasting winter storm over southwest and south central Oregon. At first the snow was limited to higher elevations...but lowered with time to some of the west side valley floors.
Feb. 8-9, 2017	Wheeler, Jefferson, and Crook Counties (Eastern Cascades, Central Oregon)	A strong Pacific storm system brought snow, sleet and freezing rain to many areas of the Interior Northwest February 7th through 9th.
Feb. 22-26, 2019	Deschutes, Jefferson, Wheeler, Crook, (Eastern Cascades)	Persistent troughing off the coast of the Pacific Northwest focused a stream of mid-level moisture over the Inland Northwest resulting in a long duration snow event as the plume drifted north and south several times between the 22nd and 27th of February. Snowfall rates were greatly enhanced over central Oregon with the proximity of a nearly stationary surface boundary where snowfall rates were in excess of 1 inch per hour. Storm total snowfall amounts were measured at: 40 inches in Sisters, 33 inches in Bend, 30 inches in Redmond, 22 inches in Prineville.

Source: Taylor and Hatton (1999); and unknown sources; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Probability

Table 2-646. Assessment of Winter Storms Probability in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	M	H	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Winter storms occur annually in Region 6. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-647. Local Assessment of Vulnerability to Winter Storms in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	H	H	M	H	H

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-648. State Assessment of Vulnerability to Winter Storms in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	H	H	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Region 6 communities are known for cold, snowy winters. This is advantageous in at least one respect: in general, the region is prepared, and those visiting the region during the winter usually come prepared. However, there are occasions when preparation cannot meet the challenge. Drifting, blowing snow has often brought highway traffic to a standstill. Also, windy, icy conditions have often closed mountain passes and canyons to certain classes of truck traffic. In these situations, travelers must seek accommodations, sometimes in communities where lodging is very limited. For local residents, heating, food, and the care of livestock and other farm animals are everyday concerns. Access to farms and ranches can be extremely difficult and present a serious challenge to local emergency managers.

Winter storms, particularly east of the Cascades where snow storms are typically more intense, bring larger amounts of snow and last longer. They can strand livestock in pastures, leaving them without food and water and exposed to extreme cold for long periods of time. As a consequence, substantial losses in livestock from starvation, dehydration and freezing, significantly impact producers, and state and local economies. In addition, water quality and health hazards develop when dead livestock are not retrieved until roads are cleared and vehicles can be used to remove the carcasses. Livestock buried under snow may not be found until the snow melts. The snowmelt may carry the carcasses to streams and wash them downstream.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Klamath and Jefferson Counties are highly socially vulnerable and are the most vulnerable in Region 6. Jefferson County has the highest share of minority residents in the state. The county is also in the 90th percentile for unemployment and its percentage of single-parent households. Klamath County ranks in the top half of counties for 13 of the 15 index variables—only the share of multi-unit housing structures and the percentage of persons living in institutionalized group quarters fall below the median.

Lake County is also highly socially vulnerable, ranking in the 90th percentile for its share of residents with a disability, percentage of manufactured homes, low per-capita income, and share of persons living in group quarters.

Crook and Wheeler Counties have low overall vulnerability but score highly in a few categories. Wheeler County has the highest percentage of residents aged 65 or older in the state and is in the 90th percentile for its poverty rate and share of residents with a disability. Crook County is in the top 10 percent of counties for unemployment. Deschutes County has low social vulnerability.

Klamath and Jefferson Counties are among the most socially vulnerable in Oregon. Lake and Wheeler Counties' social vulnerabilities render them highly vulnerable to the adverse effects of winter storms as well. Klamath, Jefferson, Lake, and Wheeler Counties are the most vulnerable to winter storms in Region 6.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 6 is approximately $616,270,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $2,014,056,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 6 since the beginning of 2015. Thirteen losses were due to winter storms statewide. Of those, it is possible that up to four may have been located in Region 6. These claims totaled a little over $72,000.

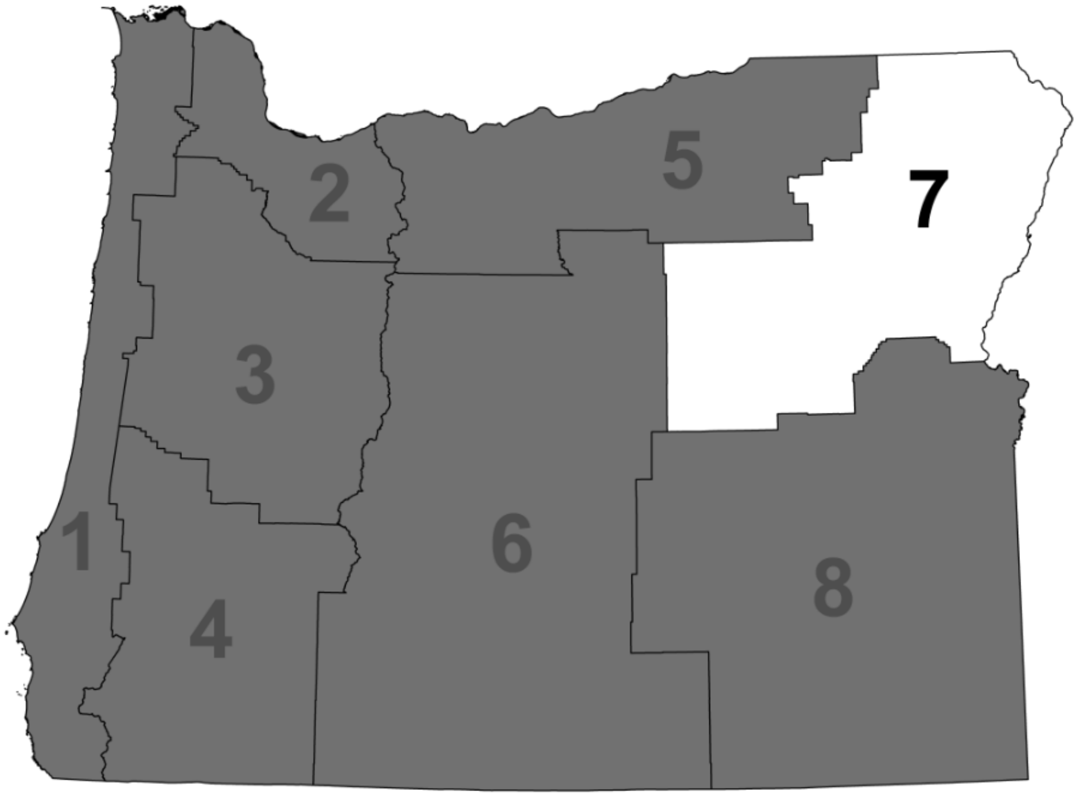
Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

All Region 6 counties are at risk from winter storms. Klamath, Jefferson, Lake, and Wheeler Counties are at greater risk than Crook and Deschutes Counties.

2.3.7 Region 7: Northeast Oregon

Baker, Grant, Wallowa, and Union Counties



2.3.7.1 Summary

Profile

The region's demographic, economic, infrastructure, and development patterns indicate that some populations, structures and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

Social vulnerability in Region 7 is driven by a declining population; high numbers of senior citizens, many of whom have disabilities; low rates of college degrees; child poverty; and low median household incomes. Additional vulnerabilities at the county level include high numbers of children in Baker and Wallowa Counties and vacant homes in Grant and Wallowa Counties.

Although Region 7 had been recovering jobs lost during the Great Recession, the financial effects of the 2020 pandemic continue to affect the region combined with the fact that the area lags behind the state overall with fewer jobs and lower wages. Unemployment remains greater than statewide. Compared to statewide numbers, the region has a higher share of its households earning less than $35,000 per year. Roads and railways are susceptible to winter storms and flooding. Damage or service interruption to the region's transportation systems can have devastating effects on the region's economy. In this region, 6% of bridges are distressed and/or deficient.

Older centralized water infrastructure is vulnerable to pollution and flooding, which can have implications for human health and water quality. Drinking water is sourced from surface water or wells and is susceptible to pollution from stormwater runoff and combined sewer overflows (CSO) during high-water events. Only Baker City employs low impact development (LID) standards in its building regulations.

Northeast Oregon's energy facilities and conveyance system infrastructure support the regional economy and are susceptible to damage and disruptions due to natural hazards. The region has five power-generating facilities (hydroelectric, wind, and biomass). Liquid natural gas pipelines run through Union and Baker Counties. However, diversity of the region's energy sources boosts its ability to provide power should service be disrupted.

The region's limited growth is occurring within Union County and some other areas along I-84. A high share of manufactured homes and homes built before floodplain management and seismic building standards coupled with the lack of modernized Flood Insurance Rate Maps (FIRMs) increase the vulnerability of development in Region 7. Updated lidar is anticipated for Grant County during 2020.

Hazards and Vulnerability

Region 7 is affected by nine of the 11 natural hazards that affect Oregon communities. Coastal hazards and tsunamis do not directly impact this region.

Droughts: Droughts are common in all Northeast Oregon counties, particularly within Baker and Grant Counties. Drought conditions can result in limited water supplies, losses in agriculture, increased fire risk, and adverse impacts to tourism and therefore to the local economy. Region 7 has been under an emergency drought declaration ten times. Baker County is considered one of the counties most vulnerable to drought conditions.

Earthquakes: Two types of earthquakes affect Region 7: (a) shallow crustal events and (b) earthquakes associated with volcanic activity. Northeast Oregon is considered moderately vulnerable to earthquake hazards due to earthquake-induced landslides, liquefaction, and ground shaking. The region's seismic lifelines have low vulnerability to a Cascadia Subduction Zone (CSZ) event as most of the region's impact will be secondary, due to disruptions to markets to the west. In Region 7, a 2500-year probabilistic earthquake scenario could generate a potential loss of over $5M in state building and critical facility assets. Baker and Union Counties each contain about 40% percent of the value of those assets. The potential loss in local critical facilities is more than triple that amount, over $16.7M. Baker County would suffer the greatest loss with 54% of the value of local critical facilities.

Extreme Heat: Extreme temperatures are moderately common in Region 7 and the frequency of prolonged periods of high temperatures has increased. Wallowa County has an average of about 23 days per year above 90°F. As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. Also like drought, impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. The value of state-owned and leased buildings and critical facilities in Region 7 is approximately $186,973,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $751,328,000.

Floods: In this region, the most damaging floods have been rain-on-snow events in the mountains during the winter. Other forms of flooding here have been associated with ice jams, normal spring runoff, and summer thunderstorms. Flooding has also been associated with heavily vegetated stream banks, low stream gradients, breeched dikes, low bridge clearances, over-topped irrigation ditches, and natural stream constrictions. All of the region's counties are considered moderately vulnerable to the flood hazard. In Region 7, there is a potential loss from flooding of almost $20M in state building and critical facility assets, 73% of it in Grant County alone. There is a potential loss due to flood of almost twice that much, about $34M, in local critical facilities. Eighty-one percent of that value is in Grant County.

Landslides: Landslides can occur throughout the region, though to a lesser extent than in parts of western Oregon. In general, areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. Rain-induced landslides can occur during winter months. Earthquakes can also trigger landslides. The Blue and Wallowa Mountains have a moderate to high incidence of landslides. Landslides can also sever transportation routes along highways and rail lines, which can impact the region's economy. DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 7. Almost $1M in value is exposed to landslide hazards in Region 7, most of it in Baker County followed by Union County. However, the region has local critical facility assets of over $12M at risk of loss to landslides, about two-thirds of it in Grant County and about a quarter of it in Union County. Baker County has none.

Volcanoes: Though volcanic activity does not occur within this region, ashfall can travel many miles and may affect the region. Communities potentially vulnerable to ashfall are Baker City, La Grande, and John Day. There are no state-owned/leased facilities located in a volcanic hazard zone. Similarly, there are no non-state-owned/leased critical/essential facilities located in this hazard zone.

Wildfires: Though population and development has declined in this region overall, development has increased in this region's non-federal forests and may impact fire protection capability. Summertime lightning-caused fires are prevalent in the mountainous and timbered regions of eastern Oregon. Wildfire in this region can adversely impact timber and rangeland, recreation and tourism, wildlife habitat and diversity including endangered species, and water quality and supply. Vulnerability is further heightened where fire stations are located far distances from many communities, resulting in longer response times. Based on data from the 2013 West Wide Wildfire Risk Assessment, in Region 7, Grant and Union Counties have high percentages of wildland acres subject to Fire Risk, Fire Effects, and Fire Threat, making them especially vulnerable. Other areas of vulnerability are within wildland-urban interface communities. In Region 7, there is a potential loss to wildfire of about $52M in state building and critical facility assets, around a third of it in each of Union and Grant Counties, and around 20% of it in each of Baker and Wallowa Counties. There is a greater potential loss in local critical facilities: about $75.6M. Grant County contains the most (43%) followed by Baker County with 30%, Union County with 16% and Wallow County with 11%.

Windstorms: Inter-mountain valley regions of Northeast Oregon are known for high winds. Windstorms generally affect the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland. The value of state-owned and leased buildings and critical facilities in Region 7 is approximately $186,973,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $751,328,000.

Winter Storms: Winter storms bring colder weather and higher precipitation to this region annually. These storms average 24 inches of snow per year. Moderate to heavy snowfall is prepared for and expected. Heavier snowfall is expected and planned for in higher elevation of the Wallowa Mountains. The value of state-owned and leased buildings and critical facilities in Region 7 is approximately $186,973,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $751,328,000.

Climate Change

The hazards faced by Region 7 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon. Coupled with projected decreases in mountain snowpack due to warmer winter temperatures, Region 7 is expected to be affected by an increased incidence of drought and wildfire. In Region 7, climate change would result in increased frequency of drought due to low spring snowpack (*very likely*, >90%), low summer runoff (*likely*, >66%), and low summer precipitation and low summer soil moisture (*more likely than not*, >50%). It is *very likely* (>90%) that Region 7 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*).

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 7, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section 2.2.1.2, **Introduction to Climate Change**.

2.3.7.2 Profile

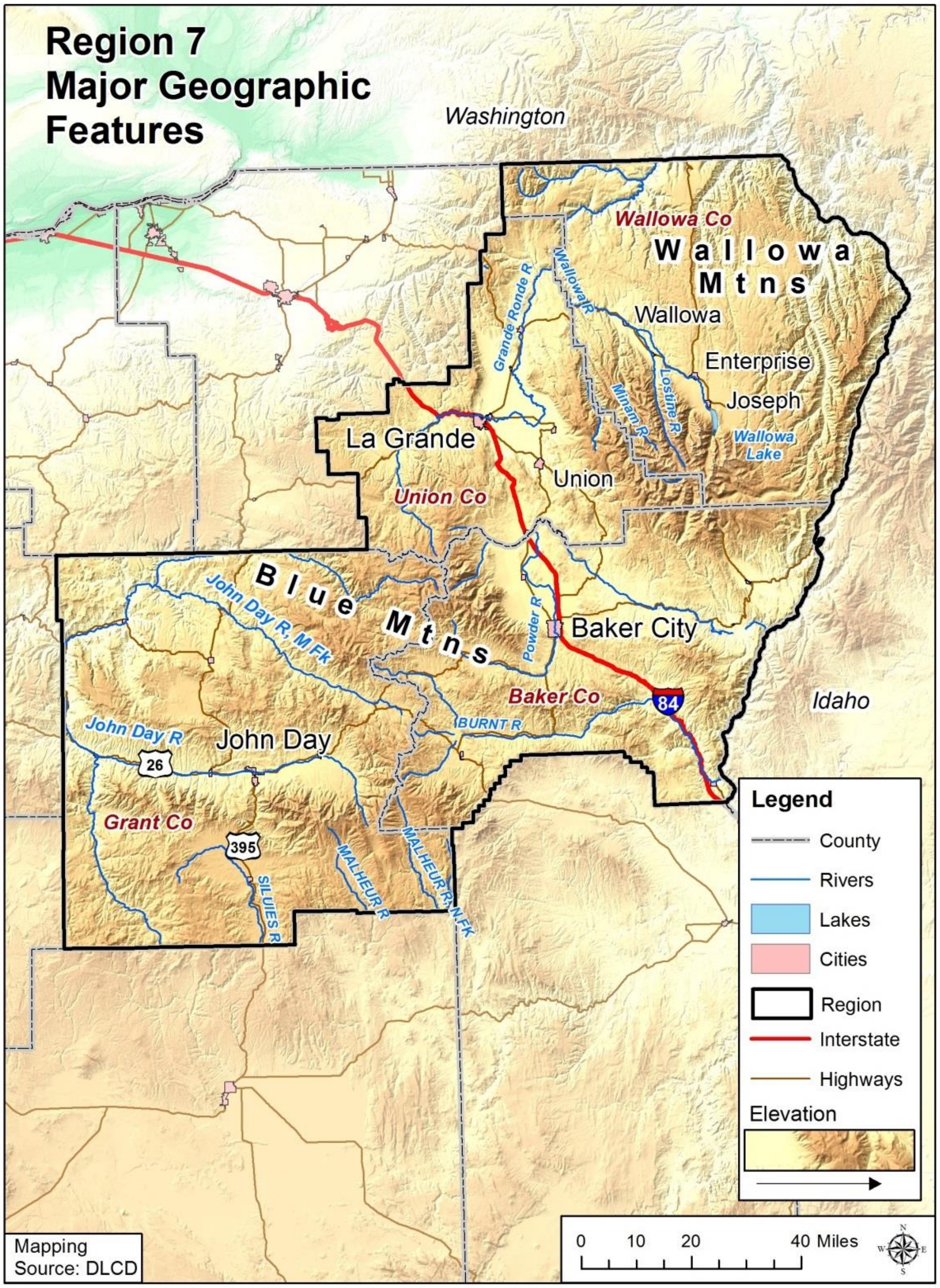
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

Northeastern Oregon is approximately 12,765 square miles in size, and includes Baker, Grant, Union, and Wallowa Counties. The region is bordered by the Snake River to the east and the Columbia River to the north. Columbia River Basalt lava flows formed the high plateaus of the region, and the Blue and Wallowa Mountains are included in the region. Major rivers in the region include the John Day, Grande Ronde, and the Snake.

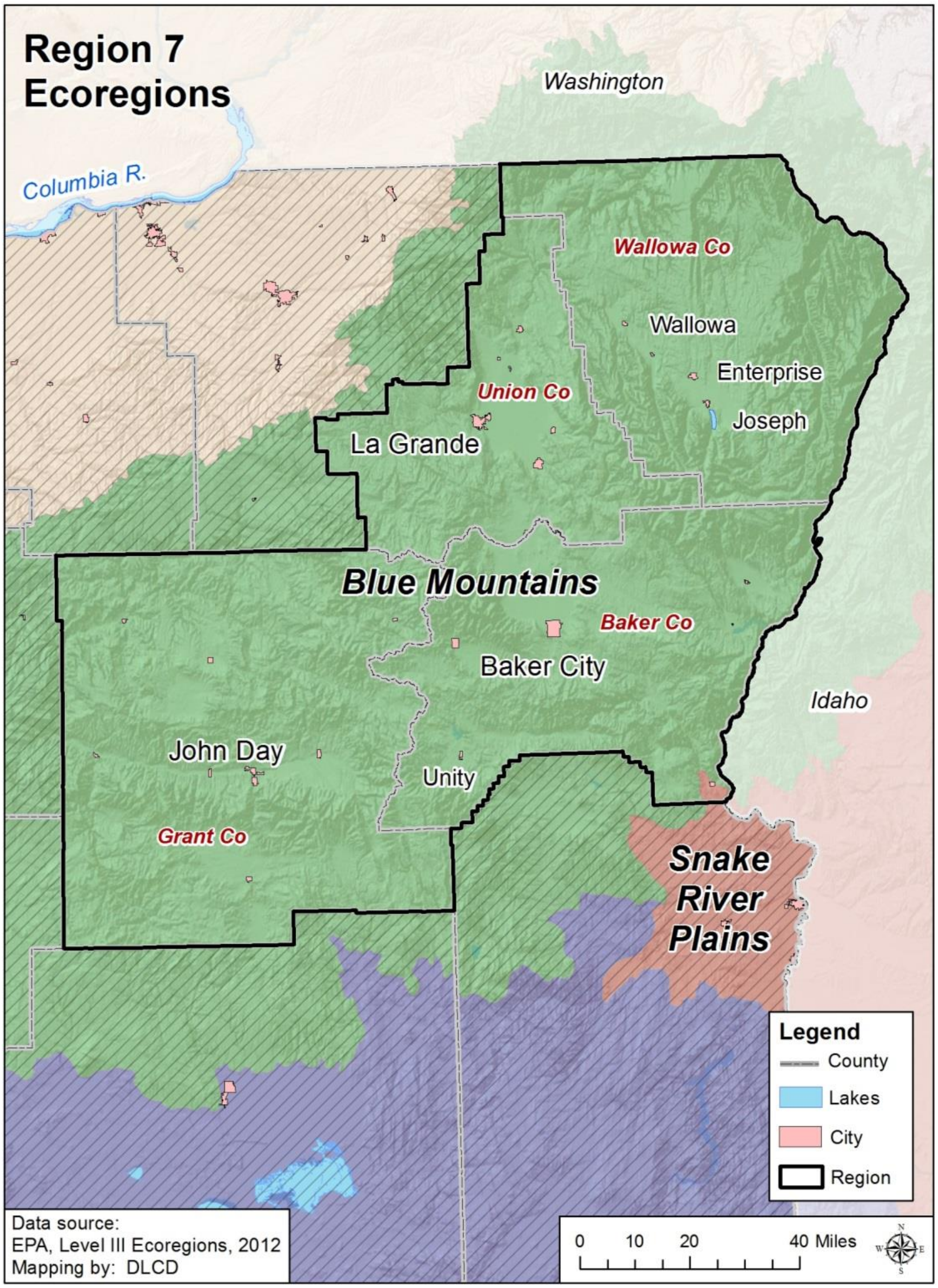
Figure 2-271. Region 7 Major Geographic Features



Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 7 is composed of two ecoregions: the Blue Mountains and very small area of the Snake River Plain ecoregion (**Figure 2-272**).

Figure 2-272. Region 7 Ecoregions



Blue Mountains: This ecoregion is complex and diverse, with many sub-ecoregions having unique conditions. In general, the Blue Mountains areas of Region 7 have dry continental climate with marine intrusions because of proximity to the Columbia Gorge. While much of the Blue Mountains are flat with arid climates, the highly dissected John Day / Clarno Highlands contain the John Day and Crooked Rivers that provide more abundant water than other parts of the Blue Mountains ecoregion, which leads to higher levels of human settlement in proximity to the rivers. Much of the Blue Mountains are underlain with volcanic rock although land in the Wallowa and Elkhorn Mountain ranges is composed of granitic intrusives, deep sea sediments, and metamorphic rocks. Grazing, logging, and fire suppression regimes have altered land cover throughout the region where juniper woodlands have given way to sagebrush grasslands and grand fir forests have given way to spruce fir forests. Other forests in the region predominantly have either a Douglas fir or ponderosa pine canopy. Ponderosa forests tend toward sparsely vegetated understories the ecoregion's Douglas fir forests tend toward dense shrub understories, making them more difficult to log. Some wet, high meadows also exist within Cold Basins of the Blue Mountains in Region 7 and unchannelized streams tend toward a meandering nature within wide floodplains, moving dynamically through the landscape. Riparian areas of the region have a diverse palette of understory shrubs with black cottonwoods, grand firs, and alders in the canopy layer.

Snake River Plain: The Region 7 portion of the Snake River Plain ecoregion is classified as the "Unwooded Alkaline Foothills," which is underlain by alkaline lacustrine deposits. The landscape includes rolling foothills, hills, benches, alluvial fans, and badlands. Wyoming sagebrush and associated grasses are the dominant vegetation with salt-tolerant shrubs found on alkaline outcrops. The land is high value rangeland and wildlife habitat.

Climate

This section covers historic climate information. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment** for statewide.

The climate of Northeast Oregon is semi-arid supporting primarily livestock grazing. More precipitation occurs in the higher elevations in the Blue and Wallowa Mountains. The region is subject to droughts and wildfires, particularly during dry summers and years with low snowpack. Despite its relative dryness, the region is also subject to floods and landslides. Flooding can be a direct result of rain-on-snow events. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-561** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 7 based on data from the NOAA National Centers for Environmental Information.

Table 2-649. Average Precipitation and Temperature in Region 7 Counties and Climate Divisions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Baker County	21.69” (15.28”–29.86”)	Jan: 2.74” Jul: 0.71”	45.2°F	Jan: 19.3°F /33.9°F Jul: 51.1°F /82.3°F
Grant County	21.6” (13.85”–30.56”)	Jan: 2.55” Jul: 0.63”	44.2°F	Jan: 20.4°F /36.8°F Jul: 47.3°F /80.4°F
Union County	28.56” (19.8”–38.4”)	Jan: 3.58” Jul: 0.79”	44.3°F	Jan: 22.0°F /35.1°F Jul: 48.5°F /78.4°F
Wallowa County	26.86” (20.03”–34.89”)	Jan: 2.94” Jul: 1.05”	43.5°F	Jan: 20.0°F /34.2°F Jul: 48.4°F /77.9°F
Climate Division 8 “Northeast”	24.93” (18.34”–32.23”)	Jan: 2.99” Jul: 0.79”	44.3°F	Jan: 0.6°F/35.1°F Jul: 48.8°F/79.5°F

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 22, 2019 from https://www.ncdc.noaa.gov/cag/.

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community’s capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

The population in Region 7 has remained relatively constant since 2010. The population in Baker County grew slowly during this period; that growth was entirely a result of sporadic net in-migration and was undercut by natural decrease (Population Research Center, Portland State University, 2019 [Baker County]). The trend is expected to continue and the region is projected to lose population over the next decade. A large number of deaths relative to births caused natural decrease in Grant County since 2010, resulting in a slight population decline (Population Research Center, Portland State University, 2019 [Grant County]). The population in Union County has increased steadily since 2010, driven both by net in-migration and natural increase (Population Research Center, Portland State University, 2019 [Union County]). Slow growth is projected to continue through 2030, with slowing natural increase undercutting net in-migration. Net in-migration in Wallowa County outpaced natural decrease from 2010 to 2018, resulting in very slow population growth. Over the next decade, natural decrease is projected to lead to population decline (Population Research Center, Portland State University, 2019 [Wallowa County]).

Table 2-650. Population Estimate and Forecast for Region 7

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 7	56,335	58,225	3.4%	55,851	−4.1%
Baker	16,134	16,765	3.9%	15,404	−8.1%
Grant	7,445	7,400	-0.6%	6,771	−8.5%
Union	25,748	26,885	4.4%	26,981	0.4%
Wallowa	7,008	7,175	2.4%	6,695	−6.7%

Source: Population Research Center, Portland State University (2018), Certified Population Estimates; Population Research Center, Portland State University (2019), Current Forecast Summaries for All Areas & Oregon Final Forecast Table by Age (2019); U.S. Census Bureau, 2010 Decennial Census. Table DP-1

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 7 (Longwoods International, 2017g) are largely centered on outdoor activities (hiking/backpacking, visiting national/state parks etc.), touring (traveling to experience scenic beauty, history, and culture), and special events (such as fairs, festivals, or sporting events) (Longwoods International, 2017g). Approximately 62% of all trips to the region occur between April and September and the average travel party contains three to four persons (Longwoods International, 2017g). The average trip length is between two and three nights (Longwoods International, 2017g). The Longwoods Travel Report includes all of the Region 7 counties, Harney and Malheur Counties (Region 8), and Morrow, Umatilla, and parts of Gilliam Counties within the Eastern Region.

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

Table 2-651. Annual Visitor Estimates in Person Nights (X1000) in Region 7

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 7	1,624	—	1,642	—	1,658	—
Baker	651	100%	656	100%	662	100%
Hotel/Motel	166	25.5%	173	26.4%	174	26.3%
Private Home	206	31.6%	207	31.6%	208	31.4%
Other	278	42.7%	275	41.9%	280	42.3%
Grant	222	100%	223	100%	225	100%
Hotel/Motel	38	17.1%	40	17.9%	40	17.8%
Private Home	72	32.4%	73	32.7%	73	32.4%
Other	112	50.5%	111	49.8%	112	49.8%
Union	560	100%	568	100%	575	100%
Hotel/Motel	138	24.6%	144	25.4%	147	25.6%
Private Home	260	46.4%	264	46.5%	266	46.3%
Other	162	28.9%	159	28.0%	162	28.2%
Wallowa	191	100%	195	100%	196	100%
Hotel/Motel	85	44.5%	89	45.6%	90	45.9%
Private Home	27	14.1%	28	14.4%	28	14.3%
Other	78	40.8%	78	40.0%	79	40.3%

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003). A higher percentage of the population in Region 7 has a disability than statewide. The percentage with a disability is also higher in each county than in the state as a whole. In Baker, Grant, and Wallowa Counties, approximately one-fifth of all residents have a disability. The share is comparatively smaller in Union County, but still higher than the statewide estimate.

Accurately measuring the number of children with a disability is challenging, especially in counties with a smaller overall population. Consequently, the estimate of young people (< 18) with a disability for each county should be used with caution or not used at all. The percentage of older adults with a disability slightly higher in the region than in the state as a whole. Considering the margins of error, all counties within the region have a similar share of older adults living with a disability.

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Table 2-652. People with a Disability by Age Group in Region 7

	With a Disability			Under 18 Years with a Disability			65 Years and Over with a Disability		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	14.6%	☑	0.1%	4.6%	☑	0.2%	37.1%	☑	0.4%
Region 7	18.8%	☑	0.9%	3.0%	⊙	0.8%	40.0%	☑	2.3%
Baker	21.2%	☑	1.6%	3.6%	⊗	1.8%	42.7%	☑	4.0%
Grant	22.1%	☑	2.4%	3.8%	⊗	2.8%	40.2%	☑	5.3%
Union	15.9%	☑	1.3%	2.5%	⊙	1.0%	38.1%	☑	4.1%
Wallowa	21.2%	☑	2.7%	3.5%	⊗	2.7%	39.2%	☑	4.9%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Homeless Population

The U.S. Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count, a biennial count of sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors. They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing & Community Services, 2019). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing & Community Services, 2019).

According to the PIT, between 2015 and 2019 the region experienced a 39% decrease in the number of people experiencing homelessness. Union and Wallowa Counties both reported decreases in homelessness, while Baker County reported no change. Grant County was the only county within the region to report an increase.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate vulnerability conditions. Disasters that result in damage to the built environment can place additional stress on temporary shelters (Peacock, Dash, Zhang, & Van Zandt, 2017). Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-653. Homeless Population Estimate for Region 7

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 7	120	62	73	85
Baker	14	7	14	12
Grant	7	4	11	7
Union	75	43	32	50
Wallowa	24	8	16	16

Source: Oregon Housing and Community Services (n.d.). Oregon Point in Time Homeless Counts. Retrieved from https://public.tableau.com/profile/oregon.housing.and.community.services#!/vizhome/2019Point-in-TimeDashboard/Story1

Biological Sex and Gender

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019). According to the survey, there is an equal ratio of men to women in the region (100.8 men to every 100 women) (U.S. Census Bureau, 2019).

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognized (Enarson, 2017). This is an area deserving of more attention as the field develops.

Age

Older adults, persons aged 65 and older, comprise a larger share of the population in Region 7 than they do in the state as a whole. In Baker, Grant, and Wallowa, approximately one-quarter of all residents are older adults. Older adults require special consideration in the planning process. They are more likely to have a disability and require assistance from others to complete routine tasks. Family or neighbors who might ordinarily assist them might be unable to help during a disaster event (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Moreover, an older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

The percentage of children in the region—and in three of the four regional counties—is slightly smaller than the statewide estimate. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. Parents might lose time from work and money when their children's childcare facilities and schools are impacted by disasters (Cutter, Boruff, & Shirley, 2003).

Table 2-654. Population by Vulnerable Age Group, in Region 7

	Total Population	Under 18 Years Old			65 and Older		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	4,025,127	21.5%	☑	0.1%	16.3%	☑	0.1%
Region 7	55,863	20.4%	☑	0.1%	22.7%	☑	0.1%
Baker	15,980	19.6%	☑	0.3%	24.9%	☑	0.2%
Grant	7,209	18.3%	☑	0.2%	27.5%	☑	0.3%
Union	25,810	22.2%	☑	*	18.8%	☑	0.2%
Wallowa	6,864	17.9%	☑	0.3%	27.3%	☑	0.7%

* Indicates that the estimate has been controlled to be equal to a fixed value and so it has no sampling error.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP05: ACS Demographics and Housing Estimates, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to language and culturally appropriate outreach materials. Compared to the statewide estimate, a very small share of the population does not speak English "very well" in Region 7. Still, communities creating outreach materials used to communicate with and plan for populations who do not speak English very well should take into consideration the language needs of these populations.

Table 2-655. English Usage in Region 7

	Speak English Less Than "Very Well"				
	Estimate	CV **	MOE (+/−)	Percent	% MOE (+/−)
Oregon	222,428	☑	4,116	5.90%	0.1%
Region 7	747	☑	165	1.41%	0.3%
Baker	190	⊙	62	1.30%	0.4%
Grant	79	⊗	84	1.10%	1.2%
Union	418	⊙	125	1.70%	0.5%
Wallowa	60	⊙	27	0.90%	0.4%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

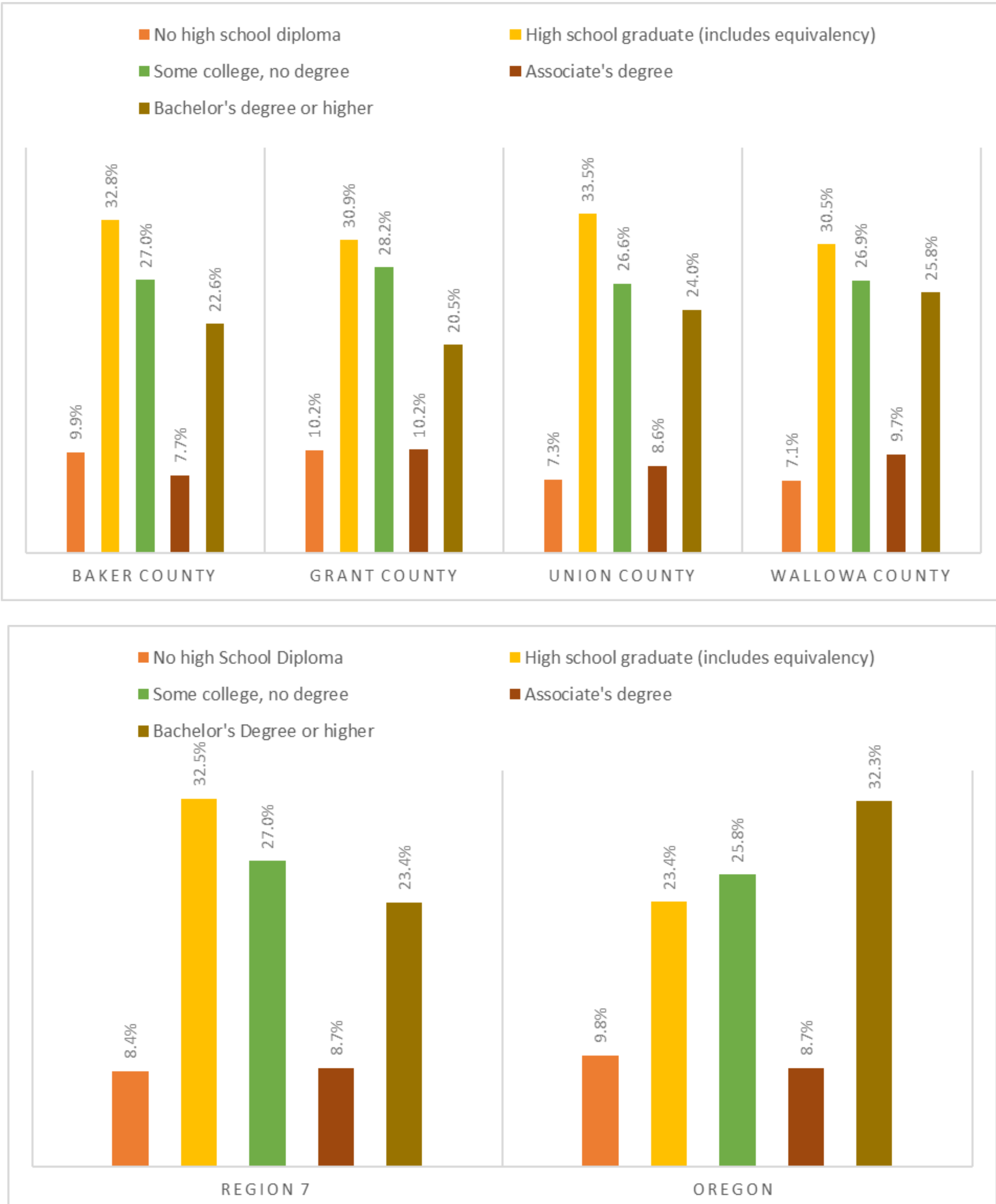
Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Education Level

Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual's ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

A smaller share of residents in Region 7 have a bachelor's degree or higher compared to the state as a whole; the difference between the two estimates is approximately nine percentage points. Educational attainment is similar for all counties within the region and so the regional profile is fairly representative. Grant County has the highest share of residents without a high school diploma and the smallest share of residents who have a four-year degree or more.

Figure 2-273. Educational Attainment in Region 7: (top) by County, (bottom) Regional vs. Statewide



Source: U.S. Census Bureau (2018). Table DP02: Selected Social Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Income and Poverty

The impact of a disaster in terms of loss and the ability to recover varies among population groups. "The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event" (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public (Stahl, P., 2000). Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, are less likely to have the savings to rebuild after a disaster, and are less likely to have access to transportation and medical care.

All counties in the region have lower median household incomes than the state average, ranging from $10,000-$12,000 below the state median. Grant County was the only county in the region to experience a statistically significant change in median household income between 2012 and 2017, although the margins of error indicate the increase might not be as high as the estimate shows.

Table 2-656. Median Household Income in Region 7

	2008-2012			2013-2017			Statistically Different*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	$53,427	☑	$338	$56,119	☑	$370.00	Yes
Region 7	—	—	—	—	—	—	—
Baker	$43,021	☑	$2,904	$43,765	☑	$3,354.00	No
Grant	$36,760	☑	$1,728	$44,826	☑	$5,576.00	Yes
Union	$44,850	☑	$2,023	$46,228	☑	$1,934.00	No
Wallowa	$43,259	☑	$4,205	$44,877	☑	$3,973.00	No

Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

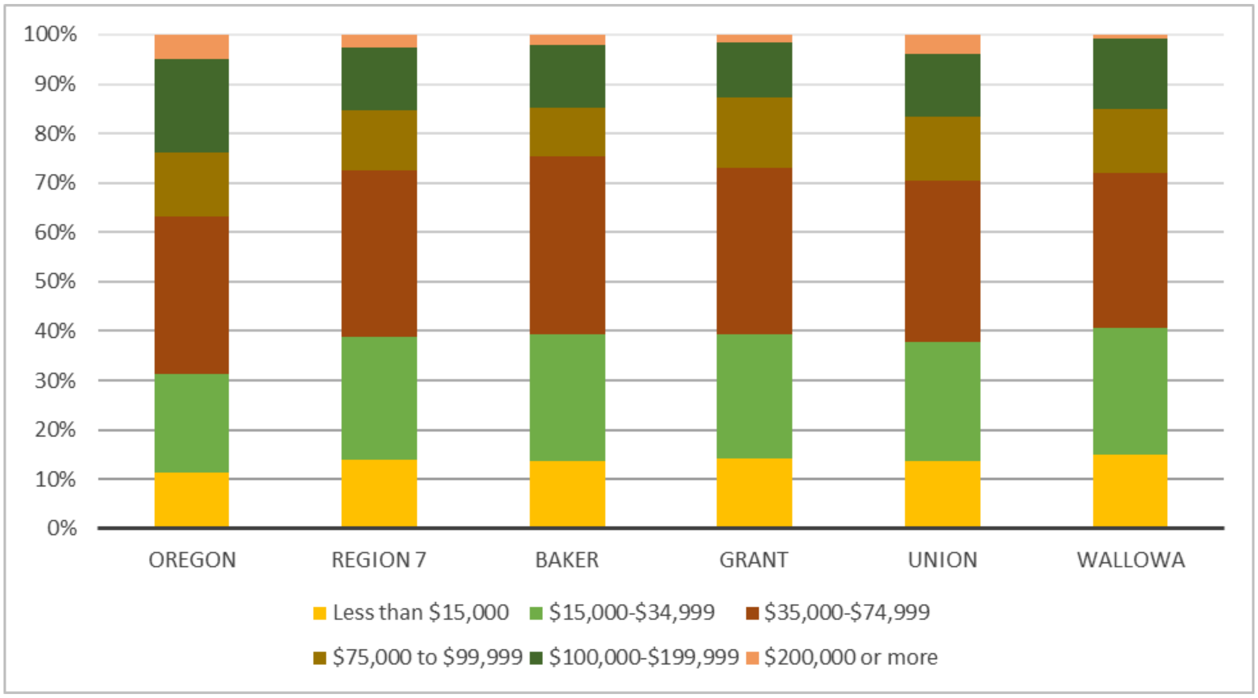
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2002 and 2013-2017. American Community Survey – 5-Year Estimates. Table CP03.

Compared to statewide numbers, the region has a higher share of its households earning less than $35,000 per year. Within the region, the percentage is highest in Wallowa County, but only slightly. Just under one-third of the region's households earn between $35,000 and $75,000 per year, similar to the statewide share. More earners in the bottom brackets means fewer in the top; approximately 27% of household in Region 7 earn more than $75,000 annually, roughly nine percentage points lower than the statewide share.

Figure 2-274. Median Household Income Distribution in Region 7



Source: U.S. Census Bureau. Table DP03: Selected Economic Characteristics, American Community Survey, 2013-2017 American Community Survey 5-Year Estimates

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018). A greater share of the regional population overall is living in poverty compared to the state as a whole. Between 2012 and 2017, Baker County was the only county within the region to experience a statistically significant decrease in poverty.

A higher percentage of children in Region 4 are living in poverty compared to the statewide share. Baker County has the highest percentage of children living in poverty; however, as with its overall population, Baker County experienced a statistically significant decrease in the total number of children living in poverty from 2012 to 2017. The estimate in Baker County remains higher than its peers and the statewide estimate, but the margins of error are significant for all counties in the region.

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources (Cutter, Boruff, & Shirley, 2003).

Table 2-657. Poverty Rates in Region 7

	Total Population in Poverty						
	2008-2012			2013-2017			Statistical Difference?*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	15.5%	☑	0.3%	14.9%	☑	0.3%	No
Region 7	17.3%	☑	1.4%	15.9%	☑	1.3%	No
Baker	19.6%	☑	2.7%	15.3%	☑	2.6%	Yes
Grant	15.7%	☑	3.9%	13.7%	☑	2.6%	No
Union	17.2%	☑	2.2%	17.4%	☑	2.1%	No
Wallowa	14.5%	☑	2.6%	13.7%	☑	2.8%	No

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Table 2-658. Child Poverty in Region 7

	Children Under 18 in Poverty						
	2008-2012			2013-2017			Statistical Difference?*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	20.6%	☑	0.5%	19.0%	☑	0.6%	Yes
Region 7	24.0%	☑	3.5%	22.5%	☑	1.3%	No
Baker	33.3%	☑	6.5%	23.8%	⊙	6.1%	Yes
Grant	19.6%	⊙	8.7%	22.1%	⊙	6.9%	No
Union	21.6%	⊙	5.5%	22.1%	☑	4.8%	No
Wallowa	17.1%	⊙	5.5%	21.3%	⊙	8.3%	No

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Housing Tenure

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

Each county in Region 7 has a higher share of owner-occupied housing compared to the state as a whole.

Table 2-659. Housing Tenure in Region 7

	Total Occupied Units	Owner-Occupied			Renter-Occupied		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	61.7%	✓	0.3%	38.3%	✓	0.3%
Region 7	23,626	66.7%	✓	1.7%	33.3%	✓	1.8%
Baker	7,033	68.3%	✓	2.7%	31.7%	✓	2.7%
Grant	3,176	73.1%	✓	2.8%	26.9%	✓	2.8%
Union	10,291	63.3%	✓	2.8%	36.7%	✓	2.8%
Wallowa	3,126	67.9%	✓	3.7%	32.1%	✓	3.7%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP04: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households. Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only.

The share of family households in Region 7 is the same as the share in the state as a whole, however, the percentage of single-person households is slightly higher in the region than the statewide share. Wallowa County has the highest share of single-person households—approximately six percentage points higher than the statewide number. Compared to the statewide estimate, single-person households comprise a larger share of households in each county across the region, except for Union County. The region as a whole has a smaller share of households with children and a slightly smaller share of single-parent households vis-a-vis the state. Not factoring in margins of error, Union County has the highest percentage of households with children and the highest percentage of single-parent households within the region.

Table 2-660. Family vs. Non-family Households in Region 7

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	63.3%	☑	0.2%	36.7%	☑	0.2%	27.7%	☑	0.2%
Region 7	23,626	63.3%	☑	0.2%	36.7%	☑	0.2%	29.9%	☑	0.2%
Baker	7,033	62.9%	☑	0.3%	37.1%	☑	0.2%	32.9%	☑	0.0%
Grant	3,176	63.0%	☑	0.2%	37.0%	☑	0.0%	30.6%	☑	0.2%
Union	10,291	63.7%	☑	0.1%	36.3%	☑	0.2%	26.5%	☑	0.1%
Wallowa	3,126	62.6%	☑	0.1%	37.4%	☑	0.1%	33.5%	☑	0.0%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-661. Family Households with Children by Head of Household in Region 7

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	26.2%	☑	0.2%	8.1%	☑	0.2%
Region 7	22.6%	☑	1.3%	7.7%	☑	1.2%
Baker	21.2%	☑	2.1%	6.3%	⊙	1.6%
Grant	19.5%	☑	2.5%	7.0%	⊙	2.1%
Union	25.6%	☑	2.1%	9.0%	☑	1.4%
Wallowa	19.1%	☑	2.3%	7.3%	⊙	2.2%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Social and Demographic Trends and Issues

This analysis shows that Region 7 has a greater number of people than the state average who are predisposed to be particularly vulnerable during a hazard event:

- The regional population is projected to decline. An aging population is expected to lead to a natural decrease (more deaths than births). Moreover, this trend is expected to outpace net in-migration.

- A higher percentage of the population in Region 7 has a disability than statewide. The percentage with a disability is also higher in each county than in the state as a whole. The percentage of older adults with a disability is also slightly higher in the region than in the state as a whole, and there is insufficient data to know the share of children with a disability.

- Older adults, persons aged 65 and older, comprise a larger share of the population in Region 7 than they do in the state as a whole.

- Fewer residents in Region 7 have a bachelor's degree or higher compared to the state as a whole; the difference between the two estimates is approximately nine percentage points.

- All counties in the region have lower median household incomes than the state average, ranging from $10,000-$12,000 below the state median. Moreover, the region has a higher share of its households earning less than $35,000 per year, and a smaller in the top income brackets.

- A greater share of the regional population overall and a higher share of children in the region are living in poverty compared to the state as a whole.

- Compared to the statewide estimate, single-person households comprise a larger share of households in each county across the region, except for Union County.

Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses' labor, capital, suppliers, and customers are all relevant factors (Zhang, Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang, Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent.

Employment and Unemployment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 7 have been steadily declining since they peaked during the Great Recession. From 2014 to 2018, unemployment rates were consistently higher in all counties vis-à-vis the state as a whole. Throughout the four-year period, unemployment in Grant and Wallowa Counties tended to be higher than rates in Baker and Union Counties.

Table 2-662. Civilian Labor Force in Region 7, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 7	25,328	23,873	94.3%	1,455	5.7%
Baker	6,976	6,593	94.5%	383	5.5%
Grant	3,099	2,874	92.7%	225	7.3%
Union	11,935	11,291	94.6%	644	5.4%
Wallowa	3,318	3,115	93.9%	203	6.1%

Source: Oregon Employment Department, 2019

Table 2-663. Civilian Unemployment Rates in Region 7, 2014-2018

	2014	2015	2016	2017	2018	Change (2014–2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	−2.6%
Region 7	8.3%	6.9%	6.3%	5.6%	5.7%	−2.6%
Baker	8.3%	6.8%	6.3%	5.5%	5.5%	−2.8%
Grant	10.5%	8.7%	7.6%	6.9%	7.3%	−3.2%
Union	7.2%	6.2%	5.9%	5.3%	5.4%	−1.8%
Wallowa	10.0%	7.8%	6.7%	5.7%	6.1%	−3.9%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups "economic units that have similar production processes" according to a six-digit hierarchical structure (Office of Management and Budget, n.d.). "The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry" (Office of Management and Budget, n.d.). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors (U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 7 were:

1. Trade, Transportation and Utilities
2. Education and Health Services
3. Local Government
4. Manufacturing
5. Leisure and Hospitality

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region's resiliency. In Region 7, the following supersectors comprise a significant share of all business establishments.

- The Other Services supersector includes the highest number of establishments in Region 7, 16.3% of all businesses (QCEW, 2018).
- Trade, Transportation, and Utilities is second largest with 16.1% of all business establishments (QCEW, 2018).
- The Construction supersector has the third largest number of establishments, with 10.6% of the regional share (QCEW, 2018).
- Leisure and Hospitality is fourth, with 9.2% of business establishments (QCEW, 2018).
- Professional and Business Services is fifth, with 8.9% of all businesses (QCEW, 2018).

While supersectors are useful abstractions, it's important to remember that within are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event.

Table 2-664. Covered Employment by Sector in Region 7, 2019

Industry	Region 7	Baker		Grant	
	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	5,544	100.0%	2,482	100.0%
Total Private Coverage	76.8%	4,424	79.8%	1,466	59.1%
Natural Resources & Mining	5.1%	220	4.0%	283	11.4%
Construction	4.6%	270	4.9%	64	2.6%
Manufacturing	10.4%	560	10.1%	119	4.8%
Trade, Transportation & Utilities	18.0%	1,084	19.6%	297	12.0%
Information	1.1%	43	0.8%	53	2.1%
Financial Activities	2.8%	137	2.5%	54	2.2%
Professional & Business Services	4.7%	290	5.2%	101	4.1%
Education & Health Services	15.6%	945	17.0%	189	7.6%
Leisure & Hospitality	10.2%	583	10.5%	214	8.6%
Other Services	4.3%	290	5.2%	91	3.7%
Unclassified	0.0%	(c)	(c)	(c)	(c)
Total All Government	23.2%	1,120	20.2%	1,016	40.9%
Total Federal Government	3.8%	201	3.6%	268	10.8%
Total State Government	3.7%	207	3.7%	135	5.4%
Total Local Government	15.6%	712	12.8%	613	24.7%

Industry	Region 7	Union		Wallowa	
	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	10,173	100.0%	2,572	100.0%
Total Private Coverage	76.8%	8,115	79.8%	1,952	75.9%
Natural Resources & Mining	5.1%	379	3.7%	177	6.9%
Construction	4.6%	468	4.6%	156	6.1%
Manufacturing	10.4%	1,327	13.0%	157	6.1%
Trade, Transportation & Utilities	18.0%	1,916	18.8%	440	17.1%
Information	1.1%	108	1.1%	18	0.7%
Financial Activities	2.8%	264	2.6%	122	4.7%
Professional & Business Services	4.7%	454	4.5%	121	4.7%
Education & Health Services	15.6%	1,743	17.1%	371	14.4%
Leisure & Hospitality	10.2%	1,051	10.3%	273	10.6%
Other Services	4.3%	402	4.0%	118	4.6%
Unclassified	0.0%	(c)	(c)	(c)	(c)
Total All Government	23.2%	2,058	20.2%	620	24.1%
Total Federal Government	3.8%	236	2.3%	88	3.4%
Total State Government	3.7%	364	3.6%	72	2.8%
Total Local Government	15.6%	1,458	14.3%	460	17.9%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region.

Education and Health Services: The industries in these sectors play important roles in emergency response in the event of a disaster. Health care is a relatively stable revenue sector regionally with an increasing distribution of businesses primarily serving a local and aging population.

Manufacturing: This sector is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons the manufacturing sector may be susceptible to disruptions in transportation infrastructure. However, manufacturers are not dependent on local markets for sales, which may contribute to the economic resilience of this sector.

Leisure and Hospitality: This sector primarily serves regional residents with disposable income and tourists. The behavior of both of these social groups would be disrupted by a natural disaster. Regional residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. Many of the top employment subsectors are similar across regions. For example, Food Services and Drinking Places and Educational Services are the two largest employment subsectors in Region 7. These subsectors also rank highly in other regions. Ambulatory Health Care Services—also known as outpatient services—and Hospitals are also major employers in Region 7 and across the state. Conversely, other subsectors, such as Wood Product Manufacturing, are more unique to the region.

Table 2-665. Industries with Greatest Share of Employment in Region 7, 2018

Industry	Employment Share	Employment (2018)
Educational Services	10.0%	2,261
Food Services and Drinking Places	9.4%	2,118
Ambulatory Health Care Services	4.8%	1,073
Food and Beverage Stores	4.6%	1,043
Wood Product Manufacturing	4.5%	1,025
Nursing and Residential Care Facilities	3.8%	863
Social Assistance	3.7%	837
Executive, Legislative, and Other General Government Support	3.4%	763
Transportation Equipment Manufacturing	2.8%	638
Professional, Scientific, and Technical Services	2.7%	613

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for employment share and average employment by DLCD

Industry Concentration and Employment Change

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

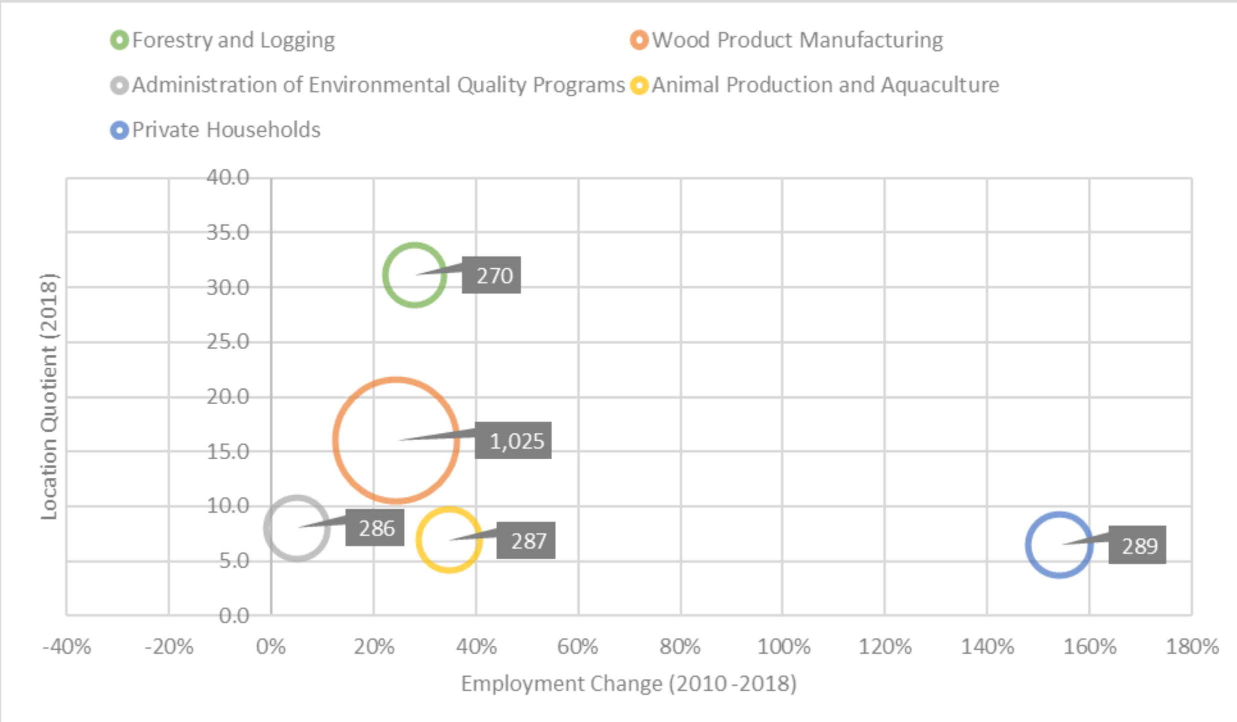
Table 2-666. Most Concentrated Industries and Employment Change in Region 7, 2018

Industry	Location Quotient	Employment (2018)	Employment Change (2010–2018)
Forestry and Logging	31.1	270	28%
Wood Product Manufacturing	16.0	1,025	24%
Admin. of Environmental Quality Programs	8.0	286	5%
Animal Production and Aquaculture	6.9	287	35%
Private Households	6.5	289	154%

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 7 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-275. Location Quotients, Employment Change, and Total Employment in Region 7, 2018



APA Citation: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD staff

Four of the region's five most concentrated industries are natural resource based. Similar to other regions, Region 7 has significant employment concentrations in timber related industries. Forestry and Logging and Wood Product Manufacturing both have a location quotient over fifteen—suggesting the industry presence is rather unique within the United States. All subsectors experienced growth during the eight-year period, with Administration of Environmental Quality Programs experiencing the least and Private Household experiencing the most. Mirroring conditions in other regions with a timber industry, manufacturing goods from wood requires more employment than harvesting timber.

Fastest Growing and Declining Industries

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang, Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining.

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 7's fastest growing and declining industries

Table 2-667. Fastest Growing and Declining Industries in Region 7, 2010-2018

Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Food Manufacturing	548%	10	65
Private Households	154%	114	289
Couriers and Messengers	116%	39	85
Waste Management and Remediation Services	89%	37	70
Amusement, Gambling, and Recreation Industries	71%	195	334
Fastest Declining			
Motion Picture and Sound Recording Industries	−100%	16	0
Primary Metal Manufacturing	−100%	45	0
Rental and Leasing Services	−100%	89	0
Transit and Ground Passenger Transportation	−100%	63	0
Clothing and Clothing Accessories Stores	−66%	87	29

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

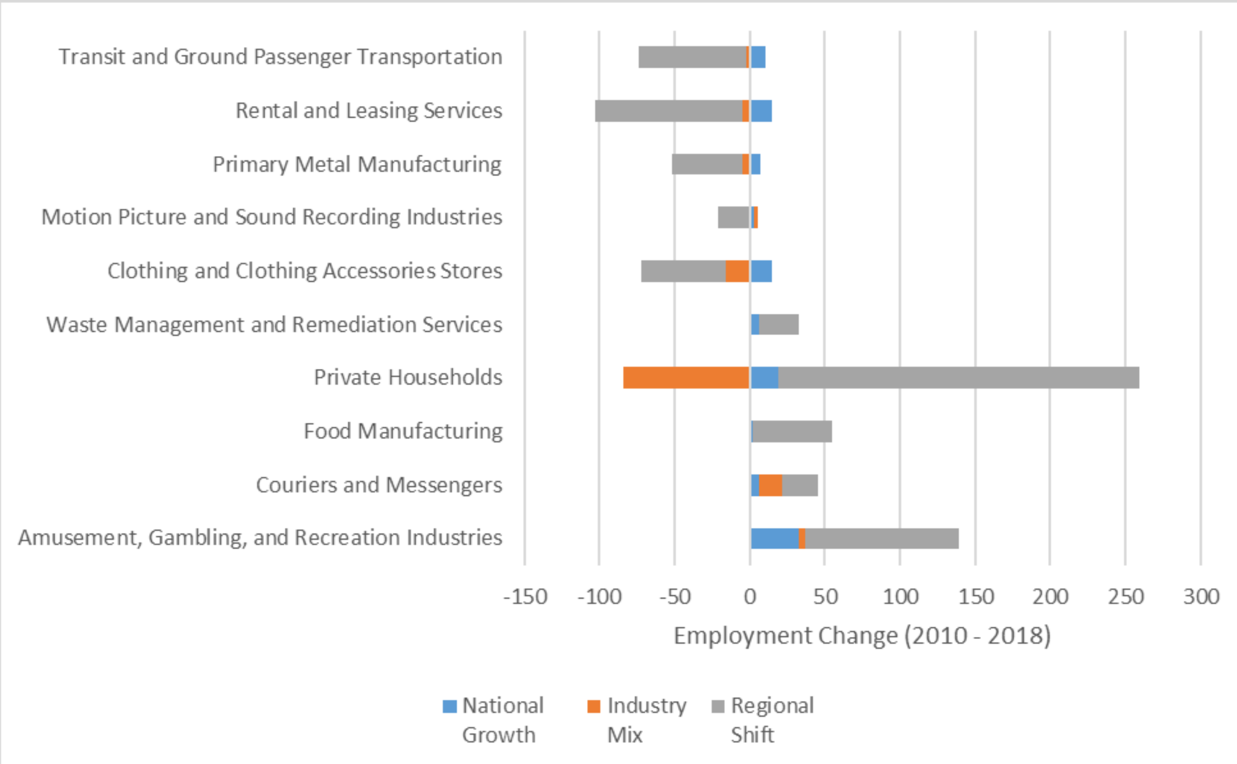
Due to a smaller population, the fastest growing industries started with meager employment in 2010—each under two-hundred. Consequently, small changes in absolute terms equate to significant percent increases. According to the shift share analysis, growth in all five subsectors was driven by largely by regional factors.

All five of the fastest declining subsectors in Region 7 started with under one-hundred employees in 2010. Four of the five collapsed entirely during the eight-year period. According to the shift-share analysis, this collapse was driven by regional factors. It should be noted that with such small numbers, subsector decline potentially represents the closure of one or two establishments, rather than larger industry trends.

The Private Households subsector more than doubled from 2010-2018. This sector employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019). The increase in employment in the Private Households industry mirrors a statewide trend (Wallis, 2019). Demand is driven in part by an aging population's need for in-home care workers (Wallis, 2019).

Employment in the Couriers and Messengers subsector is likely a reflection of the global revolution in retail sales. With an increased share of retail shopping occurring online, growth in transportation, storage, and distribution infrastructure and employment has been increasing nationally. Although the character of work is quite different, new employment in this in the subsector has helped to offset job loss in traditional "Brick and Mortar" retail (Lehner, Oregon's Shifting Retail Landscape, 2017). For example, Clothing and Clothing Accessories Store in the region shed more than half of all jobs from 2010-2018. Companies employing couriers include names like Federal Express, FedEx Ground, and United Parcel Service (Wallis, 2018).

Figure 2-276. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 7, 2010-2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by

Table 2-668. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 7, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Amusement, Gambling, and Recreation Industries	139	32	4	103
Couriers and Messengers	46	7	15	24
Food Manufacturing	55	2	0	53
Private Households	175	19	−84	240
Waste Management and Remediation Services	33	6	0	27
Fastest Declining				
Clothing and Clothing Accessories Stores	−58	14	−16	−56
Motion Picture and Sound Recording Industries	−16	3	2	−21
Primary Metal Manufacturing	−45	7	−5	−47
Rental and Leasing Services	−89	15	−5	−98
Transit and Ground Passenger Transportation	−63	10	−2	−71

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Economic Trends and Issues

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the following situations increase the region's level of vulnerability to natural hazard events:

- The region generally lacks a diversity of traded sector industries. Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- Unemployment rates across the region were higher than in the state as a whole From 2014 to 2018;
- The regional economy has fewer opportunities for highly skilled employees, limiting the income potential of regional residents.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl, et al., 2000).

Infrastructure

Transportation

Roads

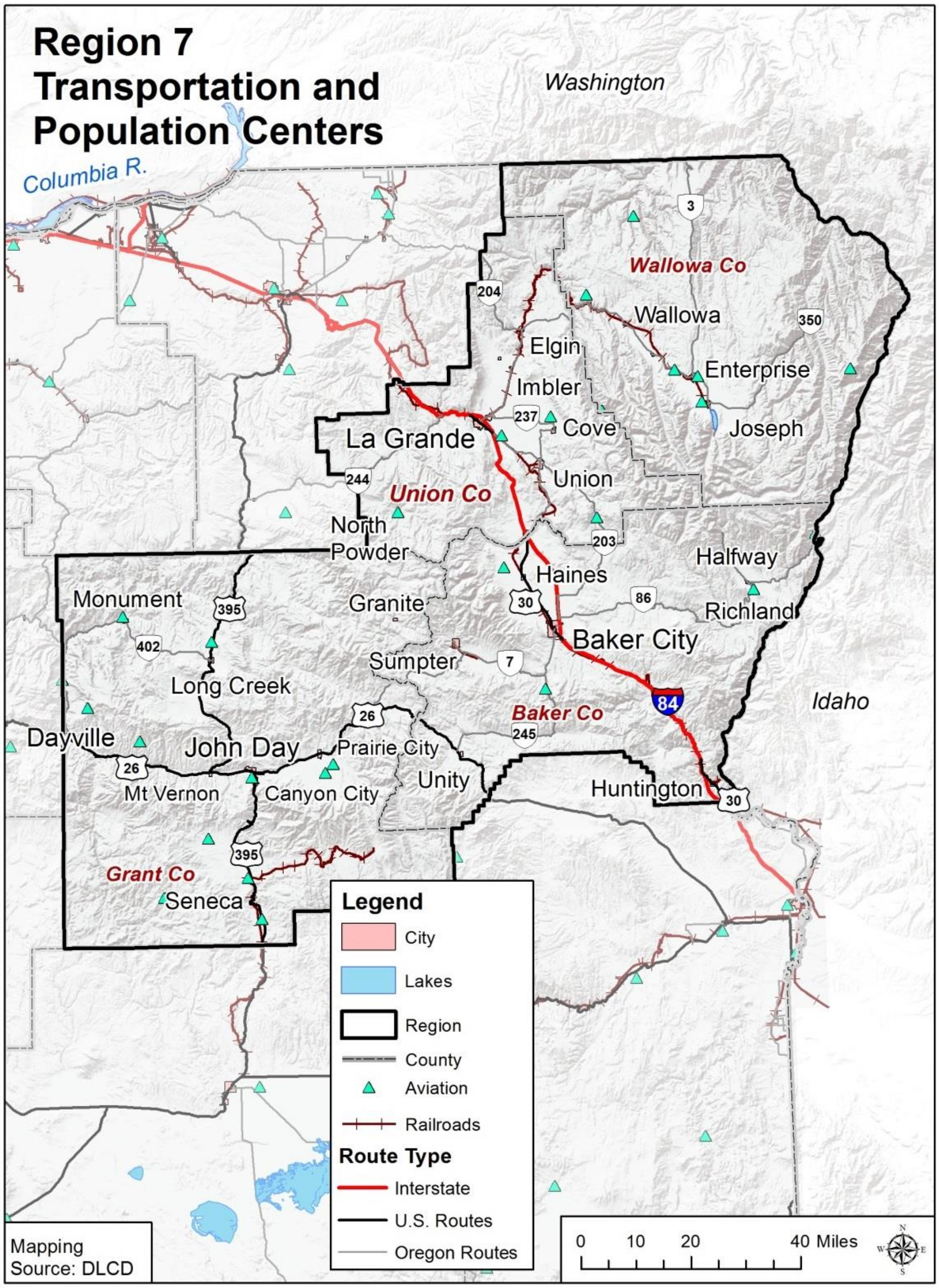
The largest population bases in Region 7 are located along the region's major freeways. I-84 runs north-south and is the main passage for automobiles and trucks traveling east of the Cascade Range between Portland and Idaho. US-26, US-244, OR-245, and US-395 provide access west into Grant County. OR-82 provides access into Wallowa County. An additional north-south access is provided from Wallowa County to Washington via OR-3.

Region 7's growing population centers bring more workers, automobiles and trucks onto roads. A high percentage of workers driving alone to work coupled with interstate and international freight movement create additional stresses on transportation systems. Some of these include added maintenance, congestion, oversized loads, and traffic accidents.

Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuations and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

According to the Oregon Department of Transportation's (2014, October) Seismic Plus Report (Appendix **9.1.13**), the projected impacts of a CSZ event are considered negligible in this part of the state. However, damage to I-84 to the west and damage to the Columbia River's freight functions could impact the region's economy. Because the projected impacts of a CSZ event are considered negligible in this part of the state Region 7 was not part of the ODOT's 2012 Seismic Lifelines Report. However, ODOT did provide the following descriptions of general impacts a CSZ would have on Region 7's seismic lifelines and the region's overall vulnerability. That information is available in **Seismic Lifelines**.

Figure 2-277. Region 7 Transportation and Population Centers



Source: Oregon Department of Transportation (2014, October)

Bridges

ODOT lists 491 bridges in the counties that comprise Region 7.

Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or are part of regional and local systems that are maintained by the region's counties and cities.

Table 2-669 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. The ratings do not imply that a bridge is unsafe (ODOT, 2020). In this region, 6% of bridges are distressed and/or deficient.

Table 2-669. Bridge Inventory for Region 7

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 7	2	215	1%	25	239	10%	3	35	9%	0	2	0%	30	491	6%
Baker	2	81	2%	11	78	14%	0	8	0%	0	0	N/A	13	167	8%
Grant	0	46	0%	5	39	13%	1	9	11%	0	1	0%	6	95	6%
Union	0	71	0%	4	62	6%	1	8	13%	0	1	0%	5	142	4%
Wallowa	0	17	0%	5	60	8%	1	10	10%	0	0	N/A	6	87	7%

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2020)

Railroads

Railroads that run through Region 7 support cargo and trade flows. The region's major (Class I) freight rail providers are the Union Pacific (UP) and the Burlington Northern-Santa Fe (BNSF) railroads. The Class I rail line follows the I-84 corridor and another non-class I rail line provides access to the city of Enterprise (Wallowa County). There are no active rail lines in Grant County. There is one rail yard in the region (in La Grande, Union County) operated by UP (Cambridge Systematics, 2014).

There is no passenger rail available in Region 7.

Oregon's rail system is critical to the state's economy, energy, and food systems. Rail systems export lumber and wood products, pulp and paper, and other goods produced in Oregon and transport products from other states to and through Oregon (Cambridge Systematics, 2014).

Rails are sensitive to icing from winter storms that can occur in Region 7. Disruptions in the rail system can result economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

There are no commercial airports in the region. There are several general aviation public airports including the Baker City and La Grande airports.

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

Table 2-670. Public and Private Airports in Region 7

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Helipad	Private Helipad	Total
Region 7	7	23	0	5	35
Baker	1	5	0	5	11
Grant	2	9	0	0	11
Union	1	3	0	0	4
Wallowa	3	6	0	0	9

Source: FAA Airport Master Record (Form 5010), 2014

Energy

Electricity

The region is served by several investor-owned, public, cooperative and municipal utilities. The Bonneville Power Administration is the area's wholesale electricity distributor. Pacific Power and Light (Pacific Power) is the primary investor-owned utility company serving Wallowa County. Idaho Power Company serves portions of Baker County. The region's electric cooperatives include: Oregon Trail Electric Cooperative (Baker, Grant, and Union), Central Electric Cooperative (Grant), Columbia Power Cooperative (Grant), and the Umatilla Electric Cooperative (Union). The Oregon Trail Electric Cooperative serves the major population centers in the region.

Table 2-671 lists electric power-generating facilities in Region 7. The region has a total of five power-generating facilities: three are hydroelectric power facilities, one is a wind power facility, and one is categorized as “other” (biomass). In total, the power-generating facilities have the ability to produce up to 1,277 megawatts (MW) of electricity.

Table 2-671. Power Plants in Region 7

	Hydro-electric	Natural Gas	Wind	Coal	Other*	Total
Region 7	3	0	1	0	1	5
Baker	2	0	0	0	0	2
Grant	0	0	0	0	1	1
Union	0	0	1	0	0	1
Wallowa	1	0	0	0	0	1
Energy Production (MW)	1,166	0	101	0	10	1,277

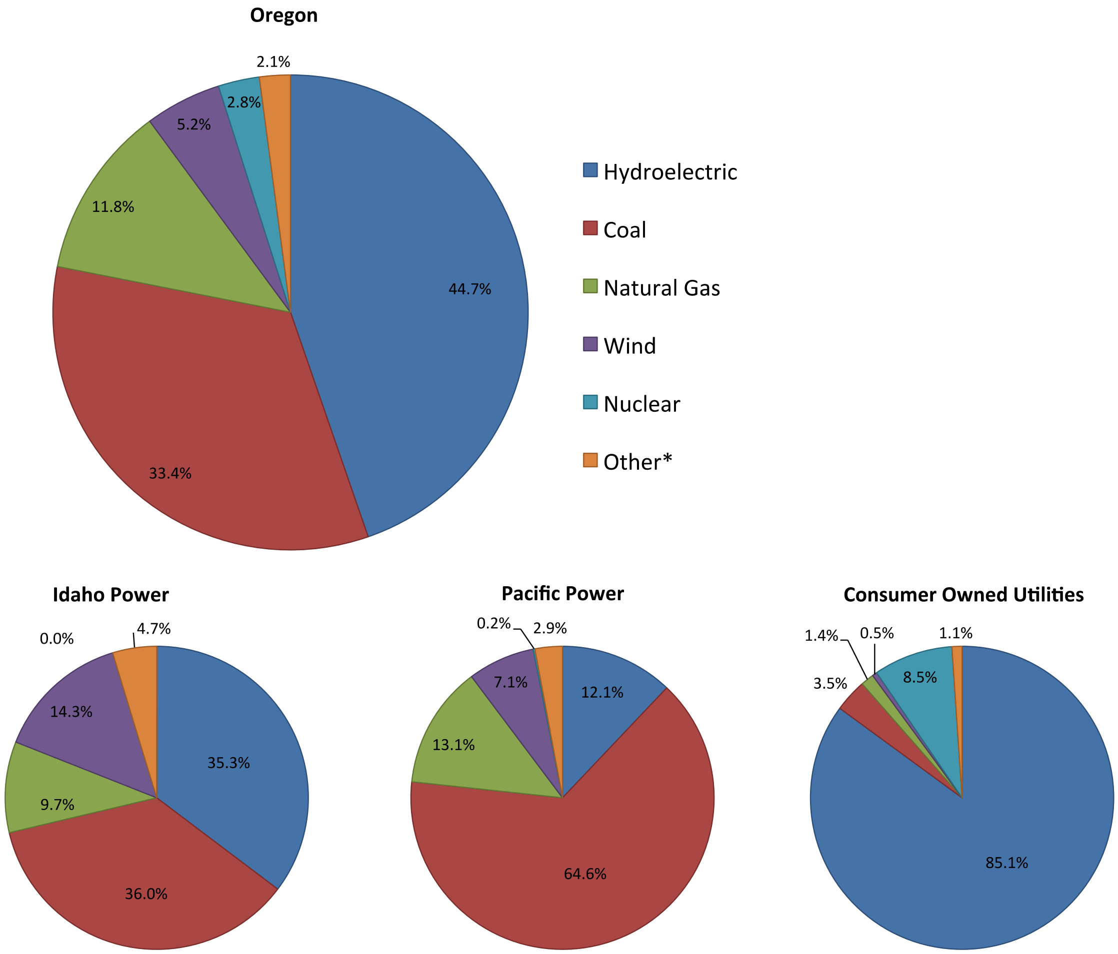
*“Other” includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

Oregon has a diverse energy portfolio (Figure 2-278) (Oregon Department of Energy, n.d.b). Consumer Owned Utilities provide for approximately 30% of the state’s electricity consumption (largely through Bonneville Power Administration’s electric generation facilities) while Pacific Power provides about 28% of the state’s electricity need.

Pacific Power generates supply from a variety of sources including sites in Oregon and other western states. Transmission lines from the Rocky Mountain Region provide additional energy sources. Natural hazard events can create additional stresses to energy infrastructure that may lead to system damage or disruption in service. The redundancies and diversity in Pacific Power’s energy generation portfolio and pipeline systems adds to the region’s resilience in the face of power system damage or service disruption.

Figure 2-278. Oregon Energy Portfolio



Note: 3.9% of Oregon's electricity needs are met through Electric Service Suppliers that are not required to provide descriptions of their power sources to the State of Oregon.

*Other includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Source: Oregon Department of Energy, 2014.

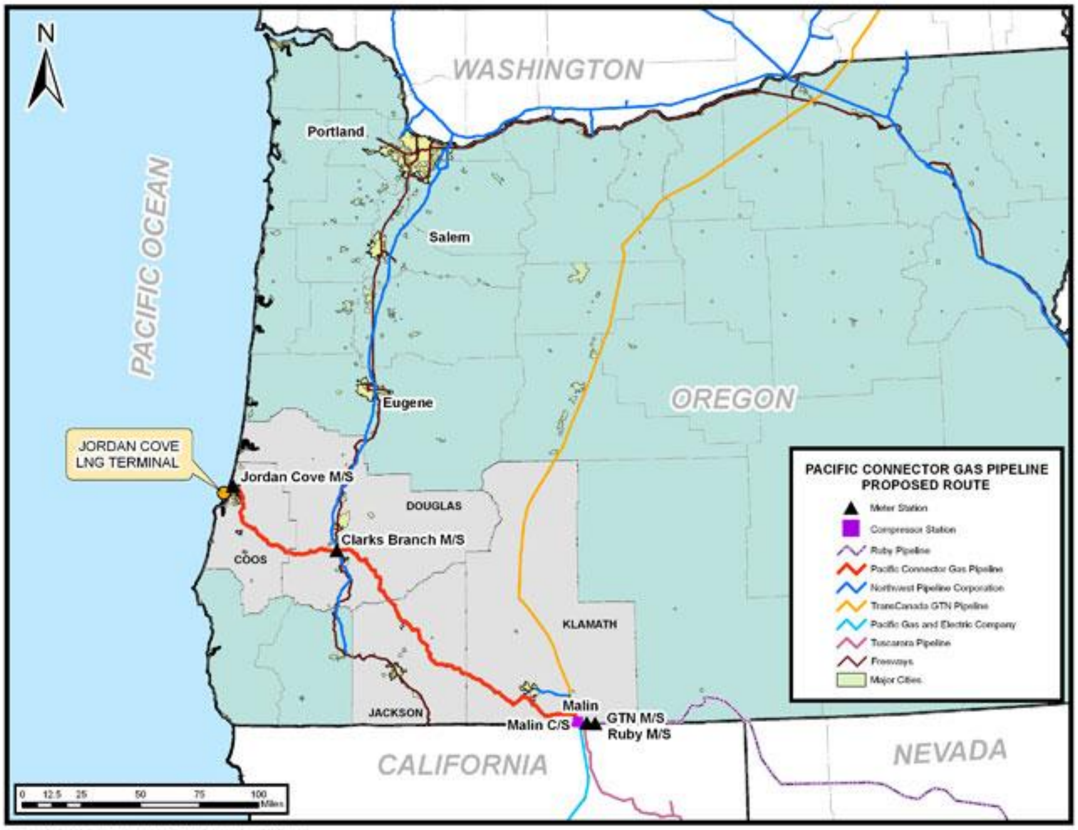
Hydropower

Major dams in the region are located on the Snake River (Brownlee, Oxbow, and Hells Canyon).

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to the region's energy portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-279** shows the Northwest Pipeline, which runs through Union and Baker Counties (in blue) (*Northwest Pipeline* Retrieved from http://www.northwest.williams.com/NWP_Portal/extLoc.action?Loc=FilesNorthwest other&File=pipelineInfo.html). LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

Figure 2-279. Liquefied Natural Gas Pipelines in Region 7



Source: Williams Corporation

Utility Lifelines

Northeast Oregon is an important throughway for oil and gas pipelines and electrical transmission lines, connecting Oregon to Idaho and Washington. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe, but infrequent natural hazards, such as earthquakes.

Region 7 primarily receives oil and gas from Alaska by way of the Puget Sound through pipelines and tankers. The electric, oil, and gas lifelines that run through the County are both municipally and privately owned (Loy, Allan, & Patton, 1976).

The network of electrical transmission lines running through Region 7 is operated primarily by Pacific Power and regional electrical cooperatives (and supplied by the Idaho Power Company and Bonneville Power Administration) and primarily facilitates local energy production and distribution (Loy, Allan, & Patton, 1976). Most of the natural gas Oregon uses originates in Alberta, Canada. The Williams Company owns the main natural gas transmission pipeline in northeastern Oregon.

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Region 7 is part of the Eastern Oregon Operational Area under The Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013). There is a memorandum of understanding between these counties that facilitates the launching of emergency messages. Counties in these areas can launch emergency messages by contacting the Oregon Emergency Response System (OERS), which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communications capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation's status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The Oregon State Emergency Alert System Plan does not identify a local primary station for emergency messages. However, messages are provided via the three state primary networks: Oregon Public Broadcasting (Portland), KOBI-TV (Medford), and KWAX-FM (Eugene).

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 7. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is readily available throughout most parts the region with a smaller number of providers and service types available in the more remote parts of the region (NTIA, n.d.). Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 7 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Due to the remote nature and sparse population Region 7 lacks a station that would serve the Eastern Oregon Operational Area. Radio transmitters for the Eastern Oregon Operational Area are:

Local Primary Stations:

- KCMB-FM, 104.7 MHZ (Baker City, Baker, Morrow, Umatilla, and Union Counties);
- KJDY-FM, 94.5 MHZ (John Day, Grant County); and
- WVR-FM, 92.1 MHZ (Enterprise, Wallowa County).

State Primary Stations:

- KOBK-FM, 104.7 MHZ, Baker City (OPB Radio Network, also monitors KBOI-AM 690, Boise, PEP station)
- KOJD-FM, 89.7 MHZ, John Day (OPB Radio Network);
- KTVR-FM, 90.3 MHZ, La Grande (OPB Radio Network); and
- KETP-FM, 88.7 MHZ, Enterprise (OPB Radio Network).

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). ARES Districts 3 (Union, Wallowa) and 6 (Baker, Grant) provide service to Region 7. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency Management, n.d.). Union County is the only county in the region with an active ham emergency station. Calls for Region 7 include (American Relay Radio League Oregon Chapter, n.d., www.arrloregon.org):

- Baker County: Vacant;
- Grant County: Vacant;
- Union County: KE7QYU; and
- Wallowa County: Vacant.

Water

Water infrastructure includes drinking water, stormwater, and wastewater systems. All of these systems possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In Region 7 municipal drinking water supply is obtained from both surface and ground sources. In Wallowa and Grant Counties, the majority of municipal drinking water is from wells drawing from the aquifer with cities having water rights for surface water sources as backup sources in late summer. In Grant County, cities draw drinking water equally from a combination of surface and ground sources. Baker City draws its water from mountain springs and is unique in the state because it uses only ultraviolet water treatment without any filtration. Other cities in Baker County depend primarily on groundwater wells for municipal drinking water. Rural residents also obtain water primarily from both surface sources and groundwater wells.

Region 7 is impacted by several threats to water quality and quantity. Low levels of snowpack can lead to severe surface water shortages in a region that is already subject to annual shortages. Low water levels in surface sources can cause stagnation, low flows, and increased mineralization downstream, which negatively impacts water quality. Effluent runoff from feedlots is a lower priority concern for the region's water quality; however, other agricultural products such as pesticides and herbicides leeching into ground and surface water sources is a concern for water quality. High water temperatures are a concern in the region because of impacts to wildlife as well as increases in bacteria levels associated with high surface water temperatures. Riparian improvement projects are being implemented in Grant County to combat the issue of high surface water temperatures. Other concerns for water quality include industrial contamination, diesel spills, chromium, arsenic, iron and sulfur levels.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. Non-point source pollution is a major threat to surface water quality, and may include stormwater runoff from roadways, agricultural operations, timber harvest, erosion and sedimentation. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Landslides, flood events, and earthquakes and resulting liquefaction can cause increased erosion and sedimentation in waterways.

Underground water supplies and aging or outdated infrastructure — such as reservoirs, treatment facilities, and pump stations — can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, limiting access to potable water. This can lead to unsanitary conditions that may threaten human health and limit fire suppression. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enter surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 7, most municipal building codes and stormwater management plans (city and county) emphasize use of centralized storm sewer systems to manage stormwater. Low impact development (LID) mitigation strategies can alleviate or lighten the burden to a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, at lower speed, and at lower temperatures. In Region 7, only Baker City refers to LID techniques in its municipal code, requiring new surface parking areas are required to use LID strategies for stormwater runoff. Requiring decentralized LID stormwater management strategies in the other Region 7 counties could help reduce the burden of new development on storm sewer systems and increase the region's resilience to many types of hazard events.

Infrastructure Trends and Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

Damage or service interruption to roads, bridges, rail systems, and ports can have devastating effects the region's economy. Hazards such as flooding and winter weather can close the highways that connect communities in Region 7 to the rest of the state. Fourteen percent of all bridges in Northeast Oregon are distressed or deficient. Railroads that run through Region 7 support cargo and trade flows, and are vulnerable to icy conditions.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. There are five power-generating facilities located in this region: three hydroelectric, one wind, and one biomass facility. The area is the location of three large dams and hydroelectric projects on the Snake River. LNG is transported through the region via the Northwest Pipeline that runs through Union and Baker Counties.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services may not cover rural areas of the region that are distant from I-84. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Water systems in the region are particularly vulnerable to hazard events because they tend to be older, centralized, and lacking system redundancies. Because most drinking water is sourced from surface water or wells, the region is at risk of high levels of pollutants entering waterways via stormwater runoff or combined sewer overflows (CSO) during high-water events. Older, centralized infrastructure in storm and wastewater infrastructure creates vulnerability in the system during flood events. Baker City is the only community Region 7 that requires low impact development (LID) stormwater management practices in its building code, and it is only required for new surface parking.

Built Environment

Settlement and Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program is 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD, https://www.oregon.gov/lcd/OP/Pages/Goal-7.aspx).

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people, or an "urban cluster" of at least 2,500 people (but less than 50,000). Grant and Wallowa Counties do not meet either definition. Therefore even though both counties contain incorporated cities, the counties are considered 100% rural. Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-672** and **Table 2-673** remain from the 2010 Census.

Statewide, Oregon counties added residents from 2000 to 2010, but several northeast counties lost population over the decade. Baker, Grant, and Wallowa Counties all decreased in population over the 10-year period, a combined population decrease of over 1,300 people. Union County increased by 5% and was the only county to experience growth in both urban and rural areas; however, its rate of urban growth was less than half of the state as a whole. At the city level, La Grande grew the most (+755).

The region's population is clustered around the I-84 corridor and the cities of Baker City, La Grande, John Day, and Enterprise. The population distribution in Region 7 presented in **Figure 2-279**.

Table 2-672. Urban and Rural Populations in Region 7, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	−0.1%
Region 7	23,883	24,427	2.3%	32,549	31,908	−2.0%
Baker	9,605	9,518	−0.9%	7,136	6,616	−7.3%
Grant	0	0	—	7,935	7,445	−6.2%
Union	14,278	14,909	4.4%	10,252	10,839	5.7%
Wallowa	0	0	—	7,226	7,008	−3.0%

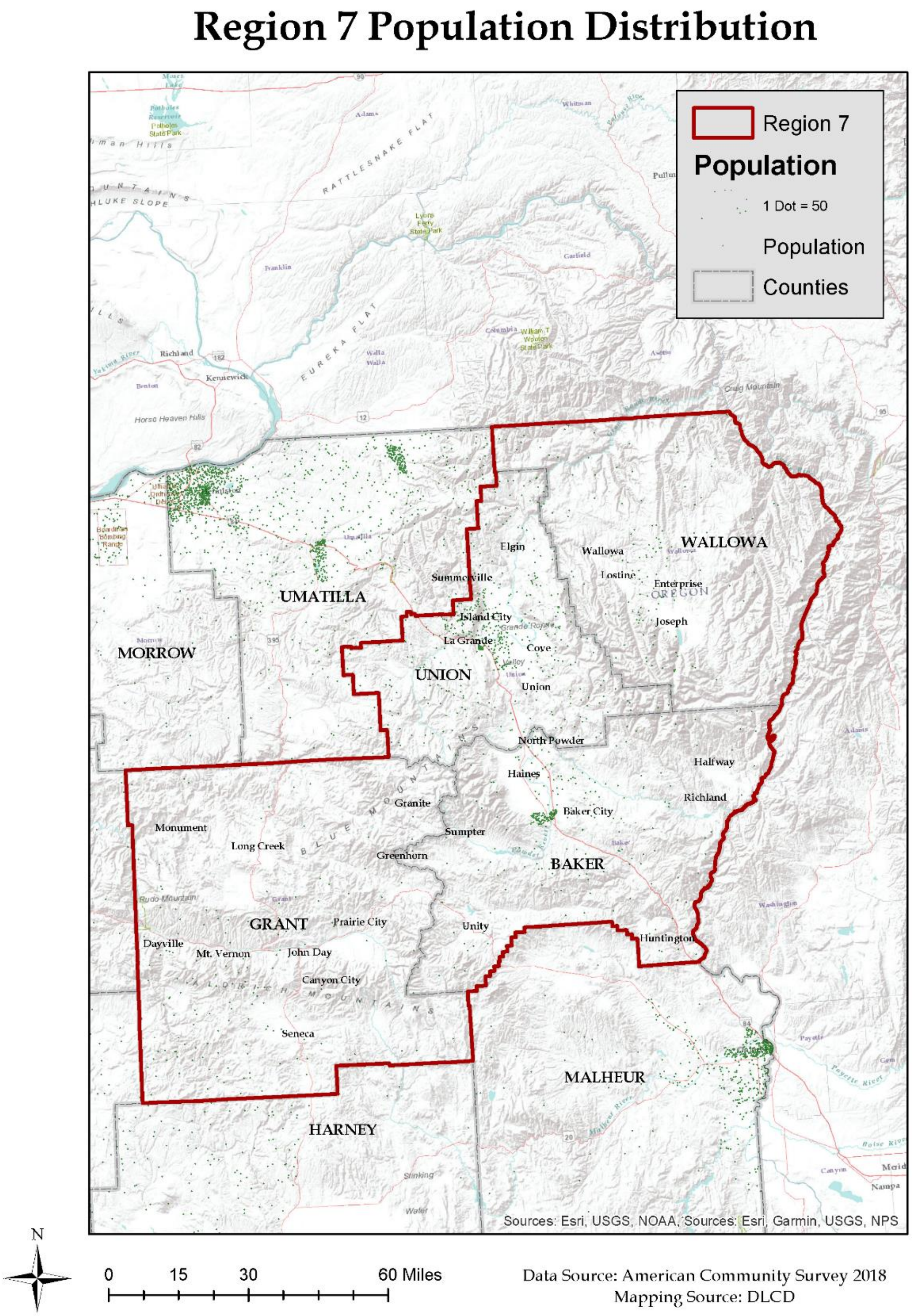
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

Table 2-673. Urban and Rural Housing Units in Region 7, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 7	10,552	11,039	4.6%	16,357	17,728	8.4%
Baker	4,342	4,498	3.6%	4,060	4,328	6.6%
Grant	0	0	—	4,004	4,344	8.5%
Union	6,210	6,541	5.3%	4,393	4,948	12.6%
Wallowa	0	0	—	3,900	4,108	5.3%

Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table H002

Figure 2-280. Region 7 Population Distribution



U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. Table 2-674 provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

Approximately 71% of the region's housing stock is single-family homes. The region's share of multi-family units roughly half that of the state, and over half of those units are in Union County. The region has roughly twice the percentage of manufactured homes as the state, comprising over one-fifth of all homes in Grant County. In natural hazard events such as earthquakes and floods, manufactured housing is more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997).

Table 2-674. Housing Profile for Region 7

	Total Housing Units	Single Family			Multi-Family			Manufactured Homes		
		Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	1,733,041	68.1%	✓	0.3%	23.5%	✓	0.3%	8.2%	✓	0.1%
Region 7	29,184	71.7%	✓	1.5%	11.9%	✓	1.2%	16.2%	✓	1.1%
Baker	8,971	74.3%	✓	2.8%	10.1%	✓	2.0%	15.4%	✓	1.9%
Grant	4,371	70.9%	✓	3.6%	7.6%	⊙	2.1%	21.3%	✓	3.3%
Union	11,684	68.6%	✓	2.6%	16.4%	✓	2.5%	14.9%	✓	1.7%
Wallowa	4,158	75.8%	✓	3.4%	7.9%	⊙	2.0%	16.3%	✓	2.4%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-675. Housing Vacancy in Region 7

	Total Housing Units	Vacant^		
		Estimate	CV**	MOE (+/−)
Oregon	1,733,041	5.6%	☑	0.2%
Region 7	29,184	10.0%	☑	1.1%
Baker	8,971	9.8%	☑	2.0%
Grant	4,371	14.2%	☑	3.1%
Union	11,684	9.2%	☑	1.9%
Wallowa	4,158	8.0%	⊙	2.3%

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.
**Green, orange, and red icons indicate the reliability of each Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table B25004: Vacancy Status

Aside from location and type of housing, the year structures were built (**Table 2-676**) has implications. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as a part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally roughly 35% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances. About 65% of the housing stock was built before 1990 and the codification of seismic building standards. Additionally, as shown in **Table 2-677** Table 2-582, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the late 1970s or mid-1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-676. Age of Housing Stock in Region 7

	Total Housing Units	Pre 1970			1970 to 1989			1990 or Later		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	34.6%	✓	0.3%	30.5%	✓	0.3%	34.9%	✓	0.3%
Region 7	29,184	46.4%	✓	1.9%	29.4%	✓	1.4%	24.2%	✓	1.5%
Baker	8,971	49.8%	✓	3.4%	24.5%	✓	2.4%	25.6%	✓	2.8%
Grant	4,371	44.4%	✓	4.2%	29.1%	✓	3.7%	26.5%	✓	4.4%
Union	11,684	44.6%	✓	3.2%	33.7%	✓	2.5%	21.7%	✓	2.3%
Wallowa	4,158	46.3%	✓	4.6%	28.1%	✓	3.6%	25.6%	✓	3.5%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25034: Year Structure Built, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood, damage is minimized. Table 2-677 shows the initial and current FIRM effective dates for Region 7 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, Flood section.

Table 2-677. Community Flood Map History in Region 7

	Initial FIRM	Current FIRM
Baker County	Feb. 28, 1978	June 3, 1988
Baker City	Apr. 17, 1984	June 3, 1988
Haines	June 3, 1988	June 3, 1988
Halfway	Sept. 24, 1984	June 3, 1988
Huntington	Sept. 24, 1984	June 3, 1988
Sumpter	Sept. 24, 1984	June 3, 1988
Grant County	Feb. 15, 1979	May 18, 1982
Canyon City	Sept. 18, 1987	Sept. 18, 1987
Dayville	Sept. 24, 1984	Sept. 24, 1984 (M)
John Day	Sept. 15, 1977	Feb. 23, 1982
Long Creek	Sept. 24, 1984	Sept. 24, 1984 (M)
Monument	Sept. 24, 1984	Sept. 24, 1984 (M)
Mt. Vernon	Sept. 18, 1987	Sept. 18, 1987
Prairie City	Feb. 17, 1988	Feb. 17, 1988
Seneca	Sept. 24, 1984	Sept. 24, 1984 (M)
Spray	Aug. 16, 1988	Aug. 16, 1988 (M)
Union County	May 15, 1980	Apr. 3, 1996
Elgin	Nov. 15, 1978	Nov. 15, 1978
Island City	Nov. 15, 1978	Sept. 30, 1987
La Grande	Sept. 30, 1980	Apr. 3, 1996
North Powder	Sept. 29, 1978	Sept. 29, 1978
Summerville	Jan. 15, 1980	Jan. 15, 1980 (M)
Union City	Dec. 15, 1978	Dec. 15, 1978
Wallowa County	June 28, 1977	Feb. 17, 1988
Enterprise	Jan. 23, 1976	Feb. 17, 1988
Joseph	Dec. 5, 1975	Feb. 17, 1988
Lostine	Nov. 8, 1975	Feb. 17, 1988
Wallowa City	Apr. 23, 1976	Feb. 17, 1988

(M) = no elevation determined; all Zone A, C, and X.

Source: Federal Emergency Management Agency (2019), Community Status Book Report, https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 7 can be found in **Table 2-678**. The region contains 2.8% of the total value of all local critical facilities and state-owned and –leased critical and non-critical facilities in the state. Cumulatively, these assets are valued just under one billion dollars.

Table 2-678. Value of State-Owned/Leased Critical and Essential Facilities in Region 7

	Value of Local and State-Owned/Leased Facilities				
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$ 2,630,306,288	$ 4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 7	$ 72,202,434	$ 114,770,863	$ 751,328,457	$ 938,301,754	2.8%
Baker	$ 32,216,676	$ 48,506,064	$ 297,807,305	$ 378,530,045	1.1%
Grant	$ 15,504,203	$ 8,362,045	$ 132,496,852	$ 156,363,100	0.5%
Union	$ 14,518,090	$ 54,186,535	$ 240,787,950	$ 309,492,575	0.9%
Wallowa	$ 9,963,465	$ 3,716,219	$ 80,236,350	$ 93,916,034	0.3%

Source: DOGAMI, 2020

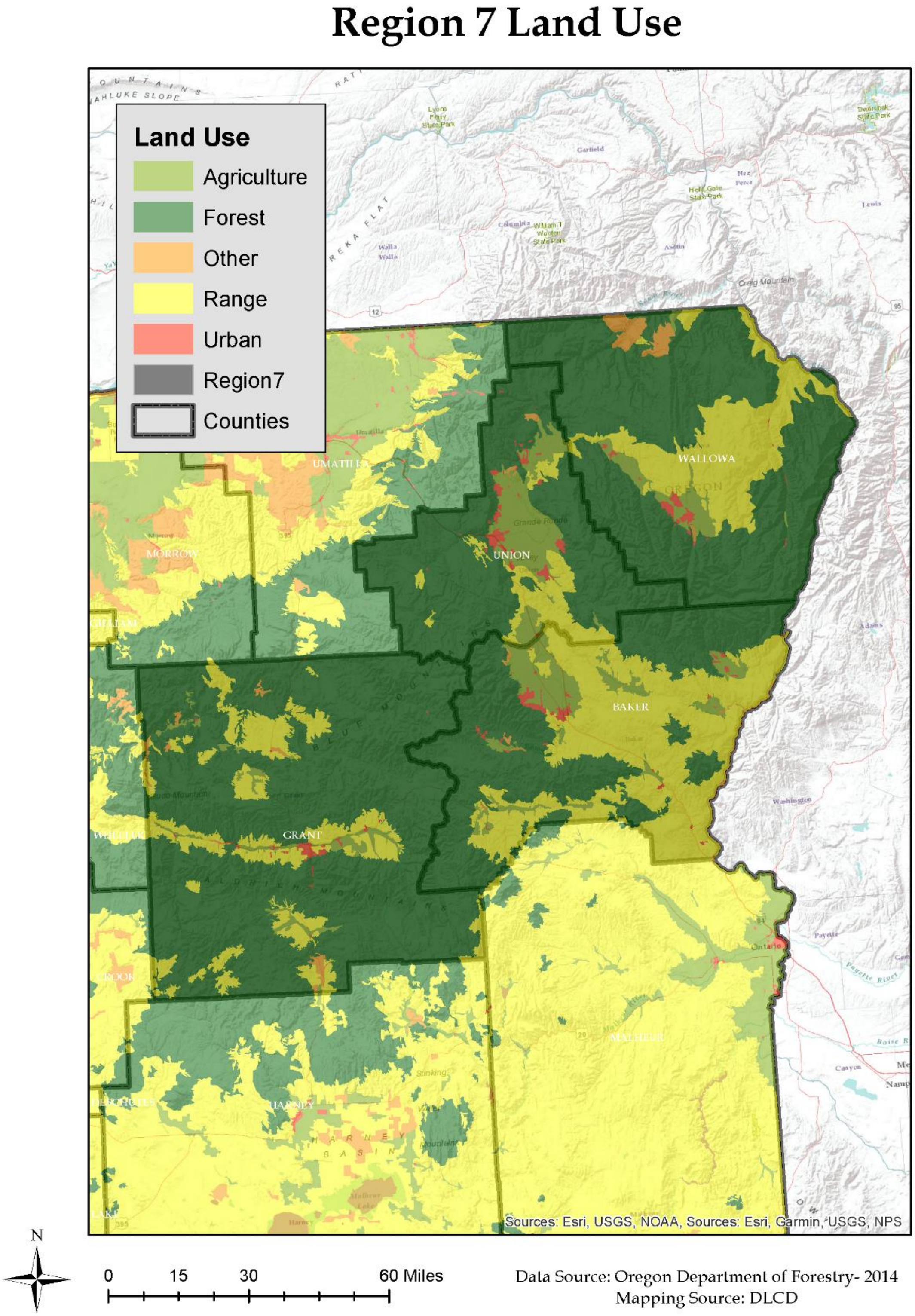
Land Use Patterns

Private land generally has developed more slowly in Eastern Oregon than in Western Oregon between 1974 and 2009. State and local programs have been successful in limiting rural residential and urban development and maintaining large parcel sizes. Demand for large-scale development in this part of the state has historically been very low. The federal government owns over half of the land in Region 7, 55.7%. Approximately 43.5% is held privately and the state owns roughly 1%.

According to the Oregon Department of Forestry's most recent land-use study, "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray , Hubner , McKay, & Thompson , 2016). In Region 7, approximately 557 acres of resource lands were converted to more urban uses during the six-year period. **Table 2-679** shows that during the six-year period, the percentage of resource lands converted in each county in Region 7 was less than one percent of each county's total acreage. During this period, the amount of conversion was fairly consistent across all counties in the region.

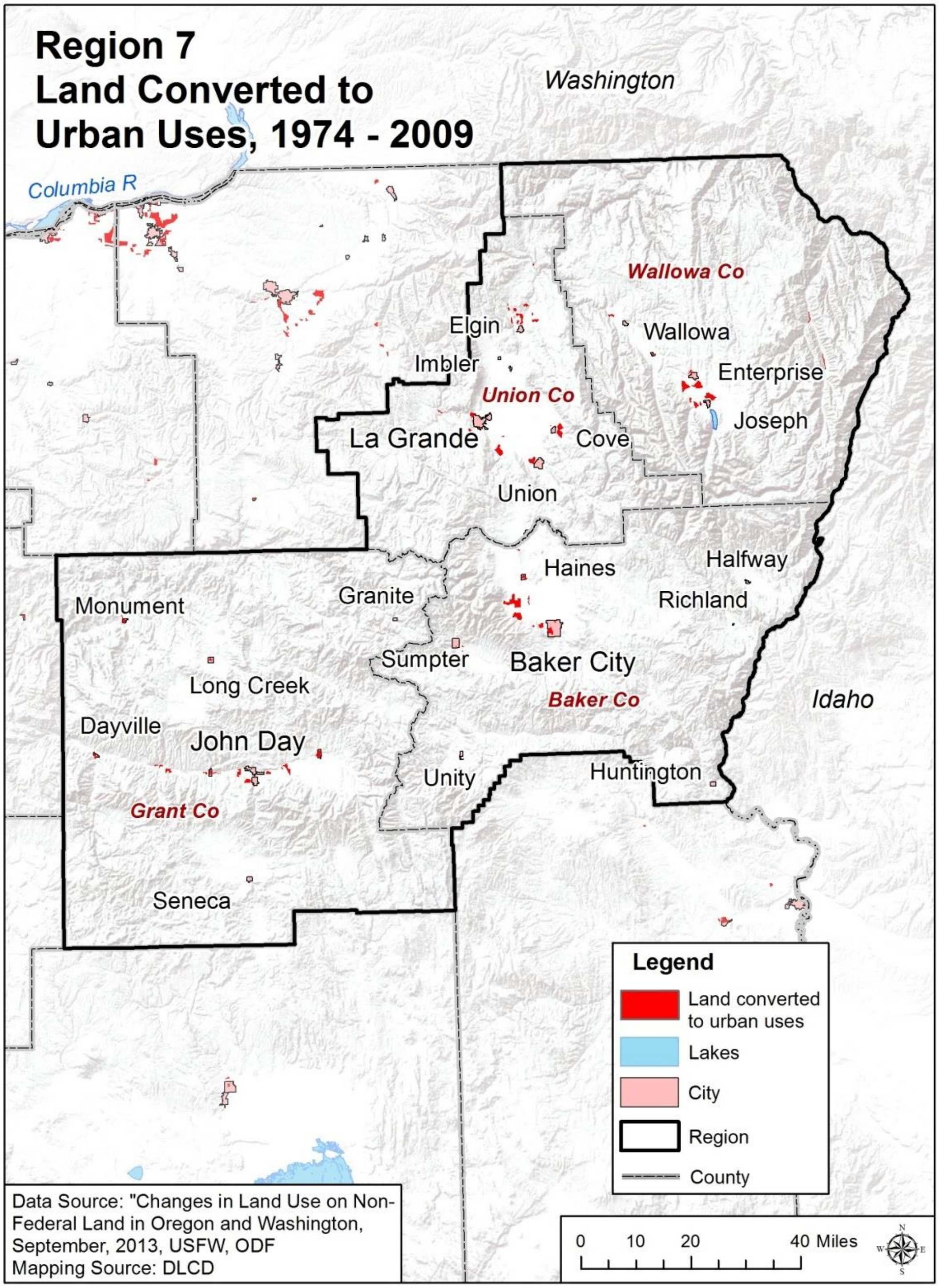
To the extent it has occurred, development has generally been located along existing transportation corridors. Nearly half of the people in Region 7 reside in the cities of Baker City, John Day, La Grande, and Enterprise, and most unincorporated development in this region is located along the I-84 corridor.

Figure 2-281. Region 7 Land Use



Source: Oregon Department of Forestry, 2014

Figure 2-282. Region 7 Land Converted to Urban Uses, 1974–2009



Source: Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

Table 2-679. Region 7 Resource Lands Converted to Urban Uses, 2009-2014

	Lost Resource Lands 2009-2014		
	Total Resource Acres (2009)	**Acres Converted to Urban Use**	**Percent Converted**
Region 7	3,571,459	557	0.02%
Wallowa	839,856	139	0.02%
Union	655,563	122	0.02%
Baker	947,459	185	0.02%
Grant	1,128,581	111	0.01%

Source: Oregon Department of Forestry, 2014; Oregon Department of Land Conservation and Development, 2020

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 7 is largely a rural county with urban development focused along I-84 and around the population centers of Baker City, Enterprise, John Day, and La Grande. Population growth in the region was mostly stagnant from 2010-2018, and all but Union County is forecast to experience population decline over the next decade. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion. Please refer to the Region 7 Risk Assessment **Demography** section for more information on population trends and forecast.

All counties in the region have higher percentages of manufactured homes compared to statewide numbers. Notably, about one fifth of all housing units in Grant County are manufactured structures. Almost half the homes in the region were built before 1970 and floodplain management standards, and at least three-quarters were built before 1990 and current seismic building standards. None of the region’s FIRMs have been modernized or updated; FEMA has recently begun a Risk MAP Discovery process in Grant and Baker Counties.

2.3.7.3 Hazards and Vulnerability

Droughts

Characteristics

Drought is a common occurrence in the northeastern portion of the state. Every county in Region 7 has been impacted by drought on several occasions during the last 20 years. Together, winter snowpack and spring rains provide water for meeting a variety of needs. Extended drought conditions in this region can result in increased fire danger as well as in significant losses for the agriculture and tourism industries and therefore to the local economy.

Baker County has been under an emergency drought declaration eight times and is considered one of the communities most vulnerable to drought conditions.

High temperatures and low precipitation accompanying drought conditions reduce soil moisture, dry vegetation, and tend to enhance winds. These conditions can increase the amount of soil entrained by high winds, particularly in semi-arid regions where temperatures are increasing and precipitation is decreasing, and where areas of substantial land disturbance and development is occurring. Therefore, during extended dry and drought conditions, productive soils are vulnerable to loss, further impacting agriculture.

Historic Drought Events

Table 2-680. Historic Droughts in Region 7

Year	Location	Description
1938-1939	statewide	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country
1977	N & S central Oregon; eastern Oregon	a severe drought for northeast Oregon
1994	Regions 4–8	in 1994, Governor's drought declaration covered 11 counties located within regions 4, 5, 6, 7, and 8
2002	southern and eastern Oregon	2001 drought declarations remain in effect for all counties, including Region 7's Baker, Union, and Wallowa Counties; Governor adds Grant County in 2002, along with five additional counties, bringing statewide total to 23 counties under a drought emergency.
2003	southern and eastern Oregon	Grant County 2002 declaration remains in effect through June 2003; Governor issues new declarations for Baker, Union, and Wallowa Counties, which are in effect through December 2003
2004	Region 5–8	Baker County receives Governor-declared drought emergency on June 2004, along with three other counties in neighboring regions
2005	Regions 5–7; 13 counties affected	Baker and Wallowa County receive a Governor drought declaration; all Region 5 counties affected, and most of Region 6 affected
2007	Regions 6–8	Grant, Baker, and Union Counties receive a Governor drought declaration; three other counties affected in neighboring regions
2013	Regions 5-8	Baker County receives a drought declaration, as well as four other counties in neighboring regions
2014	Regions 4, 6–8	Grant and Baker County receive drought declarations, including eight other counties in other regions
2015	statewide	36 Oregon Counties across the state receive federal drought declarations, including 25 under Governor's drought declaration
2018	Regions 1, 4-8	Baker and Grant County receive Governor's drought declarations, including 9 other counties in 5 other regions

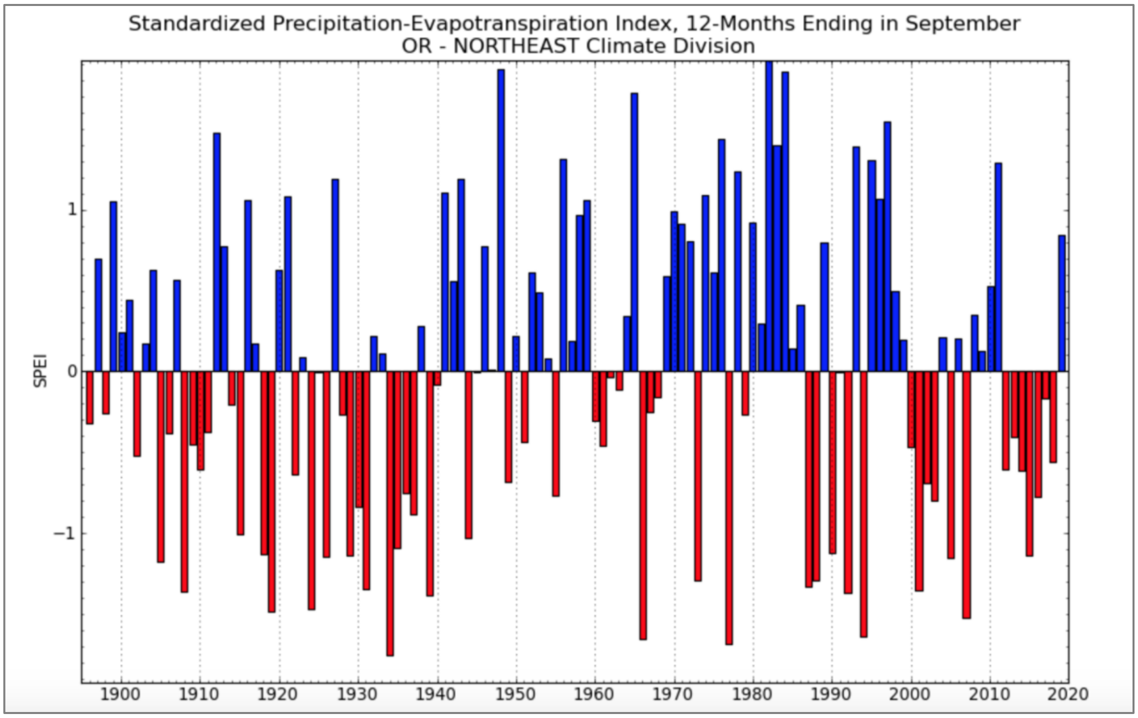
Sources: Taylor and Hatton (1999). The Oregon Weather Book: State of Extremes, and the Oregon Secretary of State's Archives Division. NOAA's Climate at a Glance. Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt. Personal Communication, Kathie Dello, Oregon Climate Service, Oregon State University.

Historic drought information can be obtained from the West Wide Drought Tracker, which provides historical climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. Figure 2-283 shows years where drought or dry conditions affected the north eastern area of Oregon (Climate Division 8).

Based on this index, 1934, 1966, 1977, 1994, and 2007 were severe drought years, while more than a dozen years in this record were moderate drought years.

U.S Climate Divisions

Figure 2-283. Standard Precipitation-Evapotranspiration Index for Region 7



Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-681. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 8 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
1919	1934	
1924	1977	
1939	1966	
1992	1994	
1908	2007	
2001		
1931		
1987		
1973		
1988		
1905		
1926		
2005		
1929		
2015		
1918		
1990		
1935		
1944		
1915		

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Probability

Table 2-682. Probability of Drought in Region 7

	Baker	Grant	Wallowa	Union
Probability	VH	H	M	M

Source: OWRD, DLCD

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases.

Oregon has yet to undertake a comprehensive risk analysis for drought on a statewide basis, to determine probability or vulnerability for a given community. Considering historical statewide droughts and the number of drought declarations made in recent years, it is reasonable to assume that it is very likely that Region 7 will experience drought in the near future. Baker County has been under an emergency drought declaration on eleven different occasions or in 48% of the years since 1992: 1992, 2001 (remained in effect during 2002), 2003, 2004, 2005, 2007, 2013, 2014, 2015, and 2018. This is only second to Klamath County in Region 6. Grant has received drought declarations in 24% of these years, Union in 21%, and Wallowa in 17%. This accounts for their different probability ratings.

Climate Change

Drought is common in northeast Oregon. Climate models project warmer, drier summers for Oregon, including Region 7. These summer conditions coupled with projected decreases in mid-to-low elevation mountain snowpack due to warmer winter temperatures increases the likelihood that Region 7 would experience increased frequency of one or more types of drought under future climate change. In Region 7, climate change would result in increased frequency of drought due to low spring snowpack (very likely, >90%), low summer runoff (likely, >66%), and low summer precipitation and low summer soil moisture (more likely than not, >50%). In addition, Region 7, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-683. Local Assessment of Vulnerability to Drought in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	H	H	M	M

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-684. State Assessment of Vulnerability to Drought in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	M	M	L	L

Source: OWRD, DLCD

Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms. There is no single comprehensive source or other sources for information to assess economic impacts.

Oregon has not undertaken a comprehensive statewide analysis to identify which communities are most vulnerable to drought. However, Baker and Grant Counties are vulnerable to and have experienced wildfire connected with drought conditions.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

All the counties rated low in social vulnerability except Grant, which rated very low. Vulnerability to wildfire as a result of drought has been taken into account in these ratings. Baker and Grant Counties are the communities most vulnerable to drought in Region 7.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 7 is approximately $186,973,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $751,328,000. Because drought could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records how many losses to state facilities were sustained in Region 7 since the beginning of 2015. Nevertheless, none of the recorded losses was due to drought.

Risk

Table 2-685. Risk of Drought in Region 7

	Baker	Grant	Wallowa	Union
Risk	H	H	M	M

Source: OWRD, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based on the probability of drought and vulnerability to it, risk of drought in Region 7 is considered high in Baker and Grant Counties and moderate in Union and Wallowa Counties.

Earthquakes

Characteristics

The geographic position of this region makes it susceptible to earthquakes from two sources: (a) shallow crustal events within the North America Plate, and (b) volcanic-earthquakes.

Region 7 contains high mountains and broad valleys. Although there is abundant evidence of faulting, seismic activity is low when compared with other areas of the state. Baker County probably has the most recorded seismic activity in the region. Not surprisingly, it appears to occur in the vicinity of Hells Canyon, an area with a complex geologic history. Several significant earthquakes have occurred in the region: the 1913 Hells Canyon; the 1927 and 1942 Pine Valley–Mountain; the 1965 John Day (M4.4); and the 1965 and 1966 Halfway (M4.3 and 4.2) (**Table 2-686**).

There are also a few identified faults in Union County that have been active in the last 20,000 years. The region has also been shaken historically by crustal earthquakes and prehistorically by subduction zone earthquakes centered outside the area (**Table 2-686**). All considered, there is good reason to believe that the most devastating future earthquakes in Region 7 would probably originate along shallow crustal faults.

Historic Earthquake Events

Table 2-686. Significant Earthquakes Affecting Region 7

Date	Location	Magnitude	Remarks
Approximate Years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	offshore, Cascadia Subduction Zone	probably 8-9	these are the mid-points of the age ranges for these six events
Jan. 1700	offshore, Cascadia Subduction Zone	about 9.0	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Oct. 1913	Hells Canyon, Oregon	VI	damage unknown
Apr. 1927	Pine Valley-Cuddy Mountain, Oregon	V	damage unknown
June 1942	Pine Valley-Cuddy Mountain, Oregon	V	damage minor
Aug. 1965	John Day, Oregon	4.4	damage unknown
Nov. 1965	Halfway, Oregon	4.3	damage unknown
Dec. 1966	Halfway, Oregon	4.2	damage unknown

Note: No significant earthquakes have affected Region 7 since December 1966.

*BCE: Before Common Era.

Sources: University of Washington. List of Magnitude 4.0 or Larger Earthquakes in Washington and Oregon 1872-2002; Wong & Bott (1995); Pacific Northwest Seismic Network, https://pnsn.org/

Probability

Table 2-687. Assessment of Earthquake Probability in Region 7

	Baker	Grant	Wallowa	Union
Probability	M	M	L	L

Source: DOGAMI, 2020

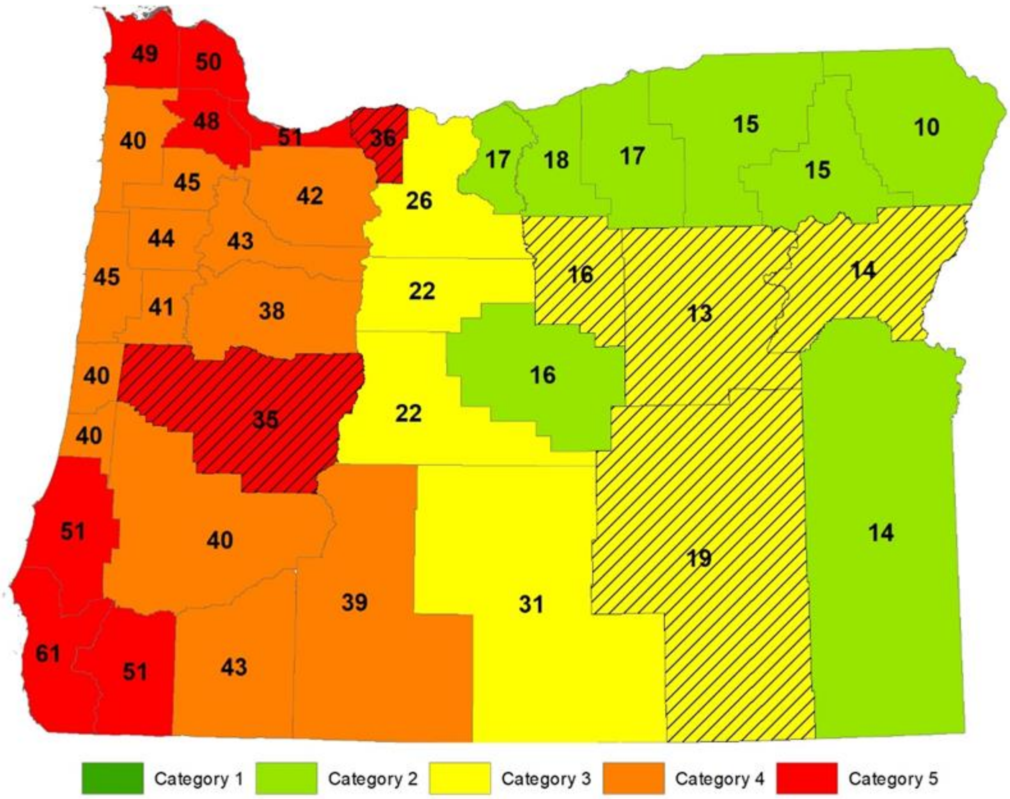
The probability of damaging earthquakes varies widely across the state. In Region 7, the hazard is dominated by local faults and background seismicity.

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-284**.

Figure 2-284. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.

Source: DOGAMI, 2020

Vulnerability

Table 2-688. Local Assessment of Vulnerability to Earthquakes in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	H	M	H	L

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-689. State Assessment of Vulnerability to Earthquakes in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	L	VL	M	L

Source: DOGAMI and DLCD, 2020

Region 7 is considered moderately vulnerable to earthquake hazards due to earthquake-induced landslides, liquefaction, and ground shaking.

In 2007, DOGAMI (Lewis, 2007) completed a rapid visual screening (RVS) of educational and emergency facilities in communities across Oregon, as directed by the Oregon Legislature in Senate Bill 2 (2005). RVS is a technique used by the Federal Emergency Management Agency (FEMA), known as FEMA 154, to identify, inventory, and rank buildings that are potentially vulnerable to seismic events. DOGAMI surveyed a total of 3,349 buildings, giving each a 'low,' 'moderate,' 'high,' or 'very high' potential of collapse in the event of an earthquake. It is important to note that these rankings represent a probability of collapse based on limited observed and analytical data and are therefore *approximate* rankings (Lewis, 2007). To fully assess a building's potential of collapse, a more detailed engineering study completed by a qualified professional is required, but the RVS study can help prioritize buildings for further study. Results are found in **Table 2-690**, **Table 2-691**, and **Table 2-692**.

Table 2-690 shows the number of school and emergency response buildings surveyed in each county with their respective rankings.

Table 2-690. Buildings with Their Collapse Potential in Region 7

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Baker	4	15	6	8
Grant	12	2	15	17
Union	10	6	14	24
Wallowa	10	2	10	3

Source: Lewis (2007)

Table 2-691. Projected Dollar Losses in Region 7, Based on an M8.5 Subduction Event and a 500-Year Model

	Economic Bae in Thousands (1999)	Greatest Absolute Loss in Thousands (1999) from a (M) 8.5 CSZ Event	Greatest Absolute Loss in Thousands (1999) from a 500-Year Event
Baker County	$943,000	less than $1,000	$13,000
Grant County	$415,000	less than $1,000	$3,000
Union County	$1,237,000	less than $1,000	$9,000
Wallowa County	$444,000	less than $1,000	$8,000

Source: Wang & Clark (1999)

Table 2-692. Estimated Losses in Region 7 Associated with a 500-Year Model

	Baker	Grant	Union	Wallowa	Remarks
Injuries	3	0	1	1	
Deaths	0	0	0	0	
Displaced households	10	0	1	1	
Operational the day after the quake[1]:					
Fire stations	N/A	N/A	N/A	N/A	
Police stations	N/A	N/A	N/A	N/A	
Bridges	N/A	N/A	N/A	N/A	
Economic losses to:					
Highways	$5 m	$3 m	$1 m	0	
Airports	$2 m	$2 m	$618,000	$3 m	
Communications	$1,000	$469,900	$$479,000	$116,000	
Debris generated (thousands of tons)	8	1	5	4	

Notes: "m" is million

The Hazus run that produced the data in this table did not account for unreinforced masonry buildings.

[1]The 500-year model includes several earthquakes; the number of facilities operational the day after the earthquake cannot be calculated.

Source: Wang & Clark (1999)

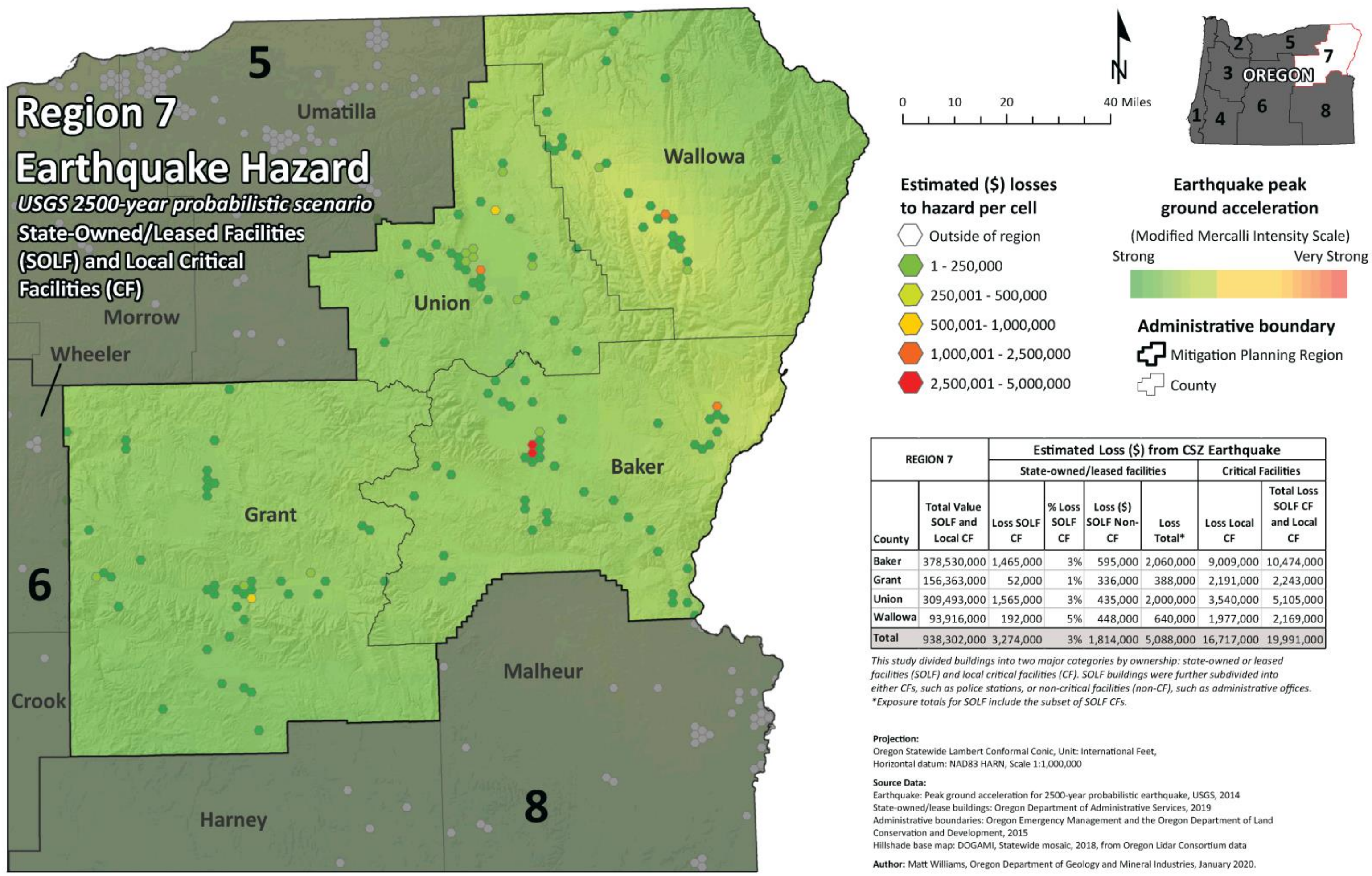
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a 2500-year probabilistic earthquake scenario in Region 7. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 7, a 2500-year probabilistic earthquake scenario could generate a potential loss of over $5M in state building and critical facility assets. Baker and Union Counties each contain about 40% percent of the value of those assets. The potential loss in local critical facilities is more than triple that amount, over $16.7M. Baker County again would suffer the greatest loss with 54% of the value of local critical facilities. **Figure 2-285** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a 2500-year probabilistic earthquake scenario.

Figure 2-285. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in an Earthquake Hazard Zone in Region 7.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 7		Estimated Loss ($) from CSZ Earthquake					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*	Loss Local CF	Total Loss SOLF CF and Local CF
Baker	378,530,000	1,465,000	3%	595,000	2,060,000	9,009,000	10,474,000
Grant	156,363,000	52,000	1%	336,000	388,000	2,191,000	2,243,000
Union	309,493,000	1,565,000	3%	435,000	2,000,000	3,540,000	5,105,000
Wallowa	93,916,000	192,000	5%	448,000	640,000	1,977,000	2,169,000
Total	938,302,000	3,274,000	3%	1,814,000	5,088,000	16,717,000	19,991,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,000,000

Source Data:
Earthquake: Peak ground acceleration for 2500-year probabilistic earthquake, USGS, 2014
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI

Historic Resources

Of the 1,246 historic resources in Region 7, only 6 are in an area of high or very high liquefaction potential, all of them in Grant County. However, 1,074 (86%) of Region 7's historic resources are located in areas of high or very high potential for ground shaking amplification. Of these, roughly a quarter is located in each county.

Archaeological Resources

Six thousand eight hundred ten archaeological resources are located in earthquake hazard areas in Region 7. Of those, eight are located in an area of high earthquake hazards. None are listed on the National Register of Historic Places and only one is eligible for listing. One has been determined not eligible and six have not been evaluated as to their potential for listing. Most archaeological resources in earthquake hazard areas in Region 7 are located in Grant County, followed by Baker and Wallowa.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Wallowa County is the most vulnerable to earthquakes in Region 7, but only moderately vulnerable.

Seismic Lifelines

According to the Oregon Department of Transportation's (ODOT) Oregon Seismic Lifeline Report (OSLR; see Appendix **9.1.16**), the projected impacts of a CSZ event are considered negligible in this part of the state. Therefore, this region was not part of the OSLR study. However, ODOT did provide the following descriptions of general impacts a CSZ would have on Region 8's seismic lifelines, and the region's overall vulnerability.

Regional Impact. Within this region, adverse impacts from the CSZ event and secondary hazards (landslides, liquefaction, etc.) are not anticipated, but damage to I-84 to the west and damage to the Columbia River's freight functions could impact the region's economy.

Regional Loss Estimates. Losses in this region are expected to be nonexistent to low locally. Economic disruption from major losses in the larger markets of the state will affect the economy in this region.

Most Vulnerable Jurisdictions. Vulnerability of this whole region to a CSZ event is low. Loss of life, property, and business are not expected to be issues in this area. However, impacts to import and export infrastructure and basic supply lines could have short- to mid-term economic impacts. With an intact surface transportation system to the east, adaptation is expected to be relatively easy.

Risk

Table 2-693. Assessment of Earthquake Risk in Region 7

	Baker	Grant	Wallowa	Union
Risk	M	VL	L	M

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Wallowa County is at greatest risk from earthquakes in Region 7, but that risk is moderate.

Extreme Heat

Characteristics

Extreme temperatures are moderately common in Region 7 and the frequency of prolonged periods of high temperatures has increased. Wallowa County has an average of about 23 days per year above 90°F.

Historic Extreme Heat Events

Table 2-694. Historic Extreme Heat Events in Region 7

Date	Location	Notes
July 10–14, 2002	Region 5–7	A record breaking heat wave shattered many daily record high temperatures across the state, with a few locations breaking all-time records.
July 20-24, 2006	Region 1–3, 5, 7	An unusually strong ridge of high pressure brought several days of record breaking hot and humid weather to NW Oregon. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row. Many daily maximums were between 10 and 20 degrees above normal. A few sites reported record high minimum temperatures during this very humid event; a couple broke all-time record high minimums as well. 4500 homes lost power during this event. In north central and eastern Oregon, daily maximum temperatures between 100 and 113 degrees were observed at lower elevations, with temperatures 90 to 100 degrees at elevations up to 4000 feet. Several people were treated for heat related illness.
June 28–30, 2008	Region 2, 3, 5, 7	An upper level ridge and thermal trough across the Pacific Northwest produced temperatures above 100 degrees for two consecutive days breaking records in many locations. Two people died of heat-related illness.
August 15–17, 2008	Region 5–7	Excessive Heat Event: An upper level ridge and dry air brought excessive heat into eastern Oregon. Many locations experienced multiple days of at least 100 degree temperatures.
July 25–26, 2010	Region 5, 7	Excessive Heat Event: Temperatures topped 100 degrees for two successive days in Hermiston, Pendleton, 5 miles northeast of Pendleton, Ione, Echo, Arlington, and Umatilla.

Source: https://www.ncdc.noaa.gov/stormevents

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning “very low.” Region 7 relative probability rankings are shown in **Table 2-695**.

Table 2-695. Probability of Extreme Heat in Region 7

	Baker	Grant	Union	Wallowa
Probability	H	L	L	L

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Region 7 experiences some extreme high temperatures and is projected to experience greater frequency of extreme temperatures under future climate change. **Table 2-696** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 7.

Table 2-696. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 7 Counties

County	Historic Baseline	2050s Future
Baker	5	27
Grant	3	21
Union	3	20
Wallowa	4	21

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

Vulnerability

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, Extreme Heat. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are house-less.

Although extreme heat is moderately rare in Region 7 (“low” probability), many people may not be accustomed or prepared in terms of air conditioning when an extreme heat event occurs (“moderate” adaptive capacity). In Cooling Zones 1 and 2, which include Region 7 counties, just over half of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1–2 earned a ranking of 1 (very low); scores of 3–4 earned a ranking of 2 (low); scores of 5–6 earned a ranking of 3 (moderate); scores of 7–8 earned a ranking of 4 (high); and scores of 9–10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-697 displays the total vulnerability rankings as well as ranking for sensitivity and adaptive capacity for each county in NHMP Region 7. Table 2-698 provides the summary descriptors of Region 7's vulnerability.

Combining sensitivity and adaptive capacity, Region 7's relative vulnerability to extreme heat is "Moderate." Grant County's is "Low." None of the counties in Region 7 are most vulnerable to extreme heat.

Table 2-697. Relative Vulnerability Rankings for Region 7 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 7	**2**	**3**	**3**
Baker	2	3	3
Grant	1	3	2
Union	2	3	3
Wallowa	2	3	3

Source: Oregon Climate Change Research Institute

Table 2-698. Vulnerability to Extreme Heat in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	M	L	M	M

Source: Oregon Climate Change Research Institute

Region 7 counties did not rank vulnerability to extreme heat.

As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. High temperature and insufficient water stunt plant growth and cause areas of crops to wither. Some livestock, especially dairy cattle, are also sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms.

Also like drought, impacts of drought on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. However, the appropriate data are not available to assess impacts of heat waves on agriculture and subsequent effects on the state economy.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 7 is approximately $186,973,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $751,328,000. Because extreme heat could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records how many losses to state facilities were sustained in Region 7 since the beginning of 2015. Nevertheless, none of the recorded losses was due to extreme heat.

Risk

With respect to extreme heat, risk is defined as the combination of exposure to extreme heat events (probability), sensitivity to extreme heat, and level of adaptive capacity in response to extreme heat.

The total relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total risk scores of 1-2 earned a ranking of 1 ("very low"); scores of 3-4 earned a ranking of 2 ("low"); scores of 5-6 earned a ranking of 3 ("moderate"); scores of 7-8 earned a ranking of 4 ("high"); and scores of 9-10 earned a ranking of 5 ("very high"). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-699 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 7. Table 2-700 provides the summary descriptors of Region 7's risk to extreme heat.

Combining probability and vulnerability, Region 7's relative risk to extreme heat is "Moderate." Baker County's is "High."

Table 2-699. Risk Rankings for Region 7 Counties

County	Probability	Vulnerability	Risk
Region 7	**3**	**3**	**3**
Baker	4	3	4
Grant	2	2	2
Union	2	3	3
Wallowa	2	3	3

Source: Oregon Climate Change Research Institute

Table 2-700. Risk of Extreme Heat in Region 7

	Baker	Grant	Union	Wallowa
Risk	H	L	M	M

Source: Oregon Climate Change Research Institute

Floods

Characteristics

The Blue Mountain area of northeastern Oregon is quite distinct from the rest of the state in landform and climate. Nevertheless, its principal flood problems are similar to those found elsewhere in Oregon. The most damaging floods have occurred during the winter months, when warm rains from tropical latitudes melt mountain snowpacks. Such conditions were especially noteworthy in February 1957, February 1963, December 1964, January 1965 and April 2019. Somewhat lesser flooding has been associated with ice jams, normal spring runoff, and summer thunderstorms. Heavily vegetated stream banks, low stream gradients (e.g., Grande Ronde Valley), and breeched dikes have contributed to past flooding at considerable economic cost. Region 7 counties also have experienced flooding associated with low bridge clearances, over-topped irrigation ditches, and natural stream constrictions such as Rhinehart Gorge between Elgin and Imbler in Union County.

Oregon's most severe flooding occurs between November and February and most floods are associated with a period of intense warm rain on a heavy mountain snowpack. These periods of flooding coincide with La Niña conditions during the winter months when very moist subtropical air follows a heavy, wet snowfall. Climate records indicate that La Niña conditions occur on average about every 3 to 6 years with the period from 1975-1994 having exhibited a long El Niño period.

The National Weather Service predicts that an ENSO-neutral condition is favored through Northern Hemisphere spring 2020 (~60% chance), continuing through summer 2020 (~50% chance). A historical overview of flooding in Oregon's Region 7 is shown in **Table 2-701**. Table 2 461 lists flood sources for each of the counties in the region.

All of the Region 7 counties have Flood Insurance Rate Maps (FIRMs); however, old maps do not reflect present flood conditions. The most recent FIRMs are as follows:

- Baker, June 3, 1988;
- Grant, May 18, 1982;
- Union, April 3, 1996; and
- Wallowa, February 17, 1988.

Updated lidar is anticipated for Grant County during 2020.

Historic Flood Events

Table 2-701. Significant Historic Floods Affecting Region 7

Date	Location	Description	Type of Flood
1894*	NE Oregon	widespread flooding	not recorded
1910*	NE Oregon	widespread flooding	not recorded
1917*	NE Oregon	widespread flooding	not recorded
1932*	NE Oregon	widespread flooding	not recorded
1935*	NE Oregon	widespread flooding	not recorded
May 1948	Columbia Basin / NE Oregon	unusually large mountain snow melt produced widespread flooding	snow melt

Date	Location	Description	Type of Flood
Dec. 1955 – Jan. 1956	Snake and Columbia basins	warm rain melted snow; runoff on frozen ground	rain on snow
Dec. 1964	entire state	widespread, very destructive flooding; warm rain, melted snow; runoff on frozen ground	rain on snow
Jan. 1974	much of state	warm rain / melted snow / runoff on frozen ground	rain on snow
Feb. 1986	entire state	warm rain / melted snow / runoff on frozen ground	rain on snow
June 1986	Wallowa County	severe thunderstorm / rain and hail / flash flooding	thunderstorm
May 1991	Union and Baker Counties	warm rain / melted snow; considerable damage to cropland and highways; a number of bridges destroyed	rain on snow
May 1998	eastern and central Oregon	persistent rains; widespread damage	rain on snow
July 2004	Union	$5,000 in property damage	
May 2008	Union and Wallowa Counties	flooding along Catherine Creek and Grande Ronde River damaged roads in Union County, causing $30,000 in damages; in Wallowa County the Imnaha River crested above flood stage	rain on snow
May 2011	Grant and Union Counties	heavy rainfall on above-average snowpack caused flooding to low lying areas of Grant and Union Counties; over $2.6 in property damage	rain on snow
March 2014	Union and Grant Counties	Heavy rain fell across much of the northern Blue Mountains and Wallowa County throughout the first week of March. March 9th received very heavy rain with snow levels around 6000ft. This allowed for a significant increase in runoff, which lead to a quick rise in rivers for the period	rain on snow
March 2017	Wallowa County	An extended period of snow melt, combined with a period of heavy rain, caused an extended period of flooding along portions of the Grande Ronde River.	rain on snow
May 2017	Wallowa County	Two hikers were injured in the flash flood. In Wallowa County the Imnaha River at Imnaha had minor flooding early on May 6th, due to snow melt.	flash flood
Sept. 2017	Baker County	Thunderstorms producing heavy rain over the 2016 Rail Fire burned area on the Wallowa-Whitman National Forest resulted in flash flooding and debris flows.	flood after fire
May 2018	Grant and Wallowa Counties	Heavy rain from slow moving thunderstorms caused rock slides and water on roadways within an area that includes Mount Vernon, John Day and Canyon City	flash flood
June 2018	Baker County	Thunderstorms with heavy rainfall developed over Southwest Baker County, Oregon on June 20th, leading to flash flooding and debris flow on the Rail and Cornet-Windy Ridge fires burn scar areas.	flood after fire

Date	Location	Description	Type of Flood
April 2019	Union, Grant, and Wallowa Counties	Snow water equivalents near 200% of normal in the Blue Mountains coupled with warm temperatures and near record rainfall totals for April produced significant river flooding across eastern Oregon. Disaster declared in Grant county (DR-4452)	rain on snow
Feb. 2020	Umatilla, Union, Wallowa	DR-4519: severe storms, flooding, landslides, and mudslides	

Source: Taylor and Hatton (1999); FEMA, Baker County Flood Insurance Study (FIS), 06/03/88; FEMA, Grant County Flood Insurance Study (FIS) 05/18/82; FEMA, Union County Flood Insurance Study (FIS), 04/03/96; FEMA, Wallowa County Flood Insurance Study (FIS), 02/17/88; Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; NOAA Storm Event Database, available from https://www.ncdc.noaa.gov/stormevents/ consulted January 2020

Table 2-702. Principal Flood Sources by County in Region 7

Baker County	Grant County	Union County	Wallowa County
Powder River	North Fork John Day River	Grande Ronde River	Wallowa River
Old Settler's Slough	South Fork John Day River	Catherine Creek	Minam River
Pine Creek	Middle Fork John Day River	North Powder River	Lostine River
Eagle Creek	Canyon Creek	Little Creek	Grande Ronde River
Summit Creek	Cottonwood Creek	Gekeler Slough	Wenaha River
Rock Creek	Prairie Creek	Taylor Creek	Imnaha River
Mill Creek		Fresno Creek	Hurricane Creek
Marble Creek		Clark Creek	Prairie Creek
Stices Gulch		Indian Creek	
Snake River		Wolf Creek	
Burnt River			

Sources: FEMA, Baker County Flood Insurance Study (FIS), 06/03/88; FEMA, Grant County Flood Insurance Study (FIS) 05/18/82; FEMA, Union County Flood Insurance Study (FIS), 04/03/96; FEMA, Wallowa County Flood Insurance Study (FIS), 02/17/88.

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the "OEM Hazard Analysis Methodology" used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in Appendix **9.1.19**.

The purpose of the probability and vulnerability scores is to identify high-priority areas to which local and state governments can target mitigation actions.

Probability

Local Assessment

Participants in each county's Natural Hazard Mitigation Plan update process used the OEM hazard analysis methodology to analyze the probability that Region 7 will experience flooding. The resulting estimates of probability are shown in **Table 2-703**.

Table 2-703. Local Assessment of Flood Probability in Region 7

	Baker	Grant	Union	Wallowa
Probability	H	H	H	H

Note: Assessment of flood probability for Grant and Baker Counties date from meetings held in 2019 during the NHMP update process. Assessments for Wallowa and Union county date from the 2014 Northeast Oregon Multi-Jurisdictional NHMP

Source: Oregon Office of Emergency Management, 2019 County Hazard Analysis Scores or *2014 County Hazard Analysis

State Assessment

Using the methodology described in Section **2.2.5.2**, Floods > Probability, the state assessed the probability of flooding in the counties that comprise Region 7.

Table 2-704. State Assessment of Flood Probability in Region 7

	Baker	Grant	Union	Wallowa
Probability	M	H	L	H

Source: DOGAMI

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-705. Local Assessment of Vulnerability to Flood in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	M	H	H	M

Note: Assessment of flood probability for Grant and Baker Counties date from meetings held in 2019 during the NHMP update process. Assessments for Wallowa and Union county date from the 2014 Northeast Oregon Multi-Jurisdictional NHMP.

Source: Oregon Office of Emergency Management, 2019 County Hazard Analysis Scores; 2014 County Hazard Analyses

Table 2-706. State Assessment of Vulnerability to Flood in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	VL	M	VL	L

Source: DOGAMI, DLCD

An exposure analysis performed by DOGAMI was conducted in Grant and Baker Counties by overlaying building locations on the 100-year flood extent. A large number (223 buildings) of Baker County's buildings were found to be within designated flood zones, 219 of which are located in Baker City. Similarly a large number (703 buildings) of Grant County's buildings were found to be within designated flood zones. By comparing the number of non-damaged buildings from Hazus-MH with exposed buildings in the flood zone, DOGAMI estimated the number of buildings that could be elevated above the level of flooding.

In Baker County of the 223 buildings that are exposed to flooding, DOGAMI estimate that 98 are above the height of the 100-year flood. In Grant County, DOGAMI estimated that 215 of the 703 buildings were elevated above the height of the 100-year.

This evaluation can also shed some light on the number of residents that might have mobility or access issues due to surrounding water.

The DOGAMI Risk Assessment and exposure analysis found that several of Grant County's critical facilities are at risk to flood hazard. None of Baker County's critical facilities are exposed to flooding hazards. The DOGAMI report for Grant County estimated that 18% of that county's 39 critical facilities area at risk to be non-functioning due to a 100-year flood. These include the following: Grant Union High School, Grant County Road Department, Oregon Dept. of Transportation, John Day Radio Station KJDY, Oregon Dept. of Forestry, Oregon Trail Electric Co-op, and the USFS Malheur District Office.

While similarly detailed information has not yet been developed for Union and Wallowa Counties, the state has determined that there are 22 state-owned or –leased facilities with a total value over $1.1 million and four local critical facilities with a total value of almost $5 million located in high flood hazard areas in Union County. They include a private school (K-7), and the City of La Grande's water treatment facility. In Wallowa County there are six state-owned or –leased facilities with a total value of over $1.4 million, mostly associated with state parks, and one local critical facility, an elementary school, with a value of almost $400,000 located in high flood hazard areas.

Repetitive Losses

FEMA has identified two Repetitive Loss properties in Region 7 (FEMA NFIP Community Information System, https://isource.fema.gov/cis/, accessed 02/12/2020).

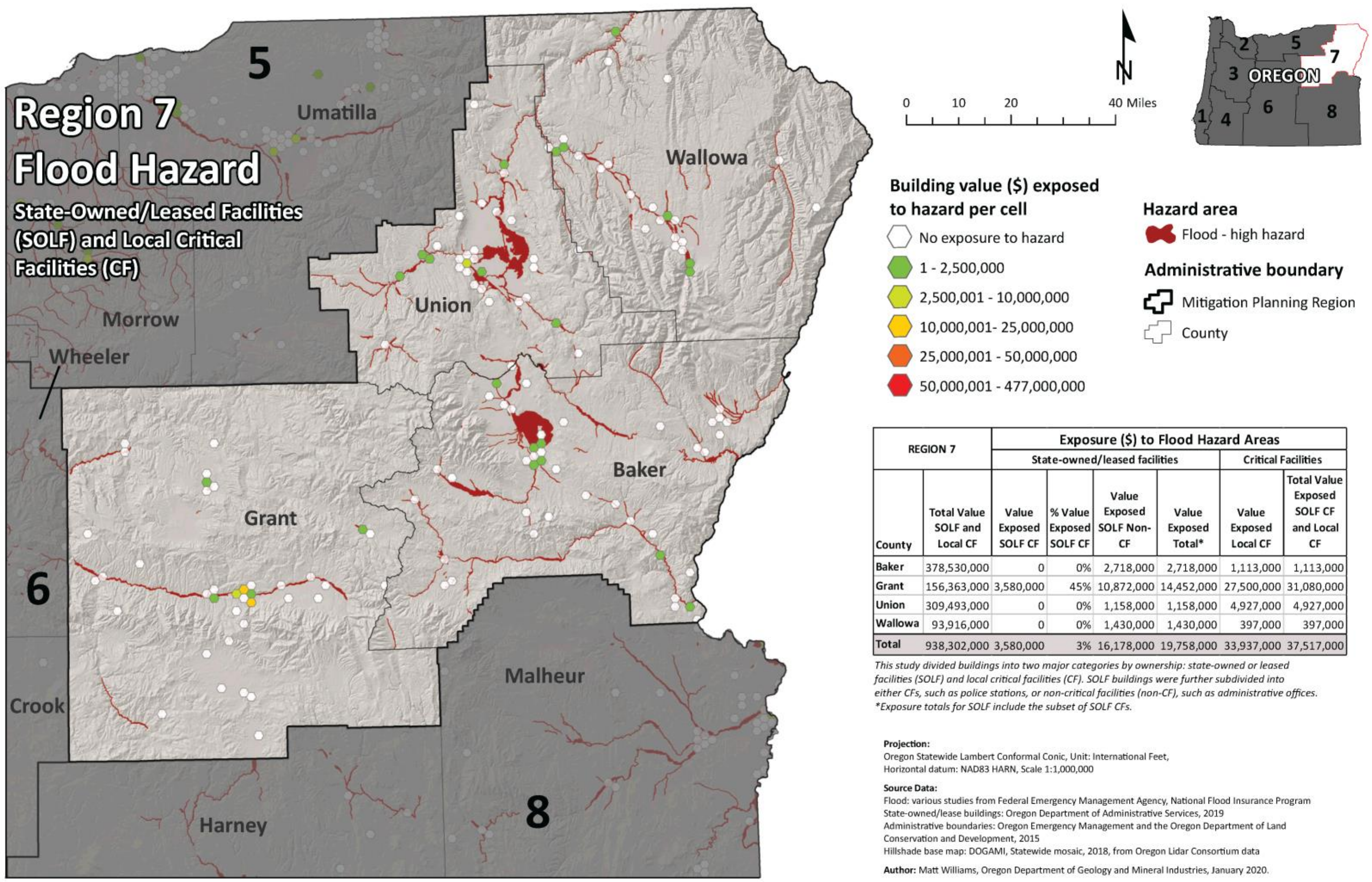
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS) Program, which results in reduced flood insurance costs. No Region 7 communities participate in the CRS Program.

State-Owned/Leased Facilities and Critical/Essential Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 7, there is a potential loss from flooding of almost $20M in state building and critical facility assets, 73% of it in Grant County alone. There is a potential loss due to flood of almost twice that much, about $34M, in local critical facilities. Eighty-one percent of that value is in Grant County. **Figure 2-286** illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding.

Figure 2-286. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 7.High-resolution, full-size image linked from Appendix [9.1.26](#).



REGION 7		Exposure ($) to Flood Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*		Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Baker	378,530,000	0	0%	2,718,000	2,718,000		1,113,000	1,113,000
Grant	156,363,000	3,580,000	45%	10,872,000	14,452,000		27,500,000	31,080,000
Union	309,493,000	0	0%	1,158,000	1,158,000		4,927,000	4,927,000
Wallowa	93,916,000	0	0%	1,430,000	1,430,000		397,000	397,000
Total	938,302,000	3,580,000	3%	16,178,000	19,758,000		33,937,000	37,517,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,000,000

Source Data:
Flood: various studies from Federal Emergency Management Agency, National Flood Insurance Program
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

Of the 1,246 historic resources in Region 7, fifty-six (4%) are located in an area of high flood hazard. Of those, 35 (63%) are located in Grant County. The next greatest share, 27%, is in Union County.

Archaeological Resources

Of the 188 archaeological resources located in high flood hazard areas in Region 7, eighty-seven percent (163) are located in Baker and Union Counties together, close to half in each county. Only two are listed on the National Register of Historic Places, one in Grant County and one in Union County. Twenty-two are eligible for listing; about half of those are in Union County. Eleven have been determined not eligible for listing and 153 have not been evaluated as to their eligibility.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Grant County, with moderate vulnerability, is the most vulnerable to flooding in Region 7. All the counties have very low or low social vulnerability; Grant County's moderate rating is driven by the large value of state buildings, state critical facilities, and local critical facilities. Grant County also has a large amount of historic resources vulnerable to flooding.

Most Vulnerable Jurisdictions

Grant County is the most vulnerable to flood hazards in Region 7.

Risk

Table 2-707. Risk of Flood Hazards in in Region 7

	Baker	Grant	Union	Wallowa
Risk	VL	H	VL	M

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, in Region 7 only Grant County is at high risk from flood events.

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owners property to community destruction with mass fatalities. The 1889 Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost. Oregon's

first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Table 2-708. Historic Significant Dam Failures in Region 7

Year	Location	Description
1896	Goodrich dam west of Baker City in Baker Co.	Flood wave killed entire family of 7
1917	Killamacue dam west of Haines in Baker Co.	Property damaged
1937	Spaulding Vaughn dam in Baker Co.	Property damaged
1956	Goodrich dam west of Baker City in Baker Co.	Property damaged in the second failure of a dam at this site

Source: Oregon Water Resources Department Dam Safety Program records

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 12 High Hazard dams and 11 Significant Hazard dams in Region 7.

Table 2-709. Summary: High Hazard and Significant Hazard Dams in Region 7

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 7	5	11	7
Baker	0	8	5
Grant	0	0	1
Union	4	3	0
Wallowa	1	0	1

Source: Oregon Water Resources Department, 2019

Table 2-710. High Hazard and Significant Hazard Dams in Region 7

County	Name	Rating	Regulator
Baker	Brownlee Dam	High	Federal
Baker	Mason Dam	High	Federal
Baker	Oxbow Hydro Dam	High	Federal
Baker	Thief Valley Reservoir	High	Federal
Baker	Unity Reservoir	High	Federal
Baker	Balm Creek Reservoir	Significant	State
Baker	Camp Creek Reservoir (Baker)	Significant	State
Baker	Clear Creek Reservoir-West Fork	Significant	State
Baker	Goodrich Reservoir	Significant	State
Baker	Killamacue Reservoir	Significant	State
Baker	Love Reservoir (Baker)	Significant	State
Baker	Salmon Creek Reservoir	Significant	State
Baker	Whited Reservoir (Baker)	Significant	State
Grant	Olive Lake	High	Federal
Union	Jubilee Lake	High	State
Union	Morgan Lake	High	State
Union	Pilcher Creek	High	State
Union	Wolf Creek	High	State
Union	Elgin Mill Trmt. Lagoon #2	Significant	State
Union	Jimmy Creek Reservoir	Significant	State
Union	Little Park Dam	Significant	State
Wallowa	Hells Canyon Dam	High	Federal
Wallowa	Wallowa Lake	High	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally regulated. A dam’s condition is considered public information for state-regulated

dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Only two of the five state-regulated high hazard dams are in satisfactory condition; three are in poor condition.

Table 2-711. Summary: Condition of High Hazard State-Regulated Dams in Region 7

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	**Fair**	**Poor**	**Unsatisfactory**	**Not Rated**
Region 7	2	0	3	0	0
Baker	0	0	0	0	0
Grant	0	0	0	0	0
Union	2	0	2	0	0
Wallowa	0	0	1	0	0

Source: Oregon Water Resources Department, 2019

Table 2-712. Condition of High Hazard State-Regulated Dams in Region 7

County	Dam Name	Condition
Union	Jubilee Lake	Poor
Union	Morgan Lake	Poor
Union	Pilcher Creek	Satisfactory
Union	Wolf Creek	Satisfactory
Wallowa	Wallowa Lake	Poor

Source: Oregon Water Resources Department, 2019

State-Regulated High Hazard Dams not Meeting Safety Standards

There are three state-regulated high hazard dams in Region 7 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). These dams and the population at risk, based on a screen using the screening tool DSS-WISE, are shown in **Table 2-713**. As the dam safety program conducts analysis over time, the number of dams in less than satisfactory condition may change. Currently dams that are in poor or unsatisfactory condition are in need of rehabilitation or other action to bring them into a fully safe condition. As of December 2019, these are the dams in Region 7 that are not yet demonstrably unsafe, but that do pose unacceptable risk. When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Table 2-713. State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 7

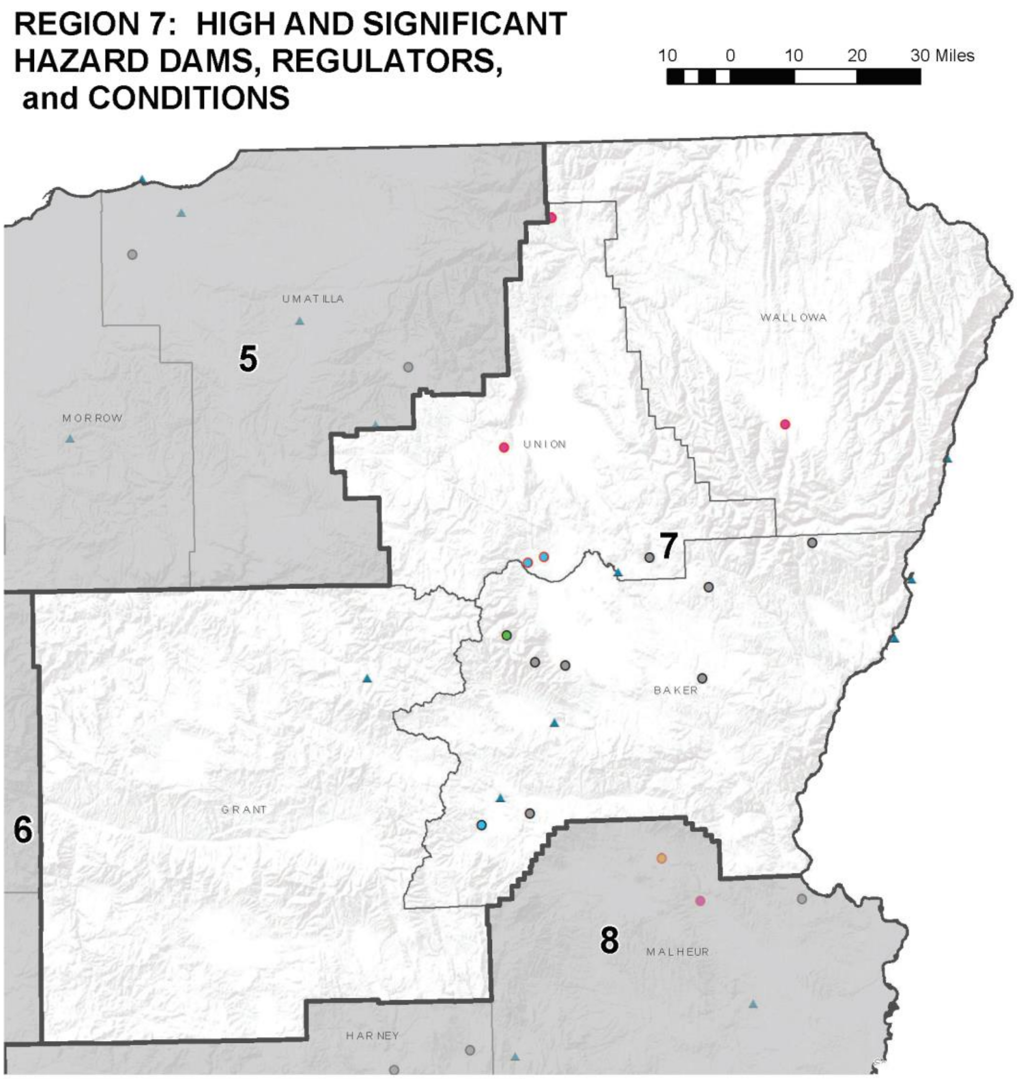
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Jubilee Lake		POOR	Small	Small	Union
Morgan Lake Dam	OR00653	POOR	11,128	6,362	Union
Wallowa Lake (Top of Dam)	OR00465	POOR	1,131	1,334	Wallowa

Note: "PAR" is number of "Persons At Risk" in the dam failure inundation zone based on a conservative estimate using DSS-Wise dam breach estimator. It includes all persons that normally could be in the inundation area. Actual impacts depend on the velocity and depth of water and will be determined as part of Oregon's HHPD grant tasks.

Source: DSS-Wise output

Figure 2-287 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 7. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-287. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 7



	Coastal	Earthquak	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 7	0	8	*	7	0	0	11
Baker	0	5	*	3	0	0	6
Grant	0	1	*	0	0	0	0
Union	0	1	*	3	0	0	5
Wallowa	0	1	*	1	0	0	0

* - flood risk affected by function and condition of dam, not by presence in mapped flood prone location

State regulated dams**

Condition assessment

- Poor
- Unsatisfactory
- Fair
- Satisfactory
- No assessment

** - Significant hazard dam symbols have a black outline.
High hazard dam symbols have a red outline.

Federal regulated dams

Hazard

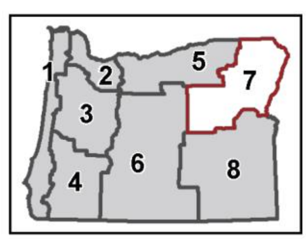
- High
- Significant

Mitigation Planning Regions
Counties

Projection:
Oregon Lambert Coordinate Reference System, Unit: International Feet, Horizontal datum: NAD83, EPSG #2992

Source Data:
State regulated dams: Oregon Water Resources Dept., July 2020
Mitigation Planning Regions: Oregon Emergency Management
Counties: U.S. Bureau of Land Management (BLM)
Base map: Esri, World Terrain Base

Author: Robert Harmon, GISP, Oregon Water Resources Dept. (July 2020)



Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

Table 2-713, State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 7, indicates the number of people currently anticipated to be impacted by potential failure of the state-regulated high hazard dams in poor or unsatisfactory condition. OWRD plans to do more analysis to determine the number and value of structures that may be impacted as well.

This region has some increased risk from debris and some changes in peak flows in wildfire areas. The increased risk from landslides is limited, however one dam was removed. It was situated on a large landslide and was prone to debris from tree fall after an intense wildfire. There is at least one state regulated high hazard dam close to a known more active fault.

Two dams in Region 7 meet FEMA HHPD eligibility criteria. Significant critical infrastructure, including a hospital and schools, are in the inundation area of one of these dams. A lifeline highway is in the dam breach inundation area of the other dam. There also appears to be a superfund site in the inundation area of this dam.

Most Vulnerable Jurisdictions

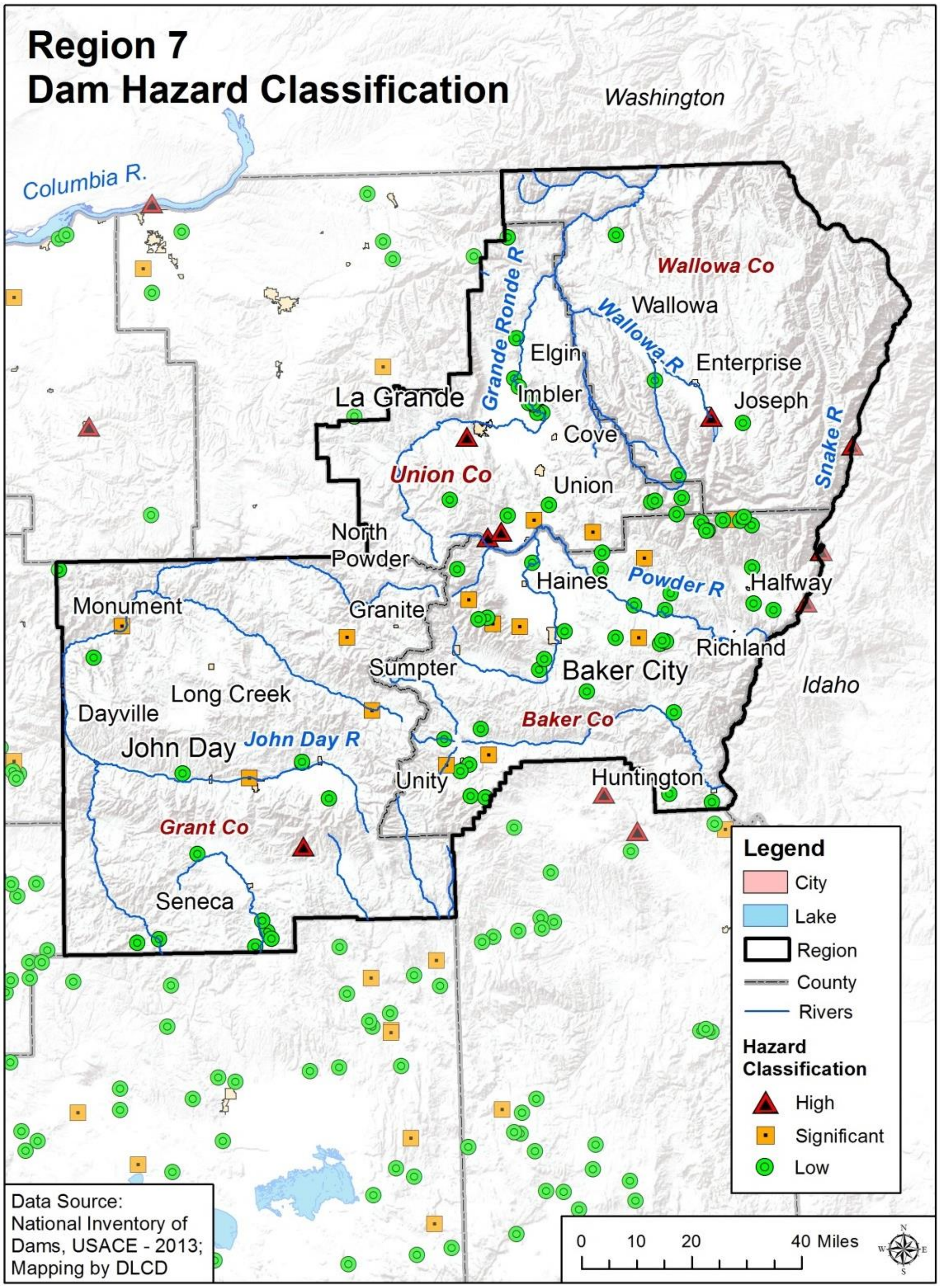
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), Union and Wallowa Counties in Region 7 have high hazard dams in poor or unsatisfactory condition are therefore considered most vulnerable. Of those, by far the greatest number of people in potentially dangerous locations if a dam were to fail are in Union County.

As with high hazard dams, whether counties with significant hazard dams are actually "most vulnerable jurisdictions" depends on the conditions of those dams. Since the dams' conditions have not yet been rated, we cannot determine the counties' vulnerability with respect to significant hazard dams. The county with the most state-regulated significant hazard dams is Baker County (8).

Risk

With FEMA and State funding, OWRD will be completing risk assessments for two of Region 7's state-regulated high hazard dams in poor or unsatisfactory condition over the next several years. For now, the potential for damage to the dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-288. Region 7 Dam Hazard Classification



Source: National Inventory of Dams, USACE, 2013

Note: Federally regulated significant hazard dams are not shown.

Landslides

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the Blue Mountains and Wallowa Mountains have a moderate to high incidence of landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage.

Landslides occur throughout Region 7 but to a much lesser extent than in western Oregon. In general, northeastern Oregon soil profiles are shallow and rainfall is less frequent and intense than in the western portion of the state. Most Region 7 landslides occur within the I-84 corridor, OR-82 (Union County), OR-86 (Baker County), OR-19 (Grant County), and OR-3 (Wallowa County). Notable slides include the 1984 Hole-in-the-Wall slide, which dammed the Powder River in Baker County, and the often-troublesome Whopper Slide near Elgin in Union County. In 1928, two people were killed in a landslide while working on a railroad near Baker City.

Historic Landslide Events

Table 2-714. Significant Landslides in Region 7

Date	Location	Description
1928	Near Baker City, Oregon	Two people lost their lives in a landslide while working on the railroad
Dec. 1964	Baker, Grant, Union, and Wallowa Counties	DR-184
Jan. 1974	Wallowa County	DR-413
1984	Baker County, Oregon	Hole-in-the-Wall slide dammed the Powder River
Feb. 1996	Union and Wallow Counties	DR-1099
Dec. 1996-Jan. 1997	Wallowa County	DR-1160
May 2003	Grant County, Oregon	Property damage: $1,000
Dec. 2003-Jan.2004	Baker, Grant, Union, and Wallowa Counties	DR-1510
Apr. 2019	Grant County	DR-4452

Source: Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; FEMA, https://www.fema.gov/disasters

Probability

Table 2-715. Assessment of Landslide Probability in Region 7

	Baker	Grant	Wallowa	Union
Probability	H	H	H	VH

Source: DOGAMI, 2020

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in this region in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-716. Local Assessment of Vulnerability to Landslides in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	L	L	L	L

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-717. State Assessment of Vulnerability to Landslides in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	VL	VL	L	VL

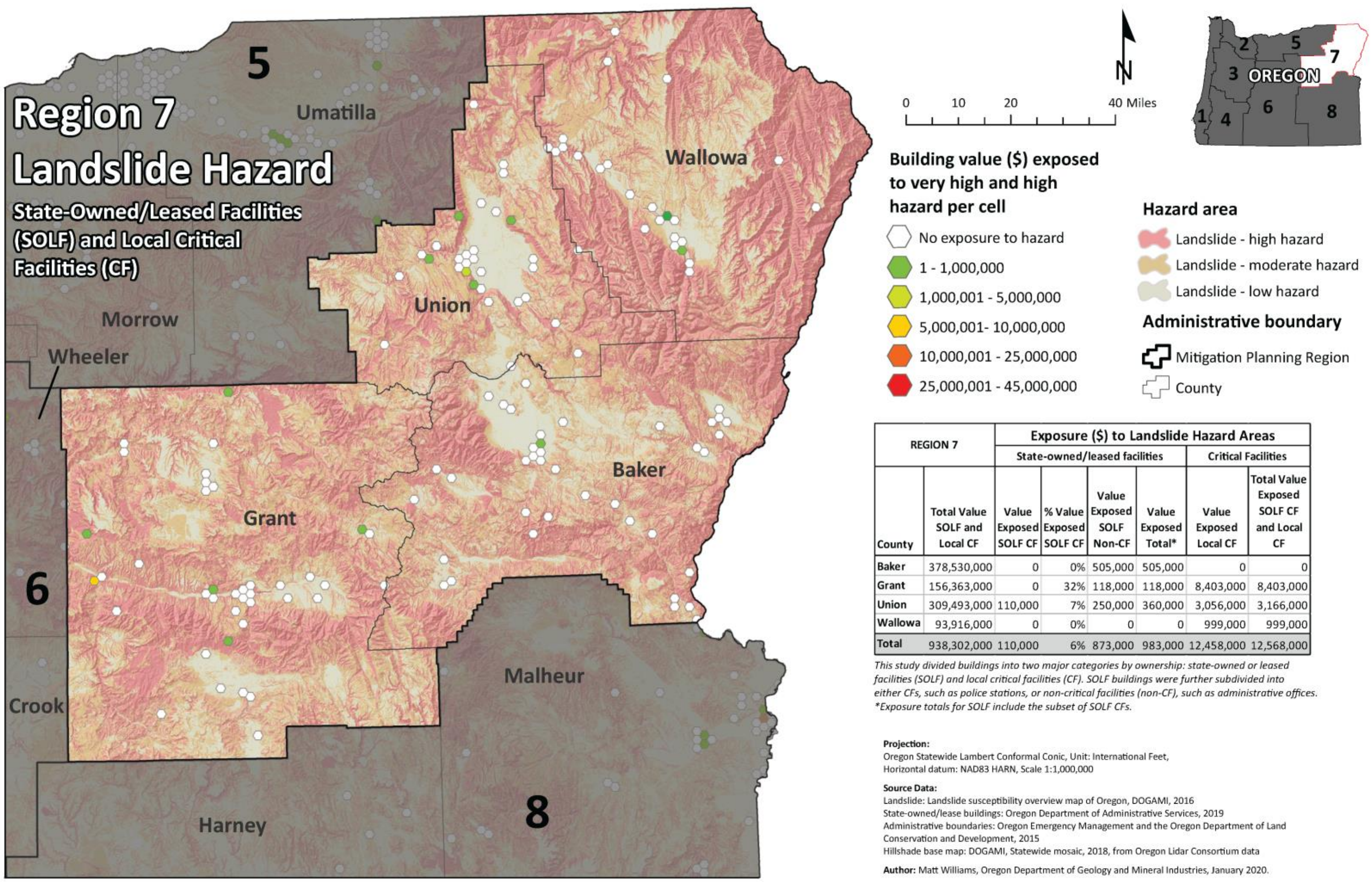
Source: DOGAMI and DLCD, 2020

Although there are fewer historic landslides in this region than most others, the SLIDO-2 landslide inventory indicates a moderate to high hazard. Baker, Union, and Grant Counties all have approximately 500 mapped landslides in SLIDO-2. The communities located in areas of steeper slopes will likely have the highest vulnerability.

State-Owned/Leased Facilities and Critical and Essential Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 7. Almost $1M in value is exposed to landslide hazards in Region 7, most of it in Baker County followed by Union County. However, the region has local critical facility assets of over $12M at risk of loss to landslides, about two-thirds of it in Grant County and about a quarter of it in Union County. Baker County has none. Figure 2-289 illustrates the potential loss to state buildings and critical facilities and local critical facilities from landslide hazards.

Figure 2-289. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 7.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 7		Exposure ($) to Landslide Hazard Areas						
		State-owned/leased facilities				Critical Facilities		
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Baker	378,530,000	0	0%	505,000	505,000	0	0
Grant	156,363,000	0	32%	118,000	118,000	8,403,000	8,403,000
Union	309,493,000	110,000	7%	250,000	360,000	3,056,000	3,166,000
Wallowa	93,916,000	0	0%	0	0	999,000	999,000
Total	938,302,000	110,000	6%	873,000	983,000	12,458,000	12,568,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,000,000

Source Data:
Landslide: Landslide susceptibility overview map of Oregon, DOGAMI, 2016
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

In addition, all of the 1,246 historic resources in Region 7 are exposed to landslide hazards: 35 are in an area of very high or high landslide hazard susceptibility; 196 in moderate; and 1,015 in low. Twenty-nine (83%) of the 35 historic resources exposed to high or very high landslide hazards and 146 of the 196 (74%) exposed to moderate landslide hazards are in Grant County. The number of historic resources in Region 7 overall are distributed fairly evenly among the counties, with Union County having slightly more and Baker County slightly fewer.

Archaeological Resources

Of the 3,849 archaeological resources located in landslide hazard areas in Region 7, seventy-three percent (2,813) are in high landslide hazard areas. Of those, 156 are listed on the National Register of Historic Places and 554 are eligible for listing. Ninety-three have been determined not eligible, and 2,010 have not been evaluated as to their eligibility. Baker, Grant, and Wallowa Counties each have in the neighborhood of 30-35% of the archaeological resources in high landslide hazard areas; only about 5% are located in Union County. Overall, the number of archaeological resources in landslide hazard areas in Region 7 are fairly evenly distributed among Baker, Grant, and Wallowa Counties; only about 6% are located in Union County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Baker, Grant, and Union Counties have very low vulnerability while Wallowa is somewhat more vulnerable with a score of low vulnerability.

Risk

Table 2-718. Assessment of Risk to Landslides in Region 7

	Baker	Grant	Union	Wallowa
Risk	M	L	M	H

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 Risk Scores and DOGAMI's expert assessment, Wallowa County is the "most vulnerable community" in Region 7.

Volcanoes

Characteristics

The volcanic Cascade Range is not within Region 7 counties; consequently, the risk from local volcano-associated hazards (e.g., lahars, pyroclastic flows, lava flows, etc.) is considered nil. However, there is some risk from volcanic ash. This fine-grained material, blown aloft during a volcanic eruption, can travel many miles from its source. For example, during the May 1980, Mount St. Helens eruption, the cities of Yakima and Spokane, Washington, 80 and 160 miles away, respectively, were inundated with ash. Ash can reduce visibility to zero and bring street, highway, and air traffic to an abrupt halt. The material is noted for its abrasive properties and is especially damaging to machinery.

Ashfall is largely controlled by the prevailing wind direction. The predominant wind direction over the Cascade Range is from west to east. Previous eruptions documented in the geologic record indicate most ashfall drifting to and settling in areas east of the Cascade volcanoes.

Historic Volcanic Events

Table 2-719. Historic Volcanic Events in Region 7

Date	Location	Description
May 1980	northeast Oregon	trace amounts of ashfall from Mount St. Helens

Source: Reports of local geologists present in northeast Oregon in May of 1980.

Probability

Table 2-720. Assessment of Volcanic Hazards Probability in Region 7

	Baker	Grant	Union	Wallowa
Probability	L	L	L	L

Source: DOGAMI, 2020

Mount St. Helens remains a probable source of airborne ash. It has repeatedly produced voluminous amounts of this material and has erupted much more frequently in recent geologic time than any other Cascade volcano. It blanketed Yakima and Spokane, Washington during the 1980 eruption and again in 2004.

The eruptive history of the Cascade volcanoes can be traced to late Pleistocene times (approximately 700,000 years ago) and will no doubt continue. But the central question remains: When? The most recent series of events at Newberry Volcano, which occurred about 1,300 years ago, consisted of lava flows and ashfall. Newberry Volcano’s recent history also includes pyroclastic flows and numerous lava flows. Volcanoes in the Three Sisters region, such as Middle and South Sister, and at Crater Lake have also erupted explosively in the past. These eruptions have produced pyroclastic flows, lava flows, lahars, debris avalanches, and ash. Any future eruptions at these volcanoes would most likely resemble those that have occurred in the past.

Geoscientists have provided some estimates of future activity in the vicinity of Newberry Caldera and its adjacent areas. They estimate a 1 in 3,000 chance that some activity will take place in a 30-year period. The estimate for activity at Crater Lake for the same time period is significantly smaller at 0.003 to 0.0003. In the Three Sisters region, the probability of future activity is roughly 1 in 10,000 but any restlessness would greatly increase this estimate.

The location, size, and shape of the area affected by ash are determined by the vigor and duration of the eruption and the wind direction. Because wind direction and velocity vary with both time and altitude, it is impossible to predict the direction and speed of ash transport more than a few hours in advance (Walder, Gardner, Conrey, Fisher, & Schilling, 1999). Mount St. Helens is about 250 air miles from the City of Enterprise (Wallowa County), consequently placing that community at risk. Mount Jefferson, located about 150 miles west of the City of John Day, is a possible but unlikely source. The annual probability of 1 cm or more of ash accumulation within the Region 7 counties, from any Cascade volcano, is about 1 in 5,000 (Sherrod, Mastin, Scott, & Schilling, 1997).

Vulnerability

Table 2-721. Local Assessment of Vulnerability to Volcanic Hazards in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	L	H	L	L

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-722. State Assessment of Vulnerability to Volcanic Hazards in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	VL	VL	VL	VL

Source: DOGAMI and DLCD, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 7. No state buildings, state or local critical facilities are located in volcanic hazard areas.

Historic Resources

None of the 1,246 historic buildings in Region 7 are exposed to volcanic hazards. See Chapter 9, Appendix **9.1.12** for details.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

Most of the region’s people and infrastructure are located in the major cities along I-84, US-26, and US-395. The communities most vulnerable to volcano-related hazards in the region are La Grande, Baker City, and John Day. The social vulnerability scores are low for Baker, Union, and Wallowa Counties; very low for Grant County.

Risk

Table 2-723. Assessment of Risk to Volcanic Hazards in Region 7

	Baker	Grant	Wallowa	Union
Risk	VL	VL	VL	VL

Source: DOGAMI and DLCD, 2020

According to the 2020 risk scores, none of the communities identified by DOGAMI as being most vulnerable to volcano hazards are located in Region 7. All communities in Region 7 have very low (VL) risk ratings.

The region’s vulnerability to the effects of volcanic eruptions is low. Areas in Region 7 could be affected by ashfall from Cascade volcanic eruptions. Most of the region’s people and infrastructure are located in the major cities along I-84, US-26, and US-395. The communities most vulnerable to volcano-related hazards in the region are La Grande, Baker City, and John Day.

Wildfires

Characteristics

Region 7 has a significant history of human-caused fires in addition to a prevalence of summer thunderstorms. These thunderstorms in the mountainous and timbered regions of eastern Oregon suggests the potential for lightning-caused fires. Most areas do not have structural fire protection available and some areas do not even have wildland fire protection.

While the rates of urban and rural residential development have declined statewide, they have increased in Eastern Oregon’s non-federal forests, potentially impacting fire protection capability. There are now 3 times as many dwellings on non-federal wildland forest in Eastern Oregon as in 1975. Dwelling density is increasing at a faster rate in Eastern Oregon’s fire-prone forests than in western Oregon’s. Development ranges from homes with city services to seasonal-use recreational cabins. Many isolated clusters of private timberland have been bought and developed into home sites and recreational communities.

Historic Wildfire Events

Table 2-724. Significant Wildfires in Region 7

Year	Name of Fire	Location	Acres Burned	Remarks
1986	Clear	Baker, Grant, Union	6,000	lightning caused (?)
1988	Turner	Baker, Union, Grant	8,000	
1989	Dooley Mountain	Baker		
1989	Stices Gulch	Baker		
1996	Sloan's Ridge	Baker, Grant	10,000	
1996	Wildcat	Grant	10,303	
1999	Cummings Creek	Grant		
2000	Carrol Creek	Grant	3,197	
2000	Thorn	Wallowa	4035	
2001	Monument Complex	Grant		
2001	Horse Creek	Wallowa	16,309	
2002	Malheur Complex/Flagtail	Grant	21,641	
2003	Lightning Creek Complex	Wallowa	16,028	1 structure was lost
2007	Battle Creek Complex	Wallowa	79,299	
2007	Cottonwood Creek	Wallowa	8,100	
2013	Grouse Mountain	Grant	12,076	threatened the town of John Day
2014	Buzzard Complex	Wallowa	>400,000	significantly impacted rangeland and cattle farms
2014	South Fork Complex	Grant	62,476	started with lightning strikes
2015	Canyon Creek Complex	Grant	110,422	started by lightning; destroyed more private property – 43 homes and almost 100 other structures - than any Oregon wildfire for 80 years before it
2015	Grizzly Bear Complex	Wallowa	82,659	started by lightning; destroyed two homes and dozens of other structures

Sources: Wallowa-Whitman National Forest (Baker City), 2002; Oregon Department of Forestry, 2020

Probability

Table 2-725. Assessment of Wildfire Probability in Region 7

	Baker	Grant	Wallowa	Union
Probability	H	H	H	H

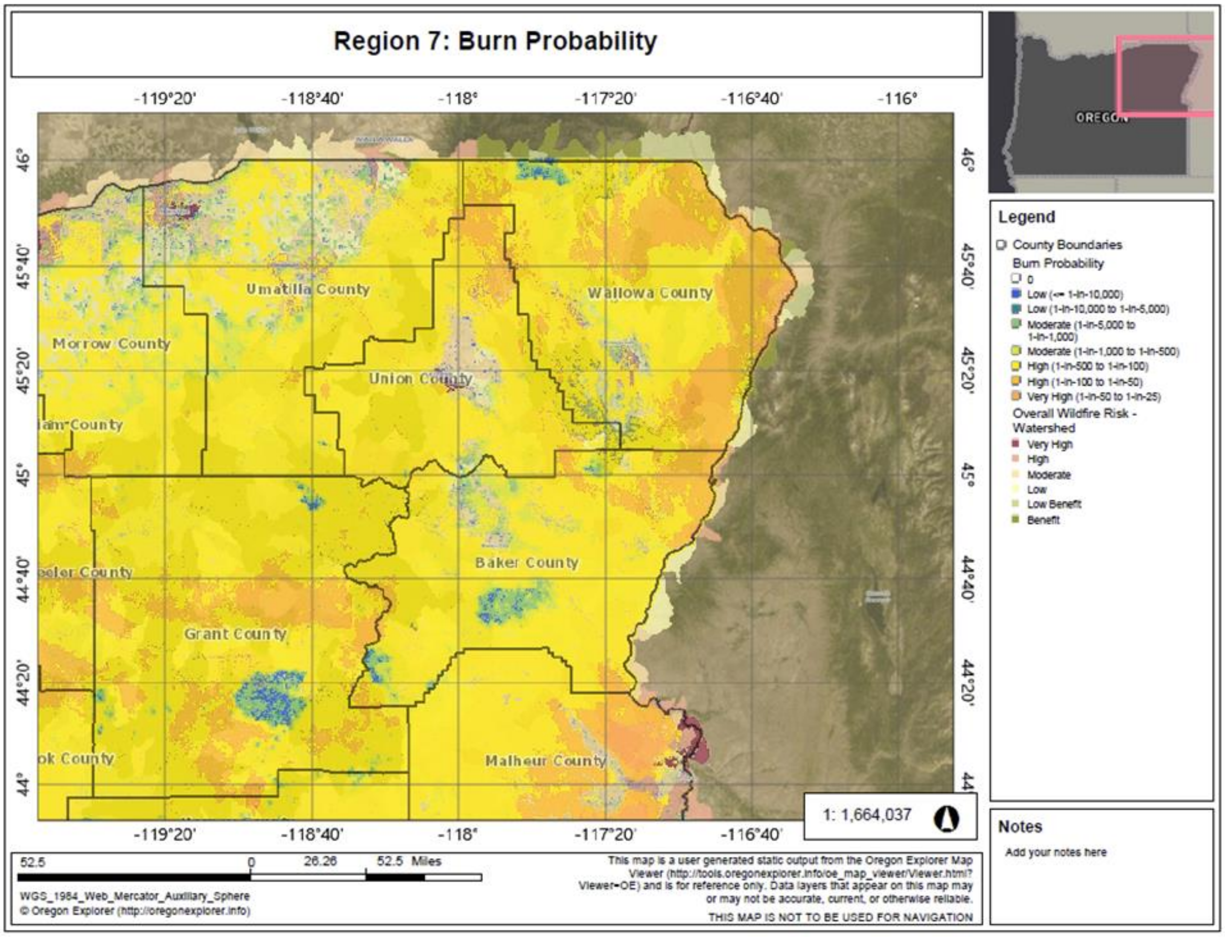
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to look at the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-290 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

Figure 2-290. Burn Probability



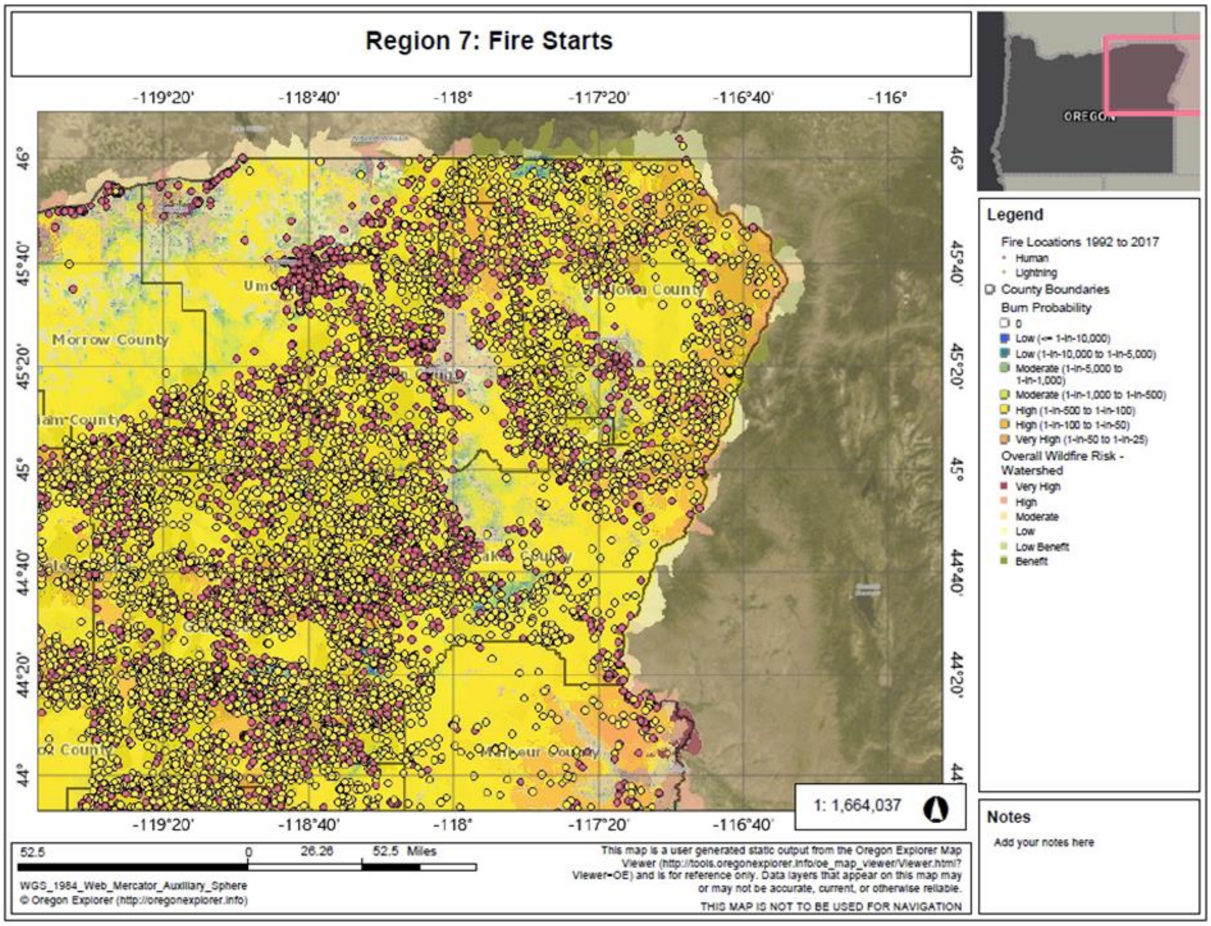
Source: Oregon Wildfire Risk Explorer, March 2020

A combination of climate, fuels, and terrain make this region prone to wildfire. The poor ecological health of the forested ecosystem, particularly in the greater Blue Mountains area, is well documented in federal and scientific reports. Past timber management practices, fire exclusion, and the subsequent buildup of forest fuels have significantly changed the vegetation composition in this region over time. The simplification of stand structure (unnaturally dense) and shift in species composition over time, combined with low precipitation and competition for limited water and nutrients, increases the probability of insect, disease epidemics, and large-scale fire.

A significant number of lightning storms pass through during the summer and fall months, starting many fires that can easily strain wildland firefighting resources. With fuels and low relative humidity, the probability for large fires can significantly increase during lightning events. The number of days per season that these conditions exist is also important to consider.

Over three quarters of all fire starts are attributed to lightning, with a higher percentage of lightning starts on public lands than on private lands. ODF reports a slightly higher percentage of human-caused fires where human activity is more prevalent.

Figure 2-291. Human- and Lightning-Caused Wildfires in Region 7, 1992-2017



Source: Oregon Wildfire Risk Explorer, March 2020

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

In ignition-limited forest systems, found on the east side of the state, a long history of fire suppression has resulted in high fuel loads and, forests that have closer canopies and experience greater water competition. These forests experience long, dry fire seasons and are frequently at high fire danger and have a very high potential to burn if exposed to an ignition source. Winter warming will lead to more fine fuels due to greater growth during the cold season; hotter and drier conditions combined with a suppression management regime will lead to large quantity of fuel and closer canopies. Large and severe fires ("unsuppressable megafires") are a result of this large fire debt and climate change combined. It is likely (>66%) that Region 7 will experience increasing wildfire frequency and intensity under future climate change.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 7 counties (Table 2-726).

Table 2-726. Projected Increase in Annual Very High Fire Danger Days in Region 7 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Baker	15	42%
Grant	14	39%
Union	16	43%
Wallowa	16	44%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-727. Local Assessment of Vulnerability to Wildfire in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	H	H	H	M

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-728. Assessment of Vulnerability to Wildfire in Region 7 – Communities at Risk

	Baker	Grant	Union	Wallowa
Vulnerability	VH	VH	M	VH

Source: ODF Communities at Risk Report, 2020

Table 2-729. Assessment of Vulnerability to Wildfire in Region 7 – 2020 Vulnerability Assessment

	Baker	Grant	Union	Wallowa
Vulnerability	L	M	M	L

Source: DOGAMI and DLCD, 2020

According to ODF's assessment of Communities at Risk, Baker, Grant, and Union Counties have the highest percentages of wildland acres subject to Fire Risk, Fire Effects, and Fire Threat, making them especially vulnerable.

In addition, each year a significant number of people build homes within or on the edge of the forest (urban-wildland interface areas), thereby increasing vulnerability. These communities have been designated "Wildland-Urban Interface Communities" and are listed in **Table 2-730**.

A large wildfire could eliminate valuable timber or rangeland for grazing, which might affect local businesses and industry. Recreational areas that draw tourists would also be impacted. Wildlife habitat and diversity, as well as threatened and endangered species of fish, wildlife, and plant life could be annihilated or severely harmed in the long-term depending on the intensity of the wildfire. Water quality could be impacted if a moderate to high intensity wildfire burned through watersheds, affecting the health of fish and wildlife as well as domestic water supplies for residents.

Many communities in this area are located a long distance from fire stations, which will result in longer response times. There are areas with a single access road that could impair ingress and egress during emergencies. Many homes do not have defensible space and would be difficult to protect from and oncoming fire. Response efforts are further hindered by the lack of water resources in the most vulnerable locations.

Region 7 is characterized as having heavy fuel loading on forestlands with a high potential for crown fires, which are very difficult to extinguish. The slopes are steep and carry fire quickly to upland flashy fuels and crowns. Ignition potential is also high, as many people visit the area.

Table 2-730. Wildland-Urban Interface Communities by County in Region 7

Baker	Grant	Union	Wallowa
Anthony Lakes	Austin	Catherine Creek	Alder
Auburn Gulch	Bates	Cove	Blue Spring
Baker City	Bear Valley	Elgin	Bartlett
Baker Valley	Beech Creek	Glass Hill	Eden
Bourne	Canyon City	Hilgard	Enterprise
Powder River	Dayville	Morgan Lake	Flora
Rattlesnake Estates	Granite	Palmer Junction	Freezeout Creek
Brownlee	John Day	Perry	Grouse
Bulger	Long Creek	Camp Elkanah	Hurricane Grange
Carson Pine Valley	Monument	Imbler	Imnaha
Copperfield	Mt Vernon	Island City	Joseph
Cornucopia	Prairie City	Kamela	Lostine
Durkee	Seneca	La Grande	Minam
Eagle Valley	Tamarack Camp Ground	Medical Springs	Prairie Creek
Elkhorn Mountains		Mt. Emily	Promise
Greenhorn		North Powder	Troy
Haines		Perry Hilgard	Little Sheep Creek
Halfway		Rysdam Duncan Canyon	Sheep Creek
Huntington		S. Fork Catherine Creek	South Fork Lostine River Subdivision
Keating		South Fork Catherine Creek	Troy
McCully Forks		Spout Springs	Upper Lostine
New Bridge		Starkey	Wallowa
Oxbow		Stubblefield Mountain	Wallowa Lake
Pleasant Valley		Summerville	Zumwalt
Richland		Union	
Rye Valley			
Sparta			
Stices Gulch			
Street Creek			
Sumpter			
Surprise Spring			
Unity			
Whitney			

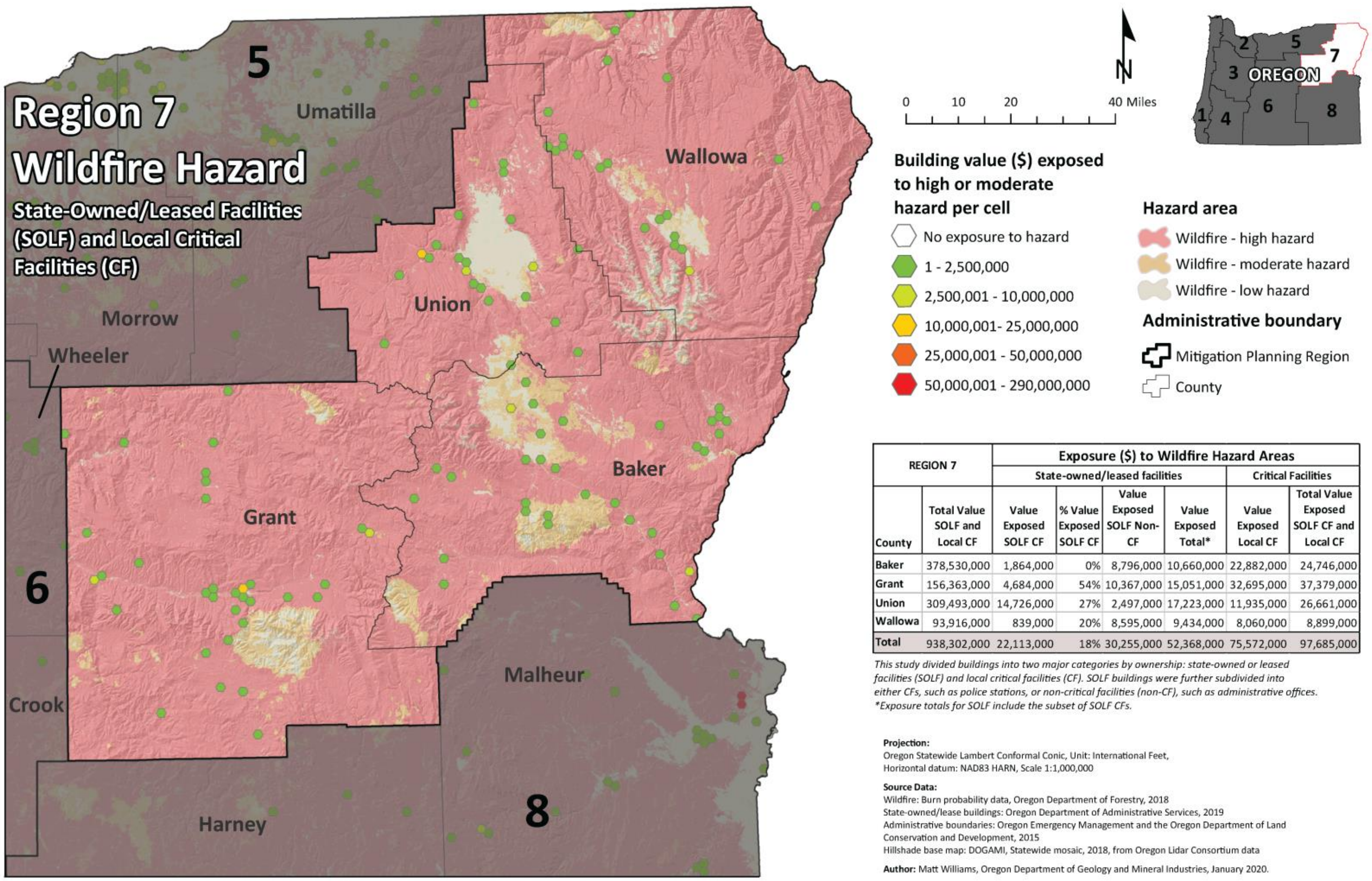
Source: Oregon Department of Forestry 2020 Communities at Risk Report

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in “High,” “Moderate,” and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as “Low.”

In Region 7, there is a potential loss to wildfire of about $52M in state building and critical facility assets, around a third of it in each of Union and Grant Counties, and around 20% of it in each of Baker and Wallowa Counties. There is a greater potential loss in local critical facilities: about $75.6M. Grant County contains the most (43%) followed by Baker County with 30%, Union County with 16% and Wallow County with 11%.

Figure 2-292. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 7.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 7		Exposure ($) to Wildfire Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Baker	378,530,000	1,864,000	0%	8,796,000	10,660,000	22,882,000	24,746,000
Grant	156,363,000	4,684,000	54%	10,367,000	15,051,000	32,695,000	37,379,000
Union	309,493,000	14,726,000	27%	2,497,000	17,223,000	11,935,000	26,661,000
Wallowa	93,916,000	839,000	20%	8,595,000	9,434,000	8,060,000	8,899,000
Total	938,302,000	22,113,000	18%	30,255,000	52,368,000	75,572,000	97,685,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,000,000

Source Data:
Wildfire: Burn probability data, Oregon Department of Forestry, 2018
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

Source: DOGAMI, 2020

Historic Resources

Of the 1,246 historic resources in Region 7, one hundred eighteen (9%) are located in an area of high wildfire hazard. Of those, 69% are located in Grant. Of the 38 (3%) located in a moderate wildfire hazard area, 61% are located in Wallowa County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, the counties in Region 7 have low or moderate vulnerability to wildfire. In contrast, the Communities at Risk assessment found all counties except Wallowa to be very highly vulnerable. This can be attributed to the different criteria used for the assessment and the counties' generally low social vulnerability depressing their 2020 overall vulnerability scores.

Risk

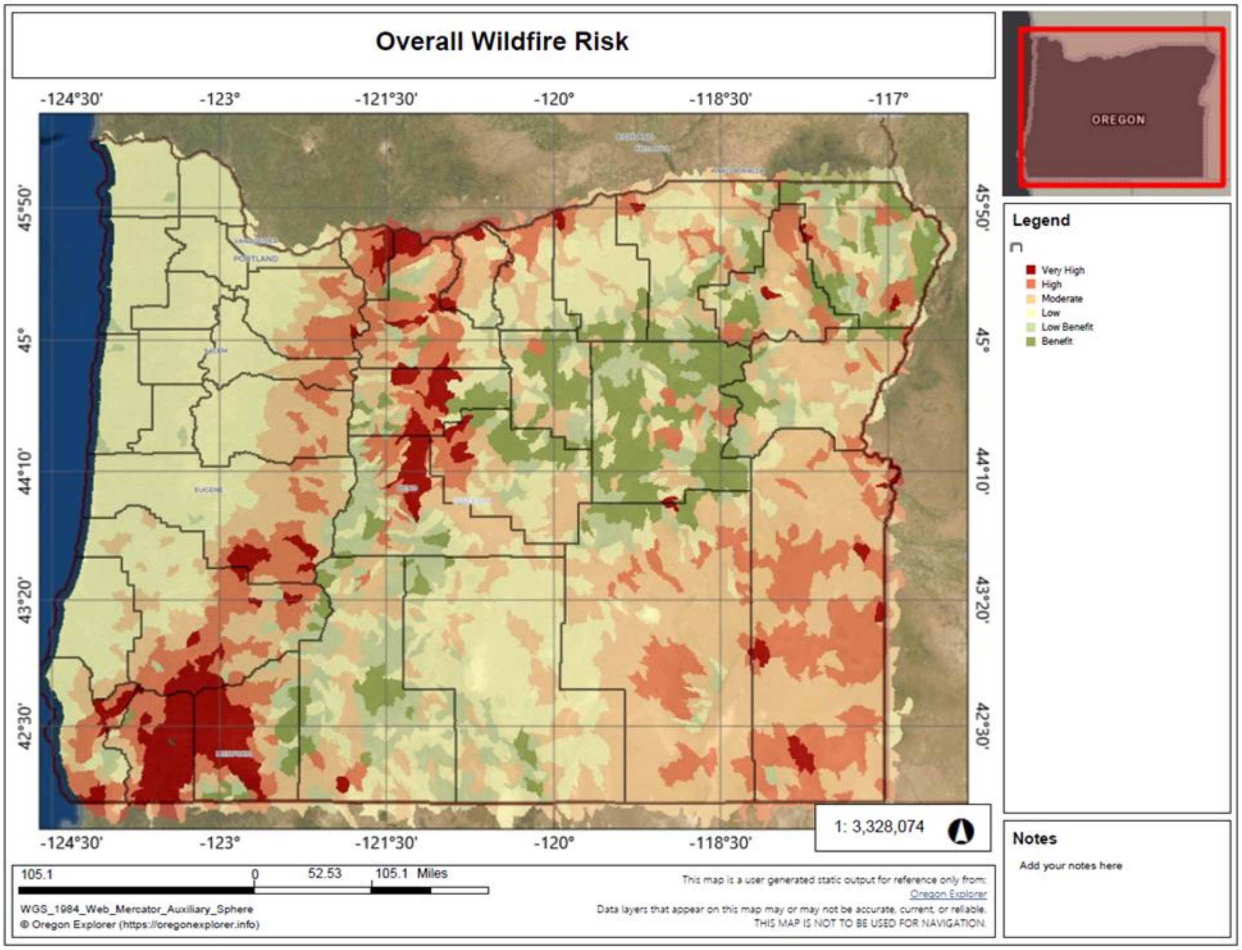
Table 2-731. Risk of Wildfire Hazards in Region 7

	Baker	Grant	Wallowa	Union
Risk	H	VH	H	M

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Grant County is at very high risk from wildfire, Baker and Union Counties at high risk, and Wallowa County at moderate risk. This is generally consistent with ODF's assessment, mapped in **Figure 2-293**.

Figure 2-293. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

Extreme winds (other than tornadoes) are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge, so much so that these areas have special building code standards. This is not the case in the Blue Mountains, although high winds in the valleys are not uncommon. For example, the residents of Union County's Grande Ronde Valley caution newcomers about living in the vicinity of Ladd Canyon, known for its high winds.

Historic Windstorm Events

Table 2-732. Historic Windstorms in Region 7

Date	Affected Area	Characteristics
Apr. 1931	northeast Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; wind speed 40–60 mph; gusts 75–80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 7-mph gusts; damage to buildings and utility lines
Dec. 1955	statewide	wind speeds 55–65 mph with 69-mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71-mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon's most destructive storm to date; 116-mph winds in Willamette Valley; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Jan. 1986	northeast Oregon	wind gusts 80–90 mph; heavy drifting snow in Ladd Canyon (Union County)
Dec. 1990	Wallowa County	severe wind storm
Mar. 1991	northeast Oregon	severe wind storm
Dec. 1991	northeast Oregon	severe wind storm
Dec. 1992	Northeast OR mtns.	severe wind storm
May 2003	Union County	$1,000 in property damage
June 2003	Wallowa County	$1,000 in property damage
July 2003	Union County	$30,000 in property damage
Oct. 2003	Wallowa County	$1,000 in property damage
Oct. 2003	Union County	$2,000 in property damage
Jan. 2004	Grant and Wallowa Counties	$500 in property damage
Feb. 2004	Union	$1,000 in property damage
Mar. 2004	Union County	$200 in property damage
July 2004	Union County	$300,000 in property damage
Nov. 2004	Union County	$1,000 in property damage
Jan. 2005	Union County	$10,000 in property damage
Nov. 2005	Union County	$100 in damages from a strong wind storm
Nov. 2006	Union and Wallowa Counties	$35,000 in damages from a wind storm with wind speeds measured at 80 mph; Morrow and Umatilla Counties also affected, causing a total storm damage of $70,000
Nov. 2007	Wallowa County	$500,000 in damages from a windstorm near Wallowa Lake State Park
July 2011	Union County	$2,000 in property damage
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides
Feb. 2020	Regions 5 and 7: Umatilla, Union, Wallowa Counties	FEMA-4519-DR: Severe storms, tornadoes, straight-line winds and flooding

Sources: Taylor and Hatton (1999); Hazard Mitigation Team Survey Report, *Severe Windstorm in Western Oregon*, February 7, 2002 (FEMA-1405-DR-OR); Hazards and Vulnerability Research Institute (2007), The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database], Columbia, SC: University of South Carolina, http://hvri.geog.sc.edu/SHELDUS/; https://www.fema.gov/disaster/

Probability

Table 2-733. Assessment of Windstorm Probability in Region 7

	Baker	Grant	Wallowa	Union
Probability	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

The 100-year storm in Region 7 is defined as one-minute average winds of 90 mph. A 50 year storm is one-minute average winds of 80 mph. The 25-year event consists of average winds of 70 mph.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-734. Local Assessment of Vulnerability to Windstorms in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	M	L	H	M

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-735. State Assessment of Vulnerability to Windstorms in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	H	H	H	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Many buildings, utilities, and transportation systems within Region 7 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, uprooted or shattered trees can down power and/or utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed when uprooted trees growing next to a house fall during a windstorm. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establishing a tree maintenance and removal program.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

Based on the information in **Table 2-732**, Union and Wallowa Counties are the most vulnerable to damages from windstorms. While none of the counties in Region 7 have even moderate social vulnerability, the high percentages of seniors in Wallowa, Baker, and Grant Counties; of residents with a disability in Wallowa County; and of people living in institutionalized group quarters in Union County increase these counties vulnerability to windstorms. Union and Wallowa Counties are considered the most vulnerable to windstorms in Region 7, followed by Baker County, then Grant County.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 7 is approximately $186,973,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $751,328,000. Because windstorms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records how many losses to state facilities due to windstorms were sustained in Region 7 since the beginning of 2015. There were two totaling just under $6,500, and possibly two others, one for about $6,200 and the other not yet settled.

Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

With similar probability of windstorms but greater vulnerabilities, Union and Wallowa Counties are considered to carry the greater risk from windstorms in Region 7.

Winter Storms

Characteristics

Severe winter weather in Region 7 can be characterized by extreme cold, snow, ice, and sleet. There are annual winter storm events in Region 7 with an average of 24 inches of snow; most communities are prepared for them. In the elevated areas of the Wallowa Mountains severe winter storms are more frequent and the snowfall is much heavier. Moderate to heavy snowfall is prepared for and expected on an annual basis in this region. Heavier snowfall is expected and planned for in the areas of the Wallowa Mountains of the region as the elevation gets higher.

Historic Winter Storm Events

Table 2-736. Severe Winter Storms in Region 7

Date	Location	Remarks
Dec. 1861	entire state	storm produced 1–3 feet of snow throughout Oregon
Dec. 1892	northern counties, Oregon	15–30 inches of snow fell throughout the northern counties
Jan. 1916	entire state	two storms; heavy snowfall, especially in mountainous areas
Jan. and Feb. 1937	entire state	deep snow drifts
Jan. 1950	entire state	record snowfalls; property damage throughout state.
Mar. 1960	entire state	many automobile accidents; two fatalities
Jan. 1969	entire state	heavy snow throughout state
Jan. 1980	entire State	series of string storms across state; many injuries and power outages
Feb. 1985	entire state	2 feet of snow in northeast mountains; downed power lines; fatalities reported
Feb. 1986	northeast mountains, Oregon	heavy snow; school closures; traffic accidents; broken power lines
Dec. 1988	northeast mountains, Oregon	three blizzards in a 4-week period; 15-foot drifts; wind over 60 mph
Feb. 1990	entire state	heavy snow throughout state
Jan. 1994	northeast mountains, Oregon	heavy snow throughout region
Jan. 1998	northeast Oregon	heavy snow throughout region
Winter 1998-99	entire state	one of the snowiest winters in Oregon history (snowfall at Crater Lake: 586 inches)
Dec.28, 2003–Jan. 9, 2004	statewide storm	DR-1510. Grant, Union, and Wallowa Counties declared in Region 7. The most significant winter storm in several years brought snowfall to most of Oregon. Two feet of snow in the Blue Mountains in eastern Oregon. Roadside snow levels exceeded six feet along the Tollgate Highway, OR-204. The eastbound lanes of I-84 closed at Ladd Canyon east of La Grande. Additional segments of I-84 eastbound at Pendleton closed as stranded motorists filled truck stops, motels and restaurants in the La Grande area. Freezing rain also in eastern Oregon. Minus 30 degrees reported in Meacham. 60 mph wind gusts in Union County created whiteout conditions, prompting the closure of I-84 between La Grande and Baker City. 2 fatalities.
Jan. 2004	Union County	one fatality
Jan. 2–Feb. 9, 2008	Union, Grant, and Baker, Counties	heavy snow and freezing rain across eastern Oregon; 5–13 inches of snow

Date	Location	Remarks
Dec. 6-23, 2015	Statewide storm events	DR-4258. Clatsop, Columbia, Multnomah, Clackamas, Washington, Tillamook, Yamhill, Polk, Lincoln, Linn, Lane, Douglas, Coos, and Curry Counties declared. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Another series of storms moved across Oregon on Dec 16-17 and Dec 21-23. Each storm system brought several inches of snow to the mountain areas. Snowfall 9.0" 6 miles east southeast of Granite. A narrow but long-lived band of precipitation moved across Wallowa County the morning of December 19th. Several reports of moderate snow occurred over the Joseph and Enterprise areas. Snowfall amounts in inches ranged from 5 to 6 inches, with northern Wallowa County receiving reports of up to 9 inches just outside of Flora. On December 21st heavy snow fell over portions of central Washington and Oregon due to a cold front. Snowfall amounts are as followed: 14" recorded at the Milk Shakes Snotel in Wallowa County.
Feb. 8-9, 2017	Grant County (Central Oregon, Ochoco-John Day Highlands)	A strong Pacific storm system brought snow, sleet, and freezing rain to many areas of the Interior Northwest February 7th through 9th.
Feb. 22-26, 2019	Grant, Baker, and Union Counties (Central Oregon, Blue Mountains, Grand Ronde Valley, John Day Basin)	Persistent troughing off the coast of the Pacific Northwest focused a stream of mid-level moisture over the Inland Northwest resulting in a long duration snow event as the plume drifted north and south several times between the 22nd and 27th of February. Snowfall rates were greatly enhanced over central Oregon with the proximity of a nearly stationary surface boundary where snowfall rates were in excess of 1 inch per hour. 26 inches in Meacham, 21 inches in Elgin, 16 inches in Mitchell, 14 inches in Lostine and La Grande, 12 inches in Pendleton and Joseph and 10 inches in John Day.

Source: Taylor and Hatton (1999); Source: Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Probability

Table 2-737. Probability Assessment of Winter Storms in Region 7

	Baker	Grant	Wallowa	Union
Probability	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Winter storms occur annually in Region 7. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-738. Local Assessment of Vulnerability to Winter Storms in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	H	H	H	M

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-739. State Assessment of Vulnerability to Winter Storms in Region 7

	Baker	Grant	Union	Wallowa
Vulnerability	H	H	H	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Region 7 counties are known for cold, snowy winters. This region is a gateway for neighboring states Washington and Idaho and for the commodity flow to those states. In general, the region is prepared for winter storm events, and those visiting the region during the winter usually come prepared. However, there are occasions when preparation cannot meet the challenge. Drifting, blowing snow has often brought highway traffic to a standstill. Also, windy, icy conditions have often closed mountain passes and canyons to certain classes of truck traffic. In these situations, travelers must seek accommodations, sometimes in communities where lodging is very limited. For local residents, heating, food, and the care of livestock and farm animals are everyday concerns. Access to farms and ranches can be extremely difficult and present a serious challenge to local emergency managers.

Winter storms, particularly east of the Cascades where snow storms are typically more intense, bring larger amounts of snow and last longer. They can strand livestock in pastures, leaving them without food and water and exposed to extreme cold for long periods of time. As a consequence, substantial losses in livestock from starvation, dehydration and freezing, significantly impact producers, and state and local economies. In addition, water quality and health hazards develop when dead livestock are not retrieved until roads are cleared and vehicles can be used to remove the carcasses. Livestock buried under snow may not be found until the snow melts. The snowmelt may carry the carcasses to streams and wash them downstream.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Baker, Wallowa, and Union Counties all have low levels of social vulnerability. Wallowa County is in the 90th percentile for the percentage of persons over the age of 64 and for its share of residents with a disability. Baker County also has a higher percentage of residents over the age of 64. Vulnerability in Union County is driven by a higher poverty rate, the share of multi-unit structures, the percentage of people living in institutionalized group quarters, and the percentage of occupied housing units with more people than rooms. Grant County has very low social vulnerability but is in the 90th percentile for its share of residents over age 65 and older.

While social vulnerability is generally low in Region 7 and the population is prepared for moderate to heavy snowfall, all the counties have specific vulnerabilities that indicate their populations are more sensitive to the adverse impacts of winter storms. All Region 7 counties are similarly vulnerable to winter storms.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 7 is approximately $186,973,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $751,328,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records how many losses to state facilities were sustained in Region 7 due to winter storms since the beginning of 2015. Thirteen losses were due to winter storms statewide. Of those, it is possible that up to four may have been located in the Region 7. These claims totaled a little over $72,000.

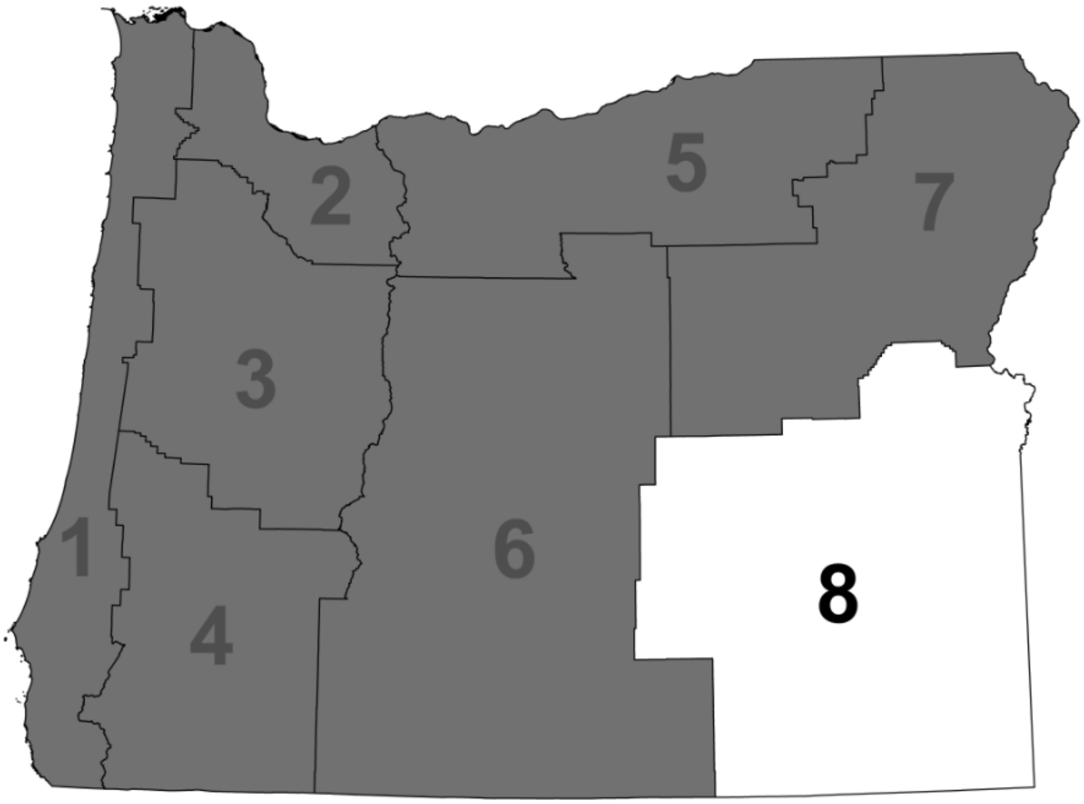
Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

All the counties in Region 7 are at risk from the adverse effects of winter storms.

2.3.8 Region 8: Southeast Oregon

Harney and Malheur Counties



2.3.8.1 Summary

Profile

Region 8's demographic, economic, infrastructure, and development patterns indicate that some populations, structures, and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

Social vulnerability in Region 8 is driven by a declining population, low median household incomes, and high levels of poverty. In Harney County there are also high percentages of seniors and people with disabilities. In Malheur County there are more tourists, higher percentages of people who do not speak English very well, a significant drop in already low incomes, and more family households with children.

This region is still recovering from the financial crisis that began in 2007 and the financial effects of the 2020 pandemic. There are few key industries and employment sectors in Region 8. Regional wages remain below the state average. Harney County continues to suffer from high unemployment. Damage or service interruption to roads, bridges, rail systems, and ports can have devastating effects the region's economy. Roads and railways are susceptible to winter storms and flooding.

Wells and rivers are primary sources of drinking water for the region. The quality of these water bodies can be threatened by regional agricultural practices that use pesticides and herbicides and by naturally occurring minerals in the soil. Malheur Lake is especially vulnerable to high mineral content.

Southeast Oregon has two power-generating facilities: one hydroelectric facility and one geothermal facility. Oil and natural gas pipelines and electrical transmission lines running through this region support the regional economy and are vulnerable to disruptions and damage from natural hazard events.

Region 8 is largely rural and is losing population. The region has high percentages of manufactured homes and homes built before floodplain management and seismic building standards. This coupled with the lack of modernized Flood Insurance Rate Maps (FIRMs) increases the vulnerability of development in Region 8.

Hazards and Vulnerability

Region 8 is affected by nine of the 11 natural hazards that affect Oregon communities. Coastal hazards and tsunamis do not directly impact this region.

Droughts: Droughts are common in Region 8 and have a significant economic impact on agricultural, livestock, and natural resources. The U.S. Department of Agriculture designated droughts in Malheur and Harney County as primary natural disasters from 2012 through 2016 and 2018 due to damages and losses caused by drought. Malheur County is considered one of the counties most vulnerable to drought in Oregon.

Earthquakes: Two types of earthquakes affect Region 8: (a) shallow crustal events and (b) earthquakes associated with volcanic activity. Region 8 is moderately vulnerable to earthquake-induced landslides, liquefaction, and ground shaking. In Region 8, a 2500-year probabilistic earthquake scenario could generate a potential loss of just under $1M in state building and critical facility assets, about 90% of it in Malheur County. The potential loss in local critical facilities is more than eight times that amount, almost $8M.

Extreme Heat: Extreme temperatures are common in Region 8 and the frequency of prolonged periods of high temperatures has increased. Owyhee, in Malheur County, has an average of about 55 days per year above 90°F. Both counties have a moderate vulnerability to extreme heat. High temperature and insufficient water stunt plant growth and cause areas of crops to wither. Some livestock, especially dairy cattle, are also sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Like drought, impacts of drought on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms.

Floods: Floods affect Southeast Oregon in the form of riverine flooding often preceded by rapid snowmelt during unseasonably warm winters, ice jams, and closed basin playa flooding. Flash floods and associated summer thunderstorms are also possible. Both counties are considered to have a moderate to high vulnerability to the hazard of flooding. A large number (1,464 buildings) of Harney County's buildings representing 20% of the county's buildings were found to be within designated flood zones, 1,117 of which are located in the City of Burns. In Region 8, there is a potential loss from flooding of about $6M in state building and critical facility assets, 56% of it in Harney County and 44% in Malheur County. There is a much greater potential loss – about 3.5 times as much – due to flood in local critical facilities: over $22M.

Landslides: Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. In general, landslide vulnerability for Region 8 is low to moderate. About $239K in value of state assets is exposed to landslide hazards in Region 8, all of it in Malheur County. The total value of the Region's local critical facility assets, $15.8M, is also located in Malheur County.

Volcanoes: Though the volcanic Cascade Range is not in Region 8 and vulnerability to effects of volcanic eruptions is low, there is some threat of ashfall from Cascade volcanic eruptions. More locally, the region is also vulnerable to small eruptions of lava from the numerous youthful volcanic cones scattered across Harney and Malheur Counties. The communities in Southeast Oregon most vulnerable to volcanic activity are the Cities of Burns, Ontario, and Jordan Valley. No state buildings, state or local critical facilities are located in volcanic hazard areas.

Wildfires: The region's arid climate, frequent lightning strikes, large tracts of ponderosa pine forests (primarily in the northern part of Harney County), and grasslands all contribute to Region 8's vulnerability to wildfire. Past management practices that suppressed all wildfires and favored growth of a brushy understory and accumulation of dead or dying trees have led to devastating fires today. State and federal agencies seek to alleviate the problem through a controlled burning program. Areas of higher vulnerability are within wildland-urban interface communities. In Region 8, there is a potential loss to wildfire of almost $352M in state building and critical facility assets, 98% of it in Malheur County. There is a much lesser potential loss in local critical facilities: about $38M. Fifty-six percent of that value is also located in Malheur County.

Windstorms: Windstorms in Region 8 are commonly associated with thunderstorms. Windstorms can be especially problematic in burned areas, where dust becomes airborne reducing visibility and causing localized damage. Windstorms generally affect the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland. Small tornadoes also have the potential to impact this region. The value of state-owned and leased buildings and critical facilities in Region 8 is approximately $573,310,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $328,497,000.

Winter Storms: This region is known for winter storms that bring cold weather and 24 inches of snow annually. Moderate to heavy snowfall is expected in this region, and residents and tourists are usually prepared for them. The value of state-owned and leased buildings and critical facilities in Region 8 is approximately $573,310,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $328,497,000.

Climate Change

The hazards faced by Region 8 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon. Coupled with projected decreases in snowpack due to warmer winter temperatures, Region 8 is expected to be affected by an increased incidence of drought and wildfire. However, projected increases in spring precipitation may counteract some of the effects of warming and result in increases in summer soil moisture and runoff (*low confidence*). In Region 8, climate change would result in increased frequency of drought due to low spring snowpack (*very likely*, >90%). It is *very likely* (>90%) that Region 8 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*).

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely* *than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 8, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section 2.2.1.2, **Introduction to Climate Change**.

2.3.8.2 Profile

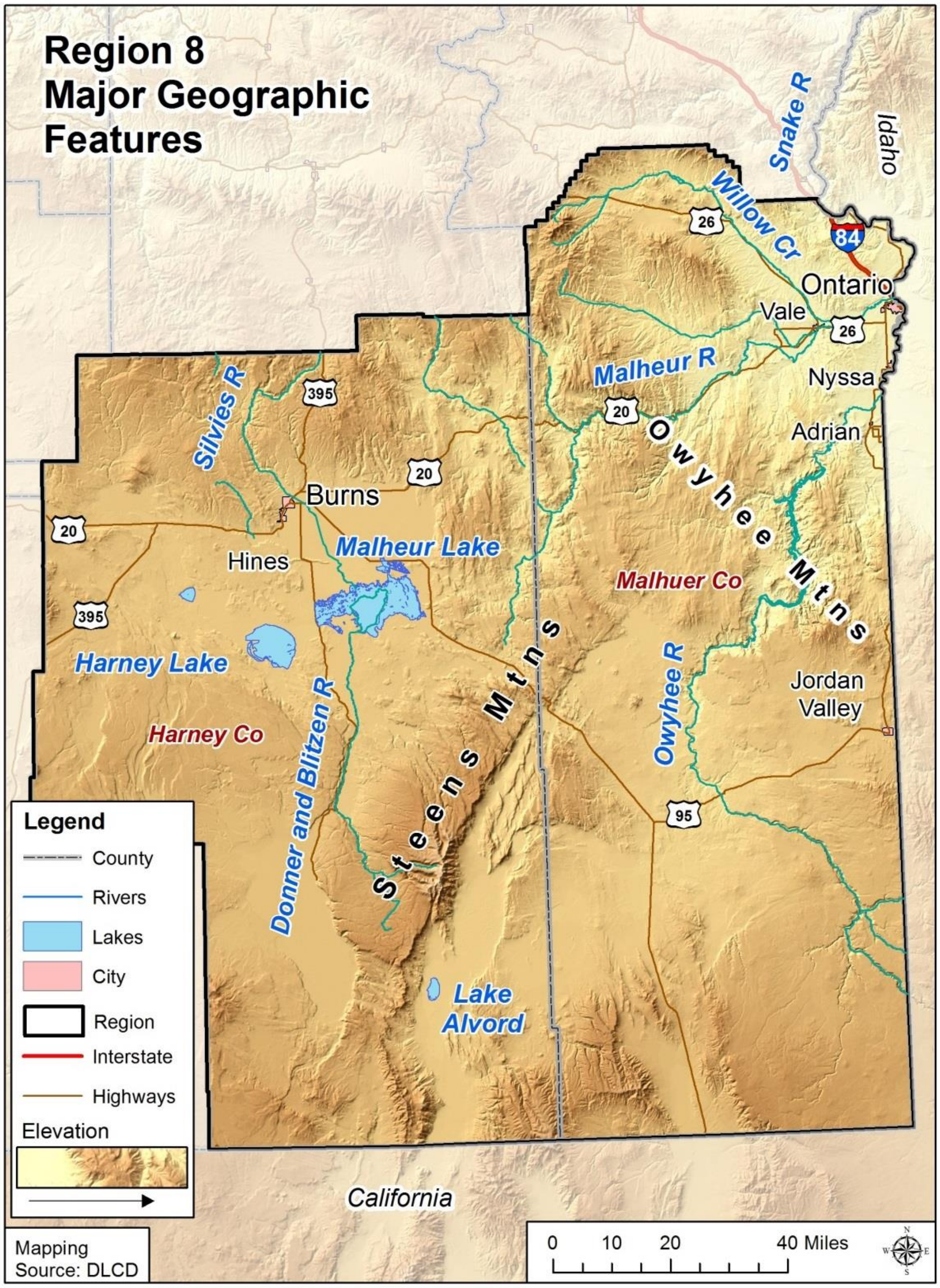
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

Region 8 is approximately 20,023 square miles in size and contains Harney and Malheur Counties. The region is bordered to the east by Idaho and to the south by Nevada and California. The Blue Mountains lie in the northern part of the region. Steens Mountain is a prominent landmass in the region and major rivers in the region include the Malheur and Owyhee.

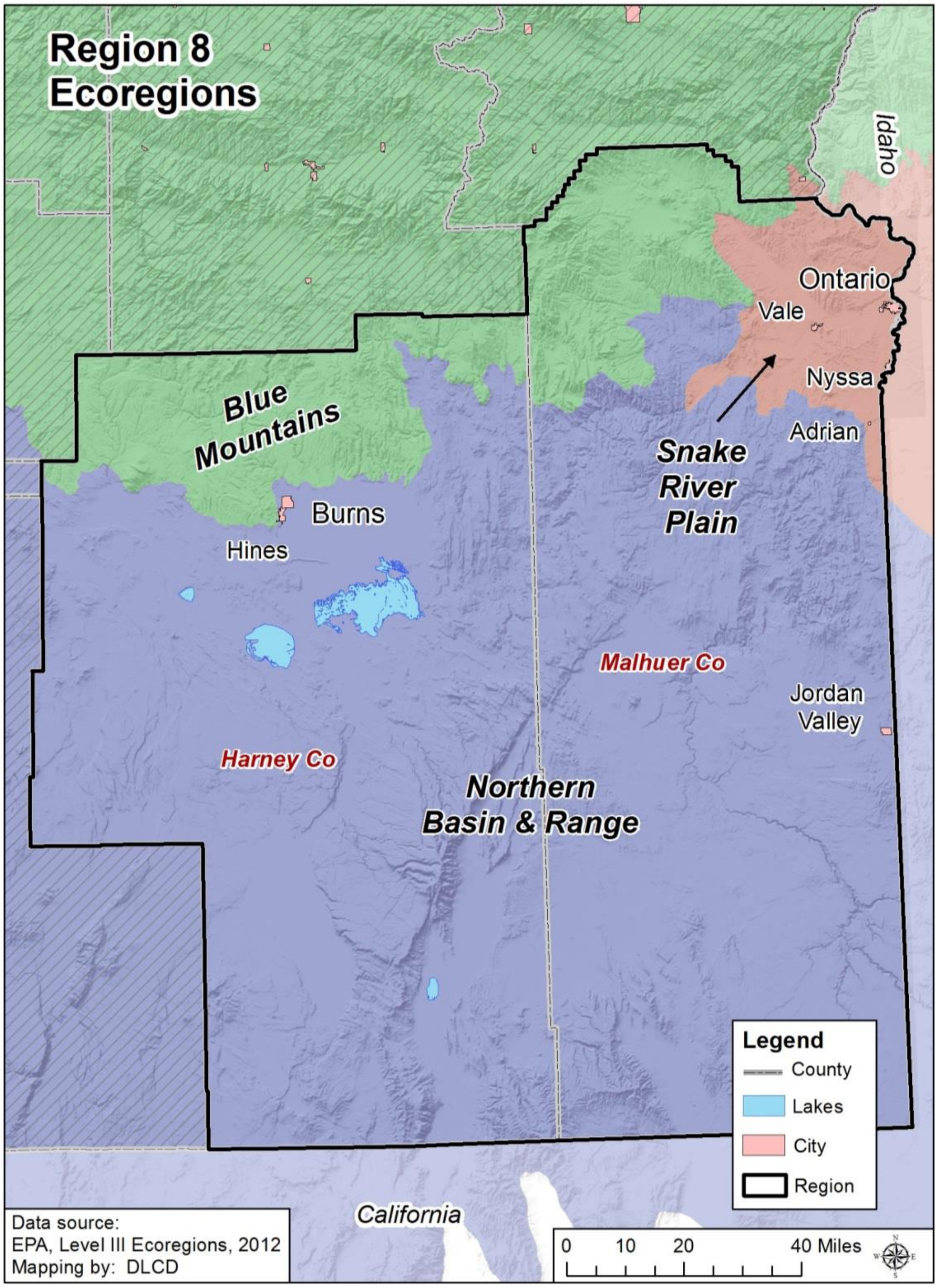
Figure 2-294. Region 8 Major Geographic Features



Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 8 is composed of three ecoregions: Northern Basin and Range, Blue Mountains, and Snake River Plain (Figure 2-295).

Figure 2-295. Region 8 Ecoregions



Blue Mountains: The Region 8 section of this ecoregion is complex and diverse having many sub-ecoregions with unique conditions. The landscape varies between steep sloped mountains of volcanic origin, scattered cinder cones, foothills, scattered buttes, and the Cold Basins, which contain cold, wet valleys, and basins. Forested areas may have ponderosa pine, mixed fir, or juniper canopies. Unforested areas are generally sagebrush steppes or wetlands with vegetation such as sedges and associated grasses. Land uses in the area are primarily livestock grazing and wildlife habitat (Thorson, et al., 2003).

Northern Basin and Range: This ecoregion dominates Region 8 with dissected lava plains, rolling hills, alluvial fans, valleys, deep river canyons, and scattered mountains. Because of the ecoregion's location in the rain shadow of the Cascades and Blue Mountains, most areas are arid or semi-arid. Basaltic rock, tuffaceous rock, or volcanic ash are dominant rock types, while soil generally varies between sediments, alluvial, colluvial and fluvial deposits, and rock outcrops. Land cover varies between sagebrush steppe, grasslands, rare wetlands, aspen stands in riparian meadows, and unvegetated deserts. Land uses in this ecoregion include recreation, wildlife habitat including federal wildlife refuges, and limited livestock grazing (Thorson, et al., 2003).

Snake River Plan: The Region 8 portion of the Snake River Plain ecoregion is classified as the "Unwooded Alkaline Foothills" and "Treasure Valley," which are underlain by volcanic and sedimentary rocks with alkaline lacustrine sediments and alluvium, loess, lacustrine and alluvial fan deposits at the surface. The landscape includes valleys, incised rivers, canals, rolling foothills, hills, benches, alluvial fans, and badlands. The land cover is dominated by sagebrush steppe with Wyoming big sagebrush, basin big sagebrush and associated grasses. Land uses in this ecoregion include croplands (potatoes, onions, beets, alfalfa, hay, wheat and sugar) as well as pastureland and wildlife habitat (Thorson, et al., 2003).

Climate

Climate refers to the temperatures, weather patterns, and precipitation in the region. This section covers historic climate information. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment** for statewide projections.

The climate of Southeast Oregon is semi-arid supporting primarily livestock grazing. The region is subject to droughts and wildfires, particularly during dry summers and years with low snowpack. Despite its relative dryness, the region is also subject to floods and landslides. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-740** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 8 based on data from the NOAA National Centers for Environmental Information.

Table 2-740. Average Precipitation and Temperature Ranges in Region 8 Ecoregions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Harney County	13.21" (7.58"–22.16")	Jan: 1.39" Jul: 0.42"	45.9°F	Jan: 19.9°F /37.4°F Jul: 50.4°F /84.1°F
Malheur County	13.13" (8.09"–21.78")	Jan: 1.41" Jul: 0.43"	48.0°F	Jan: 20.6°F /36.9°F Jul: 54.2°F /87.3°F
Climate Division 7 "South Central"	16.16" (10.02"–24.98")	Jan: 1.89" Jul: 0.49"	45.7°F	Jan: 21.5°F/38.4°F Jul: 48.6°F/82.6°F
Climate Division 9 "Southeast"	13.13" (8.09"–21.77")	Jan: 1.41" Jul: 0.43"	48.0°F	Jan: 20.6°F/36.9°F Jul: 54.2°F/87.3°F

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 22, 2019 from https://www.ncdc.noaa.gov/cag/.

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community's capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

Between 2010 and 2018, the population in Region 8 grew slightly—approximately eight percentage points behind than the statewide rate. Harney County's population declined marginally during this period, driven by natural decrease and somewhat steady out-migration. Natural decrease is expected to overtake net in-migration over the next decade in Harney County, causing the population to continue to decline at a slow rate (Population Research Center, Portland State University, 2018 [Harney County]). Malheur County's population increased slowly from 2010 to 2018, with a waning natural increase outpacing fluctuating in/out-migration. Looking forward, net out-migration is expected to outpace natural increase, resulting in a slow population decline in the county through 2030 (Population Research Center, Portland State University, 2019 [Malheur County]).

Table 2-741. Population Estimate and Forecast for Region 8

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 8	38,735	39,305	1.5%	38,133	−3.0%
Harney	7,422	7,380	−0.6%	7,334	−0.6%
Malheur	31,313	31,925	2.0%	30,799	−3.5%

Source: Population Research Center, Portland State University (2018), Certified Population Estimates; Population Research Center, Portland State University (2019), Current Forecast Summaries for All Areas & Oregon Final Forecast Table by Age (2019); U.S. Census Bureau, 2010 Decennial Census. Table DP-1

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 8 are largely centered on outdoor activities (hiking, vising state parks, etc.), touring (traveling to experience scenic beauty, history and culture), and special events (such as fairs, festivals or sporting events) (Longwoods International, 2017g). Note that the Longwoods Travel Report includes all of the Region 8 counties; Baker, Grant, Union, and Wallowa (Region 7); and Morrow, Umatilla, and parts of Gilliam Counties within the Eastern Region. Moreover, Longwoods notes that tourism data for Eastern Oregon should be used with caution due to the small sample size; to maximize reliability, the report combined samples from 2016 and 2017.

Approximately 43% of all trips to Eastern Oregon originate from other parts of Oregon (Longwoods International, 2017g). The average travel party contains between three to four persons and the average number of nights spent in in the region between two and three (Longwoods International, 2017g). Annually there are more than twice as many tourists in Malheur County than Harney County.

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

Table 2-742. Annual Visitor Estimates in Person Nights (X1000) in Region 8

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 8	906	—	928	—	912	—
Harney	268	100%	271	100%	274	100%
Hotel/Motel	95	35.4%	99	36.5%	100	36.5%
Private Home	73	27.2%	74	27.3%	74	27.0%
Other	100	37.3%	99	36.5%	100	36.5%
Malheur	638	100%	657	100%	638	100%
Hotel/Motel	227	35.6%	243	37.0%	229	35.9%
Private Home	306	48.0%	310	47.2%	303	47.5%
Other	106	16.6%	104	15.8%	106	16.6%

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003). A higher percentage of residents in Region 8 have a disability compared to the statewide estimate. The share is also higher in both counties, even considering the margins of error.

The percentage of younger people (<18) in the region with a disability is higher; however, the estimates for “Under 18 years with a disability” should be used with caution due to sampling error.

The percentage of older adults with a disability is slightly higher than the statewide estimate. Harney County has a higher percentage than Malheur County; however, the margins of error should be noted.

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Table 2-743. People with a Disability by Age Group in Region 8

	With a Disability			Under 18 Years with a Disability			65 Years and Over with a Disability		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	14.6%	✓	0.1%	4.6%	✓	0.2%	37.1%	✓	0.4%
Region 8	17.1%	✓	1.4%	6.4%	⊙	1.9%	38.5%	✓	3.6%
Harney	19.2%	✓	2.0%	8.0%	⊗	4.3%	41.2%	✓	6.4%
Malheur	16.6%	✓	1.6%	6.0%	⊙	2.2%	37.5%	✓	4.1%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/. Total population does not include institutionalized population

Homeless Population

The U.S. Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count, a biennial count of sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors. They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing & Community Services, 2019). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing & Community Services, 2019).

According to the PIT, between 2015 and 2019 the region experienced a decline in the total number of people experiencing homelessness; however, the volatility of the count between years suggests reliability issues. Malheur County reported a decline while the number of people counted in Harney County reportedly increased during the period.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate vulnerability conditions. Disasters that result in damage to the built environment can place additional stress on temporary shelters (Peacock, Dash, Zhang, & Van Zandt, 2017). Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-744. Homeless Population Estimate for Region 8

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 8	110	170	81	120
Harney	6	19	59	28
Malheur	104	151	22	92

Source: Oregon Housing and Community Services (n.d.). Oregon Point In Time Homeless Counts. Retrieved from https://public.tableau.com/profile/oregon.housing.and.community.services#!/vizhome/2019Point-in-TimeDashboard/Story1

Biological Sex and Gender

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019, Apr. 3). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019, Apr. 3).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019, Apr. 3). According to the survey, there are more men than women in the region (116.17 men to every 100 women) (U.S. Census Bureau, 2019, Mar. 31). Malheur County has the greatest imbalance (119.7 men to every 100 women), while the ratio in Harney is more even 102.4 men to every 100 women) (U.S. Census Bureau, 2019, Mar. 31).

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognized (Enarson, 2017). This is an area deserving of more attention as the field develops.

Age

Older adults, persons aged 65 and older, comprise a similar share of the population vis-à-vis the state. In Malheur County, conversely, the percentage is higher than the statewide estimate. Consequently, the regional share is also higher than the statewide estimate. Older adults require special consideration in the planning process. They are more likely to have a disability and require assistance from others to complete routine tasks. Family or neighbors who might ordinarily assist them might be unable to help during a disaster event (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Moreover, an older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

Harney County has a similar percentage of children compared to the statewide estimate (approximately one-fifth). Malheur County, conversely, has a higher share of children and a larger population. Consequently, the percentage of children in the region is also higher than the state as a whole. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. Parents might lose time from work and money when their children's childcare facilities and schools are impacted by disasters (Cutter, Boruff, & Shirley, 2003).

Table 2-745. Population by Vulnerable Age Group, in Region 8

	Total Population	Under 18 Years Old			65 and Older		
	Estimate	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	4,025,127	21.5%	☑	0.1%	16.3%	☑	0.1%
Region 8	37,616	24.6%	☑	0.1%	17.2%	☑	0.1%
Harney	7,195	21.2%	☑	0.5%	22.2%	☑	0.4%
Malheur	30,421	25.4%	☑	*	16.0%	☑	0.1%

* Indicates that the estimate has been controlled to be equal to a fixed value and so it has no sampling error.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP05: ACS Demographics and Housing Estimates, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to language and culturally appropriate outreach materials. The region has a higher percentage of residents that do not speak English "very well" compared to the state as a whole. That population overwhelmingly lives in Malheur County. The number of people in Harney County who do not speak English "very well" is small and well below that statewide share, even considering the margins of error. Communities creating outreach materials used to communicate with and plan for populations who do not speak English very well should take into consideration the language needs of these populations.

Table 2-746. English Usage in Region 8

	Speak English Less Than "Very Well"				
	Estimate	CV **	MOE (+/−)	Percent	% MOE (+/−)
Oregon	222,428	☑	4,116	5.9%	0.1%
Region 8	2,507	☑	399	7.1%	1.1%
Harney	139	⊗	85	2.0%	1.3%
Malheur	2,368	☑	390	8.4%	1.4%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

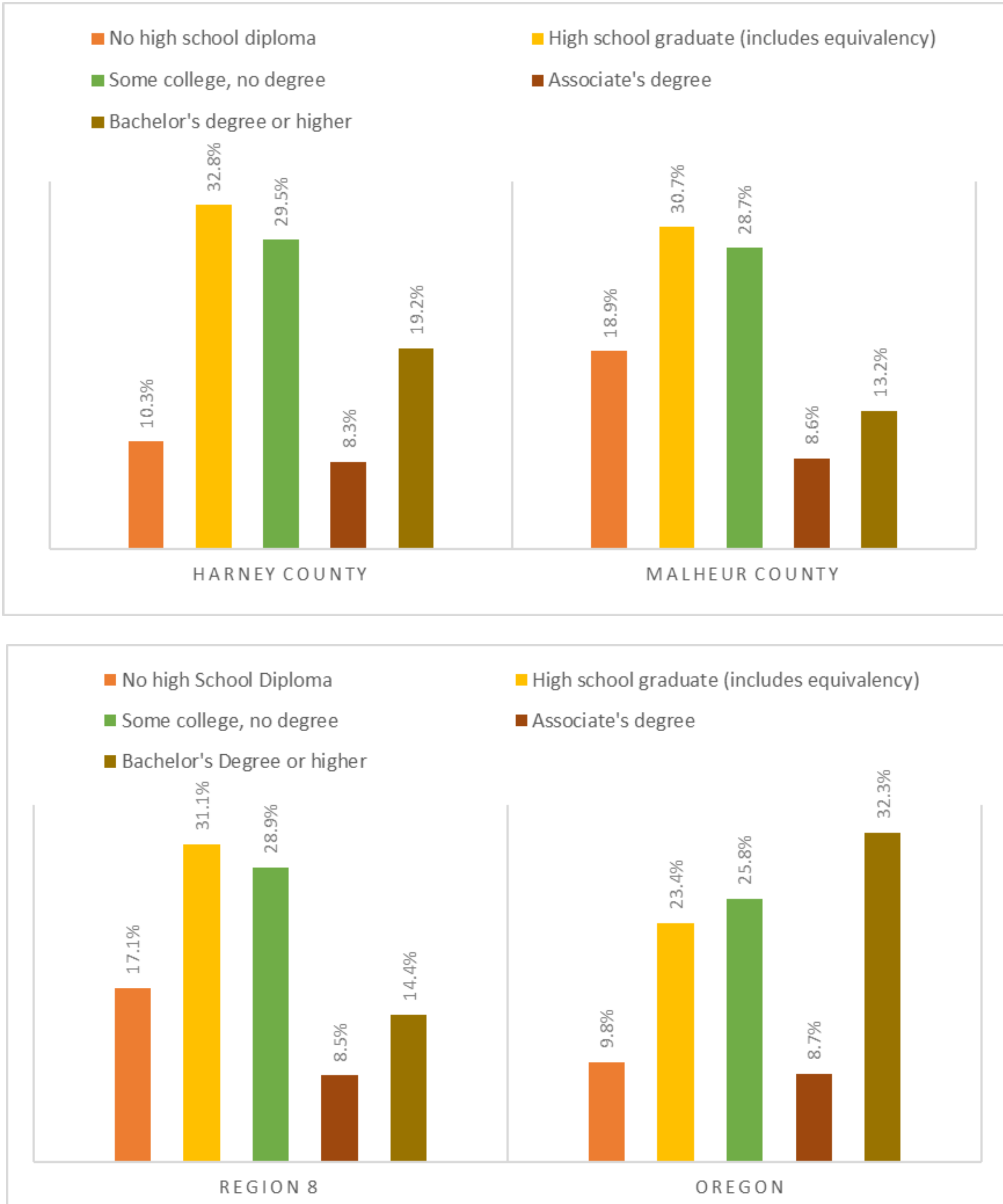
Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Education Level

Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual’s ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

The percentage of residents with a bachelor’s degree is nearly eighteen percentage points smaller in Region 8 than in the state as a whole. Between the two counties, Harney County has a higher percentage of residents with a four-year degree. Malheur County has a greater percentage of residents without a high school diploma—approximately nine percentage points higher than the statewide estimate.

Figure 2-296. Educational Attainment in Region 8: (top) by County, (bottom) Regional vs. Statewide



Source: U.S. Census Bureau. Table DP03: Selected Economic Characteristics, American Community Survey, 2013-2017 American Community Survey 5-Year Estimates

Income and Poverty

The impact of a disaster in terms of loss and the ability to recover varies among population groups. “The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event" (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public (Stahl, P., 2000). Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, are less likely to have the savings to rebuild after a disaster, and are less likely to have access to transportation and medical care.

Median household income in both counties is $16,000-$19,000 less than the statewide median. Harney County's estimate is slightly higher, however, the margins of error indicate median household income is similar in the two counties. Between 2012 and 2017, neither county experienced a statistically significant change in median household income.

Table 2-747. Median Household Income in Region 8

	2008-2012			2013-2017			Statistically Different*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	$53,427	☑	$338	$56,119	☑	$370	Yes
Region 8	—	—	—	—	—	—	—
Harney	$42,273	☑	$4,556	$39,504	☑	$4,691	No
Malheur	$39,872	☑	$2,028	$37,112	☑	$2,868	No

Note: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: 2013-2017 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Approximately 46% of all households in Region 8 earn less than $35,000 annually—fifteen percentage points higher than the statewide share. Malheur County has a higher percentage of earners in the bottom income brackets; however, the percentage earning less than $35,000 per year exceeds 40% in both counties. The higher proportion in the bottom means a smaller share at the top. Approximately 18% of residents in Region 8 earn more than 75,000 annually—roughly thirteen percentage points less than the share statewide. One-third of the region's households earn between $35,000 and $75,000 per year.

Figure 2-297. Median Household Income Distribution in Region 8

Source: U.S. Census Bureau. Table DP03: Selected Economic Characteristics, American Community Survey, 2013-2017 American Community Survey 5-Year Estimates

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018). A greater share of the regional population is living in poverty compared to the state as a whole. This is also true for both counties in the region as well. The percentage of people living in poverty is higher in Malheur County is higher than in Harney County; however, the margins of error indicate the estimates might be closer (or further apart).

A higher percentage of children in Region 5 are living in poverty compared to the statewide share; however, due to sampling error, estimates of child poverty for Harney County should be used with caution. Notably, over one-third of children in Malheur County live in poverty.

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources (Cutter, Boruff, & Shirley, 2003).

Table 2-748. Poverty Rates in Region 8

	Total Population in Poverty						
	2008-2012			2013-2017			Statistical Difference?*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	15.5%	☑	0.3%	14.9%	☑	0.30	No
Region 8	23.8%	☑	2.2%	23.6%	☑	2.10	No
Harney	19.1%	⊙	4.7%	17.5%	☑	3.90	No
Malheur	25.0%	☑	2.5%	25.2%	☑	2.50	No

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Table 2-749. Child Poverty in Region 8

	Children Under 18 in Poverty						
	2008-2012			2013-2017			Statistical Difference?*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	20.6%	☑	0.5%	19.0%	☑	0.6%	Yes
Region 8	32.3%	☑	5.1%	34.6%	☑	4.1%	No
Harney	29.0%	⊙	11.6%	23.3%	⊙	8.9%	No
Malheur	33.0%	☑	5.7%	36.8%	☑	4.6%	No

* Yes indicates that the 2013-2017 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Low-income populations require special consideration when mitigating loss from a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources (Cutter, Boruff, & Shirley, 2003).

Housing Tenure

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

Harney County's estimate is approximately eight percentage points higher than the statewide estimate. Conversely, Malheur County's share is approximately three percentage points smaller than the statewide portion. As Malheur County has more than three times the number of households as Harney County, the percentage of owner-occupied households in Region 8 is slightly smaller than the share statewide.

Table 2-750. Housing Tenure in Region 8

	Total Occupied Units	Owner-Occupied			Renter-Occupied		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	61.7%	✓	0.3%	38.3%	✓	0.3%
Region 8	13,341	60.8%	✓	2.3%	39.2%	✓	2.6%
Harney	3,079	69.9%	✓	4.2%	30.1%	✓	4.2%
Malheur	10,262	58.0%	✓	2.6%	42.0%	✓	2.6%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP04: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households. Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only. Both counties in the region have a higher percentage of family households and a smaller share of single-person households compared to the state as a whole. Harney County has a smaller percentage of single-parent households than the statewide estimate. Conversely, Malheur County's share is approximately four percentage points higher than the statewide share.

Table 2-751. Family vs. Non-family Households in Region 8

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	63.3%	✓	0.2%	36.7%	✓	0.2%	27.7%	✓	0.2%
Region 8	13,341	67.6%	✓	2.6%	32.4%	✓	2.3%	26.3%	✓	2.2%
Harney	3,079	66.1%	✓	4.3%	33.9%	✓	4.3%	24.3%	✓	4.7%
Malheur	10,262	68.0%	✓	2.5%	32.0%	✓	2.5%	26.9%	✓	2.5%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-752. Family Households with Children by Head of Household in Region 8

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	26.2%	☑	0.2%	8.1%	☑	0.2%
Region 8	28.3%	☑	2.3%	11.1%	☑	1.9%
Harney	22.6%	☑	2.7%	6.5%	⊙	2.9%
Malheur	30.0%	☑	2.5%	12.5%	☑	2.4%

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

Social and Demographic Trends

This analysis shows that Region 8 has a greater number of people than the state average who are predisposed to be particularly vulnerable during a hazard event, because:

- The region has a higher percentage of residents with disabilities than the state as a whole. The share is also higher for older adults. The percentage of children living with a disability might also be higher, but the American Community Survey estimates are unreliable.
- Compared to the state as a whole, Region 8, and Malheur County, in particular, has a higher percentage of residents that do not speak English "very well".
- The share of residents with a bachelor's degree or more is considerably lower in the region compared to the state as a whole. Moreover, the percentage of residents without a high school diploma in Malheur County is significantly higher than the statewide share—approximately nine percentage points higher than the statewide estimate.
- Median household income in both counties is $16,000-$19,000 less than the statewide median. And approximately 46% of all households in Region 8 earn less than $35,000 annually—fifteen percentage points higher than the statewide share.
- A greater share of the regional population is living in poverty compared to the state as a whole, and over one-third of all children in Malheur County live in poverty.
- Malheur County’s share of single-parent households is approximately four percentage points higher than the statewide share.

Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses’ labor, capital, suppliers, and customers are all relevant factors (Zhang, Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang, Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent.

Employment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 8 have been steadily declining since they peaked during the Great Recession. From 2014 to 2018, the unemployment rate in Harney County has always higher than in Malheur County; however, unemployment in both counties was consistently higher than the statewide rate.

Table 2-753. Civilian Labor Force in Region 8, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 8	15,910	15,123	95.1%	787	4.9%
Harney	3,417	3,205	93.8%	212	6.2%
Malheur	12,493	11,918	95.4%	575	4.6%

Source: Oregon Employment Department, 2019

Table 2-754. Civilian Unemployment Rates in Region 8, 2014-2018

	2014	2015	2016	2017	2018	Change (2014–2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	-2.6%
Region 8	8.3%	6.5%	5.7%	5.0%	4.9%	-3.3%
Harney	9.6%	7.2%	6.2%	6.3%	6.2%	-3.4%
Malheur	7.9%	6.4%	5.5%	4.6%	4.6%	-3.3%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups “economic units that have similar production processes” according to a six-digit hierarchical structure (Office of Management and Budget, n.d.). “The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry” (Office of Management and Budget, n.d.). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors (U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 8 were:

1. Trade, Transportation and Utilities
2. Local Government

3. Education and Health Services
4. Natural Resources and Mining
5. Leisure and Hospitality

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region's resiliency. In Region 8, the following supersectors comprise a significant share of all business establishments.

- The Trade, Transportation, and Utilities supersector includes the highest number of establishments in Region 1, 17.8% of all businesses (QCEW, 2018).
- Other Services is second largest, with 16.0% of all business establishments (QCEW, 2018).
- The Natural Resources and Mining supersector is third, with 11.8% of the regional share (QCEW, 2018).
- Leisure and Hospitality is fourth largest with 9.2% of all establishments (QCEW, 2018).
- The Education and Health Services supersector is the fifth comprising 8.7% of all business establishments (QCEW, 2018).

While supersectors are useful abstractions, it's important to remember that within are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event.

Table 2-755. Covered Employment by Sector in Region 8, 2019

Industry	Region 8	Harney County		Malheur County	
	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	2,464	100.0%	12,875	100.0%
Total Private Coverage	73.0%	1,470	59.7%	9,725	75.5%
Natural Resources & Mining	10.1%	220	8.9%	1,332	10.3%
Construction	2.7%	105	4.3%	304	2.4%
Manufacturing	6.8%	(c)	(c)	1,044	8.1%
Trade, Transportation & Utilities	21.2%	420	17.0%	2,837	22.0%
Information	1.3%	(c)	(c)	194	1.5%
Financial Activities	2.2%	47	1.9%	290	2.3%
Professional & Business Services	3.2%	84	3.4%	412	3.2%
Education & Health Services	12.6%	222	9.0%	1,711	13.3%
Leisure & Hospitality	9.5%	268	10.9%	1,195	9.3%
Other Services	3.2%	84	3.4%	405	3.1%
Unclassified	0.0%	0	0.0%	(c)	(c)
Total All Government	27.0%	994	40.3%	3,149	24.5%
Total Federal Government	2.8%	229	9.3%	198	1.5%
Total State Government	8.2%	100	4.1%	1,156	9.0%
Total Local Government	16.0%	666	27.0%	1,795	13.9%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region.

Education and Health Services: The industries in these sectors play important roles in emergency response in the event of a disaster. Health care is a relatively stable revenue sector regionally with an increasing distribution of businesses primarily serving a local and aging population. Natural

Resources and Mining: The primary industries within this sector regionally are largely crop and animal production. These industries tend to fluctuate seasonally and are vulnerable to a variety of natural hazard (winter storms, floods, etc.). Further, to the loss of farm production, wages could be lost due to natural disasters. In addition, these industries are dependent upon transportation systems that are vulnerable to disasters.

Leisure and Hospitality: This sector primarily serves regional residents with disposable income and tourists. The behavior of both of these social groups would be disrupted by a natural disaster. Regional residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. Many of the top employment subsectors are similar across regions. For example, Food Services and Drinking Places and Educational Services are the two largest employment subsectors in Region 8. These subsectors also rank highly in other regions. Ambulatory Health Care Services—also known as outpatient services—and Hospitals are also major employers in Region 8 and across the state. Conversely, other subsectors, such as Crop Production and Food Manufacturing, are more unique to the region.

Table 2-756. Industries with Greatest Share of Employment in Region 8, 2018

Industry	Employment Share	Employment (2018)
Food Services and Drinking Places	8.9%	1,602
Educational Services	8.9%	1,589
Justice, Public Order, and Safety Activities	7.2%	1,298
Crop Production	6.2%	1,111
Food Manufacturing	6.1%	1,100
General Merchandise Stores	4.8%	869
Social Assistance	4.8%	855
Ambulatory Health Care Services	4.6%	831
Food and Beverage Stores	3.7%	665
Support Activities for Agriculture and Forestry	3.5%	637

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for employment share and average employment by DLCD

Industry Concentration and Employment Change

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

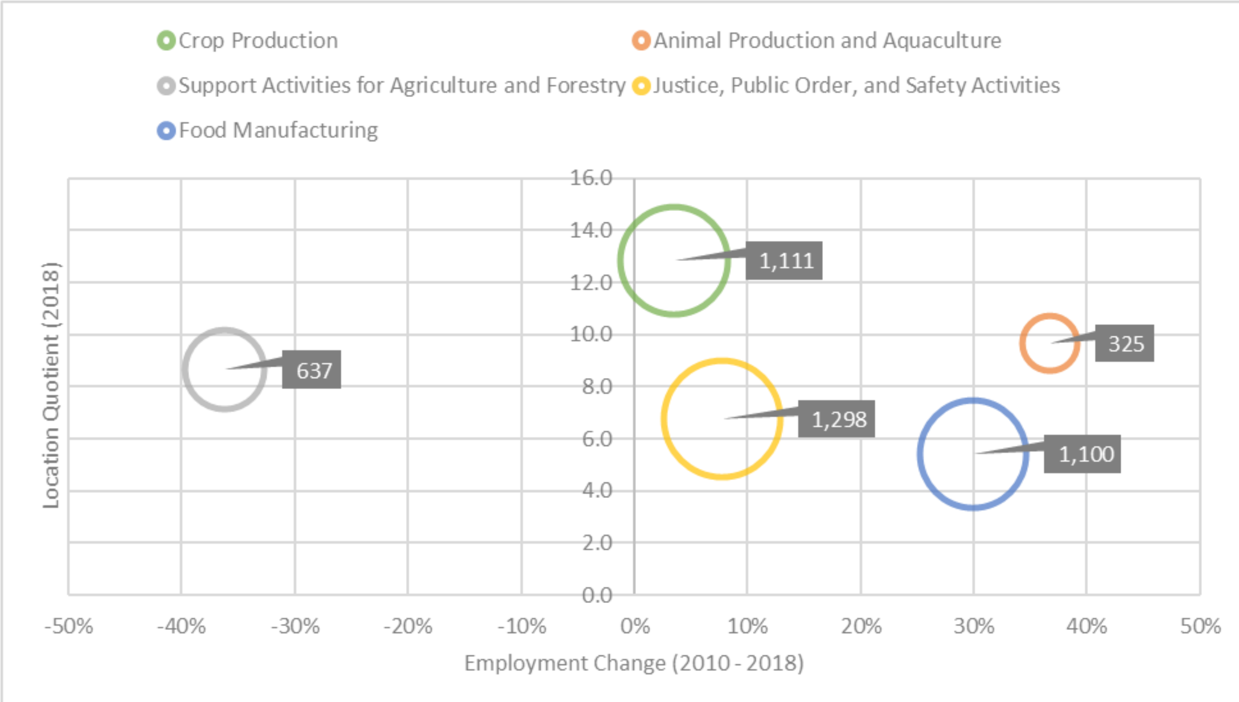
Table 2-757. Most Concentrated Industries and Employment Change in Region 8, 2018

Industry	Location Quotient	Employment (2018)	Employment Change (2010–2018)
Crop Production	12.9	1,111	3%
Animal Production and Aquaculture	9.7	325	37%
Support Activities for Agriculture and Forestry	8.7	637	−36%
Justice, Public Order, and Safety Activities	6.8	1,298	8%
Food Manufacturing	5.4	1,100	30%

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 8 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-298. Location Quotients, Employment Change, and Total Employment in Region 8, 2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

Four of the region's most concentrated industries are either natural resource based or directly dependent on natural resource industries. Looking at these four subsectors as a whole, it's clear that the region has a competitive advantage in growing and processing food products. Three of the four also represent some of the largest subsectors by share of employment. The Food Manufacturing and Animal Production and Aquaculture subsectors experienced the most growth during the 2010-2018 period. Conversely, the Support Activities of Agriculture and Forestry subsector shed jobs during the period.

Fastest Growing and Declining Industries

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang, Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining.

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 8's fastest growing and declining industries

Table 2-758. Fastest Growing and Declining Industries in Region 8, 2010-2018

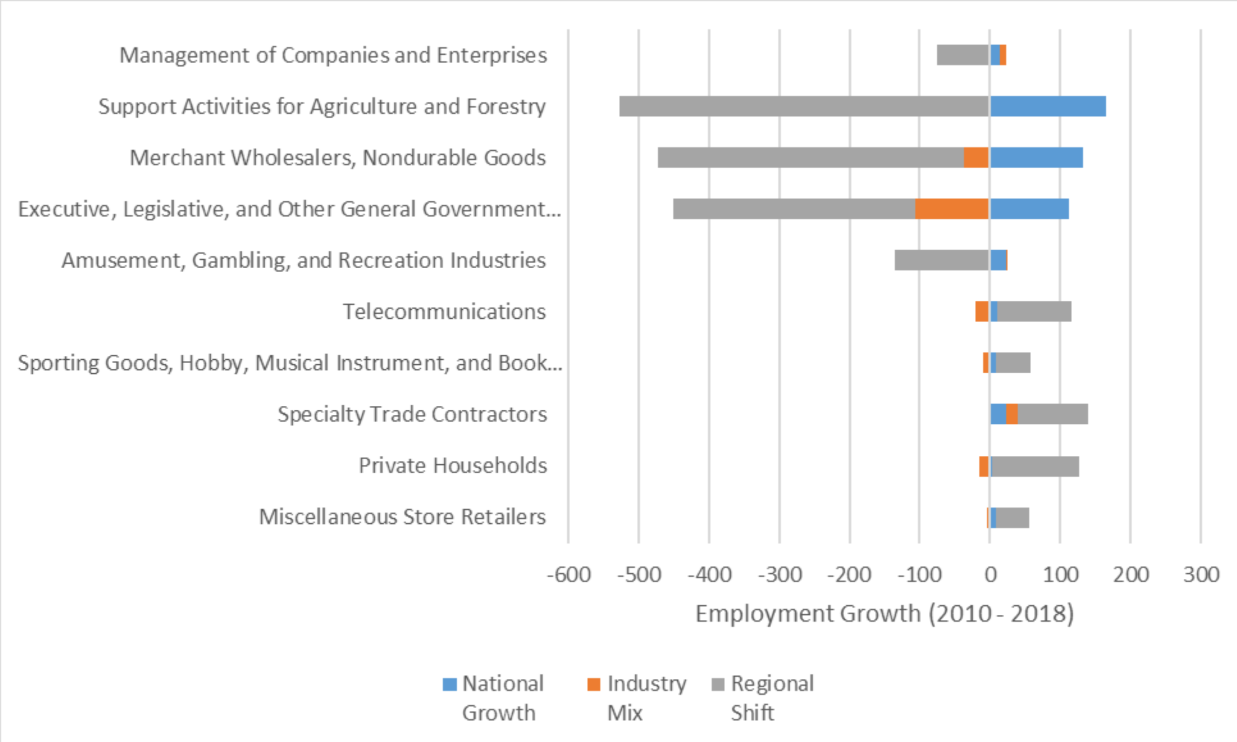
Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Private Households	546%	21	133
Telecommunications	149%	63	158
Miscellaneous Store Retailers	104%	50	103
Sporting Goods, Hobby, Musical Instrument, and Book Stores	104%	47	97
Specialty Trade Contractors	102%	136	275
Fastest Declining			
Amusement, Gambling, and Recreation Industries	−80%	137	28
Management of Companies and Enterprises	−59%	90	37
Executive, Legislative, and Other General Government Support	−50%	672	333
Merchant Wholesalers, Nondurable Goods	−42%	801	462
Support Activities for Agriculture and Forestry	−36%	997	637

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

Due to a smaller regional population, the fastest growing industries started with meager employment in 2010—each under two-hundred. Consequently, small changes in absolute terms equate to significant percent increases. According to the shift share analysis, growth in all five subsectors was driven by largely by regional factors. However, it should be noted that with such small numbers, subsector growth potentially represents the opening of one or two establishments, rather than a larger industry trend.

Region 8 experienced notable declining employment in the Merchant Wholesalers, Nondurable Goods subsector; the Executive, Legislative, and other General Governmental Support subsector; and the Support Activities for Agriculture and Forestry subsector. Each shed over three-hundred jobs. While some of the jobs loss in the first two can be attributed to decline in the subsector at the national level, loss in all three was driven primarily by regional factors.

Figure 2-299. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 8, 2010-2018



Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Table 2-759. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 8, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Miscellaneous Store Retailers	53	8	−4	48
Private Households	112	3	−15	124
Specialty Trade Contractors	139	23	17	99
Sporting Goods, Hobby, Musical Instrument, and Book Stores	49	8	−9	50
Telecommunications	95	11	−21	105
Fastest Declining				
Amusement, Gambling, and Recreation Industries	−109	23	3	−135
Executive, Legislative, and Other General Government Support	−339	112	−107	−344
Merchant Wholesalers, Nondurable Goods	−340	133	−37	−436
Support Activities for Agriculture and Forestry	−361	166	−3	−524
Management of Companies and Enterprises	−53	15	8	−76

U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

Economic Trends and Issues

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the following situations increase the region's level of vulnerability to natural hazard events:

- The region generally lacks a diversity of traded sector industries. Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- Unemployment rates across the region were higher than in the state as a whole From 2014 to 2018;
- The Support Activities for Agriculture and Forestry subsector, an area of competitive advantage for the region, shed jobs from 2010-2018.
- The regional economy has few opportunities for highly skilled employees, limiting the income potential of regional residents.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl, et al., 2000).

Infrastructure

Transportation

Roads

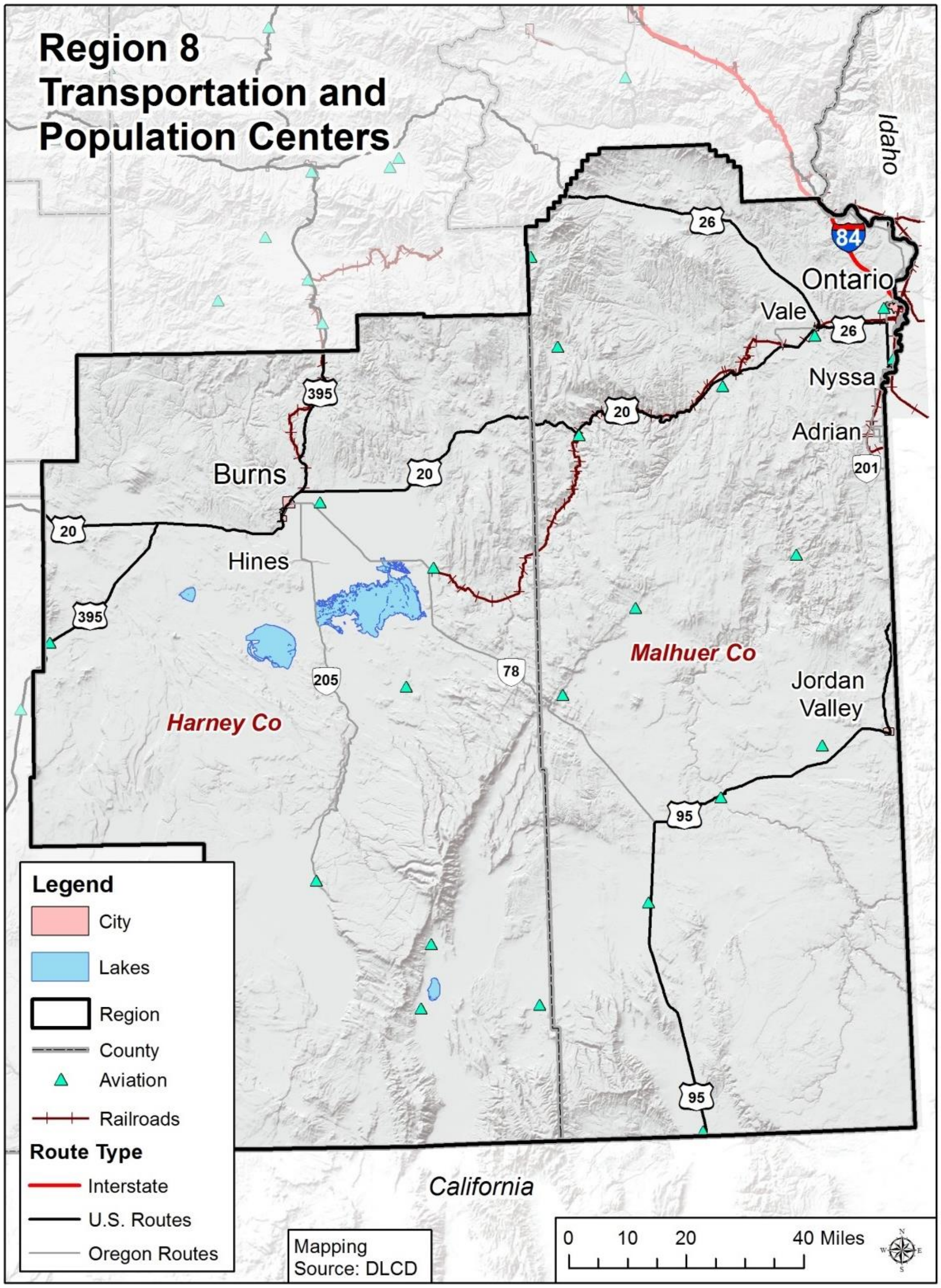
The largest population bases in Region 8 are located along the region's major highways: I-84, US-20, US-26, and US-95. I-84 runs north-south and is the main passage for automobiles and trucks traveling east of the Cascade Range between Portland and Idaho **Figure 2-300** shows Region 8's highways and population centers. US-20, US-26, and US-95 provide access east and west into Idaho and central Oregon counties. US-395 provides access into Lake County. Additional access is provided within Idaho to adjacent counties via US-30 and US-95.

Region 8's growing population centers bring more workers, automobiles, and trucks onto roads. A high percentage of workers driving alone to work coupled with interstate and international freight movement create additional stresses on transportation systems. Some of these include added maintenance, congestion, oversized loads, and traffic accidents.

Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuations and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

According to the Oregon Department of Transportation's (2014, October) Seismic Plus Report (Appendix **9.1.13**), the projected impacts of a CSZ event are considered negligible in this part of the state. However, economic disruption from major losses in the larger markets of the state will affect the economy in this region.

Figure 2-300. Region 8 Transportation and Population Centers



Source: Oregon Department of Transportation (2014, October)

Bridges

ODOT lists 287 bridges in the counties that comprise Region 8.

Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or are part of regional and local systems that are maintained by the region's counties and cities.

A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. The ratings do not imply that a bridge is unsafe (ODOT, 2020). The region has a lower percentage of bridges that are distressed and/or deficient (2%) than the state overall (5%).

Table 2-760. Bridge Inventory for Region 8

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 8	0	111	0%	7	176	4%	0	0	N/A	0	0	N/A	7	287	2%
Harney	0	37	0%	2	71	3%	0	0	N/A	0	0	N/A	2	108	2%
Malheur	0	74	0%	5	105	5%	0	0	N/A	0	0	N/A	5	179	3%

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2020)

Railroads

Railroads that run through Region 8 support cargo and trade flows. The region's major freight rail providers are the Union Pacific (UP) and the Burlington Northern-Santa Fe (BNSF) railroads. The rail line follows the I-84 corridor and another non-Class I rail line provides access to the City of Vale. There are no active rail lines in Harney County. There are two rail yards in the region — in Ontario and Nyssa — operated by UP (Cambridge Systematics, 2014). There is no passenger rail available in Region 8.

Oregon's rail system is critical to the state's economy, energy, and food systems. Rail systems export lumber and wood products, pulp and paper, and other goods produced in Oregon and products from other states that are shipped to and through Oregon by rail (Cambridge Systematics, 2014).

Rails are sensitive to icing from winter storms that can occur in Region 8. Disruptions in the rail system can result economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

There are no commercial airports in the region, however. There are several general aviation public airports including the Burns and Ontario Municipal airports.

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

Table 2-761. Public and Private Airports in Region 8

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Helipad	Private Helipad	Total
Region 8	6	17	0	1	24
Harney	1	8	0	0	9
Malheur	5	9	0	1	15

Source: FAA Airport Master Record (Form 5010), 2014

Energy

Electricity

The region is served by several investor-owned, public, cooperative, and municipal utilities. The Bonneville Power Administration is the area's wholesale electricity distributor. Idaho Power is the primary investor-owned utility company serving Harney and Malheur Counties. The region's electric cooperatives include the Harney Electric Cooperative (Harney, Malheur), and the Oregon Trail Electric Cooperative (Harney).

Table 2-762 lists electric power-generating facilities that are within Region 8. The region has two power-generating facilities: one hydroelectric power facility and one geothermal facility. There are no power-generating facilities in Harney County. In total, the power-generating facilities have the ability to produce up to 40 megawatts (MW) of electricity.

Table 2-762. Power Plants in Region 8

	Hydro-electric	Natural Gas	Wind	Coal	Other*	Total
Region 8	1	0	0	0	1	2
Harney	0	0	0	0	0	0
Malheur	1	0	0	0	1	2
Energy Production (MW)	35	0	0	0	5	40

*"Other" includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

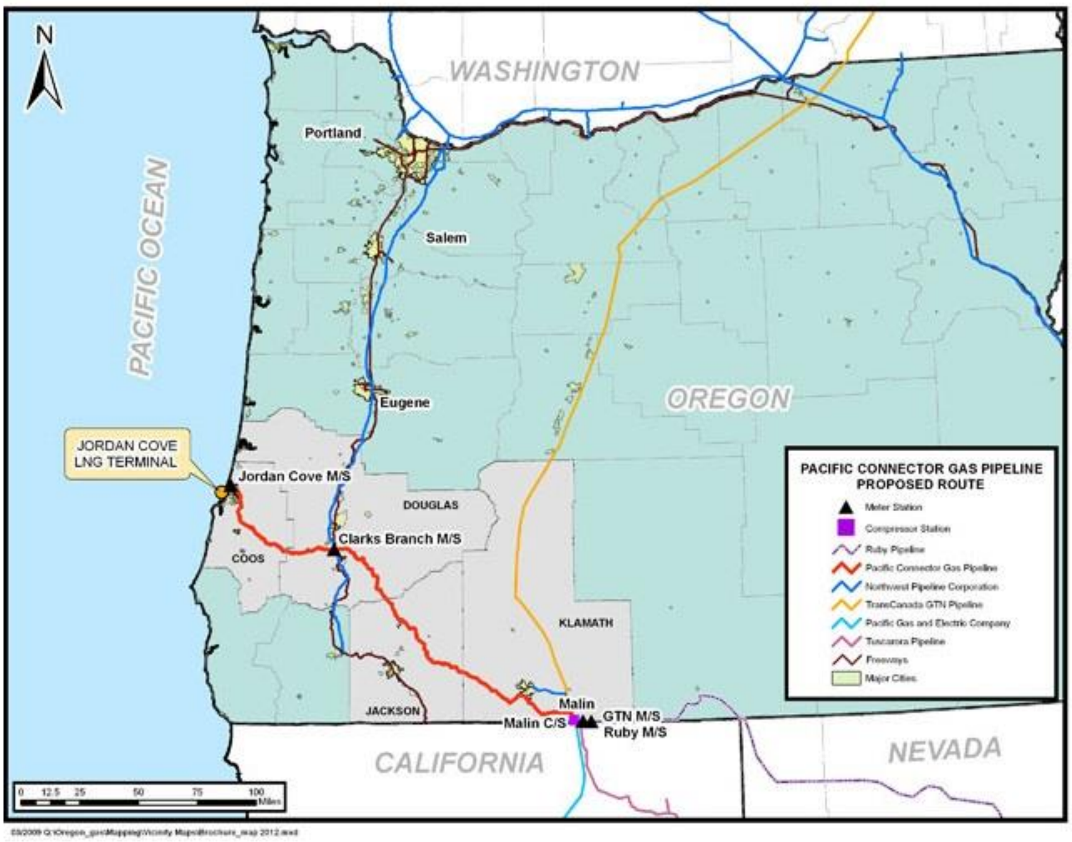
Hydropower

There are several major dams owned by Idaho Power along the Lower Snake River just north of Region 8 which produce a significant amount of hydropower.

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to the region's energy portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-301** shows the Northwest Pipeline, which runs through Malheur County (near Ontario, shown in blue). (http://www.northwest.williams.com/NWP_Portal/extLoc.action?Loc=FilesNorthwestother&File=pipelineInfo.html). LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

Figure 2-301. Liquefied Natural Gas Pipelines in Region 8



Source: Williams Corporation

Utility Lifelines

The northeast corner of Malheur County is an important throughway for oil and gas pipelines and electrical transmission lines. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe but infrequent natural hazards such as earthquakes.

Region 8 primarily receives oil and gas from Alaska by way of the Puget Sound through pipelines and tankers. The electric, oil, and gas lifelines that run through the region are both municipally and privately owned (Loy, Allan, & Patton, 1976).

The network of electrical transmission lines running through Region 8 is operated primarily by Idaho Power, Pacific Power, and regional electrical cooperatives (and supplied by the Idaho Power Company and Bonneville Power Administration) and primarily facilitates local energy production and distribution (Loy, Allan, & Patton, 1976). Most of the natural gas Oregon uses originates in Alberta, Canada. The Williams Company owns the main natural gas transmission pipeline in southeastern Oregon.

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Region 8 is part of the Lake-Harney Operational Area under The Oregon State Emergency Alert System Plan (Oregon OEM, 2013). There is a memorandum of understanding between these counties that facilitates the launching of emergency messages. Counties in these areas can launch emergency messages by contacting the Oregon Emergency Response System (OERS), which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communication capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation’s status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The Oregon State Emergency Alert System Plan does not identify a local primary station for emergency messages; however, messages are provided via the three state primary networks: Oregon Public Broadcasting (Portland), KOBI TV (Medford), and KWAX-FM (Eugene).

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 8. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is readily available throughout most parts the region with a smaller number of providers and service types available in the more remote parts of the region (NTIA, n.d.). Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 8 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for the Eastern Oregon Operational Area are:

Local Primary Station:

- KBHN-FM, 1230 KHZ (Burns); and

State Primary Station:

- KOBN-FM, 90.1 MHZ (Burns).

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). ARES District 6 provides service to Region 8. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency Management, n.d.)The official ham emergency station calls for Region 8 are (American Relay Radio League Oregon Chapter, www.arrloregon.org):

- Harney County: KF7CIS; and
- Malheur County: K&RHB.

Water

Water infrastructure includes drinking water, stormwater, and wastewater systems. All of these systems possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In southeastern Oregon, the majority of municipal drinking water is supplied from groundwater wells, including in the cities of Burns and Hines. The City of Ontario primarily draws its drinking water from the Snake River. The City of Nyssa also has water rights for municipal water on the Snake River as a secondary water source. The City of Vale primarily relies on the Malheur River for drinking water and has groundwater wells as a backup water source. Rural areas in Malheur County draw drinking water from the Owyhee River, Beulah Reservoir, and Billy Creek. In Harney County, rural drinking water is drawn primarily from groundwater wells.

Irrigation water is generally pulled from surface sources and distributed through established irrigation districts in Malheur County. In Harney County, irrigation water is drawn from a combination of groundwater wells and surface sources including the Silvies, Donner und Blitzen River, and smaller tributary creeks.

There are several threats to the region’s water quality and quantity. In Malheur County agricultural products such as pesticides and herbicides leech nitrates into ground and surface water. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Other concerns for water quality in Malheur County include naturally occurring arsenic and phosphorus in the soil and bacterial contaminants such as *Escherichia coli* (*E. coli*). Naturally occurring arsenic and other minerals threatens water quality in Harney County. Mineral concentrations become higher in proximity to Malheur Lake and during drought seasons, increasing water quality threats in Harney County.

Water shortages have become common in Region 8. 2011 was the last year with a predictable water supply. The region had drought declarations for three consecutive years, from 2012 to 2014.

Low levels of snowpack can lead to severe shortages in a region that is already subject to annual shortages. Low precipitation levels can lead to low levels of groundwater recharge, which could impact both agricultural and municipal supplies. Additionally, no new water rights are available for surface water, although groundwater rights are still available in Malheur County.

At the time of this writing, water supply in irrigation districts is not meeting demand to sustain local agricultural operations. In 2014, irrigation water supplies are expected to be unavailable two and a half months less than usual. This is compounded by the fact that Harney County currently has no above-ground reservoir for municipalities or rural residents.

Underground water supplies and aging or outdated infrastructure such as reservoirs, treatment facilities, and pump stations can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, limiting access to potable water. This can lead to unsanitary conditions that may threaten human health and limit fire suppression. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enter surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 8, county and building codes (city and county) emphasize use of centralized storm sewer systems to manage stormwater. Low impact development (LID) mitigation strategies can alleviate or lighten the burden to a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so it enters the storm sewer system at lower volumes, at lower speed, and at lower temperatures. LID strategies are not required any community in Region 8. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems, and increase a community's resilience to many types of hazard events.

Infrastructure Trends and Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

Damage or service interruption to roads, bridges, and rail systems can have devastating effects the region's economy. Hazards such as flooding and winter weather can close the highways that connect communities in Region 8 to the rest of the state and neighboring states. Eight percent of all bridges in Region 8 are distressed or deficient. In Malheur County there are two rail yards, and rails that support cargo and trade flows and are vulnerable to icy conditions.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. Two power-generating facilities are located here, a hydroelectric and a geothermal facility. The majority of the region's dams are located in Malheur County. Ten have High Threat Potential dams and 13 have Significant Threat Potential. The northeast corner of Malheur County is an important throughway for oil and gas pipelines and electrical transmission lines. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services may not cover areas that are distant from major transportation routes. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Drinking water is primarily sourced from groundwater wells, the Snake River, Malheur River Owyhee River, Beulah Reservoir, and Billy Creek. These water bodies are vulnerable to pollution from agricultural pesticides and herbicides. Naturally occurring mineral concentrations become higher in proximity to Malheur Lake and during drought seasons, increasing water quality vulnerability in Harney County. No communities in the region require low impact development (LID) regulations.

Built Environment

Settlement and Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program is 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD, https://www.oregon.gov/lcd/OP/Pages/Goal-7.aspx).

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people or an "urban cluster" of at least 2,500 people (but less than 50,000). Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-763** and **Table 2-764** remain from the 2010 Census.

Contrary to statewide patterns of urban growth and rural decline between 2000 and 2010, Region 8's urban populations shrank by about 13% and rural populations grew by roughly 15%. Harney County experienced a greater increase in housing units in both urban and rural communities.

The region's population is clustered around the I-84 corridor and the cities of Burns, Hines, Ontario, and Vale. The population distribution in Region 8 is presented in **Figure 2-302**.

Table 2-763. Urban and Rural Populations in Region 8, 2010

	Urban			Rural		
	2000	**2010**	**Percent Change**	**2000**	**2010**	**Percent Change**
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	-0.1%
Region 8	23,194	20,283	-12.6%	16,030	18,452	15.1%
Harney	4,330	4,131	-4.6%	3,279	3,291	0.4%
Malheur	18,864	16,152	-14.4%	12,751	15,161	18.9%

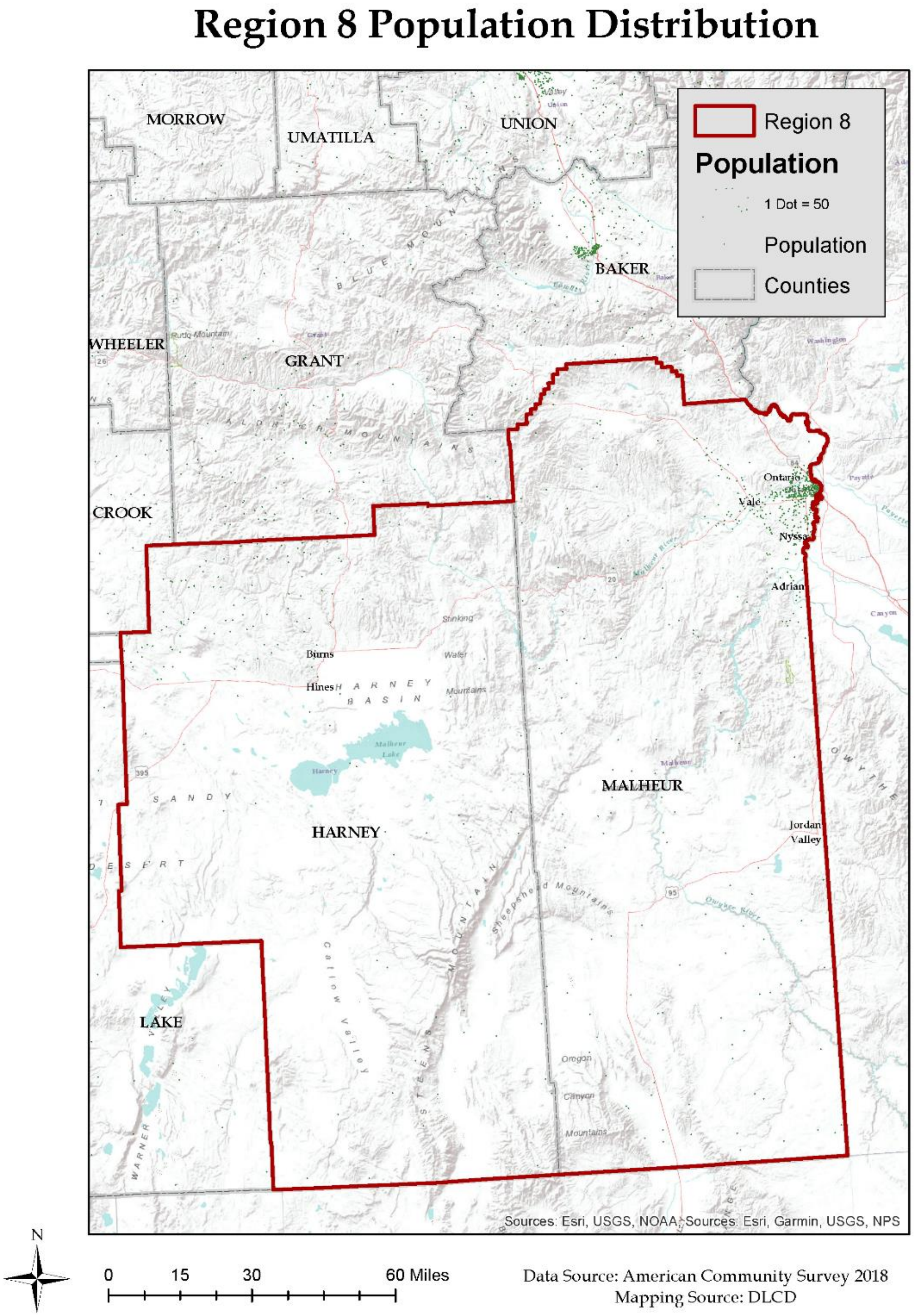
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

Table 2-764. Urban and Rural Housing Units in Region 8, 2010

	Urban			Rural		
	2000	**2010**	**Percent Change**	**2000**	**2010**	**Percent Change**
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region8	8,186	8,453	3.3%	6,580	7,074	7.5%
Harney	1,990	2,111	6.1%	1,543	1,724	11.7%
Malheur	6,196	6,342	2.4%	5,037	5,350	6.2%

Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table H002

Figure 2-302. Region 8 Population Distribution



Source: U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. **Table 2-703** provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

Similar to the state, about two-thirds of the region's housing stock is single-family homes. In contrast, multi-family housing comprises a smaller share of the region's housing stock, approximately 15%. The share of manufactured homes is more than double the share statewide. Notably, more than a fifth of homes in Harney County are manufactured units. In natural hazard events such as earthquakes and floods, manufactured homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997).

Table 2-765. Housing Profile for Region 8

	Total Housing Units	Single Family			Multi-Family			Manufactured Homes		
		Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	1,733,041	68.1%	✓	0.3%	23.5%	✓	0.3%	8.2%	✓	0.1%
Region 8	15,676	65.9%	✓	2.3%	15.2%	✓	1.7%	18.8%	✓	1.6%
Harney	3,870	67.0%	✓	5.2%	8.8%	✓	0.8%	23.9%	✓	3.5%
Malheur	11,806	65.6%	✓	2.6%	17.2%	✓	2.3%	17.1%	✓	1.7%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Aside from location and type of housing, the year structures were built (**Table 2-767**) has implications. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally, about 45% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances. Over three-quarters of the housing stock was built before 1990 and the codification of seismic building standards. Additionally, as shown in **Table 2-768**Table 2-582, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the middle to late 1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-766. Housing Vacancy in Region 8

	Total Housing Units	Vacant^		
		Estimate	**CV ****	**MOE (+/–)**
Oregon	1,733,041	5.6%	☑	0.3%
Region 8	15,676	11.8%	☑	2.5%
Harney	3,870	17.1%	⊙	6.2%
Malheur	11,806	10.0%	⊙	2.6%

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.

**Green, orange, and red icons indicate the reliability of each Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table B25004: Vacancy Status

Table 2-767. Age of Housing Stock in Region 8

	Total Housing Units	Pre 1970			1970 to 1989			1990 or Later		
		Estimate	**CV ****	**MOE (+/–)**	**Estimate**	**CV ****	**MOE (+/–)**	**Estimate**	**CV ****	**MOE (+/–)**
Oregon	1,733,041	34.6%	☑	0.3%	30.5%	☑	0.3%	34.9%	☑	0.3%
Region 8	15,676	45.6%	☑	2.9%	31.0%	☑	2.4%	23.4%	☑	2.2%
Harney	3,870	53.4%	☑	6.6%	23.3%	☑	4.7%	23.3%	☑	4.1%
Malheur	11,806	43.0%	☑	3.1%	33.6%	☑	2.8%	23.4%	☑	2.6%

Notes: **Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018). Table B25034: Year Structure Built, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood, damage is minimized. **Table 2-768** shows the initial and current FIRM effective dates for Region 8 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, **Flood** section.

Table 2-768. Community Flood Map History in Region 8

	Initial FIRM	Current FIRM
Harney County	Apr. 17, 1984	Apr. 17, 1984
Burns	Aug. 15, 1984	Dec. 22, 1998
Hines	Sept. 28, 1984	Nov. 3, 1989
Burns-Paiute Reservation	Sept. 28, 1984	Sept. 28, 1984
Malheur County	Sept. 29, 1986	Sept. 29, 1986
Adrian	Sept. 19, 1984	Sept. 19, 1984
Jordan Valley	Sept. 19, 1984	Sept. 19, 1984
Nyssa	Dec. 14, 1982	Dec. 14, 1982 (M)
Ontario	Apr. 17, 1984	Apr. 17, 1984
Vale	Sept. 4, 1987	Sept. 4, 1987

(M) = no elevation determined; all Zone A, C and X.

Source: Federal Emergency Management Agency (2019), Community Status Book Report, https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 8 can be found in Table 2-769. The region contains 2.7% of the total value of all local critical facilities and state-owned and –leased critical and non-critical facilities in the state. Cumulatively, these assets are valued just under one billion dollars.

Table 2-769. Value of State-Owned/Leased Critical and Essential Facilities in Region 8

	Value of Local and State-Owned/Leased Facilities				
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$2,630,306,288	$4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 8	$ 16,722,870	$ 556,587,272	$ 328,497,252	$ 901,807,394	2.7%
Harney	$ 5,930,555	$ 17,086,378	$ 55,966,002	$ 78,982,935	0.2%
Malheur	$ 10,792,315	$ 539,500,894	$ 272,531,250	$ 822,824,459	2.5%

Source: DOGAMI, 2020

Land Use Patterns

Similar to Region 7, the past 40 years have seen a slower pace of development of private land in Region 8 than in western Oregon. In this time period very little loss of private land in forest, agriculture, and range uses occurred. Land use programs have limited rural residential and urban development and have maintained large parcel sizes. Demand for large-scale development has historically been very low. To the extent it has occurred, it has generally been located along existing transportation corridors (DLCD, internal communications, 2014).

Just over one fifth of all land in the region is privately owned, 23.3%. The federal government owns the vast majority of land, 71%, and the state owns approximately 4%. The remainder is owned by other public entities.

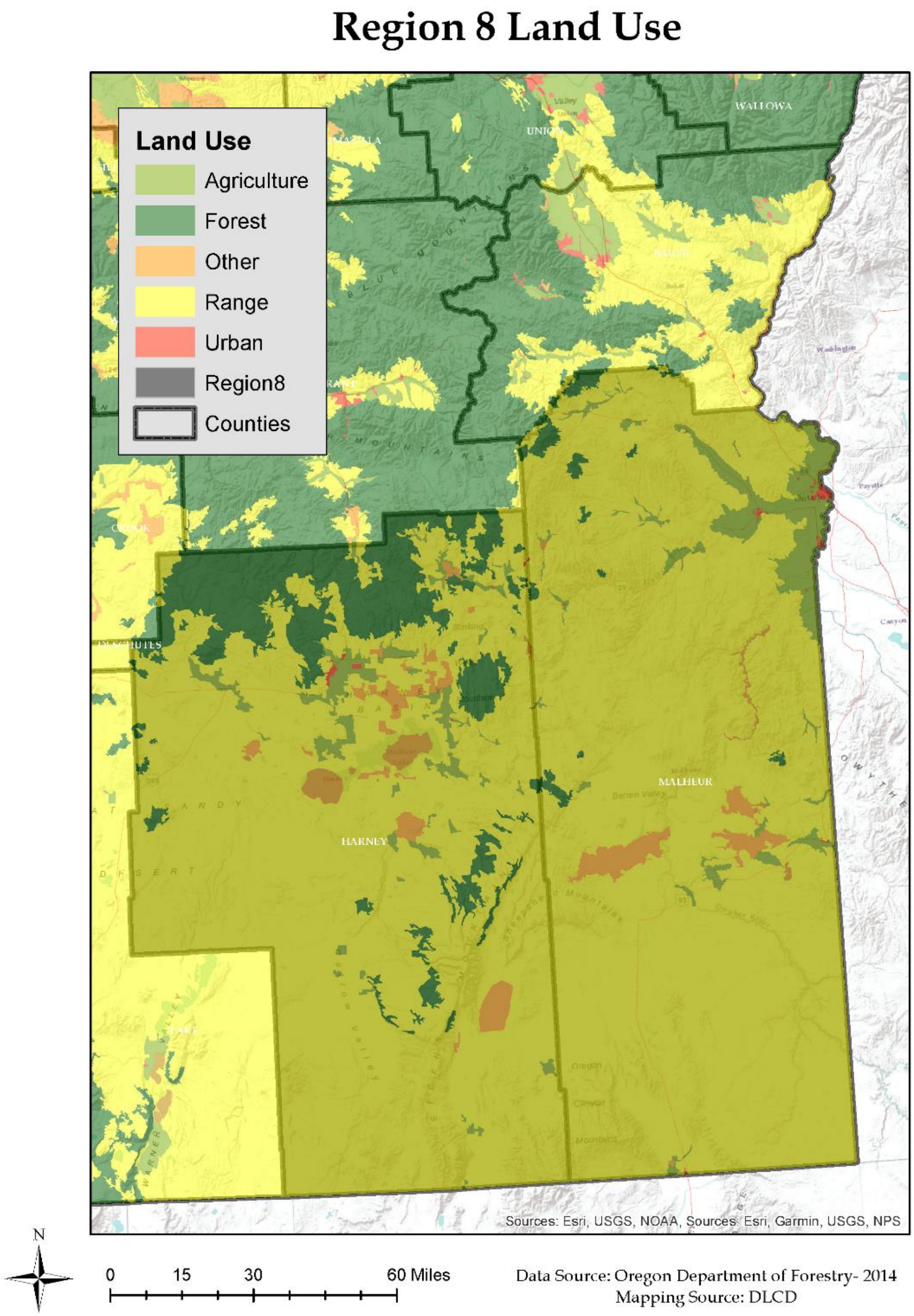
According to the Oregon Department of Forestry's most recent land-use study, "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray , Hubner , McKay, & Thompson , 2016). In Region 8, approximately 174 acres of resource lands were converted to more urban uses during the six-year period. Table 2-770 shows that during the six-year period, the percentage of resource lands converted in Malheur and Harney Counties was less than one percent of the county's total resource acreage.

Overall, Region 8 is overwhelmingly rangeland, with the Bureau of Land Management (BLM) controlling much of the land. The land cover is largely grasslands and shrubs. Irrigated fields in the county's northeast corner, known as Western Treasure Valley, are the center of intensive and diversified farming.

The region's wide-open spaces have a total of only seven incorporated cities. Ontario, relatively close to the Boise, Idaho metropolitan area is economically active. Burns-Hines is an important center for commerce as well as tourism. Timber and logging remained important to that local economy until the 1990s, when the area's last lumber mill closed for lack of timber.

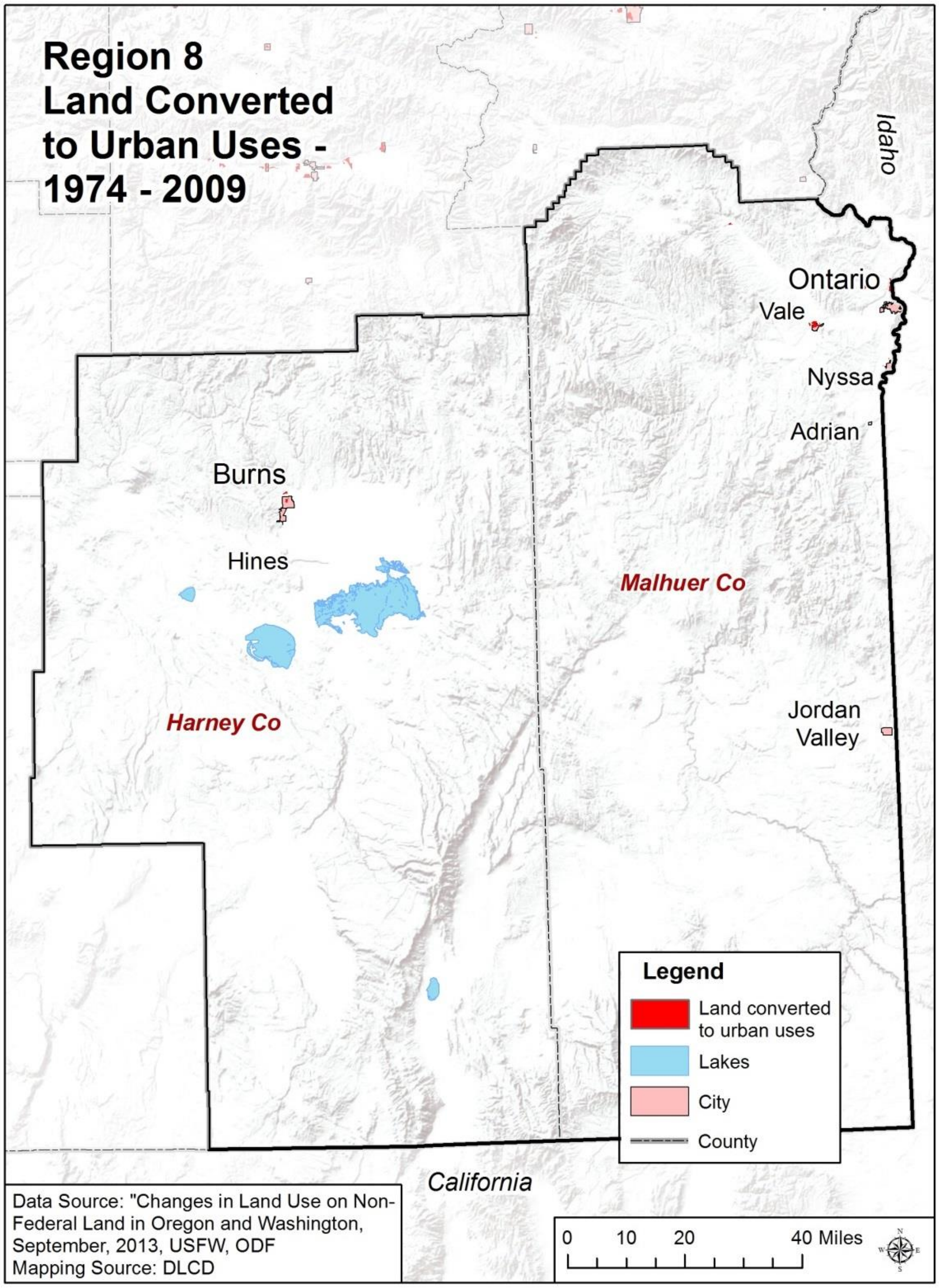
In July 2015, the Land Conservation and Development Commission adopted the "Sage Grouse Rule" to prevent listing of sage-grouse as under the Endangered Species Act. The rule protects sage-grouse habitat and limits the loss of core habitat from development. Counties review development applications for compliance with the rule and DLCD tracks development using an online tool. DLCD reports annually to the Commission on development in sage-grouse conservation areas. Very little development has occurred in these areas since August 2015 (https://www.oregon.gov/lcd/NRRE/Pages/Endangered-Species.aspx, August 2020).

Figure 2-303. Region 8 Land Use



Source: Oregon Department of Forestry, 2014

Figure 2-304. Region 8 Land Converted to Urban Uses, 1974–2009



Source: Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

Table 2-770. Region 8 Resource Lands Converted to Urban Uses, 2009-2014

	Lost Resource Lands 2009-2014		
	Total Resource Acres (2009)	**Acres Converted to Urban Use**	**Percent Converted**
Region 8	3,500,340	174	0.00%
Harney	1,844,795	66	0.00%
Malheur	1,655,545	71	0.00%

Source: Oregon Department of Forestry, 2014; Oregon Department of Land Conservation and Development, 2020

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 8 is largely a rural county with urban development focused along I-84 and around the population centers of Burns, Hines, Ontario, and Vale. Population growth from 2010-2018 was stagnant and is projected to decline over the next decade. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion. Please refer to the Region 8 Risk Assessment **Demography** section for more information on population trends and forecast.

The region's housing stock is largely single-family homes. The region has more than double the state's percentage of manufactured homes. About 45% of the homes were built before 1970 and floodplain management standards; 76% were built before 1990 seismic standards. None of the region's FIRMs has been modernized or updated. Most of the region's share of state-owned and –leased, and local critical facilities are located in Malheur County

2.3.8.3 Hazards and Vulnerability

Droughts

Characteristics

Droughts are a common occurrence in Region 8 and can have a significant economic impact on agricultural, livestock, and natural resources. In 2013, for example, most irrigation reservoirs started the season at a third of capacity, with some irrigation districts running out of water by mid to late June. The Governor has declared a drought emergency in Region 8 numerous times since 1992. The U.S. Department of Agriculture designated Malheur and Harney Counties as primary natural disaster areas from 2012 through 2016 and 2018 due to damages and losses caused by drought. Malheur County is considered one of the counties most vulnerable to drought in Oregon.

Because of late winter 2014 reservoir storage levels and predicted streamflow forecasts, the Natural Resources Conservation Service predicted water shortages for the summer of 2014. Governor Kitzhaber issued drought emergencies for both Malheur and Harney Counties. Poor reservoir carryover and an almost non-existent snowpack during the 2014-15 winter resulted in very low reservoir levels for the 2015 water year. In part, prompting an almost statewide governor's declaration of drought. In 2018 low precipitation coupled with above-normal temperatures brought about another governor's declaration of drought in Harney and Malheur Counties.

High temperatures and low precipitation accompanying drought conditions reduce soil moisture, dry vegetation, and tend to enhance winds. These conditions can increase the amount of soil entrained by high winds, particularly in semi-arid regions where temperatures are increasing and precipitation is decreasing, and where areas of substantial land disturbance or development is occurring. Therefore, during extended dry and drought conditions, productive soils are vulnerable to loss, further impacting agriculture.

Historic Drought Events

Table 2-771. Historic Droughts in Region 8

Year	Location	Description
1930s	statewide	generally, a very dry period for much of Oregon; Malheur County experiences its most extreme drought years in 1931, 1934, and 1935
1988	Regions 7, 8	extreme drought for Malheur County (PDSI value of -4.14); this was also a severe drought year for northeast Oregon
1992	statewide	Governor declared drought emergency for all 36 counties in Oregon; 1992 was a severe drought year for Malheur County
1994	Regions 4–8	in 1994, Malheur County received a Governor drought declaration, along with 10 other counties located within regions 4, 5, 6, and 7
2001	eastern and southern Oregon	Governor-declared drought emergency for Harney County and 17 other counties throughout the state
2002	eastern and southern Oregon	Governor-declared drought emergency for Malheur and Harney Counties; total of 23 counties under a drought emergency during 2002
2003	eastern and southern Oregon	Governor-declared drought emergency issued for Malheur and Harney Counties; most counties remain under a drought emergency from the 2001 and 2002 declarations through June 2003
2004	Regions 5–8	Governor-declared drought emergency issued for Malheur County, along with three counties from neighboring regions
2007	Regions 6–8	Governor-declared drought emergency issued for Malheur and Harney County, along with four other counties in Region 6 and 7
2013	Region 5–8	Governor-declared drought emergency issued for Malheur County, along with four other counties in neighboring regions
2014	Regions 4, 6–8	Governor-declared drought emergency issued for Malheur and Harney Counties, along with eight other counties in other regions
2015	statewide	All 36 Oregon Counties receive federal drought declarations, including 25 under a Governor's drought declaration
2018	Regions 4, 6–8	Harney and Malheur County receive Governor's drought declarations along with 9 other counties in 5 other regions

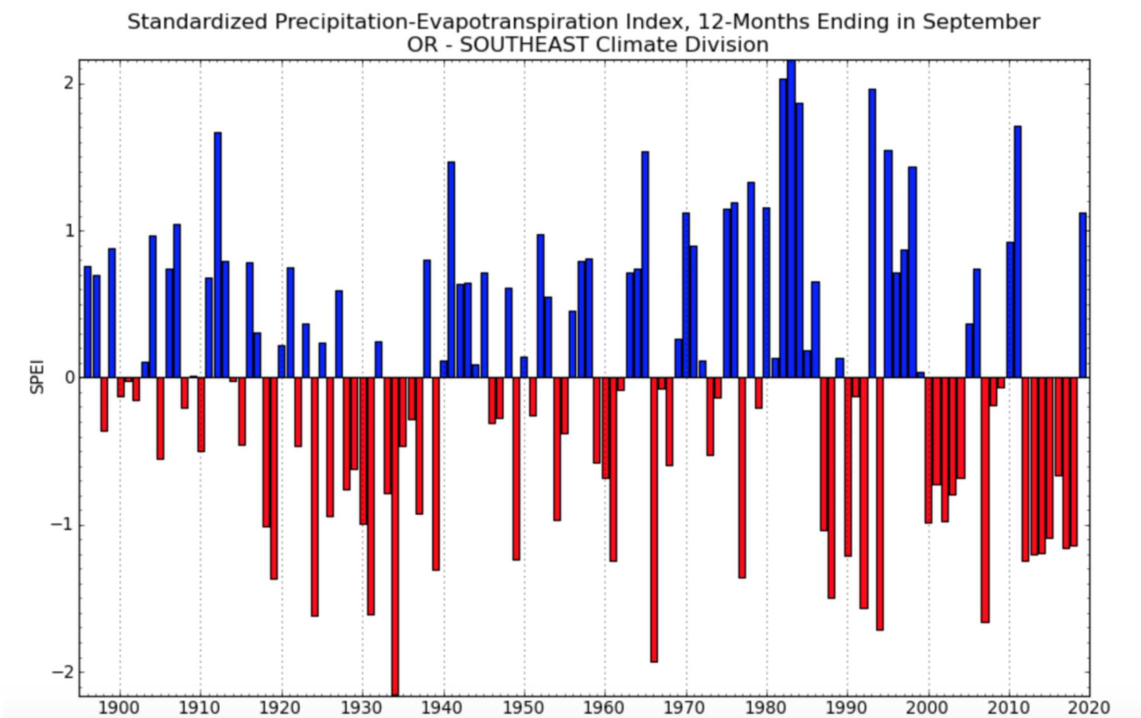
Sources: Taylor and Hatton (1999); and the Oregon Secretary of State's Archives Division. NOAA's Climate at a Glance. Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt. Personal Communication, Kathie Dello, Oregon Climate Service, Oregon State University

Historical drought information can also be obtained from the West Wide Drought Tracker, which provides historical climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895.

Figure 2-305 shows years where drought or dry conditions affected the south eastern area of Oregon, known as Climate Division 9, which encompasses Malheur County only.

Based on this index, 1934 was an extreme drought year for Malheur County. Water Years 1924, 1931, 1966, 1992, 1994, and 2007 were severe drought years. Malheur County has experienced more than a dozen moderate drought years, including the stretch from 2012–2018, with the exception of 2016.

Figure 2-305. Standard Precipitation-Evapotranspiration Index for Region 8



Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Table 2-772. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 9 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
1988	1966	1934
1919	1994	
1977	2007	
1939	1924	
1961	1931	
2012	1992	
1949		
1990		
2013		
2014		
2017		
2018		
2015		
1987		
1918		

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Probability

Table 2-773. Probability of Drought in Region 8

	Harney	Malheur
Probability	H	VH

Source: OWRD, DLCD

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases. Oregon has yet to undertake a comprehensive risk analysis for drought on a statewide basis to determine probability or vulnerability for a given community.

With that said, the likelihood that Malheur and Harney County will experience drought conditions in the near future is very likely. As mentioned, the Governor has declared drought in both counties on several occasions since 1992. During the period of 1896-2019, both counties experienced at least moderate drought conditions about 18% of the time. Harney County has received a drought declaration in 28% of the years since 1992, while Malheur has received a drought declaration in 34%. This accounts for the difference in their probability ratings.

Climate Change

Climate models project warmer, drier summers for Oregon as a whole though Region 8 may see slight increases in summer precipitation along with the Great Basin. Climate models also project decreases in mid-to-low elevation mountain snowpack due to warmer winter temperatures. In Region 8, climate change would result in increased frequency of drought due to low spring snowpack (very likely, >90%). With less confidence, climate models project increases in summer runoff and summer soil moisture for lowland parts of eastern Oregon, including Region 8. Increases in summer soil moisture are the result of increased precipitation in the spring, which dominates the effects of warming temperatures (Gergel, et al., 2017). However, Region 8, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-774. Local Assessment of Vulnerability to Drought in Region 8

	Harney	Malheur
Vulnerability	H	H

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-775. State Assessment of Vulnerability to Drought in Region 8

	Harney	Malheur
Vulnerability	H	VH

Source: OWRD, DLCD

Oregon has not undertaken a comprehensive statewide analysis to identify which communities are most vulnerable to drought. However, ranching, farming, and other agricultural activities greatly contribute to the economy of both counties. Malheur County ranks fourth in the state for agricultural sales, with $373 million in gross farm and ranch sales in 2012. Drought can have a significant impact on the agricultural community and associated businesses that rely on this industry.

Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms. There is no single comprehensive source or other sources for information to assess economic impacts.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

Malheur County's social vulnerability rating is very high indicating that any natural hazard, including drought, would have significant impacts on its population. Harney County's social vulnerability rating is moderate. Its economic vulnerability has been taken into account in its high vulnerability rating. Both Harney and Malheur Counties are most vulnerable to drought in Region 8.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 8 is approximately $573,310,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $328,497,000. Because drought could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records how many losses to state facilities were sustained in Region 8 since the beginning of 2015. Nevertheless, none of the recorded losses was due to drought.

Risk

Table 2-776. Risk of Drought in Region 8

	Harney	Malheur
Risk	H	VH

Source: OWRD, DLCD

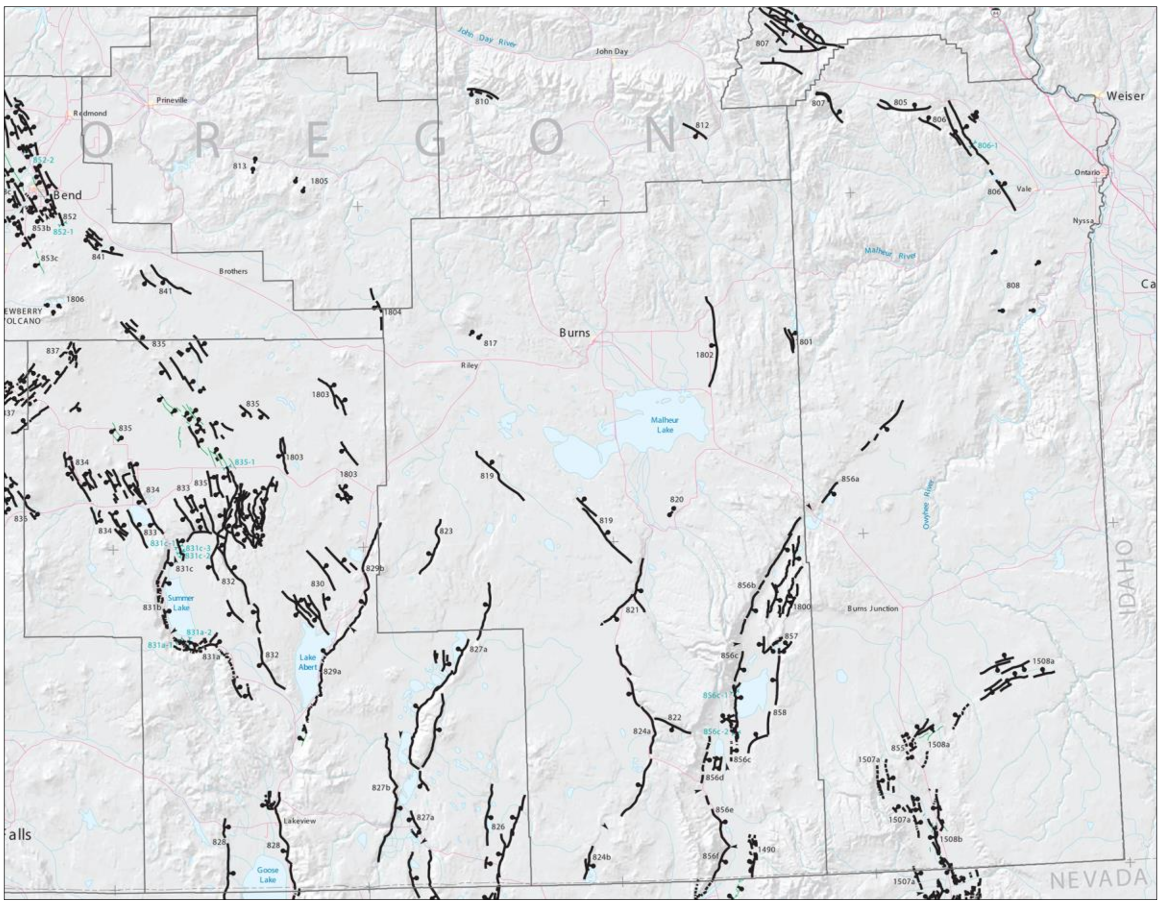
With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based on the very high probability of drought and vulnerability to it, risk of drought in Region 8 is considered very high.

Earthquakes

Characteristics

The geographic position of this region makes it susceptible to earthquakes from two sources: crustal events and volcanic-earthquakes. Generally, crustal faults can produce earthquakes with magnitudes up to roughly M7.0. Because only certain faults have been studied in detail and determined to be active, there may be many more crustal faults in the region capable of producing earthquakes which have not yet been identified. **Figure 2-306** shows the locations of faults in Region 8.

Figure 2-306. Quaternary Faults and Folds in Region 8

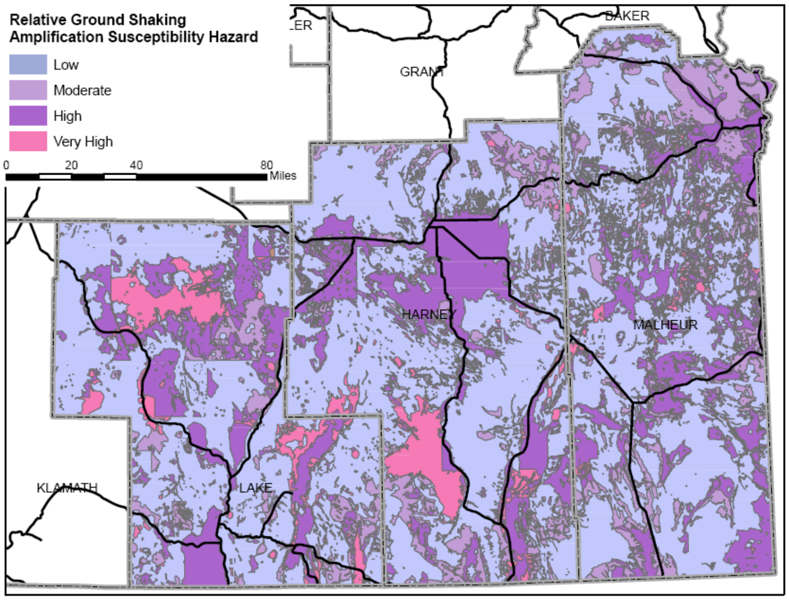


Source: Modified from Personius, et al. (2003)

When all of these earthquake sources are added together, the general earthquake hazard in the region can be displayed as a whole and is reflected in the USGS national seismic hazard maps. When compared to the rest of the United States, most of the region is within a relatively moderate seismicity area.

Figure 2-307 displays the relative ground shaking amplification hazard throughout Region 8.

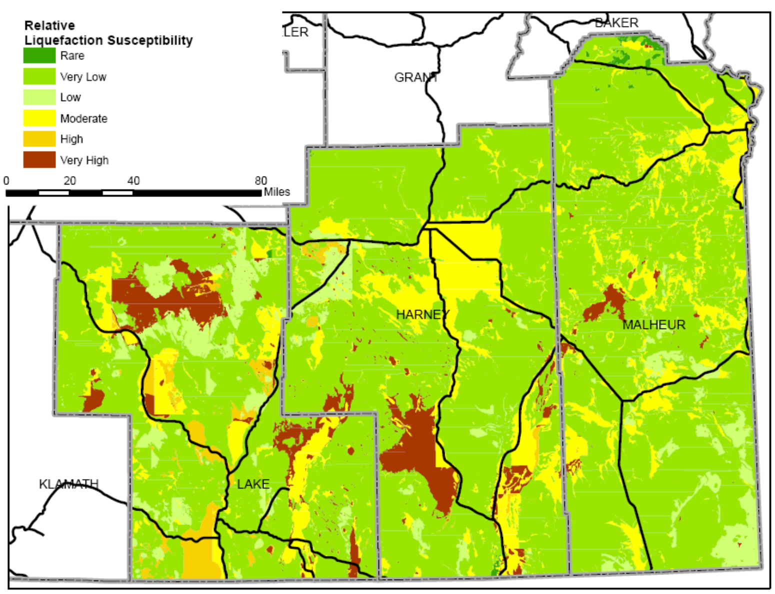
Figure 2-307. Relative Ground Shaking Amplification Hazard in Region 8



Source: Burns (2007)

During seismic shaking, deposits of loose saturated sands can be subjected to contraction resulting in an increase in pore water pressure. If the increase in pore water pressure is high enough, the deposit becomes "liquefied," losing its strength and its ability to support loads. Figure 2-308 displays the relative liquefaction hazard throughout Region 8.

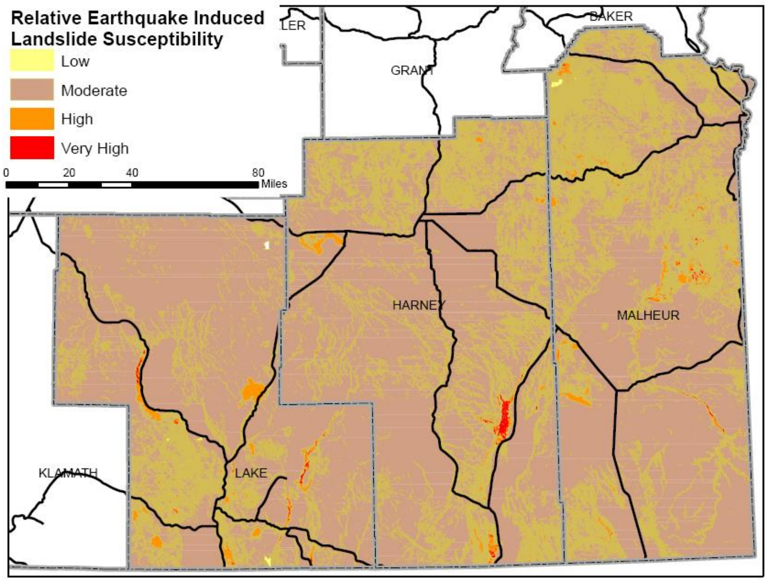
Figure 2-308. Relative Liquefaction Susceptibility Hazard in Region 8



Source: Burns (2007)

Strong ground shaking can also cause landslides and reactivate dormant landslides. Commonly, slopes that are marginally stable prior to an earthquake become unstable and fail. Some landslides result from liquefaction that causes lateral movement of soil, or lateral spread. **Figure 2-309** displays the relative earthquake induced landslide hazard throughout Region 8.

Figure 2-309. Relative Earthquake Induced Landslide Susceptibility Hazard in Region 8



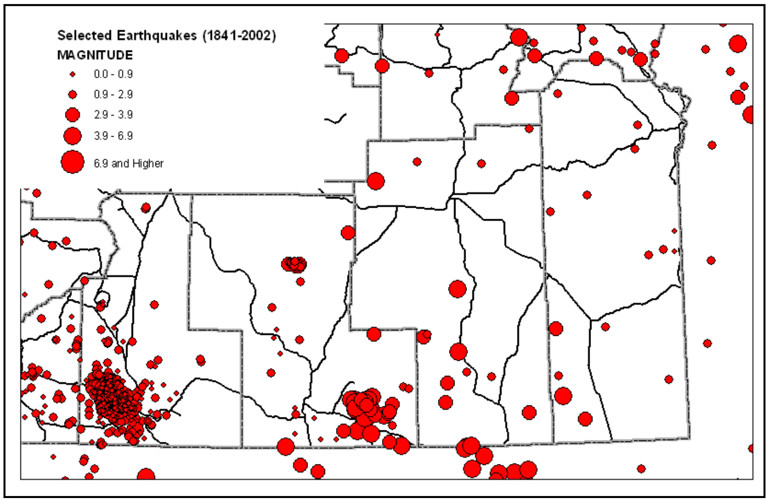
Source: Burns (2007)

Region 8 has experienced many earthquakes. Several earthquake sequences (swarms) have occurred in the region within the last 20 years. There are also identified faults in the region that have been active in the last 20,000 years. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. **Figure 2-310** maps earthquakes in the region from 1841 to 2002, and **Table 2-777** provides a general history of earthquakes in Oregon.

When all of these earthquakes sources are added together, the general earthquake hazard in the region can be displayed as a whole and is reflected in the USGS national seismic hazard maps. When compared to the rest of the United States, most of the region is within a relative moderate seismicity area.

Figure 2-310 displays over 1,000 earthquakes that have been recorded in the region during the last century. Because the instrument network in the region was very sparse until the mid-2000s, it is likely that thousands of earthquakes have occurred in the region but were not recorded.

Figure 2-310. Selected Earthquakes in Region 8, 1841–2002



Source: Niewendorp & Neuhaus (2003)

Historic Earthquake Events

Table 2-777. Significant Earthquakes Affecting Region 8

Date	Location	Magnitude	Comments
Approximate years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	offshore, Cascadia Subduction Zone	probably 8-9	these are the midpoints of the age ranges for these six events
Jan. 26, 1700	offshore, Cascadia Subduction Zone	about 9	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Nov. 23, 1873	near Brookings, Oregon at the Oregon-California border	6.8	may have been an intraplate event because of lack of aftershocks; felt as far away as Portland and San Francisco
Mar. 1893	Umatilla	VI-VII (Modified Mercalli Intensity)	damage: unknown
July 15, 1936	Milton-Freewater	6.4	damage: $100,000 damage (in 1936 dollars); two foreshocks and many aftershocks felt
Apr. 13, 1949	Olympia, Washington	7.1	fatalities: eight; damage: $25 million damage (in 1949 dollars); cracked plaster, other minor damage in northwest Oregon
Jan. 1951	Hermiston	V (Modified Mercalli Intensity)	damage: unknown
Nov. 5, 1962	Portland/ Vancouver	5.5	shaking up to 30 seconds; damage: chimneys cracked, windows broken, furniture moved
Apr. 12, 1976	near Maupin	4.8	sounds described as distant thunder, sonic booms, and strong wind
Apr. 25, 1992	Cape Mendocino, California	7.0	subduction earthquake at the triple-junction of the Cascadia Subduction Zone and the San Andreas and Mendocino faults
Mar. 25, 1993	Scotts Mill	5.6	center: Mount Angel-Gates Creek fault; damage: $30 million, including Molalla High School and Mount Angel church
Sep. 20, 1993	Klamath Falls	5.9 and 6.0	fatalities: two; damage: $10 million, including county courthouse; rockfalls
Jan. 4, 2015	NW Nevada	4.1	
Jan. 22, 2015	NW Nevada	4.5	
Jul. – Dec. 2015	NW Nevada	4.0-4.7	cluster of earthquakes

*BCE: Before Common Era.

Sources: Wong & Bott (1995); Pacific Northwest Seismic Network, https://pnsn.org/

Probability

Table 2-778. Assessment of Earthquake Probability in Region 8

	Harney	Malheur
Probability	M	L

Source: DOGAMI, 2020

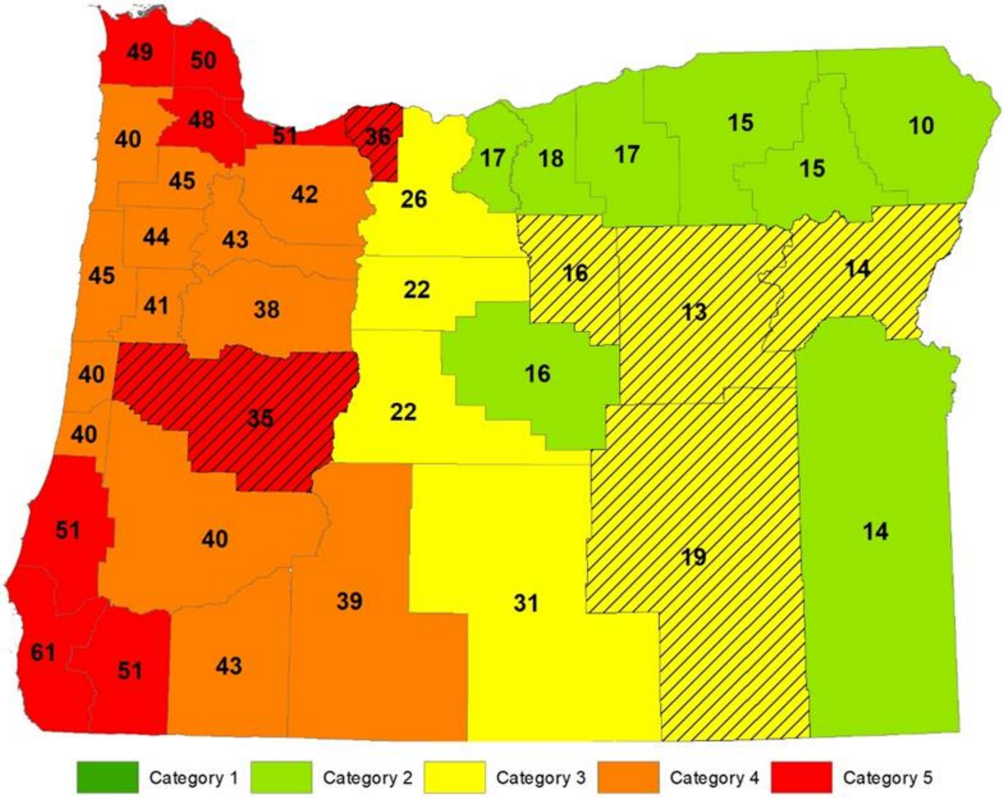
The probability of damaging earthquakes varies widely across the state. In Region 8, the hazard is dominated by local faults and background seismicity.

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

- Category 1 100-year probability < 10%
- Category 2 100 year probability 10-20%
- Category 3 100 year probability 21-31%
- Category 4 100 year probability 32-45%
- Category 5 100 year probability > 45%

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-311**.

Figure 2-311. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



Note: Counties with hatching had their probability category increased one step due to newly discovered faults.

Source: DOGAMI, 2020

Vulnerability

Table 2-779. Local Assessment of Vulnerability to Earthquakes in Region 8

	Harney	Malheur
Vulnerability	L	L

Source: Most recent local hazard vulnerability analyses (Table 2-4)

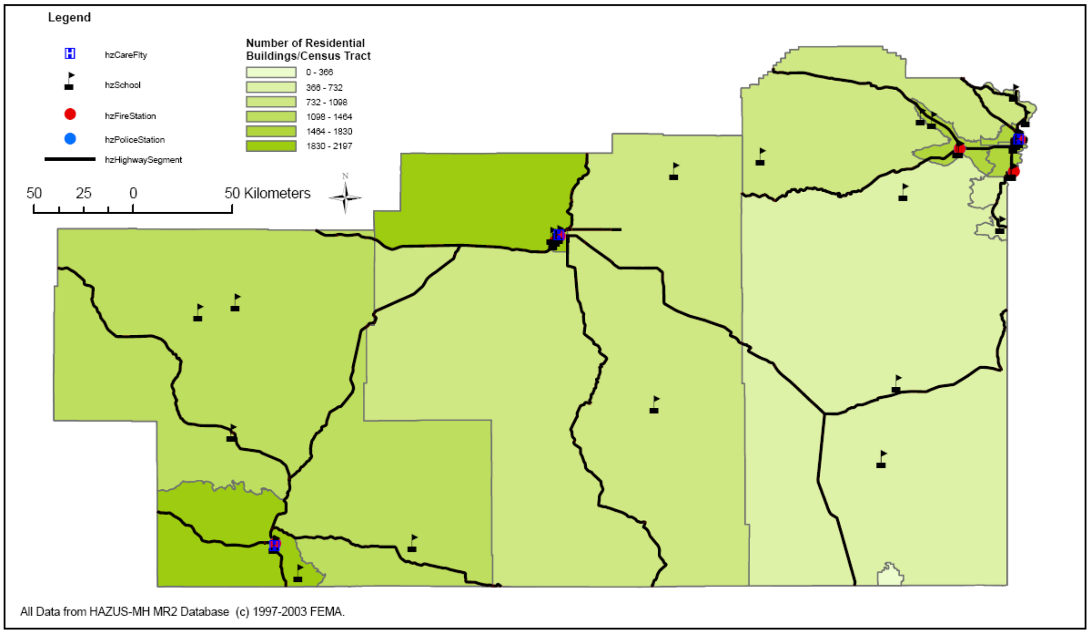
Table 2-780. Assessment of Vulnerability to Earthquakes in Region 8

	Harney	Malheur
Vulnerability	L	H

Source: DOGAMI and DLCD, 2020

Region 8 is moderately vulnerable to earthquake hazards from earthquake-induced landslides, liquefaction, and ground shaking. Most of the region's people and infrastructure are located in the major cities along I-84, US-20, and US-395. Figure 2-312 shows a map of the generalized exposure of buildings to earthquakes in Region 8.

Figure 2-312. Region 8 Generalized Earthquake Exposure



Source: Hazus-MH MR2 database, Burns, 2007.

The Oregon Department of Geology and Mineral Industries (DOGAMI) has developed two earthquake loss models for Oregon based on the two sources of seismic events: (a) a M6.9 arbitrary crustal event, and (b) 2,500 year probabilistic driving earthquake scenario. Both models are based on Hazus-MH, a computer program used by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The arbitrary crustal event is based on a potential M6.9 earthquake generated from an arbitrarily chosen fault using the Hazus software, and assuming a worst-case scenario. The 2,500-year probabilistic driving earthquake does not look at a single earthquake; instead, it encompasses many faults and potential earthquake sources, each with a 2% chance of producing an earthquake in the next 50 years. The analysis assumes that each fault will produce a single "average" earthquake during this time.

DOGAMI investigators caution that the analysis contains a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the analysis does provide some approximate estimates of damage.

Table 2-781. School and Emergency Response Buildings' Collapse Potential in Region 8

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Harney	5	3	7	3
Malheur	16	6	5	23

Source: Lewis (2007)

Table 2-782. Building, Transportation, and Utility Exposure in Region 8

County	Building Exposure	Transportation Exposure	Utility Exposure	Total Exposure
Harney	$448,000,000	$2,281,900,000	$733,200,000	$3,463,100,000
Malheur	$1,441,000,000	$4,396,900,000	$810,300,000	$6,648,200,000
Region Total	$1,889,000,000	$6,678,800,000	$1,543,500,000	$10,111,300,000

Source: W. J. Burns (DOGAMI), 2007 (unpublished), Geologic hazards of the southeast Oregon region

Table 2-783. Building, Transportation, and Utility Losses in Region 8 Associated with a 2,500-Year Probable M6.5 Driving Earthquake Scenario

County	Building Losses	Transportation Losses	Utility Losses	Total Losses	Loss Percent of Total
Harney	$9,260,000	$21,600,000	$2,000,000	$32,860,000	0.9%
Malheur	$143,370,000	$47,000,000	$19,680,000	$210,050,000	3.2%
Region Total	$152,630,000	$68,600,000	$21,680,000	$264,590,000	2.6%

Source: W. J. Burns (DOGAMI), 2007 (unpublished), Geologic hazards of the southeast Oregon region

Table 2-784. Building, Transportation, and Utility Losses in Region 8 Associated with a (M) 6.9 Arbitrary Crustal Earthquake Event

County	Building Losses	Transportation Losses	Utility Losses	Total Losses	Loss Percent of Total
Harney	$1,600,000	$39,200,000	$390,000	$41,191,000	1.1%
Malheur	$453,470,000	$114,100,000	$36,820,000	$604,390,000	9.0%
Region Total	$455,070,000	$153,300,000	$37,210,000	$645,581,000	6.4%

Source: W. J. Burns (DOGAMI), 2007 (unpublished), Geologic hazards of the southeast Oregon

Table 2-785. Estimated Losses in Region 8 Associated with a M6.9 Arbitrary Crustal Earthquake Event

	Harney	Malheur
Injuries (5 pm time frame)	3	444
Death (5 pm time frame)	0	28
Displaced households	0	1,224
Economic losses from buildings	$1.6 mil	$453.47 mil
Operational day after quake:		
Fire stations	0%	25%
Police stations	0%	50%
Schools	29%	48%
Bridges	98%	93%
Economic losses to:		
Highways	$29.8 mil	$107.10 mil
Airports	$8.6 mil	$4.8 mil
Communications	$0.04 mil	$0.03 mil
Debris generated (million tons)	0	0

Source: W. J. Burns (DOGAMI), 2007 (unpublished), Geologic hazards of the southeast Oregon region

Table 2-786. Estimated Losses in Region 8 Associated with a 2,500-Year Probable M6.5 Driving Earthquake Scenario

	Harney	Malheur
Injuries (5 pm time frame)	3	106
Deaths (5 pm time frame)	0	5
Displaced Households	2	357
Economic losses from buildings	$9.26 m	$143.37 m
Operational the day after the quake		
Fire stations	100%	100%
Police stations	100%	100%
Schools	100%	100%
Bridges	100%	100%
Economic Losses to /for:		
Highways	$14.3 m	$34.3 m
Airports	$6.9 m	$11.8 m
Communication systems	$ 0.01 m	$0.01 m
Debris generated (million tons)	0	0

Source: W. J. Burns (DOGAMI), 2007 (unpublished), Geologic hazards of the southeast Oregon region

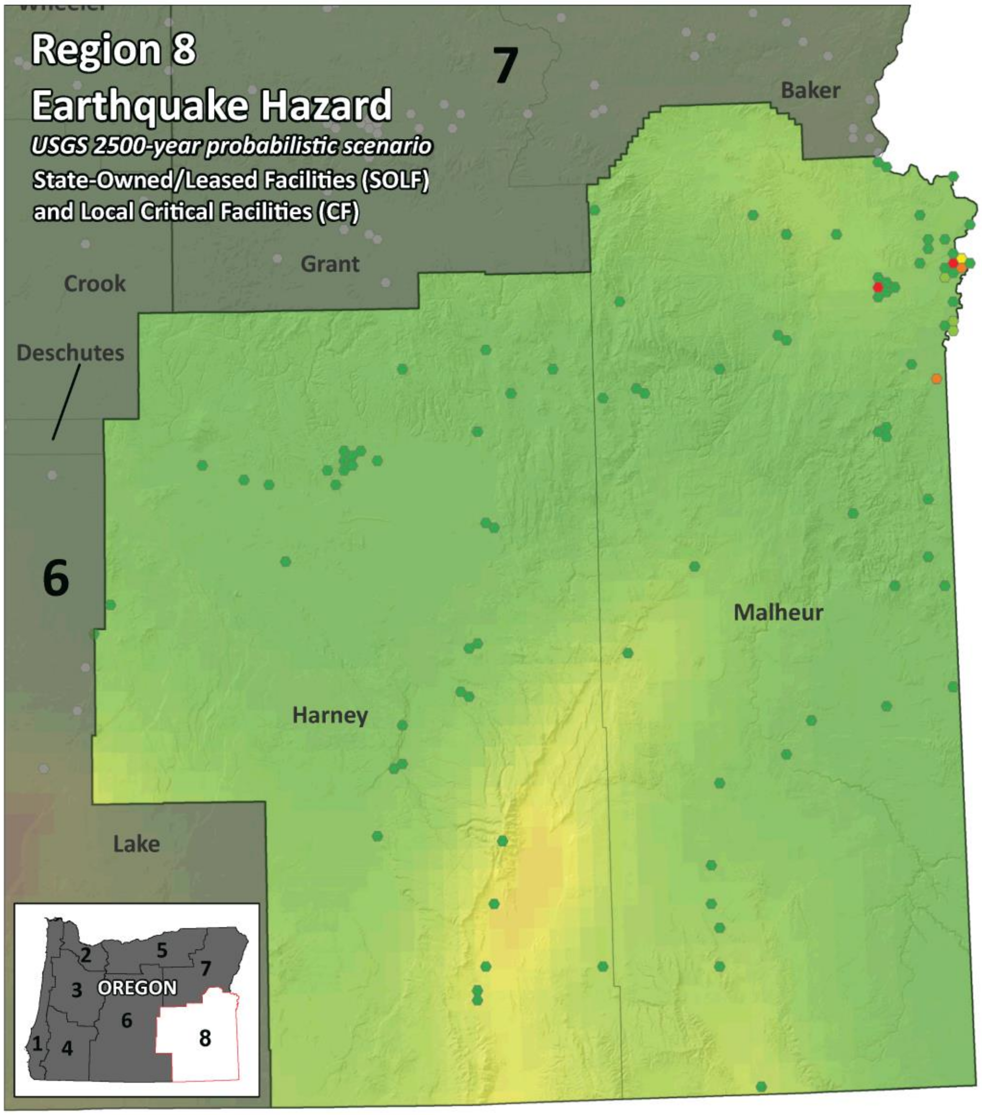
State-Owned/Leased Buildings And Critical Facilities And Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a 2500-year probabilistic earthquake scenario in Region 8. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 8, a 2500-year probabilistic earthquake scenario could generate a potential loss of just under $1M in state building and critical facility assets, about 90% of it in Malheur County. The potential loss in local critical facilities is more than eight times that amount, almost $8M. Again, 95% of that value is in Malheur County. **Figure 2-313** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a 2500-year probabilistic earthquake scenario.

Figure 2-313. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in an Earthquake Hazard Zone in Region 8.High-resolution, full-size image linked from Appendix 9.1.26.



Estimated ($) losses to hazard per cell
Outside of region
1 - 250,000
250,001 - 500,000
500,001 - 750,000
750,001 - 1,000,000
1,000,001 - 2,000,000

Earthquake peak ground acceleration
(Modified Mercalli Intensity Scale)
Strong — Very Strong

Administrative boundary
Mitigation Planning Region
County

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,000,000

Source Data:
Earthquake: Peak ground acceleration for 2500-year probabilistic earthquake, USGS, 2014
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

REGION 8		Estimated Loss ($) from CSZ Earthquake						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*		Loss Local CF	Total Loss SOLF CF and Local CF
Harney	78,983,000	57,000	0%	49,000	106,000		438,000	495,000
Malheur	822,824,000	632,000	0%	256,000	888,000		7,554,000	8,186,000
Total	901,807,000	689,000	0%	305,000	994,000		7,992,000	8,681,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

0 12.5 25 50 Miles

N

Source: DOGAMI

Historic Resources

Of the 337 historic resources in Region 8, only 2 are in an area of high or very high liquefaction potential, both of them in Malheur County. However, 251 (74%) of Region 7's historic resources are located in areas of high or very high potential for ground shaking amplification. Of these, 194 (77%) are in Malheur County.

Archaeological Resources

Seven thousand five hundred ninety archaeological resources are located in earthquake hazard areas in Region 8. Of those, 138 are located in an area of high earthquake hazards. None are listed on the National Register of Historic Places and only one is eligible for listing. Nine have been determined not eligible and 128 have not been evaluated as to their potential for listing. Most (69%) of the archaeological resources in earthquake hazard areas in Region 8 are located in Harney County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Harney County has low vulnerability to earthquake hazards and Malheur County is highly vulnerable.

Seismic Lifelines

Because the projected impacts of a CSZ event are considered negligible in this part of the state, this region was not part of the Oregon Department of Transportation's (ODOT) Oregon Seismic Lifeline Report (OSLR; Appendix **9.1.16**).

Regional Impact. Within this region, significant adverse impacts from the CSZ event and secondary hazards (landslides, liquefaction etc.) are not anticipated.

Regional Loss Estimates. Losses in this region are expected to be nonexistent to low. Economic disruption from major losses in the larger markets of the state will affect the economy in this region.

MOST VULNERABLE JURISDICTIONS. Vulnerability of this whole region to a CSZ event is low. Loss of life, property and business are not expected to be issues in this area. However, impacts to import and export infrastructure and basic supply lines could have short- to mid-term economic impacts. With an intact surface transportation system to the east, adaptation is expected to be relatively easy.

Risk

Table 2-787. Assessment of Earthquake Risk in Region 8

	Harney	Malheur
Risk	M	M

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, both Harney and Malheur Counties are at moderate risk of earthquake hazards.

Extreme Heat

Characteristics

Extreme temperatures are common in Region 8 and the frequency of prolonged periods of high temperatures has increased. Owyhee, in Malheur County, has an average of about 55 days per year above 90°F.

Historic Extreme Heat Events

The NOAA Storm Events Database does not record any excessive heat or heat events in Harney or Malheur Counties; however, region-wide heat events do impact Region 8. Excessive heat events may not have been declared by the National Weather Service for these counties.

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning "very low." Region 8's relative probability rankings are shown in **Table 2-788**.

Table 2-788. Probability of Extreme Heat in Region 8

	Harney	Malheur
Probability	H	VH

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Region 8 experiences some of the hottest temperatures in the state and is projected to experience greater frequency of extreme temperatures under future climate change. **Table 2-789** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 8.

Table 2-789. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 8 Counties

County	Historic Baseline	2050s Future
Harney	4	30
Malheur	12	45

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

Vulnerability

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, Extreme Heat. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning; however, the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are house-less.

Because extreme heat is common in Region 8 ("very high" probability), many people are accustomed or prepared in terms of air conditioning when an extreme heat event occurs ("high" adaptive capacity). In Cooling Zone 3, which includes Malheur County, 91% of single-family homes have air conditioning. In Cooling Zone 1, which includes Harney County, just over half of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1–2 earned a ranking of 1 (very low); scores of 3–4 earned a ranking of 2 (low); scores of 5–6 earned a ranking of 3 (moderate); scores of 7–8 earned a ranking of 4 (high); and scores of 9–10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-790 displays the total vulnerability rankings as well as ranking for sensitivity and adaptive capacity for each county in NHMP Region 8. Table 2-791 provides the summary descriptors of Region 8's vulnerability.

Combining sensitivity and adaptive capacity, Region 8's total relative vulnerability to extreme heat is "Moderate." Neither of the counties in Region 8 is most vulnerable to extreme heat.

Table 2-790. Relative Vulnerability Rankings for Region 8 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 8	**4**	**2**	**3**
Harney	3	3	3
Malheur	5	1	3

Source: Oregon Climate Change Research Institute

Table 2-791. Vulnerability to Extreme Heat in Region 8

	Harney	Malheur
Vulnerability	M	M

Source: Oregon Climate Change Research Institute

Region 8 counties did not rank vulnerability to extreme heat.

As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. High temperature and insufficient water stunt plant growth and cause areas of crops to wither. Some livestock, especially dairy cattle, are also sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms.

Like drought, impacts of drought on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. However, the appropriate data are not available to assess impacts of heat waves on agriculture and subsequent effects on the state economy.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 8 is approximately $573,310,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $328,497,000. Because extreme heat could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records how many losses to state facilities were sustained in Region 8 since the beginning of 2015. Nevertheless, none of the recorded losses was due to extreme heat.

Risk

With respect to extreme heat, risk is defined as the combination of the probability of extreme heat events, sensitivity to extreme heat, and level of adaptive capacity in response to extreme heat.

The total relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total risk scores of 1-2 earned a ranking of 1 (“very low”); scores of 3-4 earned a ranking of 2 (“low”); scores of 5-6 earned a ranking of 3 (“moderate”); scores of 7-8 earned a ranking of 4 (“high”); and scores of 9-10 earned a ranking of 5 (“very high”). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-792 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 8. Table 2-793 provides the summary descriptors of Region 8’s risk to extreme heat.

Table 2-792. Risk Rankings for Region 8 Counties

County	Probability	Vulnerability	Risk
Region 8	**5**	**3**	**4**
Harney	4	3	4
Malheur	5	3	4

Source: Oregon Climate Change Research Institute

Table 2-793. Risk of Extreme Heat in Region 8

	Harney	Malheur
Risk	H	H

Source: Oregon Climate Change Research Institute

Floods

Characteristics

Although flooding occurs throughout Oregon, the climate, local geology and the relatively low population of Region 8 lessen its effects. Region 8 contains a variable landscape that greatly influences flood conditions. The region is subject to a variety of flood conditions including:

- Spring runoff from rain and melting snow;
- Warming and rain during the winter months;
- Ice-jam flooding;
- Local flash flooding; and
- Closed basin playa flooding.

Most flooding throughout the region is linked to the spring cycle of melting snow. Rain-on-snow events, particularly those associated with La Niña years are associated with some of Oregon's most devastating floods in this region. Spring melting may also result in ice jams on the Snake and Malheur rivers creating flood conditions in the region.

Ice jams on the Snake and Malheur rivers have created flood conditions in the past. Ice jams happen during the winter and early spring, while the river is still frozen. Sudden warming of higher altitude snow and ice results in increased runoff and break-up of river ice. On the way downstream, floating ice can "jam" in a narrow reach of the drainage or against a road crossing, causing a dam. Subsequent breach of the dam releases a torrent of water.

Summer thunderstorms are common throughout the region. During these events, normally dry gulches quickly become raging torrents, a flash flood. Although flash flooding occurs throughout Oregon, local geology in the region can increase this hazard. Bedrock, composed mostly of igneous rocks, is exposed at the surface throughout much of the region. Consequently, runoff is increased significantly.

Many parts of Harney and Malheur Counties are characterized by interior drainage or closed basins called playas. Some playas contain lakes that grow and diminish with the seasons and from year to year. Harney and Malheur lakes are good examples. At times, they are almost dry, but conditions change with prolonged periods of rainfall or snowmelt. Since the water has nowhere to go except into the lakes, the lakes just keep filling up until they overflow. Evaporation is the primary way the water levels recede and it can take years to significantly reduce swollen lake levels through this slow process.

Flooding may follow winters with deep snow accumulation. Such was the case in 1982 and subsequent years, when high lake levels caused economic damage within the region (especially in Harney County). Farms, ranches, homesteads, utilities, highways, and a railroad branch line are at risk from this type of flooding.

In Malheur County, the Owyhee uplands and the Snake River plains give rise to streams that flow into the Snake River, a tributary of the Columbia. Several reaches of the Snake River have flood control structures. Consequently, flooding is less of a problem on these rivers than on other rivers in the region.

All of the Region 8 counties have Flood Insurance Rate Maps (FIRM); however, the maps are old and not available in digital format. The FIRM maps were issued on the following dates:

- Harney: April 17, 1984, and
- Malheur: September 29, 1986.

A remapping initiative is underway in Harney County employing updated LiDAR in the Silvies River watershed.

Notable floods affecting Region 8 are shown in Table 2-794.

Historic Flood Events

Table 2-794. Significant Flood Events in Region 8

Date	Location	Description	Remarks
1897	Harney County	severe flooding on Silvies River	flood of record on the Silvies River (300-year flood)
1904	Harney and Malheur Counties	severe flooding on Silvies and Malheur Rivers	
1910	Malheur County	severe Malheur River flooding	flood of record on the Malheur River
1921	Harney County	severe flooding on Silvies River	
1943	Harney County	severe flooding on Silvies River	
1952	Harney and Malheur Counties	severe flooding on Jordan Creek, the Silvies and Malheur rivers	
Feb. 1957	Harney and Malheur Counties	severe flooding on Jordan Creek, the Silvies and Malheur rivers	warm rain on snow / frozen ground
Dec. 1964	entire state	severe flooding throughout region	warm rain on snow / frozen ground
1982	Harney County	severe flooding from Harney and Malheur lakes	Long history: not the first lake floods; other floods followed
Dec. 1985	Malheur County	ice jam flooding	40 miles of ice on Snake River between Farewell
June 1989	Malheur County	flash flood; crops damaged; high winds	vicinity of Nyssa
Mar. 1993	Malheur and Harney Counties	widespread flooding in rural areas; highways closed	warm rain on heavy snowpack; flood of record on
Owyhee River			
May 1998	Malheur and Harney Counties	widespread flooding. Mudslides in Malheur County	persistent rain on mountain snowpack

Date	Location	Description	Remarks
May 2005	Harney County	$10,000 in property damage	
Apr. 2011	Harney County	widespread basin flooding	Oregon DOT closed and breached U.S. 20 at milepost 132.6 on April 8, 2011, for flood relief; the breach was done at the request of Harney County Emergency Operations Center to avoid damage to nearby residences; larger culverts were later installed
Feb. 2017	Harney and Malheur Counties	Flooding due to ice jams	Flows on the John Day river reached flood levels downstream of Monument due to the breaking up of an ice jam. Rainfall and snow melt combined to increase the flow on the Silvies River to minor flood stage. Flooding occurred along the Silvies River around the Burns, Oregon area and surrounding fields and roads.
March 2017	Malheur County	Rain on snow flooding	Flooding occurred along the Snake River around the Ontario, Oregon area and surrounding fields and roads.

Sources: FEMA, Malheur County Flood Insurance Study (FIS), 09/29/86; Harney County FIS, 12/22/98; Taylor and Hatton (1999), The Oregon Weather Book, p. 96-103; Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; NOAA National Centers for Environmental Information, Storm Events database, https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=697190

Table 2-795 lists flood sources for each of the counties in the region.

Table 2-795. Principal Flood Sources in Region 8

Harney County	Malheur County
Silvies River	Snake River
Silver Creek	Malheur River
Silver Lake	Bully Creek
Cow Creek	Willow Creek
Donner und Blitzen River	Jordan Creek
McCoy Creek	Indian Creek
Trout Creek	Clover Creek
Whitehorse Creek	Owyhee River
Harney Lake	Cottonwood Creek
Malheur Lake	

Sources: FEMA, Malheur County Flood Insurance Study (FIS), 09/29/86; FEMA, Harney County FIS, 12/22/98

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the "OEM Hazard Analysis Methodology" used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in Appendix **9.1.19**.

The purpose of the probability and vulnerability scores is to identify high-priority areas to which local and state governments can target mitigation actions.

Probability

Local Assessment

Participants in each county's Natural Hazard Mitigation Plan update process used the OEM hazard analysis methodology to analyze the probability that Region 8 will experience flooding. The resulting estimates of probability are shown in **Table 2-796**.

Table 2-796. Local Assessment of Flood Probability in Region 8

	Harney	Malheur
Probability	H	H

Source: Oregon Office of Emergency Management, 2019 County Hazard Analysis Scores

State Assessment

Using the methodology described in the Section 2.2.7.1, Floods/Probability, the state assessed the probability of flooding in the counties that comprise Region 8. The results are shown in **Table 2-797**.

Table 2-797. State Assessment of Flood Probability in Region 88

	Harney	Malheur
Probability	M	M

Source: DOGAMI

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-798. Local Assessment of Vulnerability to Flood in Region 8

	Harney	Malheur
Vulnerability	M	M

Source: Oregon Office of Emergency Management, 2019 County Hazard Analysis Scores

Table 2-799. State Assessment of Vulnerability to Flood in Region 8

	Harney	Malheur
Vulnerability	H	H

Source: DOGAMI, DLCD

DOGAMI performed an exposure analysis for Harney County by overlaying building locations on the 100-year flood extent. A large number (1,464 buildings) of Harney County's buildings representing 20% of the county's buildings were found to be within designated flood zones, 1,117 of which are located in the City of Burns. By comparing the number of non-damaged buildings from Hazus-MH with exposed buildings in the flood zone, DOGAMI estimated the number of buildings that could be elevated above the level of flooding. This evaluation can also shed some light on the number of residents that might have mobility or access issues due to surrounding water.

The DOGAMI Risk Assessment and exposure analysis found that three of Harney County's critical facilities are at risk to flood hazard (Burns Municipal Airport, Burns Fire and Police Department, and Harney County Roads Department buildings).

The exposure of critical infrastructure and facilities was analyzed in Malheur County by the Steering Committee members who participated in the development of the 2019 Malheur County NHMP. A comprehensive list of the 84 facilities is listed in this plan, only 7 of which were not considered by the SC members to be at risk from flooding. Although this analysis of vulnerability is not as rigorous as the exposure analysis performed by DOGAMI, it does indicate a high level of concern by the SC members about the impact of flooding on critical infrastructure and facilities.

Repetitive Losses

FEMA has identified one Repetitive Loss property in Region 8 (FEMA NFIP Community Information System, https://isource.fema.gov/cis/ accessed 02/11/2020).

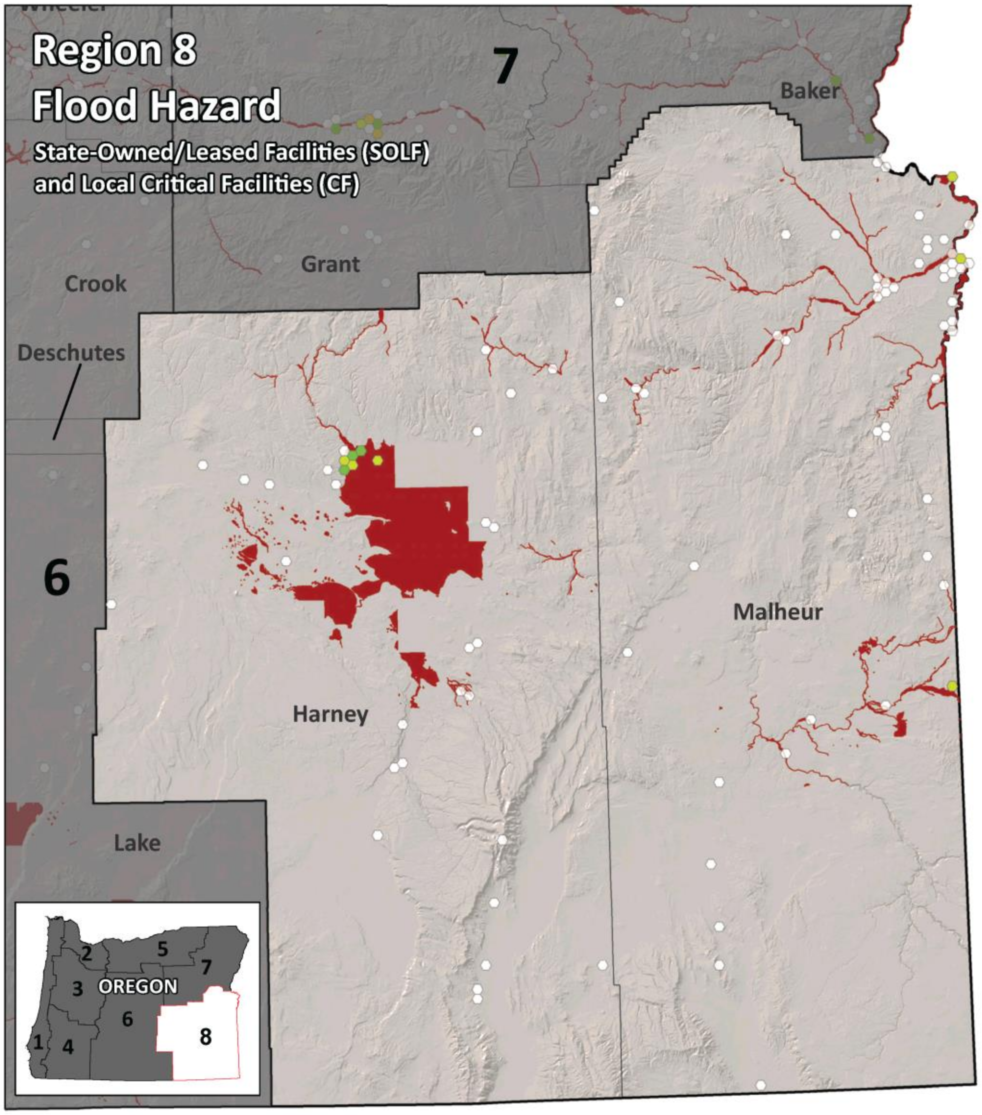
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS) Program, which results in reduced flood insurance costs. No Region 8 communities participate in the CRS Program

State-Owned/Leased Facilities and Critical/Essential Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a “High” flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated “Other.” Sites with “Other” designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 8, there is a potential loss from flooding of about $6M in state building and critical facility assets, 56% of it in Harney County and 44% in Malheur County. There is a much greater potential loss – about 3.5 times as much – due to flood in local critical facilities: over $22M. About 52% of that value is in Malheur County, 48% in Harney County. **Figure 2-314** illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding.

Figure 2-314. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 8.High-resolution, full-size image linked from Appendix 9.1.26.



Building value ($) exposed to hazard per cell

- No exposure to hazard
- 1 - 2,500,000
- 2,500,001 - 10,000,000
- 10,000,001- 25,000,000
- 25,000,001 - 50,000,000
- 50,000,001 - 477,000,000

Hazard area

- Flood - high hazard

Administrative boundary

- Mitigation Planning Region
- County

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,000,000

Source Data:
Flood: various studies from Federal Emergency Management Agency, National Flood Insurance Program
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

Author: Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

REGION 8		Exposure ($) to Flood Hazard Areas						
		State-owned/leased facilities					Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Harney	78,983,000	3,364,000	21%	84,000	3,448,000	10,652,000	14,016,000
Malheur	822,824,000	2,725,000	0%	0	2,725,000	11,569,000	14,294,000
Total	901,807,000	6,089,000	1%	84,000	6,173,000	22,221,000	28,310,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

0 12.5 25 50 Miles

N

Source: DOGAMI

Historic Resources

Of the 337 historic resources in Region 8, fifty-four (16%) are located in an area of high flood hazard. Of those, 46 (85%) are located in Harney County.

Archaeological Resources

Of the 278 archaeological resources located in high flood hazard areas in Region 8, eighty-seven percent (251) are located in Harney County. None are listed on the National Register of Historic Places but nine are eligible for listing. Seven of the nine are located in Harney County. One has been determined not eligible and 268 have not been evaluated as to their eligibility. Two hundred thirty-three (87%) of those not yet evaluated are also in Harney County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, both Harney and Malheur Counties are highly vulnerable to the impacts of flooding. While Harney County is not as socially vulnerable as Malheur County, it has more value in state buildings, state critical facilities, and almost as much in local critical facilities vulnerable to flooding. Harney County also has many more historic and archaeological resources vulnerable to flooding.

Most Vulnerable Jurisdictions

Both Harney and Malheur Counties are most vulnerable to flood hazards in Region 8.

Risk

Table 2-800. Risk of Flood Hazards in Region 8

	Harney	Malheur
Risk	H	H

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, both Harney and Malheur Counties are at high risk from flood events.

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owners property to community destruction with mass fatalities. The 1889 Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost. Oregon's

first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Table 2-801. Historic Significant Dam Failures in Region 8

Year	Location	Description
1925	Bully Creek dam west of Vale in Malheur Co.	Multiple homes badly damaged, loss of livestock
1941	Willow Creek (Malheur) dam west of Vale in Malheur Co.	Near catastrophic failure with more than 100 persons at risk, extreme flooding prevented
1949	Kern Brothers dam south of Burns in Harney Co.	Property damaged
1951	N. Indian Creek dam in northern Malheur Co.	Property damaged
1952	Rock Creek dam east of Burns in Harney Co.	Property damaged
1958	Vaughn Reservoir in rural Malheur Co.	Property damaged
1978	Kern Brothers dam south of Burns in Harney Co.	Property damaged including failure of Krumbo dam, second failure at this dam site
1983	Star Mountain dam near Riverside in Malheur Co.	Washed out railroad and roads, damaged homes

Source: Oregon Water Resources Department Dam Safety Program records

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 10 High Hazard dams and 13 Significant Hazard dams in Region 8**.**

Table 2-802. Summary: High Hazard and Significant Hazard Dams in Region 8

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 8	5	13	5
Harney	0	10	0
Malheur	5	3	5

Source: Oregon Water Resources Department, 2019

Table 2-803. High Hazard and Significant Hazard Dams in Region 8

County	Name	Rating	Regulator
Harney	Beede North	Significant	State
Harney	Beede South	Significant	State
Harney	Chickahominy Reservoir	Significant	State
Harney	Corcoran	Significant	State
Harney	Cottonwood (Drewsey)	Significant	State
Harney	Griffin Creek Dam	Significant	State
Harney	Hunter Reservoir (Harney)	Significant	State
Harney	Moon Reservoir	Significant	State
Harney	South Fork Reservoir	Significant	State
Harney	Stinking Water Creek	Significant	State
Malheur	Agency Valley Dam	High	Federal
Malheur	Bully Creek Dam	High	Federal
Malheur	Owyhee	High	Federal
Malheur	Rock Creek (Malheur)	High	Federal
Malheur	Warm Springs Reservoir (USBR)	High	Federal
Malheur	Antelope	High	State
Malheur	Crowley	High	State
Malheur	Lonesome Lake	High	State
Malheur	Pole Creek	High	State
Malheur	Willow Creek 3 (Malheur)	High	State
Malheur	Love Reservoir (Malheur)	Significant	State
Malheur	Parsnip Creek Diversion	Significant	State
Malheur	Star Mountain Reservoir	Significant	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally regulated. A dam's condition is considered public information for state-regulated dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Only one of the five state-regulated high hazard dams in Region 8 is in satisfactory condition; four are in poor or unsatisfactory condition.

Table 2-804. Summary: Condition of High Hazard State-Regulated Dams in Region 8

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	Fair	Poor	Unsatisfactory	Not Rated
Region 8	1	0	2	2	0
Harney	0	0	0	0	0
Malheur	1	0	2	2	0

Source: Oregon Water Resources Department, 2019

Table 2-805. Condition of High Hazard State-Regulated Dams in Region 8

County	Dam Name	Condition
Malheur	Lonesome Lake	Poor
Malheur	Pole Creek	Poor
Malheur	Antelope	Satisfactory
Malheur	Crowley	Unsatisfactory
Malheur	Willow Creek 3 (Malheur)	Unsatisfactory

Source: Oregon Water Resources Department, 2019

State-Regulated High Hazard Dams not Meeting Safety Standards

There are four state-regulated high hazard dams in Region 8 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). These dams and the population at risk, based on a screen using the screening tool DSS-WISE, are shown in Table

2-806. As the dam safety program conducts analysis over time, the number of dams in less than satisfactory condition may change. Currently dams that are in poor or unsatisfactory condition are in need of rehabilitation or other action to bring them into a fully safe condition. As of December 2019, these are the dams in Region 8 that are not yet demonstrably unsafe, but that do pose unacceptable risk. When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Table 2-806. State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 8

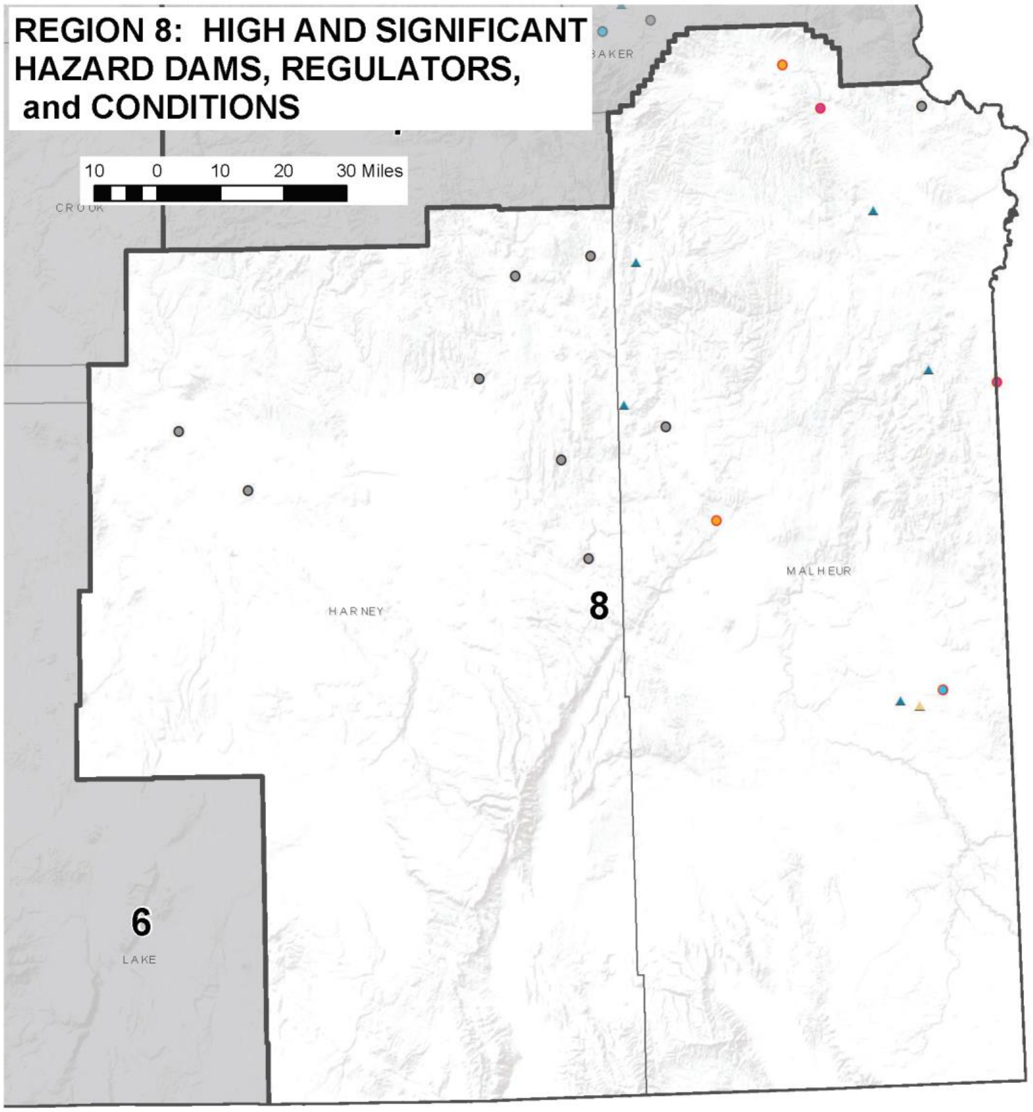
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Crowley Reservoir	OR00132	UNSAT	3	3	Malheur
Lonesome Lake		POOR	Small	Small	Malheur
Pole Creek	OR00239	POOR	37	103	Malheur
Willow Creek 3 (Malheur)	OR00390	UNSAT	3,426	3,518	Malheur

Note: "PAR" is number of "Persons At Risk" in the dam failure inundation zone based on a conservative estimate using DSS-Wise dam breach estimator. It includes all persons that normally could be in the inundation area. Actual impacts depend on the velocity and depth of water and will be determined as part of Oregon's HHPD grant tasks.

Source: DSS-Wise output

Figure 2-315 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 8. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-315. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 8



	Coastal	Earthquake	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 8	0	11	*	6	0	0	11
Harney	0	6	*	1	0	0	6
Malheur	0	5	*	5	0	0	5

* - flood risk affected by function and condition of dam, not by presence in mapped flood prone location

State regulated dams**

Condition assessment

- Poor
- Unsatisfactory
- Fair
- Satisfactory
- No assessment

** - Significant hazard dam symbols have a black outline.
High hazard dam symbols have a red outline.

Federal regulated dams

Hazard

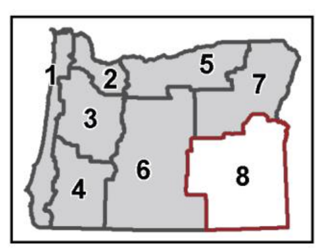
- High
- Significant

Mitigation Planning Regions
Counties

Projection:
Oregon Lambert Coordinate Reference System, Unit: International Feet, Horizontal datum: NAD83, EPSG #2992

Source Data:
State regulated dams: Oregon Water Resources Dept., July 2020
Mitigation Planning Regions: Oregon Emergency Management
Counties: U.S. Bureau of Land Management (BLM)
Base map: Esri, World Terrain Base

Author: Robert Harmon, GISP, Oregon Water Resources Dept. (July 2020)



Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

Table 2-806, State-Regulated High Hazard Dams Not Meeting Safety Standards in Region 8, indicates the number of people currently anticipated to be impacted by potential failure of the state-regulated high hazard dams in poor or unsatisfactory condition. OWRD plans to do more analysis to determine the number and value of structures that may be impacted as well.

Risk to dams from non-flood hazards in Region 8 is generally fairly low, with some volcanic risk possible for at least one dam.

Three dams meet FEMA HHPD eligibility criteria in Region 8. There is one major highway in the inundation area below two of these dams.

Most Vulnerable Jurisdictions

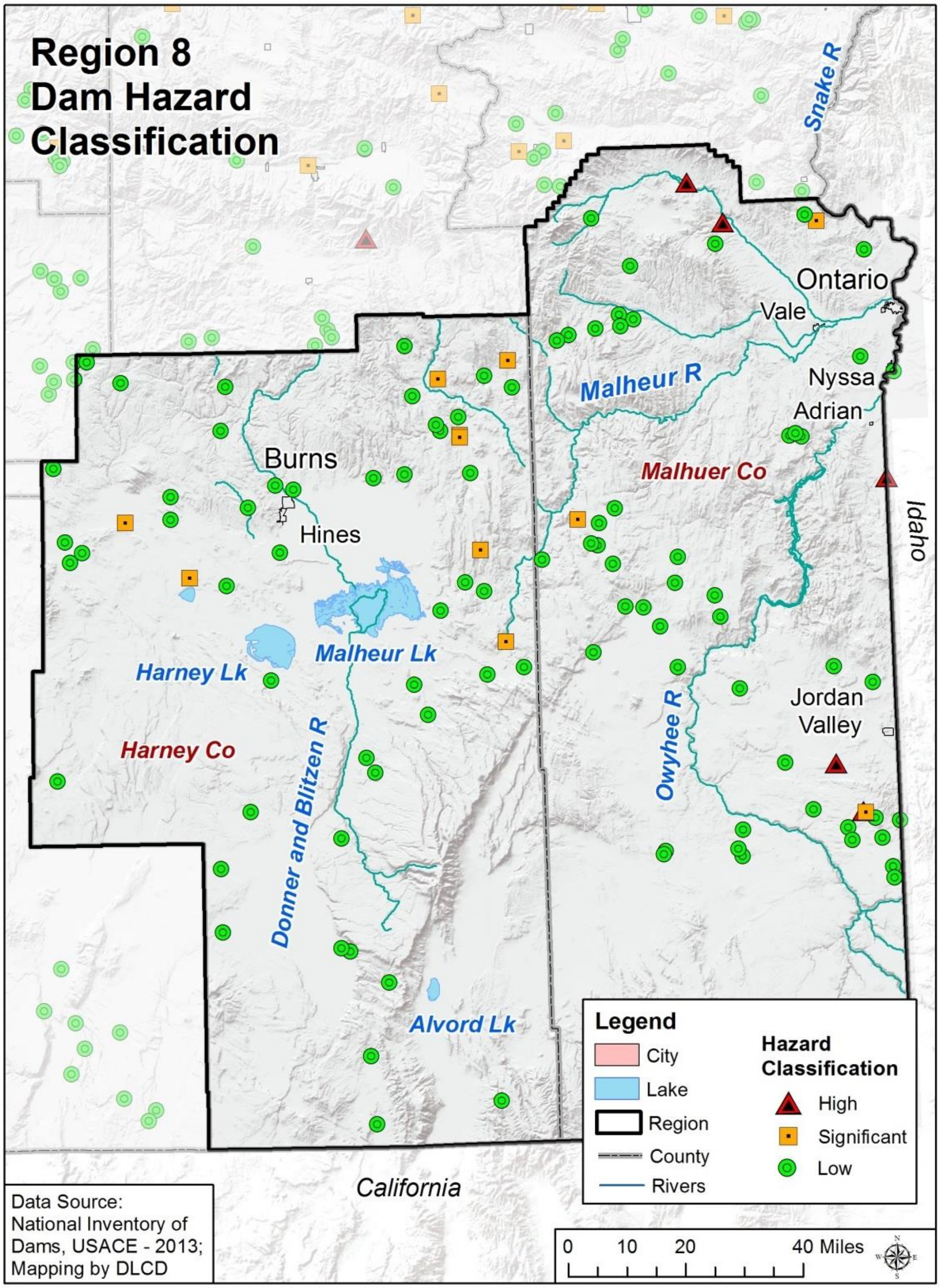
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), only Malheur County in Region 8 has high hazard dams in poor or unsatisfactory condition is therefore considered most vulnerable.

As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable jurisdictions” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The county with the most state-regulated significant hazard dams is Harney County (10).

Risk

With FEMA and State funding, OWRD will be completing risk assessments for three of Region 8’s state-regulated high hazard dams in poor or unsatisfactory condition over the next several years. For now, the potential for damage to the dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-316. Region 8 Dam Hazard Classification



Source: National Inventory of Dams, USACE, 2013

Note: Federally regulated significant hazard dams are not shown.

Landslides

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage.

Historic Landslide Events

There are no readily known significant landslides in this region.

Probability

Table 2-807. Assessment of Landslide Probability in Region 8

	Harney	Malheur
Probability	L	L

Source: DOGAMI, 2020

The probability of future landslides in the southeastern Oregon region is low to moderate. The probability of an area to have a landslide is increased depending on the factors that reduce the stability without causing failure. When several of these factors are combined, such as an area with steep slopes, weak geologic material, and previous landslide movement, the probability of future landsliding is increased. There is a strong correlation between intensive winter rainstorms and the occurrence of rapidly moving landslides (debris flows).

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-808. Local Assessment of Vulnerability to Landslides in Region 8

	Harney	Malheur
Vulnerability	L	L

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-809. State Assessment of Vulnerability to Landslides in Region 8

	Harney	Malheur
Vulnerability	L	H

Source: DOGAMI and DLCD, 2020

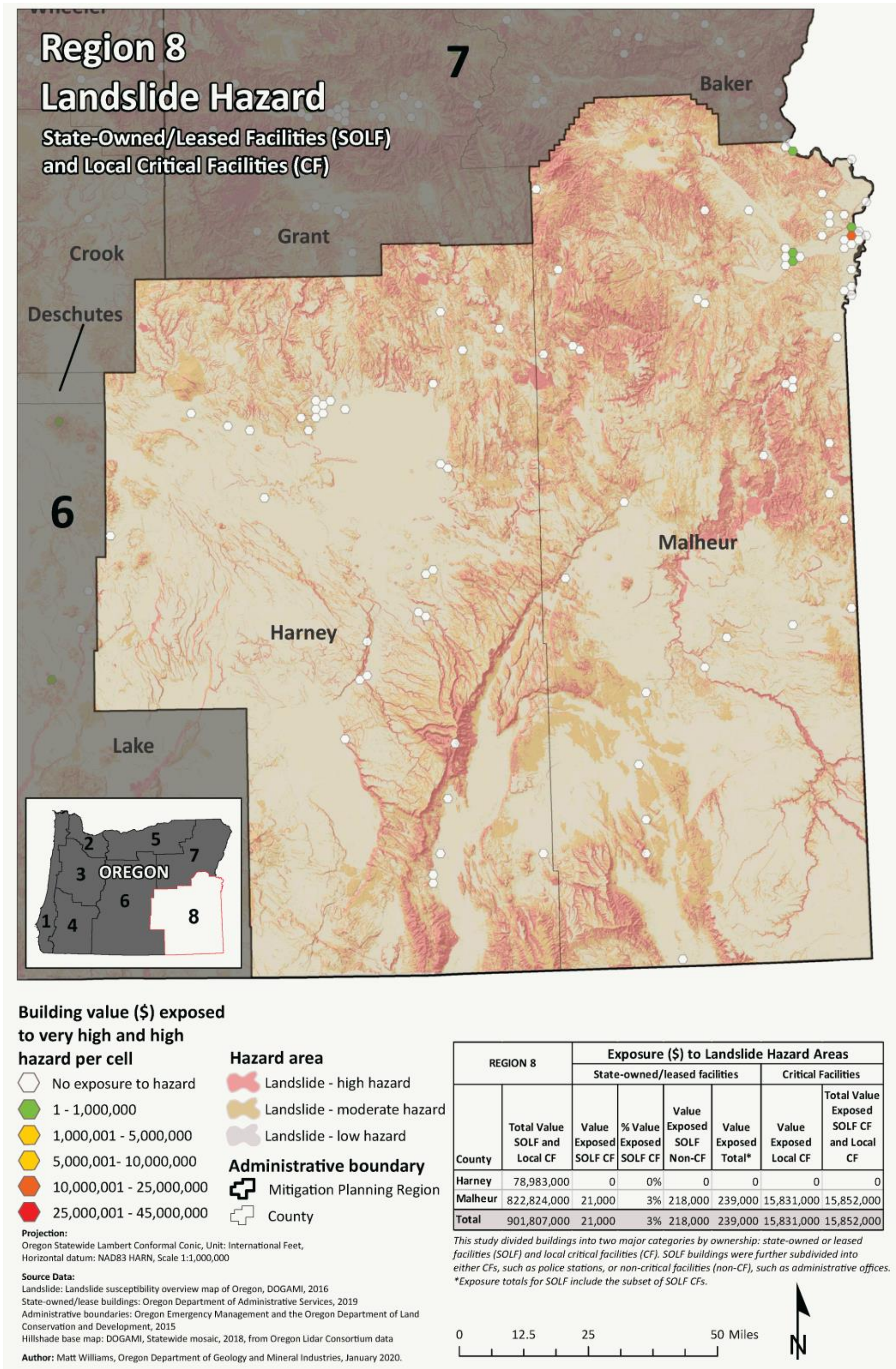
Landslides pose significant threats to people and infrastructure. Landslides have caused damage and loss in Region 8, and it is very likely that they will again. Most of the people and infrastructure in Region 8 are located in one of the major cities in the region which are located along highways. The generalized landslide hazard for the region is low to moderate.

According to the 2020 risk assessment, Harney County's high vulnerability is driven by its very high social vulnerability score. Malheur County's social vulnerability score is appreciably lower, and the presence of state buildings and state and local critical facilities in landslide hazard areas is low enough to keep Malheur County's overall vulnerability score low.

State-Owned/Leased Facilities and Critical and Essential Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 8. About $239K in value of state assets is exposed to landslide hazards in Region 8, all of it in Malheur County. The total value of the Region's local critical facility assets, $15.8M, is also located in Malheur County. **Figure 2-317** illustrates the potential loss to state buildings and critical facilities and local critical facilities from landslide hazards.

Figure 2-317. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 8.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 8		Exposure ($) to Landslide Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Harney	78,983,000	0	0%	0	0	0	0
Malheur	822,824,000	21,000	3%	218,000	239,000	15,831,000	15,852,000
Total	901,807,000	21,000	3%	218,000	239,000	15,831,000	15,852,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

All of the 337 historic resources in Region 8 are exposed to landslide hazards: 8 are exposed to very high or high landslide hazards; 41 to moderate; and 288 to low. Sixty percent of the historic resources in Region 8 are located in Malheur County, as are seven of the eight exposed to high or very high landslide hazards.

Archaeological Resources

Of the 3,058 archaeological resources located in landslide hazard areas in Region 8, fifty-two percent (1,596) are in high landslide hazard areas. Of those, only one is listed on the National Register of Historic Places and 156 are eligible for listing. Twenty have been determined not eligible, and 1,419 have not been evaluated as to their eligibility. About half the archaeological resources in high or very high landslide hazard areas are located in each county. Overall, 71% of the archaeological resources in landslide hazard areas in Region 8 are in Harney County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Malheur County is much more vulnerable to landslides than Harney County.

Risk

Table 2-810. Assessment of Risk to Landslides in Region 8

	Harney	Malheur
Risk	VL	M

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 Risk Scores and DOGAMI's expert assessment, Malheur County carries more risk to landslides than Harney County, but with moderate and very low risk ratings, neither is a "most vulnerable community."

Volcanoes

Characteristics

The volcanic Cascade Range is not within Region 8 counties, but there is some risk from volcanic ash derived from these volcanoes. This fine-grained material, blown aloft during a volcanic eruption, can travel many miles from its source. For example, during the May 1980, Mount St. Helens eruption, the cities of Yakima and Spokane, Washington, 80 and 160 miles away, respectively, were inundated with ash. Ash can reduce visibility to zero and bring street, highway, and air traffic to an abrupt halt. The material is noted for its abrasive properties and is especially damaging to machinery.

Ashfall is largely controlled by the prevailing wind direction. The predominant wind direction over the Cascade Range is west to east. Previous eruptions documented in the geologic record indicate most ashfall drifting to and settling in areas east of the Cascade volcanoes. Geologic hazard maps have been created for most of the volcanoes in the Cascade Range by the U.S. Geological Survey Volcano Hazards Program at the Cascade Volcano Observatory in Vancouver, Washington and are available at http://volcanoes.usgs.gov/observatories/cvo/.

Besides the distant Cascade volcanoes to the west, there are numerous examples of local volcanic activity throughout southeastern Oregon, such as the abundant thermal hot springs, and some large volcanic fields (e.g., Diamond and Jordan Craters), which attest to its not too distant volcanic past. Jordan Craters, located about 36 miles southwest of Adrian, is thought to have erupted lava roughly 3,200 years ago.

Historic Volcanic Events

Table 2-811. Historic Volcanic Events in Region 8

Date	Location	Description
< 7,000 YBP	Diamond Craters, eastern Oregon	lava flows and tephra in Diamond Craters field
< 3,200 YBP	Jordan Craters, eastern Oregon	lava flows and tephra in Jordan Craters field

Note: YBP is years before present.

Source: Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/

Probability

Table 2-812. Assessment of Volcanic Hazards Probability in Region 8

	Harney	Malheur
Probability	L	L

Source: DOGAMI, 2020

Mount St. Helens remains a probable source of ash. It has repeatedly produced voluminous amounts of this material and has erupted much more frequently in recent geologic time than any other Cascade volcano. It blanketed Yakima and Spokane, Washington, during the 1980 eruption and again in 2004. The location, size, and shape of the area affected by ash are determined by the vigor and duration of the eruption and the wind direction.

The eruptive history of the nearby Cascade volcanoes to this region can be traced to late Pleistocene times (approximately 700,000 years ago) and will no doubt continue. But the central question remains: When? The most recent series of events at Newberry Volcano, which occurred about 1,300 years ago, consisted of lava flows and ashfall. Newberry Volcano's history also includes pyroclastic flows and numerous lava flows. Volcanoes in the Three Sisters region, such as Middle and South Sister, and at Crater Lake have also erupted explosively in the past. These eruptions have produced pyroclastic flows, lava flows, lahars, debris avalanches, and ash. Any future eruptions at these volcanoes would most likely resemble those that have occurred in the past.

Geoscientists have provided some estimates of future activity in the vicinity of Newberry Caldera and its adjacent areas. They estimate a 1 in 3,000 chance that some activity will take place in a 30-year period. The estimate for activity at Crater Lake for the same time period is significantly smaller at 0.003 to 0.0003. In the Three Sisters region, the probability of future activity is roughly 1 in 10,000 but any restlessness would greatly increase this estimate.

Local eruptions within Region 8 occurred most recently at Diamond Craters about 6000 years ago and younger activity at Jordan Craters dates after 3,200 years ago. These events consisted of short-lived effusion of basaltic lava and blanketing of the surrounding landscape with basaltic ash. These volcanoes are now extinct, but future eruptions in Southeast Oregon will occur. However, neither the timing nor the location of such events can be forecast in the absence of volcanic unrest.

Vulnerability

Table 2-813. Local Assessment of Vulnerability to Volcanic Hazards in Region 8

	Harney	Malheur
Vulnerability	L	L

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-814. State Assessment of Volcanic Hazards Vulnerability in Region 8

	Harney	Malheur
Vulnerability	L	M

Source: DOGAMI and DLCD, 2020

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 8. No state buildings, state or local critical facilities are located in volcanic hazard areas.

Historic Resources

None of the 337 historic buildings in Region 8 are exposed to volcanic hazards. See Appendix **9.1.12** for details.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

According to the 2020 vulnerability scores, Harney County is the more vulnerable to volcanic hazards of the two counties in Region 8. Harney County's high vulnerability score is driven by very high social vulnerability. Malheur County, by contrast, has moderate social vulnerability.

Risk

Table 2-815. Assessment of Risk to Volcanic Hazards in Region 8

	Harney	Malheur
Risk	M	VL

Source: DOGAMI and DLCD, 2020

According to the 2020 risk scores, none of the communities identified by DOGAMI as being most vulnerable to volcanic hazards are located in Region 8.

Areas within Region 8 could be affected by ashfall from Cascade volcanic eruptions and more locally by small eruptions of lava from the numerous youthful volcanic cones scattered across Harney and Malheur Counties. Most of the region's people and infrastructure are located in the major cities along I-84, US-20, and US-395. The most vulnerable jurisdictions are Burns, Ontario, and Jordan Valley.

Wildfires

Characteristics

Southeastern Oregon contains large tracts of ponderosa pine forests, primarily in the northern part of Harney County. Less extensive forests occur in Malheur County near Ironside and in scattered mountain ranges throughout the region. These areas are highly vulnerable to wildfire because of natural aridity and the frequency of lightning strikes. Grasslands, which naturally cover most of the region, also are problematic. Wildfire always has been a part of these ecosystems. Past management practices, which included the suppression of all wildfires, has favored the growth of a brushy understory and the accumulation of dead or dying trees. This leads to devastating fires. State and federal agencies seek to alleviate the problem through a controlled (i.e., prescribed) burning program. **Table 2-816** lists some of the significant wildfires that have occurred in the region.

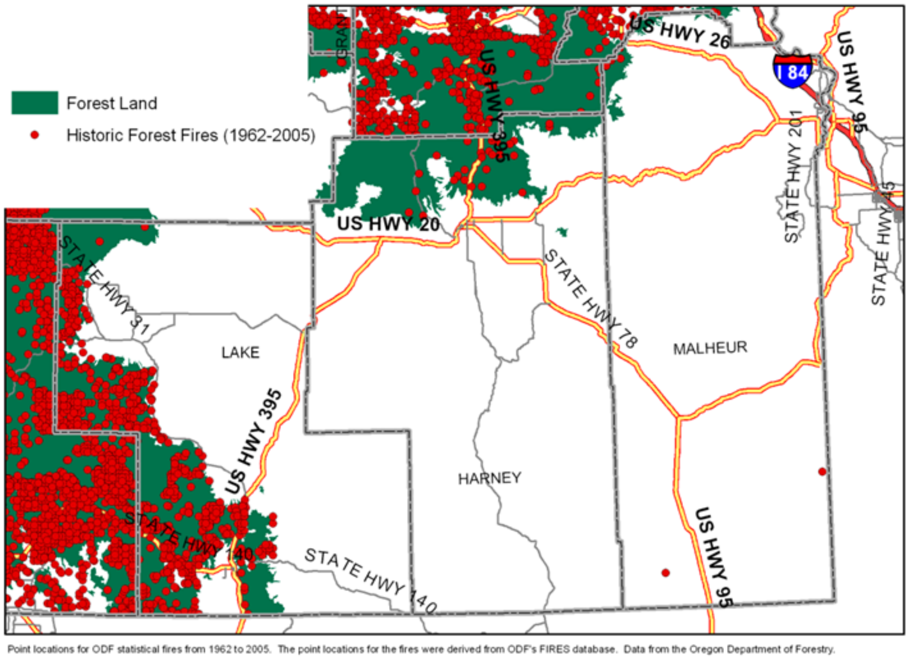
Historic Wildfire Events

Table 2-816. Significant Wildfires in Region 8

Date	Name of Fire	Location	Acres Burned	Remarks
1998	Ontario	Malheur County		
2000	Jackson	Malheur County	79,875	
2001	Sheepshead	Malheur County	51,452	
2006	South End Complex	Harney County	117,553	
2007	Egley	Harney	140,360	
2017	Cinder Butte	Harney	>52,000	human-caused; burned rangeland; threatened Tribal archaeological sites

Source: Oregon Department of Forestry, 2020

Figure 2-318. Historic Forest Fires in Region 8



Source: The Oregon Department of Forestry Database and extent of forested land (http://egov.oregon.gov/ODF/GIS).

Probability

Table 2-817. Assessment of Wildfire Probability in Region 8

	Harney	Malheur
Probability	H	H

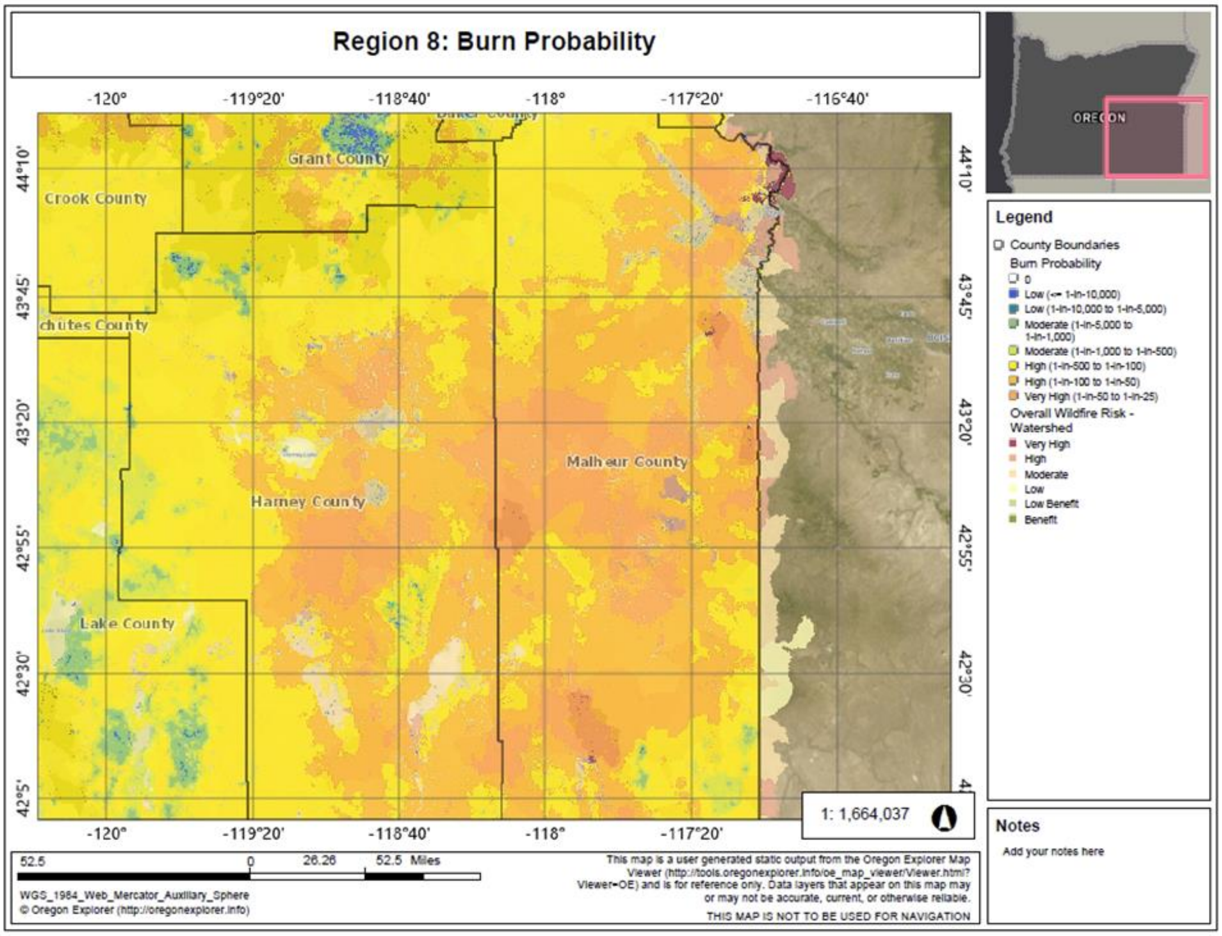
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to look at the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-319 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

Figure 2-319. Burn Probability



Source: Oregon Wildfire Risk Explorer, March 2020

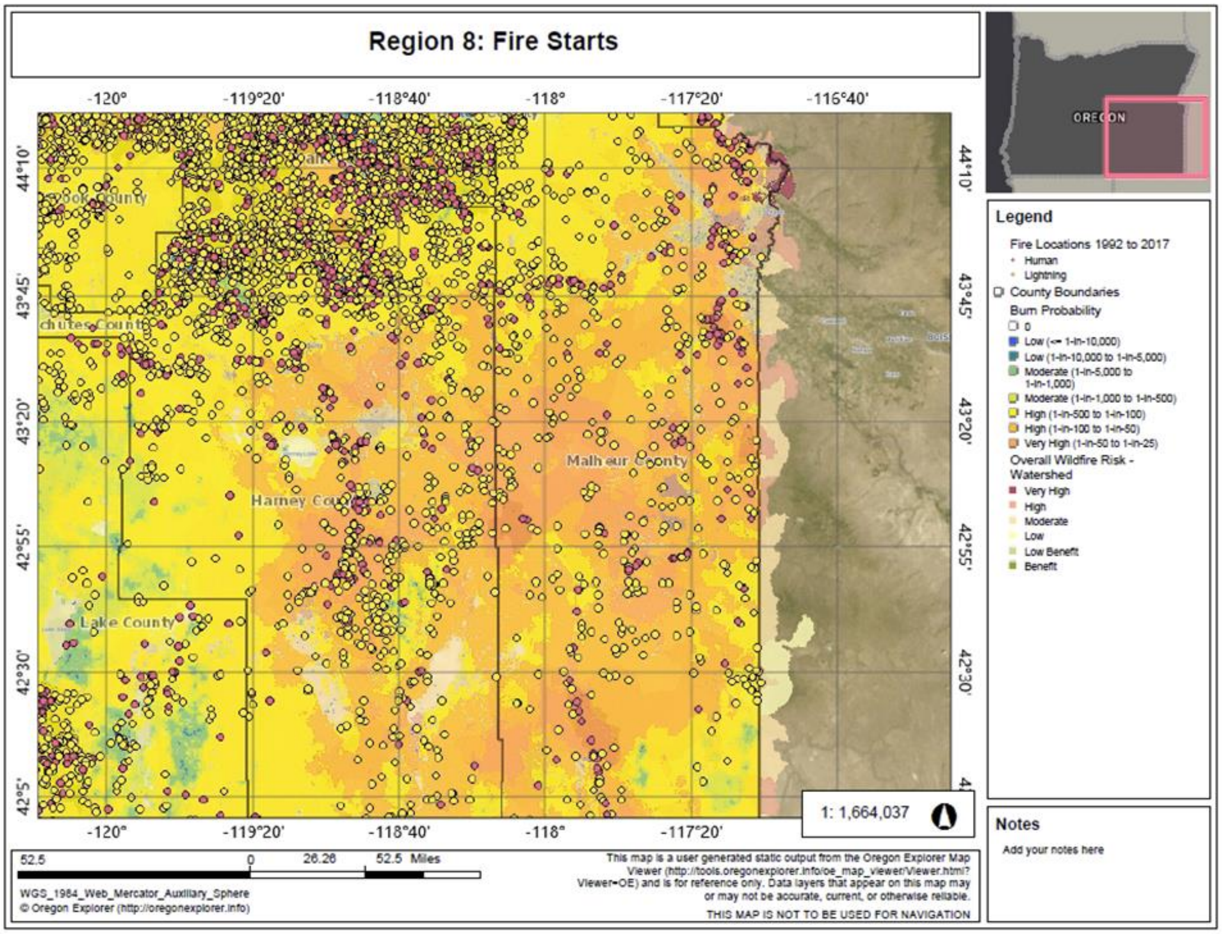
The forests and grasslands of Region 8 are highly susceptible to wildfire and many of the cities and unincorporated communities, in addition to rangelands and agricultural lands, are vulnerable to its effects. Wildfires are an annual occurrence and have varied in size from under 10 acres to over 100,000 acres.

Most wildfires started by lightning. Human causes are mostly associated with abandoned campfires, debris burning, or fires started along the interstate and highways (faulty vehicle equipment, cigarettes tossed out of windows of vehicles, etc.).

Hilly or mountainous topography exacerbates wildfire hazards. These areas can cause a wildfire to spread rapidly and burn larger areas in a shorter period of time, especially as fires migrate uphill. Wildfire has been known to move at speeds of 30 mph or higher on grasslands.

Large fires have, at times, exceeded the capability of structural and wildland resources, not only calling for the declaration of the Conflagration Act, but also requiring National Incident Management Teams to manage fires at the project fire level.

Figure 2-320. Human- and Lightning-Caused Wildfires in Region 8, 1992-2017



Source: Oregon Wildfire Risk Explorer, March 2020

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Fuel-limited systems, such as those in eastern and southeastern Oregon, have non-contiguous fuels including sagebrush and bunchgrasses. As invasive annual grasses increase (e.g., Cheatgrass), fuels become contiguous since invasive grasses regrow quickly outcompeting other vegetation. Warming winters will lead to more fine fuels from greater cold season growth. Also, conditions conducive to conversion to invasive grasses can lead to frequent fires and conversion to invasive-dominated systems as climate changes, including reduction in habitat for sage grouse. It is likely (>66%) that Region 8 will experience increasing wildfire frequency and intensity under future climate change.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 8 counties (Table 2-818).

Table 2-818. Projected Increase in Annual Very High Fire Danger Days in Region 8 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Harney	14	39%
Malheur	15	40%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-819. Local Assessment of Vulnerability to Wildfire in Region 8

	Harney	Malheur
Vulnerability	H	M

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-820. State Assessment of Vulnerability to Wildfire in Region 8 – Communities at Risk

	Harney	Malheur
Vulnerability	H	H

Source: ODF Communities at Risk Report, 2020

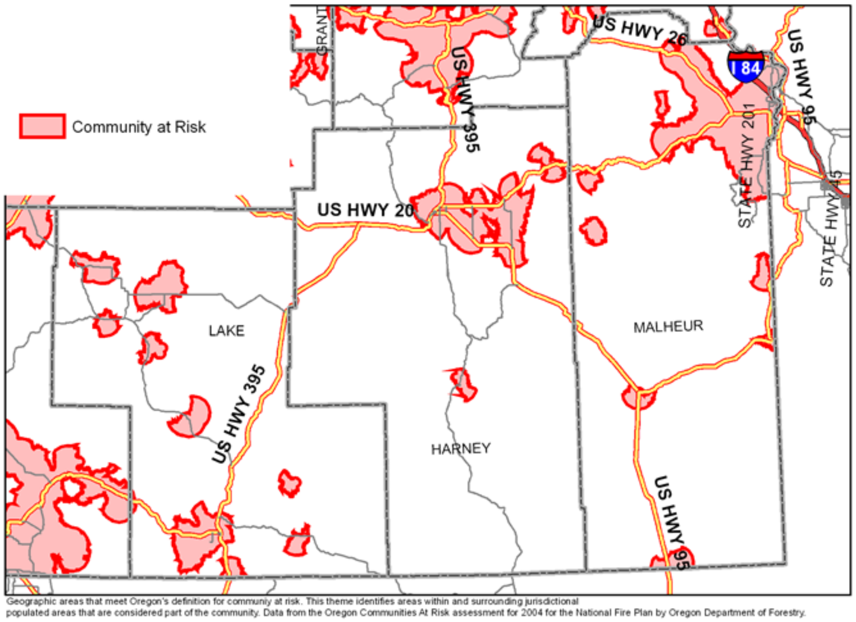
Table 2-821. Assessment of Vulnerability to Wildfire in Region 8 – 2020 Vulnerability Assessment

	Harney	Malheur
Vulnerability	M	VH

Source: DOGAMI and DLCD, 2020

According to ODF's assessment of Communities at Risk, the generalized wildfire hazard for Region 8 is moderate to high; however, there are areas within the region that have a very high hazard. Most of the region's people and infrastructure are located in the major cities along I-84, US-20, and US-395 (Figure 2-321). The region's total exposure for buildings and transportation systems alone is roughly 11.5 billion dollars.

Figure 2-321. Region 8 Communities at Risk of Wildfire



Source: ODF Communities at Risk Report, 2004

Preliminary analyses indicate a high likelihood of damage and losses from future wildfire in the region. Threatened assets include businesses, farmland, ranchland, grazing land, and hunting and recreation land. Action should be taken to reduce the damage and losses through pre-disaster mitigation and prepare for effective emergency response after the disaster. Special action should be taken for critical facilities including schools and emergency facilities and infrastructure such as roadways.

Wildland fire protection in unincorporated areas is protected by Rangeland Fire Protection Associations or BLM. Where the majority of BLM land is leased for ranching operations, large wildfires can have significant economic impacts on ranchers' stock and range allotments, as burned land is unfit for grazing use for several years after a fire.

Known sage-grouse habitat is a top wildfire suppression priority in this region. Rangeland Protection Associations and Oregon Department of Forestry have implemented conservation measures to reduce the negative impacts of wildland fire on sagebrush plant communities within the range of the sage-grouse.

The communities in Region 8 are particularly vulnerable because they are scattered throughout the landscape on large acreages with highly flammable vegetation. Many communities have no structural fire protection, and wildland agencies would have extended response times.

Table 2-822. Wildland-Urban Interface Communities in Region 8

Harney	Malheur
Andrews	Annex
Blitzen	Arock
Burns	Brogan
Crane	Danner
Diamond	Jamieson
Double O	Ironside
Drewsey	Adrian
Fields	Burns Junction
Frenchglen	Harper
Narrows	Jordan Valley
Riley	Juntura
	McDermitt
	Nyssa
	Ontario
	Ontario Heights
	Owyhee Reservoir
	Riverside
	Rockville
	Rome
	Vale

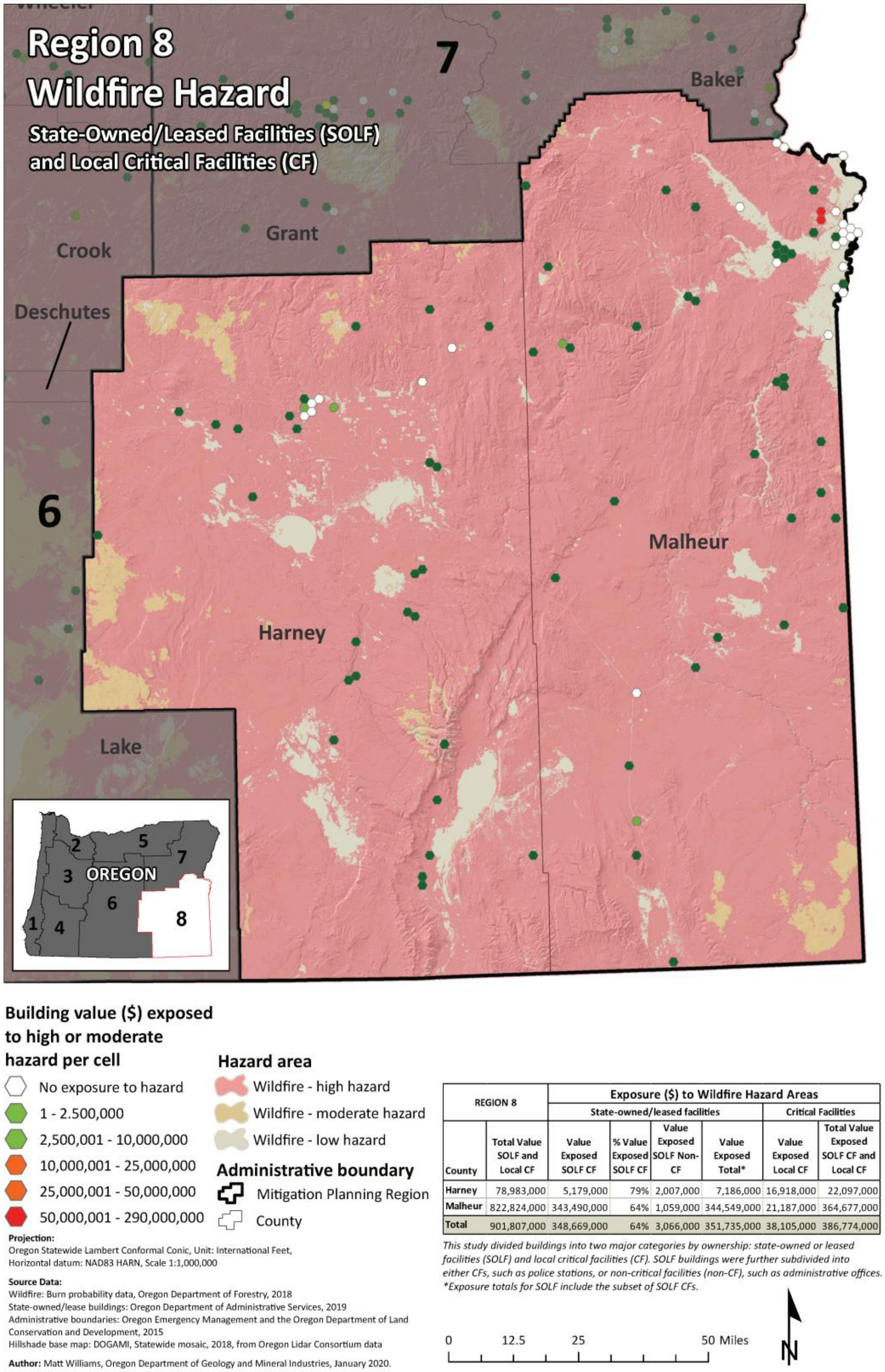
Source: Oregon Department of Forestry 2020 Communities at Risk Report

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in “High,” “Moderate,” and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as “Low.”

In Region 8, there is a potential loss to wildfire of almost $352M in state building and critical facility assets, 98% of it in Malheur County. There is a much lesser potential loss in local critical facilities: about $38M. Fifty-six percent of that value is also located in Malheur County.

Figure 2-322. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 8.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 8		Exposure ($) to Wildfire Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Harney	78,983,000	5,179,000	79%	2,007,000	7,186,000	16,918,000	22,097,000
Malheur	822,824,000	343,490,000	64%	1,059,000	344,549,000	21,187,000	364,677,000
Total	901,807,000	348,669,000	64%	3,066,000	351,735,000	38,105,000	386,774,000

This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

Historic Resources

Of the 337 historic resources in Region 8, fifty-nine (18%) are located in an area of high wildfire hazard. Of those, around 56% are located in Malheur County and 44% in Harney County. Only three historic resources are located in a moderate wildfire hazard area, all of them in Harney County.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Malheur County has very high vulnerability to wildfire and Harney County has moderate vulnerability. The Communities at Risk assessment found both counties highly vulnerable.

Risk

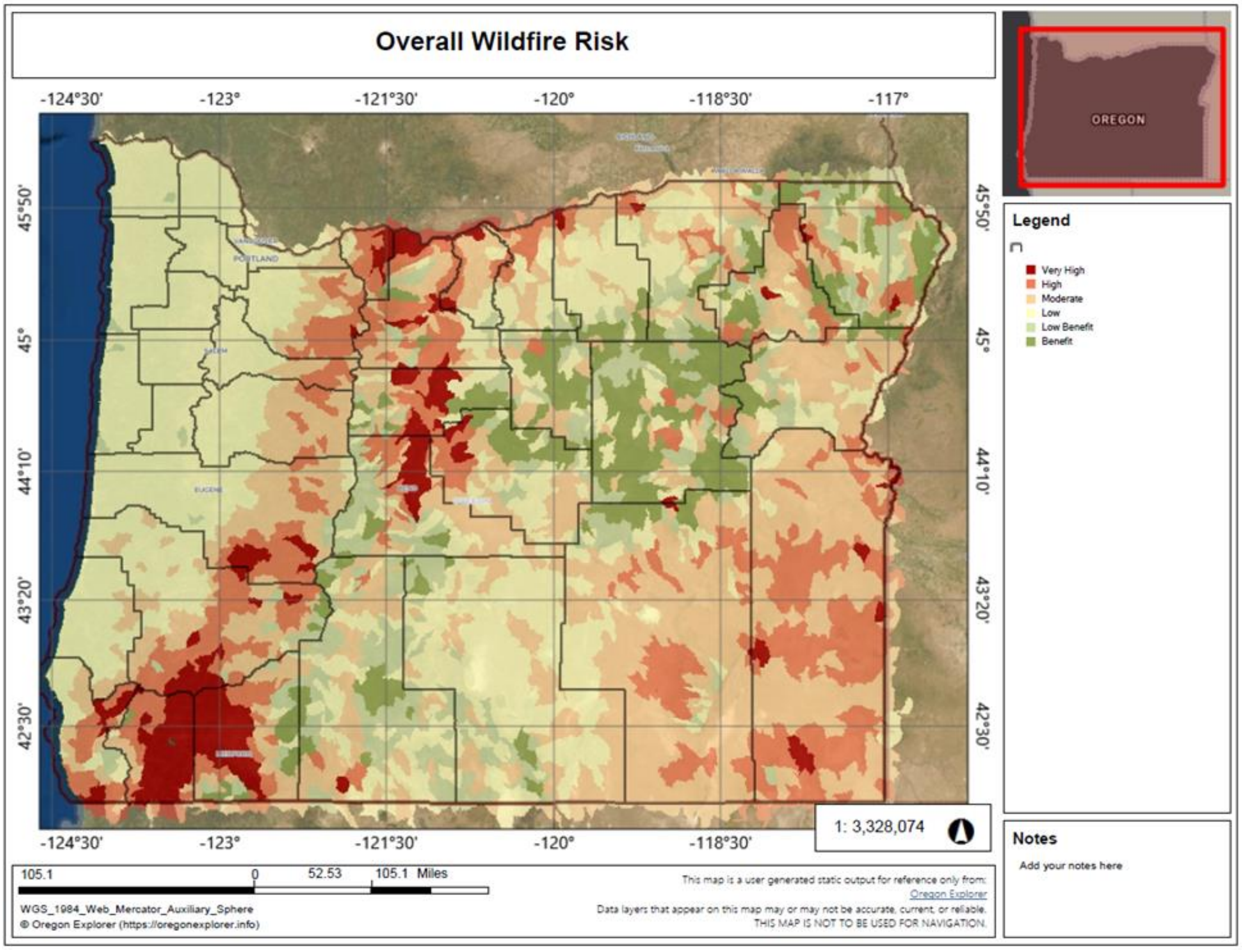
Table 2-823. Risk of Wildfire Hazards in Region 8

	Harney	Malheur
Risk	H	VH

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Malheur County is at very high risk from wildfire and Harney County is at high risk. This is generally consistent with ODF's assessment, mapped in **Figure 2-323**.

Figure 2-323. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

High winds in the intermountain areas of Region 8 are not uncommon. There is little in the way of mountain protection for much of these counties; the landscape is flat and open with the exception of a few areas. Winds in Harney and Malheur Counties are often associated with thunderstorms, which have strong outflow and coincidentally strong surface winds. Windstorms can be problematic in burned areas, where dust may be lifted and transported across the landscape, causing reductions in visibility and localized damage.

Tornadoes

Small to moderate sized tornadoes have been recorded in virtually every area of Oregon. Six have been recorded in Region 8 (**Table 2-824**), but others probably have occurred. Wind speeds have varied; estimates are somewhere between 40 to 112 mph, corresponding to “gale” (F0 on the Fujita Scale of Tornado Intensity) and “moderate” (F1 on the Fujita Scale) tornadoes. Damage was estimated to be an amount between $5,000 and $50,000 (Taylor & Hatton, 1999).

Historic Windstorm Events

Table 2-824. Historic Windstorms in Region 8

Date	Affected Area	Characteristics
Apr. 1931	northeast Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; Wind speed 40–60 mph; Gusts 75–80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 75-mph gusts; damage to buildings and utility lines
Dec. 1955	statewide	wind speeds 55–65 mph with 69 mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71 mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon's most destructive storm to date.; 116-mph winds in Willamette Valley; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Aug. 1966	Malheur County	tornado between Nyssa and Ontario; telephone poles and some farm buildings destroyed
June 1967	Malheur County	two tornadoes reported; some damage
June 1969	Malheur County	tornado reported 40-60 miles south of Jordan Valley (Malheur County)
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Apr. 1974	Malheur County	tornado path parallel to Oregon- Idaho border; farm building destroyed
Nov. 1981	statewide	60-mph winds common throughout state
Jan. 1990	statewide	severe wind storm
Jan. 1991	most of Oregon	severe wind storm
Dec. 1991	NE and central Oregon	severe wind storm
Dec. 1992	northeastern mountains, Oregon	severe wind storm
May 1994	eastern Oregon	strong winds in Treasure Valley area (Ontario); blowing dust caused many car accidents
May 2005	Malheur County	hail storm causes $3,000 in crop damage
July 2006	Harney County	wind storm produces winds of 75 mph
Aug. 2006	Harney County	three high windstorms in Harney County with winds measured at 67, 58 and 58 mph, respectively
Aug. 2007	Harney County	high wind storm produces winds of 58 mph
Apr. 2010	Harney County	75-mph winds caused $200,000 in property damage, including 52 downed power poles

Source: Taylor and Hannan (1999), *The Oregon Weather book;* The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org

Table 2-825. Tornadoes Recorded in Region 8

County	Date	Location	Damage
Malheur	Aug. 1966	Adrian to Oregon border just north of Ontario, Oregon	several farm buildings destroyed; trees uprooted; telephone poles displaced
Malheur	June 1967	13 miles west of Sheaville, Oregon	two tornadoes; limited in extent and duration; one damaging; the other, no damage
Malheur	June 1967	remote	some damage
Malheur	June 1969	40–60 miles west of Jordan Valley, Oregon	grain fields damaged
Malheur	Apr. 1974	10 miles SW of Nyssa, Oregon	farm buildings destroyed
Harney	Mar 1995	near Happy Valley	no damages
Malheur	Apr. 1997	near Ontario Oregon	two tornadoes; limited damage to barn and farm equipment
Harney	Sept 1997	Near Burns	damage to ranch property - $15,000
Malheur	June 1997	north of Ontario Oregon	tornado blew a pick-up truck off the road
Harney	Aug 2001	Burns	two tornadoes; both F0 no damages from either
Harney	Jun. 2006	Wagontire	F0; no damage reported
Harney	Jun. 2019	Blitzen; north of French Glen	EF0; no damage reported

Source: Taylor and Hatton (1999), pp. 123-137; https://www.ncdc.noaa.gov/stormevents/

Probability

Table 2-826. Assessment of Windstorm Probability in Region 8

	Harney	Malheur
Probability	M	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

The 100-year storm in this region is defined as one-minute average winds of 75 mph. A 50-year storm includes winds of 65 mph. A 25-year storm has winds of up to 55 mph.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-827. Local Assessment of Vulnerability to Windstorms in Region 8

	Harney	Malheur
Vulnerability	L	M

Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-828. State Assessment of Vulnerability to Windstorms in Region 8

	Harney	Malheur
Vulnerability	L	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Many buildings, utilities, and transportation systems within Region 8 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, uprooted or shattered trees can down power or utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed when uprooted trees growing next to a house fall during a windstorm. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establishing a tree maintenance and removal program.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

Based on the information in **Table 2-824** and **Table 2-825**, Malheur County appears to have suffered greater damages from windstorms. Coupled with its higher social vulnerability, Malheur County is considered to be the more vulnerable to windstorms in Region 8.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 8 is approximately $573,310,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $328,497,000. Because windstorms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records how many losses to state facilities were sustained in Region 8 since the beginning of 2015. Eight losses were due to windstorms statewide. Of those, it is possible that one or two may have been located in Region 8. One claim was for approximately $6,200 and the other has not been settled.

Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

With greater probability of windstorms and greater vulnerability, Malheur County is considered to have the greater risk from windstorms in Region 8.

Winter Storms

Characteristics

Within the State of Oregon, Region 8 communities are known for cold, snowy winters. Winter weather in Region 8 can be characterized by extreme cold, snow, ice, and sleet. There are annual winter storm events in Region 8 with an average of 24 inches of snow; most communities are prepared for them. Moderate to heavy snowfall is prepared for and expected on an annual basis in this region.

Historic Winter Storm Events

Table 2-829. Significant Winter Storms in Region 8

Date	Location	Remarks
Dec. 1861	entire state	storm produced 1–3 feet of snow throughout Oregon
Dec. 1892	northern counties, Oregon	15–30 inches of snow fell throughout the northern counties
Jan. 1916	entire state	two storms; heavy snowfall, especially in mountainous areas
Jan. and Feb. 1937	entire state	deep snow drifts
Jan. 1950	entire state	record snowfalls; property damage throughout state
Mar. 1960	entire state	many automobile accidents; two fatalities
Jan. 1969	entire state	heavy snow throughout state
Jan. 1980	entire state	series of string storms across state; many injuries and power outages
Feb. 1985	entire state	2 feet of snow in northeast mountains; downed power lines; fatalities reported
Feb. 1986	central /eastern Oregon	heavy snow; traffic accidents; broken power lines
Mar. 1988	entire state	strong winds; heavy snow
Feb. 1990	entire state	heavy snow throughout state
Nov. 1993	Cascade Mountains, Oregon	heavy snow throughout region
Feb. 1994	southeastern Oregon	heavy snow throughout region
Winter 1998-99	entire state	one of the snowiest winters in Oregon history (snowfall at Crater Lake: 586 inches)
Dec.28, 2003–Jan. 9, 2004	statewide storm	DR-1510 Harney and Malheur declared in Region 8. The most significant winter storm in several years brought snowfall to most of Oregon. Freezing rain in eastern Oregon. President Bush issued a major disaster declaration for 26 Oregon counties affected by the winter storm, later extended to 30 of Oregon's 36 counties. Estimated the cost of damages to public property at $16 million.
Dec. 6-23, 2015	statewide storm events	DR-4258. Clatsop, Columbia, Multnomah, Clackamas, Washington, Tillamook, Yamhill, Polk, Lincoln, Linn, Lane, Douglas, Coos, and Curry Counties declared. Severe winter storms, straight-line winds, flooding, landslides, and mudslides. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Another series of storms moved across Oregon on Dec 16-17 and Dec 21-23. Each storm system brought several inches of snow to the mountain areas. Another in a long series of storms brought heavy snow to portions of south central Oregon in 24 hours ending Dec. 17th.
Feb. 22-26, 2019	Malheur County (central Oregon)	DR-4432. Jefferson, Lane, Douglas, Coos and Curry Counties declared. Severe Winter Storms, Flooding, Landslides, And Mudslides. Persistent troughing off the coast of the Pacific Northwest focused a stream of mid-level moisture over the Inland Northwest resulting in a long duration snow event as the plume drifted north and south several times between the 22nd and 27th of February.

Source: Taylor and Hatton (1999), p. 118–122; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Probability

Table 2-830. Probability Assessment of Winter Storms for Region 8

	Harney	Malheur
Probability	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-831. Local Assessment of Vulnerability to Winter Storms in Region 8

	Harney	Malheur
Vulnerability	H	H

Source: Most recent local hazard vulnerability analyses (**Table 2-4**)

Table 2-832. State Assessment of Vulnerability to Winter Storms in Region 8

	Harney	Malheur
Vulnerability	M	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

Within the State of Oregon, Region 8 communities are known for cold, snowy winters. This is advantageous in at least one respect: in general, the region is prepared, and those visiting the region during the winter usually come prepared. However, there are occasions when preparation cannot meet the challenge. Drifting, blowing snow has often brought highway traffic to a standstill. Also, windy, icy conditions have often closed mountain passes and canyons to certain classes of truck traffic. In these situations, travelers must seek accommodations, sometimes in communities where lodging is very limited. Local residents also experience problems. During the winter, heating, food, and the care of livestock and farm animals are everyday concerns. Access to farms and ranches can be extremely difficult and present a serious challenge to local emergency managers. Road closures due to winter weather are more common in this region. In general, the impacts of winter storms to southeastern Oregon communities are less significant because communities are prepared for long winters.

Winter storms, particularly east of the Cascades where snow storms are typically more intense, bring larger amounts of snow and last longer. They can strand livestock in pastures, leaving them without food and water and exposed to extreme cold for long periods of time. As a consequence, substantial losses in livestock from starvation, dehydration and freezing, significantly impact producers, and state and local economies. In addition, water quality and health hazards develop when dead livestock are not retrieved until roads are cleared and vehicles can be used to remove the carcasses. Livestock buried under snow may not be found until the snow melts. The snowmelt may carry the carcasses to streams and wash them downstream.

Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1–5). Social vulnerability scores do not vary by hazard. The counties with the greatest social vulnerability statewide are Marion, Morrow, Umatilla, Wasco, Jefferson, Klamath, and Malheur.

According to the CDC Social Vulnerability Index, Malheur County is the most socially vulnerable in the state. The county has the highest poverty rates, lowest per-capita income, and the highest share of people living in institutionalized group quarters. The county is also in the 90th percentile for the following variables: the share of residents without a high school diploma, the percentage of single-parent households, the share of people aged 17 and younger, the percentage of minorities, the percentage of occupied housing units with more people than rooms, and the share of households that lack access to a vehicle. Vulnerability in Harney County is moderate and driven by high unemployment and the percentage of manufactured homes.

While both Harney and Malheur Counties are vulnerable to the economic impacts of winter storms, Malheur County's very high social vulnerability makes it more vulnerable to the adverse effects of winter storms than Harney County.

State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

The value of state-owned and leased buildings and critical facilities in Region 8 is approximately $573,310,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $328,497,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records how many losses to state facilities were sustained in Region 8 since the beginning of 2015. Thirteen losses were due to winter storms statewide. Of those, one loss for over $353,000, the most expensive recorded, was in Region 8. It is possible that up to four more totaling a little over $72,000 may also have been located in the Region 8.

Risk

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.

Both counties in Region 8 are at risk from the adverse impacts of winter storms. Malheur County's elevated social vulnerability increases its risk beyond that of Harney County.

Chapter 3 MITIGATION STRATEGY

In This Chapter

The Oregon NHMP Mitigation Strategy is divided into five sections:

1. **Introduction:** States the purpose of the mitigation strategy.
2. **Mission, Vision, and Goals:** Presents Oregon's natural hazard mitigation mission, vision, and goals, and describes the review and revision of the goals that guide the selection of mitigation actions. Discusses the links between the risk assessment, goals, and mitigation actions and demonstrates how the goals guide the selection of mitigation actions.
3. **Mitigation Actions:** Includes the following components:
    - Mitigation Actions: Describes the process for identifying, evaluating, and prioritizing cost-effective, environmentally sound, and technically feasible mitigation actions and activities the state is considering implementing over the next 5 years (Priority); that the state implements as part of its agencies' regular work programs (Ongoing); and that the state has or will not implement (Removed). Presents the 2020 Priority, Ongoing, and Removed mitigation action tables. Descriptions of the mitigation actions in the tables explain how each action contributes to the overall mitigation strategy. Identifies changes in mitigation action priorities from the 2015 Plan. Presents the status of the 2015 mitigation actions. A crosswalk shows the disposition of the 2015 mitigation actions in the 2020 Plan. Results of the two surveys used for prioritizing mitigation actions are located in Appendix 9.2.1 and 9.2.2, respectively.
    - Funding Sources for Mitigation Actions: Current and potential sources of funding for mitigation actions are discussed briefly in this section and more fully in the State Capability Assessment section of this chapter. They are also noted on the Priority and Ongoing mitigation action tables.
    - Mitigation Successes: Describes successful mitigation actions and losses avoided throughout Oregon since 2014.
4. **Capability Assessment:**
    - State: Assesses the state's capability to carry out the mitigation strategy through its pre- and post-disaster hazard management policies (including those related to development in hazard-prone areas), programs, and funding capabilities. Discusses changes in these capabilities since approval of the 2015 Oregon NHMP.
    - Local: Generally describes and analyzes in table format the effectiveness of local mitigation policies, programs, and capabilities. Also in table format, indicates status of local jurisdictions' NHMPs and participation in the National Flood Insurance and CRS Programs.
5. **Coordinating State and Local Mitigation Planning:** Describes the state's support of local mitigation planning through funding and technical assistance, as well as the way the state prioritizes funding for local mitigation planning and projects. Describes the processes the state uses to review local NHMPs and to coordinate and link local NHMPs to the Oregon NHMP.

3.1 Introduction

The purpose of this chapter is to establish Oregon's mission and vision for mitigation planning, and to present the State's strategy for achieving that vision. The mission, vision, and goals are purposefully aspirational, providing the foundation for the state's overall mitigation strategy. The culture of our state is influenced by its rich natural resources and pioneering spirit. Oregon has often taken a leading role in the development of innovative and progressive strategies to address issues that impact our residents, our economy and our natural and built environment. The Oregon Beach Bill (1967), the Oregon Bottle Bill (1971) and the Oregon Land Use Program (1973) are but three historical examples of Oregon's visionary spirit.

As it relates to natural hazard mitigation, Oregon is no less visionary. The state adopted its first natural hazards mitigation plan in 1992 with subsequent updates occurring in 2000, 2004, 2006, 2009, 2012, 2015 and now 2020. In addition, Oregon's Clackamas County adopted the nation's first FEMA-approved natural hazards mitigation plan under DMA2K in 2002. Hazard mitigation planning as a foundation for risk reduction project activities is a top priority in Oregon when using available state funding, post-disaster FEMA mitigation grants, and non-disaster FEMA grant funding.

Given the current economic climate and global pandemic, it is important to acknowledge that state resources are increasingly limited and operating conditions are far from normal. Oregon is not unique in that regard. Even so, Oregon is committed to remaining at the forefront of mitigation planning and will continue to innovate and leverage limited resources to reduce losses resulting from natural hazards. The mitigation strategy presented herein reflects that commitment.

3.2 Mission, Vision, and Goals

Requirement 44 CFR §201.4(c), *To be effective the plan must include the following elements:*
(3) A Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment. This section shall include:
(i) A description of State goals to guide the selection of activities to mitigate and reduce potential losses.

MISSION — Create a disaster-resilient state of Oregon.

VISION — Natural hazard events result in no loss of life, minimal property damage, and limited long-term impacts to the economy.

GOALS

1. Protect life and reduce injuries resulting from natural hazards.
2. Minimize property damage from natural hazards.
3. Minimize damage to critical or essential infrastructure and services from natural hazards.
4. Enhance the ability of Oregon's economies to rebound quickly from the effects of natural hazard events.
5. Minimize project impacts to the environment and utilize natural solutions to protect people and property from natural hazards.

6 Enhance the state's capability to implement a comprehensive statewide natural hazards mitigation strategy.

7 Motivate the "whole community" to build resilience and mitigate against the effects of natural hazards through engagement, listening, learning, information-sharing, and funding opportunities.

8 Eliminate development within mapped hazardous areas where the risks to people and property cannot be practicably mitigated.

9 Minimize damage to historic and cultural resources from natural hazards.

10 Enhance communication, collaboration, and coordination among agencies at all levels of government, sovereign tribal nations, and the private sector to mitigate natural hazards.

11 Mitigate the inequitable impacts of natural hazards by prioritizing and directing resources and investments to build resilience in the most vulnerable populations and the communities least able to respond and recover.

12 Develop, integrate, and align natural hazards mitigation and climate adaptation efforts based on the evolving understanding of the interrelationships between climate change and climate-related natural hazard events.

13 Reduce repetitive and severe repetitive flood losses.

14 Minimize or eliminate potential impacts from dams posing the greatest risk to people, property, and infrastructure

3.2.1 Goals: Review and Revision

During the 2015 NHMP update, Oregon's NHMP goal statements were reviewed and revised during a single convening of the State IHMT. During that meeting, eight goals from the 2012 plan were either affirmed or revised and three additional goals were added to better align the State IHMT goal statements with those in Oregon's local natural hazard mitigation plans. Due to the novel coronavirus pandemic, this process could not be repeated in 2020. In lieu of in-person meetings, the Plan's goal statements and mitigation actions for the 2020 update were reviewed and revised using the online survey. A video conference was discussed as a possible replacement for the in-person meeting; however, DLCD and OEM determined that the number of stakeholders and time required, along with the iterative nature of reviewing and prioritizing mitigation actions, would make such a meeting unwieldly.

In early July 2020, the survey was distributed to members of the State IHMT and other state agency staff concerned with hazard mitigation. In total, the survey was sent to sixty-eight individuals and twenty-two responses were collected for a 32% response rate. Respondents were asked to review the results of the 2020 Risk Assessment and based on those results, to review the eleven goal statements from the 2015 plan and recommend retaining, revising, or removing each goal. An explanation was requested when a respondent recommended revising or removing a goal. Additionally, respondents were provided an opportunity to suggest new general goals as well as hazard- or region-specific goals. DLCD used this feedback to make revisions to the 2015 goal statements. Of the eleven existing goals, eight were revised, two (Goals 6 and 11) were removed, and one (Goal 1) remained unchanged. Additionally, one goal (Goal 2) was divided into two, and four new goal statements were added: Goals 11, 12, 13, and 14.

The new goals were derived directly from respondents' suggestions and Goals 13 and 14 also from program requirements. Other suggested goals were mitigation actions in character (very specific) or already covered by other goals. When in-person meetings are possible again, during the plan maintenance process we will return to this discussion and re-review the 2020 mitigation goals. **Table 3-1** presents the goal statements from the 2015 NHMP, the revised 2020 NHMP goal statements, and explanations for the changes that were made.

Table 3-1. From 2015 to 2020 NHMP Goal Statements

#	2015 Statement	#	2020 Statement	Explanation
1	Protect life and reduce injuries resulting from natural hazards.	1	Protect life and reduce injuries resulting from natural hazards.	While survey responses indicated a need for rewording, they were not sufficiently consistent to justify revision. Therefore the goal remains unchanged.
2	Minimize public and private property damages and the disruption of essential infrastructure and services from natural hazards.	2	Minimize property damage from natural hazards.	Survey respondents suggested that while both are important, preventing damage to public and private property and to critical infrastructure are not equivalent, and a separate goal focused on critical or essential infrastructure is warranted. In addition, respondents indicated that it is unnecessary to specify public and private property
		3	Minimize damage to critical or essential infrastructure and services from natural hazards.	
3	Increase the resilience of local, regional, and statewide economies.	4	Enhance the ability of Oregon's economies to rebound quickly from the effects of natural hazard events.	Multiple survey respondents recommended making this goal more inclusive to recognize various subeconomies that exist within the state. The language was changed to keep the statement concise while expanding the scope to recognize the value of Oregon's many economic actors and clarifying "resilience" in this context.
4	Minimize the impact of natural hazards while protecting, restoring, and sustaining environmental processes.	5	Minimize project impacts to the environment and utilize natural solutions to protect people and property from natural hazards.	This goal was refined for clarity. Survey respondents were unclear about its intent. The revision underscores that the intent is to implement mitigation actions that are environmentally sound and to leverage environmental processes that inherently mitigate the impacts of natural disasters.
5	Enhance and maintain state capability to implement a comprehensive statewide hazard loss reduction strategy.	6	Enhance the state's capability to implement a comprehensive statewide natural hazards mitigation strategy.	This goal was revised for clarity. Survey respondents found the phrase "loss reduction strategy" confusing and preferred the more commonly used phrase "natural hazards mitigation strategy."
6	Document and evaluate Oregon's progress in achieving hazard mitigation.			This goal was removed because FEMA requires states to document and evaluate their hazards mitigation progress.

#	2015 Statement	#	2020 Statement	Explanation
7	Motivate the public, private sector, and government agencies to mitigate against the effects of natural hazards through information and education.	7	Motivate the "whole community" to build resilience and mitigate against the effects of natural hazards through engagement, listening, learning, information-sharing, and funding opportunities.	Survey respondents pointed to the redundancy of naming both the public sector and government agencies. Additionally, some recommended specifying more partners. The phrase "whole community" was used to recognize all of the state's partners in its mitigation work. This goal was also revised to recognize the value of engagement – in which listening, learning and information sharing are multi-directional instead of informing and educating which are uni-directional – along with the importance of motivating through funding opportunities, both suggestions of respondents.
8	Eliminate development within mapped hazardous areas where the risks to people and property cannot be mitigated.	8	Eliminate development within mapped hazardous areas where the risks to people and property cannot be practicably mitigated.	This change acknowledges that with modern engineering and building practices much can be done to mitigate against natural hazards but that such action is not always practicable — financially or otherwise.
9	Minimize damage to historic and cultural resources.	9	Minimize damage to historic and cultural resources from natural hazards.	Survey respondents recommended specifying "from natural hazards" to be more clear about the threat to historic and cultural resources.
10	Increase communication, collaboration, and coordination among agencies at all levels of government and the private sector to mitigate natural hazards.	10	Enhance communication, collaboration, and coordination among agencies at all levels of government, sovereign tribal nations, and the private sector to mitigate natural hazards.	This statement was revised to highlight that the state aspires to improve the quality of communication, collaboration, and coordination between its public, private, and indigenous partners.
11	Integrate local NHMPs with comprehensive plans and implementing measures.			This statement was determined to be a mitigation action rather than a goal and therefore was removed.
		11	Mitigate the inequitable impacts of natural hazards by prioritizing and directing resources and investments to build resilience in the most vulnerable populations and the communities least able to respond and recover.	Multiple survey respondents underscored the need to center equity when prioritizing natural hazard mitigation investments. This goal demonstrates Oregon's commitment to directing resources for mitigating the impacts of natural disasters and building resiliency toward vulnerable populations and frontline communities.
		12	Develop, integrate, and align natural hazards mitigation and climate adaptation efforts based on the evolving understanding of the interrelationships between climate change and climate-related natural hazard events.	Climate change, while not a natural hazard in and of itself, influences the severity and frequency of natural hazard events. The state strives to better understand and align mitigation and climate adaptation efforts.
		13	Reduce repetitive and severe repetitive flood losses.	Repetitive loss and severe repetitive loss structures present clear opportunities for mitigation where hazard risk is well understood.

#	2015 Statement	#	2020 Statement	Explanation
		14	Minimize or eliminate potential impacts from dams posing the greatest risk to people, property, and infrastructure.	Through adopting this new goal, the state is demonstrating its commitment to improve the safety of high hazard potential dams, mitigating the threat such dams pose to people, property, and critical or essential infrastructure.

3.2.2 Goals: Linking the Risk Assessment and Mitigation Actions

Natural hazard mitigation plan goals link the risk assessment and mitigation actions, guiding the direction of future natural hazard risk reduction and loss prevention activities.

The risk assessment speaks directly to protection of life and property, infrastructure and services, and local, regional, and state economic resilience, the topics of Goals 1, 2, 3 and 4. The vulnerability assessments for each hazard and the potential loss estimates highlight the importance of informing and educating citizens about the risks and what they can do to reduce potential losses, including eliminating development where risks cannot be practicably mitigated, the topics of Goals 7, 8, 9, and 10. New Goal 13 specifically calls out the need to reduce losses from structures that have been damaged repetitively by flooding, one of the hazards with the greatest risk statewide according to the 2020 risk assessment. New Goal 14 sets policy direction for addressing the flood hazard posed by high-hazard potential dams. Goal 8 sets policy direction for prohibiting development in or moving development out of hazard areas, a clear connection to the vulnerabilities established by the risk assessment. Environmental stewardship, the topic of Goal 5, plays a role in mitigating some hazards, and must be considered in designing mitigation projects.

New Goal 12 speaks to the connections between natural hazards and climate change—discussed in the risk assessment—and sets policy direction for aligning climate adaptation and natural hazard mitigation efforts. New Goal 11 underscores the inequitable impacts of natural hazards and the importance of prioritizing and directing resources to vulnerable populations and those communities least able to respond and recover from hazard events. This is also a focus of climate change adaptation. Both equity and climate change are among Governor Brown’s priorities and gaining attention statewide.

Finally, Goal 6 focuses on the state’s ability to implement the Plan, providing a policy foundation for state support of mitigation actions and activities.

The mitigation action tables (Priority, Ongoing, and Removed) demonstrate the link between the goals and mitigation actions by noting the goal(s) that each mitigation action addresses.

3.3 Mitigation Actions

Requirement 44 CFR §201.4(c), To be effective the plan must include the following elements:

(3) A Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment. This section shall include:

(iii) An identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section should be linked to local plans, where specific local actions and projects are identified.

(iv) Identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities.

3.3.1 Identification, Evaluation, and Prioritization

Mitigation actions are detailed recommendations for activities that the state is considering implementing to reduce risk and prevent loss from natural hazards.

The 2015 NHMP update placed mitigation actions into one of three categories: priority, ongoing, or removed. Priority actions are those the state aspires to begin or complete. Ongoing actions are those the state is doing in the normal course of business, continually over a long period of time. Removed actions are those that have been completed; will not be completed for various reasons; have been replaced by other actions; are not mitigation actions; or have been determined not to be within the State's purview. These categories are utilized again for the 2020 update. The first step in updating the tables was to document the status of each action included in the 2015 plan (**Table 3-5**). This was done by IHMT agency leads responsible for implementing and monitoring the progress of the various actions included in the 2015 update. Based on the status reports, some mitigation actions were removed from the Priority and Ongoing tables.

The next task was to prioritize the remaining mitigation actions. Due to the inability to have in-person meetings and the inefficacy of long virtual meetings, we decided to prioritize only the mitigation actions remaining on the Priority table via an online survey. The survey asked respondents to review and evaluate the priority mitigation actions from the 2015 Plan, along with new mitigation actions suggested by subject matter experts and hazard leads.

The 2020 Risk Assessment addressed risk for each of the hazards by region, county and statewide. Therefore, the mitigation actions were grouped and prioritized by hazard in the survey. Although climate change is not considered a hazard in and of itself but rather an influence on the character and probability of hazard events, for purposes of the survey climate change-related actions were grouped separately. Reviewers were asked to evaluate each mitigation action based on the following nine criteria drawn from the 2015 Plan goals and the results of the 2020 Risk Assessment:

1. Save lives
2. Reduce property damage
3. Reduce infrastructure damage
4. Reduce environmental damage

5. Address greatest hazards (according to 2020 Risk Assessment results)
6. Addresses highest risk counties (according to 2020 Risk Assessment results)
7. Create, enhance, maintain partnerships
8. Addresses capability or capacity gaps
9. Inform, educate

Scores were calculated for each mitigation action by adding the total number of times respondents considered a criterion to be addressed by the action and then summing the scores of all criteria by mitigation action. Put differently, if seven respondents said a mitigation action addressed only the second criterion, “reduce property damage,” and three respondents said it addressed only the first, “save lives,” the total score for that mitigation action would be ten. These scores were used to prioritize each hazard mitigation action within its respective hazard group. Beyond the eleven hazard groups—one for each hazard addressed in the Plan—two additional groups were used. The first is for mitigation actions that address all hazards and the second is for mitigation actions that address multiple hazards. Climate change is included in this group because it influences multiple but not all hazards.

Later in the process, FEMA alerted DLCD to an oversight: mitigation actions were not evaluated against the required criteria of cost-effectiveness, environmental soundness, and technical feasibility. Because the mitigation actions held over from the 2015 Plan had been evaluated according to these criteria, only the new, priority actions were subjected to this review by IHMT members in a second online survey. None of the mitigation actions were assessed by more than 50% of responders as not meeting a single criterion, and in those very few cases in which exactly 50% assessed it as met, both of the other criteria were assessed as met by at least and usually many more than 60% of responders. Therefore, no changes were necessary to the mitigation action rankings.

The results of the two surveys may be found in Appendix **9.2.1** and Appendix **9.2.2**, respectively.

3.3.2 Changes in Mitigation Action Priorities

The 2015 Plan identified 78 priority mitigation actions and 71 ongoing mitigation actions for a total of 149. The priority mitigation actions were ranked using a numerical scoring method that incorporated an indirect measure of cost-effectiveness and political feasibility and were not prioritized by hazard. For the 2020 NHMP, mitigation actions were evaluated against a different set of criteria based on the Plan’s mitigation goals and 2020 risk assessment results and, for consistency with the risk assessment results, prioritized within hazard groups. The use of two different methods makes a direct comparison between the 2015 and 2020 priorities very difficult. There are 107 priority mitigation actions and 73 ongoing mitigation actions in the 2020 NHMP, for a total of 180.

Of the 2015 Plan’s 78 priority and 71 ongoing actions:

- Twenty-two were completed
- Twenty-four are no longer being pursued.
    - Ten are no longer being pursued due to lack of funding or other resources.
    - Six are no longer being pursued because the intent is being met through other means.
    - Four are no longer being pursued because they were dependent on another action that is no longer being pursed because it was determined no longer needed.
    - The intent of two were incorporated into new mitigation actions and are therefore no longer being pursued.

- One is not actively being pursued but the State does engage upon request.
- One is not being pursued because it was linked to the State Risk MAP Coordinator, a position Oregon no longer has.

In total, 46 priority and ongoing mitigation actions from the 2015 NHMP were either completed or removed; 103 remain in the 2020 Plan.

Of the ten no longer being pursued for lack of funding or other resources, only those that would establish new programs and therefore require large financial commitments would be unlikely to be reconsidered. The majority would probably be pursued once again were funding and other resources to become available. They could be generally categorized as outreach, education, data development, and capacity-building. Most of those no longer being pursued for other reasons have been addressed in other ways or determined unnecessary. Therefore, the removed items do not represent a major shift in mitigation priorities.

3.3.3 Funding Sources for Mitigation Actions

Oregon's mitigation activities are funded directly and most visibly through sources such as FEMA's Pre-Disaster Mitigation Grant, Flood Mitigation Assistance, Public Assistance, Hazard Mitigation Grant Program and High Hazard Potential Dam Grants, as well as NOAA grants with state, local, or private funds providing the non-federal cost share. The State's Seismic Rehabilitation Grant Program is a direct funding source for earthquake mitigation projects. The Oregon Disaster Assistance Loan and Grant account provides post-disaster mitigation funds to local governments and school districts. Currently the state's 2021-2023 budget is being re-evaluated based on the drastically reduced state revenue forecast resulting from the global pandemic. Final State budget decisions will be made by the Oregon Legislature. More indirect and less visible funding comes from state general funds through in-kind activities and other state funds. More detailed information about mitigation funding sources is in the State Capability Assessment, **Funding Sources** section.

3.3.4 Mitigation Action Tables

The 2020 Oregon NHMP mitigation actions are arranged in a series of three tables: *Priority*, *Ongoing*, and *Removed* (**Table 3-2**, **Table 3-3**, and **Table 3-4**, respectively). On each table, individual mitigation actions are numbered and presented as a brief statement with a longer description that explains its contribution to the overall mitigation strategy of the 2020 Plan. The goal(s) each action addresses are identified as are the hazards. The Priority table includes the individual action item scores that resulted from the survey process. Only the actions pertaining to high hazard potential dams were not scored against other actions as they are an element of a discrete body of mitigation work and are all considered high priority. On the Priority and Ongoing tables, other state initiative(s) with which an action is integrated are identified, although fully updating all relevant initiative(s) was not prioritized during this update since the 2020 Oregon NHMP is being submitted as a standard plan.

Current and potential funding sources are also identified. Funding sources should be understood primarily as potential sources since the state budget is being adjusted based on a drastically reduced revenue forecast resulting from the economic consequences of the coronavirus pandemic, and many are based on outside grant funding that is still uncertain.

Table 3-5, 2015 Mitigation Actions: Status, lists each mitigation action from the 2015 Oregon NHMP with its status and a brief note of explanation. A crosswalk (**Table 3-6**) has been developed to aid in demonstrating how the 2015 Plan's mitigation actions are represented in the 2020 plan.

3.3.4.1 2020 Mitigation Action Table: Priority

Table 3-2. 2020 Mitigation Actions: Priority

2020 MITIGATION ACTIONS: PRIORITY																								
Action Item				**Goal**														**Hazard**	**Integrated**	**Implementation**				
#	**Score**	**Statement**	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Hazard**	**Other Initiative**	**Lead**	**Support**	**Current or Potential Funding Source(s)**	**Target Date**
1	69	Update hazard probabilities in NHMP for all hazards	The method to develop hazard probabilities in the 2025 NHMP should incorporate best scientific methods.	X	X			X									X	All Hazards		DOGAMI	DLCD	DLCD	2022
2	67	Develop guidance for local Gov'ts on how to use Goal 7 together with other pertinent Statewide Land Use Planning Goals to classify lands subject to natural hazards in the buildable lands inventory and adjust urban growth boundaries in a manner that minimizes or eliminates potential damage to life, property, and the environment while continuing to provide for efficient development patterns	Goal 7 discourages new development in areas subject to natural hazards. Goal 14 and other Statewide Land Use Planning Goals encourage development within urban growth boundaries. Local Gov'ts need guidance on how to classify lands subject to natural hazards in their buildable lands inventories and adjust urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns within urban growth boundaries. This guidance will assist local Gov'ts in integrating local natural hazards mitigation plans with comprehensive plans.	X	X				X	X							X	All Hazards	Statewide Planning Goals	DLCD	DOGAMI, ODF	State-DLCD	2025
3	67	Provide funding and technical assistance to local Gov'ts to use the new guidance on classifying lands subject to natural hazards in their buildable lands inventories and adjusting urban growth boundaries	Local Gov'ts need funding and technical assistance to be able to use the new guidance on how to classify lands subject to natural hazards and adjust urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns within urban growth boundaries. Comprehensive Plan amendments are likely to result. This funding and technical assistance will promote integration of local natural hazards mitigation plans with comprehensive plans.	X					X								X	All Hazards	Statewide Planning Goals	DLCD		State-DLCD	2025
4	67	Update Risk Scores in NHMP based on updated hazard probabilities and vulnerabilities for all hazards	The method to develop the 2025 Risk Scores should incorporate best scientific methods.	X	X			X									X	All Hazards	Climate Change Adaptation Framework	DLCD	DOGAMI, ODF, OWRD, OHA, ODOT, OPUC, OCCRI	FEMA (HMGP, BRIC), State	2024
5	66	Provide technical assistance to local Gov'ts to help integrate hazard mitigation plans with local comprehensive plans	Local NHMPs are often adopted as an appendix to the comprehensive plan or separately and are therefore in practice not used to their full potential. By assisting local Gov'ts in integrating the two plans, hazard mitigation will be more easily and meaningfully implemented in local land use planning practice.	X					X			X					X	All Hazards	Statewide Planning Goal 7	DLCD, OPDR	OEM	FEMA-PDM, Risk MAP, State-DLCD	2025

2020 MITIGATION ACTIONS: PRIORITY

Action Item				Goal														Hazard	Integrated	Implementation			
#	Score	Statement	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Hazard	Other Initiative	Lead	Support	Current or Potential Funding Source(s)	Target Date
6	63	Use the lessons learned from the 2020 Risk Assessment to develop a more robust and scientific standardized risk assessment methodology across all hazards, at the state and local levels	Oregon does not have a clear and common methodology to identify the most vulnerable populations across all hazards at the state and local levels. In 2013, the State IHMT Risk Assessment Sub-Committee in partnership with the OPDR and the U of O InfoGraphics Lab developed a model concept, work plan, and budget. Pending funding, this model could be fully developed between 2014 and 2019 and then be used to inform the 2020 Oregon NHMP. Upon full development, the model will allow state and local Gov'ts to strategically target mitigation resources. In the intervening years the state has not been able to fund development of the model, so in 2020, we implemented a simple risk assessment pilot on seven hazards. The lessons learned from this pilot will help the state support the need for funding a more robust and scientific methodology.	X	X							X	X				X	All Hazards	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework, Oregon Health Authority	DLCD	DOGAMI, ODF, OWRD, OHA, ODOT, OPUC, OCCRI	FEMA (HMGP, BRIC), State	2024
7	60	Develop and fund a legislative package for general funds or lottery funds to match federal funding for local hazard mitigation planning, including additional funds for DLCD Technical Assistance Grants	Continue — and enhance where possible — state technical and planning grant assistance to cities and counties for addressing issues associated with local hazards.	X				X	X								X	All Hazards	Oregon Local Disaster Assistance Loan and Grant Account.	DLCD	OEM	State-OEM, DLCD	2023
8	60	Pursue Enhanced Plan status	Oregon is losing enhanced plan status in September 2020 due in large measure to budget and capacity issues. It has been definitively demonstrated that investing in mitigation generates a significant return and reduces the need for costly response and recovery activities. OEM and IHMT agencies need non-federal financial support for additional staff to match federal mitigation dollars and to engage in non-federally supported yet necessary mitigation activities. These activities include but are not limited to implementation of related state programs; integration among related state programs; integration with local government and tribal programs; and technical assistance, both financial and non-financial, for local governments and tribes.	X				X	X			X					X	All Hazards	Business Oregon-IFA, NFIP, Climate Change Adaptation Framework, DCBS-DFR	OEM	DLCD, all IHMT agencies	State	2022
9	60	Establish an online platform and procedure for collecting and sharing mitigation actions from state, local, and tribal NHMPs	Currently there is no easy way for governments to research and share mitigation actions. Having an online "mitigation action tracker" would facilitate communication, cooperation, collaboration among state, local, and tribal governments, enhancing mitigation planning statewide.	X				X	X			X					X	All Hazards	Local Governments' and Tribes' natural hazards mitigation programs, FEMA Region X's Mitigation Division	DLCD	OEM, OPDR, local and tribal governments	State of Oregon	2023
10	59	Establish an online repository and procedure for storing finalized, FEMA-approved local and tribal NHMPs as well as the Oregon NHMP	Currently there is no single repository for local and tribal NHMPs and very few that can be found online are in their final format. Assisting local governments and tribes with finalizing their NHMPs after FEMA's final approval and uploading them to a single, online repository in a timely manner will provide opportunities for collaboration and improving state and local coordination in mitigation planning.	X				X	X			X						All Hazards	Climate Change Adaptation Framework, Oregon Explorer	DLCD	OEM, OPDR, FEMA	State of Oregon	2022

2020 MITIGATION ACTIONS: PRIORITY

Action Item				Goal														Hazard	Integrated	Implementation			
#	Score	Statement	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Hazard	Other Initiative	Lead	Support	Current or Potential Funding Source(s)	Target Date
11	58	Create a statewide georeferenced digital database of critical infrastructure including Emergency Transportation Routes (ETR)	Develop a critical infrastructure database that is suitable for sharing with the public for the purposes of hazard vulnerability assessments. This should include emergency transportation routes (ETR).	X	X			X			X						X	All Hazards	Climate Change Adaptation Framework	DOGAMI	DAS GEO, ODOT	DAS GEO	2025
12	57	Establish the Oregon NHMP as a living document.	Establish a platform for housing the Oregon NHMP and a procedure for continually updating and enhancing it.					X				X						All Hazards	Climate Change Adaptation Framework	DLCD	All IHMT agencies	State of Oregon	2022
13	56	Request the Oregon Legislature to fund the State Disaster Loan and Grant Account" immediately following a presidentially declared disaster or other disaster	The State Disaster Loan and Grant Account includes an account that can be used to fund local government and school district mitigation projects after a Presidentially declared disaster. The Oregon Legislature may authorize deposits to the account when requested.	X	X				X								X	All Hazards	DLCD Technical Assistance Grants	OEM	BusOR-IFA	State-EMPG	2023
14	54	Improve state agency procedures for tracking data on state-owned/leased buildings and critical or essential facilities	Create a policy standard for facilities data collection required from state agencies on an annual basis. Develop a facilities data framework standard that best enables hazard mitigation analysis; incorporate data into DAS-CFO DataMart and make available to partner agencies at will.	X	X			X									X	All Hazards	Oregon Resilience Plan	DAS-CFO, DAS-CIO	DOGAMI	State-DAS-CFO, DAS-CIO	2021
15	53	Create a "Clearinghouse" for natural hazards data	Emergency responders and community planners alike need access to the best and most current natural hazards data that is available. This project would be a cooperative effort between authoritative data sources — DLCD, DOGAMI, OEM, OWRD, and federal partners (FEMA, USACE, NWS, USGS) — and would include: • Establishing a single point of online access to reliable data, maps, and information about natural hazards; • Developing, in conjunction with DAS-GEO, a "portal" to distribute this data; • Developing a multi-agency State of Oregon flood hazard website; • Providing an ongoing inventory and assessment of existing natural hazards data; and • Creating a central library for natural hazard risk assessments.	X					X			X					X	All Hazards	Risk MAP; Risk Plan; Framework Implementation Teams; OEM's Master Data Set; Local Natural Hazards Mitigation Plans; Governor's interagency collaboration initiative; Goal 7 implementation; NFIP; DEQ's IRIS database; etc.	DLCD	DAS-GEO, DEQ, DOGAMI, OWRD, OEM, FEMA, USACE, NDWS, USGS	FEMA (HMGP), State-DAS-GEO	2025
16	53	Develop a database of non-state-owned critical/essential facilities and their property values	FEMA requires the state's plan to: (a) identify critical facilities located in the identified hazard areas, and (b) estimate the potential dollar losses to those structures. Data for non-state-owned critical facilities are incomplete and lack standardization, therefore creating a wide margin of error. Identifying local non-state-owned critical facilities and gathering descriptive data for these structures will help increase the quality of the data, resulting in a more precise understanding of state and regional vulnerabilities and mitigation priorities.	X	X				X			X					X	All Hazards	Oregon Resilience Plan	OEM, DAS-GEO	DOGAMI	FEMA (HMGP, BRIC), State-OEM, DAS-GEO	2023

2020 MITIGATION ACTIONS: PRIORITY

Action Item				Goal														Hazard	Integrated	Implementation			
#	**Score**	**Statement**	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Hazard**	**Other Initiative**	**Lead**	**Support**	**Current or Potential Funding Source(s)**	**Target Date**
17	48	Coordinate development of a post-disaster scientific and technical clearinghouse with other state and federal agencies, higher education, and associations	When an earthquake, flood, tsunami, or other disaster strikes the state, there will be an influx of scientists and engineers from inside and outside the state to study the event and offer help. There needs to be a coordination of their efforts to put them to use in the most efficient and effective way possible. This clearinghouse will work with the emergency coordination center established immediately after the earthquake, flood, tsunami, or other disaster.		X			X	X	X		X					X	All Hazards	Silver Jackets	DOGAMI	OEM, DLCD	FEMA (HMGP, BRIC, Risk MAP), USGS, USACE, NOAA, State-DOGAMI, OEM	2025
18	47	Complete a hazard mitigation policy legislative needs assessment	The Oregon NHMP contains a number of specific policy recommendations. In addition, the state of Oregon maintains a number of policies related to natural hazards and the mitigation thereof. It is unclear at this time what legislative action may be needed in order to fully implement existing and proposed mitigation actions. The State IHMT recommends completing an assessment of the potential legislation needed to implement hazard mitigation policies.		X	X	X	X	X	X	X	X	X	X				All Hazards	NFIP, Goal 7	OEM	State IHMT Agencies	State-OEM	2021
19	41	DCBS-DFR will teach classes for the Business community about financial resiliency against natural disasters in 2020-21	Fire, flood, winter storms, and earthquakes impact Oregon's businesses as much as they do individual Oregonians. DFR is committed to leading Oregon's business community towards financial resiliency. DCBS hosts information for businesses about insurance against natural disasters. They also have published an insurance guide for small businesses. DFR will also lead disaster preparedness classes with Oregon's business community.			x			X			X						All Hazards	Climate Change Adaptation Framework	DCBS-DFR	DCBS-IFA, private partners	State	2021
20	40	Establish formal and official authority for the State IHMT	Since its formation, the State IHMT has continued to play a major role in hazard mitigation activities, including the development of this hazard mitigation plan. There is strong agreement that the State IHMT is important, should be continued, and ought to be made permanent because it is the only state body focused on coordination of natural hazard mitigation. It is recommended that the State IHMT be formally and officially established.					X			X							All Hazards	OSSPAC	OEM, State Resilience Office	IHMT agencies	State, EMPG	2023
21	38	Review and adjust State IHMT membership	As state and agency priorities and personnel change, agency membership should be reviewed and adjusted, and member agencies should be encouraged to budget for participation in State IHMT activities. In late 2014, Emergency Support Functions were reassigned, and the new structure should be considered when reviewing State IHMT membership. When membership is aligned with its goals and mitigation actions, the State IHMT will provide better oversight and leadership of the state's mitigation strategy and programs.									X						All Hazards	All state and quasi-state agencies' hazards mitigation or climate change adaptation programs	OEM	DLCD	State, EMPG	2021
22	80	Provide technical assistance to "most vulnerable jurisdictions" to undertake resilience activities for the hazards to which they are most vulnerable	Most vulnerable jurisdictions require technical support to understand how to best improve their resilience. A priority region is the coast, and should include critical facilities, specifically hospitals, healthcare facilities and vulnerable populations, and lifeline infrastructure, specifically water and power.		X	X		X					X				X	Multi-Hazard/ Climate Change		DOGAMI	DLCD	DLCD	2022

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Action Item				Goal														Hazard	Integrated	Implementation			
#	Score	Statement	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Hazard	Other Initiative	Lead	Support	Current or Potential Funding Source(s)	Target Date
23	79	Complete comprehensive multi-hazard and climate change vulnerability assessments	Vulnerability assessments are necessary for assessing risk and developing mitigation actions and adaptation strategies. There is a significant amount of overlap between them, providing opportunities to coordinate, integrate, streamline, and leverage resources.									X		X			X	Multi-Hazard / Climate Change	Climate Change Adaptation Framework	DLCD	DOGAMI, OCCRI, IHMT agencies, Climate Work Group agencies	State, FEMA (HMGP, BRIC), NOAA	2023
24	74	Develop plan to create a lifelines backbone for the 11 coastal communities with hospitals	Coastal hospitals will require fuel, electricity and water to operate after a Cascadia event. Currently, power and water infrastructure is extremely vulnerable. Cost effective methods to ensure a reliable power and water are urgently needed.		X							X						Multi-Hazard / Climate Change	Oregon Resilience Plan	OHA	DOGAMI, ODOE, OERS	State, FEMA, NOAA, Oregon Coastal Hospital Resilience Network	2022
25	74	Set climate change adaptation policies and priorities	The state is working on developing a leadership structure for leading, directing, and resourcing coordinated statewide climate change adaptation strategies. In the near term (2021-23), the Governor's Carbon Policy Office, Natural Resources Cabinet, Global Warming Commission, and Environmental Justice Task Force intend to work together to set climate change adaptation policies and priorities.											X			X	Multi-Hazard / Climate Change	Climate Change Adaptation Framework	The Governor's Carbon Policy Office	Natural Resources Cabinet, Global Warming Commission, and Environmental Justice Task Force	State	2023
26	72	Request and compile seismic and flood information for personnel-occupied buildings from other agencies	Determine flood and earthquake damage and losses expected to occur to the state-owned building inventory and provide advice on higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	X	X							X						Multi-Hazard / Climate Change	Oregon Resilience Plan, NFIP	DAS-CFO	DOGAMI	State-DAS-CFO, Local Gov'ts	2022
27	71	Prioritize resilience activities in "most vulnerable jurisdictions" for the hazards to which they are most vulnerable	Most vulnerable jurisdictions require analyses and technical support to improve their resilience. A priority region is the coast, and should include critical facilities, specifically hospitals, healthcare facilities and vulnerable populations, and lifeline infrastructure, specifically water and power.		X								X				X	Multi-Hazard / Climate Change		DOGAMI	DLCD	DLCD	2022
28	71	Provide outreach to "most vulnerable jurisdictions" and tribal governments to help citizens understand hazards and how to better prepare for the hazard events to which they are most vulnerable	Most vulnerable jurisdictions and tribal governments require educational and learning opportunities to understand how to best improve their resilience. A priority region is the coast, and should include critical facilities, specifically hospitals, healthcare facilities and vulnerable populations, and lifeline infrastructure, specifically water and power.		X				X			X	X				X	Multi-Hazard / Climate Change		DOGAMI	DLCD	DLCD	2022

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29	69	Identify funding to support various public transportation providers and local jurisdictions to conduct comprehensive vulnerability assessments of their transportation facilities and services	OSSPAC, in the Oregon Resilience Plan has identified an immediate near-term need to inventory and assess vulnerability and mitigation opportunities for local street networks, transit assets, ports, airports, and railroads. The Oregon Resilience Task Force in its October 2014 report to the Oregon Legislature suggested ongoing funding inventory, assessment, and mitigation. These activities would serve to reduce vulnerability to a Cascadia Subduction Zone event.		X			X										Multi-Hazard / Climate Change	Oregon Highway Plan (OHP); The Oregon Resilience Plan	ODOT	DOGAMI	FEMA (HMGP, BRIC), State-ODOT	2023
30	69	Develop probabilistic multi-hazard risk maps for the Oregon Coast	Consider and examine combinations and permutations of multi-hazard risk exposure and maps for the entire Oregon Coast.	X									x				X	Multi-Hazard / Climate Change	Oregon Resilience Plan, NFIP, Risk MAP, Oregon Climate Change Adaptation Framework	DOGAMI	NOAA	NOAA, State-DOGAMI	2025
31	69	Conduct critical infrastructure vulnerability analysis in “most vulnerable jurisdictions” for the hazards to which they are most vulnerable	Most vulnerable jurisdictions require analyses and technical support to improve their resilience. A priority region is the coast, and should include critical facilities, specifically hospitals, healthcare facilities and vulnerable populations, and lifeline infrastructure, specifically water and power.		X				x				X				X	Multi-Hazard / Climate Change		DOGAMI	DLCD	DLCD	2022
32	67	Activate the Climate Change Adaptation Work Group	The Climate Change Adaptation Workgroup begins supporting the Carbon Policy Office, Natural Resources Cabinet, and Global Warming Commission.									X		X				Multi-Hazard / Climate Change	Climate Change Adaptation Framework	The Governor’s Office	Carbon Policy Office, Natural Resources Cabinet, and Global Warming Commission	State	2023
33	66	Formalize the Climate Change Adaptation Work Group	The purpose of the Climate Change Adaptation Work Group is to continue interagency collaboration and lend technical support to the Carbon Policy Office, Natural Resources Cabinet, and Global Warming Commission. One state agency will be assigned to coordinate the Work Group.									x		x				Multi-Hazard / Climate Change	Climate Change Adaptation Framework	The Governor’s Office	Carbon Policy Office, Natural Resources Cabinet, and Global Warming Commission	State	2023
34	65	Establish a Multi-agency Climate Change Adaptation Leadership Structure	Establish a climate leadership structure including both a short- and long-term plan for leading, directing, and resourcing coordinated statewide climate change adaptation strategies.									x		x				Multi-Hazard / Climate Change	Climate Change Adaptation Framework	The Governor’s Office	Carbon Policy Office, Natural Resources Cabinet, and Global Warming Commission	State	2023
35	64	Develop coastal staging areas to address post-Cascadia disaster damage	Coastal Oregon will be geographically isolated into “islands” after a Cascadia event. Staging areas and equipment should be identified and developed. Pre-disaster planning and mitigation should be conducted factoring in the staging areas and include identifying how to connect islands using various modes of transportation, such as planes and boats, and with use of temporary emergency roads, such as with culverts and gravel.	x	x												X	Multi-Hazard / Climate Change	Oregon Resilience Plan	DOGAMI	Governor’s Office, ODOT, OERS, local governments	State, Local Governments, FEMA (Risk MAP), NOAA	2022

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36	62	Request seismic and flood information from landlords of state-leased spaces as part of analyzing potential leased spaces going forward in new leases and potential renewals	Determine flood and earthquake damage and losses expected to occur to the state-owned/leased building inventory including higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	X	x		x											Multi-Hazard / Climate Change	Oregon Resilience Plan, NFIP	DAS-EAM	DOGAMI	State-DAS-EAM, Local Gov'ts	2021
37	60	Establish funding for climate change adaptation activities	Establish 2023-2025 biennial funding targets for climate change adaptation activities. Continue to fund the Oregon Climate Change Research Institute to provide Oregon state agencies with usable, down-scaled climate change information.					x				x		X			X	Multi-Hazard / Climate Change	Climate Change Adaptation Framework	The Governor's Office	Carbon Policy Office, Natural Resources Cabinet, and Global Warming Commission	State	2025
38	59	Use DAS-CFO data and investigation/inventory of seismic and flood risk to DAS-owned/leased buildings in an effective, routine decision-making process for building occupancy, maintenance, use and potential mitigation treatments	This information over time can provide for strategic and responsible voluntary flood and seismic upgrades in areas of greatest need for reasonable cost as a part of broader facilities management.	X	x			x										Multi-Hazard / Climate Change	Oregon Resilience Plan, NFIP	DAS-CFO	DAS-EAM, DOGAMI	State-DAS-CFO	2023
39	58	Collaborate on a landslide workshop to increase the State's understanding of coseismic landslides	We believe there will be many coseismic landslide triggered in the next earthquake. However, we don't understand where and how far inland and the risk. The coseismic landslides will be a significant portion of the earthquake hazard and understanding it will help with pre and post disaster mitigation.	X				X										Multi-Hazard / Climate Change		DOGAMI	DOGAMI, OEM, USGS Landslide Program, NOAA	FEMA (Risk MAP), USGS, USACE, NOAA, NASA	2023
40	58	Pursue funding for developing data to support assessments of probability, vulnerability and risk for drought, extreme heat, windstorms, and winter storms	Drought, extreme heat, windstorms, and winter storms are significant hazards in Oregon, but very little data is available to properly assess probability, vulnerability and risk. To better protect the public, Oregon must find funding to develop the necessary data.	X				X										Multi-Hazard / Climate Change	USDA Natural Resources Conservation Service	DLCD	OWRD, OHA, OPUC, ODOT, OCCRI	State of Oregon, FEMA (HMGP, BRIC), NOAA, FHWA, USDA	2020-2025
41	57	Conduct a pilot project on two coastal estuaries to develop a framework for modeling sea level rise and to assess the overall impact of sea level rise on the estuaries	Implement sea level rise modeling for the pilot study areas. Study results will be used to guide a future, more comprehensive and coast-wide assessment of sea level rise impacts. Once completed, the results can be used minimize future damage or loss of property and the environment.				x							X				Multi-Hazard / Climate Change	Climate Change Adaptation Framework	DOGAMI	DLCD	NOAA through OSU	2022
42	57	Collaborate on a workshop to increase the State's understanding of coseismic landslide triggered tsunami	We have a very poor understanding of coseismic landslides which can cause tsunamis. Some of these can occur underwater. New high resolution bathymetry data would help us understand what has happened in past earthquakes and thus understand the future.					x				x						Multi-Hazard / Climate Change	Oregon Resilience Plan	DOGAMI	DOGAMI, OEM, USGS Landslide Program, NOAA	FEMA (Risk MAP, NEHRP), USGS, USACE, NOAA, NASA	2021

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43	46	Formalize a small Climate Change Adaptation (CCA) Leadership Team	The CCA Leadership Team would focus on prioritizing actions that optimize use state resources to achieve multiple co-benefits among the most affected communities and ecosystems and have the ability to strategically plan over multi-biennium.									x	X	x				Multi-Hazard / Climate Change	Climate Change Adaptation Framework	The Governor's Carbon Policy Office	Global Warming Commission and three to five state agency executives	State	2025
44	82	Undertake open-coast assessment of the impact of future sea-level rise combined with storm wave erosion assessments	Undertake assessments of future sea level rise change for open coast beaches and shorelines in order to determine susceptibility and risk from storm-induced erosion, overtopping and flooding.					X						X				Coastal Hazards		DOGAMI	DLCD, OPRD, ODOT	NOAA, Universities, ODOT, OPRD, DLCD	2025
45	52	Undertake inner bay total water level modeling	Modeling would incorporate inner bay and outer coast processes, similar to modeling performed in Grays Harbor, WA					X						X				Coastal Hazards		DOGAMI	DLCD, OPRD, ODOT	NOAA, Universities, ODOT, OPRD, DLCD	2025
46	63	Develop an improved methodology for gathering data and identifying the communities most vulnerable to drought and related impacts	Although we know that areas in Oregon have suffered from drought, there has not been a coordinated effort to systematically characterize how frequently droughts have occurred, or the impact on Oregonians and ecosystems. Communities are beginning to plan for worst case drought scenarios and need better information about the frequency, duration, and intensity of previous droughts in order to assess the appropriate response. Comprehensive information is not currently available by region, or statewide.					X					X					Drought	Goal 7	OWRD, OCCRI	OEM	State-OWRD, OEM, OCCRI	2023
47	63	Implement the improved methodology for gathering data and identifying the communities most vulnerable to drought and related impacts	Although we know that areas in Oregon have suffered from drought, there has not been a coordinated effort to systematically characterize how frequently droughts have occurred, or the impact on Oregonians and ecosystems. Communities are beginning to plan for worst case drought scenarios and need better information about the frequency, duration, and intensity of previous droughts in order to assess the appropriate response. Comprehensive information is not currently available by region, or statewide.					X					X					Drought	Integrated Water System Strategy	OWRD	OEM	State-OWRD, OEM	2023
48	56	Document the economic, social, cultural, and environmental impacts of drought	Documenting drought conditions, especially its impacts on people and the environment, is an important component of understanding and preparing for future droughts. Oregon does not have the resources to conduct a thorough analysis of drought's impact to various sectors. Today, most impact-related data is collected anecdotally. The state should invest in ways to track and quantify the effects of drought and assist the most vulnerable jurisdictions. Any drought assessment should also include a summary of drought frequency, distribution, intensity, and duration. Doing so is critical, especially as climate projections indicate that the Pacific Northwest will more regularly experience warmer temperatures.	X		X		X						X				Drought	USDA Natural Resources Conservation Service	OWRD	Lead Agency OWRD, ODA, OEM	National Integrated Drought Information System (NIDIS), State General Fund	2025

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49	82	Support and implement the actions in the February 2013 Oregon Resilience Plan and recommended in the Oregon Resilience Plan Task Force's October 2014 report	The Oregon Resilience Task Force was established by Senate Bill 33. It was tasked to facilitate a comprehensive and robust plan to implement the strategic vision and roadmap of the Oregon Resilience Plan for responding to the consequences of naturally occurring seismic events associated with geologic shift along the Cascadia subduction zone. The Task Force's report was delivered to the legislature on October 1, 2014.	X	X			X	X									Earthquakes	Oregon Resilience Plan	OEM	BCD, ODE, DOGAMI, ODF, OHA, DLCD, ODOT, OPDR, PUC, UO, OSU, PSU	State-OEM	2025
50	82	Update the Statewide HAZUS analyses for earthquakes	The State requires an updated analysis to understand and improve its resilience. The last analysis was conducted in 1999 and is very outdated. The analyses should include a magnitude 9 Cascadia earthquake and tsunami including soil types, co-seismic landslides and liquefaction. Also, a probabilistic analysis should be completed.	X	X			X										Earthquakes		DOGAMI	DLCD, OEM, OERS	DLCD	2023
51	82	Prioritize mitigation actions of critical State of Oregon infrastructure for Cascadia Continuity of Government (COG) in high risk communities	Identify vulnerable critical State of Oregon infrastructure for Continuity of Government, including emergency service buildings and other important government buildings, and prioritize mitigation actions starting in high risk communities. Include state assets in Marion County.	X	X													Earthquakes	Oregon Resilience Plan	DOGAMI	all IHMT agencies	FEMA (HMGP, BRIC)	2025
52	74	Prioritize mitigation and retrofit projects on seismic lifelines	ODOT Seismic Lifelines Evaluation, Vulnerability Synthesis and Identification Report provides recommended priority corridors but does not provide sufficient detail to actually prioritize retrofit investment packages. Engineering evaluations and cost estimation are ongoing on a funding-available basis and will inform that prioritization process.	X	X													Earthquakes	Oregon Highway Plan (OHP); The Oregon Resilience Plan	ODOT		FHWA, STATE-ODOT	2025
53	72	Update Statewide Ground deformation maps	Updated maps of soil amplification and liquefaction should be used to make new maps of the risks of coseismic liquefaction and landslide ground deformation to be included in an update of 2013 statewide earthquake hazard layers.					X										Earthquakes	Oregon Resilience Plan	DOGAMI	DAS GEO	DAS GEO	2021
54	72	Conduct an earthquake risk analysis that focuses hazards relating to hazardous materials	The State does not understand the risk that earthquakes pose to sites with hazardous materials and does not have location specific awareness or emergency plans.					x										Earthquakes	Oregon Resilience Plan	DEQ	DOGAMI, OERS	DEQ	2023
55	71	Conduct seismic mitigation of 5 coastal facilities for the purposes of medical care and sheltering	The coast will experience the strongest shaking and a tsunami from a Cascadia disaster, resulting in injuries and displaced people. Residents and visitors will require medical attention. Tsunami refugees will require sheltering.	x	x													Earthquakes	Oregon Resilience Plan	OBDD	OSSPAC, DHS, OERS	OBDD Seismic Rehabilitation Grant Program	2025
56	70	Update Statewide Liquefaction maps	New highly detailed geologic maps produced with LIDAR should be used to make new maps of soil types which may liquefy due to earthquake shaking to be included in an update of 2013 statewide earthquake hazard layers.					x										Earthquakes	Oregon Resilience Plan	DOGAMI	DAS GEO	FEMA (HMGP, BRIC, NEHRP), State	2021
57	70	Publish new probability of earthquake damage maps	New USGS hazard data should be used to make simple maps showing the probability of experiencing damaging shaking be included in an update of 2013 statewide earthquake hazard layers.					x				x						Earthquakes	Oregon Resilience Plan	DOGAMI	DAS GEO	DAS GEO	2021

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58	70	DCBS-DFR will teach classes about Earthquake Insurance in 2020-21	Earthquake insurance is offered by private sector agents, generally as a rider to a standard homeowner or business property insurance policy. Because earthquake insurance is a type of catastrophic coverage, most policies carry a high deductible. Oregon's Department of Consumer and Business Services Division of Financial Regulation offers information about earthquake insurance on its website and provides personal assistance through its insurance hotline. In addition, the Division is active in outreach activities, partnering with other agencies and organizations to bring insurance information to the public.			x			x			x						Earthquakes	Oregon Resilience Plan	DCBS-DFR	OEM, DOGAMI	State Funds	2021
59	69	Update Statewide NEHRP maps	New highly detailed geologic maps produced with LIDAR should be used to make new maps of soil types which may amplify earthquake shaking to be included in an update of 2013 statewide earthquake hazard layers.						x									Earthquakes	Oregon Resilience Plan	DOGAMI	DAS GEO	DAS GEO	2021
60	68	Publish available information about new faults	DOGAMI has identified dozens of new faults from LIDAR acquired to date, few of which have been described in publications, which is a prerequisite for inclusion in the USGS hazard maps. Summary data about these faults should be published as part of a currently funded update of statewide earthquake data.					x	x			x						Earthquakes		DOGAMI	DAS GEO	DAS GEO	2021
61	66	Assess hazards associated with active crustal faults newly discovered by statewide lidar program	Particularly in central and eastern Oregon, the major earthquake hazards result from poorly known crustal faults. Lidar has greatly expanded the ability to find these faults, which should be systematically evaluated for their potential to generate damaging earthquakes using trenching, geophysical and field studies. This action would help communities prepare and mitigate for newly defined hazard areas in central and eastern Oregon.					x										Earthquakes	Oregon Resilience Plan	DOGAMI	USGS	USGS, State-DOGAMI	2020
62	66	Create new regulatory authority to address the State's fuel insecurity at the Critical Energy Infrastructure Hub	The State requires new regulatory authority that may be created through new legislation. OSSPAC issued a CEI Hub report with recommendations in Dec 2019.					x	x				x					Earthquakes	Oregon Resilience Plan	OEM	Governor's office, OSSPAC, ODOE, DEQ, DOGAMI, OERS, OSSPAC	OEM	2021
63	66	Develop State of Oregon Cascadia Continuity of Government (COG) plan	Develop a response and recovery plan that integrates state assets to ensure State continuity of government at the leadership and agency levels for a Cascadia earthquake. Improve capacity of state agencies to minimize damage and be responsive to urgent post-disaster needs					x	x				x					Earthquakes	Oregon Resilience Plan	DOGAMI	SRO, DAS, all IHMT agencies	FEMA (Risk MAP)	2023
64	64	Evaluate earthquake hazards in Bend region	Faults in the Bend-Sisters area should be systematically mapped and evaluated for evidence of recent activity in order to assess the earthquake hazards for Central Oregon communities.					x										Earthquakes		DOGAMI	Universities	USGS NEHRP	2021

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65	63	Update DOGAMI Rapid Visual Survey database on emergency service buildings	Update the Rapid Visual Survey data for the emergency service buildings in DOGAMI 2007 statewide seismic needs assessment. Include data to assist with conducting benefit cost analyses and for prioritization of mitigation		x			x										Earthquakes	Oregon Resilience Plan	DOGAMI	DAS GEO	DAS GEO	2023
66	61	Lidar survey the State's ROW (rights of way), west of the Cascade Range, to determine where seismic fault potential exists	The acquired information can improve critical infrastructure resilience in the face of seismic events, by providing useful information to planners, design professionals and decision makers prior to delivery system construction.		x			x										Earthquakes	Oregon Resilience Plan	DOGAMI	ODOT	State-ODOT	2022
67	61	Rectify state "border" faults with Nevada, Idaho, CA and Washington	The USGS fault database includes numerous discontinuous faults, particularly in Eastern Oregon, so that the probabilistic national seismic hazard maps underestimate the hazard. The continuation of mapped faults need to be evaluated and descriptions need to be published in order for them to be used by USGS.					x										Earthquakes		DOGAMI	USGS, Universities	USGS NEHRP	2021
68	60	Plan using Regional Resilience Assessment Program (RRAP) multi-modal transportation report	Develop local and state plans including push solutions to connect islands as discussed in the DHS Regional Resilience Assessment Program (RRAP) report. Integrate emergency transportation routes, including multimodal transportation methods by air, land and water. Include Willamette Valley planning and coastal communities planning.	X					X			X						Earthquakes	Oregon Resilience Plan	DOGAMI	ODOT, Dept. of Aviation, all IHMT agencies	FEMA (Risk MAP, NEHRP), DHS, ODOT	2022
69	53	Achieve 100% state agency participation in the Great Oregon ShakeOut	Practicing to "drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. State agencies are setting an example by conducting a drill annually. The State of Oregon will have 100% State agency participation in the Great Oregon ShakeOut and will encourage schools and universities to participate.	X					X									Earthquakes	Oregon Resilience Plan	OEM		FEMA (NEHRP), State-EMPG	2025
70	44	Increase penetration of air conditioning systems for most vulnerable jurisdictions in areas most at risk to extreme heat events	Increasing penetration of air conditioning systems particularly in manufactured homes in Cooling Zone 3 and in multifamily homes/apartments across the state, would help alleviate adverse impacts from extreme heat events.	X									X					Extreme Heat		OHA	OCCRI	State, private partners	2025
71	43	Map climate and environmental data with demographic and health data	Map climate and environmental data with demographic and health data to help identify most impacted communities for targeted interventions and investment.										X	X				Extreme Heat	Climate Change Adaptation Framework	OHA	OCCRI	State	2023
72	86	Produce new lidar-based flood hazard maps	Lidar-based flood hazard maps are produced for counties or watershed as funding is provided. These maps have newly delineated flood zones based on new detailed studies, new coastal analysis, and/or delineation of existing zones based on new topography data (lidar). Lidar-based flood hazard maps are being produced for rivers in Marion, Morrow, Benton, Hood River, Wasco, and Sherman Counties.	X				X									X	Flood	NFIP, Risk MAP	DOGAMI	DLCD	State, FEMA (Risk MAP), Local Gov'ts	2025

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73	83	Through FEMA's Risk MAP program, update 1,000 miles of streams with lidar-based flood mapping	FEMA's Risk MAP program funds revisions of Flood Insurance Studies and Flood Insurance Rate Maps. The State should focus on updating these products so they are based on high quality topographic data (e.g., lidar). Lidar-derived streams are a by-product of high quality topographic data. These more accurately located streams will assist in the improvement of a community's flood maps to more accurately show flood risk to life and property. The State should continue to pursue Risk MAP funds for this purpose.	X					X									Flood	NFIP	DOGAMI	DLCD	FEMA (Risk MAP)	2023
74	78	Install real-time monitoring capabilities on the remaining 51 state-operated stream gages, with the goal of making the network 100% real-time by the year 2020	The availability of timely and accurate data from stream gages is essential for flood forecasting, for prediction of imminent flood hazards, and for response to flood emergencies. Today, 178 of the state's 229 stream gages provide real-time data. Upgrade the state's existing stream gaging network, with the goal of installing real-time capability on all remaining gages.	X														Flood	Integrated Water Resource Strategy; Silver Jackets	OWRD	Silver Jackets	State-OWRD	2022
75	77	Investigate the impact of climate change on flood conditions in Oregon	Research and Investigations. Flood risk is strongly associated with the dominant form of precipitation in a basin, with mixed rain-snow basins in Oregon already seeing increases in flood risk. Generally, western Oregon basins are projected to experience increased precipitation, and therefore flood risk, in future decades. Federal and state agencies should seek to learn more about the potential impacts of climate change on flood conditions in Oregon and identify mitigation actions that will reduce the potentially increased risk.											X			X	Flood	Climate Change Adaptation Framework	DOGAMI	DOGAMI, USGS, USACE	FEMA (HMGP, BRIC, CAP-SSSE), EPA, USGS, BLM, USACE, USFS, DOGAMI, OCCRI, Oregon counties, cities, watershed councils and other entities	2025
76	75	Add at least five jurisdictions, with emphasis on coastal jurisdictions, to the Community Rating System (CRS) program during the life of each Oregon NHMP	The CRS, part of the NFIP, is a program that rewards communities for going above and beyond the minimum requirements of the NFIP in minimizing potential losses due to flooding. Participating in the CRS benefits the jurisdiction with extra flood protection and benefits property owners by lowering flood insurance rates. See the CRS Information Center at: http://training.fema.gov/EMIWeb/CRS/ for more information. Each year DLCD conducts community assistance visits in an average of five NFIP communities. During this process, qualified jurisdictions will be encouraged to participate in CRS or strengthen CRS ratings. DLCD will also create a "pathway to CRS" schedule for each jurisdiction for which it conducts a community assistance visit. The state has also started CRS Users' Groups (#C, Removed and #112, Ongoing) to encourage greater participation in the CRS program.						X			X						Flood	NFIP	DLCD	FEMA	FEMA-CAP-SSSE	2025

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Action Item				Goal														Hazard	Integrated	Implementation			
#	**Score**	**Statement**	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Hazard**	**Other Initiative**	**Lead**	**Support**	**Current or Potential Funding Source(s)**	**Target Date**
77	75	Update the state's Peak Discharge Estimation Program	Peak discharge estimation tools can help determine the magnitude and frequency of floods. The state's program provides engineers and land managers with the information needed to make informed decisions about development in or near watercourses. The Peak Discharge Estimation Program is based on a modified version of the U.S. Geological Survey's "Bulletin 17b." The U.S. Geological Survey is in the process of updating this bulletin. OWRD's methodology will need to be brought up to date to reflect these recent findings.					X									X	Flood	Integrated Water Resource Strategy	OWRD	ODOT OEM	State-OWRD	2025
78	72	Develop guidance on determination of mudslides triggers and relation to rain or flood events	Work with FEMA Region 10, DOGAMI, and other interested parties to develop scientifically and legally based guidance on when mudflows are to be considered part of a rain or flood event pursuant to the NFIP. Address the definition of mudflow, regulatory factors, scientific understanding of mudslides, and implications for flood insurance.					X				X						Flood	NFIP	DOGAMI DLCD	Silver Jackets, ODF	FEMA (CAP-SSSE), State-DOGAMI, DLCD	2023
79	68	Strengthen the existing Community Rating System (CRS) rating of at least five jurisdictions, with emphasis on coastal jurisdictions, during the life of each Oregon NHMP	The CRS, part of the NFIP, is a program that rewards communities for going above and beyond the minimum requirements of the NFIP in minimizing potential losses due to flooding. There are a number of measures a community can implement to obtain a CRS rating, and most communities do not implement them all. As a community implements more CRS flood protection measures, its CRS rating is strengthened, and the community is rewarded with better flood protection and lower flood insurance rates.	X											X			Flood	NFIP	DLCD	FEMA	FEMA (CAP-SSSE), State	2025
80	66	Install High Water Mark (HWM) signs after flood events and co-locate stage crest gages on select HWM signs	HWM signs installed in high visibility areas increase the general public's awareness of flood risk and drive flood mitigation actions in communities. They spark conversations about past floods and are a good entry point for discussions promoting mitigation actions such as elevating buildings, purchasing flood insurance, and participating in FEMA's Community Rating System Program. Stage crest gages co-located with select HWM signs will capture new high-water data when floods occur.						X									Flood	NFIP	Silver Jackets	OEM, DLCD	USACE, FEMA (CAP-SSSE)	2022
81	62	Develop a statewide strategy to encourage the purchase of flood insurance	It's well-known that well-insured communities recover faster. A strategy will help the state direct information to under-insured areas thereby reducing vulnerability, facilitating recovery, and increasing access to "increased cost of compliance" funding.			X			X									Flood	NFIP, CRS	DLCD	OEM	FEMA (CAP-SSSE)	2023
82	50	DCBS-DFR will teach classes about Flood Insurance in 2020-21	While Oregon does not regulate the NFIP, it does regulate the agents who sell it. It also has an interest in leading Oregonians towards financial resiliency. Flood insurance plays an important part of that objective. DFR hosts information about flood insurance on our website and will continue to lead outreach to the public about the value of flood insurance for both home owners and businesses			X			X									Flood	NFIP, CRS	DCBS-DFR, State Lands, DLCD	OEM, OFD	DCBS	2021

2020 MITIGATION ACTIONS: PRIORITY																							
Action Item				Goal														Hazard	Integrated	Implementation			
#	Score	Statement	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Hazard	Other Initiative	Lead	Support	Current or Potential Funding Source(s)	Target Date
DS1	NA	Complete risk assessments for 16 state-regulated high hazard dams in Poor or Unsatisfactory condition (not meeting safety standards)	This work is FEMA HHPD grant funded, with state match. The Dam Safety Program has partnered with FEMA to complete these as part of the HHPD grant. All work will be completed by the Dam Safety Program.	X	X		X			X				X		X	X	Flood/Dam Safety		OWRD	FEMA	State, FEMA (HHPD Rehab)	2022
DS2	NA	Complete risk assessments for remaining state-regulated high hazard dams	Partial funding for this work had been proposed in SB 1537 (Oregon's 2020 legislative session). The dam safety program will partner with the Governor's Office and the State Resilience Officer to continue to support this project.	X	X		X			X				X		X	X	Flood/Dam Safety		OWRD	Governor's Office, State Resilience Officer	State	2025
DS3	NA	Complete floodplain management plans for inundation areas below priority dams	The Dam Safety Program has partnered with FEMA to complete these as part of the HHPD grant. All work will be completed by the Dam Safety Program. The Dam Safety Program will partner with the Cities of LaGrande and Newport to complete these plans. Dam Safety staff will complete these assessments.	X		X	X		X	X	X	X	X	X		X	X	Flood/Dam Safety		OWRD	OWRD. FEMA, City of La Grande, City of Newport	State, FEMA (HHPD Rehab)	2022
DS4	NA	Support a task force to develop funding for and prioritize rehabilitation efforts	This task force and funding for it had been proposed as part of SB 1537 in 2020. The 2020 legislative session ended before action could be taken on most bills, including SB 1537. The Dam Safety Program will partner with the Governor's Office and the State Resilience Officer to continue to support this project.	X	X			X				X		X		X	X	Flood/Dam Safety		OWRD	Governor's Office, State Resilience Officer	State	2023
DS5	NA	Re-evaluate extreme flood potential and begin to develop new methodologies for determination of inflow design flood for state-regulated high hazard dams	This flood potential analysis and methodology and its funding had been proposed as part of SB 1537 in 2020. The 2020 legislative session ended before action could be taken on most Bills, including SB 1537. The Dam Safety Program will partner with the Governor's Office and the State Resilience Officer to continue to support this project.	X	X		X							X		X	X	Flood/Dam Safety		OWRD	Governor's Office, State Resilience Officer	State	2024
83	84	Create new lidar-based Landslide Inventory and Susceptibility Maps, especially near population centers	DOGAMI will create these maps in cooperation with local jurisdictions. Specific methods and priority locations are still to be determined. The locations will be determined by the Oregon Landslide Workgroup (#6, Priority). These new maps will enable communities to introduce development restrictions or recommend mitigation strategies in areas highly susceptible to landslides.							X		X						Landslide	Statewide Planning Goal 7	DOGAMI		State-DOGAMI, Local Gov'ts	2025
84	78	Assist 5 communities with post-fire landslide risk reduction	After a wildfire, there is an increased potential for landslides and specifically debris flows which are potentially life-threatening. We should be assisting communities in understanding where this hazard exists.						X			X						Landslide		DOGAMI	DOGAMI, ODF, OEM, USGS Landslide Program	FEMA (HMGP), USGS, USACE, BLM, ODF, USFS	2025
85	73	Upgrade the Oregon Landslide Warning System	The current warning system needs updating to include rainfall thresholds from local rainfall gauges. A permanent real-time website will be constructed to show the areas under a landslide warning that will include guidance on what people should do to help protect their life and property from a landslide.	X														Landslide		DOGAMI		DOGAMI, USGS	2025

2020 MITIGATION ACTIONS: PRIORITY

Action Item				Goal														Hazard	Integrated	Implementation			
#	Score	Statement	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Hazard	Other Initiative	Lead	Support	Current or Potential Funding Source(s)	Target Date
86	73	Evaluate the impact of climate change on landslides	The precipitation-triggered landslides will increase or decrease with changes in climate. Evaluation of this change will be important for the future of Oregon.											X				Landslide	Oregon Climate Change Adaptation Framework	DOGAMI		NOAA, State-DOGAMI	2022
87	73	Use Lidar along State's ROW (rights of way) in 5 communities to map landslides and model where future landslides may occur	Because most landslides are reactivations, mapping the existing landslides is essential to future landslide prediction and mitigation.		X			X										Landslide		DOGAMI	DOGAMI, ODOT	FEMA (HMGP, BRIC, Risk MAP), USGS, USACE, BLM, ODOT, Federal Highways	2025
88	71	Lidar survey the State's ROW (rights of way), west of the Cascade Range, to determine where landslide potential exists	The acquired information can improve critical infrastructure resilience in the face of landslide events, by providing useful information to planners, design professionals and decision makers prior to delivery system construction.		X			X										Landslide	Statewide Planning Goal 7	DOGAMI	ODOT	State-ODOT	2022
89	68	Collect repeat LIDAR in 5 communities and use to monitor areas of movement	After the landslide inventory has been mapped, additional information about each landslide will assist in understanding the hazard. Specifically, the landslide activity is important and can be determined using repeat LIDAR surveys and differencing of the surveys to detect movement.					X										Landslide		DOGAMI	DOGAMI, USGS 3-DEP, ODOT, FEMA	FEMA, USGS, USACE, BLM, State (Lidar Consortium)	2025
90	68	Install landslide mitigation measures along transportation corridors that impact 5 most vulnerable jurisdictions	Landslide mitigation measures, such as rock bolts, rock nets, catchment basins, benched slopes, horizontal drains, retaining walls, will be installed to reduce the risk of landslide hazards along key corridors. This will improve the reliability of transportation mobility.	X	X													Landslide		ODOT	DOGAMI,	ODOT, Federal Highway Administration	2025
91	55	Collaborate on a landslide workshop to increase the State's understanding of post-fire landslide hazards in Oregon	We have a very poor understanding of the post wildfire effect on landslide risk. Understanding this relationship will help us to understand the hazard and how to mitigate.					X										Landslide		DOGAMI	DOGAMI, ODF, OEM, USGS Landslide Program	FEMA (Risk MAP), USGS, USACE, BLM, ODF, USFS	2023
92	47	Evaluate sediment impacts to Oregon's water resources	Oregon has unique water resources, some of which are for drinking water. Landslides can have a great impact on this resource by input of large amounts of sediment. Evaluation of erosion potential by watershed would help the regulators and providers identify areas for mitigation.		X			X									X	Landslide	DEQ and ODFW Water Quality Programs	DOGAMI	DEQ, OHA	Federal, State-DEQ, OHA, and Local Gov'ts	2025
93	46	Collaborate on a landslide workshop to increase the State's understanding of climate change effects on landslide hazards in Oregon	Climate change may have multiple effects on landslides in Oregon including increased post wildfire and intensity/duration rainfall events. Understanding these factors better will help us understand the change to the landslide hazard and how to mitigate.									X		X				Landslide		DOGAMI	DOGAMI, OEM, USGS Landslide Program	FEMA (Risk MAP), USGS, USACE, BLM, NOAA, NASA	2023

2020 MITIGATION ACTIONS: PRIORITY

Action Item				Goal														Hazard	Integrated	Implementation			
#	**Score**	**Statement**	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Hazard**	**Other Initiative**	**Lead**	**Support**	**Current or Potential Funding Source(s)**	**Target Date**
94	77	Implement better way-finding solutions for tsunami evacuation. Create hardened and improved evacuation routes to include elevated safe areas above the level of modeled inundation	After a Cascadia Subduction Zone earthquake, a tsunami could arrive within minutes. It is essential that residents and visitors be able to quickly move to high ground on foot. This requires clearly marked and safe routes that pedestrians are able to navigate even in dark and stormy weather. Where high ground is available, projects should be identified that will enable Oregon to establish new standards and guidelines for methods to harden and mark way-finding of tsunami evacuation routes to natural high ground. Where natural high ground is not within the expected evacuation time, evaluate the retrofit of existing facilities and/or construction of new facilities that rise above the level of tsunami inundation and can serve as safe haven refuges.	X														Tsunami	Oregon Resilience Plan	OEM	DOGAMI	NOAA-NTHMP, Local Gov'ts	2023
95	74	Assist one coastal community per year in considering vertical evacuation structures and improved evacuation routes due to evacuation constraints	Use the anisotropic path modeling to measure the time needed to evacuate all parts of the maximum-considered Cascadia tsunami inundation zone in order to evaluate the need for vertical evacuation structures and improvements in evacuation routes. These actions will provide guidance to communities on the best locations to build vertical evacuation structures that will save lives in a catastrophic tsunami event. The results will also inform communities of priority evacuation routes needing additional signage or way-finding markers. Beat the Wave modeling is currently underway in Port Orford and Manzanita/Nehalem and planned for Gold Beach, Astoria, and Bandon.	X														Tsunami	Oregon Resilience Plan	DOGAMI	OEM	NOAA	2023
96	72	Develop evacuation plans for ports and harbors at the rate of one per year	Ports and harbors are the haven for commercial and recreational fishing and recreational boating industries. They are often the major centers of economic activity in coastal communities that have bays. To protect the vessels from tsunami damage requires a unique evacuation plan for both distant and local tsunamis. The plans should be integrated with community evacuation plans. The Oregon State University Extension Sea Grant Program has identified this as a major issue in their pilot project in Yaquina Bay. Their project is titled *Reducing Earthquake and Tsunami Hazards in the Pacific Northwest Ports and Harbors.* For distant tsunami events and storm surge events that can occur during any winter, evaluate potential port and harbor mitigation retrofit projects that protect and strengthen floating and anchored infrastructure such as piers, bulkheads and landings.	X	X	X												Tsunami	Oregon Resilience Plan, OSU Extension Sea Grant Program	DOGAMI	DLCD, OPDR	NOAA	2023
97	70	Fund and provide technical assistance for local Gov'ts to engage in evacuation route planning and project implementation	After a Cascadia Subduction Zone earthquake, a tsunami could arrive within minutes. It is essential that residents and visitors be able to quickly move to high ground. Some evacuation planning is already underway. Local Gov'ts need funding and technical assistance to begin or continue to engage in evacuation planning.	X				X	X			X						Tsunami	OSSPAC, Statewide Planning Goal 7, ORS 455	DOGAMI	OEM, DLCD	NOAA	2025

2020 MITIGATION ACTIONS: PRIORITY

Action Item				Goal														Hazard	Integrated	Implementation			
#	Score	Statement	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Hazard	Other Initiative	Lead	Support	Current or Potential Funding Source(s)	Target Date
98	58	Prepare/Publish 5 multi-hazard and risk studies for communities around Cascade Volcanoes, including Newberry (e.g., Burns and others, 2011)	To help 5 communities on or near Oregon Volcanoes become more resilient to geologic hazards (volcano, landslide, flood, and earthquake) by providing detailed information about the hazards and the community assets at risk.	X	X			X	X									Volcanic Hazards		DOGAMI	DOGAMI, USGS	USGS, FEMA (Risk MAP), Counties, Cities	2025
99	57	Create LIDAR-based channelized debris flow hazard maps in 5 communities	Models are needed to assess areas of potential channelized debris flow hazards. These areas are potentially life threating.	X				X										Volcanic Hazards		DOGAMI	DOGAMI, USGS	FEMA (Risk MAP), USGS, USACE, BLM	2025
100	51	Develop volcano hazard evacuation maps for 5 communities in the proximal vicinity of Cascade volcanoes	Hazard maps exist for major Cascade Volcanoes, but evacuation maps based on predicted events are not yet jurisdictions. Develop evacuation maps in 5 most vulnerable jurisdictions, and conduct outreach on the maps.	X				X	X			X						Volcanic Hazards		DOGAMI	DOGAMI, USGS	USGS, FEMA (Risk MAP), Counties, Cities	2025
101	50	Update 2 volcano hazard maps	New highly detailed geologic maps produced with LIDAR around Oregon Volcanoes should be used to update at least 2 volcano hazard maps (e.g., current Mount Hood mapping)	X				X										Volcanic Hazards		DOGAMI	DOGAMI, USGS, USFS, BLM	USGS, FEMA (Risk MAP), Counties, Cities	2025
102	45	Conduct LIDAR-based geologic mapping targeted around 2 Cascade and other Quaternary volcanoes	There is a continuing need to have detailed geologic maps that portray and thoroughly detail the eruptive histories of all major volcanoes in the Cascade Range, starting with two Quaternary volcanoes that pose hazards to most vulnerable jurisdictions.	X				X										Volcanic Hazards		DOGAMI	DOGAMI, USGS, USFS, BLM	USGS, FEMA (Risk MAP), Counties, Cities	2025
103	45	Update statewide volcano inventory database and map	Revise the statewide spatial database/interactive web map of active/dormant/extinct volcanoes in Oregon attributed by type, eruptive history, tectonic setting, and age. Significant data is not shown in the present database.	X				X										Volcanic Hazards		DOGAMI	DOGAMI, USGS, USFS, BLM	USGS, FEMA (Risk MAP), Counties, Cities	2025
104	65	Update wildfire risk assessment data every 5 years with more up to date data	In 2019 the Oregon Wildfire Risk Explore (OWRE) Tool was completed through federal grant funding to make available the most up to date information available on wildfire risk. This tool was created to develop an online portal available to the public to look at current and potential risk and assist in planning and development. Data utilized as a base for this wildfire risk portal was taken from the Quantitative Wildfire Risk assessment developed by the USFS. The purpose of this online tool is to deliver the best wildfire risk information to homeowners, communities, local managers, and planners. It has been utilized in updating CWPP's and provides guidance and educational resources for the public. Beyond the wildfire risk information, this tool is used as an avenue to show current large fire perimeters and where historical fire starts have happened. ODF has goals to improve and add to this mapping tool in collaboration with OSU into the future by adding in a new Wildland Urban Interface layer and a new Communities at Risk layer. Other updates will be implemented as data becomes available to help planners and the public assess wildfire risk.	X				X	X									Wildfire		ODF	USFS, OSU Extension, OCCRI	Federal grants. OSU Extension was awarded $2 million to map and assess parcel level wildfire risk.	2025

2020 MITIGATION ACTIONS: PRIORITY

Action Item				Goal														Hazard	Integrated	Implementation			
#	**Score**	**Statement**	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Hazard**	**Other Initiative**	**Lead**	**Support**	**Current or Potential Funding Source(s)**	**Target Date**
105	60	Add Climate change modeling into Oregon Wildfire Risk Explorer (OWRE). Add prescribed fire live burns, WUI, and Communities at Risk data into the OWRE. Integrate data and assessment information from OSU Extension projects	In 2019 the Oregon Wildfire Risk Explore (OWRE) Tool was completed through federal grant funding to make available the most up to date information available on wildfire risk. This tool was created to develop an online portal available to the public to look at current and potential risk and assist in planning and development. Data utilized as a base for this wildfire risk portal was taken from the Quantitative Wildfire Risk assessment developed by the USFS. The purpose of this online tool is to deliver the best wildfire risk information to homeowners, communities, local managers, and planners. It has been utilized in updating CWPP's and provides guidance and educational resources for the public. Beyond the wildfire risk information, this tool is used as an avenue to show current large fire perimeters and where historical fire starts have happened. ODF has goals to improve and add to this mapping tool in collaboration with OSU into the future by adding in a new Wildland Urban Interface layer and a new Communities at Risk layer. Other updates will be implemented as data becomes available to help planners and the public assess wildfire risk.	X					X	X				X				Wildfire	Climate Change Adaptation Framework	ODF	USFS, OSU Extension, OCCRI	Federal grants. OSU Extension was awarded $2 million to map and assess parcel level wildfire risk.	2025
106	56	DFR will teach classes about wildfire coverage in 2020-21	Wildfires are all too common in Oregon and have displaced thousands of Oregonians over the last few years. Homeowners and renters insurance is a vital tool to financially withstand the impacts of wildfires. DFR hosts information about insuring against wildfire on its website and will continue to lead outreach classes to the public about the value of homeowners and renters insurance.	X		x			X									Wildfire		DCBS-DFR	ODF	State Funds and Federal Grants	2021
107	39	Establish a program for studying winter storms and their impacts statewide. As a part of that program, develop a system for gathering snowfall data statewide	Establish a network of snow accumulation tracking stations at strategic locations throughout the state to provide data tracking of snowfall accumulation over the short term and long term in order to develop statistics for studying snow level trends across the state.					X				X						Winter Storm	Climate Change Adaptation Framework	ODOT	OEM, NOAA-NWS	NOAA-NWS, State-OCCRI	2023

3.3.4.2 2020 Mitigation Action Table: Ongoing

Table 3-3. 2020 Mitigation Actions: Ongoing

2020 MITIGATION ACTIONS: ONGOING																					
Action Item			Goal														Hazard	Integrated	Implementation		
#	Statement	Description	1 – Protect Life	2 – Minimize Damage	3 – Essential Infrastructure	4 – Economic Resilience	5 – Environmental Impact	6 – Enhance Capabilities	7 – Whole Community	8 – Eliminate Dev.	9 – Historic and Cultural	10 – Communication	11 – Inequitable Impacts	12 – Climate Change	13 – Repetitive Losses	14 – Dams Posing Risk	Hazard	Other Initiative	Lead	Support	Current or Potential Funding Source(s)
108	Continue to refine statewide natural hazard identification and characterization	The Oregon NHMP identifies the types of natural hazards affecting Oregon, their geographic extent, history, and probability of occurrence, and as they may be affected by climate change. Throughout the life of the Plan, new and continuing research studies and projects provide new data and analysis, improving our ability to identify and understand Oregon's natural hazards and their probability of occurrence. To advance hazard mitigation in Oregon, it is important for the State to plan, budget, and take advantage of opportunities that arise for continued research and new studies to enhance our knowledge of Oregon's natural hazards.	X	X	X			X			X	X		X	X	X	All Hazards	Oregon Resilience Plan; Goal 7; NFIP; Risk MAP; Oregon Climate Change Adaptation Framework; Integrated Water Resources Strategy; Community Wildfire Protection Plans, Seismic Lifeline Studies	DOGAMI, ODF, OWRD, OEM, ODOT, OHA	FEMA, NOAA, BLM, OCCRI, OCS, Other State IHMT Agencies	FEMA (HMGP, BRIC, NEHRP), NOAA, BLM, National Fire Plan, State-DOGAMI, ODF, OWRD, OEM, ODOT
109	Continue to refine the State's risk assessment methodology and statewide assessments of natural hazard exposure, vulnerability, and potential losses	At the core of the Oregon NHMP is a statewide risk assessment of exposure and vulnerability, and an estimate of potential dollar losses to state-owned/leased buildings, infrastructure, and critical or essential facilities from natural hazard events. Schools, emergency facilities, water and waste water, dams and levees, transportation, telecommunications, and energy facilities are examples of structures, infrastructure, and facilities that could be exposed and vulnerable to natural hazards. Other examples include populations, businesses, and industries. At this time, the state does not have a standardized risk assessment methodology across all hazards at the state and local levels. To advance hazard mitigation in Oregon, it is important for the State to plan, budget, and take advantage of opportunities that arise for continued enhancement of the risk assessment, better enabling limited mitigation resources to be directed to the areas that most need them.	X	X	X		X	X			X	X	X	X	X	X	All Hazards	Oregon Resilience Plan; Goal 7; NFIP; Risk MAP; Oregon Climate Change Adaptation Framework; Integrated Water Resources Strategy; Community Wildfire Protection Plans, Seismic Lifeline Studies	DOGAMI, ODF, OWRD, OEM, ODOT, DLCD, OHA	FEMA, NOAA, BLM, OCCRI, OCS, OPDR, Other State IHMT Agencies	FEMA (HMGP, BRIC, NEHRP), NOAA, BLM, National Fire Plan, State-DOGAMI, ODF, OWRD, OEM, ODOT, DLCD
110	Continue to refine statewide identification and prioritization of the greatest risks from and communities most vulnerable to Oregon's natural hazards	Identifying and prioritizing the greatest risks from and communities most vulnerable to natural hazard events will enable the state to leverage its limited mitigation resources in ways that efficiently protect life, property, and the environment from natural hazard events and facilitate recovery.	X	X	X			X			X	X	X	X	X	X	All Hazards	Oregon Resilience Plan; Goal 7; NFIP; Risk MAP; Oregon Climate Change Adaptation Framework; Integrated Water Resources Strategy; Community Wildfire Protection Plans, Seismic Lifeline Studies	DOGAMI, ODF, OWRD, OEM, ODOT, DLCD, OHA	FEMA, NOAA, BLM, OCCRI, OCS, OPDR, Other State IHMT Agencies	FEMA, (HMGP, BRIC, NEHRP), NOAA, BLM, National Fire Plan, State-DOGAMI, ODF, OWRD, OEM, ODOT, DLCD

2020 MITIGATION ACTIONS: ONGOING

Action Item			Goal														Hazard	Integrated	Implementation		
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111	Continue to develop and implement resilience initiatives statewide	Natural hazard mitigation is a fundamental element of resilience. It is important for the state to plan, budget, and partner with other public and private entities to alleviate potential damage from natural hazard events before they occur by (a) improving the reliability of critical/essential facilities, services, and infrastructure during and after a natural hazard event; (b) developing evacuation routes and facilities; (c) informing the public; (d) planning for long-term recovery; and (e) taking other necessary actions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	All Hazards	Oregon Resilience Plan; Goal 7; NFIP; Risk MAP; Oregon Climate Change Adaptation Framework; Integrated Water Resources Strategy; Community Wildfire Protection Plans, Seismic Lifeline Studies	DOGAMI, ODF, OWRD, OEM, ODOT, DLCD, OHA	FEMA, NOAA, BLM, OCCRI, OCS, OPDR, Other State IHMT Agencies	FEMA, (HMGP, BRIC, NEHRP), NOAA, BLM, National Fire Plan, State-DOGAMI, ODF, OWRD, OEM, ODOT, DLCD
112	Provide support for development and update of local and state hazard mitigation plans	The State provides support for development of local NHMPs and the state NHMP by managing federal grant funding in ways that assist the state and local governments with NHMP development and update tasks and processes.	X	X	X				X		X	X					All Hazards	Goal 7	OEM	DLCD, OPDR, DOGAMI	FEMA (HMGP, BRIC), State-DLCD, Local Gov'ts
113	Improve and sustain public information and education programs aimed at mitigating the damage caused by natural hazards	While ongoing efforts are being made in this area, a strong message conveyed by several State IHMT Reports notes the need to strengthen and sustain public information, education, and training efforts by providing additional resources. Although commonly recognized that interest in reducing losses increase during and after events, there is an ongoing need to provide residents and key stakeholder groups (such as infrastructure operators) with hazard mitigation information. These reports cite the need to have timely seasonal information available, better methods to inform residents of sources of hazard mitigation information, use improved electronic methods (e.g., web sites), and materials oriented toward the intended users. This helps keep awareness levels higher, will stimulate actions by some, and reminds users to consider and include hazard mitigation measures in the contexts of regular activities, such as building a new home, relocating an office, or repairing a business.	X	X	X				X		X	X					All Hazards	Oregon Resilience Plan, NFIP, Risk MAP	OEM, DOGAMI	State IHMT Agencies	DOGAMI, NOAA, FEMA (HMGP, BRIC, NEHRP), USGS, STATE-EMPG, Local Gov'ts
114	Continue to improve inventory of state-owned/leased buildings in all hazard areas	Using DAS's data, DOGAMI developed an inventory of state-owned/leased buildings and identified those in hazard areas for the 2012 Plan and updated the inventory for the 2015 Plan. The data should be continuously updated by DAS-CFO to facilitate DOGAMI's inventory updates in future plan cycles.		X				X			X						All Hazards	Oregon Resilience Plan	DAS-CFO	DOGAMI	State-DAS-CFO
115	Encourage citizens to prepare and maintain at least two weeks' worth of emergency supplies	State agencies should work with the American Red Cross and local emergency managers to encourage citizens to be prepared to survive on their own for at least two weeks.	X						X			X					All Hazards		OEM	OERS agencies	NEHRP, State-EMPG

2020 MITIGATION ACTIONS: ONGOING

Action Item			Goal														Hazard	Integrated	Implementation		
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116	Use lidar for statewide analysis of all natural hazards	Lidar is currently the best source of regional topographic data and allows for highly precise and accurate natural hazard mapping (landslide, flooding, volcanic hazards, channel migration zones, tsunami, geologic faults, etc.) and infrastructure inventories (buildings, utilities, lifelines, etc.). Many Oregon state agencies currently use lidar for natural hazard analyses and will continue to do so where lidar is available.		X	X			X	X		X	X			X	X	All Hazards	NFIP, Risk MAP, Goal 7, Oregon Resilience Plan	DOGAMI	DAS-GEO	State-DOGAMI and Local Gov'ts
117	Support research proposals by PSU, OSU, and UO to improve Oregon's disaster resilience	Support research proposals by PSU, OSU, and UO to improve Oregon's disaster resilience, in particular to federal agencies including the National Science Foundation	X	X	X	X	X	X	X		X	X	X	X	X	X	All Hazards		DOGAMI	SRO, OSSPAC, all IHMT agencies	FEMA (HMGP, BRIC, Risk MAP)
118	Evaluate and update mitigation priorities regularly and as otherwise necessary	The current pandemic has created a less-than-optimal situation for full vetting and prioritization of mitigation actions. With the changing revenue, budget, and social landscapes, continuing to review the actions and assess priorities on a regular basis and as otherwise necessary is the most prudent and practical course of action for continuing to advance mitigation in the State of Oregon	X	X	X			X	X		X	X	X	X			All Hazards		DLCD	OEM, all IHMT agencies	FEMA (HMGP, BRIC), State of Oregon
119	Support awareness and activities on FEMA Community Lifelines, Functional Recovery and BRIC	Support meetings to improve awareness of FEMA Community Lifelines, Functional Recovery and the Building Resilience Infrastructure and Communities (BRIC) to increase awareness, activities, preparedness, mitigation and response and recovery			X				X			X					All Hazards		DOGAMI	DLCD, OEM, all IHMT agencies	FEMA (BRIC)
120	Integrate Climate Change Adaptation throughout Agency Operations	Require that state agencies address climate change adaptation at every budget cycle in their strategic plans. Regularly assess progress towards adaptation objectives.										X		X			Multi-Hazard / Climate Change		DLCD		State
121	Enable continued interagency collaboration on climate change adaptation	Provide state agencies with a curated information platform and a means to continue collaborating. This includes access to internal file sharing platforms, electronic meeting space, internal blogs, and other cross-agency communication systems, equipment, and venues.										X		X			Multi-Hazard / Climate Change		DLCD		State, NOAA
122	Embrace diversity, equity, and inclusion (DEI) in climate change adaptation planning and investment	Produce and implement a DEI Blueprint that will outline guiding principles and include one or more Equity Lens tools that will assist state agencies in taking the first steps toward integrating DEI best practices into their climate-related work. The DEI Blueprint will draw from the Environmental Justice Task Force (EJTF) Best Practices Handbook and other existing resources.				X			X				X	X			Multi-Hazard / Climate Change		DLCD		State

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123	Support the Interagency Workgroup on Climate Impacts and Impacted Communities	Many of the agencies involved in the Climate Adaptation Framework (CAF) are also beginning to engage in a new workgroup on climate impacts and impacted communities as directed through Governor Kate Brown's Executive Order 20-04 on Climate Change. This workgroup will intersect with the work of the CAF Climate Equity Workgroup. This work, along with future interagency vulnerability analysis, will further define and identify populations most vulnerable to climate change in Oregon.	X			X	X	X				X	X	X	X		Multi-Hazard / Climate Change		DLCD		State
124	Fund targets set by the CCA Leadership Team	Foster interagency cooperation to develop and put forth climate change adaptation actions in state agency biennial budget requests according to targets set forth by the CCA Leadership Team.	X	X	X	X	X	X	X		X	X	X	X	X	X	Multi-Hazard / Climate Change		CCAWG	Other State agencies	State
125	Measure overall state progress toward climate adaptation	Develop baseline metrics against which progress toward adaptation is compared.	X	X	X	X	X	X	X		X	X	X	X	X		Multi-Hazard / Climate Change		Global Warming Commission	Governor's Climate Policy Office	State
126	Foster exchange of information about climate adaptation strategies	Sponsor the first annual "state of the climate" conference open to all employees and the public.							X			X		X			Multi-Hazard / Climate Change		DLCD		State
127	Provide materials and opportunities to learn about direct and indirect climate change effects generally and on natural hazards in Oregon	Provide a comprehensive information portal for use by state agencies, local government, businesses, non-governmental organizations (NGOs), and individuals to learn about direct and indirect climate change effects in Oregon. The portal would be scoped with feedback from users during multiple stages in the development process. Involving stakeholders in the scoping process is critical to its success.										X		X			Multi-Hazard / Climate Change		DLCD		State, NOAA
128	Incorporate the social cost of carbon into cost-benefit analyses	Develop guidelines on use of social cost of carbon to perform cost-benefit analysis.	X	X	X			X			X		X	X			Multi-Hazard / Climate Change		Global Warming Commission	Governor's Climate Policy Office	State
129	Measure progress toward actions prioritized by the Climate Change Adaptation Leadership Team	Report progress toward and challenges with completing projects identified in previous budget requests with each agency budget request.	X	X	X	X	X	X			X	X	X	X			Multi-Hazard / Climate Change		DLCD		State

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130	Continue to act upon opportunities to advance the State's lifeline mitigation investment practice	Expand upon the State's mitigation investment practice by (a) supporting efforts by jurisdictions and transportation districts to develop mitigation policy and retrofit plans for lifeline assets and service facilities; (b) continuing to advance design and maintenance standards and requirements for bridges and unstable slopes, transit, rail, ports, and priority lifeline airfields; (c) developing a temporary bridge installation policy and standards; (d) supporting research on retrofit methods and strategies for Cascadia subduction zone earthquake loads and tsunamis.	X	X	X				X			X					Multi-Hazard / Climate Change	Oregon Highway Plan (OHP); The Oregon Resilience Plan	ODOT	OEM, DOGAMI, DLCD	FHWA, FTA, STATE-ODOT, OEM, DOGAMI, DLCD
131	Improve reliability and resiliency of critical infrastructure statewide by adopting industry-specific best practices, guidelines, and standards	Lifeline Service Delivery Systems (critical infrastructure), including electric supply, natural gas, telecommunications, water/wastewater, hydraulic structures (e.g., dikes, levees, dams), transportation corridors, pipelines and petroleum fuels storage facilities, are all vital resources for a community's life-safety and economic viability. However, much of Oregon's existing critical infrastructure has not been designed or constructed to withstand the impact of severe natural disasters such as extreme wind & winter storms, major earthquakes, or large landslides. Lifeline Service Delivery Systems (critical infrastructure) should be evaluated statewide, and reliable and measurable performance objectives which insure the region's critical infrastructure can withstand future damage without crippling consequences should be instituted.			X							X					Multi-Hazard / Climate Change	Oregon Resilience Plan, Oregon Highway Plan	OPUC, OWRD, ODOT	Other State IHMT Agencies	FEMA (HMGP, BRIC, Risk MAP), State-OWRD, State Highway Fund, Private Utility Fees, Private Property Owners
132	Acquire statewide lidar coverage for the purpose of improving natural hazard mapping and infrastructure inventories	Lidar is currently the best source of regional topographic data and allows for highly precise and accurate natural hazard mapping (landslide, flooding, volcanic hazards, channel migration zones, tsunami, geologic faults, etc.) and infrastructure inventories (buildings, utilities, lifelines, etc.). The state should continue to invest in lidar acquisition for the purpose of understanding risk to natural hazards at a local scale.	X	X	X			X				X			X	X	Multi-Hazard / Climate Change	NFIP, Risk MAP, Goal 7, Oregon Resilience Plan	DOGAMI	State IHMT Agencies	FEMA (Risk MAP), USGS, NRCS, BLM, State-DOGAMI, Local, Gov'ts, Lidar Consortium
133	Provide technical assistance and funding to local governments to evaluate the need and opportunities for inter-tie projects in Local Natural Hazards Mitigation Plans	The capital expense associated with this action needs to be carried mostly by local governments, perhaps with some grant or low-interest loan funding provided by the state or federal governments. The role of the state in this action is to encourage local governments located proximate to one another, yet with separate water systems, to develop the physical capability to send water from one system to the other. Often during drought situations, one local government will have a bit of water to spare while a nearby government is struggling to meet its needs. Transferring water by truck is expensive and inefficient when compared to transferring water via pipeline. Water inter-ties are also effective mitigation for the flood and earthquake hazards where one system can serve as backup for another.			X				X			X					Multi-Hazard / Climate Change	NFIP, Oregon Resilience Plan, Integrated Water Resources Strategy Action 7B	OWRD		OWRD, Local Gov'ts, FEMA (HMGP, BRIC)

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134	Continue to maintain the existing roster of qualified post-earthquake, flood, and wind inspectors with ATC-20 earthquake and ATC-45 flood & wind inspection training	Continue to compile and maintain a list of individuals trained and certified for post-disaster inspection. Support the recruitment and training of qualified ATC-20 post earthquake inspectors and inspection teams.						X									Multi-Hazard / Climate Change	NFIP, Oregon Resilience Plan	BCD	OEM, ODOT	State-BCD
135	Expand the state's stream gaging network. Seek stable funding for the operation, and maintenance of stream gages	The availability of timely and accurate telemetered data from stream gages is essential for flood forecasting, for prediction of imminent flood hazards, and for response to flood emergencies. Streamflow data also provides basic hydrologic information for floodplain mapping and watershed management by communities throughout the state, and is critical for understanding and forecasting drought conditions. Numerous local, state and federal water management agencies rely on data from stream gages for effective management of projects and resources. The installation and maintenance of stream gages has traditionally been a responsibility of state and federal agencies. State agencies plan to work with their partners, including the United States Geological Survey and Bureau of Reclamation, to ensure adequate funding and support for existing gages and for the installation of new gaging sites where needed. It is recommended that state agencies endeavor to leverage federal funding with state resources and local matching commitments to achieve a reliable network of stream gages around the state. The data from these gages is used to support the RAFT and Raptor tools highlighted in Action #10, Priority.		X				X				X					Multi-Hazard / Climate Change	Integrated Water Resources Strategy Action 1B	OWRD		USFWS, State-OWRD, OWEB
136	Educate homeowners about choosing ice and windstorm-resistant trees and landscaping practices to reduce tree-related hazards in future ice storms	Trees that don't stand up well to ice and wind, especially when planted near power lines, can cause power outages and other damage. Certain species of trees hold up better to winter's fury than others. Other factors, such as where a tree is planted and use of proper pruning techniques, can also help trees be more resistant to ice storm damage.	X	X	X		X		X			X					Multi-Hazard / Climate Change	ODF Urban Forestry Strategy	ODF	PUC, OSU Ext.	ODF, OSU Ext.
137	Each year, ask the Governor to designate October to be Earthquake and Tsunami Awareness Month	Practicing to "Drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. A gubernatorial declaration will promote increased participation in the Great Oregon ShakeOut, or other annual earthquake Drop, Cover, and Hold On drill.	X						X			X					Multi-Hazard / Climate Change	Oregon Resilience Plan	OEM	Governor's Office	NEHRP, State-EMPG

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138	Continue to facilitate accessibility and use of the *Coastal Atlas* GIS resources	Make the *Coastal Atlas* geographic information system (GIS) more useful for a wider audience, from local and state staff to interested citizens, by continuing to improve its data and tools, and providing training on how to access and use them.						X	X			X					Coastal Hazards	Goal 7, Risk MAP, NFIP	DLCD, OPRD		NOAA, State-OPRD
139	Research the effects of changing ocean water levels and wave dynamics along the central and southern Oregon coast, and use that data to augment the coastal geomorphic database	As recent research has shown, ocean water levels and wave dynamics along the Oregon coast are changing. These will, in turn, affect beach sand budgets and rates of erosion. More research must be done on alternative shore protection methods, effects of hard shore protection structures, near-shore circulation processes and sediment budgets, sea cliff erosion processes, and other hazard processes		X				X		X				X			Coastal Hazards	NFIP, Risk MAP, Goal 7	DOGAMI, OSU	DLCD	NOAA (309)
140	Survey coastline to monitor erosion	Continue to periodically measure and monitor the Oregon coastline in order to document the response of Oregon's beach and bluffs to changes in ocean water levels (sea level rise and storm surges), storms (frequency and intensity), precipitation patterns that may threaten lives and property. Maintain a long-term, permanent Oregon Beach and Shoreline Mapping and Analysis Program (OBSMAP). The program will be a partnership with local, state, and federal agencies that have responsibility over coastal and ocean activities.	X	X				X	X	X		X					Coastal Hazards	NFIP, Risk MAP, Goal 7	DOGAMI	OSU, DLCD, OPRD	NOAA, State-DOGAMI, OPRD, OSU, and Local Gov'ts
141	Maintain the updated inventory of shoreline protection structures	Maintain the inventory of existing and new coastal engineering (shore protection) structures on the Oregon Coast in order to provide local governments and applicable agencies an important coastal management tool to address anticipated increasing coastal erosion. It is anticipated that this inventory and information will assist in potential future policy changes to address a changing climate and associated coastal erosion impacts.		X				X	X	X		X					Coastal Hazards		OPRD		Permit Fees
142	Provide information and technical assistance to implement mitigation of non-structural hazards in K-12 schools	Provide training to school officials and teachers in reducing non-structural hazards in schools such as unsecured bookcases, filing cabinets, and light fixtures, which can cause injuries and block exits. The program should include a procedure for periodic life safety inspections of non-structural seismic hazards in schools that can be implemented by local fire department inspectors. BCD will have an important role in providing technical assistance in the development of educational materials.	X						X			X					Earthquake	Oregon Resilience Plan	OEM	OSSPAC, BCD, OSFM, ODE	NEHRP, State- SRGP

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143	Each year, ask the Governor to designate the third Thursday of the month of October as the Great Oregon ShakeOut Day by proclamation	Practicing to "drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. A gubernatorial declaration will promote increased participation in the Great Oregon ShakeOut, or other annual earthquake Drop, Cover, and Hold On drill.	X						X			X					Earthquake	Oregon Resilience Plan	OEM	Governor's Office	NEHRP, State-EMPG
144	Include information about the benefits of purchasing earthquake insurance in public outreach materials and disseminate those materials through appropriate public outreach programs and venues	Unlike flood insurance, which is underwritten by the U.S. Government (through the National Flood Insurance Program), earthquake insurance is offered by private sector agents, generally as a rider to a standard homeowner or business property insurance policy. Because earthquake insurance is a type of catastrophic coverage, most policies carry a high deductible, Oregon's Department of Consumer and Business Services Insurance Division offers information about earthquake insurance on its website and provides personal assistance through its insurance hotline. In addition, the Division is active in outreach activities, partnering with other agencies and organizations to bring insurance information to the public.				X			X			X					Earthquake	Oregon Resilience Plan	DCBS-ID	DOGAMI, OEM	State-DCBS-ID
145	Continue seismic rehabilitation of hospital, fire, and police facilities under the Seismic Rehabilitation Grant Program administered by Business Oregon's Infrastructure Finance Division	Continue to rehabilitate to operational readiness in the event of an earthquake essential hospital buildings, fire, and police stations that pose a threat to occupant safety. Senate Bill 15 of the 2001 Legislative Session requires that rehabilitation or other actions to be completed by January 1, 2022. Senate Bills 2 to 5 (2005) provided the mechanism to accomplish some of these legislatively mandated tasks. Under SB 2, Oregon Department of Geology and Mineral Industries developed a seismic needs assessment database of emergency response facilities buildings. These data are being used by the Seismic Rehabilitation Grant Program to provide funding for seismic rehabilitation of eligible buildings (SB 3). Senate Bill 5 allows the State Treasury to sell Government Obligation Bonds to fund the program.	X		X				X								Earthquake	Oregon Resilience Plan	BusOR-IFA	OSSPAC, DOGAMI, BCD, OSFM (SB 3). OEM, OHD	State-BusOR-IFA

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146	Continue seismic rehabilitation of public schools buildings under the Seismic Rehabilitation Grant Program administered by Business Oregon's Infrastructure Finance Division	Continue to rehabilitate to occupant life safety standards certain public school and community college buildings. Senate Bill 14 from the 2001 Session of the Oregon Legislature requires that the State Board of Education examine buildings used for both instructional and non-instructional activities, including libraries, auditoriums, and dining facilities in order to determine which buildings are in most need of additional analysis. Following the identification of high-risk buildings and additional analysis, high-risk buildings must be rehabilitated by January 1, 2032, subject to available funding. SJR 21 and 22 are bond measures (November 2002 election) which would provide funding to implement this proposed action. SB 2 to 5 (2005) provided the mechanism to accomplish some of these legislatively mandated tasks. Under SB 2, Oregon Department of Geology and Mineral Industries developed a seismic needs assessment database of K-12 and Community College public school buildings. These data are being used the SRGP to administer a grant program for seismic rehabilitation of eligible buildings (SB 3). SB 4 allows the State Treasury to sell Government Obligation Bonds to fund the program.	X		X				X								Earthquake	Oregon Resilience Plan	BusOR-IFA	OSSPAC, DOGAMI, BCD, ODE	State-BusOR-IFA
147	Track progress on the 2013 Oregon Resilience Plan	In 2013, OSSPAC released the Oregon Resilience Plan with over 100 recommendations. A tracking method is needed to better understand where resilience progress is being made and where more attention is needed. This is in the area of responsibility of the State Resilience Officer in the Governor's Office.	X	X	X	X	X			X							Earthquake	Governor's Office	OSSPAC		State
148	Continue implementing the Oregon Community Rating System (CRS) Users Group Program	DLCD will continue to coordinate Oregon's two NFIP CRS Users' Groups. Each group will meet a minimum of three times per year to share floodplain best management practices and to receive technical support from the State, FEMA's Insurance Support Organization, and others as needed. The State anticipates that the support provided through the CRS Users' Groups will encourage more communities to participate in the CRS program and participating communities to strengthen their CRS ratings, resulting in greater protection from flood damage at lower cost to property owners.	X	X		X			X			X			X		Flood	NFIP, Goal 7, Local Natural Hazards Mitigation Plans	DLCD	FEMA, Local Gov'ts	FEMA (CAP-SSSE)

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149	Monitor the effectiveness of the statewide strategy to encourage the purchase of flood insurance by demonstrating that the number of flood insurance policies held throughout the state continues to increase	Despite the statewide availability of flood insurance, coverage in place in most communities in Oregon varies from 10% to 20% of the homes and businesses located in the Special Flood Hazard Area (100-year floodplain). Not only does flood insurance reduce the financial vulnerability of individuals, families, businesses, government agencies, other organizations, and the community to the costs posed by flooding, but through the "increased cost of compliance" provision of flood insurance, it also provides funding for the elevation, flood-proofing, demolition, or relocation of homes and businesses when required due to "substantial damage" to the structure.				X			X								Flood	NFIP	DLCD	DCBS-ID	FEMA (CAP-SSSE)
150	Maintain the Riparian Lands Tax Incentive Program	This program is administered by the ODFW. This program involves the preparation of a plan and agreement between the landowner and the ODFW. The plan details measures the landowner will implement to preserve, enhance, or restore the riparian areas. Landowners receive a complete property tax exemption for the riparian property (up to 100 feet from the top of stream bank or the edge of non-aquatic vegetation). This program helps reduce sediment and protect stream banks which helps reduce the filling of river and stream channels.	X	X			X		X								Flood	NFIP, DEQ-Water Quality	ODFW	ODR	State-ODFW
151	Provide information and potentially resources to local governments for developing "flood fight" plans and protocols	Several post-disaster mitigation strategy reports call for the development of flood fight plans and protocols in advance of flood emergencies. In addition to the state agencies potentially involved in flood fighting such as OEM and OWRD, environmental protection and habitat conservation agencies such as DEQ and ODFW should be involved in flood fight planning. At the federal level, the U.S. Army Corps of Engineers is a key partner. These plans and protocols might include improving emergency warnings, strengthening communications systems, stockpiling needed materials, preparing procedures for emergency vehicle access to flooded areas, and other related subjects, including ongoing public education efforts.	X	X			X		X			X					Flood	Silver Jackets	OEM	ODOT	USACE, State-EMPG
152	Continue the State's active Floodplain Management Outreach Program	DLCD has an active floodplain and natural hazards outreach program. The department publishes and distributes newsletters and other outreach information to local governments and other interested parties. DLCD also maintains a website which includes a link to this NHMP. The natural hazards website (http://www.oregon.gov/LCD/HAZ/index.shtml) contains information and links to floodplain management information including many of the documents and booklets prepared by FEMA. DLCD uses an email distribution service for its Natural Hazard Newsletter and other correspondence. The email distribution service affords interested subscribers a greater opportunity to obtain flood management and natural hazards information from DLCD in a timely manner and for DLCD to more readily share information from a variety of sources.	X	X					X			X					Flood	NFIP	DLCD		FEMA (CAP-SSSE)

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153	Continue the State's active Floodplain Management Training Program	DLCD and other State IHMT participants conduct or sponsor training sessions and meetings throughout the year focused on up-to-date floodplain management practices and projects. DLCD will continue to deliver focused training to surveyors, building officials, real estate agents and planners as well as local floodplain managers. The interdependent relationships among these key players in providing comprehensive floodplain management will also be highlighted during trainings.	X	X					X			X			X		Flood	NFIP	DLCD	OEM, DCBS-DFR	FEMA (CAP-SSSE)
154	Prepare text for local broadcast of one Public Service Announcement (PSA) each year on a seasonal topic	PSAs are an effective method for disseminating pertinent seasonal information about hazard preparedness and mitigation.	X						X			X			X		Flood	NFIP	DLCD		FEMA (CAP-SSSE)
155	Assist local communities in securing funding to mitigate damage to repetitive flood loss properties or those substantially damaged by flooding	The state maintains an inventory of high priority repetitively damaged buildings located in floodplains. DLCD and OEM have worked closely with communities to secure funding to mitigate buildings located in the flood hazard zone and to buyout properties located in the floodway. These agencies will continue to provide such expertise statewide where needed.	X	X					X	X		X			X		Flood	NFIP	OEM, DLCD	State IHMT Agencies	FEMA (CAP-SSSE), FMA, Local Gov'ts
156	Continue developing Emergency Action Plans for all remaining high hazard dams in Oregon	In Oregon, money from FEMA grants and state funds is used to help dam owners create Emergency Action Plans (EAP). An EAP helps identify situations where a dam failure might occur, actions to take that could save the dam, if possible, and evacuation routes for a dam failure situation. There is an Oregon-specific EAP template available, designed for owners of remote dams that have limited personnel. Approximately 75% of state-regulated high hazard dams have or are currently developing EAPs. There are 67 state regulated high hazard dams, and another 65 federal high hazard dams in which OWRD plays a coordinating role.	X	X	X			X	X		X	X				X	Flood/Dam Safety	Integrated Water Resources Strategy Action 7a	OWRD	Silver Jackets	FEMA (HHPD Rehab), State-OWRD
157	Acquire existing homes and businesses seriously threatened or damaged by landslide hazards	When opportunities and funding become available (pre- and/or post-disaster) explore options for the acquisition of developed property, particularly homes, in areas of repetitive or ongoing landslide hazards. Acquired properties will be maintained as open space in perpetuity and may also provide a buffer for landslide movements and debris that could otherwise impact improvements such as transportation routes.	X	X						X							Landslide	Goal 7	OEM	DOGAMI, ODF, DLCD	FEMA (HMGP, CAP-SSSE, FMA), Local Resources
158	Assist local governments in implementing the tsunami land use guidance	The risk of tsunami hazard for Oregon's coastal communities is well-documented with the completion of comprehensive tsunami inundation maps developed by DOGAMI. The State of Oregon can assist affected communities with its implementation, leading to better protection of life and property from tsunamis.	X	X	X			X	X	X	X	X					Tsunami	Goal 7	DLCD		NOAA, State-DLCD

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159	Monitor implementation of the tsunami land use guidance by tracking the number of jurisdictions that have used it	The risk of tsunami hazard for Oregon's coastal communities is well-documented with the completion of comprehensive tsunami inundation maps developed by DOGAMI. Monitoring success of the guidance will allow the State to adjust its approach and update the guidance as necessary, leading to better protection of life and property.	X	X	X			X	X	X	X	X					Tsunami	Goal 7	DLCD		NOAA, State-DLCD
160	Continue to renew coastal communities' enrollments in the Tsunami Ready Program	The Tsunami Ready Program is a program sponsored by the National Weather Service that is designed to provide communities with incentives to reduce their tsunami risk. Cannon Beach was the first community for Oregon. Under a proposed plan through the NTHMP, additional communities will be added until there is full participation. This program is currently evolving through a review process being carried out by the NTHMP National Coordinating Committee. OEM is the primary point of contact for more information about the Tsunami Ready Program.	X						X			X					Tsunami	Oregon Resilience Plan	OEM	DLCD, DOGAMI	NOAA, State-EMPG
161	Continue supporting school participation in annual tsunami evacuation drills	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	X						X			X					Tsunami	Oregon Resilience Plan, Goal 7	OEM, DOGAMI	DLCD, ODOT	NOAA, State-EMPG, DOGAMI
162	Continue supporting local agencies and local non-profits, such as CERT, in participating in educational efforts such as door-to-door campaigns to educate those living or working in the inundation zone on how to respond to an earthquake and tsunami	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	X						X			X					Tsunami	Oregon Resilience Plan, Goal 7	OEM, DOGAMI	DLCD, ODOT	NOAA, State-EMPG, DOGAMI
163	Continue innovative outreach activities, such as tsunami evacuation route fun runs	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	X						X			X					Tsunami	Oregon Resilience Plan, Goal 7	OEM, DOGAMI	DLCD, ODOT	FEMA (Risk MAP, HMGP), NOAA, State-EMPG, DOGAMI

2020 MITIGATION ACTIONS: ONGOING

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164	Continue to develop training and information packets and articles for local building officials informing them of their responsibilities and authority under ORS 455.446 and 455.447 and the State Building Code	Statutes and the State Building Code limit construction of new essential facilities and special occupancy structures in the mapped tsunami inundation zone. Definitions of essential and special occupancy structures are in the Oregon State Structural Specialty Code. As personnel change and time passes, additional training and information for officials will be provided.			X				X	X		X					Tsunami	Oregon Resilience Plan	BCD, DLCD	DOGAMI, OEM	State-BCD, DLCD
165	Work with ODOT to replace or move existing Entering/Leaving Tsunami Hazard Zone signs to correspond with the XXL inundation line developed by DOGAMI	Existing tsunami hazard zone signs are considered inadequate for placement along stretches of US-101, or on any roads, that are within the tsunami hazard zone. A single tsunami hazard zone sign will not indicate the boundaries of the inundation zone. Tsunami Hazard Zone signs should be located to correspond with the XXL inundation line developed by DOGAMI.	X									X					Tsunami	Oregon Resilience Plan	OEM	ODOT	NOAA, Local Gov'ts
166	Develop volcanic hazard evacuation maps	Volcanic eruptions often produce lahars that travel down river valleys. Evacuation maps should include the hazard area as well as preferred evacuation routes and evacuation sites. USGS staff should support local and state agencies in this effort.	X									X					Volcanic Hazards	Oregon Resilience Plan	DOGAMI	ODOT, OEM	DOGAMI, USGS
167	Each year, ask the Governor to designate May to be Volcano Awareness Month by proclamation	Working with federal partners, such as the USGS Cascades Volcano Observatory, the state of Oregon will increase the ability for citizens to respond to volcanic eruptions by increasing the level of awareness and preparedness in the public and governmental agencies.	X						X			X					Volcanic Hazards	Oregon Resilience Plan	OEM	Governor's Office	NEHRP, State-EMPG

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168	Support development, enhancement and implementation of local education programs designed to mitigate the wildfire hazard and to reduce wildfire losses, such as the Firewise Communities/NFPA Program and the annual Wildfire Awareness Week Campaign	As part of its statewide fire prevention program, the Oregon Department of Forestry actively encourages and promotes local education and awareness programs that are designed to mitigate or reduce the impacts of wildfires. This action reflects ODF's ongoing intentions to: (a) collaborate with agencies and organizations to promote consistency in the development and application of fire prevention standards,(b) work to make individuals aware of their personal accountability and responsibility for wildfire safety, (c) determine local resources and capacity, and (d) define needs and solutions required to increase capacity.	X	X				X	X		X	X					Wildfire		ODF	OSFM, BCD, DCBS-ID, DLCD, KOG, OSU Ext.	BLM-Title III, ODF, OSFM
169	Continue to increase the number of local governments using the Wildfire Hazard Zone process to mitigate wildfire risk and losses	The Wildfire Hazard Zone (WHZ) process allows local governments to require the use of fire resistant roofing materials in jurisdictions assessed to be at a high risk of wildland fire. Currently, only a few eligible entities have used the WHZ process. To promote additional use, an assessment will be made of the portions of the state where it appears the WHZ process will have the greatest benefit. Following this assessment, local governments in the areas identified will be educated on the desirability of implementing the process. Those governments that express an interest in applying the process will be assisted in completing the required analysis work.	X	X					X		X	X					Wildfire	Local Community Wildfire Protection Plan processes, Goal 7	ODF, BCD	OSFM	BLM-Title III, State-ODF
170	Continue to develop and increase the number of updated Community Wildfire Protection Plans (CWPPs) with the goal of aligning CWPP updates with 5-year NHMP updates, where possible	The federal Healthy Forests Restoration Act (HFRA) includes statutory incentives for federal agencies to give consideration to the priorities of local communities as they develop and implement wildfire hazard mitigation projects. To become eligible for priority consideration under HFRA, a community must first prepare a *Community Wildfire Protection Plan* (CWPP). Most Oregon counties and many Oregon communities have completed CWPPs. To encourage the completion of additional CWPPs, as well as future updates of CWPP's counties and communities will be informed of the benefits to be gained from maintaining a CWPP and assistance will be offered to help facilitate the development and/or update of the plans. Because the majority of Counties refer to CWPP's as their Wildfire Chapters, aligning CWPP updates with NHMP updates will ensure consistency and promote efficiencies in planning processes.	X	X	X	X	X	X	X	X	X	X	X	X			Wildfire	Community Wildfire Protection Plans	ODF	OSFM	BLM-Title III, USDA-USFS & USDOI-National Fire Plan, FEMA (BRIC, HMGP, FMAG)

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171	Continue to provide technical assistance in accessing funding for fire prevention or wildfire mitigation projects through Title III, the National Fire Plan, or other funding mechanisms	Under the federal *Secure Rural Schools and Community Self-Determination Act of 2000* (Title III, Section 301(5) of PL 106-393, commonly known as *Title III*), counties have the ability to receive and spend federal funds for projects that educate homeowners about wildfire mitigation efforts they can apply on their property and for planning projects that increase the protection of people and property from wildfires. National Fire Plan and other funding mechanisms may also be available for assisting communities in preventing wildfires and implementing wildfire mitigation projects.	X	X					X		X	X					Wildfire		ODF	OSFM	National Fire Plan, State-ODF
172	Implement the Oregon Forestland-Urban Interface Fire Protection Act ("Senate Bill 360") in all Oregon counties that meet criteria under the law	The *Oregon Forestland-Urban Interface Fire Protection Act*, more commonly known as "Senate Bill 360," was enacted by the Oregon Legislature in response to the growing incidence of wildfire destroying homes and communities in Oregon's wildland-urban interface. The Act recognizes that individual property owners are in the best position to take mitigation actions which will have the most direct impact to whether or not a structure will survive a wildfire. Under this action item, the Act will be implemented county by county in those portions of the state, based on weather, fire incidence, fuels, or on the number of structures at risk. It has been Legislature's stated preference that implementation be accomplished with federal grant funds.	X	X					X		X						Wildfire	Goal 7	ODF	OSFM	State-ODF
173	Analyze wildfire ignition probability statistics to better target prevention efforts at the leading causes of fires	There is currently no single database or common method of collecting fire cause information for wildfires occurring in Oregon. This results in different entities focusing their prevention and mitigation efforts on those causes which may not be the state's leading causes of fires. This likelihood can be lessened by developing a process to compare fire cause data collected by the Oregon Department of Forestry, the Office of the State Fire Marshal, and federal wildfire agencies. It is also important to understand the ignition probability from homes within and adjacent to the wildland interface because of the ignition risk to nearby wildlands. While there is no centralized database, wildland and structural fire agencies will continue to work collaboratively to determine leading fire causes and focus efforts statewide and locally to prevent future ignitions.	X	X	X			X	X		X	X					Wildfire	PNWCG	ODF	OSFM, KOG	State-ODF, OSFM

2020 MITIGATION ACTIONS: ONGOING

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174	Collaborate through work groups within the Pacific Northwest Coordination Group (PNWCG) to continue collecting and analyzing wildfire occurrence data using the standardized statewide method and report to the state legislature as required	Previously, data concerning the causes of wildfire incidents was collected and analyzed by at least two state agencies, five federal agencies, and numerous local fire departments. These agencies had no database standardization or common reporting requirements. A standardized data collection system has been developed, and data collection and reporting continue collaboratively through work groups within the Pacific Northwest Coordination Group (PNWCG). The new system allows rapid identification of fire ignition trends and permits timely design and delivery of targeted prevention programs and activities.	X	X	X			X			X	X					Wildfire		ODF	PNWCG	State-ODF
175	Develop a single, comprehensive statewide method or process to collect and analyze wildfire occurrence data in a timely manner	Currently, data concerning the causes of wildfire incidents is collected and analyzed by at least two state agencies, five federal agencies, and numerous local fire departments. These agencies have no database standardization or common reporting requirements. This results in great difficulty, when attempting to determine the number of wildfires that occur in Oregon, when identifying fire cause trends, and generally in obtaining information concerning wildfire trends in a timely manner. Under this action item, all agencies responsible for suppressing wildfires will be requested to report incident occurrence information to a central data repository, in a standard format, and within prescribed reporting time limits. Such a system would allow for the rapid identification of fire ignition trends and would permit the timely design and delivery of targeted prevention programs and activities. The State Fire Marshal's Oregon All Incident Reporting System (OAIRS) may be a key component in the solution.	X	X	X			X			X	X					Wildfire		OSFM, ODF		State-OSFM, ODF

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176	Upload the newest available data into the Oregon Wildfire Explorer portal as available	In 2019 the Oregon Wildfire Risk Explore (OWRE) Tool was completed through federal grant funding to make available the most up to date information available on wildfire risk. This tool was created to develop an online portal available to the public to look at current and potential risk and assist in planning and development. Data utilized as a base for this wildfire risk portal was taken from the Quantitative Wildfire Risk assessment developed by the USFS. The purpose of this online tool is to deliver the best wildfire risk information to homeowners, communities, local managers, and planners. It has been utilized in updating CWPP's and provides guidance and educational resources for the public. Beyond the wildfire risk information, this tool is used as an avenue to show current large fire perimeters and where historical fire starts have happened. ODF has goals to improve and add to this mapping tool in collaboration with OSU into the future by adding in a new Wildland Urban Interface layer and a new Communities at Risk layer. Other updates will be implemented as data becomes available to help planners and the public assess wildfire risk.	X	x	X	X	X	X	X	X	X	X	X	X			Wildfire		ODF	USFS, OSU Extension, OCCRI	Federal grants. OSU Extension was awarded $2 million to map and assess parcel level wildfire risk.
177	Continue to educate communities, workers, and the public about the role of proper tree pruning and care in preventing damage during windstorms	Arboricultural groups, public agencies, and utilities should cooperate in promoting proper tree pruning and care practices that can reduce the risk of tree failure and property damage. Common messages refined by state level entities such as the Oregon Department of Forestry (ODF) and OSU Extension can help provide continuity and efficiency across the state. While implementation of this action largely takes place at the local government level, the state has a role in encouraging and providing incentives for best management practices. ODF maintains and implements a communication plan that includes educational initiatives aimed at improving tree health in cities. This includes a variety of products, including a bimonthly newsletter, a website, and brochures that help convey these messages. OSHA requires utilities to: • Provide training to crews working on power lines in worker safety and the identification of trees to prune or remove; and • Review regulations and standards for easement and right of way maintenance, and provide training to foresters and logging crews. Utilities should instruct homeowners in pruning of vegetation, tree care safety, and proper tree care for trees bordering utility corridors and public rights of way.	X	X	X				X		X	X					Windstorm	OSU Land Steward Program, Oregon Small Woodland Association Tree Schools	ODF	PUC, OEM, OSU Ext.	ODF, OSU Ext.
178	Use industry best practices to minimize impact and outages to service delivery system of overhead line operators, during windstorm events	Implement outreach efforts through existing safety-related programs managed by the PUC in coordination with private and public utilities. Compliance with PUC administrative rules includes safety codes and vegetation management. The PUC provides administrative to support to the Oregon Utility Safety Committee where all utility operators (electric, natural gas, telecommunication & water) discuss safety issues and best practices.	X	X	X				X			X					Windstorm		PUC	ODF, ODOT, OR-OSHA	State-OPUC, Public and Private Utilities

2020 MITIGATION ACTIONS: ONGOING

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179	Educate citizens about safe emergency heating equipment	Improper use of alternate heat sources during winter storms can cause fires. Ongoing efforts of the Office of State Fire Marshal and its work with local fire departments through the Life Safety Team (http://www.oregon.gov/OSP/SFM/Pages/CommEd_OLST.aspx). In addition, people can be killed by carbon monoxide emitted by fuels such as charcoal briquettes when used for heating homes. To reduce the threat of carbon monoxide poisoning, known as the silent killer, the 2009 Legislature passed HB 3450a requiring landlords to install carbon monoxide alarms in rentals with a carbon monoxide source and homeowners must ensure they are installed in homes at the time of sale, if the home has a source. Sources include gas heating or fireplaces, wood-burning fireplaces or stoves and attached garages. Partnerships for consistent public education messages and outreach are underway and will include information on the dangers of introducing a carbon monoxide risk.	X	X					X			X					Winter Storm		OSFM	OPH, BCD	State-OSFM
180	Continue educating motorists on safe winter driving, including how to be prepared for traveling over snowy and icy mountain passes	Actions such as sanding, applying de-icing chemicals, and snowplowing do not make the road safe. Motorists must drive at speeds appropriate for the weather and road conditions and be prepared to handle adverse conditions. Many drivers do not carry chains and do not know how or simply do not install them when conditions warrant. Also, many drivers are not prepared for a long wait in their car. Education programs would help save lives on snowy and icy roads.	X						X			X					Winter Storm		ODOT	OSP	State-ODOT

3.3.4.3 2015 Mitigation Action Table: Removed

Table 3-4. 2015 Mitigation Actions: Removed

2015 MITIGATION ACTIONS: REMOVED				
Action Item				
#	Statement	Description	Reason for Removal	Comments
3	Enroll three coastal communities in the Tsunami Ready Program each year	The Tsunami Ready Program is a program sponsored by the National Weather Service that is designed to provide communities with incentives to reduce their tsunami risk. Cannon Beach was the first community for Oregon. Under a proposed plan through the National Tsunami Hazard Mitigation Program (NTHMP), three communities per year will be added to the rolls of the program. This program is currently evolving through a review process being carried out by the NTHMP National Coordinating Committee. OEM is the primary point of contact for more information about the Tsunami Ready Program.	Completed	2019
5	Develop model risk reduction techniques and ordinances for landslide-prone communities	Techniques can involve requiring geological or geotechnical studies for new development, stormwater control for neighborhoods on hillsides, strict land use ordinances for active landslides, working with infrastructure operators to increase reliability of services after storms, and more.	Completed	DOGAMI and DLCD developed and issued a Landslide Guide for Oregon Communities in 2019.
6	Form an Oregon Landslide Workgroup	An Oregon Landslide Workgroup will be created to prioritize areas for new mapping projects, to promote landslide hazard awareness through education & outreach, to develop and influence policy at the federal state, and local levels, and to assist in response & recovery efforts during disasters.	Completed	However, the group has had a slow start. The group will need to be expanded in the future. https://www.oregongeology.org/Landslide/olrrt.htm
8	Create a new lidar-based statewide landslide susceptibility map	DOGAMI will develop a statewide landslide susceptibility map of Oregon as part of the Oregon Geographic Information Council (OGIC) Framework Data Development Program. This map will be used by the Oregon Landslide Workgroup (#6, Priority) to prioritize locations for more detailed Landslide Inventory and Susceptibility Maps.	Completed	Although this item is "completed," there will be needed updates in the future as more lidar, landslide inventory, and geology maps are completed. https://www.oregongeology.org/pubs/ofr/p-O-16-02.htm
10	Implement the Rapid Assessment of Flooding Tool (RAFT)	The RAFT has been funded and developed by the U.S. Army Corps of Engineers (USACE) through FY 14 for $115,000. The goal of the RAFT is to take real time flood forecasts and relate them to flood frequency curves from FEMA, USGS, and OWRD. This will help decision makers prioritize real-time flood fighting assistance. The tool will also incorporate other important decision-influencing factors, possibly including structures in danger of flooding, population affected, and likelihood of levee failure. The RAFT is intended to work in concert with and feed data to other emergency management tools, such as OEM's RAPTOR. The RAFT is in very early development, and the scope and schedule are under development. Once RAFT is completed, OEM will have operational oversight when the ECC is activated.	Completed	The US Army Corps of Engineers (USACE) developed the Rapid Assessment of Flooding Tool and has completed this task before 2019. This is tool is regularly used by USACE staff to assess potential flooding impacts. The tool is being considered for national-level deployment by FEMA.
14	Create an informational website for the new Base Flood Elevation Determination Service	Create website that describes the state's base Flood Elevation Determination Service. Website will include brochure, pricing, map of completed determinations, and data clearinghouse for completed determinations.	Completed	DOGAMI created an informational website with pricing and a data clearinghouse for completed determinations. No brochure or map of completed determinations will be created.
16	Complete a Climate Change Vulnerability Assessment and Adaptation Pilot for north coast highways	The goal of ODOT's pilot is to conduct a regional vulnerability assessment and prepare options for adaptation actions and priorities. In coordination with ODOT Maintenance, the project will collect and map vulnerability and risk data based on climate science, asset conditions, and known and anticipated natural hazards. Hazard sites will be selected within a study corridor for more detailed analysis. Based on engineering and technical reviews, adaptation measures will be developed for vulnerable infrastructure and assembled into a coastal adaptation implementation plan. ODOT received a Federal Highway Administration grant to conduct the project, scheduled for completion in fall 2014.	Completed	Completed in 2015.
17	Request LCDC to include Local Natural Hazards Mitigation Planning as a priority for DLCD Technical Assistance Grant awards to use as match for federal funds when available	The Land Conservation and Development Commission (LCDC) awards Technical Assistance Grants to local Gov'ts to support local planning efforts in certain priority land use topic areas which at this time do not include natural hazard mitigation. If LCDC were to include natural hazards mitigation planning as a priority topic area, local Gov'ts would have the opportunity to compete for funding and the state would be better able to provide technical assistance for natural hazards mitigation planning.	Completed	LCDC has included natural hazards mitigation planning as Priority #3 of five priorities for Technical Assistance Grants.
18	Develop a process for implementing Goal 7	Under Goal 7, DLCD is responsible for notifying local Gov'ts if new hazard information requires a local response. The process for determining which information should trigger local land use evaluations and notifying local Gov'ts, however, remains untested. DLCD will implement the process, review the results, and determine whether any changes are necessary. This action is necessary to ensure that local Gov'ts evaluate new hazard information and take necessary action to protect life and property.	Completed	DLCD has developed a process for implementing Goal 7.

2015 MITIGATION ACTIONS: REMOVED

Action Item				
#	Statement	Description	Reason for Removal	Comments
19	Work with Business Oregon to introduce in 2015 legislation allowing reconstruction of structures that cannot feasibly be retrofitted	Revise SRGP legislation or develop an alternate funding mechanism to help replace schools and emergency facilities that are too structurally deficient for cost-effective retrofit and need to be replaced instead. This would also include structures in the "local" tsunami inundation zone that should not be retrofit in-place but, rather, rebuilt on natural high ground.	Not being pursued	The Department of Education has a new bond funded program for this type of activity.
21	Update the inventory of shoreline protective structures	Update the inventory of existing and new coastal engineering (shore protection) structures on the Oregon Coast in order to provide local Gov'ts and applicable agencies an important coastal management tool to address anticipated increasing coastal erosion.	Completed	Inventory has been up to date since 2015 and is added to as new permits are issued.
22	Develop flood protection standards for state-owned/leased buildings	According to the SB 814 Task Force (Oregon Legislature, 1997 Session), there is a need to develop and effectively implement a strict standard governing the siting, construction, and leasing of buildings occupied by state agencies in flood-prone areas.	Completed	Flood protection standards for state-owned and –leased buildings were in place and were updated in 2015.
25	Integrate the GIS database of tsunami safe zones and assembly areas into local government databases	Assist counties not only with how to integrate the data, but also how the data can be used for tsunami evacuation planning.	Completed, where possible	2019. Not all communities have a GIS department. Also, these have been integrated into RAPTOR.
26	Incorporate text addressing hazard mitigation into natural resource agencies' guidance and process documents focusing on environmental quality to ensure that natural resources are protected in the design and construction of hazard mitigation projects	Government and private nonprofit agencies in Oregon must address complex issues associated with flood hazard mitigation in the context of clean drinking water, riparian habitat, watershed health, fisheries, wetlands protection, and overall environmental quality. An important plan related to this effort is the *Oregon Plan for Salmon and Watersheds.* Solutions require multi-agency and intergovernmental efforts. While the decisions and projects will vary with each disaster, the state will continue its efforts to develop appropriate policies and criteria to ensure that these are considered along with hazard mitigation needs. This includes guidance on large wood placement, restoration after flood events, and habitat-friendly methods to accomplish pre- and post-disaster hazard mitigation. Watershed assessments being completed around the state by local watershed councils will be used in the evaluation of flood hazards and floodplain processes.	Completed	2015
28	Establish a web page where building owners can register their interest in participating in acquisition programs for flood-damaged buildings	FEMA funds can be used to buyout repetitive loss and severe repetitive loss properties in the floodplain. The paperwork and process to achieve a buyout are lengthy and complex. First and foremost, a property owner must be willing to sell. Buyout funds could be more efficiently and effectively spent if willing sellers were identified and paperwork prepared before funds became available. This registry would augment the state's current outreach efforts, making it easy for willing sellers to identify themselves and for the state to prepare for and execute buyouts.	Not being pursued	Lack of resources
35	Investigate/inventory DAS-owned buildings for seismic risk	Determine earthquake damage and losses expected to occur to the state-owned building inventory and provide advice on higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	Completed	2016
36	Host at least one workshop or other educational opportunity on a biennial basis in communities where a Volcano Coordination Plan has been adopted	The State of Oregon will actively work to increase the public's knowledge of the volcano hazard in Oregon.	Not being pursued	Lack of funding
41	Develop an incentive or subsidy program for retrofit of one and two family residences	Design a system of grants or tax credits to encourage homeowners to retrofit residences to minimize displaced post-earthquake shelter demand and reduce population loss during recovery. At the same time, take advantage of weatherization measures such as energy audits, cash rebates, and tax credits to help keep the cold out during winter.	Not being pursued	Lack of resources
45	Develop a system for prioritizing and ranking state-owned facilities, including critical facilities, for mitigation	Create an evaluation framework for determining a comprehensive list of critical state-owned facilities in terms of local and regional service needs in the event of a natural disaster; prioritize these critical facilities based on mitigation needs by disaster type; and evaluate each critical facility on the basis of investment cost and potential relocation/decommission in locations with increased hazard risk.	Not being pursued	Lack of resources

2015 MITIGATION ACTIONS: REMOVED

Action Item				
#	**Statement**	**Description**	**Reason for Removal**	**Comments**
46	Provide the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* to local governments	To encourage communities to use *Planning for Natural Hazards: Oregon Technical Resource Guide* it must be provided to them.	Not being pursued	The Technical Resource Guide has not been updated, and therefore the updated Guide has not been provided to local governments.
47	Produce Coastal Development Handbook	Produce a *Coastal Development Handbook* that addresses coastal process and hazards, beach and shoreland public policy, buying oceanfront property [what to look for, what questions to ask], building on oceanfront property, choosing appropriate hazard mitigation techniques, and choosing and using geotechnical consultants and engineers.	Not being pursued	This was considered and it was determined that this information already exists and is available to the public through DLCD's website. Video: "Living on the edge: Buying and building property on the OR coast." DLCD, NOAA, Sea Grant.
50	Update *Planning for Natural Hazards: Oregon Technical Resource Guide*	*Planning for Natural Hazards: Oregon Technical Resource Guide* was published in 2000 and needs to be updated.	Not being pursued	This was considered. It was determined that the Guide, while old, is still useful, and updating the Guide is not necessary.
51	Facilitate self-sustaining outreach programs staffed by Community Emergency Response Teams (CERT) in each coastal population center aimed at creating a culture of preparedness and response for both local Cascadia and distant tsunami events	Establish Community Emergency Response Teams (CERT). These teams will work to save lives and restore communities following a major disaster. Encourage CERT to use outreach techniques tested in a 2005 pilot study of Seaside (#1 priority = door-to-door education; #2 priority = community evacuation drill; #3 = K-12 education supplemented by workshops targeted at specific user groups such as the lodging industry). Create measures of sustainability and success.	Not being pursued	Lack of funding
52	Determine the effectiveness of and the feasibility of using the Emergency Alert System (EAS) in dust prone areas to provide timely information to the traveling public about dangerous blowing dust conditions and make improvements if needed	ODOT and OSP have primary responsibility for activating the traffic advisory components of the dust storm response plan for the Mid-Columbia Region. The National Weather Service can also activate EAS from their forecast offices in Pendleton, Boise, Medford, and Portland. Many local emergency program managers can also activate the system. Providing this information can save lives in the event of a dust storm.	Not being pursued	ODOT already has reader boards and low power radio stations that broadcast traveler information throughout the Mid-Columbia region that are dedicated for weather related incidents like dust storms, severe weather, and blowing snow that are triggered by NWS alerts. Additionally, locally emergency managers already have access to EAS and IPAWS. Through IPAWS, they can issue a Wireless Emergency Alert (WEA), which is much more effective and reliable than EAS. Our current EAS infrastructure in Oregon is antiquated and much less reliable that IPAWS. Many of the units at the local level are more than 20 years old and are not very reliable. Additionally, not all county PSAPs have EAS units and rely on neighboring counties for analog access to EAS. The Oregon Association of Broadcasters has put together a package to request funding from the Oregon Legislature to upgrade the EAS network, but the bill was never voted on, due to early shutdown of the senate.
53	Add at least three new flood inundation forecast points to the National Weather Service's Flood Inundation Mapping website and the USGS's Flood Inundation Mapper before 2018	The National Weather Service (NWS) Advanced Hydrologic Prediction Service (AHPS) has developed inundation mapping sites for various stream gage locations nationwide. Currently there are none in Oregon. This is a useful tool for understanding potential inundation areas based on NWS forecasts. NWS: http://water.weather.gov/ahps/inundation.php; USGS: http://wim.usgs.gov/fimi/)	Not being pursued	The National Weather Service's Advanced Hydrologic Prediction Service uses dozens of real-time or near-real-time observed water level data in Oregon from the United State Geological Survey's National Streamflow Information Program to produce a suite of River Forecast Center products. These products include water resource forecasting, ensemble streamflow prediction, and hydrometeorological analysis and support that enable government agencies, private institutions, and individuals to make more informed decisions about risk-based policies and actions to mitigate the dangers posed by floods and droughts. (NWS: https://water.weather.gov/ahps/rfc/rfc.php; USGS: https://waterdata.usgs.gov/nwis/rt)
56	Identify, prioritize, and map areas susceptible to rapid channel migration	Identify areas susceptible to rapid channel migration. Prioritize those areas' susceptibility and rank their risk from a rapid channel migration event. Create channel migration zone and risk maps for the areas determined to have the highest risk for rapid channel migration.	Completed.	DOGAMI completed and published the Statewide Subbasin-Level Channel Migration Screening for Oregon in 2017 (IMS-56). This study classified first-order streams into segments of high, medium, and low channel migration susceptibility for each of the 86 subbasins in Oregon, made recommendations for further mapping and assessment based on classifications, and produced a geodatabase containing the classified stream segments and associated metadata.
57	Prepare model coordination protocols for local Floodplain Managers and Building Officials	Local government Floodplain Managers and Building Officials are often unaware of the other's role in floodplain management and how they could work together to better manage floodplain development and mitigate flood hazards. Providing model protocols for the two positions to coordinate would increase each one's awareness of the other's role, ultimately enhancing local flood hazard mitigation.	Completed	Model Standard Operating Procedures for processing floodplain development permits have been developed that address and incorporate model protocols for coordination between local Floodplain Managers and Building Officials.

2015 MITIGATION ACTIONS: REMOVED

Action Item				
#	**Statement**	**Description**	**Reason for Removal**	**Comments**
59	Schedule three opportunities over the life of this Plan for state-local dialogue on vulnerability assessments to improve consistency and mutual understanding	Traditionally, local jurisdictions have used the OEM Hazard Analysis Methodology to update LNHMP vulnerability assessments. State agencies with hazard oversight use a wide range of methods to conduct statewide vulnerability assessments for the Oregon NHMP. The results are varying degrees of similarities and differences among local and state vulnerability scores. This dialogue is intended for the state and local Gov'ts to educate each other on the rationale behind the differing scores and to identify ways to better align local and state vulnerability assessments.	Not being pursued	One state-local dialog on this topic took place at the Oregon Emergency Management Conference in April 2016. This action can be incorporated into the continued development of a new standardized risk assessment methodology.
62	Develop incentives to increase the rate of replacement of 6 times seismically deficient buildings	Develop tax incentives, permit facilitation, and other means to increase the natural rate of building turnover.	Not being pursued	Lack of funding
63	Identify areas on the coast that will be "islands", or cut off, from other cities or critical recovery resources following a Cascadia Subduction Zone earthquake & tsunami	Produce GIS database of resources in each "island" expected to be isolated after a Cascadia Subduction Zone (CSZ) earthquake and resulting tsunami in order to preplan for response. Shape files are to be imported into RAPTOR, Oregon Explorer, and other GIS tools. This action item supports the local community's ability to prepare for and sustain or recover function following a CSZ earthquake and tsunami.	Completed	2016
67	Initiate an outreach strategy to encourage local jurisdictions to disseminate volcano preparedness educational materials	Increase the ability of Oregonians to prepare for and recover from volcanic hazards.	Not being pursued	Lack of funding
69	Update the 2000 Guidelines for conducting site-specific geohazard investigations	The state has guidelines for conducting site-specific seismic investigations. The guidelines date from 2000 and need to be updated. The update should expand the scope of the guidelines to cover site-specific investigations for all geohazards. This will improve local government implementation of development regulations in areas subject to geohazards.	Completed	The Oregon State Board of Geologist Examiners guidelines were updated to "Guidelines for Engineering Geologic Reports (2014), and is at: https://www.oregon.gov/osbge/Documents/engineeringgeologicreports_5.2014.pdf For liquefaction, this National Academies Liquefaction Study Report (2016) should be used: https://www.nap.edu/catalog/23474/state-of-the-art-and-practice-in-the-assessment-of-earthquake-induced-soil-liquefaction-and-its-consequences
72	Update DOGAMI Special Paper 29 (Wang & Clark, 1999)	Update 1999 Special Paper 29, Earthquake Damage In Oregon: Preliminary Estimates of Future Earthquake Losses, a statewide damage and loss estimation study (Wang & Clark, 1999). This update, at a minimum, should incorporate damage and loss estimates for a magnitude 9 Cascadia earthquake, an exposure analysis of tsunami hazards, and probabilistic hazards including updated probabilistic earthquake ground motions and flooding zones. School and emergency facilities from the 2007 DOGAMI database should be incorporated.	Removed	Replaced with an updated mitigation action.
76	Establish process for assigning inspection teams to needed areas for post-disaster facility inspection	Work with OEM, local government building officials, and emergency planners to establish an effective process for assigning inspection teams to needed areas and educating local Gov'ts regarding the circumstances and process for initiating BCD and state involvement.	Completed	Current process is for local staff to meet this need. If local staff is unable to meet the need, the county makes a request (may be elevated from a city to the County) to the State Emergency Management response team through the Ops Center portal. After this request is made, the State will work to identify resources. This system was tested and was successful for the Umatilla flooding in February of 2020.
83	Assist local governments in using the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* to update their comprehensive plans and development regulations	The original purpose of *Planning for Natural Hazards: Oregon Technical Resource Guide* was to assist communities in amending their comprehensive plans and development regulations to reduce risk from natural hazards, implementing Statewide Goal 7. The updated document will also be helpful in developing local hazard mitigation plans and integrating them with local comprehensive plans and development regulations.	Not being pursued	The Technical Resource Guide has not been updated and therefore technical assistance in using it is not being provided to local governments.
84	Monitor the implementation of the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* provided to local governments by tracking the number of jurisdictions that have used it	Monitoring success of *Planning for Natural Hazards: Oregon Technical Resource Guide* will allow the State to adjust its approach and update the guidance as necessary, leading to better protection of life and property.	Not being pursued	The Technical Resource Guide has not been updated and therefore not provided to local governments so its use is not being monitored.
89	Continue to assist local governments with GIS capability development	Assist local governments with GIS program development, including system planning, hardware/software costs, training, and data development in relation to all hazards mapping and regulation of coastal development.	Not being pursued	The State will not be establishing a formal program but does assist local governments upon request.
95	Educate citizens about the different National Weather Service announcements	State agencies should work with the National Weather Service and local governments to educate the public about the meaning of the different National Weather Service announcements: winter storm watch, winter storm warning, ice storm warning, heavy snow warning, blizzard warning, severe blizzard warning, dust storm and high wind warning.	Not being pursued	ODOT already has reader boards and low power radio stations that broadcast traveler information throughout the Mid-Columbia region that are dedicated for weather related incidents like dust storms, severe weather, and blowing snow that are triggered by NWS alerts. Additionally, locally emergency managers already have access to EAS and IPAWS. Through IPAWS, they can issue a Wireless Emergency Alert (WEA), which is much more effective and reliable than EAS.

2015 MITIGATION ACTIONS: REMOVED

Action Item				
#	**Statement**	**Description**	**Reason for Removal**	**Comments**
98	Better coordinate, fund, and publicize programs to reduce the abundance of juniper trees in arid landscapes across Oregon	Juniper trees develop extensive root systems that draw critically needed water from arid soils, transpiring water vapor into the atmosphere, intensifying drought and increasing the risk of wildfire. There are programs in Oregon to reduce juniper trees from areas where their competition for groundwater resources is harmful, but these programs need to be better coordinated, funded, and publicized.	Not being pursued	ODF currently doesn't have a dedicated program, but other programs including NRCS have funded similar projects. Might be better phrased as supporting rangeland health, combatting juniper encroachment and noxious weeds and grasses that pose threats to the ecosystem and alter fire regimes. A common theme seems to be prescribed fire with these juniper treatments.
106	Publicize and facilitate the implementation of both structural and non-structural seismic mitigation measures for home owners, business owners, renters, and contractors, including methods of reducing hazards	Working with federal partners, such as FEMA, and non-profit industry groups, such as AIA, Oregon will enhance education on structural and non-structural seismic mitigation measures by adopting the following actions: • Increase the number of educational opportunities by working with FEMA to offer courses from the National Earthquake Technical Assistance Program. • Work with the Construction Contractors Board, public and private sector lenders, private sector construction material suppliers and nonprofit organizations to develop programs to assist home and business owners and renters to implement innovative structural and non-structural seismic mitigation measures.	Completed	2017
114	Update the Model Ordinance for Flood Damage Prevention	FEMA Region 10 has approved for use in Oregon a model ordinance for flood damage prevention. DLCD views the model ordinance as a living document and will continue to work with Region 10 and other interested parties to develop model ordinance provisions that address issues such as "fish-friendly" floodplain management, reducing flood insurance costs, etc.	Completed	The Oregon Model Flood Hazard Ordinance was updated and approved by FEMA Region X in August 2019.
121	Continue implementation of FEMA's Risk MAP program in Oregon, including building effective community strategies for reducing risk	Measurably increase the public's awareness of flood and other natural hazards through a combination of regulatory and non-regulatory products, tools, community outreach. Address gaps in flood hazard data, identifying areas of dated and/or inconsistent mapping and updating high-priority areas with new mapping and innovative natural hazard mapping techniques that lead to actions that reduce risk to life and property. Provide support to help manage the FEMA Map Modernization projects that remain to be completed.	Not being pursued	The State no longer has a Risk MAP Program Coordinator. FEMA has taken over management of the Risk MAP program for the State of Oregon.
123	Implement flood protection standards for state-owned/leased buildings	According to the Senate Bill 814 Task Force (Oregon Legislature, 1997 Session), there is a need to develop and effectively implement a strict standard governing the siting, construction, and leasing of buildings occupied by state agencies in flood-prone areas.	Completed	2015
133	Work with ODOT to develop additional signage as needed to increase awareness of the tsunami hazard	Existing tsunami hazard zone signs are considered inadequate for placement along stretches of US-101, or on any roads, that are within the tsunami hazard zone. A single tsunami hazard zone sign will not indicate the boundaries of the inundation zone. There is need for increased public education program to let the public, including motorists who are not local residents, know what the signs mean and what actions they should take.	Not being pursued	Lack of funding
134	Work with Oregon Parks & Recreation Department and Oregon Travel Experience to increase the number of interpretive educational installations along US-101	Existing tsunami hazard zone signs are considered inadequate for placement along stretches of US-101, or on any roads, that are within the tsunami hazard zone. There is need for increased public education program to let the public, including motorists who are not local residents, know what the signs mean and what actions they should take.	Not being pursued	Lack of funding
144	Collaborate through work groups within the Pacific Northwest Coordination Group to encourage the U.S. Forest Service to allow the owners of long-term dwelling leases to apply mitigation standards adjacent to their dwellings	In Oregon, several thousand seasonal homes, which are located in high-risk wildland-urban interface areas, are on lands owned by the U.S. Forest Service. Because these structures are located on ground owned by the federal government, they are not subject to the *Oregon Forestland-Urban Interface Fire Protection Act*. In many locations, even when the owners of these homes desire to complete wildfire mitigation practices, federal lease requirements totally or substantially prevent them from doing so. Under this action item, a survey will be made of all lease locations in Oregon and the federal mitigation limitation and prohibitions will be identified. This information will then be used to approach the appropriate federal officials with a request to change their policies or regulations, to allow for the application of mitigation practices on leased property.	Not being pursued	Due to capacity issues and lack of funding, this is not being pursued by ODF at this time.

3.3.4.4 2015 Mitigation Action Table: Status

Table 3-5. 2015 Mitigation Actions: Status

2015 MITIGATION ACTIONS: STATUS Priority and Ongoing				
Action Item				
#	**Statement**	**Description**	**Status**	**Explanation**
1	Develop and fund a legislative package for general funds or lottery funds to match federal funding for local hazard mitigation planning, including additional funds for DLCD Technical Assistance Grants	Continue—and enhance where possible—state technical and planning grant assistance to cities and counties for addressing issues associated with local hazards.	Progressing	State agencies have developed requests but not been successful in having them funded.
2	Create a “Clearinghouse” for natural hazards data	Emergency responders and community planners alike need access to the best and most current natural hazards data that is available. This project would be a cooperative effort between authoritative data sources -- DLCD, DOGAMI, OEM, OWRD, and federal partners (FEMA, USACE, NWS, USGS)—and would include: • Establishing a single point of online access to reliable data, maps, and information about natural hazards; • Developing, in conjunction with DAS-GEO, a “portal” to distribute this data; • Developing a multi-agency State of Oregon flood hazard website; • Providing an ongoing inventory and assessment of existing natural hazards data; and • Creating a central library for natural hazard risk assessments.	Progressing	FEMA has established the Map Service Center portal that provides access to all of the existing FEMA regulatory floodplain mapping information (in GIS format whenever available). The State of Oregon DLCD has a National Flood Insurance Program (NFIP) website which links through to other State sites that provide flood hazard geospatial data and to the FEMA Map Service Center. The State of Oregon provides flood hazard geospatial information through the Oregon Spatial Data Library and in partnership with other entities through the Oregon Explorer viewer. In addition, RAPTOR provides much of this information. There is currently no library for natural hazards risk assessments.
3	Enroll three coastal communities in the Tsunami Ready Program each year	The Tsunami Ready Program is a program sponsored by the National Weather Service that is designed to provide communities with incentives to reduce their tsunami risk. Cannon Beach was the first community for Oregon. Under a proposed plan through the National Tsunami Hazard Mitigation Program (NTHMP), three communities per year will be added to the rolls of the program. This program is currently evolving through a review process being carried out by the NTHMP National Coordinating Committee. OEM is the primary point of contact for more information about the Tsunami Ready Program.	Completed	2019
4	Complete a hazard mitigation policy legislative needs assessment	The Oregon NHMP contains a number of specific policy recommendations. In addition, the state of Oregon maintains a number of policies related to natural hazards and the mitigation thereof. It is unclear at this time what legislative action may be needed in order to fully implement existing and proposed mitigation actions. The State IHMT recommends completing an assessment of the potential legislation needed to implement hazard mitigation policies.	Not Started	This work has been tabled for the time being due primarily to changes in leadership and IHMT representation as well as to some extent resources and capacity.
5	Develop model risk reduction techniques and ordinances for landslide-prone communities	Techniques can involve requiring geological or geotechnical studies for new development, stormwater control for neighborhoods on hillsides, strict land use ordinances for active landslides, working with infrastructure operators to increase reliability of services after storms, and more.	Completed	DOGAMI and DLCD developed and issued a Landslide Guide for Oregon Communities in 2019.
6	Form an Oregon Landslide Workgroup	An Oregon Landslide Workgroup will be created to prioritize areas for new mapping projects, to promote landslide hazard awareness through education & outreach, to develop and influence policy at the federal state, and local levels, and to assist in response & recovery efforts during disasters.	Completed	However, the group has had a slow start. The group will need to be expanded in the future. https://www.oregongeology.org/Landslide/olrrt.htm

2015 MITIGATION ACTIONS: STATUS
Priority and Ongoing

Action Item				
#	**Statement**	**Description**	**Status**	**Explanation**
7	Through FEMA's Risk MAP program, update 1,000 miles of streams with lidar-based flood mapping	FEMA's Risk MAP program funds revisions of Flood Insurance Studies and Flood Insurance Rate Maps. The State should focus on updating these products so they are based on high quality topographic data (e.g., lidar). Lidar-derived streams are a by-product of high quality topographic data. These more accurately located streams will assist in the improvement of a community's flood maps to more accurately show flood risk to life and property. The State should continue to pursue Risk MAP funds for this purpose.	Progressing	DOGAMI has completed and published 5 sets of Digital Flood Insurance Rate Maps based on lidar for 6 coastal counties (Clatsop County, Lincoln County, Curry County, Tillamook County, Lane County and Douglas County). Risk MAP has also funded private contractors to revise Flood Insurance Studies and Rate Maps throughout Oregon. Between 2015 and 2019, this effort has led to new adopted maps in Benton, Clackamas, Clatsop, Coos, Curry, Jackson, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, and Washington, but not all maps are based on lidar-derived topography. DLCD no longer has a RiskMAP Program Coordinator. FEMA is continuing to undertake RiskMAP projects to update Flood Insurance Rate Maps for Oregon communities. The Silver Jackets program has pursued grant funding from the USACE to conduct detailed flood studies for limited stream reaches within Oregon communities and works to submit these as Letters of Map Revision (LOMRs) to update community FIRMs. FEMA has ongoing RiskMAP projects for Lane County, Harney County, Grant County, Baker County, Klamath County, and Douglas County as of 2020.
8	Create a new lidar-based statewide landslide susceptibility map	DOGAMI will develop a statewide landslide susceptibility map of Oregon as part of the Oregon Geographic Information Council (OGIC) Framework Data Development Program. This map will be used by the Oregon Landslide Workgroup (#6, Priority) to prioritize locations for more detailed Landslide Inventory and Susceptibility Maps.	Completed	Although this item is "completed," there will be needed updates in the future as more lidar, landslide inventory, and geology maps are completed. https://www.oregongeology.org/pubs/ofr/p-O-16-02.htm
9	Upgrade the Oregon Landslide Warning System	The current warning system needs updating to include rainfall thresholds from local rainfall gauges. A permanent real-time website will be constructed to show the areas under a landslide warning that will include guidance on what people should do to help protect their life and property from a landslide.	Progressing	This is a current project which is approximately 30% complete. The project will identify the recommended upgrades to the system.
10	Implement the Rapid Assessment of Flooding Tool (RAFT)	The RAFT has been funded and developed by the US Army Corps of Engineers (USACE) through FY 14 for $115,000. The goal of the RAFT is to take real time flood forecasts and relate them to flood frequency curves from FEMA, USGS, and OWRD. This will help decision makers prioritize real-time flood fighting assistance. The tool will also incorporate other important decision-influencing factors, possibly including structures in danger of flooding, population affected, and likelihood of levee failure. The RAFT is intended to work in concert with and feed data to other emergency management tools, such as OEM's RAPTOR. The RAFT is in very early development, and the scope and schedule are under development. Once RAFT is completed, OEM will have operational oversight when the ECC is activated.	Completed	The US Army Corps of Engineers (USACE) developed the Rapid Assessment of Flooding Tool and has completed this task before 2019. This is tool is regularly used by USACE staff to assess potential flooding impacts. The tool is being considered for national-level deployment by FEMA.
11	Develop guidance for local Gov'ts on how to use Goal 7 together with other pertinent Statewide Land Use Planning Goals to classify lands subject to natural hazards in the buildable lands inventory and adjust urban growth boundaries in a manner that minimizes or eliminates potential damage to life, property, and the environment while continuing to provide for efficient development patterns	Goal 7 discourages new development in areas subject to natural hazards. Goal 14 and other Statewide Land Use Planning Goals encourage development within urban growth boundaries. Local Gov'ts need guidance on how to classify lands subject to natural hazards in their buildable lands inventories and adjust urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns within urban growth boundaries. This guidance will assist local Gov'ts in integrating local natural hazards mitigation plans with comprehensive plans.	Progressing	There have been some discussions without agreement to date about the appropriate approach to this issue and whether rule changes or guidance are necessary. These conversations will continue to occur. If it is decided to develop the guidance, we will seek funding to do so.

2015 MITIGATION ACTIONS: STATUS
Priority and Ongoing

Action Item				
#	Statement	Description	Status	Explanation
12	Assist one coastal community per year in considering vertical evacuation structures and improved evacuation routes due to evacuation constraints	Use the anisotropic path modeling to measure the time needed to evacuate all parts of the maximum-considered Cascadia tsunami inundation zone in order to evaluate the need for vertical evacuation structures and improvements in evacuation routes. These actions will provide guidance to communities on the best locations to build vertical evacuation structures that will save lives in a catastrophic tsunami event. The results will also inform communities of priority evacuation routes needing additional signage or way-finding markers. The planned communities are: 2014 = Seaside 2015 = Warrenton 2016 = Rockaway Beach 2017 = Siletz Bay area 2018 = Pacific City	Completed and Progressing	With funding via the NTHMP and from DLCD, DOGAMI has accelerated its efforts to evaluate tsunami evacuation routes and possible vertical structure needs using "Beat the Wave (BTW)" evacuation modeling. To-date, we have completed BTW modeling in the following communities: Gearhart, Seaside, Rockaway Beach, Pacific City, Newport, Florence, Reedsport, Cape Meares, Netarts, Neskowin, Lincoln City, Lincoln Beach/Siletz Spit, Seal Rock, Waldport, Yachats, North Bend/Coos Bay, Charleston. "Beat the Wave" modeling is presently underway for Port Orford and Manzanita/Nehalem. Modeling in Gold Beach is planned for Spring 2020. Similar modeling is proposed for Astoria in 2021, and Bandon in 2022. We anticipated having completed evacuation modeling by approximately 2023.
13	Produce new lidar-based flood hazard maps	Lidar-based flood hazard maps are produced for counties or watershed as funding is provided. These maps have newly delineated flood zones based on new detailed studies, new coastal analysis, and/or delineation of existing zones based on new topography data (lidar). Lidar-based flood hazard maps are being produced or are anticipated to be produced for: • Silvies Watershed • Lower Columbia River/Sandy River Watershed • Clatsop County • Tillamook County • Lincoln County • Curry County • Lane County • Douglas County	Completed and Progressing	DOGAMI has produced new lidar-based flood hazard maps for all of the 8 study areas previously listed in the action description. In addition, new maps were created for 6 more study areas (Grant County, Baker County, Tualatin Watershed, Multnomah County Drainage Districts, the Upper Rogue Watershed, and Lane County). DOGAMI is currently in the process of producing flood hazard maps for rivers in 6 new counties (Marion County, Morrow County, Benton County, Hood River County, Wasco County, and Sherman County). FEMA is producing new flood hazard maps under existing RiskMAP projects utilizing flood studies based on LiDAR and new hydrology and hydraulics. USACE is conducting new flood hazard mapping that utilizes LiDAR data.
14	Create an informational website for the new Base Flood Elevation Determination Service	Create website that describes the state's base Flood Elevation Determination Service. Website will include brochure, pricing, map of completed determinations, and data clearinghouse for completed determinations.	Completed.	DOGAMI created an informational website with pricing and a data clearinghouse for completed determinations. No brochure or map of completed determinations will be created.
15	Develop new standardized risk assessment methodology across all hazards, at the state and local levels	Oregon does not have a clear and common methodology to identify the most vulnerable populations across all hazards at the state and local levels. In 2013, the State IHMT Risk Assessment Sub-Committee in partnership with the OPDR and the U of O InfoGraphics Lab developed a model concept, work plan and budget. Pending funding, this model could be fully developed between 2014 and 2019 and then be used to inform the 2020 Oregon NHMP. Upon full development, the model will allow state and local Gov'ts to strategically target mitigation resources.	Progressing	The State has been unsuccessful in obtaining funding for the 2013 concept model to be developed and implemented. DLCD and DOGAMI developed a simple risk assessment methodology and piloted it for the 2020 Oregon NHMP update. It has a number of limitations and the State still needs to either have the 2013 concept model funded or try to improve upon the 2020 model.
16	Complete a Climate Change Vulnerability Assessment and Adaptation Pilot for north coast highways	The goal of ODOT's pilot is to conduct a regional vulnerability assessment and prepare options for adaptation actions and priorities. In coordination with ODOT Maintenance, the project will collect and map vulnerability and risk data based on climate science, asset conditions, and known and anticipated natural hazards. Hazard sites will be selected within a study corridor for more detailed analysis. Based on engineering and technical reviews, adaptation measures will be developed for vulnerable infrastructure and assembled into a coastal adaptation implementation plan. ODOT received a Federal Highway Administration grant to conduct the project, scheduled for completion in fall 2014.	Completed.	Completed in 2015.
17	Request LCDC to include Local Natural Hazards Mitigation Planning as a priority for DLCD Technical Assistance Grant awards to use as match for federal funds when available	The Land Conservation and Development Commission (LCDC) awards Technical Assistance Grants to local Gov'ts to support local planning efforts in certain priority land use topic areas which at this time do not include natural hazard mitigation. If LCDC were to include natural hazards mitigation planning as a priority topic area, local Gov'ts would have the opportunity to compete for funding and the state would be better able to provide technical assistance for natural hazards mitigation planning.	Completed	LCDC has included natural hazards mitigation planning as Priority #3 of five priorities for Technical Assistance Grants.

2015 MITIGATION ACTIONS: STATUS
Priority and Ongoing

Action Item				
#	**Statement**	**Description**	**Status**	**Explanation**
18	Develop a process for implementing Goal 7	Under Goal 7, DLCD is responsible for notifying local Gov'ts if new hazard information requires a local response. The process for determining which information should trigger local land use evaluations and notifying local Gov'ts, however, remains untested. DLCD will implement the process, review the results, and determine whether any changes are necessary. This action is necessary to ensure that local Gov'ts evaluate new hazard information and take necessary action to protect life and property.	Completed	DLCD has developed a process for implementing Goal 7.
19	Work with Business Oregon to introduce in 2015 legislation allowing reconstruction of structures that cannot feasibly be retrofitted	Revise SRGP legislation or develop an alternate funding mechanism to help replace schools and emergency facilities that are too structurally deficient for cost-effective retrofit and need to be replaced instead. This would also include structures in the "local" tsunami inundation zone that should not be retrofit in-place but, rather, rebuilt on natural high ground.	Not being pursued.	The Department of Education has a new bond funded program for this type of activity.
20	Add at least five jurisdictions, with emphasis on coastal jurisdictions, to the Community Rating System (CRS) program during the life of each Oregon NHMP	The CRS, part of the NFIP, is a program that rewards communities for going above and beyond the minimum requirements of the NFIP in minimizing potential losses due to flooding. Participating in the CRS benefits the jurisdiction with extra flood protection and benefits property owners by lowering flood insurance rates. See the CRS Information Center at: http://training.fema.gov/EMIWeb/CRS/ for more information. Each year DLCD conducts community assistance visits in an average of five NFIP communities. During this process, qualified jurisdictions will be encouraged to participate in CRS or strengthen CRS ratings. DLCD will also create a "pathway to CRS" schedule for each jurisdiction for which it conducts a community assistance visit. The state has also started CRS Users' Groups (#C, Removed and #112, Ongoing) to encourage greater participation in the CRS program.	Progressing	No new jurisdictions have been added to the CRS Program. However, DLCD has promoted CRS participation at all Community Assistance Visits (CAVs) and Community Assistance Contacts (CACs). The State has conducted over 100 CAVs and CACs since 2015. DLCD has provided support to the community driven CRS User Group that was re-established in 2019.
21	Update the inventory of shoreline protective structures	Update the inventory of existing and new coastal engineering (shore protection) structures on the Oregon Coast in order to provide local Gov'ts and applicable agencies an important coastal management tool to address anticipated increasing coastal erosion.	Completed	Inventory has been up to date since 2015 and is added to as new permits are issued.
22	Develop flood protection standards for State-owned/leased buildings	According to the SB 814 Task Force (Oregon Legislature, 1997 Session), there is a need to develop and effectively implement a strict standard governing the siting, construction, and leasing of buildings occupied by state agencies in flood-prone areas.	Completed	Flood protection standards for state-owned and –leased buildings were in place and were updated in 2015.
23	Update the state's Peak Discharge Estimation Program	Peak discharge estimation tools can help determine the magnitude and frequency of floods. The state's program provides engineers and land managers with the information needed to make informed decisions about development in or near watercourses. The Peak Discharge Estimation Program is based on a modified version of the U.S. Geological Survey's "Bulletin 17b." The U.S. Geological Survey is in the process of updating this bulletin. OWRD's methodology will need to be brought up to date to reflect these recent findings.	Not Started	Inadequate staffing and higher priorities at current staffing level. Possible 2024 start.
24	Develop evacuation plans for ports and harbors at the rate of one per year	Ports and harbors are the haven for commercial and recreational fishing and recreational boating industries. They are often the major centers of economic activity in coastal communities that have bays. To protect the vessels from tsunami damage requires a unique evacuation plan for both distant and local tsunamis. The plans should be integrated with community evacuation plans. The Oregon State University Extension Sea Grant Program has identified this as a major issue in their pilot project in Yaquina Bay. Their project is titled *Reducing Earthquake and Tsunami Hazards in the Pacific Northwest Ports and Harbors.* For distant tsunami events and storm surge events that can occur during any winter, evaluate potential port and harbor mitigation retrofit projects that protect and strengthen floating and anchored infrastructure such as piers, bulkheads and landings.	Progressing	DOGAMI has initiated new tsunami maritime modeling in select ports and harbors. This effort was initiated in the Columbia River system, where new sophisticated modeling was developed that integrates river flows, fluctuating tides, the tsunami, and landscape friction in order to better understand non-linear responses that occur as the tsunami interacts with variations in river discharge and tidal currents, leading to a more improved (real-world) understanding of the combined processes and their effects in ports and harbors and on land. Similar modeling has been implemented in Coos Bay and is based on the approach developed for the Columbia River. DOGAMI has proposed to do new maritime tsunami modeling in the Umpqua River in 2021, Yaquina Bay in 2022, and Brookings in 2023.
25	Integrate the GIS database of tsunami safe zones and assembly areas into local government databases	Assist counties not only with how to integrate the data, but also how the data can be used for tsunami evacuation planning.	Completed, where possible	2019. Not all communities have a GIS department. Also, these have been integrated into RAPTOR.

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#	**Statement**	**Description**	**Status**	**Explanation**
26	Incorporate text addressing hazard mitigation into natural resource agencies' guidance and process documents focusing on environmental quality to ensure that natural resources are protected in the design and construction of hazard mitigation projects	Government and private nonprofit agencies in Oregon must address complex issues associated with flood hazard mitigation in the context of clean drinking water, riparian habitat, watershed health, fisheries, wetlands protection, and overall environmental quality. An important plan related to this effort is the *Oregon Plan for Salmon and Watersheds.* Solutions require multi-agency and intergovernmental efforts. While the decisions and projects will vary with each disaster, the state will continue its efforts to develop appropriate policies and criteria to ensure that these are considered along with hazard mitigation needs. This includes guidance on large wood placement, restoration after flood events, and habitat-friendly methods to accomplish pre- and post-disaster hazard mitigation. Watershed assessments being completed around the state by local watershed councils will be used in the evaluation of flood hazards and floodplain processes.	Completed	2015
27	Develop a statewide strategy to encourage the purchase of flood insurance	It's well-known that well-insured communities recover faster. A strategy will help the state direct information to under-insured areas thereby reducing vulnerability, facilitating recovery, and increasing access to "increased cost of compliance" funding.	Progressing	DLCD has consistently worked with FEMA to assist local communities in promoting and encouraging the purchase of flood insurance. A formal statewide strategy has not yet been adopted, but outreach efforts have been undertaken.
28	Establish a web page where building owners can register their interest in participating in acquisition programs for flood-damaged buildings	FEMA funds can be used to buyout repetitive loss and severe repetitive loss properties in the floodplain. The paperwork and process to achieve a buyout are lengthy and complex. First and foremost, a property owner must be willing to sell. Buyout funds could be more efficiently and effectively spent if willing sellers were identified and paperwork prepared before funds became available. This registry would augment the state's current outreach efforts, making it easy for willing sellers to identify themselves and for the state to prepare for and execute buyouts.	Not being pursued	Lack of resources
29	Strengthen the existing Community Rating System (CRS) rating of at least five jurisdictions, with emphasis on coastal jurisdictions, during the life of each Oregon NHMP	The CRS, part of the NFIP, is a program that rewards communities for going above and beyond the minimum requirements of the NFIP in minimizing potential losses due to flooding. There are a number of measures a community can implement to obtain a CRS rating, and most communities do not implement them all. As a community implements more CRS flood protection measures, its CRS rating is strengthened, and the community is rewarded with better flood protection and lower flood insurance rates.	Progressing	No jurisdictions have strengthened their CRS rating. However DLCD supports a community driven CRS User Group that helps communities increase their CRS rating by providing them with support, resources, and access to local, state, and federal expertise. The CRS User Group meetings are a way for current and future (interested) CRS communities to come together and share best practices, learn more about CRS activities, and share resources. DLCD has promoted CRS participation at all Community Assistance Visits (CAVs) and Community Assistance Contacts (CACs). The State has conducted over 100 CAVs and CACs since 2015.
30	Provide technical assistance to local Gov'ts to help integrate hazard mitigation plans with local comprehensive plans	Local NHMPs are often adopted as an appendix to the comprehensive plan or separately and are therefore in practice not used to their full potential. By assisting local Gov'ts in integrating the two plans, hazard mitigation will be more easily and meaningfully implemented in local land use planning practice.	Progressing	DLCD, in partnership with DOGAMI, completed one NOAA-funded tsunami land use resilience project and is in process with a second NOAA-funded tsunami land use resilience project. These efforts have led to several local jurisdictions incorporating tsunami mitigation actions from their local hazard mitigation plans into their local comprehensive plans. The following coastal jurisdictions have adopted Tsunami Hazard Overlay Zones into their land use plans between 2016 and 2019: Coos County, Douglas County, Reedsport, Florence, North Bend, Rockaway Beach, Gearhart, Port Orford, and Tillamook County. Most of those jurisdictions have also completed Tsunami Evacuation Facilities Improvement Plans to identify evacuation routes and improvement projects. Coos County also adopted new and updated provisions to their Natural Hazard Overlay Zone, which addressed mitigation actions identified in their NHMP.
31	Improve state agency procedures for tracking data on State-owned/leased buildings and critical or essential facilities	Create a policy standard for facilities data collection required from state agencies on an annual basis. Develop a facilities data framework standard that best enables hazard mitigation analysis; incorporate data into DAS-CFO DataMart and make available to partner agencies at will.	Progressing	We have implemented a data collection standard and adopted a FEMA Rapid Visual Screening method for assessing facility risks for agencies participating in our facility condition assessment program. Risk data is not complete for the entire portfolio, and Benefit Cost Analyses have only been complete for a handful of state buildings. Currently, our central database is not setup to accommodate the BCS data. Completion is dependent on funding priority, so an estimated date is difficult.

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#	**Statement**	**Description**	**Status**	**Explanation**
32	Request and compile seismic and flood information for personnel-occupied buildings from other agencies	Determine flood and earthquake damage and losses expected to occur to the State-owned building inventory and provide advice on higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	Progressing	We have implemented a data collection standard and adopted a FEMA Rapid Visual Screening method for assessing facility risks for agencies participating in our facility condition assessment program. Risk data is not complete for the entire portfolio, and Benefit Cost Analyses have only been complete for a handful of state buildings. Currently, our central database is not setup to accommodate the BCA data. Completion is dependent on funding priority, so an estimated date is difficult.
33	Request seismic and flood information from landlords as part of analyzing potential leased spaces going forward in new leases and potential renewals	Determine flood and earthquake damage and losses expected to occur to the state owned building inventory including higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	Progressing	The information is requested on an ongoing basis. However, landlords typically have not done seismic evaluations of their buildings.
34	Lidar survey the State's ROW (rights of way), west of the Cascade Range, to determine where landslide potential exists	The acquired information can improve critical infrastructure resilience in the face of landslide events, by providing useful information to planners, design professionals and decision makers prior to delivery system construction.	Progressing.	In 2017, ODOT began work on prioritizing landslide risks at the landscape scale (along high-risk highway corridors) and will help to optimize mitigation projects and seismic resiliency. This project will result in a user-friendly landslide risk mapping tool, along with guidance and training for ODOT staff.
35	Investigate/inventory DAS-owned buildings for seismic risk	Determine earthquake damage and losses expected to occur to the state owned building inventory and provide advice on higher education buildings. Produce information to enable development of statewide priorities and strategies to guide mitigation of earthquake risk, to protect lives during an earthquake, and to preserve ongoing operations after an earthquake. Use accepted methods to determine building type, construction and occupancy, to estimate damage and losses due to various earthquake scenarios and probabilities relating to building codes.	Completed	2016
36	Host at least one workshop or other educational opportunity on a biennial basis in communities where a Volcano Coordination Plan has been adopted	The State of Oregon will actively work to increase the public's knowledge of the volcano hazard in Oregon.	Not being pursued	Lack of funding
37	Achieve 100% state agency participation in the Great Oregon ShakeOut	Practicing to "drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. State agencies are setting an example by conducting a drill annually. The State of Oregon will have 100% State agency participation in the Great Oregon ShakeOut and will encourage schools and universities to participate.	Progressing	The state continues efforts to improve participation with the goal of reaching 100% participation.
38	Fund and provide technical assistance for local Gov'ts to engage in evacuation route planning and project implementation	After a Cascadia Subduction Zone earthquake, a tsunami could arrive within minutes. It is essential that residents and visitors be able to quickly move to high ground. Some evacuation planning is already underway. Local Gov'ts need funding and technical assistance to begin or continue to engage in evacuation planning.	Progressing	As a result of BTW tsunami evacuation modeling, DOGAMI and OEM are encouraging local communities to use these results where available, to help guide their local tsunami signage planning. A beach to safety plan is now encouraged, whereby communities evaluate signage needs along the entire evacuation route. Funding for sign purchase is presently provided via the NTHMP, while sign installation is achieved through local in-kind support. The following coastal jurisdictions have adopted Tsunami Hazard Overlay Zones into their land use plans between 2016 and 2019: Coos County, Douglas County, Reedsport, Florence, North Bend, Rockaway Beach, Gearhart, Port Orford, and Tillamook County. Most of those jurisdictions have also completed Tsunami Evacuation Facilities Improvement Plans to identify evacuation routes and improvement projects. Several more communities are in process to adopt tsunami resilience measures in the near future.
39	Install real-time monitoring capabilities on the remaining 51 state-operated stream gages, with the goal of making the network 100% real-time by the year 2020	The availability of timely and accurate data from stream gages is essential for flood forecasting, for prediction of imminent flood hazards, and for response to flood emergencies. Today, 178 of the state's 229 stream gages provide real-time data. Upgrade the state's existing stream gaging network, with the goal of installing real-time capability on all remaining gages.	Progressing	238 out of a total of 255 gages are now real-time. Continue expansion and upgrading of network.

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#	**Statement**	**Description**	**Status**	**Explanation**
40	Implement better way-finding solutions for tsunami evacuation. Create hardened and improved evacuation routes to include elevated safe areas above the level of modeled inundation	After a Cascadia Subduction Zone earthquake, a tsunami could arrive within minutes. It is essential that residents and visitors be able to quickly move to high ground on foot. This requires clearly marked and safe routes that pedestrians are able to navigate even in dark and stormy weather. Where high ground is available, projects should be identified that will enable Oregon to establish new standards and guidelines for methods to harden and mark way-finding of tsunami evacuation routes to natural high ground. Where natural high ground is not within the expected evacuation time, evaluate the retrofit of existing facilities and/or construction of new facilities that rise above the level of tsunami inundation and can serve as safe haven refuges.	Progressing	This is on-going because there is always something that can be improved.
41	Develop an incentive or subsidy program for retrofit of one and two family residences	Design a system of grants or tax credits to encourage homeowners to retrofit residences to minimize displaced post-earthquake shelter demand and reduce population loss during recovery. At the same time, take advantage of weatherization measures such as energy audits, cash rebates, and tax credits to help keep the cold out during winter.	Not being pursued	Lack of resources
42	Request the Oregon Legislature to fund the State Disaster Loan and Grant Account" immediately following a presidentially declared disaster or other disaster	The State Disaster Loan and Grant Account includes an account that can be used to fund local government and school district mitigation projects after a Presidentially declared disaster. The Oregon Legislature may authorize deposits to the account when requested.	Progressing	The account has been funded and used on occasion.
43	Review and adjust State IHMT membership	As state and agency priorities and personnel change, agency membership should be reviewed and adjusted, and member agencies should be encouraged to budget for participation in State IHMT activities. In late 2014, Emergency Support Functions were reassigned, and the new structure should be considered when reviewing State IHMT membership. When membership is aligned with its goals and mitigation actions, the State IHMT will provide better oversight and leadership of the state's mitigation strategy and programs.	Completed	IHMT membership was reviewed and adjusted in 2018 together with a request to IHMT agency directors to budget for participation in the Oregon NHMP update.
44	Establish formal and official authority for the State IHMT	Since its formation, the State IHMT has continued to play a major role in hazard mitigation activities, including the development of this hazard mitigation plan. There is strong agreement that the State IHMT is important, should be continued, and ought to be made permanent because it is the only state body focused on coordination of natural hazard mitigation. It is recommended that the State IHMT be formally and officially established.	Progressing	There has been discussion about whether this is necessary or desirable and if so, the best way to accomplish it. No decisions have been made.
45	Develop a system for prioritizing and ranking State-owned facilities, including critical facilities, for mitigation	Create an evaluation framework for determining a comprehensive list of critical State-owned facilities in terms of local and regional service needs in the event of a natural disaster; prioritize these critical facilities based on mitigation needs by disaster type; and evaluate each critical facility on the basis of investment cost and potential relocation/decommission in locations with increased hazard risk.	Not being pursued	Lack of resources
46	Provide the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* to local Gov'ts	To encourage communities to use *Planning for Natural Hazards: Oregon Technical Resource Guide* it must be provided to them.	Not being pursued	The Technical Resource Guide has not been updated, and update is not being pursued. Therefore the updated Guide has not been provided to local governments.
47	Produce Coastal Development Handbook	Produce a *Coastal Development Handbook* that addresses coastal process and hazards, beach and shoreland public policy, buying oceanfront property [what to look for, what questions to ask], building on oceanfront property, choosing appropriate hazard mitigation techniques, and choosing and using geotechnical consultants and engineers.	Not being pursued	This was considered and it was determined that this information already exists and is available to the public through DLCD's website. Video: "Living on the edge: Buying and building property on the OR coast." DLCD, NOAA, Sea Grant.
48	Evaluate the impact of climate change on landslides	The precipitation-triggered landslides will increase or decrease with changes in climate. Evaluation of this change will be important for the future of Oregon.	Progressing.	We collaborated with NASA on a project to look at the impacts of climate change on landslides in Oregon. This is a current project, so no results are available yet.
49	Create new lidar-based Landslide Inventory and Susceptibility Maps, especially near population centers	DOGAMI will create these maps in cooperation with local jurisdictions. Specific methods and priority locations are still to be determined. The locations will be determined by the Oregon Landslide Workgroup (#6, Priority). These new maps will enable communities to introduce development restrictions or recommend mitigation strategies in areas highly susceptible to landslides.	Progressing.	This is happening in a piecemeal fashion through individual projects which may or may not cover population centers.
50	Update *Planning for Natural Hazards: Oregon Technical Resource Guide*	*Planning for Natural Hazards: Oregon Technical Resource Guide* was published in 2000 and needs to be updated.	Not being pursued	This was considered. It was determined that the Guide, while old, is still useful, and updating the Guide is not necessary.

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#	**Statement**	**Description**	**Status**	**Explanation**
51	Facilitate self-sustaining outreach programs staffed by Community Emergency Response Teams (CERT) in each coastal population center aimed at creating a culture of preparedness and response for both local Cascadia and distant tsunami events	Establish Community Emergency Response Teams (CERT). These teams will work to save lives and restore communities following a major disaster. Encourage CERT to use outreach techniques tested in a 2005 pilot study of Seaside (#1 priority = door-to-door education; #2 priority = community evacuation drill; #3 = K-12 education supplemented by workshops targeted at specific user groups such as the lodging industry). Create measures of sustainability and success.	Not being pursued	Lack of funding
52	Determine the effectiveness of and the feasibility of using the Emergency Alert System (EAS) in dust prone areas to provide timely information to the traveling public about dangerous blowing dust conditions and make improvements if needed	ODOT and OSP have primary responsibility for activating the traffic advisory components of the dust storm response plan for the Mid-Columbia Region. The National Weather Service can also activate EAS from their forecast offices in Pendleton, Boise, Medford, and Portland. Many local emergency program managers can also activate the system. Providing this information can save lives in the event of a dust storm.	Not being pursued	ODOT already has reader boards and low power radio stations that broadcast traveler information throughout the Mid-Columbia region that are dedicated for weather related incidents like dust storms, severe weather, and blowing snow that are triggered by NWS alerts. Additionally, locally emergency managers already have access to EAS and IPAWS. Through IPAWS, they can issue a Wireless Emergency Alert (WEA), which is much more effective and reliable than EAS. Our current EAS infrastructure in Oregon is antiquated and much less reliable that IPAWS. Many of the units at the local level are more than 20 years old and are not very reliable. Additionally, not all county PSAPs have EAS units and rely on neighboring counties for analog access to EAS. The Oregon Association of Broadcasters has put together a package to request funding from the Oregon Legislature to upgrade the EAS network, but the bill was never voted on, due to early shutdown of the senate.
53	Add at least three new flood inundation forecast points to the National Weather Service's Flood Inundation Mapping website and the USGS's Flood Inundation Mapper before 2018	The National Weather Service (NWS) Advanced Hydrologic Prediction Service (AHPS) has developed inundation mapping sites for various stream gage locations nationwide. Currently there are none in Oregon. This is a useful tool for understanding potential inundation areas based on NWS forecasts. NWS: http://water.weather.gov/ahps/inundation.php; USGS: http://wim.usgs.gov/fimi/)	Not being pursued	The National Weather Service's Advanced Hydrologic Prediction Service uses dozens of real-time or near-real-time observed water level data in Oregon from the United State Geological Survey's National Streamflow Information Program to produce a suite of River Forecast Center products. These products include water resource forecasting, ensemble streamflow prediction, and hydrometeorological analysis and support that enable government agencies, private institutions, and individuals to make more informed decisions about risk-based policies and actions to mitigate the dangers posed by floods and droughts. (NWS: https://water.weather.gov/ahps/rfc/rfc.php; USGS: https://waterdata.usgs.gov/nwis/rt)
54	Support and implement the actions in the February 2013 Oregon Resilience Plan and recommended in the Oregon Resilience Plan Task Force's October 2014 report	The Oregon Resilience Task Force was established by Senate Bill 33. It was tasked to facilitate a comprehensive and robust plan to implement the strategic vision and roadmap of the Oregon Resilience Plan for responding to the consequences of naturally occurring seismic events associated with geologic shift along the Cascadia subduction zone. The Task Force's report was delivered to the legislature on October 1, 2014.	Progressing	OSSPAC continues to strive to implement the measures recommended in the 2013 Oregon Resilience Plan, especially those prioritized in the Resilience Task Forces 2014 Report to the Legislature.
55	Use DAS-CFO data and investigation/inventory of seismic and flood risk to DAS-owned/leased buildings in an effective, routine decision-making process for building occupancy, maintenance, use and potential mitigation treatments	This information over time can provide for strategic and responsible voluntary flood and seismic upgrades in areas of greatest need for reasonable cost as a part of broader facilities management.	Progressing	Information is used to inform/prioritize DAS facility planning on a biennial basis. Continuously ongoing.
56	Identify, prioritize, and map areas susceptible to rapid channel migration	Identify areas susceptible to rapid channel migration. Prioritize those areas' susceptibility and rank their risk from a rapid channel migration event. Create channel migration zone and risk maps for the areas determined to have the highest risk for rapid channel migration.	Completed	DOGAMI completed and published the Statewide Subbasin-Level Channel Migration Screening for Oregon in 2017 (IMS-56). This study classified first-order streams into segments of high, medium, and low channel migration susceptibility for each of the 86 subbasins in Oregon, made recommendations for further mapping and assessment based on classifications, and produced a geodatabase containing the classified stream segments and associated metadata.
57	Prepare model coordination protocols for local Floodplain Managers and Building Officials	Local government Floodplain Managers and Building Officials are often unaware of the other's role in floodplain management and how they could work together to better manage floodplain development and mitigate flood hazards. Providing model protocols for the two positions to coordinate would increase each one's awareness of the other's role, ultimately enhancing local flood hazard mitigation.	Completed	Model Standard Operating Procedures for processing floodplain development permits have been developed that address and incorporate model protocols for coordination between local Floodplain Managers and Building Officials.

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58	Develop a database of non-State-owned critical/essential facilities and their property values	FEMA requires the state's plan to: 1) identify critical facilities located in the identified hazard areas; and 2) estimate the potential dollar losses to those structures. Data for non-State-owned critical facilities is incomplete and lacks standardization, therefore creating a wide margin of error. Identifying local non-State-owned critical facilities and gathering descriptive data for these structures will help increase the quality of the data, resulting in a more precise understanding of state and regional vulnerabilities and mitigation priorities.	Progressing	Such a database was developed for the 2020 Oregon NHMP update, but the data still has limitations.
59	Schedule three opportunities over the life of this plan for state-local dialogue on vulnerability assessments to improve consistency and mutual understanding	Traditionally, local jurisdictions have used the OEM Hazard Analysis Methodology to update LNHMP vulnerability assessments. State agencies with hazard oversight use a wide range of methods to conduct statewide vulnerability assessments for the Oregon NHMP. The results are varying degrees of similarities and differences among local and state vulnerability scores. This dialogue is intended for the state and local Gov'ts to educate each other on the rationale behind the differing scores and to identify ways to better align local and state vulnerability assessments.	Not being pursued	One state-local dialog on this topic took place at the Oregon Emergency Management Conference in April 2016. This action can be incorporated into the continued development of a new standardized risk assessment methodology.
60	Identify funding to support various public transportation providers and local jurisdictions to conduct comprehensive vulnerability assessments of their transportation facilities and services	OSSPAC, in the Oregon Resilience Plan has identified an immediate near-term need to inventory and assess vulnerability and mitigation opportunities for local street networks, transit assets, ports, airports, and railroads. The Oregon Resilience Task Force in its October 2014 report to the Oregon Legislature suggested ongoing funding inventory, assessment, and mitigation. These activities would serve to reduce vulnerability to a Cascadia Subduction Zone event.	Progressing	ODOT's Transportation and Climate Change Program that is conducting Vulnerability assessments, FHWA pilot studies for coastal highways, case studies for impacted communities, and leading initiatives for sea level rise mapping and guidance. The Program also sponsors long-term research for coastal landslide and bluff erosion monitoring and development of automated landslide hot-spot mapping (considering future impacts of climate change).
61	Install High Water Mark (HWM) signs after flood events and co-locate stage crest gages on select HWM signs	HWM signs installed in high visibility areas increase the general public's awareness of flood risk and drive flood mitigation actions in communities. They spark conversations about past floods and are a good entry point for discussions promoting mitigation actions such as elevating buildings, purchasing flood insurance, and participating in FEMA's Community Rating System Program. Stage crest gages co-located with select HWM signs will capture new high-water data when floods occur.	Progressing	The interagency Oregon Silver Jackets Team has installed high water mark signs in several communities to demonstrate the height of flooding during past, historical floods in Oregon. In 2014, the Team installed signs in Albany and Oregon City; in 2015, the Team installed signs in Turner and Vernonia; in 2019, the Team installed temporary signs in Salem and Eugene. These signs have attracted media attention and served to raise awareness of potential future flooding. The team is pursuing funding for placing HWM in Umatilla County in response to the February 2020 flood events.
62	Develop incentives to increase the rate of replacement of privately owned seismically deficient buildings	Develop tax incentives, permit facilitation, and other means to increase the natural rate of building turnover.	Not being pursued	Lack of funding
63	Identify areas on the coast that will be "islands", or cut off, from other cities or critical recovery resources following a Cascadia Subduction Zone earthquake & tsunami	Produce GIS database of resources in each "island" expected to be isolated after a Cascadia Subduction Zone (CSZ) earthquake and resulting tsunami in order to preplan for response. Shape files are to be imported into RAPTOR, Oregon Explorer, and other GIS tools. This action item supports the local community's ability to prepare for and sustain or recover function following a CSZ earthquake and tsunami.	Completed	2016
64	Evaluate sediment impacts to Oregon's water resources	Oregon has unique water resources, some of which are for drinking water. Landslides can have a great impact on this resource by input of large amounts of sediment. Evaluation of erosion potential by watershed would help the regulators and providers identify areas for mitigation.	Progressing	A detailed study was completed for the Bull Run watershed https://www.oregongeology.org/pubs/sp/p-SP-46.htm. This is happening in a piecemeal fashion through individual projects.
65	Prioritize mitigation and retrofit projects on seismic lifelines	ODOT Seismic Lifelines Evaluation, Vulnerability Synthesis and Identification Report provides recommended priority corridors but does not provide sufficient detail to actually prioritize retrofit investment packages. Engineering evaluations and cost estimation are ongoing on a funding-available basis and will inform that prioritization process.	Progressing	ODOT has prioritized and obtained funding for its first set of retrofits.
66	Provide funding and technical assistance to local Gov'ts to use the new guidance on classifying lands subject to natural hazards in their buildable lands inventories and adjusting urban growth boundaries	Local Gov'ts need funding and technical assistance to be able to use the new guidance on how to classify lands subject to natural hazards and adjust urban growth boundaries to protect life, property, and the environment from natural hazards while providing for efficient development patterns within urban growth boundaries. Comprehensive Plan amendments are likely to result. This funding and technical assistance will promote integration of local natural hazards mitigation plans with comprehensive plans.	Not Started	If the guidance is developed, the State will undertake this action.

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#	**Statement**	**Description**	**Status**	**Explanation**
67	Initiate an outreach strategy to encourage local jurisdictions to disseminate volcano preparedness educational materials	Increase the ability of Oregonians to prepare for and recover from volcanic hazards.	Not being pursued	Lack of funding
68	Develop guidance on determination of mudslide triggers and relation to rain or flood events	Work with FEMA Region 10, DOGAMI, and other interested parties to develop scientifically and legally based guidance on when mudflows are to be considered part of a rain or flood event pursuant to the NFIP. Address the definition of mudflow, regulatory factors, scientific understanding of mudslides, and implications for flood insurance.	Not started	No work has been completed as of February 2020. If funding becomes available to support this work, the state will pursue this action.
69	Update the 2000 Guidelines for conducting site-specific geohazard investigations	The state has guidelines for conducting site-specific seismic investigations. The guidelines date from 2000 and need to be updated. The update should expand the scope of the guidelines to cover site-specific investigations for all geohazards. This will improve local government implementation of development regulations in areas subject to geohazards.	Completed	The Oregon State Board of Geologist Examiners guidelines were updated to "Guidelines for Engineering Geologic Reports (2014), and is at: https://www.oregon.gov/osbge/Documents/engineeringgeologicreports_5.2014.pdf For liquefaction, this National Academies Liquefaction Study Report (2016) should be used: https://www.nap.edu/catalog/23474/state-of-the-art-and-practice-in-the-assessment-of-earthquake-induced-soil-liquefaction-and-its-consequences
70	Conduct a pilot project on two coastal estuaries to develop a framework for modeling sea level rise and to assess the overall impact of sea level rise on the estuaries	Implement sea level rise modeling for the pilot study areas. Study results will be used to guide a future, more comprehensive and coast-wide assessment of sea level rise impacts. Once completed, the results can be used minimize future damage or loss of property and the environment.	Progressing	Modeling was undertaken by researchers at Oregon State University as part of a pilot study in Tillamook Bay in an effort to better understand the relationship between future climate change and its effects in the estuary. Although these results have been published in scientific journals, more work is need in this area in order to refine on past techniques. Presently, however, there is no funding to support this task and limited capacity within DOGAMI to move this forward. As a result, this task is stalled until both situations improve.

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71	Coordinate development of a post-disaster scientific and technical clearinghouse with other state and federal agencies, higher education, and associations	When an earthquake, flood, tsunami, or other disaster strikes the state, there will be an influx of scientists and engineers from inside and outside the state to study the event and offer help. There needs to be a coordination of their efforts to put them to use in the most efficient and effective way possible. This clearinghouse will work with the emergency coordination center established immediately after the earthquake, flood, tsunami, or other disaster.	Progressing	After the Eagle Creek forest fire in 2017, many entities came together in coordinated, task-based and subject-specific groups, culminating with a Table Top exercise for a post-fire landslide scenario, organized by Multnomah County Emergency Management and involving DOGAMI along with over 10 other agencies. Scientists and emergency managers continue to collaborate through data sharing of landslide data and aerial photography, along with contribution to a landslide response plan, implemented when a landslide occurs in the Columbia River Gorge. As a part of this coordinated, post-fire effort, ODOT collected intermittent aerial photography and monitored for change through helicopter flights, and DOGAMI collaborated with ODOT and USGS for a generalized landslide hazard map for First Responders, including emergency management and the Sheriff's Office. The Oregon Silver Jackets Team has both a Communication Plan and a Perishable Data Plan that are used to coordinate efforts during and after flood events. This Team hosts call-in meetings to distribute information and help coordinate flood response between agencies including DOGAMI, US Army Corps of Engineers, US Geological Survey, Office of Emergency Management, and National Oceanic and Atmospheric Administration's National Weather Service. They also collect perishable data, such as high water marks, that can be used to map the area of inundation and can be used to calibrate or validate flood models. The Communications and Perishable Data Plans were utilized regularly during the last five years. The Oregon Office of Emergency Management (OEM) runs the Oregon Emergency Response System (OERS) that serves to coordinate and manage state resources in response to natural disasters and man-made emergencies. OEM also maintains the Real-time Assessment and Planning Tool for Oregon (RAPTOR) which shares emergency response and hazard information before, during, and after an event. These datasets help to coordinate interagency disaster response. OEM also prepares After-Action Reports and Oregon Disaster Story Maps that summarize the impacts of the event. DLCD is included in the State Disaster Recovery Plan as State Recovery Function (SRF) 1 as the lead of community planning and capacity building. DLCD representatives are members of the OERS council.
72	Update DOGAMI Special Paper 29 ((Wang & Clark, 1999))	Update 1999 Special Paper 29, Earthquake Damage In Oregon: Preliminary Estimates of Future Earthquake Losses, a statewide damage and loss estimation study (Wang and Clark, 1999). This update, at a minimum, should incorporate damage and loss estimates for a magnitude 9 Cascadia earthquake, an exposure analysis of tsunami hazards, and probabilistic hazards including updated probabilistic earthquake ground motions and flooding zones. School and emergency facilities from the 2007 DOGAMI database should be incorporated.	Removed	Replaced with an updated mitigation action.
73	Develop probabilistic multi-hazard risk maps for the Oregon Coast	Consider and examine combinations and permutations of multi-hazard risk exposure and maps for the entire Oregon Coast.	Progressing	DOGAMI completed probabilistic coastal flood modeling for all 7 counties. In 2020, DOGAMI will be working with scientific experts on Cascadia to produce new updated earthquake source scenarios, which in time can be used to develop an improved probabilistic tsunami hazard analysis (PTHA) of Cascadia for the Pacific Northwest, with the eventual goal of replacing the existing ASCE7-16 tsunami design zone and geodatabase that have fundamental scientific flaws.
74	Lidar survey the State's ROW (rights of way), west of the Cascade Range, to determine where seismic fault potential exists	The acquired information can improve critical infrastructure resilience in the face of seismic events, by providing useful information to planners, design professionals and decision makers prior to delivery system construction.	Progressing	In 2017, ODOT began work on prioritizing landslide risks at the landscape scale (along high-risk highway corridors) and will help to optimize mitigation projects and seismic resiliency. This project will result in a user-friendly landslide risk mapping tool, along with guidance and training for ODOT staff.

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75	Assess hazards associated with active crustal faults newly discovered by statewide lidar program	Particularly in central and eastern Oregon, the major earthquake hazards result from poorly known crustal faults. Lidar has greatly expanded the ability to find these faults, which should be systematically evaluated for their potential to generate damaging earthquakes using trenching, geophysical and field studies. This action would help communities prepare and mitigate for newly defined hazard areas in central and eastern Oregon.	Progressing	Over the last decade, DOGAMI has been acquiring and analyzing large swaths of high-resolution lidar topographic data throughout Oregon. In Eastern Oregon and the Cascades, this has led to the identification of dozens of previously unknown, active young fault segments. Very few have been investigated, none in detail.
76	Establish process for assigning inspection teams to needed areas for post-disaster facility inspection	Work with OEM, local government building officials, and emergency planners to establish an effective process for assigning inspection teams to needed areas and educating local Gov'ts regarding the circumstances and process for initiating BCD and state involvement.	Completed	Current process is for local staff to meet this need. If local staff is unable to meet the need, the county makes a request (may be elevated from a city to the County) to the State Emergency Management response team through the Ops Center portal. After this request is made, the State will work to identify resources. This system was tested and was successful for the Umatilla flooding in February of 2020.
77	Develop an improved methodology for gathering data and identifying the communities most vulnerable to drought and related impacts	Although we know that areas in Oregon have suffered from drought, there has not been a coordinated effort to systematically characterize how frequently droughts have occurred, or the impact on Oregonians and ecosystems. Communities are beginning to plan for worst case drought scenarios and need better information about the frequency, duration, and intensity of previous droughts in order to assess the appropriate response. Comprehensive information is not currently available by region, or statewide.	Not started	Inadequate staffing and higher priorities at current staffing level. Possible 2024 start.
78	Establish a program for studying winter storms and their impacts statewide. As a part of that program, develop a system for gathering snowfall data statewide	Establish a network of snow accumulation tracking stations at strategic locations throughout the state to provide data tracking of snow fall accumulation over the short term and long term in order to develop statistics for studying snow level trends across the state.	Progressing	No funding and no champion for this work.

79	Continue to refine statewide natural hazard identification and characterization	The Oregon NHMP identifies the types of natural hazards affecting Oregon, their geographic extent, history and probability of occurrence, and as they may be affected by climate change. Throughout the life of the Plan, new and continuing research studies and projects provide new data and analysis, improving our ability to identify and understand Oregon's natural hazards and their probability of occurrence. To advance hazard mitigation in Oregon, it is important for the State to plan, budget, and take advantage of opportunities that arise for continued research and new studies to enhance our knowledge of Oregon's natural hazards.	ODF - Completed ODF – Ongoing DOGAMI - Ongoing	2018 PNW Quantitative Wildfire Risk Assessment addressed some of this need. ODF has also looked into potential research products that study wildfire potential with climate change, though these are still in planning stages. DOGAMI continues to receive funding support from the Northwest Association of Networked Ocean Observing System (NANOOS) in order to maintain its Oregon Beach Shoreline Mapping and Analysis Program (OBSMAP). DOGAMI monitors beach profile changes at 178 sites. Those established in Tillamook/Clatsop County are typically observed on a seasonal basis, while sites in Lincoln County are observed annually (time and funding permitting). DOGAMI formalized monitoring on the southern Oregon coast at Gold Beach and Nesika Beach, and in the Netarts littoral cell. Besides the transects, DOGAMI continues to collect MHHW tidal datum-based shorelines along each littoral cell. DOGAMI continues to work with NANOOS on developing improved climatologies of ocean waves, air and water temperature, and sea level changes. DOGAMI working on a pilot study to update the dune overlay for Tillamook County based on new statewide lidar, FEMA coastal flood modeling, and OBSMAP monitoring. The pilot study will be completed in 2020. However, it is anticipated that future funding will support expansion of this effort to other coastal counties. DOGAMI continues to play a key role in the National Tsunami Hazard Mitigation Program (NTHMP). Tsunami related work undertaken over the past several years include an acceleration in community-based evacuation modeling, new maritime tsunami modeling in the Columbia River and most recently in the Coos estuary. In 2020, DOGAMI will be working with scientific experts on Cascadia to produce new updated earthquake source scenarios, which in time can be used to develop an improved probabilistic tsunami hazard analysis (PTHA) for the Pacific Northwest, with the eventual goal of replacing the existing ASCE7-16 tsunami design zone and geodatabase that have fundamental scientific flaws. DOGAMI continues to seek funding to carry out studies that use lidar topography as a base for more detailed and accurate hazard maps for all hazards. Detailed earthquake hazard maps have been completed for Multnomah, Clackamas, Washington and Columbia Counties, and work is underway in Marion, Benton and Morrow counties and others. Work is also underway on an update to the statewide earthquake hazard maps using DAS-GEO funding and slated for publication in 2021. The update will include new products from the USGS 2018 National Seismic Hazard Maps. Lidar based DOGAMI geologic mapping and research starting in 2014 through 2020 is focused around and east of Mount Hood with a purpose to identify and age-date young volcanic vents and their flows that may pose hazards to nearby communities. This work is outlining both the volcanism pre-Modern Mount Hood and detailing the character of younger events. The work is being conducted in partnership with staff from the USGS Cascades Volcano Observatory (CVO). DOGAMI will apply for FY 2020 funding to study fault hazards in the Bend area, and for 2021 funds to study newly discovered faults in Grant County. DOGAMI hopes to create a new statewide fault database that includes faults recently discovered throughout the state using new lidar. DOGAMI has completed and published 26 new studies that refine statewide natural hazards identification and characterization and is currently in the process of performing at least 9 more studies that further this mitigation action. 2015: O-15-05, Coastal flood hazard study, Clatsop County, Oregon; O-15-06, Coastal flood hazard study, Lincoln County, Oregon; O-15-07, Coastal flood hazard study, Curry County, Oregon; SP-46, Surficial and bedrock engineering geology, landslide inventory and susceptibility, and surface hydrography of the Bull Run Watershed, Clackamas and Multnomah Counties, Oregon; SP-47, Coastal flood hazard study, Tillamook County, Oregon 2016: O-16-02, Landslide susceptibility overview map of Oregon; O-16-07, Monitoring the response and efficacy of a dynamic revetment constructed adjacent to the Columbia River south jetty, Clatsop County, Oregon; SP-48, Protocol for deep landslide susceptibility mapping 2017: IMS-56, Statewide subbasin-level channel migration screening for Oregon; O-17-02, Statewide Levee Database for Oregon, release 1.0: Major agricultural and urban areas in western Oregon and along the Columbia River; O-17-03, Landslide inventory of eastern Multnomah County, Oregon; O-17-

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				04, Landslide inventory of portions of northwest Douglas County, Oregon; O-17-05, Coastal flood hazard study, Lane and Douglas Counties, Oregon; SLIDO-3.0 / 3.4, Statewide Landslide Information Database for Oregon, release 3.0 (SLIDO-3.0) 2018: IMS-57, Landslide hazard and risk study of central and western Multnomah County, Oregon; IMS-60, Landslide hazard and risk study of Eugene-Springfield and Lane County, Oregon; O-18-01, Radon potential in Oregon; O-18-04, ArcGIS Python script alternative to the Hazus-MH Flood Model for User-Defined Facilities; SP-49, Beach and shoreline dynamics in the Cannon Beach littoral cell: Implications for dune management; SP-50, Flood risk assessment for the Columbia Corridor drainage districts in Multnomah County, Oregon; SP-51, Columbia River tsunami modeling: toward improved maritime planning response 2019: O-19-03, Columbia River simulated tsunami scenarios; O-19-04, Comparison of Oregon tsunami hazard scenarios to a probabilistic tsunami hazard analysis (PTHA); O-19-09, Coseismic landslide susceptibility, liquefaction susceptibility, and soil amplification class maps, Clackamas, Columbia, Multnomah, and Washington Counties, Oregon: For use in Hazus: FEMA's methodology for estimating potential losses from disaster; SP-52, The Scarp Identification and Contour Connection Method (SICCM): A tool for use in semi-automatic landslide mapping; SLIDO-4.0, Statewide Landslide Information Database for Oregon, release 4.0 (SLIDO-4.0)

80	Continue to refine the State's risk assessment methodology and statewide assessments of natural hazard exposure, vulnerability, and potential losses	At the core of the Oregon NHMP is a statewide risk assessment of exposure and vulnerability, and an estimate of potential dollar losses to State-owned/leased buildings, infrastructure, and critical or essential facilities from natural hazard events. Schools, emergency facilities, water and waste water, dams and levees, transportation, telecommunications, and energy facilities are examples of structures, infrastructure, and facilities that could be exposed and vulnerable to natural hazards. Other examples include populations, businesses, and industries. At this time, the state does not have a standardized risk assessment methodology across all hazards at the state and local levels. To advance hazard mitigation in Oregon, it is important for the State to plan, budget, and take advantage of opportunities that arise for continued enhancement of the risk assessment, better enabling limited mitigation resources to be directed to the areas that most need them.	DCBS-BCD – Ongoing ODF – Ongoing DOGAMI - Ongoing	DCBS-BCD: With the adoption of the 2019 Oregon Structural Specialty Code (OSSC) on October 1, 2019, building designs in Oregon must now comply with latest building and construction science available. This includes lateral force resisting elements to address; wind, earthquake, flood and where adopted locally, tsunami. It also captures the best science available for establishing ground snow loads. ODF: Oregon State University (OSU) Extension has now created the Oregon Explorer tool, an online portal to access GIS mapping with different data sets to address wildfire risk. In collaboration with Oregon Department of Forestry and the US Forest Service, this tool has taken the assessment data from the Quantitative Wildfire Risk Assessment (QWRA) and identified critical infrastructure, communities at risk, wildland urban interface, hazard (frequency & intensity), vulnerability (exposure & susceptibility), and overall wildfire risk information. This information can be utilized for planners or homeowners to assess risk throughout the state of Oregon. This assessment and GIS mapping tool will continue to be upgraded and improved as more information is made available. Within this tool there is data that address the hazard to potential structures. This analyzes potential losses if structures were to be built in those areas. There are current studies through OSU that will be attempting to address assessments of parcel level data that will help inform, with more accuracy, potential losses and risk to home, property, and critical infrastructure. DOGAMI continues to seek funding for studies to use updated earthquake hazard data to produce detailed earthquake loss estimates and risk studies. Projects have recently been completed for Multnomah, Clackamas, Washington and Columbia Counties and others. DOGAMI has initiated Hazus exposure and fatality modeling as a pilot study in five coastal communities: Gearhart, Rockaway Beach, Lincoln City, Newport, and Port Orford. This work is being undertaken collaboratively with DLCD and was funded through a NOAA coastal resilience grant. The technical report associated with this work will be published in early summer 2020, summarizing the overall study approach, and community profile results. With funding from the NTHMP, DOGAMI staff expanded on the initial coastal resilience grant pilot study and is now using Hazus to examine tsunami risk and exposure for three scenarios, M1, L1 and XXL1, in Clatsop, Tillamook, and Lincoln Counties. Funding has been requested from the NTHMP to undertake similar work in Coos County in 2021. Our goal is to eventually have Hazus completed for all coastal communities in the next five years. DOGAMI has completed and published 17 new studies that assess risk or advance the risk, vulnerability, or loss estimate methodology. In addition, DOGAMI has completed, but not published, 14 multi-hazard risk assessments for the following communities: Clatsop County, Tillamook County, Lincoln County, Coastal Lane County, Coastal Douglas County, Coos County, Curry County, Columbia County, Tualatin Watershed, Upper Rogue Watershed, Sandy River Watershed, Grant County, Baker County and Harney County. DOGAMI is currently in the process of performing 4 additional multi-hazard risk assessments for the following communities: Hood River County, Wasco County, and Sherman County. <u>2015</u>: O-15-01, Landslide susceptibility analysis of lifeline routes in the Oregon Coast Range; O-15-02, Local tsunami evacuation analysis of Seaside and Gearhart, Clatsop County, Oregon <u>2016</u>: O-16-08, Local tsunami evacuation analysis of Warrenton and Clatsop Spit, Clatsop County, Oregon <u>2017</u>; O-17-01, Oregon Hospital and Water System Earthquake Risk Evaluation Pilot Study; O-17-06, Local tsunami evacuation analysis of Rockaway Beach, Tillamook County, Oregon; Tsunami evacuation brochure/map for Waldport <u>2018</u>: IMS-57, Landslide hazard and risk study of central and western Multnomah County, Oregon; IMS-60, Landslide hazard and risk study of Eugene-Springfield and Lane County, Oregon; O-18-05, Tsunami evacuation analysis of Florence and Reedsport, Lane and Douglas Counties, Oregon; O-18-05, Tsunami evacuation analysis of Florence and Reedsport, Lane and Douglas Counties, Oregon; O-18-06, Tsunami evacuation analysis of Pacific City, Tillamook County, Oregon; SP-50, Flood risk assessment for the Columbia Corridor drainage districts in Multnomah County, Oregon; SP-51, Columbia River tsunami modeling: toward improved maritime planning response <u>2019</u>: O-19-05, Tsunami evacuation analysis of Newport, Lincoln County, Oregon; O-19-06, Tsunami evacuation analysis of Lincoln City and unincorporated Lincoln County: Building community resilience on the Oregon coast; O-19-07, Tsunami evacuation analysis of communities surrounding the Coos Bay estuary: Building community resilience on the Oregon coast; O-19-08, Tsunami evacuation analysis of

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				some unincorporated Tillamook County communities: Building community resilience on the Oregon coast
81	Continue to refine statewide identification and prioritization of the greatest risks from and communities most vulnerable to Oregon's natural hazards	Identifying and prioritizing the greatest risks from and communities most vulnerable to natural hazard events will enable the state to leverage its limited mitigation resources in ways that efficiently protect life, property, and the environment from natural hazard events and facilitate recovery.	ODF - Completed and Ongoing DOGAMI - Ongoing	ODF has recently completed the new 2020 Communities at Risk report and assessment that identifies Communities in the Wildland Urban Interface and their risk rating. This rating allows the state to prioritize fuels mitigation, education, and outreach opportunities to better protect life, property, and the environment from wildfire. There is a goal to update this report every 5 years with fresh data. DOGAMI has completed and published 17 new studies that identify the greatest risks from and communities most vulnerable to Oregon's geological hazards. 2015: O-15-01, Landslide susceptibility analysis of lifeline routes in the Oregon Coast Range; O-15-02, Local tsunami evacuation analysis of Seaside and Gearhart, Clatsop County, Oregon 2016: O-16-08, Local tsunami evacuation analysis of Warrenton and Clatsop Spit, Clatsop County, Oregon 2017: O-17-01, Oregon Hospital and Water System Earthquake Risk Evaluation Pilot Study; O-17-06, Local tsunami evacuation analysis of Rockaway Beach, Tillamook County, Oregon; Tsunami evacuation brochure/map for Waldport 2018: IMS-57, Landslide hazard and risk study of central and western Multnomah County, Oregon; IMS-60, Landslide hazard and risk study of Eugene-Springfield and Lane County, Oregon; O-18-05, Tsunami evacuation analysis of Florence and Reedsport, Lane and Douglas Counties, Oregon; O-18-05, Tsunami evacuation analysis of Florence and Reedsport, Lane and Douglas Counties, Oregon; O-18-06, Tsunami evacuation analysis of Pacific City, Tillamook County, Oregon; SP-50, Flood risk assessment for the Columbia Corridor drainage districts in Multnomah County, Oregon; SP-51, Columbia River tsunami modeling: toward improved maritime planning response 2019: O-19-05, Tsunami evacuation analysis of Newport, Lincoln County, Oregon; O-19-06, Tsunami evacuation analysis of Lincoln City and unincorporated Lincoln County: Building community resilience on the Oregon coast; O-19-07, Tsunami evacuation analysis of communities surrounding the Coos Bay estuary: Building community resilience on the Oregon coast; O-19-08, Tsunami evacuation analysis of some unincorporated Tillamook County communities: Building community resilience on the Oregon coast

82	Continue to develop and implement resilience initiatives statewide	Natural hazard mitigation is a fundamental element of resilience. It is important for the state to plan, budget, and partner with other public and private entities to alleviate potential damage from natural hazard events before they occur by (a) improving the reliability of critical/essential facilities, services, and infrastructure during and after a natural hazard event; (b) developing evacuation routes and facilities; (c) informing the public; (d) planning for long-term recovery; and (e) taking other necessary actions.	BCD – Completed OPRD – Ongoing ODF – Ongoing DOGAMI - Ongoing	BCD's statutory authority is limited to item (a) in so far as "new construction, reconstruction, alteration and repair" of buildings needs to be addressed. We have no authority to regulate items such as infrastructure, services, long term recovery and establishing evacuation routes. OPRD has been working on many activities related to statewide resilience in the last year. With regards to the items listed in the description: (a) OPRD has been working on inventories of critical facilities and supplies along with building resiliency into projects such as installing backup generators on wastewater lift stations, (b) continuing to develop evacuation routes for the parks and facilities along with (c) installing additional signage, designating official evacuation routes and pavement markings of evacuation routes and inundation zones, (d) development of the COOP (Continuity of Operations Plan) for the agency along with assembling an AOC (Agency Operations Center) for being able to provide agency responses to natural hazards as they occur and identifying essential staff and finally (e) conducting table top exercises both internal to the agency and participating in multi-agency exercises to think through responses to natural disasters at an agency wide level and local levels. This work is ongoing and as such does not have a completion date. ODF - This is part of ongoing urban and community forestry outreach to communities and other entities, such as nonprofit organizations, counties, etc. At least one program e-newsletter is sent to over 500 subscribers with storm and other natural disaster preparedness information annually. Local mitigation and planning for wildfire events are done through our partners of the Ready, Set, Go program, the State Fire Marshals, Keep Oregon Green, and other entities. Much of this is address when Firewise USA ® communities are established as well. With funding via the NTHMP and from DLCD, DOGAMI has accelerated its efforts to evaluate tsunami evacuation routes using "Beat the Wave (BTW)" evacuation modeling. To-date, we have completed BTW modeling in the following communities: Gearhart, Seaside, Rockaway Beach, Pacific City, Newport, Florence, Reedsport, Cape Meares, Netarts, Neskowin, Lincoln City, Lincoln Beach/Siletz Spit, Seal Rock, and Waldport. DOGAMI has completed and published 20 new studies that develop and implement resilience initiatives in Oregon. DOGAMI is currently in the process of performing at least 4 additional studies that also will continue to further this mitigation action. 2015: O-15-01, Landslide susceptibility analysis of lifeline routes in the Oregon Coast Range; O-15-02, Local tsunami evacuation analysis of Seaside and Gearhart, Clatsop County, Oregon; MTRG-2015-OR-01, Maritime tsunami response guidance for the Ports of Newport and Toledo, Lincoln County, Oregon; 2016: O-16-07, Monitoring the response and efficacy of a dynamic revetment constructed adjacent to the Columbia River south jetty, Clatsop County, Oregon; O-16-08, Local tsunami evacuation analysis of Warrenton and Clatsop Spit, Clatsop County, Oregon 2017: O-17-01, Oregon Hospital and Water System Earthquake Risk Evaluation Pilot Study; O-17-06, Local tsunami evacuation analysis of Rockaway Beach, Tillamook County, Oregon; Tsunami evacuation brochure/map for Waldport 2018: O-18-03, Oregon coastal hospitals preparing for Cascadia; O-18-05, Tsunami evacuation analysis of Florence and Reedsport, Lane and Douglas Counties, Oregon; O-18-05, Tsunami evacuation analysis of Florence and Reedsport, Lane and Douglas Counties, Oregon; O-18-06, Tsunami evacuation analysis of Pacific City, Tillamook County, Oregon; SP-49, Beach and shoreline dynamics in the Cannon Beach littoral cell: Implications for dune management; SP-51, Columbia River tsunami modeling: toward improved maritime planning response 2019: O-19-01, Summary report on the Oregon Coastal Hospital Special Leadership Event; O-19-02, Resilience guidance for Oregon hospitals; O-19-05, Tsunami evacuation analysis of Newport, Lincoln County, Oregon O-19-06, Tsunami evacuation analysis of Lincoln City and unincorporated Lincoln County: Building community resilience on the Oregon coast; O-19-07, Tsunami evacuation analysis of communities surrounding the Coos Bay estuary: Building community resilience on the Oregon coast; O-19-08, Tsunami evacuation analysis of some unincorporated Tillamook County communities: Building community resilience on the Oregon coast
83	Assist local governments in using the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* to update their comprehensive plans and development regulations	The original purpose of *Planning for Natural Hazards: Oregon Technical Resource Guide* was to assist communities in amending their comprehensive plans and development regulations to reduce risk from natural hazards, implementing Statewide Goal 7. The updated document will also be helpful in developing local hazard mitigation plans and integrating them with local comprehensive plans and development regulations.	Not being pursued	The Technical Resource Guide will not be updated and therefore technical assistance in using it is not being provided to local governments.

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84	Monitor the implementation of the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* provided to local governments by tracking the number of jurisdictions that have used it	Monitoring success of *Planning for Natural Hazards: Oregon Technical Resource Guide* will allow the State to adjust its approach and update the guidance as necessary, leading to better protection of life and property.	Not being pursued	The Technical Resource Guide will not be updated and therefore not provided to local governments so its use is not being monitored.
85	Provide support for development and update of local and state hazard mitigation plans	The State provides support for development of local NHMPs and the state NHMP by managing federal grant funding in ways that assist the state and local governments with NHMP development and update tasks and processes.	Ongoing	OEM has also long provided assistance with developing NHMPs to local governments and to special districts. DLCD began to assist local governments and special districts in 2016, and has already provided assistance to 14 counties and numerous cities, special districts, and one tribe. Assistance is planned for five more multi-jurisdictional plan updates and three stand-alone city updates. In addition, OPDR, a program in the University of Oregon's Institute for Policy Research and Engagement has long provided assistance with developing NHMPs to local governments and continues to do so at a reduced level. OPDR, OEM, and DLCD intend to continue this work.
86	Improve and sustain public information and education programs aimed at mitigating the damage caused by natural hazards	While ongoing efforts are being made in this area, a strong message conveyed by several State IHMT Reports notes the need to strengthen and sustain public information, education, and training efforts by providing additional resources. Although commonly recognized that interest in reducing losses increase during and after events, there is an ongoing need to provide residents and key stakeholder groups (such as infrastructure operators) with hazard mitigation information. These reports cite the need to have timely seasonal information available, better methods to inform residents of sources of hazard mitigation information, use improved electronic methods (e.g., web sites), and materials oriented toward the intended users. This helps keep awareness levels higher, will stimulate actions by some, and reminds users to consider and include hazard mitigation measures in the contexts of regular activities, such as building a new home, relocating an office, or repairing a business.	Ongoing	Progress at DOGAMI has been slowed due to the eliminating of the Communications Director position and activities due to lack of resources. Some progress is being made by DOGAMI's Strong Motion Instrument Program activities and education on ShakeAlert.
87	Continue to improve inventory of State-owned/leased buildings in all hazard areas	Using DAS's data, DOGAMI developed an inventory of State-owned/leased buildings and identified those in hazard areas for the 2012 Plan and updated the inventory for the 2015 Plan. The data should be continuously updated by DAS-CFO to facilitate DOGAMI's inventory updates in future plan cycles.	Ongoing	The Statewide Facility Inventory is managed by the CFO (our unit) and updated continuously, including precise geolocation. It is provided to agencies that request it.
88	Encourage citizens to prepare and maintain at least two weeks' worth of emergency supplies	State agencies should work with the American Red Cross and local emergency managers to encourage citizens to be prepared to survive on their own for at least two weeks.	Ongoing	Part of on-going public outreach strategy
89	Continue to assist local governments with GIS capability development	Assist local governments with GIS program development, including system planning, hardware/software costs, training, and data development in relation to all hazards mapping and regulation of coastal development.	Not Being Pursued	The State will not be establishing a formal program but does assist local governments upon request.

90	Use lidar for statewide analysis of all natural hazards	Lidar is currently the best source of regional topographic data and allows for highly precise and accurate natural hazard mapping (landslide, flooding, volcanic hazards, channel migration zones, tsunami, geologic faults, etc.) and infrastructure inventories (buildings, utilities, lifelines, etc.). Many Oregon state agencies currently use lidar for natural hazard analyses and will continue to do so where lidar is available.	Ongoing	DOGAMI bases all of its community hazard studies on lidar derived topography, and uses it for statewide projects wherever it is available. DOGAMI continues to develop new techniques to incorporate lidar topography into more detailed and accurate hazard and risk studies. Lidar-based DOGAMI geologic mapping and research starting in 2014 through 2020 is focused around and east of Mount Hood with a purpose to identify and age-date young volcanic vents and their flows that may pose hazards to nearby communities. This work is outlining both the volcanism pre-Modern Mount Hood and detailing the character of younger events. The work is being conducted in partnership with staff from the USGS Cascades Volcano Observatory (CVO). DOGAMI has completed and published 51 new studies that have used lidar for analysis of natural hazards in Oregon. DOGAMI is currently in the process of performing at least 10 additional studies that also will continue to further this mitigation action. <u>2015</u>: BF-15-01, Base Flood Elevation Determination for Reach of North Santiam River, Marion and Linn Counties, Oregon; BF-15-01, Base Flood Elevation Determination for Reaches of Frazier Creek and Mountain View Creek, Benton County, Oregon; O-15-01, Landslide susceptibility analysis of lifeline routes in the Oregon Coast Range; O-15-02, Local tsunami evacuation analysis of Seaside and Gearhart, Clatsop County, Oregon; O-15-04, Geologic map of the southern Oregon coast between Bandon, Coquille, and Sunset Bay, Coos County, Oregon; O-15-05, Coastal flood hazard study, Clatsop County, Oregon; O-15-06, Coastal flood hazard study, Lincoln County, Oregon; O-15-07, Coastal flood hazard study, Curry County, Oregon; SP-46, Surficial and bedrock engineering geology, landslide inventory and susceptibility, and surface hydrography of the Bull Run Watershed, Clackamas and Multnomah Counties, Oregon; SP-47, Coastal flood hazard study, Tillamook County, Oregon; OGDC-6, Oregon geologic data compilation [OGDC], release 6 (statewide) <u>2016</u>: BF-16-01, Base Flood Elevation Determination for Lower Reach of Gate Creek Near Vida, Lane County, Oregon; BF-16-02, Base Flood Elevation Determination for Reaches of Lake Creek, Deadwood Creek, and Nelson Creek Near Deadwood, Lane County, Oregon; O-16-02, Landslide susceptibility overview map of Oregon; O-16-07, Monitoring the response and efficacy of a dynamic revetment constructed adjacent to the Columbia River south jetty, Clatsop County, Oregon; O-16-08, Local tsunami evacuation analysis of Warrenton and Clatsop Spit, Clatsop County, Oregon; SP-48, Protocol for deep landslide susceptibility mapping <u>2017</u>: IMS-56, Statewide subbasin-level channel migration screening for Oregon; O-17-01, Oregon Hospital and Water System Earthquake Risk Evaluation Pilot Study; O-17-02, Statewide Levee Database for Oregon, release 1.0: Major agricultural and urban areas in western Oregon and along the Columbia River; O-17-03, Landslide inventory of eastern Multnomah County, Oregon; O-17-04, Landslide inventory of portions of northwest Douglas County, Oregon; O-17-05, Coastal flood hazard study, Lane and Douglas Counties, Oregon; O-17-06, Local tsunami evacuation analysis of Rockaway Beach, Tillamook County, Oregon; SLIDO-3.0 / 3.4, Statewide Landslide Information Database for Oregon, release 3.0 (SLIDO-3.0); DOGAMI Lidar Viewer Publication; Tsunami evacuation brochure/map for Waldport <u>2018</u>: GMS-120, Geologic map of the Devine Ridge South 7.5' quadrangle, Harney County, Oregon; GMS-121, Geologic map of the Devine Ridge North 7.5' quadrangle, Harney County, Oregon; IMS-57, Landslide hazard and risk study of central and western Multnomah County, Oregon; IMS-60, Landslide hazard and risk study of Eugene-Springfield and Lane County, Oregon; O-18-01, Radon potential in Oregon; O-18-02, Earthquake regional impact analysis for Clackamas, Multnomah, and Washington counties, Oregon; O-18-04, ArcGIS Python script alternative to the Hazus-MH Flood Model for User-Defined Facilities; O-18-05, Tsunami evacuation analysis of Florence and Reedsport, Lane and Douglas Counties, Oregon; O-18-05, Tsunami evacuation analysis of Florence and Reedsport, Lane and Douglas Counties, Oregon; O-18-06, Tsunami evacuation analysis of Pacific City, Tillamook County, Oregon; SP-49, Beach and shoreline dynamics in the Cannon Beach littoral cell: Implications for dune management; SP-50, Flood risk assessment for the Columbia Corridor drainage districts in Multnomah

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				County, Oregon; SP-51, Columbia River tsunami modeling: toward improved maritime planning response 2019: GMS-123, Geologic map of the Poison Creek and Burns 7.5; quadrangles, Harney County, Oregon; GMS-124, Geologic map of the Biggs Junction and Rufus 7.5′ quadrangles, Sherman and Gilliam Counties, Oregon; O-19-03, Columbia River simulated tsunami scenarios; O-19-04, Comparison of Oregon tsunami hazard scenarios to a probabilistic tsunami hazard analysis (PTHA); O-19-05, Tsunami evacuation analysis of Newport, Lincoln County, Oregon; O-19-06, Tsunami evacuation analysis of Lincoln City and unincorporated Lincoln County: Building community resilience on the Oregon coast; O-19-07, Tsunami evacuation analysis of communities surrounding the Coos Bay estuary: Building community resilience on the Oregon coast; O-19-08, Tsunami evacuation analysis of some unincorporated Tillamook County communities: Building community resilience on the Oregon coast; O-19-09, Coseismic landslide susceptibility, liquefaction susceptibility, and soil amplification class maps, Clackamas, Columbia, Multnomah, and Washington Counties, Oregon: For use in Hazus: FEMA's methodology for estimating potential losses from disaster; SP-52, The Scarp Identification and Contour Connection Method (SICCM): A tool for use in semi-automatic landslide mapping; SLIDO-4.0, Statewide Landslide Information Database for Oregon, release 4.0 (SLIDO-4.0)
91	Continue to act upon opportunities to advance the State's lifeline mitigation investment practice	Expand upon the State's mitigation investment practice by: (1) Supporting efforts by jurisdictions and transportation districts to develop mitigation policy and retrofit plans for lifeline assets and service facilities; (2) Continuing to advance design and maintenance standards and requirements for bridges and unstable slopes, transit, rail, ports, and priority lifeline airfields; (3) Developing a temporary bridge installation policy and standards; (4) Supporting research on retrofit methods and strategies for Cascadia subduction zone earthquake loads and tsunamis.	Ongoing	The Oregon Highway Plan was reviewed and updated in May of 2015. The ODOT Bridge Section has evaluated a variety of options for blending the seismic mitigation effort with other bridge structural needs. Retrofitting bridges in poor health does not make good sense, so ODOT has looked for opportunities where it is more cost-effective in the long term to replace aging bridges, as well as for cases where retrofits can be combined with repair projects to extend a bridge's life. This report lays out a comprehensive program that will address seismic vulnerability, as well as mitigate structural deficiencies. The strategy is being implemented as resources allow.
92	Improve reliability and resiliency of critical infrastructure statewide by adopting industry-specific best practices, guidelines, and standards	Lifeline Service Delivery Systems (critical infrastructure), including electric supply, natural gas, telecommunications, water/wastewater, hydraulic structures (e.g., dikes, levees, dams), transportation corridors, pipelines and petroleum fuels storage facilities, are all vital resources for a community's life-safety and economic viability. However, much of Oregon's existing critical infrastructure has not been designed or constructed to withstand the impact of severe natural disasters such as extreme wind & winter storms, major earthquakes, or large landslides. Lifeline Service Delivery Systems (critical infrastructure) should be evaluated statewide, and reliable and measurable performance objectives which insure the region's critical infrastructure can withstand future damage without crippling consequences should be instituted.	Ongoing	This is an ongoing effort and not a discreet project. OPUC continues to enforce requirements that are in the National Electrical Safety Code and OPUC's administrative rules (OARs) for vegetation management. The effort to address vegetation management is being accelerated due to the impact of climate change on the increased risk from wildfires. Clearance requirements may change with time. Currently utilities are unable to remove vegetation outside of the utility Right of Way even when something like a tree could fall into utility facilities in a windstorm. Also, for both windstorms and wildfires, utilities have difficulties gaining access to federally owned lands such as US Forest Service and BLM managed lands. BLM has adopted policies to make access to their lands more streamlined. The US Forest Service has not adopted any streamlined policies to access its properties and each district (there may be several in each state) has different processes.
93	Acquire statewide lidar coverage for the purpose of improving natural hazard mapping and infrastructure inventories	Lidar is currently the best source of regional topographic data and allows for highly precise and accurate natural hazard mapping (landslide, flooding, volcanic hazards, channel migration zones, tsunami, geologic faults, etc.) and infrastructure inventories (buildings, utilities, lifelines, etc.). The state should continue to invest in lidar acquisition for the purpose of understanding risk to natural hazards at a local scale.	Ongoing	DOGAMI continues to seek funding and partnership to expand lidar coverage throughout the state. At this point, all communities in Western Oregon are covered, as are most Eastern Oregon communities. Ongoing data collection efforts in eastern Oregon are focused on flood hazards in unincorporated areas and fault hazards.
94	Provide technical assistance and funding to local governments to evaluate the need and opportunities for inter-tie projects in Local Natural Hazards Mitigation Plans	The capital expense associated with this action needs to be carried mostly by local governments, perhaps with some grant or low-interest loan funding provided by the state or federal governments. The role of the state in this action is to encourage local governments located proximate to one another, yet with separate water systems, to develop the physical capability to send water from one system to the other. Oftentimes during drought situations, one local government will have a bit of water to spare while a nearby government is struggling to meet its needs. Transferring water by truck is expensive and inefficient when compared to transferring water via pipeline. Water inter-ties are also effective mitigation for the flood and earthquake hazards where one system can serve as back-up for another.	Ongoing	Addressed in the 2017 Integrated Water Resources Strategy. Water project grants and loans may be available in some circumstances, through the Water Resources Development Program.

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95	Educate citizens about the different National Weather Service announcements	State agencies should work with the National Weather Service and local governments to educate the public about the meaning of the different National Weather Service announcements: winter storm watch, winter storm warning, ice storm warning, heavy snow warning, blizzard warning, severe blizzard warning, dust storm and high wind warning.	Not being pursued	ODOT already has reader boards and low power radio stations that broadcast traveler information throughout the Mid-Columbia region that are dedicated for weather related incidents like dust storms, severe weather, and blowing snow that are triggered by NWS alerts. Additionally, locally emergency managers already have access to EAS and IPAWS. Through IPAWS, they can issue a Wireless Emergency Alert (WEA), which is much more effective and reliable than EAS.
96	Continue to maintain the existing roster of qualified post-earthquake, flood, and wind inspectors with ATC-20 earthquake and ATC-45 flood & wind inspection training	Continue to compile and maintain a list of individuals trained and certified for post-disaster inspection. Support the recruitment and training of qualified ATC-20 post earthquake inspectors and inspection teams.	Not Started	On August 9, 2019, Governor Brown signed House Bill 2206, which directs the State Fire Marshal to develop and administer a statewide program to evaluate the condition of buildings after an emergency and determine whether the buildings may be safely occupied. The approved measure directs the State Fire Marshal to implement a statewide registry of local program coordinators, certified building evaluators, and approved trainers to conduct such safety assessments. In order to conduct the required duties in these positions, a significant training and travel budget would be expected to allow travel around the state to provide training, to administer and to track certifications for local governments, for professional organizations and for other relevant agencies.
97	Expand the state's stream gaging network. Seek stable funding for the operation, and maintenance of stream gages	The availability of timely and accurate telemetered data from stream gages is essential for flood forecasting, for prediction of imminent flood hazards, and for response to flood emergencies. Streamflow data also provides basic hydrologic information for floodplain mapping and watershed management by communities throughout the state, and is critical for understanding and forecasting drought conditions. Numerous local, state and federal water management agencies rely on data from stream gages for effective management of projects and resources; the installation and maintenance of stream gages has traditionally been a responsibility of state and federal agencies. State agencies plan to work with their partners to ensure adequate funding and support for existing gages and for the installation of new gaging sites where needed. It is recommended that state agencies endeavor to leverage federal funding with state resources and local matching commitments to achieve a reliable network of stream gages around the state. The data from these gages is used to support the RAFT and Raptor tools highlighted in Action #10, Priority.	Ongoing	238 out of a total of 255 OWRD operated gages are now real-time. This is an increase of 26 since the last report. Continue expansion and upgrading of network.
98	Better coordinate, fund, and publicize programs to reduce the abundance of Juniper trees in arid landscapes across Oregon	Juniper trees develop extensive root systems that draw critically needed water from arid soils, transpiring water vapor into the atmosphere, intensifying drought and increasing the risk of wildfire. There are programs in Oregon to reduce Juniper trees from areas where their competition for groundwater resources is harmful, but these programs need to be better coordinated, funded, and publicized.	Not being pursued	ODF currently doesn't have a dedicated program, but other programs including NRCS have funded similar projects. Might be better phrased as supporting rangeland health, combatting juniper encroachment and noxious weeds and grasses that pose threats to the ecosystem and alter fire regimes. A common theme seems to be prescribed fire with these juniper treatments.
99	Educate homeowners about choosing ice and windstorm-resistant trees and landscaping practices to reduce tree-related hazards in future ice storms	Trees that don't stand up well to ice and wind, especially when planted near power lines, can cause power outages and other damage. Certain species of trees hold up better to winter's fury than others. Other factors, such as where a tree is planted and use of proper pruning techniques, can also help trees be more resistant to ice storm damage.	Ongoing	This is part of ongoing urban and community forestry outreach to communities and other entities, such as nonprofit organizations, counties, etc. At least one program e-newsletter is sent to over 500 subscribers with storm and other natural disaster preparedness information annually.
100	Each year, ask the Governor to designate October to be Earthquake and Tsunami Awareness Month	Practicing to "Drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. A gubernatorial declaration will promote increased participation in the Great Oregon ShakeOut, or other annual earthquake Drop, Cover, and Hold On drill.	Ongoing	This has been and continues to be done each year.
101	Continue to facilitate accessibility and use of the *Coastal Atlas* GIS resources	Make the *Coastal Atlas* geographic information system (GIS) more useful for a wider audience, from local and state staff to interested citizens, by continuing to improve its data and tools, and providing training on how to access and use them.	Ongoing	Relevant GIS resources maintained by OPRD are shared through Web Services which can be presented and combined with other resources through the Coastal Atlas.

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102	Research the effects of changing ocean water levels and wave dynamics along the central and southern Oregon coast, and use that data to augment the coastal geomorphic database	As recent research has shown, ocean water levels and wave dynamics along the Oregon coast are changing. These will, in turn, affect beach sand budgets and rates of erosion. More research must be done on alternative shore protection methods, effects of hard shore protection structures, near-shore circulation processes and sediment budgets, sea cliff erosion processes, and other hazard processes	Ongoing	DOGAMI continues to undertake evaluation of soft forms of shoreline armoring (e.g. dynamic revetments, a.k.a. cobble berm), having completed recent evaluations of a dynamic revetment constructed at the South Columbia River jetty, and adjacent to the Hatfield Marine Science center. DOGAMI is presently working with OSU researchers to evaluate bluff erosion and coastal landslide movement and forcing at five sites along the Oregon coast: Silver Point/Cannon Beach, Arch Cape tunnel, Spencer Creek bridge/Newport, Arizona Inn landslide/Curry County, and Hooskanaden/Curry County. This study is a 7-year investigation and is expected to conclude in July 2023 DOGAMI continues to work with NANOOS on developing improved climatologies of ocean waves, air and water temperature, and sea level changes. DOGAMI working on a pilot study to update the dune hazard overlay for Tillamook County based on new statewide lidar, FEMA coastal flood modeling, historical photos, and OBSMAP beach and shoreline change monitoring.
103	Survey coastline to monitor erosion	Continue to periodically measure and monitor the Oregon coastline in order to document the response of Oregon's beach and bluffs to changes in ocean water levels (sea level rise and storm surges), storms (frequency and intensity), precipitation patterns that may threaten lives and property. Maintain a long-term, permanent Oregon Beach and Shoreline Mapping and Analysis Program (OBSMAP). The program will be a partnership with local, state, and federal agencies that have responsibility over coastal and ocean activities.	Ongoing	DOGAMI continues to receive funding support from the Northwest Association of Networked Ocean Observing System (NANOOS) in order to maintain its Oregon Beach Shoreline Mapping and Analysis Program (OBSMAP). DOGAMI monitors beach profile changes at 178 sites. Those established in Tillamook/Clatsop County are typically observed on a seasonal basis, while sites in Lincoln County are observed annually (time and funding permitting). DOGAMI formalized monitoring on the southern Oregon coast at Gold Beach and Nesika Beach, and in the Netarts littoral cell. Besides the transects, DOGAMI continues to collect MHHW tidal datum-based shorelines along each littoral cell.
104	Maintain the updated inventory of shoreline protection structures	Maintain the inventory of existing and new coastal engineering (shore protection) structures on the Oregon Coast in order to provide local governments and applicable agencies an important coastal management tool to address anticipated increasing coastal erosion. It is anticipated that this inventory and information will assist in potential future policy changes to address a changing climate and associated coastal erosion impacts.	Ongoing	Inventory has been up to date since 2015 and is added to as new permits are issued. Maintaining the inventory is accomplished through permit additions on an as issued basis.
105	Implement the improved methodology for gathering data and identifying the communities most vulnerable to drought and related impacts	Although we know that areas in Oregon have suffered from drought, there has not been a coordinated effort to systematically characterize how frequently droughts have occurred, or the impact on Oregonians and ecosystems. Communities are beginning to plan for worst case drought scenarios and need better information about the frequency, duration, and intensity of previous droughts in order to assess the appropriate response. Comprehensive information is not currently available by region, or statewide.	Not started	Development of the improved methodology has not yet started, so implementation could not begin. There is potential for a 2024 start date for developing the improved methodology. Implementation would follow development.
106	Publicize and facilitate the implementation of both structural and non-structural seismic mitigation measures for home owners, business owners, renters, and contractors, including methods of reducing hazards	Working with federal partners, such as FEMA, and non-profit industry groups, such as AIA, Oregon will enhance education on structural and non-structural seismic mitigation measures by adopting the following actions: • Increase the number of educational opportunities by working with FEMA to offer courses from the National Earthquake Technical Assistance Program. • Work with the Construction Contractors Board, public and private sector lenders, private sector construction material suppliers and nonprofit organizations to develop programs to assist home and business owners and renters to implement innovative structural and non-structural seismic mitigation measures.	Completed	2017
107	Provide information and technical assistance to implement mitigation of non-structural hazards in K-12 schools	Provide training to school officials and teachers in reducing non-structural hazards in schools such as unsecured bookcases, filing cabinets, and light fixtures, which can cause injuries and block exits. The program should include a procedure for periodic life safety inspections of non-structural seismic hazards in schools that can be implemented by local fire department inspectors. BCD will have an important role in providing technical assistance in the development of educational materials.	Ongoing	This has been and continues to be done each year as part of the annual Great Oregon ShakeOut.
108	Each year, ask the Governor to designate the third Thursday of the month of October as the Great Oregon ShakeOut Day by proclamation	Practicing to "drop, cover, and hold" is critical in reducing injury and loss of life in the workplace and home during an earthquake. The more people practice the drill, the better they will respond to a real event. A gubernatorial declaration will promote increased participation in the Great Oregon ShakeOut, or other annual earthquake Drop, Cover, and Hold On drill.	Ongoing	This has been and continues to be done each year.

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109	Include information about the benefits of purchasing earthquake insurance in public outreach materials and disseminate those materials through appropriate public outreach programs and venues	Unlike flood insurance, which is underwritten by the U.S. Government (through the National Flood Insurance Program), earthquake insurance is offered by private sector agents, generally as a rider to a standard homeowner or business property insurance policy. Because earthquake insurance is a type of catastrophic coverage, most policies carry a high deductible, Oregon's Department of Consumer and Business Services Insurance Division offers information about earthquake insurance on its website and provides personal assistance through its insurance hotline. In addition, the Division is active in outreach activities, partnering with other agencies and organizations to bring insurance information to the public.	Ongoing	This is an ongoing program. DCBS-DFR lead 20 classes throughout the state in 2019 where we discussed flood insurance and earthquake insurance. DCBS-DFR will continue to lead trainings on Earthquake insurance in the coming year.
110	Continue seismic rehabilitation of hospital, fire, and police facilities under the Seismic Rehabilitation Grant Program administered by Business Oregon's Infrastructure Finance Division	Continue to rehabilitate to operational readiness in the event of an earthquake essential hospital buildings, fire, and police stations that pose a threat to occupant safety. Senate Bill 15 of the 2001 Legislative Session requires that rehabilitation or other actions to be completed by January 1, 2022. Senate Bills 2 to 5 (2005) provided the mechanism to accomplish some of these legislatively mandated tasks. Under SB 2, Oregon Department of Geology and Mineral Industries developed a seismic needs assessment database of emergency response facilities buildings. These data are being used by the Seismic Rehabilitation Grant Program to provide funding for seismic rehabilitation of eligible buildings (SB 3). Senate Bill 5 allows the State Treasury to sell Government Obligation Bonds to fund the program.	Ongoing	Emergency Services award announcements scheduled for April/May of 2020 and 2021. Work continues each biennium depending on funding.
111	Continue seismic rehabilitation of public schools buildings under the Seismic Rehabilitation Grant Program administered by Business Oregon's Infrastructure Finance Division	Continue to rehabilitate to occupant life safety standards certain public school and community college buildings. Senate Bill 14 from the 2001 Session of the Oregon Legislature requires that the State Board of Education examine buildings used for both instructional and non-instructional activities, including libraries, auditoriums, and dining facilities in order to determine which buildings are in most need of additional analysis. Following the identification of high-risk buildings and additional analysis, high-risk buildings must be rehabilitated by January 1, 2032, subject to available funding. SJR 21 and 22 are bond measures (November 2002 election) which would provide funding to implement this proposed action. SB 2 to 5 (2005) provided the mechanism to accomplish some of these legislatively mandated tasks. Under SB 2, Oregon Department of Geology and Mineral Industries developed a seismic needs assessment database of K-12 and Community College public school buildings. These data are being used the SRGP to administer a grant program for seismic rehabilitation of eligible buildings (SB 3). SB 4 allows the State Treasury to sell Government Obligation Bonds to fund the program.	Ongoing	School award announcements scheduled for April/May of 2020 and 2021. Work continues each biennium depending on funding.
112	Continue implementing the Oregon CRS Users Group Program	DLCD will continue to coordinate Oregon's two NFIP CRS Users' Groups. Each group will meet a minimum of three times per year to share floodplain best management practices and to receive technical support from the State, FEMA's Insurance Support Organization, and others as needed. The State anticipates that the support provided through the CRS Users' Groups will encourage more communities to participate in the CRS program and participating communities to strengthen their CRS ratings, resulting in greater protection from flood damage at lower cost to property owners.	Ongoing	The State of Oregon DLCD supports a community driven state-wide CRS user group that meets every other month.
113	Monitor the effectiveness of the statewide strategy to encourage the purchase of flood insurance by demonstrating that the number of flood insurance policies held throughout the state continues to increase	Despite the statewide availability of flood insurance, coverage in place in most communities in Oregon varies from 10% to 20% of the homes and businesses located in the Special Flood Hazard Area (100-year floodplain). Not only does flood insurance reduce the financial vulnerability of individuals, families, businesses, government agencies, other organizations, and the community to the costs posed by flooding, but through the "increased cost of compliance" provision of flood insurance, it also provides funding for the elevation, flood-proofing, demolition, or relocation of homes and businesses when required due to "substantial damage" to the structure.	Ongoing	FEMA is collecting and tracking the data for National Flood Insurance Program (NFIP) policies purchased and in place within Oregon. However, there has been an uptake of private flood insurance policies and neither DLCD nor FEMA have a means to track the number of private flood insurance policies that have been purchased or are in place.
114	Update the Model Ordinance for Flood Damage Prevention	FEMA Region 10 has approved for use in Oregon a model ordinance for flood damage prevention. DLCD views the model ordinance as a living document and will continue to work with Region 10 and other interested parties to develop model ordinance provisions that address issues such as "fish-friendly" floodplain management, reducing flood insurance costs, etc.	Completed	The Oregon Model Flood Hazard Ordinance was updated and approved by FEMA Region X in August 2019.

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115	Maintain the Riparian Lands Tax Incentive Program	This program is administered by the ODFW. This program involves the preparation of a plan and agreement between the landowner and the ODFW. The plan details measures the landowner will implement to preserve, enhance, or restore the riparian areas. Landowners receive a complete property tax exemption for the riparian property (up to 100 feet from the top of stream bank or the edge of non-aquatic vegetation). This program helps reduce sediment and protect stream banks which helps reduce the filling of river and stream channels.	Ongoing	The program remains active.
116	Provide information and potentially resources to local governments for developing "flood fight" plans and protocols	Several post-disaster mitigation strategy reports call for the development of flood fight plans and protocols in advance of flood emergencies. In addition to the state agencies potentially involved in flood fighting such as OEM and OWRD, environmental protection and habitat conservation agencies such as DEQ and ODFW should be involved in flood fight planning. At the federal level, the U.S. Army Corps of Engineers is a key partner. These plans and protocols might include improving emergency warnings, strengthening communications systems, stockpiling needed materials, preparing procedures for emergency vehicle access to flooded areas, and other related subjects, including ongoing public education efforts.	Ongoing	In 2018, the Oregon Silver Jackets team, an official sub-committee of the IHMT, published the *Oregon Post-Wildfire Flood Playbook*, a resource for citizens and governments. https://silverjackets.nfrmp.us/portals/0/doc/Oregon/PostFireFloodPlaybook_2018-09-30.pdf The group continues to work on other flood fight strategies as this is its core mission.
117	Continue the State's active Floodplain Management Outreach Program	DLCD has an active floodplain and natural hazards outreach program. The department publishes and distributes newsletters and other outreach information to local governments and other interested parties. DLCD also maintains a website which includes a link to this NHMP. The natural hazards website (http://www.oregon.gov/LCD/HAZ/index.shtml) contains information and links to floodplain management information including many of the documents and booklets prepared by FEMA. DLCD uses an email distribution service for its Natural Hazard Newsletter and other correspondence. The email distribution service affords interested subscribers a greater opportunity to obtain flood management and natural hazards information from DLCD in a timely manner and for DLCD to more readily share information from a variety of sources.	Ongoing	DLCD continues to implement an active Floodplain Management Outreach Program. The DLCD NFIP website was revamped in 2019. Many trainings, workshops, and other outreach events are organized and led by DLCD staff each year for a wide variety of audiences including: local floodplain managers, surveyors, engineers, flood insurance agents, realtors, and other relevant parties. DLCD also provides outreach and training to local communities during Community Assistance Visits (CAVs) and Community Assistance Contacts (CACs).
118	Continue the State's active Floodplain Management Training Program	DLCD and other State IHMT participants conduct or sponsor training sessions and meetings throughout the year focused on up-to-date floodplain management practices and projects. DLCD will continue to deliver focused training to surveyors, building officials, real estate agents and planners as well as local floodplain managers. The interdependent relationships among these key players in providing comprehensive floodplain management will also be highlighted during trainings.	Ongoing	DLCD continues to implement an active Floodplain Management Outreach Program. The DLCD NFIP website was revamped in 2019. Many trainings, workshops, and other outreach events are organized and led by DLCD staff each year for a wide variety of audiences including: local floodplain managers, surveyors, engineers, flood insurance agents, realtors, and other relevant parties. DLCD also provides outreach and training to local communities during Community Assistance Visits (CAVs) and Community Assistance Contacts (CACs).
119	Prepare text for local broadcast of one Public Service Announcement (PSA) each year on a seasonal topic	PSAs are an effective method for disseminating pertinent seasonal information about hazard preparedness and mitigation.	Ongoing	Each year the State NFIP Coordinator prepares text for local broadcast of a Public Service Announcement (PSA).
120	Assist local communities in securing funding to mitigate damage to repetitive flood loss properties or those substantially damaged by flooding	The state maintains an inventory of high priority repetitively damaged buildings located in floodplains. DLCD and OEM have worked closely with communities to secure funding to mitigate buildings located in the flood hazard zone and to buyout properties located in the floodway. These agencies will continue to provide such expertise statewide where needed.	Ongoing	DLCD and OEM work with local communities to support efforts to secure funding to mitigate repetitive loss flood properties and severe repetitive loss flood properties. DLCD works with local, state, federal, and non-governmental organizations to the extent possible to identify funding options to mitigate substantially damaged structures after flood events.
121	Continue implementation of FEMA's Risk MAP program in Oregon, including building effective community strategies for reducing risk	Measurably increase the public's awareness of flood and other natural hazards through a combination of regulatory and non-regulatory products, tools, community outreach. Address gaps in flood hazard data, identifying areas of dated and/or inconsistent mapping and updating high-priority areas with new mapping and innovative natural hazard mapping techniques that lead to actions that reduce risk to life and property. Provide support to help manage the FEMA Map Modernization projects that remain to be completed.	Not being pursued	The State no longer has a Risk MAP Program Coordinator. FEMA has taken over management of the Risk MAP program for the State of Oregon.
122	Continue developing Emergency Action Plans for all remaining high hazard dams in Oregon	In Oregon, money from FEMA grants and state funds is used to help dam owners create Emergency Action Plans (EAP). An EAP helps identify situations where a dam failure might occur, actions to take that could save the dam, if possible, and evacuation routes for a dam failure situation. There is an Oregon-specific EAP template available, designed for owners of remote dams that have limited personnel. Approximately 75% of state-regulated high hazard dams have, or are currently developing EAPs. There are 67 state regulated high hazard dams, and another 65 federal high hazard dams in which OWRD plays a coordinating role.	Ongoing	EAPs are developed as required.

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#	**Statement**	**Description**	**Status**	**Explanation**
123	Implement flood protection standards for State-owned/leased buildings	According to the Senate Bill 814 Task Force (Oregon Legislature, 1997 Session), there is a need to develop and effectively implement a strict standard governing the siting, construction, and leasing of buildings occupied by state agencies in flood-prone areas.	Completed	2015
124	Acquire existing homes and businesses seriously threatened or damaged by landslide hazards	When opportunities and funding become available (pre- and/or post-disaster) explore options for the acquisition of developed property, particularly homes, in areas of repetitive or ongoing landslide hazards. Acquired properties will be maintained as open space in perpetuity and may also provide a buffer for landslide movements and debris that could otherwise impact improvements such as transportation routes.	Ongoing	Pursued on an opportunistic basis
125	Assist local governments in implementing the tsunami land use guidance	The risk of tsunami hazard for Oregon's coastal communities is well-documented with the completion of comprehensive tsunami inundation maps developed by DOGAMI. The State of Oregon can assist affected communities with its implementation, leading to better protection of life and property from tsunamis.	Ongoing	DLCD, in partnership with DOGAMI, completed one NOAA-funded tsunami land use resilience project as of Sept. 2019 and is in process with a second NOAA-funded tsunami land use resilience project (to be completed June 2021). These efforts utilized the resources within the DLCD Tsunami Land Use Guide and have led to several local jurisdictions developing and adopting tsunami resilience regulations and identifying evacuation improvement projects. The following coastal jurisdictions have adopted Tsunami Hazard Overlay Zones into their land use plans between 2016 and 2019: Coos County, Douglas County, Reedsport, Florence, North Bend, Rockaway Beach, Gearhart, Port Orford, and Tillamook County. Most of those jurisdictions have also completed Tsunami Evacuation Facilities Improvement Plans to identify evacuation routes and improvement projects. Several more communities are in process to adopt tsunami resilience measures in the near future. DLCD also provides general assistance/support to communities on an ongoing and as needed basis as questions arise about land use planning in the context of tsunami hazards.
126	Monitor implementation of the tsunami land use guidance by tracking the number of jurisdictions that have used it	The risk of tsunami hazard for Oregon's coastal communities is well-documented with the completion of comprehensive tsunami inundation maps developed by DOGAMI. Monitoring success of the guidance will allow the State to adjust its approach and update the guidance as necessary, leading to better protection of life and property.	Ongoing	Nine coastal jurisdictions have adopted Tsunami Hazard Overlay Zones into their land use plans between 2016 and 2019: Coos County, Douglas County, Reedsport, Florence, North Bend, Rockaway Beach, Gearhart, Port Orford, and Tillamook County. Several more communities are in process to adopt tsunami resilience measures in the near future.
127	Continue to renew coastal communities' enrollments in the Tsunami Ready Program	The Tsunami Ready Program is a program sponsored by the National Weather Service that is designed to provide communities with incentives to reduce their tsunami risk. Cannon Beach was the first community for Oregon. Under a proposed plan through the NTHMP, additional communities will be added until there is full participation. This program is currently evolving through a review process being carried out by the NTHMP National Coordinating Committee. OEM is the primary point of contact for more information about the Tsunami Ready Program.	Ongoing	NWS continues to process new and renewing applications
128	Continue supporting school participation in annual tsunami evacuation drills	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	Ongoing	Part of on-going public outreach strategy
129	Continue supporting local agencies and local non-profits, such as CERT, in participating in educational efforts such as door-to-door campaigns to educate those living or working in the inundation zone on how to respond to an earthquake and tsunami	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	Ongoing	Part of on-going public outreach strategy
130	Continue innovative outreach activities, such as tsunami evacuation route fun runs	Increase the ability of Oregonians to prepare for and recover from earthquakes and tsunamis on the Oregon Coast.	Ongoing	Part of on-going public outreach strategy
131	Continue to develop training and information packets and articles for local building officials informing them of their responsibilities and authority under ORS 455.446 and 455.447 and the State Building Code	Statutes and the State Building Code limit construction of new essential facilities and special occupancy structures in the mapped tsunami inundation zone. Definitions of essential and special occupancy structures are in the Oregon State Structural Specialty Code. As personnel change and time passes, additional training and information for officials will be provided.	DCBS-BCD – Completed DLCD - Ongoing	HB 3309, 2019 session removed the prohibition of constructing essential facilities and other defined structures in the tsunami inundation zone. BCD also adopted an Appendix O in the 2019 OSSC addressing tsunami loading which is available for local adoption. Outreach to local building officials is conducted whenever possible, especially during Community Assistance Visits (CAVs) and Community Assistance Contacts (CACs) conducted by DLCD.
132	Work with ODOT to replace or move existing Entering/Leaving Tsunami Hazard Zone signs to correspond with the XXL inundation line developed by DOGAMI	Existing tsunami hazard zone signs are considered inadequate for placement along stretches of Highway 101, or on any roads, that are within the tsunami hazard zone. A single tsunami hazard zone sign will not indicate the boundaries of the inundation zone. Tsunami Hazard Zone signs should be located to correspond with the XXL inundation line developed by DOGAMI.	Ongoing	DOGAMI and ODOT have completed most of this project

2015 MITIGATION ACTIONS: STATUS
Priority and Ongoing

Action Item				
#	**Statement**	**Description**	**Status**	**Explanation**
133	Work with ODOT to develop additional signage as needed to increase awareness of the tsunami hazard	Existing tsunami hazard zone signs are considered inadequate for placement along stretches of Highway 101, or on any roads, that are within the tsunami hazard zone. A single tsunami hazard zone sign will not indicate the boundaries of the inundation zone. There is need for increased public education program to let the public, including motorists who are not local residents, know what the signs mean and what actions they should take.	Not being pursued	Lack of funding
134	Work with Oregon Parks & Recreation Department and Oregon Travel Experience to increase the number of interpretive educational installations along Highway 101	Existing tsunami hazard zone signs are considered inadequate for placement along stretches of Highway 101, or on any roads, that are within the tsunami hazard zone. There is need for increased public education program to let the public, including motorists who are not local residents, know what the signs mean and what actions they should take.	Not being pursued	Lack of funding
135	Develop volcanic hazard evacuation maps	Volcanic eruptions often produce lahars that travel down river valleys. Evacuation maps should include the hazard area as well as preferred evacuation routes and evacuation sites. USGS staff should support local and state agencies in this effort.	Not started	Lack of funding
136	Each year, ask the Governor to designate May to be Volcano Awareness Month by proclamation	Working with federal partners, such as the USGS Cascades Volcano Observatory, the state of Oregon will increase the ability for citizens to respond to volcanic eruptions by increasing the level of awareness and preparedness in the public and governmental agencies.	Ongoing	This has been and continues to be done each year.
137	Support development, enhancement and implementation of local education programs designed to mitigate the wildfire hazard and to reduce wildfire losses, such as the Firewise Communities/NFPA Program and the annual Wildfire Awareness Week Campaign	As part of its statewide fire prevention program, the Oregon Department of Forestry actively encourages and promotes local education and awareness programs that are designed to mitigate, or reduce the impacts of wildfires. This action reflects ODF's ongoing intentions to: 1) collaborate with agencies and organizations to promote consistency in the development and application of fire prevention standards; 2) work to make individuals aware of their personal accountability and responsibility for wildfire safety; 3) determine local resources and capacity; and 4) define needs and solutions required to increase capacity.	Ongoing	175 communities have been established through NFPA's Firewise USA ® program as of December 2019 in Oregon. There is continued efforts to establish more communities and renew Firewise USA status annually to promote outreach and education efforts on wildfire. Western States Fire Managers Grant projects and Community Assistance Grant projects both have elements of outreach and education associated with them to continue this work as well. Oregon Department of Forestry works closely with Keep Oregon Green (KOG) to promote prevention and mitigation practices when it comes to wildfire. Wildfire Awareness month and day are also annually promoted.
138	Continue to increase the number of local governments using the Wildfire Hazard Zone process to mitigate wildfire risk and losses	The Wildfire Hazard Zone (WHZ) process allows local governments to require the use of fire resistant roofing materials in jurisdictions assessed to be at a high risk of wildland fire. Currently, only a few eligible entities have utilized the WHZ process. To promote additional use, an assessment will be made of the portions of the state where it appears the WHZ process will have the greatest benefit. Following this assessment, local governments in the areas identified will be educated on the desirability of implementing the process. Those governments that express an interest in applying the process will be assisted in completing the required analysis work.	DCBS-BCD – Completed ODF – Ongoing	New section R327 Wildfire hazard mitigation adopted as part of the Oregon Residential Specialty Code. These amendments provide additional wildfire hazard mitigation provisions that are available for local adoption. Effective: Jan. 24, 2019, https://www.oregon.gov/bcd/codes-stand/Documents/17orsc-wildfire-mitigation-insert-pages.pdf ODF - This legislation is currently under review and will be considered when updating defensible space laws.
139	Continue to develop and increase the number of updated Community Wildfire Protection Plans (CWPPs) with the goal of aligning CWPP updates with 5-year NHMP updates, where possible	The federal Healthy Forests Restoration Act (HFRA) includes statutory incentives for federal agencies to give consideration to the priorities of local communities as they develop and implement wildfire hazard mitigation projects. To become eligible for priority consideration under HFRA, a community must first prepare a *Community Wildfire Protection Plan* (CWPP). Most Oregon counties and many Oregon communities have completed CWPPs. To encourage the completion of additional CWPPs, as well as future updates of CWPP's counties and communities will be informed of the benefits to be gained from maintaining a CWPP and assistance will be offered to help facilitate the development and/or update of the plans. Since the majority of Counties refer to CWPP's as their Wildfire Chapters, aligning CWPP updates with NHMP updates will ensure consistency and promote efficiencies in planning processes.	Ongoing	CWPP's are encouraged and supported whenever possible to be updated every 5 years. In the last couple of years during the Oregon Wildfire Risk Explorer grant process, there was a pilot that supported the renewal of 3 CWPP's in Grant, Wheeler, and Lane county through the use of the Oregon Wildfire Risk Explorer Tool. So far this has been successful and all three updates are in the final stages of completion. This tool will be promoted as a way for other counties to update their CWPP's easier in the future. Coordination with Office of Emergency Management has created some opportunities for some counties to work on their CWPP's and NHMP's at the same time, but this has not become a uniform or guided process as of yet.
140	Continue to provide technical assistance in accessing funding for fire prevention or wildfire mitigation projects through Title III, the National Fire Plan, or other funding mechanisms	Under the federal *Secure Rural Schools and Community Self-Determination Act of 2000* (Title III, Section 301(5) of PL 106-393, commonly known as *Title III*), counties have the ability to receive and spend federal funds for projects that educate homeowners about wildfire mitigation efforts they can apply on their property and for planning projects that increase the protection of people and property from wildfires. National Fire Plan and other funding mechanisms may also be available for assisting communities in preventing wildfires and implementing wildfire mitigation projects.	Ongoing	This work is still active and continuing to be implemented. Title III funds are still supported, Western State Fire Managers Grants are utilized and worked on the ground annually, Community Assistance grants are also utilized, and on occasion Joint Chiefs grants are used for implementing wildfire mitigation projects.

2015 MITIGATION ACTIONS: STATUS
Priority and Ongoing

Action Item				
#	**Statement**	**Description**	**Status**	**Explanation**
141	Implement the Oregon Forestland-Urban Interface Fire Protection Act ("Senate Bill 360") in all Oregon counties that meet criteria under the law	The *Oregon Forestland-Urban Interface Fire Protection Act*, more commonly known as "Senate Bill 360," was enacted by the Oregon Legislature in response to the growing incidence of wildfire destroying homes and communities in Oregon's wildland-urban interface. The Act recognizes that individual property owners are in the best position to take mitigation actions which will have the most direct impact to whether or not a structure will survive a wildfire. Under this action item, the Act will be implemented county by county in those portions of the state, based on weather, fire incidence, fuels, or on the number of structures at risk. It has been Legislature's stated preference that implementation be accomplished with federal grant funds.	Ongoing	"Senate Bill 360" language has been changed to "Oregon's Defensible Space Law". This legislation is currently under review and may see statewide application (including areas outside ODF protection) in the future.
142	Analyze wildfire ignition probability statistics to better target prevention efforts at the leading causes of fires	There is currently no single database or common method of collecting fire cause information for wildfires occurring in Oregon. This results in different entities focusing their prevention and mitigation efforts on those causes which may not be the state's leading causes of fires. This likelihood can be lessened by developing a process to compare fire cause data collected by the Oregon Department of Forestry, the Office of the State Fire Marshal, and federal wildfire agencies. It is also important to understand the ignition probability from homes within and adjacent to the wildland interface because of the ignition risk to nearby wildlands. While there is no centralized database, wildland and structural fire agencies will continue to work collaboratively to determine leading fire causes and focus efforts statewide and locally to prevent future ignitions.	Ongoing	Looking into Common Operating Picture software and collaborating more with Northwest Coordination Center and other fire management partners. Produce several annual statistical products on human caused fires, and looking into NFDRS (National Fire Danger Rating System seasonal indicators for fire ignition potentials.
143	Collaborate through work groups within the Pacific Northwest Coordination Group (PNWCG) to continue collecting and analyzing wildfire occurrence data using the standardized statewide method and report to the state legislature as required	Previously, data concerning the causes of wildfire incidents was collected and analyzed by at least two state agencies, five federal agencies, and numerous local fire departments. These agencies had no database standardization or common reporting requirements. A standardized data collection system has been developed and data collection and reporting continues collaboratively through work groups within the Pacific Northwest Coordination Group (PNWCG). The new system allows rapid identification of fire ignition trends and permits timely design and delivery of targeted prevention programs and activities.	Ongoing	Looking into Common Operating Picture software and collaborating more with Northwest Coordination Center and other fire management partners.
144	Collaborate through work groups within the Pacific Northwest Coordination Group to encourage the U.S. Forest Service to allow the owners of long-term dwelling leases to apply mitigation standards adjacent to their dwellings	In Oregon, several thousand seasonal homes, which are located in high-risk wildland-urban interface areas, are on lands owned by the U.S. Forest Service. Because these structures are located on ground owned by the federal government, they are not subject to the *Oregon Forestland-Urban Interface Fire Protection Act*. In many locations, even when the owners of these homes desire to complete wildfire mitigation practices, federal lease requirements totally or substantially prevent them from doing so. Under this action item, a survey will be made of all lease locations in Oregon and the federal mitigation limitation and prohibitions will be identified. This information will then be used to approach the appropriate federal officials with a request to change their policies or regulations, to allow for the application of mitigation practices on leased property.	Not Being pursued	Due to capacity issues and lack of funding, this is not being pursued by ODF at this time.
145	Develop a single, comprehensive statewide method or process to collect and analyze wildfire occurrence data in a timely manner	Currently, data concerning the causes of wildfire incidents is collected and analyzed by at least two state agencies, five federal agencies, and numerous local fire departments. These agencies have no database standardization or common reporting requirements. This results in great difficulty, when attempting to determine the number of wildfires that occur in Oregon, when identifying fire cause trends, and generally in obtaining information concerning wildfire trends in a timely manner. Under this action item, all agencies responsible for suppressing wildfires will be requested to report incident occurrence information to a central data repository, in a standard format, and within prescribed reporting time limits. Such a system would allow for the rapid identification of fire ignition trends and would permit the timely design and delivery of targeted prevention programs and activities. The State Fire Marshal's Oregon All Incident Reporting System (OAIRS) may be a key component in the solution.	Ongoing	Looking into Common Operating Picture software and collaborating more with Northwest Coordination Center and other fire management partners. Looking into participating in the federal IRWIN data sharing infrastructure.

2015 MITIGATION ACTIONS: STATUS
Priority and Ongoing

Action Item				
#	**Statement**	**Description**	**Status**	**Explanation**
146	Continue to educate communities, workers, and the public about the role of proper tree pruning and care in preventing damage during windstorms	Arboricultural groups, public agencies, and utilities should cooperate in promoting proper tree pruning and care practices that can reduce the risk of tree failure and property damage. Common messages refined by state level entities such as the Oregon Department of Forestry (ODF) and OSU Extension can help provide continuity and efficiency across the state. While implementation of this action largely takes place at the local government level, the state has a role in encouraging and providing incentives for best management practices. ODF maintains and implements a communication plan that includes educational initiatives aimed at improving tree health in cities. This includes a variety of products, including a bimonthly newsletter, a website, and brochures that help convey these messages. OSHA requires utilities to: • Provide training to crews working on power lines in worker safety and the identification of trees to prune or remove; and • Review regulations and standards for easement and right of way maintenance, and provide training to foresters and logging crews. Utilities should instruct homeowners in pruning of vegetation, tree care safety, and proper tree care for trees bordering utility corridors and public rights of way.	Ongoing	This is part of ongoing urban and community forestry outreach to communities and other entities, such as nonprofit organizations, counties, etc. At least one program e-newsletter is sent annually to over 500 subscribers with information on Best Management Practices for ongoing tree care, including tree pruning and utility safety. ODF-UCF also administers the Tree Line USA program that recognizes electrical utilities for utility tree management Best Practices (currently only one utility in Oregon, Pacific Power, receives this recognition); recruits membership of utility foresters on the state urban forestry advisory council; solicits power line safety presentations at state UCF conferences; and partners with utilities to produce webinars on tree-powerline safety, when possible.
147	Use industry best practices to minimize impact and outages to service delivery system of overhead line operators, during windstorm events	Implement outreach efforts through existing safety-related programs managed by the PUC in coordination with private and public utilities. Compliance with PUC administrative rules includes safety codes and vegetation management. The PUC provides administrative to support to the Oregon Utility Safety Committee where all utility operators (electric, natural gas, telecommunication & water) discuss safety issues and best practices.	Ongoing	This is not a discrete project and is part of the ongoing programs at the OPUC.
148	Educate citizens about safe emergency heating equipment	Improper use of alternate heat sources during winter storms can cause fires. Ongoing efforts of the Office of State Fire Marshal and its work with local fire departments through the Life Safety Team (http://www.oregon.gov/OSP/SFM/Pages/CommEd_OLST.aspx). In addition, people can be killed by carbon monoxide emitted by fuels such as charcoal briquettes when used for heating homes. To reduce the threat of carbon monoxide poisoning, known as the silent killer, the 2009 Legislature passed HB 3450a requiring landlords to install carbon monoxide alarms in rentals with a carbon monoxide source and homeowners must ensure they are installed in homes at the time of sale, if the home has a source. Sources include gas heating or fireplaces, wood-burning fireplaces or stoves and attached garages. Partnerships for consistent public education messages and outreach are underway, and will include information on the dangers of introducing a carbon monoxide risk.	Ongoing	The OSFM has a division dedicated exclusively to educating citizens on home fire safety, in general. This includes safety campaigns related to heating sources and alternate heating sources in the event of an emergency. These safety campaigns are continually monitored, measured, evaluated and revised. In the event of a natural disaster that affected a citizens' ability to heat their residence, the Fire and Life Safety Section would reinforce their existing messaging to those areas affected.
149	Continue educating motorists on safe winter driving, including how to be prepared for traveling over snowy and icy mountain passes	Actions such as sanding, applying de-icing chemicals, and snowplowing do not make the road safe. Motorists must drive at speeds appropriate for the weather and road conditions, and be prepared to handle adverse conditions. Many drivers do not carry chains and do not know how or simply do not install them when conditions warrant. Also, many drivers are not prepared for a long wait in their car. Education programs would help save lives on snowy and icy roads.	Ongoing	These efforts include a variety of programs throughout ODOT. The Public Information Officers in each region assist the media with providing timely and accurate information to the public regarding impacts to the transportation system including news releases, announcements of projects and closures, hazards conditions such as snow and flooding conditions on the highways. Advisories for requirements for the use of chains or traction tires during severe weather conditions in the winter season. Driver safety publications and brochures are distributed through the DMV and available at Highway Rest areas. ODOT has permanent and moveable variable message signs that are utilized for emergency messaging for the traveling public during any type of hazardous conditions such as Dust, Fog, Smoke, Snow, Ice and Fire. ODOT also utilizes social media for sharing information with the public including Facebook, Twitter and YouTube.

3.3.4.5 2015-2020 Mitigation Action Table: Crosswalk

Table 3-6. 2015 to 2020 Mitigation Action Crosswalk

2015 to 2020 MITIGATION ACTION CROSSWALK				
2015 #	**2020 #**	**Statement**	**Disposition**	**Table**
1	7	Develop and fund a legislative package for general funds or lottery funds to match federal funding for local hazard mitigation planning, including additional funds for DLCD Technical Assistance Grants	Retained	Priority
2	15	Create a "Clearinghouse" for natural hazards data	Retained	Priority
3	• —	Enroll three coastal communities in the Tsunami Ready Program each year	Removed	Removed
4	18	Complete a hazard mitigation policy legislative needs assessment	Retained	Priority
5	• —	Develop model risk reduction techniques and ordinances for landslide-prone communities	Removed	Removed
6	• —	Form an Oregon Landslide Workgroup	Removed	Removed
7	73	Through FEMA's Risk MAP program, update 1,000 miles of streams with lidar-based flood mapping	Retained	Priority
8	• —	Create a new lidar-based statewide landslide susceptibility map	Removed	Removed
9	85	Upgrade the Oregon Landslide Warning System	Retained	Priority
10	• —	Implement the Rapid Assessment of Flooding Tool (RAFT)	Removed	Removed
11	2	Develop guidance for local Gov'ts on how to use Goal 7 together with other pertinent Statewide Land Use Planning Goals to classify lands subject to natural hazards in the buildable lands inventory and adjust urban growth boundaries in a manner that minimizes or eliminates potential damage to life, property, and the environment while continuing to provide for efficient development patterns	Retained	Priority
12	95	Assist one coastal community per year in considering vertical evacuation structures and improved evacuation routes due to evacuation constraints	Retained	Priority
13	72	Produce new lidar-based flood hazard maps	Retained	Priority
14	• —	Create an informational website for the new Base Flood Elevation Determination Service	Removed	Removed
15	6	Develop new standardized risk assessment methodology across all hazards, at the state and local levels	Revised	Priority
16	• —	Complete a Climate Change Vulnerability Assessment and Adaptation Pilot for north coast highways	Removed	Removed
17	• —	Request LCDC to include Local Natural Hazards Mitigation Planning as a priority for DLCD Technical Assistance Grant awards to use as match for federal funds when available	Removed	Removed
18	• —	Develop a process for implementing Goal 7	Removed	Removed
19	• —	Work with Business Oregon to introduce in 2015 legislation allowing reconstruction of structures that cannot feasibly be retrofitted	Removed	Removed
20	76	Add at least five jurisdictions, with emphasis on coastal jurisdictions, to the Community Rating System (CRS) program during the life of each Oregon NHMP	Retained	Priority
21	• —	Update the inventory of shoreline protective structures	Removed	Removed
22	• —	Develop flood protection standards for state-owned/leased buildings	Removed	Removed
23	77	Update the state's Peak Discharge Estimation Program	Retained	Priority
24	96	Develop evacuation plans for ports and harbors at the rate of one per year	Retained	Priority
25	• —	Integrate the GIS database of tsunami safe zones and assembly areas into local government databases	Removed	Removed
26	• —	Incorporate text addressing hazard mitigation into natural resource agencies' guidance and process documents focusing on environmental quality to ensure that natural resources are protected in the design and construction of hazard mitigation projects	Removed	Removed

2015 to 2020 MITIGATION ACTION CROSSWALK

2015 #	2020 #	Statement	Disposition	Table
27	81	Develop a statewide strategy to encourage the purchase of flood insurance	Retained	Priority
28	• —	Establish a web page where building owners can register their interest in participating in acquisition programs for flood-damaged buildings	Removed	Removed
29	79	Strengthen the existing Community Rating System (CRS) rating of at least five jurisdictions, with emphasis on coastal jurisdictions, during the life of each Oregon NHMP	Retained	Priority
30	5	Provide technical assistance to local Gov'ts to help integrate hazard mitigation plans with local comprehensive plans	Retained	Priority
31	14	Improve state agency procedures for tracking data on state-owned/leased buildings and critical or essential facilities	Retained	Priority
32	26	Request and compile seismic and flood information for personnel-occupied buildings from other agencies	Retained	Priority
33	36	Request seismic and flood information from landlords as part of analyzing potential leased spaces going forward in new leases and potential renewals	Retained	Priority
34	88	Lidar survey the State's ROW (rights of way), west of the Cascade Range, to determine where landslide potential exists	Retained	Priority
35	• —	Investigate/inventory DAS-owned buildings for seismic risk	Removed	Removed
36	• —	Host at least one workshop or other educational opportunity on a biennial basis in communities where a Volcano Coordination Plan has been adopted	Removed	Removed
37	69	Achieve 100% state agency participation in the Great Oregon ShakeOut	Retained	Priority
38	97	Fund and provide technical assistance for local Gov'ts to engage in evacuation route planning and project implementation	Retained	Priority
39	74	Install real-time monitoring capabilities on the remaining 51 state-operated stream gages, with the goal of making the network 100% real-time by the year 2020	Retained	Priority
40	94	Implement better way-finding solutions for tsunami evacuation. Create hardened and improved evacuation routes to include elevated safe areas above the level of modeled inundation	Retained	Priority
41	• —	Develop an incentive or subsidy program for retrofit of one and two family residences	Removed	Removed
42	13	Request the Oregon Legislature to fund the "State Disaster Loan and Grant Account" immediately following a presidentially declared disaster or other disaster	Retained	Priority
43	21	Review and adjust State IHMT membership	Retained	Priority
44	20	Establish formal and official authority for the State IHMT	Retained	Priority
45	• —	Develop a system for prioritizing and ranking state-owned facilities, including critical facilities, for mitigation	Removed	Removed
46	• —	Provide the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* to local governments.	Removed	Removed
47	• —	Produce Coastal Development Handbook	Removed	Removed
48	86	Evaluate the impact of climate change on landslides	Retained	Priority
49	83	Create new lidar-based Landslide Inventory and Susceptibility Maps, especially near population centers	Retained	Priority
50	• —	Update *Planning for Natural Hazards: Oregon Technical Resource Guide*	Removed	Removed
51	• —	Facilitate self-sustaining outreach programs staffed by Community Emergency Response Teams (CERT) in each coastal population center aimed at creating a culture of preparedness and response for both local Cascadia and distant tsunami events	Removed	Removed
52	• —	Determine the effectiveness of and the feasibility of using the Emergency Alert System (EAS) in dust prone areas to provide timely information to the traveling public about dangerous blowing dust conditions and make improvements if needed	Removed	Removed
53	• —	Add at least three new flood inundation forecast points to the National Weather Service's Flood Inundation Mapping website and the USGS's Flood Inundation Mapper before 2018	Removed	Removed
54	49	Support and implement the actions in the February 2013 Oregon Resilience Plan and recommended in the Oregon Resilience Plan Task Force's October 2014 report	Retained	Priority

2015 to 2020 MITIGATION ACTION CROSSWALK				
2015 #	**2020 #**	**Statement**	**Disposition**	**Table**
55	38	Use DAS-CFO data and investigation/inventory of seismic and flood risk to DAS-owned/leased buildings in an effective, routine decision-making process for building occupancy, maintenance, use and potential mitigation treatments	Retained	Priority
56	• —	Identify, prioritize, and map areas susceptible to rapid channel migration	Removed	Removed
57	• —	Prepare model coordination protocols for local Floodplain Managers and Building Officials	Removed	Removed
58	53	Develop a database of non-state-owned critical/essential facilities and their property values	Retained	Priority
59	• —	Schedule three opportunities over the life of this Plan for state-local dialogue on vulnerability assessments to improve consistency and mutual understanding	Removed	Removed
60	29	Identify funding to support various public transportation providers and local jurisdictions to conduct comprehensive vulnerability assessments of their transportation facilities and services	Retained	Priority
61	80	Install High Water Mark (HWM) signs after flood events and co-locate stage crest gages on select HWM signs	Retained	Priority
62	• —	Develop incentives to increase the rate of replacement of 6 times seismically deficient buildings	Removed	Removed
63	• —	Identify areas on the coast that will be "islands", or cut off, from other cities or critical recovery resources following a Cascadia Subduction Zone earthquake & tsunami	Removed	Removed
64	92	Evaluate sediment impacts to Oregon’s water resources	Retained	Priority
65	52	Prioritize mitigation and retrofit projects on seismic lifelines	Retained	Priority
66	3	Provide funding and technical assistance to local Gov’ts to use the new guidance on classifying lands subject to natural hazards in their buildable lands inventories and adjusting urban growth boundaries	Retained	Priority
67	• —	Initiate an outreach strategy to encourage local jurisdictions to disseminate volcano preparedness educational materials	Removed	Removed
68	78	Develop guidance on determination of mudslides triggers and relation to rain or flood events	Retained	Priority
69	• —	Update the 2000 Guidelines for conducting site-specific geohazard investigations	Removed	Removed
70	41	Conduct a pilot project on two coastal estuaries to develop a framework for modeling sea level rise and to assess the overall impact of sea level rise on the estuaries	Retained	Priority
71	17	Coordinate development of a post-disaster scientific and technical clearinghouse with other state and federal agencies, higher education, and associations	Retained	Priority
72	• —	Update DOGAMI Special Paper 29 (Wang & Clark, 1999)	Removed	Removed
73	30	Develop probabilistic multi-hazard risk maps for the Oregon Coast	Retained	Priority
74	66	Lidar survey the State’s ROW (rights of way), west of the Cascade Range, to determine where seismic fault potential exists	Retained	Priority
75	61	Assess hazards associated with active crustal faults newly discovered by statewide lidar program	Retained	Priority
76	• —	Establish process for assigning inspection teams to needed areas for post-disaster facility inspection	Removed	Removed
77	46	Develop an improved methodology for gathering data and identifying the communities most vulnerable to drought and related impacts	Retained	Priority
78	107	Establish a program for studying winter storms and their impacts statewide. As a part of that program, develop a system for gathering snowfall data statewide	Retained	Priority
79	108	Continue to refine statewide natural hazard identification and characterization	Retained	Ongoing
80	109	Continue to refine the State’s risk assessment methodology and statewide assessments of natural hazard exposure, vulnerability, and potential losses	Retained	Ongoing
81	110	Continue to refine statewide identification and prioritization of the greatest risks from and communities most vulnerable to Oregon’s natural hazards	Retained	Ongoing
82	111	Continue to develop and implement resilience initiatives statewide	Retained	Ongoing

2015 to 2020 MITIGATION ACTION CROSSWALK

2015 #	2020 #	Statement	Disposition	Table
83	• —	Assist local governments in using the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* to update their comprehensive plans and development regulations	Removed	Removed
84	• —	Monitor the implementation of the updated *Planning for Natural Hazards: Oregon Technical Resource Guide* provided to local governments by tracking the number of jurisdictions that have used it	Removed	Removed
85	112	Provide support for development and update of local and state hazard mitigation plans	Retained	Ongoing
86	113	Improve and sustain public information and education programs aimed at mitigating the damage caused by natural hazards	Retained	Ongoing
87	114	Continue to improve inventory of state-owned/leased buildings in all hazard areas	Retained	Ongoing
88	115	Encourage citizens to prepare and maintain at least two weeks' worth of emergency supplies	Retained	Ongoing
89	• —	Continue to assist local governments with GIS capability development	Removed	Removed
90	116	Use lidar for statewide analysis of all natural hazards	Retained	Ongoing
91	130	Continue to act upon opportunities to advance the State's lifeline mitigation investment practice	Retained	Ongoing
92	131	Improve reliability and resiliency of critical infrastructure statewide by adopting industry-specific best practices, guidelines, and standards	Retained	Ongoing
93	132	Acquire statewide lidar coverage for the purpose of improving natural hazard mapping and infrastructure inventories	Retained	Ongoing
94	133	Provide technical assistance and funding to local governments to evaluate the need and opportunities for inter-tie projects in Local Natural Hazards Mitigation Plans	Retained	Ongoing
95	• —	Educate citizens about the different National Weather Service announcements	Removed	Removed
96	134	Continue to maintain the existing roster of qualified post-earthquake, flood, and wind inspectors with ATC-20 earthquake and ATC-45 flood & wind inspection training	Retained	Ongoing
97	135	Expand the state's stream gaging network. Seek stable funding for the operation, and maintenance of stream gages	Retained	Ongoing
98	• —	Better coordinate, fund, and publicize programs to reduce the abundance of juniper trees in arid landscapes across Oregon	Removed	Removed
99	136	Educate homeowners about choosing ice and windstorm-resistant trees and landscaping practices to reduce tree-related hazards in future ice storms	Retained	Ongoing
100	137	Each year, ask the Governor to designate October to be Earthquake and Tsunami Awareness Month	Retained	Ongoing
101	138	Continue to facilitate accessibility and use of the *Coastal Atlas* GIS resources	Retained	Ongoing
102	139	Research the effects of changing ocean water levels and wave dynamics along the central and southern Oregon coast, and use that data to augment the coastal geomorphic database	Retained	Ongoing
103	140	Survey coastline to monitor erosion	Retained	Ongoing
104	141	Maintain the updated inventory of shoreline protection structures	Retained	Ongoing
105	47	Implement the improved methodology for gathering data and identifying the communities most vulnerable to drought and related impacts	Retained	Priority
106	• —	Publicize and facilitate the implementation of both structural and non-structural seismic mitigation measures for home owners, business owners, renters, and contractors, including methods of reducing hazards	Removed	Removed
107	142	Provide information and technical assistance to implement mitigation of non-structural hazards in K-12 schools	Retained	Ongoing
108	143	Each year, ask the Governor to designate the third Thursday of the month of October as the Great Oregon ShakeOut Day by proclamation	Retained	Ongoing
109	144	Include information about the benefits of purchasing earthquake insurance in public outreach materials and disseminate those materials through appropriate public outreach programs and venues	Retained	Ongoing
110	145	Continue seismic rehabilitation of hospital, fire, and police facilities under the Seismic Rehabilitation Grant Program administered by Business Oregon's Infrastructure Finance Division	Retained	Ongoing

2015 to 2020 MITIGATION ACTION CROSSWALK

2015 #	2020 #	Statement	Disposition	Table
111	146	Continue seismic rehabilitation of public schools buildings under the Seismic Rehabilitation Grant Program administered by Business Oregon's Infrastructure Finance Division	Retained	Ongoing
112	148	Continue implementing the Oregon CRS Users Group Program	Retained	Ongoing
113	149	Monitor the effectiveness of the statewide strategy to encourage the purchase of flood insurance by demonstrating that the number of flood insurance policies held throughout the state continues to increase	Retained	Ongoing
114	• —	Update the Model Ordinance for Flood Damage Prevention	Removed	Removed
115	150	Maintain the Riparian Lands Tax Incentive Program	Retained	Ongoing
116	151	Provide information and potentially resources to local governments for developing "flood fight" plans and protocols	Retained	Ongoing
117	152	Continue the State's active Floodplain Management Outreach Program	Retained	Ongoing
118	153	Continue the State's active Floodplain Management Training Program	Retained	Ongoing
119	154	Prepare text for local broadcast of one Public Service Announcement (PSA) each year on a seasonal topic	Retained	Ongoing
120	155	Assist local communities in securing funding to mitigate damage to repetitive flood loss properties or those substantially damaged by flooding	Retained	Ongoing
121	• —	Continue implementation of FEMA's Risk MAP program in Oregon, including building effective community strategies for reducing risk	Removed	Removed
122	156	Continue developing Emergency Action Plans for all remaining high hazard dams in Oregon	Retained	Ongoing
123	• —	Implement flood protection standards for state-owned/leased buildings	Removed	Removed
124	157	Acquire existing homes and businesses seriously threatened or damaged by landslide hazards	Retained	Ongoing
125	158	Assist local governments in implementing the tsunami land use guidance	Retained	Ongoing
126	159	Monitor implementation of the tsunami land use guidance by tracking the number of jurisdictions that have used it	Retained	Ongoing
127	160	Continue to renew coastal communities' enrollments in the Tsunami Ready Program	Retained	Ongoing
128	161	Continue supporting school participation in annual tsunami evacuation drills	Retained	Ongoing
129	162	Continue supporting local agencies and local non-profits, such as CERT, in participating in educational efforts such as door-to-door campaigns to educate those living or working in the inundation zone on how to respond to an earthquake and tsunami	Retained	Ongoing
130	163	Continue innovative outreach activities, such as tsunami evacuation route fun runs	Retained	Ongoing
131	164	Continue to develop training and information packets and articles for local building officials informing them of their responsibilities and authority under ORS 455.446 and 455.447 and the State Building Code	Retained	Ongoing
132	165	Work with ODOT to replace or move existing Entering/Leaving Tsunami Hazard Zone signs to correspond with the XXL inundation line developed by DOGAMI	Retained	Ongoing
133	• —	Work with ODOT to develop additional signage as needed to increase awareness of the tsunami hazard	Removed	Removed
134	• —	Work with Oregon Parks & Recreation Department and Oregon Travel Experience to increase the number of interpretive educational installations along US-101	Removed	Removed
135	166	Develop volcanic hazard evacuation maps	Retained	Ongoing
136	167	Each year, ask the Governor to designate May to be Volcano Awareness Month by proclamation	Retained	Ongoing
137	168	Support development, enhancement and implementation of local education programs designed to mitigate the wildfire hazard and to reduce wildfire losses, such as the Firewise Communities/NFPA Program and the annual Wildfire Awareness Week Campaign	Retained	Ongoing
138	169	Continue to increase the number of local governments using the Wildfire Hazard Zone process to mitigate wildfire risk and losses	Retained	Ongoing
139	170	Continue to develop and increase the number of updated Community Wildfire Protection Plans (CWPPs) with the goal of aligning CWPP updates with 5-year NHMP updates, where possible	Retained	Ongoing

2015 to 2020 MITIGATION ACTION CROSSWALK

2015 #	2020 #	Statement	Disposition	Table
140	171	Continue to provide technical assistance in accessing funding for fire prevention or wildfire mitigation projects through Title III, the National Fire Plan, or other funding mechanisms	Retained	Ongoing
141	172	Implement the Oregon Forestland-Urban Interface Fire Protection Act ("Senate Bill 360") in all Oregon counties that meet criteria under the law	Retained	Ongoing
142	173	Analyze wildfire ignition probability statistics to better target prevention efforts at the leading causes of fires	Retained	Ongoing
143	174	Collaborate through work groups within the Pacific Northwest Coordination Group (PNWCG) to continue collecting and analyzing wildfire occurrence data using the standardized statewide method and report to the state legislature as required	Retained	Ongoing
144	• —	Collaborate through work groups within the Pacific Northwest Coordination Group to encourage the U.S. Forest Service to allow the owners of long-term dwelling leases to apply mitigation standards adjacent to their dwellings	Removed	Removed
145	175	Develop a single, comprehensive statewide method or process to collect and analyze wildfire occurrence data in a timely manner	Retained	Ongoing
146	177	Continue to educate communities, workers, and the public about the role of proper tree pruning and care in preventing damage during windstorms	Retained	Ongoing
147	178	Use industry best practices to minimize impact and outages to service delivery system of overhead line operators, during windstorm events	Retained	Ongoing
148	179	Educate citizens about safe emergency heating equipment	Retained	Ongoing
149	180	Continue educating motorists on safe winter driving, including how to be prepared for traveling over snowy and icy mountain passes	Retained	Ongoing

3.3.5 Mitigation Successes

Oregon maintains documentation of "mitigation success stories." These are completed mitigation actions that have shown to be successful by either (a) avoiding potential losses or (b) demonstrating cost-effectiveness through benefit-cost analysis, qualitative assessment, or both. Likewise, actions that support mitigation efforts, like risk or vulnerability assessment studies, are included. Mitigation success stories are completed by or with input from the action's coordinating agency.

3.3.5.1 Mitigation Success — Oregon State Resilience Office and Governor's Resilience 2025 Vision

Hazard: Earthquake, Tsunami, and All Hazards
Location: State of Oregon

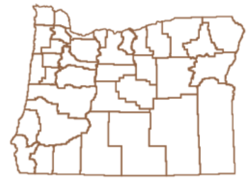
Problem:

Oregonians face a tremendous threat of a magnitude 9 earthquake on the Cascadia subduction zone, a 600-mile long fault zone located just off the Pacific Northwest coastline. The Cascadia earthquake will cause extensive ground shaking damage, create a destructive tsunami that will reach coast within 10–15 minutes, and result in serious impacts to all Oregonians. Although disaster preparations have been made, serious deficiencies remain.

Shortly after the 2011 Tohoku, Japan disaster with over 16,000 fatalities, the Oregon Legislature passed House Resolution 3 that directed the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) to develop a Cascadia resilience plan for the State. By 2013, the Oregon Resilience Plan (ORP) outlining the urgency to build resilience over the next 50 years was delivered to the Legislature. Among about 150 recommendations, a top recommendation was "Establishing a State Resilience Office to provide leadership, resources, advocacy, and expertise in implementing statewide resilience plans."

Solution:

In response to the numerous ORP findings, the Legislature passed 2013 Senate Bill 33, which created a task force to prioritize the recommendations and guide next steps. By October 2014, the task force determined that the highest priority recommendation was to establish a Resilience Policy Advisor to the Governor. The 2015 House Bill 2270, passed in July 2015 and codified as Oregon Revised Statute 401.913, formally established a State Resilience Office (https://www.oregon.gov/gov/policy/Pages/resilience.aspx) in the Office of the Governor. The executive appointment of a State Resilience Officer is unique: Senate confirmation is required as stipulated by Article III, Section 4 of the Oregon Constitution.



Quick Facts

Goals:

1 Protect Life
2 Minimize property damage
3 Minimize critical infrastructure damage
4 Enhance economic resilience
5 Minimize environmental impacts and utilize natural solutions
6 Enhance the state's natural hazards mitigation capability
7 Motivate the "whole community" to build resilience and mitigate
10 Enhance communication, collaboration, coordination

Mitigation Actions:

18 Complete a hazard mitigation policy legislative needs assessment
49 Support and implement the actions in the February 2014 Oregon Resilience Plan and October 2014 Task Force Report
…and many others

Lead agencies: Office of the Governor
Project Type: State of Oregon Resiliency Vision, Priorities, and Leadership
Project Start: 5/25/16
Project End: Statutory; Ongoing
Project Cost: $150,000 Annually
Funded by: State General Funds

Figure 1. Mike Harryman, State Resilience Officer

On May 25, 2016, Michael K. Harryman (Figure 1), officially became the first State Resilience Officer (SRO) in the nation to be instated BEFORE the disaster strikes. Mr. Harryman, working in the Office of Governor Kate Brown, is a well-recognized leader who focuses on Cascadia disaster resilience. In his SRO role and through his influence highlighting urgent disaster preparation needs, the State of Oregon has made great strides in improving Cascadia disaster resilience.

Benefit:

With the adopted 2013 ORP as the State's roadmap, SRO Harryman assisted in defining State of Oregon priorities in the Governor's Resiliency 2025 Vision (https://www.oregon.gov/gov/policy/Documents/resiliency-policy-agenda.pdf), released in October 2018. In the Vision, Governor Brown highlights her six resilience priorities:

1. Continue state investments in seismic upgrades of schools and emergency services buildings throughout Oregon.
2. Develop a plan for the Critical Energy Infrastructure (CEI) Hub to prevent and mitigate catastrophic failure and ensure fuel supplies and alternate energy sources are available to responders and the public.
3. Implement a state-wide earthquake early warning system by 2023.
4. Work with local governments, community groups, and the American Red Cross to ensure that 250,000 vulnerable homes have 2-week ready supplies within the next three years.
5. Strengthen local emergency management organizations and develop more robust logistical staging bases, local supply chains, and more earthquake and mass displacement insurance options.
6. Update the Oregon Resilience Plan in 2021 to reflect current best practices, community input, and academic research, including a specific plan for the Oregon Coast.

These six resilience priorities took shape in the Governor's Recommended Budget 2019-2021 (released November 28, 2018) as these six initiatives:

1.	Seismic Rehabilitation Grants:	$120 million
2.	CEI Hub Mitigation:	$500,000
3.	ShakeAlert, an earthquake early warning system, and Alert Wildfire:	$12 million
4.	2 Weeks Ready for 250,000 Homes:	$1.7 million
5.	Logistical Staging Bases to include selected public airports:	$10.1 million
6.	Update the 2013 ORP and assist coastal schools and hospitals:	$300,000

The purpose of these investments is to build infrastructure, improve citizen awareness and education, and ultimately ensure that more Oregon families are supplied for an eventual Cascadia subduction earthquake and other large-scale natural disasters. By July 2019, resilience Seismic Rehabilitation Grants and CEI Hub Mitigation were partially funded by the Legislature.

For the 2020 Legislative "short" Session, the Senate Committee on General Government and Emergency Preparedness introduced Senate Bill 1537 (SB 1537) at the request of Governor Brown. Three of her unfunded resilience priorities were included. The bill also included a fourth component that focused on dam safety. Governor Brown testified (http://oregon.granicus.com/MediaPlayer.php?clip_id=27838) before the Senate Committee on February 6, 2020, underscoring the gravity of the coming Cascadia event and the importance of SB 1537 to saving lives.

Although SB 1537 did not pass into law due to unrelated political challenges, Governor Brown has called the State to action by:

1. Establishing the State Resilience Office;
2. Installing the first Senate-confirmed State Resilience Officer;
3. Issuing the Governor's Resiliency 2025 Vision; and
4. Initiating SB 1537 to fund priority, life-saving resilience initiatives.

Not only has Governor Brown clearly articulated the challenges of the forthcoming Cascadia subduction zone earthquake and tsunami, she has identified and robustly supported priority initiatives to minimize disruption and prepare the people of Oregon. The Governor's message was well-received by the Legislature and SB 1537 was recommended to pass. It is anticipated that in the future these priorities will indeed be funded.

3.3.5.2 Mitigation Success — Oregon's Unique Seismic Rehabilitation Grant Program (SRGP)

Hazard: Earthquake
Location: State of Oregon

Background:

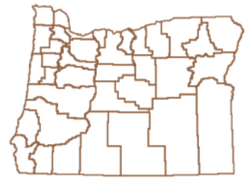
Schools are often considered as the hearts of communities where children receive education and neighbors congregate. Emergency service facilities, including fire and police stations and hospitals, are considered as community safety nets due to the emergency response services they help provide to the public. Schools and emergency response facilities are critically important community assets that support our modern way of life. When they are not functioning, such as due to earthquake damage, our society can be seriously disrupted and harmed. A future Cascadia earthquake will cause extensive ground shaking damage, create a destructive tsunami that will reach the coast within 10-15 minutes, and is expected to damage many hundreds of schools and emergency response facilities. This would result in terrifying societal impacts.

Problem:

In Oregon, seismic building codes that address Cascadia earthquakes were not adopted until the mid-1990s. Consequently, many existing kindergarten through 12th grade (K-12) school buildings, community colleges, and education service district buildings were built to standards currently known as seismically deficient. Similarly, emergency service buildings built before the mid-1990s are also at-risk of serious seismic damage. In 2007, DOGAMI completed a statewide seismic needs assessment (https://www.oregongeology.org/pubs/ofr/p-O-07-02.htm) that indicated hundreds of at-risk facilities that may be dangerous. Oftentimes, the public expects schools and emergency service buildings to perform to a higher standard during disasters; however, Oregon communities with pre-mid-1990s facilities, unless mitigated, may suffer enormous setbacks.

Solution:

To mitigate existing dangerous critical community assets, the State of Oregon created a unique program that is



Quick Facts

Goals:

1 Protect Life
3 Minimize critical infrastructure damage
4 Enhance economic resilience
6 Enhance the state's natural hazards mitigation capability
7 Motivate the "whole community" to build resilience and mitigate
9 Minimize damage to historic and cultural resources
10 Enhance communication, collaboration, coordination

Mitigation Actions:

49 Support and implement actions in the 2013 Oregon Resilience Plan
111 Continue to develop and implement resilience initiatives statewide.
…and many others

Lead agencies: Oregon Business Development Department (OBDD)
Project Type: Earthquake Mitigation Grants for Schools and Emergency Service Buildings
Project Start: 07/2005
Project End: Ongoing
Project Cost: Approximately $460 Million
Funded by: State General Obligation Bonds

improving community resilience across the state. The Seismic Rehabilitation Grant Program (SRGP) is a state of Oregon competitive grant program that provides funding for the seismic rehabilitation of critical public buildings, particularly public schools and emergency services facilities. This includes hospital buildings with acute inpatient care facilities, fire stations, police stations, sheriff's offices, 911 centers, and Emergency Operations Centers. More can be viewed at http://www.orinfrastructure.org/Infrastructure-Programs/Seismic-Rehab/. The buildings Oregon communities depend on in the face of a disaster will be stronger and improved due to Oregon's unique SRGP.

Oregon's SRGP provides state general obligation bond funds to retrofit public schools and emergency services buildings to meet current or exceed Oregon building code performance levels. Schools must meet a life-safety performance level so students can safely exit the retrofitted building. Seismic rehabilitation of common areas within schools, such as cafeterias, gyms, auditoriums, and emergency service public buildings must be built to immediate occupancy performance levels so that the building can function soon after the disaster. These retrofits help to reduce initial damage, minimize response needs for the facility that was upgraded, allow its resources to be community assets, and accelerate local recovery efforts.

In 2005, due to the leadership of Senator Peter Courtney (Figure 1), the Oregon Legislature authorized Oregon Office of Emergency Management (OEM) to administer the SRGP. In 2009, OEM awarded its first grants. In 2014, administration was transferred to Business Oregon, a state agency better suited to manage bond-dependent funds. Business Oregon administers this grant program to help develop safe, livable, and prosperous communities. The SRGP provides up to $2.5 million of state funds per project on a reimbursable basis.

Figure 1. Peter Courtney, Oregon Senate President, standing in front of the Oregon State Capitol (Source: Office of Senator Peter Courtney)

This program is not intended to address all school and emergency districts' needs, but to be a safety net for those owners who cannot fund their own retrofits. The State offers assistance when possible and is eliminating the risk of mass casualties. The SRGP is dependent on the Legislature allocating funding to Oregon Constitutional Article M (education) and Article N (emergency services) bond sales. In general, the funding awarded is broken into two bond sales each spring of the biennium. Eligible school buildings must (a) have a capacity of 250 or more persons; (b) be routinely used for student activities by K-12 public schools, community colleges and education service districts (ESDs); and (c) be owned by a school district, an education service district, a community college district, or a community college service district.

Figure. 2. Kindergarten to 8th grade students from the Applegate School in Grants Pass pose after being awarded with 2009-2010 SRGP grant funds (Source: SRGP)

As of May 2020, a total of 252 schools and 108 emergency services buildings have been awarded $456,732,427 in funding for improvements since the program's first awards in 2009. This includes 35 grants totaling $74,478,834 in the SRGP's sixth round of funding announced in May 2020. Figures 2 and 3 provide examples of school awardees.

Figure 3. The 1915 Central Elementary School in Albany was a 2010-2011 SRGP awardee (Source: SRGP)

Benefits:

Benefits from the SRGP include protecting students in public schools, as well as teachers, school staff and administrators and visitors from injuries. Seismic retrofit activities garner attention due to the planning and construction activities, which at times can be disruptive. As such, retrofits often serve to increase awareness about the importance of earthquake safety, and provides education opportunities to students, parents, neighbors, and other stakeholders. Opportunities include engaging in earthquake safety drills, such as practicing "drop, cover and hold on" during the annual ShakeOut exercise, preparing emergency kits, learning about earthquake science, and more. Oftentimes, school activities and concerns serve as catalysts for the larger community, thus education extends well beyond the schools. As an example, parents learn about earthquake preparedness from their children, and take steps to prepare at home and their workplace.

The SRGP provides direct benefits by protecting the lives of people in emergency service facilities as well as their assets. Further benefits involve improving the ability for first responders to provide their services, whether operating a 9-11 call center, fighting fires, enforcing laws, or caring for injured victims. Having reliable emergency services is a fundamental part of community resilience.

All SRGP applicants are required to conduct a quantitative benefit cost analysis as part of their application. Direct project benefits are clearly presented for all awardees.

3.3.5.3 Mitigation Success — State-of-the-Art Tsunami Vertical Evacuation Building at Oregon State University

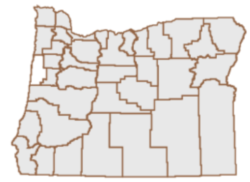
Hazard: Tsunami, Earthquake
Location: Lincoln County, Oregon

Background

Cascadia earthquakes pose a significant risk to the State of Oregon due to a combination of the existing seismic and tsunami hazards, vulnerability of the built infrastructure and potential consequences to communities. A Magnitude 9 Cascadia earthquake and tsunami would likely produce an unprecedented catastrophe much larger than any disaster the U.S. has faced. Tsunamis are expected to flood low lying coastal communities and inflict catastrophic damage. Constructing disaster resilient buildings in coastal communities is needed to improve personal safety and safeguard communities.

Problem:

Oregon State University (OSU) has the prestigious Hatfield Marine Science Center (HMSC) that boasts internationally recognized research as well as education for public members. HMSC is located on the banks of Yaquina Bay, Newport, and has a high Cascadia earthquake and tsunami hazard. More building space is needed for marine studies, education and research. Although a conventional new building would be designed to tolerate earthquake shaking, such a building would not withstand tsunami forces. After a Cascadia earthquake, occupants in a conventional building would need to immediately drop, cover and hold on to protect oneself from earthquake shaking impacts, then quickly evacuate to high ground in the attempt to avoid an arriving tsunami. However, at HMSC, tsunami evacuation would very challenging given the short evacuation time constraints combined with the long evacuation route options to high ground that provides safety from tsunami hazards. Furthermore, the closest tsunami assembly area currently would require HMSC employees and visitors to travel towards (not away from) the incoming tsunami.



Quick Facts

Goals:
- **1** Protect Life
- **7** Motivate the "whole community" to build resilience and mitigate
- **10** Enhance communication,

Mitigation Actions:
- **95** Assist one coastal community per year in considering vertical evacuation structures
- **49** Support actions to assist coastal communities in the 2013 Oregon Resilience Plan
- **131** Improve resiliency of critical infrastructure by adopting industry-specific standards.
- **161** Support school participation in tsunami evacuation drills

Lead agencies: Oregon State University
Project Type: Tsunami Vertical Evacuation Building
Project Start: 03/2018
Project End: 06/2020
Project Cost: $61.7 Million
Funded by: Oregon State University Revenue Bonds; Wayne and Gladys Valley Foundation and other donors; State Paid Bonds; Oregon State University Paid Bonds.

Solution:

Figure 1. Image showing the wide ramp designed for tsunami vertical evacuation by many people to access the rooftop, which is designed to be above the tsunami inundation levels (Source: https://today.oregonstate.edu/news/osu-marine-studies-building-be-national-model-tsunami-“vertical-evacuation”)

Instead of building a conventional building that meets building code requirements, OSU elected to build a new three-story tsunami resistant building with “above code” design parameters. The new Gladys Valley Marine Studies Building is specifically designed to accommodate tsunami “vertical evacuation” for its building occupants as well as hundreds of nearby people. Building occupants would evacuate up, or vertically, via stairs or a wide outdoor ramp onto the spacious rooftop up to a height above the tsunami hazards (Figure 1). Similarly, nearby people would not need to attempt the tenuous journey along the long evacuation route to high ground. Instead, they could use the wide outdoor ramp designed for mass ingress to escape the tsunami. The ramp leads from ground level to the top of the auditorium, and from there to the roof of the three-story building at a height of 47 feet. This solution will dramatically shorten the evacuation time to arrive at a community designated tsunami-safe assembly location and will safely harbor more than 900 people.

Figure 2. The construction of the new tsunami resistant building nearing completion. Accessed on February 12, 2020 from http://webcam.oregonstate.edu/cam/msisouth/live/live.jpg

Hundreds of lives may be saved due to the Gladys Valley Marine Studies Building, which is in the final stages of construction. The new building is scheduled to officially open in the summer of 2020 (Source: Bob Cowen, written communication, director of the Hatfield Marine Science Center, April 28, 2020). According to Dr. Cowen, “this new building will not only meet our programming goals for the Marine Studies Initiative, coastal and oceanic research, and public outreach, but it will include added safety options for the Hatfield campus through its vertical evacuation.” The 72,000 square-foot building has a three-story academic and research core, where the core is connected to a two-story wing that includes community space, an auditorium, an innovation laboratory, and other facilities (Figure 2).

Dr. Cowen explains that the building will not only increase the region's marine science education and research capacity, it will use state-of-the-art architectural and engineering techniques to serve as one of the first "vertical evacuation" (http://today.oregonstate.edu/news/osu-marine-studies-building-be-national-model-tsunami-%E2%80%9Cvertical-evacuation%E2%80%9D) tsunami sites in the United States. This will serve as an international model on how to apply newly available engineering methods as well as help other coastal communities with safety. According to Dr Cowen, “We have designed academic spaces that will enhance collaboration among students as a teaching tool, as well as drawing on the diversity of disciplines that the Marine Studies Initiative will represent. There also will be an innovation lab and studio that will enable students, faculty researchers and even entrepreneurs to design, build, test and market new technologies, as well as promote creative artistic projects. The auditorium will not only enhance OSU's academic mission, but also serve the Hatfield Marine Science Center's community role."

As a result of this new building as part of OSU's Marine Studies Initiative, OSU plans to have up to 500 students annually studying and doing research at the Hatfield campus by 2025. In addition to the new building supporting Marine Studies Initiative programs, it will provide headquarters for OSU's nationally recognized Marine Mammal Institute and its marine genetics and genomics programs. The move by those programs into the new building will free up space for expanding Hatfield's seawater laboratories in existing buildings, Dr. Cowen said.

Economic development and growth are more results of this new building. OSU has purchased a site of more than five acres near Oregon Coast Community College and outside the tsunami inundation zone, where it will begin construction of a residence hall that will house up to 360 students. For more information, see OSU news article dated November 22, 2017 (https://today.oregonstate.edu/news/osu-marine-studies-building-be-national-model-tsunami-%E2%80%9Cvertical-evacuation%E2%80%9D).

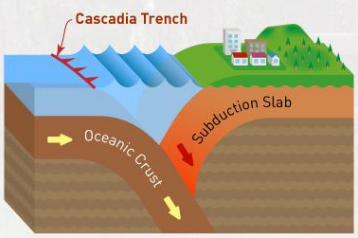
FEMA

HMA Hazard Mitigation Assistance

Mitigation Minute

Shaking Up Seismic Preparedness in Newport, Oregon

Newport's South Beach district is a low-lying area at risk of major seismic impacts and tsunamis due to its proximity to the Cascadia subduction zone.



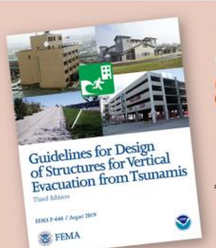
A study of this area has documented at least 40 high-magnitude earthquakes in the past 10,000 years, all with corresponding tsunamis.

To ensure the safety and resilience of the South Beach community, FEMA awarded the city **$680,478 in Hazard Mitigation Grant Program funding** to retrofit **SAFE HAVEN HILL**, an existing tsunami evacuation zone.

RETROFITS INCLUDED:

- Establishing a **cleared safe area** at the top of the hill for people to assemble.
- Installing a **disaster cache** with enough supplies to support evacuees for up to 72 hours.

> **Community engagement and collaboration was a key to the success of the Safe Haven Hill tsunami evacuation assembly area retrofit project.**
>
> —Derrick Tokos, City of Newport Community Development Director



SAFE HAVEN HILL BY THE NUMBERS

80 feet above sea level*

23,000 square feet (about 1/2 acre)

2,300 people can safely assemble in the safe area (10 square feet per person)

* FEMA-recommended safe elevation for tsunami vertical evacuation as specified in FEMA P-646: *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis* (Third Edition, 2019)

FEMA

"The community of Newport and the Hatfield Marine Science Center would like to recognize the exceptional leadership of Maryann Bozza. Maryann was instrumental in the Safe Haven Hill project and her tireless efforts helped the community make great strides in emergency preparedness. She may be gone from us, but her vision and planning will live on in all our endeavors to build a more resilient and prepared coastal community."

– Mark Farley, On Behalf of the Hatfield Marine Science Center and Newport Community

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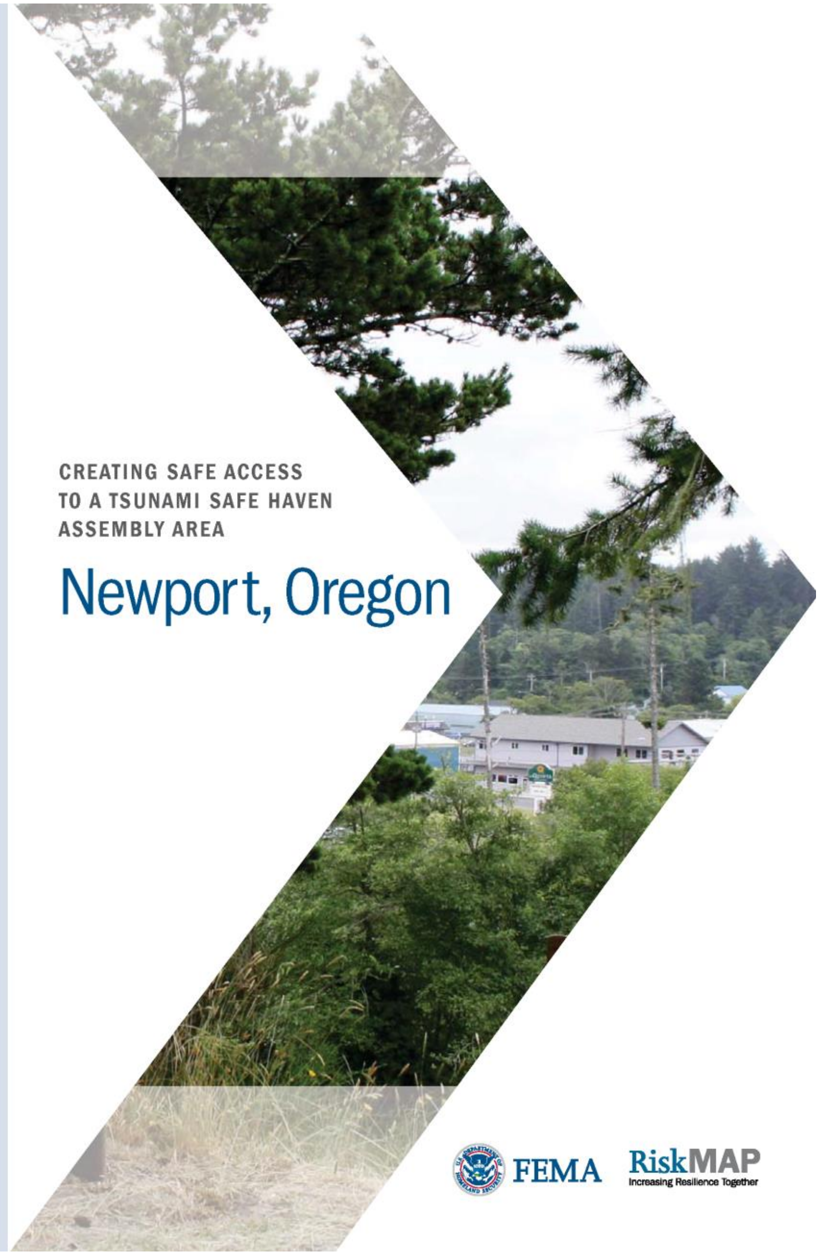


CREATING SAFE ACCESS TO A TSUNAMI SAFE HAVEN ASSEMBLY AREA

Newport, Oregon

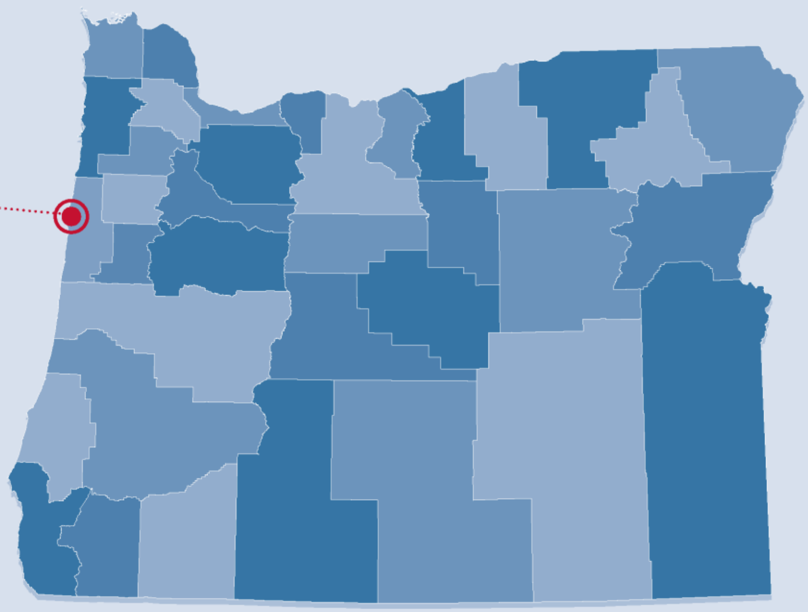
FEMA RiskMAP Increasing Resilience Together

NEWPORT, OR

The Place, Its History, and Life on the Coast

Since 2011, Newport, Oregon has worked to increase the safety of its residents and businesses against the threat of a tsunami. In partnership with other public and private entities, the city identified and retrofitted a tsunami assembly area, "Safe Haven Hill." This effort ensured a stable, elevated tsunami evacuation area is accessible to surrounding communities and that these communities know how and where to evacuate in the event of a tsunami.

This guide highlights how the City of Newport achieved a successful tsunami mitigation project by coordinating key partnerships, leveraging and managing a FEMA Hazard Mitigation Assistance grant, and engaging and encouraging public outreach and awareness efforts. This information is intended to support other communities who are interested in pursuing similar projects.



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Goal of Showcase:

This booklet provides information how the City of Newport increased the public safety of its community by successfully completing a tsunami mitigation project. This booklet, telling Newport's story, is part of a collection, the FEMA Region X Mitigation Showcase, to illustrate different ways in which local communities have leveraged partnerships and collaborated with state and federal partners to complete mitigation projects that address vulnerabilities to earthquakes and/or tsunamis. These narratives describe how project partners worked together to effectively navigate FEMA Hazard Mitigation Assistance requirements, build political and public support, and describe what lessons were learned throughout the project process. Information provided in each booklet intends to inspire and support other communities that wish to pursue similar mitigation action.

Mitigation Project:

In 2016, the City of Newport, Oregon increased the community's access to a safe assembly area through the Tsunami Safe Haven Hill mitigation project. This project improved an existing evacuation area, Safe Havel Hill, and leveraged additional resources to improve an existing evacuation route and provide interpretative signs estimating travel time to the assembly area. Success of the project can be attributed to robust public-private partnerships developed throughout the process and strategic collaboration with state. The Comprehensive Plan and Hazard Mitigation Planning processes were leveraged to engage the public. The process of completing the mitigation project increased public awareness by bringing the community together to make tsunami preparedness, such as evacuation drills, a part of regular life in Newport.

Defining the Hazard:

The City of Newport's risk to a tsunami is approximately 100 times higher than the risk to a tornado anywhere in the United States. The Safe Haven Hill project addresses Newport's vulnerability of access to high ground in the event of a tsunami due to an earthquake. While tsunamis may result from other events, the paleoseismic study of the Cascadia Subduction Zone (CSZ) has documented at least 40 high magnitude (M8+ to M9.0+) earthquakes in the past 10,000 years, all with corresponding tsunamis. The last major earthquake occurred in January 1700—over 300 years ago.

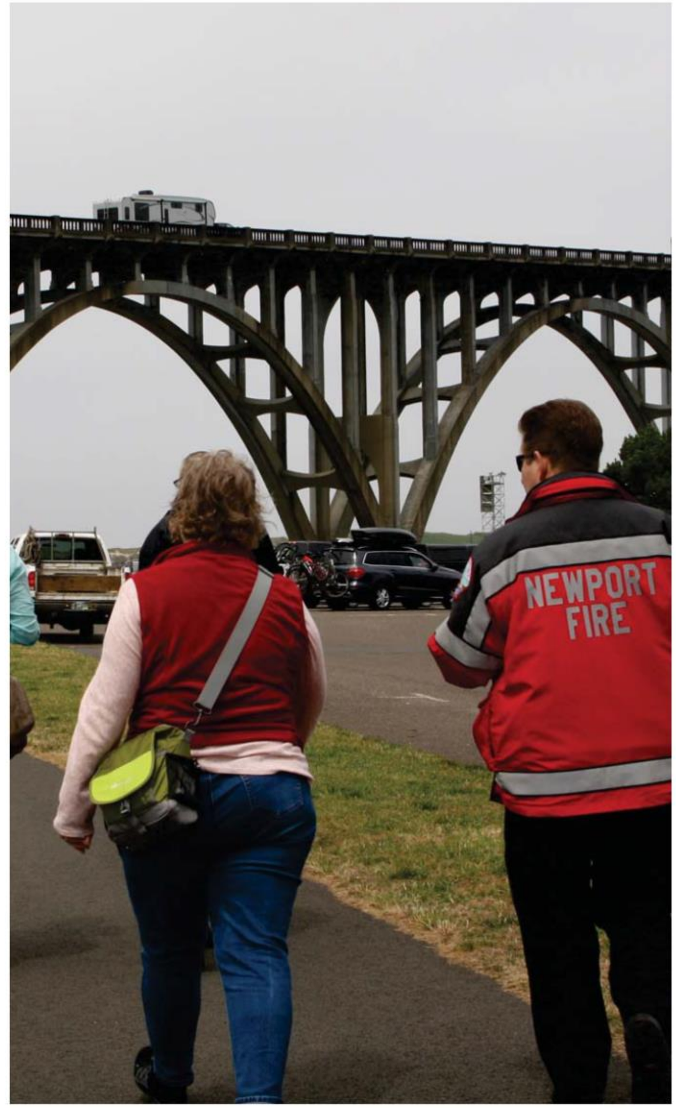

PHOTO: Walking the evacuation route to Safe Haven Hill from Hatfield Marine Center.

PHOTO: Looking north from top of Safe Haven Hill.

Risk to Community

The geography of Newport's South Beach community, a low-lying area at the base of steep hillsides, leaves it at risk to the impacts of a tsunami, especially a local tsunami generated by an earthquake along the Cascadia subduction zone. The risk of a tsunami striking South Beach is about 100 times greater than the risk of a tornado occurring anywhere in the United States. Therefore, an easily identifiable evacuation route and short-term (1 to 3 days) assembly area people can reach quickly are critical to ensuring the safety, economy, community identity, and overall resilience of the South Beach community.

The South Beach community is the area most vulnerable to tsunamis in Newport because: (1) Most of the community is situated at a very low elevation and is mapped within tsunami inundation zones; (2) Only one location is reachable in under 30 minutes that is also high enough to be safe from a tsunami (80 feet); (3) This high elevation area, which is owned by the Oregon Department of Transportation (DOT), was known for having poor access with steep and heavily forested slopes; and (4) More than 1,000 people in the South Beach community are at risk to the next major tsunami. The culmination of elevated public concern around seismic hazards, new data depicting tsunami inundation areas, public and political interest, and available financial assistance led to the creation of a project to improve the tsunami evacuation route and to designate and retrofit the high elevation area as an official tsunami assembly area.

> "This great project shows us what can be accomplished when stakeholders come together. Everyone just dug in and got to work on making the South Beach area safer."
>
> – Althea Rizzo, *Tsunami and Earthquake Program Manager*

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Project Timeline:

- **2005**
  - Hatfield Marine Science Center Begins Practicing Tsunami Evacuation Drills
- **2011**
  - Tohoku, Japanese Earthquake and Tsunami
  - DOGAMI Finalized Oregon Coast Tsunami Inundation Data
- **2012**
  - DOGAMI Works with the City of Newport to Update Tsunami Evacuation Route Maps
  - Debris from Japanese Tsunami Washes Ashore
  - Hatfield Marine Science Center-led Tsunami Evacuation Drill
- **2013**
  - DOGAMI Updates Tsunami Inundation Maps for Newport
  - Tsunami Readiness Rally
  - Tsunami Interpretive Trail Signs Complete
  - Project Phase 1: City Completed a Supplemental Geotechnical Assessment & Benefit-Cost Analysis to Meet FEMA Requirements for Release of HMGP Funds
- **2014**
  - HRA Archeological Survey of the Project Area
  - Project Phase II: Approval for Project Construction
- **2015**
  - *The Really Big One*, by Kathryn Schulz, New Yorker Article Published
- **2016**
  - Follow-Up Archaeological Monitoring Report
  - Completion of Evacuation Route and Safety Refuge Assembly Area
- **2017**
  - Project Closeout

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Timeline

In March 2011, Tohoku, Japan experienced a devastating magnitude 9.0 earthquake and a subsequent tsunami. The impacts of these events mobilized Newport public safety officials to ensure their community would be prepared if a similar event struck Oregon. The Oregon Department of Geology and Mineral Industries (DOGAMI) had also finalized data to begin improving tsunami inundation maps (TIMs) for the entire Oregon coast through the National Oceanic and Atmospheric Administration's (NOAA) National Tsunami Hazard Mitigation Program. Final TIMs were published in 2013. DOGAMI began working closely with the City of Newport in 2012 to improve tsunami evacuation maps by identifying assembly areas, ground-truthing recommended routes, and verifying base maps. These updated and improved evacuation and inundation maps confirmed that the proposed tsunami assembly area, Safe Haven Hill, would indeed be a safe assembly area during a tsunami event. The new data, followed by the updated maps, provided further purpose and encouraged momentum to continue with the allocation of city funds for tsunami mitigation efforts.

Other essential partners in the South Beach area that significantly contributed to the project's success were Rogue Brewery, the Oregon Museum of Science and Industry's Camp Gray, NOAA's Pacific Marine Operations Center, and the Oregon Coast Aquarium.

Key Partnerships

Coordinating with partners and community representatives was key to these efforts. One primary partner was Oregon State University's Hatfield Marine Science Center. Hatfield is a critical facility located in the tsunami inundation zone with a historic presence and an engaged community. Hatfield was an essential partner in ongoing tsunami public outreach efforts and has been hosting evacuation drills regularly since 2005. A tsunami evacuation drill in 2012 complemented recent city efforts to pursue FEMA grant funding to enhance an evacuation and assembly area. The 2012 drill also helped foster partnerships that contributed to public and political support, securing success for the future of Safe Haven Hill. The drill included participation from the Newport Police and Fire Department, Lincoln County Emergency Management, local Community Emergency Response Team (CERT) members, the Oregon State Office of Emergency Management, and the Oregon DOT. Public safety officials participated by closing Highway 101 and escorting participants of the tsunami evacuation drill across to the base of the hill. Participants walked to the top of the hill; approximately a 20-minute walk from the Hatfield Marine Science Center. At the time of this drill in 2012, the proposed Safe Haven Hill had limited pedestrian access to the safe elevation, as terrain was steep, rough, and overgrown. With the city facilitating the process, community partners were motivated and engaged throughout the entire project.

"Those of us working in the inundation zone who rely on Safe Haven Hill's accessibility after an earthquake were grateful for the chance to provide input at every stage of the project. The result is increased confidence in our ability as individuals to get ourselves up and out of the danger zone. Knowing that the city cared about our safety and was willing to go the distance on this complex and difficult project inspired us to strengthen and grow a lasting culture of preparedness."

– Maryann Bozza, *Program Manager, Hatfield Marine Science Center*

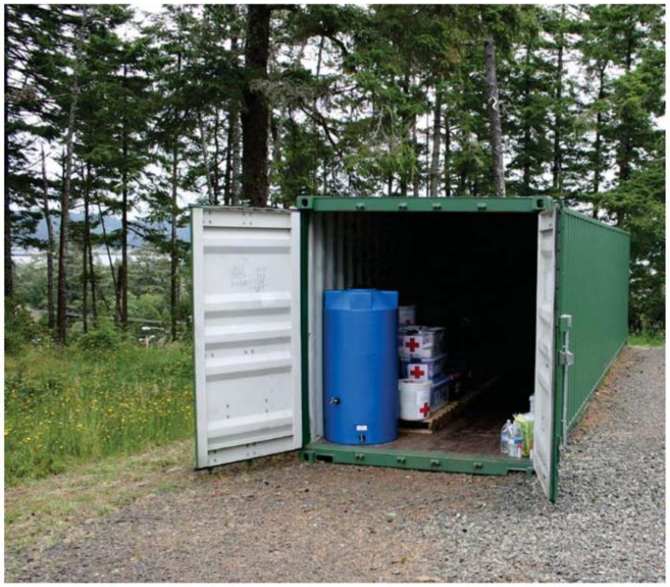

PHOTO: Disaster cache on the top of Safe Haven Hill. Partners continually monitor and contribute to growing emergency supplies.

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Grants Management

In 2012, the city's Community Development Department Director took the lead on leveraging the momentum of post-Tohoku public and political interest in tsunami risk reduction to pursue a project increasing the city's level of tsunami preparedness. Since the city had already identified Safe Haven Hill as a potential evacuation assembly area, and because of feedback from the Hatfield Marine Science Center's evacuation drills, a potential mitigation project to improve the accessibility and public awareness of this evacuation route was put forward. Around this same time, the Oregon State Tsunami and Earthquake Program Manager connected city officials with the State Hazard Mitigation Officer (SHMO) who had available FEMA Hazard Mitigation Assistance funds through the Hazard Mitigation Grant Program (HMGP). The State Earthquake Program Manager served as a matchmaker for the city's project and the available FEMA funding, administered by the State. This success highlights the importance of establishing strong relationships with partners, especially those who can be an advocate for critical projects.

The city Community Development Director and the SHMO worked together throughout 2013, in collaboration with other city, county, private, and public entities, to navigate options for the HMGP grant's required funding match and management needs. In the end, the city provided $221,091 through the South Beach Urban Renewal District and $43,473 from other funds as the local match for $680,478 in HMGP funds. The official purpose given on the HMGP application for this tsunami mitigation project was to "increase life safety and avoid deaths and injuries in future tsunami events by improving access and safety of trails to and on the Safe Haven Hill assembly area."

The city was awarded an HMGP grant with the condition that more information be provided to the SHMO and FEMA about the feasibility of the project, including a benefit-cost analysis and an archeological assessment. To help meet this requirement, the city leveraged an existing neighborhood refinement planning process to develop and seek public input on a low-cost (approximately $2,000) concept plan using the city's Urban Renewal funds. This plan illustrated the site work that would be needed to retrofit Safe Haven Hill so that it could safely support 2,300 people for at least 24 hours. Incorporating this concept plan into the neighborhood refinement planning process allowed this mitigation project to be a part of a larger and ongoing neighborhood refinement planning process. This resulted in the integration of tsunami risk reduction conversations into larger community planning discussions around how and where to invest and develop in the city and neighborhood's future.

Retrofits to Safe Haven Hill included establishing a cleared safe area at the top of the hill for people to assemble, stabilizing and improving trails to the top of the hill from many directions, installing a disaster cache, and installing a retaining wall near the highway to prevent erosion of the hill onto the highway. Participation and input from partners continued throughout the entire design and construction process. The evacuation routes were designed with the entire community and surrounding neighborhoods in mind, ensuring the connection of new trails to the city's existing trail system. Before the Safe Haven Hill retrofits were complete, a tsunami interpretive trail was completed through support from FEMA's National Earthquake Hazards Reduction Program, coordinated by the Oregon State Earthquake Program Coordinator. Educational and evacuation informational signs begin at the Hatfield Marine Science Center and continue along a pedestrian path, past the Rogue Brewery, up to the top of the hill. These signs illustrate the locations of the tsunami inundation zone, information on earthquake and tsunami safety, and an estimated walking time to reach a safe elevation.

Lessons Learned

City, State, and public and private partnerships were strengthened over the course of this mitigation project through continued meetings, discussions, public outreach efforts, and collaborative funding. They continue today to support the maintenance of Safe Haven Hill and the emergency supply cache. As resources become available, partners—including the Oregon Museum of Science and Industry's Camp Gray, Hatfield Marine Science Center, and the city—take turns purchasing supplies for the cache, such as food, water, batteries, solar panels, tents, and supplies for survivors, and building latrines. Ongoing coordination ensures partners know the conditions of the trails and assembly area and can identify needs to ensure the cache will support up to 2,300 people in the event of a tsunami evacuation. Further, both Camp Gray, Hatfield and the south beach community regularly participate in evacuation drills to maintain public awareness of where the evacuation trails are, to provide expectations for the level of effort required to get to safe ground, and to increase the public's comfort in how to proceed after an earthquake. An evacuation drill and review of safety procedures are also now integrated into the onboarding process for new hires at the Hatfield Marine Science Center and for students new to camp at OMSI.

The Safe Haven Hill project not only resulted in a safe assembly area, but also included a comprehensive public outreach strategy and extensive collaboration among partners that has led to the integration of tsunami safety into daily activities.

"Community engagement and collaboration was a key to the success of the Safe Haven Hill tsunami evacuation assembly area retrofit project. Our partners in the area recognized the need and were generous with their time to assist the city, from conceptual design all the way through construction and now maintenance of the emergency supply cache. It was then, and continues to be, truly a team effort!"

– Derrick Tokos, *City of Newport Community Development Director*

PHOTO: Interpretive trail sign at the top of Safe Haven Hill providing tsunami information.

Technical Grant Information

Hazard Mitigation Grant Program, DR-1964, HMGP-1964-5-R Newport Tsunami Safe Haven Hill Retrofit, Hardening and Access Improvements – Phase 1 (Feasibility Study) and Phase II (Construction)

TOTAL COST OF PROJECT:

- $945,042
- $16,000+ overrun because ODOT required a change to the type of retaining wall materials and the height of the wall. The redesign and the material for these changes were costly.

GRANT ORGANIZATION:

- Two Grant Phases – (1) Feasibility Study, (2) Construction. The feasibility study in Phase I was completed to determine the Benefit-Cost Analysis (BCA) of the tsunami hill retrofit. This was a geotechnical evaluation and engineering analysis to determine if the hill retrofit would be both feasible and effective as high ground to protect people from tsunami inundation. In this phase, the project was considered an "outdoor tsunami safe area" similar to a tornado or hurricane safe area and subject to post-closeout operations and maintenance requirements consistent with that eligible project type. The BCA was completed by a contractor using FEMA Version 4.8 Damage-Frequency Assessment BCA software. The only category of benefits counted in the BCA was deaths avoided. The project was found to be very cost-effective. With the conservative, lower-bound type estimates for the number of deaths under the as-is before mitigation condition of Safe Haven Hill, and for the effectiveness of the proposed improvements to facilitate access to the safe area, the results yielded a benefit-cost ratio of 26.40.

  Approval for Phase II was granted after Phase I analysis was completed and clearly demonstrated the cost benefit to FEMA. Phase II included surveying, final engineering and design of the retrofit, Environmental Planning and Historic Preservation (EHP) requirements, construction, post-construction site stabilization, signage/lighting, and construction management costs.

SCOPE OF WORK DETAIL:

- Establish a clear and safe area at the top of Safe Haven Hill.
- Improve existing crude trail on the north side and the existing gravel path on the southwest side of the hill and stabilize these pathways to prevent failure from slumping/sliding during strong earthquake ground shaking preceding tsunami arrival.
- Add a stairway on the south side of the hill to expedite access to the safe area for people approaching the hill from the south.
- Add a sidewalk on the east side of the hill (west edge of Highway 101) to ensure safe access for people coming from the east.
- Improve access, visibility, and awareness of the tsunami safe area with path lighting and signage.
- Install a disaster supply shed in the safe area.
- Install a retaining wall near the highway to prevent erosion of the hill onto the highway.
- **Permits were required by ODOT of the city to construct a necessary retaining wall. The city obtained permits and ODOT participated in a review of the retaining wall engineering and design plans.**

[Note to highlight, lesson learned: ODOT required a late change to the design of the retaining wall above Highway 101 resulting in a change order with the contractor and engineer to redesign the wall. The result was a significant overrun in the cost of the project that the city absorbed.]

SAFE HAVEN HILL NUMBERS:

- 80 feet above sea level
- Above the FEMA recommended safe elevation for tsunami vertical evacuation as specified in FEMA P-646: Guidelines for Design of Structures for Vertical Evacuation from Tsunamis (Second Edition, 2012).
- 23,000 square feet (about one-half acre)
- Provides safe assembly area for 2,300 people (10 square feet per person)
- Current state – can be accessed easily from all sides of the hill, with a paved path and two other stairways that access the hill. The area is open and lighted, and contains a large storage unit that houses supplies to last 48-72 hours, depending on the number of people that access the hill during a tsunami event.

For more information, contact: Amanda.Siok@fema.dhs.gov

3.3.5.4 Mitigation Success — Student Safety in Seaside, Oregon

Hazard: Tsunami, Earthquake, Landslide
Location: Clatsop County, Oregon

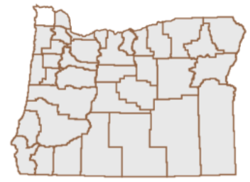
Background:

Seaside School District in coastal Oregon has the highest risk of injuries and fatalities from an expected magnitude 9 Cascadia subduction zone earthquake and accompanying tsunami among Oregon’s school districts. Three of the four existing schools—Gearhart Elementary, Broadway Middle, and Seaside High Schools—which serve the communities of Seaside, Gearhart, Cannon Beach and surrounding communities, are located in the tsunami hazard zone and face an extremely high likelihood of destruction in a Cascadia earthquake and tsunami.

Problem:

Despite many years of disaster planning to drop, cover and hold on during earthquake shaking followed by evacuation by foot to high ground to escape a tsunami, students remained inadequately protected. The existing schools were built long before there was an understanding of the hazards posed by the Cascadia subduction zone. Consequently, three were constructed in the tsunami zone and all four with insufficient seismic design provisions. The extensive, hazardous tsunami evacuation routes proved too burdensome. Based on scientific studies and student education, exercises and drills, a high number of casualties would likely occur. New, modern schools would need to be constructed above the tsunami zone to protect students from collapse-prone buildings and powerful tsunami waves.

In November 2013, a $129 million school bond to construct a safe, new school campus in the hills overlooking Seaside was issued. Due to the costs associated with building an elementary, middle and high school, the bond failed with a 39 percent “yes” to 62 percent “no” vote. At that time, it appeared that the current students and upcoming generations of students would remain at high risk.



Quick Facts

Goals:

- **1** Protect Life
- **3** Minimize critical infrastructure damage
- **4** Enhance economic resilience
- **7** Motivate the “whole community” to build resilience and mitigate
- **8** Eliminate development where mitigation is impracticable
- **10** Enhance communication, collaboration, coordination

Mitigation Actions:

- **94** Create…elevated safe areas above the level of modeled inundation
- **95** Assist local gov’t with tsunami mitigation

…and many others

Lead agencies: Seaside School District; DOGAMI; Oregon Department of Education

Project Type: Tsunami Mitigation
Project Start: 11/07/16
Project End: 03/31/20
Project Cost: $100 Million
Funded by: Seaside School District; Oregon Department of Education; Oregon Business: Seismic Rehabilitation Grant Program

Solution:

In 2016, Dr. Doug Dougherty, Seaside School District Superintendent, made an important personal decision that would change the course for the residents of the greater Seaside area. Dr. Dougherty opted to retire so that he could focus on his vision to create a new school campus where students would be safe and able to learn in modern facilities. He also wanted to offer a gathering space for community activities as well as an area that, after a Cascadia disaster, could provide a safe haven for the region. He banded with students, community leaders and residents to find a solution.

Figure 1. Seaside High School students rallying for support for the 2016 school bond.

As a result of Dr. Dougherty's leadership as Superintendent Emeritus, the Weyerhaeuser Company donated 80 acres of land for the new school campus in June 2016. With the support of this new public-private partnership, in November 2016 a similar but significantly trimmed school bond for $100 million was proposed. With Dr. Dougherty as the champion, new partnership and student supporters in place, the bond passed (Figure 1).

As a result of the bond passage, the Oregon Department of Education provided $4 million of additional matching funds from state bond funds. Oregon Business provided a $2.5 million grant to perform seismic rehabilitation of Seaside Heights Elementary School, which is co-located with the new school campus in the hills. A new safe and modern school campus is under construction and scheduled to open in fall 2020 (Figure 2).

Figure 2. Photograph of the new Seaside School District campus during construction in January 2020. The view is from the hills looking southwest towards the community of Seaside and the Pacific Ocean. (Source: http://www.seaside.k12.or.us; credit Seth Morrisey of Kelis Social Media; downloaded 2/12/20)

Benefits:

The most significant benefit is that the lives of over 1600 students are protected from earthquake and tsunami hazards. Faculty, staff, volunteers and visitors will also be out of harm's way. In addition to protecting lives, the existing school buildings in the tsunami zone will be closed when the new campus opens.

The new campus will offer new modern educational facilities and opportunities. The campus design embraces sustainable and disaster resilient elements, such as being served by a new seismically robust city water reservoir and having solar-ready facilities for a future solar-plus-battery microgrid. The campus will serve as a community gathering location during normal and post-disaster times. This includes Seaside Heights Elementary School, which is co-located with the new campus, and is undergoing seismic rehabilitation.

The development of the new school campus also encourages future development opportunities above the tsunami hazard zone in the City of Seaside. The likelihood of post-disaster recovery for the entire city is now apparent. This Seaside experience serves as a role model for other coastal communities.

3.3.5.5 Mitigation Success — Disaster Planning in the Portland Metropolitan Region

Hazard: Earthquake, Landslide
Location: Clackamas, Columbia, Multnomah, Washington Counties, Oregon

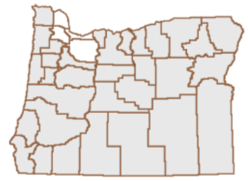
Problem:

The Portland metropolitan area faces significant earthquake hazards from a Cascadia earthquake and Portland Hills fault earthquake. However, the impacts of earthquakes in the greater Portland Oregon area were not well quantified, which prevented the development of science-based disaster planning. Earthquake impact analyses using updated data, current subduction zone science and the latest mapping and modelling techniques were needed.

Solution:

Leaders from the Regional Disaster Preparedness Organization (RDPO) worked with the Oregon Department of Geology and Mineral Industries (DOGAMI) and the Oregon Office of Emergency Management (OEM) to perform earthquake impact studies for the Portland Oregon metropolitan area, including Clackamas, Columbia, Multnomah and Washington counties in Oregon and Clark County in Washington. In February 2018, an initial study (https://www.oregongeology.org/pubs/ofr/p-O-18-02.htm) was released and results were integrated into planning activities. By March 2020, DOGAMI issued a second report (https://www.oregongeology.org/pubs/ofr/p-O-20-01.htm) that covered the remainder of the two part study area. The results include building and infrastructure damage, casualty and debris estimates for a magnitude 9 Cascadia earthquake (Figures 1 and 2) and magnitude 6.8 earthquake on the Portland Hills Fault.

The DOGAMI earthquake impact analyses address a major need for consistent, updated earthquake damage estimates in the Portland metropolitan region and enhance the understanding of potential impacts for the region. This allows for improved planning by communities, the region, and the state to prepare for, respond to, and recover from major earthquakes.



Quick Facts

Goals:

1 Protect Life
2 Minimize property damage
3 Minimize critical infrastructure damage
4 Enhance economic resilience
7 Motivate the "whole community" to build resilience and mitigate
10 Enhance communication, collaboration, coordination
11 Mitigate the inequitable impacts of natural hazards

Mitigation Actions:

108 Refine hazard characterization
109 Refine risk assessment methods
110 Identify greatest risks
133 Assist local NHMP plans
134 Assist with post-disaster inspection planning

Lead agencies: Regional Disaster Preparedness Organization (RDPO)
Project Type: Earthquake Risk Assessment and Hazard Mapping
Project Start: 10/01/15
Project End: 03/31/20
Project Cost: $462,698.00
Funded by: FEMA UASI

Damage and casualty estimates are tabulated at county, jurisdiction, and neighborhood levels, providing actionable information for further use in emergency planning, earthquake mitigation, public awareness, and post-earthquake response and recovery.

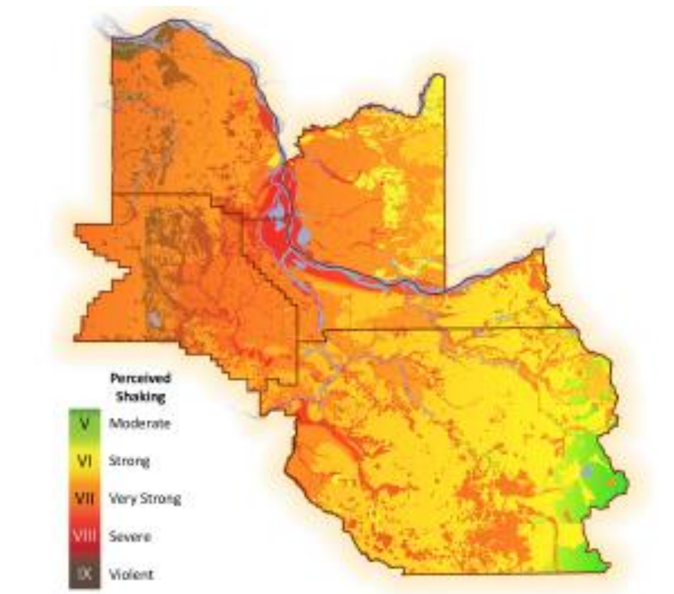


Figure 1. An earthquake intensity map for the Portland Oregon metropolitan region showing areas with expected moderate to violent shaking from a Magnitude 9 Cascadia earthquake (Bauer, et al., 2020)

Benefits:

According to Laura Hanson, RDPO Senior Regional Planning Coordinator, since DOGAMI's publication of the first phase of the RDPO enhanced earthquake impact study for Clackamas, Multnomah and Washington Counties, the data has been put to use in a variety of other regional and local projects.

Hanson states, "First, the RDPO commissioned an economic impact study with ECONorthwest (ECONW) that is building directly on the DOGAMI dataset to construct an economic impact model and test various policies that could improve economic resilience to a catastrophic earthquake in the region.

Second, the RDPO and Metro are partnering on an update to the region's Emergency Transportation Routes to apply a seismic lens, using the earthquake damage and earthquake induced landslide estimates produced by DOGAMI. The seismic updates from DOGAMI also informed seismic route resilience work with the Oregon Department of Transportation (ODOT); counties in the region are working with ODOT to conduct a cost benefit analysis of needed upgrades to make the state lifeline routes more seismically resilient, including investigations into adjacent county level routes that could serve as more cost-effective seismically hardened detours for the state lifelines.

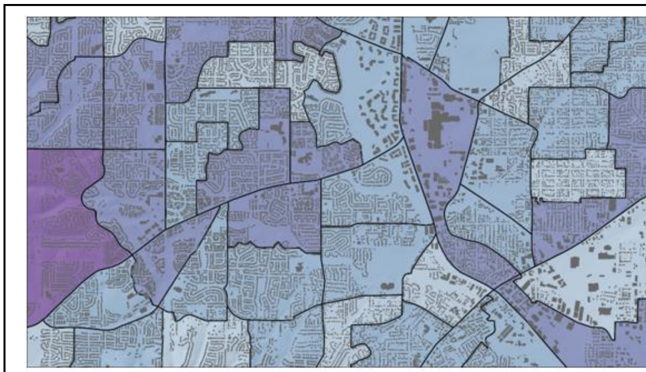


Figure 2. An example of damage results on a neighborhood level where areas darker colors indicate higher damage and lighter colors indicate lower damage (Source: DOGAMI, unpublished).

The DOGAMI earthquake impact studies will inform each local county's Mitigation Plan Update in the next five-year plan update cycle; and is likely to be referenced in an upcoming October 2020 regional mitigation plan analysis workshop with the EPA and FEMA.

The DOGAMI and ECONW earthquake impact studies also led to an RDPO project to develop more robust mapping of social vulnerabilities in the region. This was done so planners and policy makers in the region can better understand how the damage to infrastructure will impact the most vulnerable populations, and how economic policies can influence the resilience and recovery of those populations as well.

Finally, the DOGAMI studies inform the annual Threat and Hazard Identification and Risk Assessment (THIRA) submitted to FEMA on behalf of the Urban Area Security Initiative (UASI) grant program; the enhanced earthquake estimates are of great value for that annual assessment process" (Written personal communication, March 4, 2019).

The study results and accompanying data are intended not as an end in themselves, but as a platform for counties, jurisdictions, and communities to better understand their needs to prepare for, respond to, and recover from a major earthquake. The publicly available information from the DOGAMI studies are being used to reduce the region's vulnerability, shorten recovery time, and improve emergency operations in a variety of ways, as described (above).

Publicly available information that are being used for planning purposes include:

- **Building and infrastructure databases:** a region-wide building footprint database, a building database containing detailed descriptions of each building, and an electric power transmission structure database
- **Geotechnical mapping updates:** earthquake-induced landslide susceptibility, liquefaction susceptibility, and soil classification, using recently published high-resolution geologic mapping
- **Ground motion and ground deformation updates:** local ground motion and ground failure data for two earthquake scenarios using the geotechnical mapping updates
- **Earthquake damage estimates:** estimated impacts to buildings and the people that occupy them, to the region's designated emergency transportation routes, and to the electrical grid

3.3.5.6 Mitigation Success — Coastal Hospital Resilience Project

Hazard: Earthquake, Tsunami
Location: Clatsop, Tillamook, Lincoln, Lane, Douglas, Coos, and Curry Counties, Oregon

Background:

A magnitude 9 Cascadia earthquake is expected to produce destructive ground shaking and a tsunami that could arrive at the coast in 10 minutes. Due to expected highway damage, coastal communities will be geographically isolated and experience long-term disruptions with emergency fuel and water supplies (Wang, 2017). Hospitals are expected to be severely impacted, which will limit their ability to provide healthcare services in the communities at a time when there will be a high demand for services (OSSPAC Oregon Resilience Plan, 2013; Wang, 2018). Hospitals serve as community safety nets. Even during extreme events, they need to be resilient—they should incur only minimal losses and recover quickly to provide healthcare services.

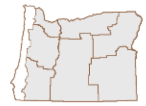
Problem:

All eleven of the coastal hospitals are prepared to provide services after major storms, where lifeline service downtimes can last for several hours to several days. However, hospital personnel who work in emergency management determined that they need to make more preparations in order to be prepared for future Cascadia disasters. They require more information, collaboration, and support, including increased support from their top leaders as well as technical support.

Solution:

The Oregon Health Authority (OHA) Public Health Division, Health Security Preparedness and Response (HSPR) program worked with DOGAMI on the Coastal Hospitals Resilience Project to provide subject matter expertise on earthquake and tsunami hazards, risk and building resilience. The main purpose of this project was to:

1. Assess the level of disaster preparedness of all eleven hospitals located along Oregon's coast;



Quick Facts

Goals:

- **1** Protect Life
- **3** Minimize critical infrastructure damage
- **4** Enhance economic resilience
- **6** Enhance the state's natural hazards mitigation capability
- **7** Motivate the "whole community" to build resilience and mitigate
- **10** Enhance communication, collaboration, and coordination

Mitigation Actions:

- **49** Implement the actions in the February 2013 Oregon Resilience Plan
- **110** Continue to refine statewide identification and prioritization of the greatest risks from and communities most vulnerable to Oregon's natural hazards
- **111** Continue to develop and implement resilience initiatives

…and many others

Lead agencies: Oregon Department of Geology and Mineral Industries, Oregon Health Authority, Health Security Preparedness and Response
Project Type: Coastal Hospitals Technical Assistance
Project Start: 01/2017
Project End: 06/30/2020
Project Cost: Approximately $280,000
Funded by: OHA HSPR funds from a Center for Disease Control and Prevention (CDC) grant

2. Elevate the awareness of the importance to prepare for a magnitude 9 Cascadia earthquake and accompanying tsunami to coastal hospital leadership; and
3. Provide technical assistance to coastal hospitals on resilience planning so hospitals will be able to be locally self-sufficient for 3 weeks to provide post-disaster medical services. OHA HSPR information can be found at https:\www.oregon.gov\OHA\PH\PREPAREDNESS\Pages\Program-Information.aspx

This project addressed the problem that hospitals would be too overwhelmed to provide adequate medical services after a major Cascadia earthquake and accompanying tsunami. Hospitals provide critical services in their communities every day and are especially needed to provide medical services after major disasters. Project activities listed below have been highly effective in reducing earthquake risk on a local, regional, and state level.

1. At the start of the Coastal Hospital Resilience Project, OHA and DOGAMI assessed the preparedness levels of 11 coastal hospitals and determined that they are prepared for typical winter storms but not prepared for a Cascadia earthquake and tsunami. This publication summarizes the assessment findings: Oregon Coastal Hospitals Preparing for Cascadia, DOGAMI report O-18-03 (http://www.oregongeology.org/pubs/ofr/O-18-03_report.pdf).
2. OHA and DOGAMI convened a meeting of leaders from all eleven of the coastal hospitals to discuss the need for all hospital to be ready for Cascadia earthquakes and to develop resilience action plans. Activities of the meeting helped to elevate to hospital leadership the importance of preparing for Cascadia earthquakes and tsunamis. As a result of the meeting, hospital leaders committed to preparing themselves to be able to provide healthcare services immediately after a Cascadia earthquake and tsunami. Hospital personnel gained a stronger appreciation of the need to not only strengthen their own hospital but to also work with community partners including water districts, electricity providers, fuel suppliers, county emergency managers and many others.

   Dr. Lesley Ogden, CEO of two coastal hospitals, said, "I had always thought that, in the event of a natural disaster, we could rely on our other hospitals throughout the system to send help our way, but I now understand that they will have their own challenges and we will be cut off from each other. We need to factor that into our planning. We've got a good start with new and safer facilities, but there is more we need to do to be a resource to our communities in the event of disaster." Dr. Ogden has built a new resilient hospital (Figure 1) and said that planning is now ramping up for both her hospitals to create hospital resilience action plans.

   This publication summarizes the first event that gathered leadership from the 11 coastal hospitals: Summary report on the Oregon Coastal Hospital Special Leadership Event, DOGAMI Report O-19-01 (https://www.oregongeology.org/pubs/ofr/p-O-19-01.htm).

Figure 1. Dr. Lesley Ogden, hospital CEO standing next to robust steel members for the new resilient coastal hospital that opened in February 2020.

3. OHA and DOGAMI provided technical assistance, including at regional group meetings as well as individualized on-site support to each of the eleven hospitals. Guidance was developed and provided on reducing hospital building (structural and nonstructural) vulnerabilities, and on developing reliable water and power services. These guidelines refer to best practices, standards, building codes and seismically certified equipment (Figure 2). DOGAMI Report O-19-02 (http://www.oregongeology.org/pubs/ofr/p-O-19-02.htm.) was developed with the support from the Cascadia Region Earthquake Workgroup (CREW) and includes guidance specifically developed for the coastal hospitals: Resilience Guidance for Oregon Hospitals (https://www.oregongeology.org/pubs/ofr/p-O-19-02.htm). In addition, hospital resilience planning maps have been developed for each hospital to assist hospitals to prepare for Cascadia earthquakes and to encourage community activism to seismically improve water and power systems for the hospitals among other activities (Figure 3). Continued engagement is needed to help hospitals with their journey of building disaster resilience.

Figure 2. This hospital chiller equipment has been tested to perform well after earthquake shaking and has a "seismically certified" label.

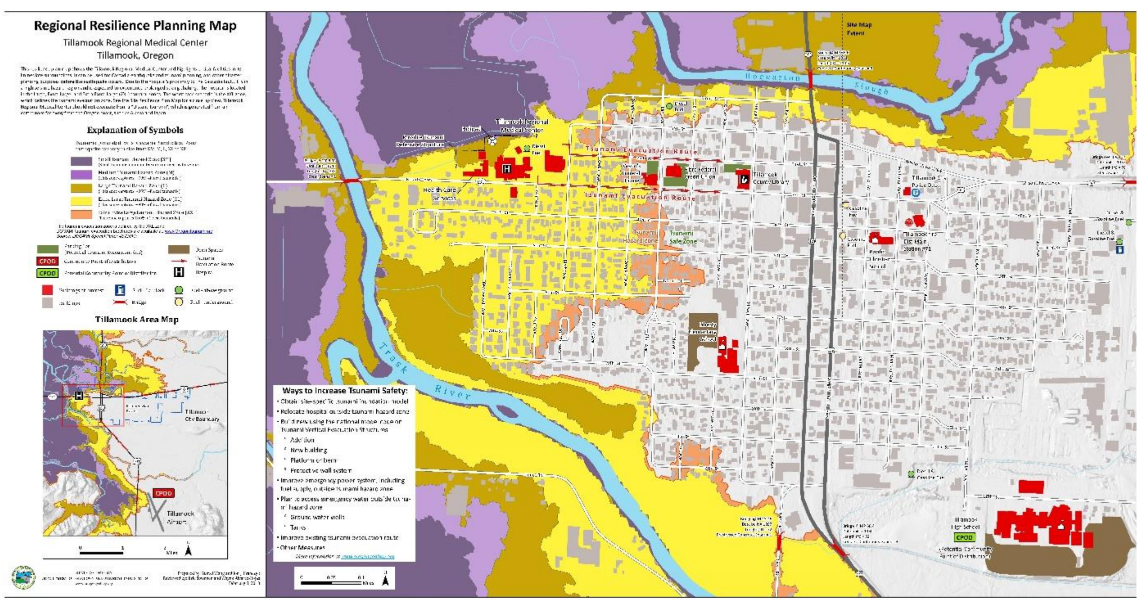


Figure 3. Example of a Regional Resilience Planning Map showing the hospital with tsunami hazards as well as other community facilities, such as the nearby school outside of the tsunami hazard zone.

4. Seven key messages were repeatedly discussed as a means to improving coastal hospital resilience:
    - Identify alternate care sites
    - Plan to be locally self-sufficient for three weeks
    - Evaluate seismic vulnerabilities for hospital buildings, emergency power and emergency water
    - Develop a hospital resilience action plan to address identified vulnerabilities
    - Engage in the Oregon Coastal Hospital Resilience Network
    - Partner with community members
    - Lead as a community resilience champion

Benefits:

As part of this project, we have established strong public-private partnerships (P3) as a foundation to enable continued strides in strengthening disaster resilience.

OHA HSPR has received overwhelming enthusiasm, engagement and support from coastal hospital staff and their partners about the effectiveness and importance of the Coastal Hospital Resilience Project. Many talks, conference sessions, news articles, papers and other educational and outreach activities have taken place. OHA received the 2019 recognition mitigation award (https://www.wsspc.org/wp-content/uploads/2020/02/February-2020-Bulletin-1.pdf) on earthquake mitigation from the Western States Seismic Policy Council at the 2020 National Earthquake Conference.

Widespread actions have recently been taken and more is continually underway. Coastal hospital executives from two hospitals created new full-time Hospital Emergency Preparedness Manager positions, based upon their realization of the need in relation to Cascadia earthquake and tsunami impacts as indicated on DOGAMI tsunami inundation zone maps and information shared at the Coastal Hospitals Special Leadership Event. Example of resilience actions include: seismically upgrading hospital buildings and equipment; improving business continuity plans; signing memoranda of understanding their suppliers; adopting the Oregon Crisis Care Management Guidelines; partnering with water and electricity service providers; and more.

Hospital personnel feedback on project activities has been positive—comments include, “it was tremendously helpful for us;“ “We have gained further insight into our water and power needs;” “I gained knowledge that I have been able to share with the community multiple times;” and “It has brought our community partners closer to us.”

Project studies have helped to support the replacement of a highly vulnerable hospital to the building of a new resilient hospital (https://www.samhealth.org/find-a-location/s/samaritan-north-lincoln-hospital/new-hospital-project-lincoln-city). The new hospital, opened in February 2020, includes numerous features that will help the community in a post- Cascadia earthquake situation.

Two hospitals have received State of Oregon funds to conduct seismic mitigation. In 2019, one coastal hospital (https://www.oregon4biz.com/About-Us/Investments-Report/FY2018.php; https:/djcoregon.com/news/2018/02/15/samaritan-pacific-communities-hospital-in-the-rise-in-newport/) received $1.5 million from Oregon Business’s Seismic Rehabilitation Grant Program (SRGP; see listing near bottom of list. In 2019, another coastal hospital (https://www.peacehealth.org/florence-peace-harbor-seismic-grant) received $2.5 million SRGP funds.

Project activities have also involved lifeline infrastructure owners that provide hospitals with power and water. Innovative ways to address prolonged electrical outages with solar plus battery microgrids are being explored (https://www.opb.org/news/article/hospitals-oregon-coast-earthquake-preparedness), along with ways to address financial needs.

Many new and creative approaches taken for this project were particularly effective, which included:

- Hosting a Coastal Hospitals Special Leadership Event focused on engaging executive leadership from all coastal hospitals for the purpose of:
    - Elevating understanding of the impact of a Cascadia Subduction Zone earthquake and tsunami
    - Encouraging progressive ways to prepare to be able to serve coastal communities post-disaster
    - Exploring launching a coastal hospital-driven collaborative network
- Having the State Resilience Officer from the Governor's Office speak out on the importance of hospital leadership engagement on disaster resilience
- Describing the need to prepare to be self-sufficient for three weeks for a Cascadia earthquake, and that the 96 hours required by hospital regulators is insufficient
- Partnering with the Oregon Association of Hospitals and Healthcare Systems to support a new Coastal Hospital Resilience Network to facilitate resilience planning at coastal hospitals
- Encouraging a hospital-led community approach to improving resilience, including water and electricity service providers as well as ShakeAlert
- Conducting feasibility analyses of installing a solar plus battery storage microgrid for resilient local power to hospitals

3.3.5.7 Mitigation Success — East Face of the Elkhorn Mountains Joint Chiefs' Landscape Restoration Partnership Project

Hazard: Wildfire
Location: Baker and Union Counties, Oregon

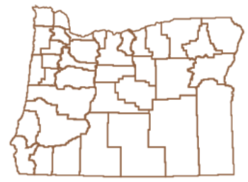
Background:

The Elkhorn Mountains Joint Chiefs Project consists of multiple layers of federal, state, local and private lands. Although they have different ownerships, they all feel the impact of wildfire in this area. In general, most fires in the Elkhorn Mountains start from natural causes, namely lightning, and are part of the ecosystem of the Ponderosa pine and Douglas fir forests found on the granite peaks of this area. This is a recreation destination for many people and holds many stunning views and hiking areas. Agriculture, timber harvesters, and other natural resource businesses are prevalent here. The shared connection of the landowners in this area to their land is the foundation of this Joint Chiefs' Landscape Restoration Partnership (JCLRP) project. Stakeholders work together on this project to improve understanding, grow relationships and make the country better prepared and resilient to wildfire.

There is a high potential for wildfire in this area. The Wallowa-Whitman National Forest consists of over 47,000 acres which includes 1,187 acres of BLM land and 89,000 acres of private land. It is immediately adjacent to 4,000 acres of the State-managed Elkhorn Wildlife Management Area and shares more than 20 miles of boundary with industrial, non-industrial, and residential lands. The project straddles Baker and Union Counties, and is within all or portions of three existing Wildland Urban Interface Areas as described in the Baker and Union County Community Wildfire Protection Plans.

Problem:

This area is at high risk of wildfire. Effective mitigation required cross boundary treatments. Heavy sediment loading after wildfires can impair water quality, significantly impacting aquatic species and potable water sources. Wildlife habitat is also at risk as elk and many other species need forest areas for winter forage and habitat.



Quick Facts

Goals:
1 Protect Life
2 Minimize property damage
5 Minimize environmental impacts and utilize natural solutions

Mitigation Actions:
- Fuels Reduction
- Protect Water Resources
- Wildlife Habitat

Lead agencies:
- ODF
- USFS
- NRCS
- ODFW
- BLM
- Counties

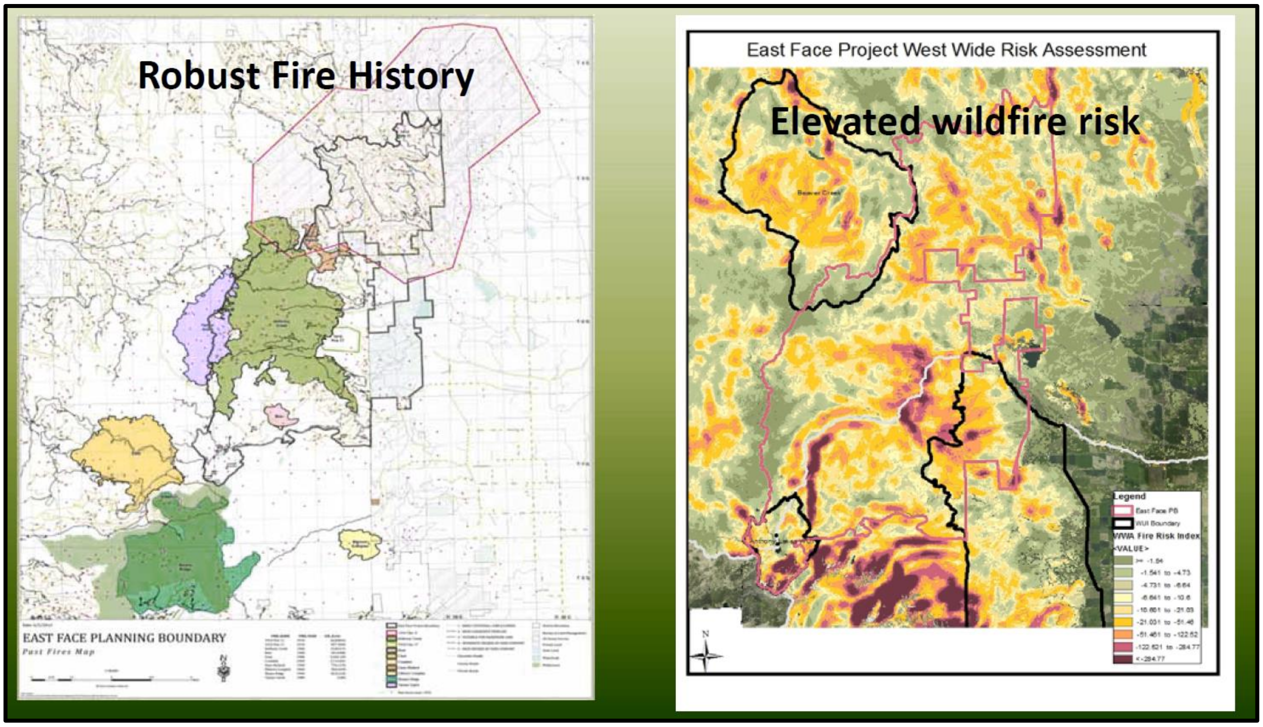
Project Type: Fuels Reduction

Project Start: 2014

Project End: 2016

Project Cost: $6.2M

Funded by: USFS



Solution:

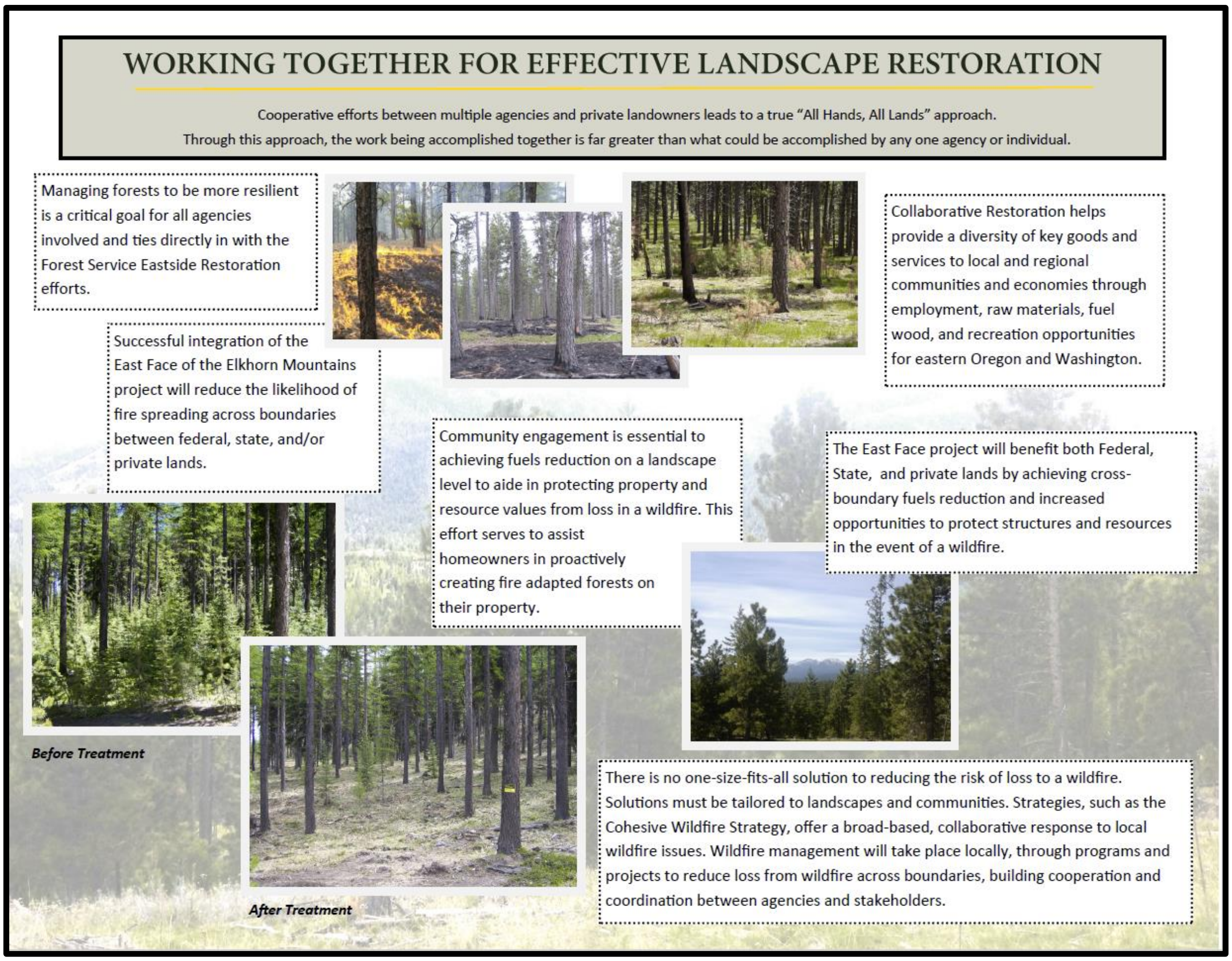
Five agencies and two counties were involved in this project. Landowners were also heavily involved, investing $3.25M to match Federal funding. Over 16,000 acres of land were treated for fuels reduction. This not only reduced the wildfire threat, but also created jobs for 264 people. Total amounts awarded through the Project came to $6.2M. The Project became a pilot of the National Cohesive Wildfire Strategy (CSW) and encompasses the "all hands, all lands" principles. This project was also a way to create collaboration between multiple agencies and partners. It encompassed four Wildland Urban Interface Areas (WUIs) and includes important agricultural water sources. It also enabled volunteer firefighters in one county to assess the fire risk and readiness of 1,700 structures through the Firewise USA program to address defensible space.

Benefits:

The strong integrated partnership forged with the Wallowa-Whitman National Forest Collaborative Group, the US Forest Service (USFS), Oregon Department of Forestry (ODF), Natural Resource Conservation Service (NRCS), Oregon Department of Fish and Wildlife (ODFW), and Bureau of Land Management (BLM) was a significant benefit of this project. Building on a past history of strong working relationships has allowed for a true "All Hands, All Lands" landscape restoration approach with strong support from all partners.

Communication and collaboration between Northeast Oregon agencies (FS, ODF, ODFW, BLM, and counties) have been enhanced because of the local focus on the Cohesive Wildfire Strategy (CWS) and application of CWS principles in the East Face area.

This project was able to advance three goals: Reduce wildfire threats, protect water quality, and improve wildlife habitat.



Source: East Face Project brochure. USFS, NRCS, ODF, ODFW, BLM

3.3.5.8 Mitigation Success — Losses Avoided!

Prior to the February 2019 severe winter storms characterized by, flooding, landslides, and mudslides that resulted in Presidential Disaster Declaration DR-4432-OR, FEMA and OEM had worked with utilities to implement mitigation projects. These projects significantly reduced impacts to both public and private facilities during the February 2019 event.

Following the joint Preliminary Damage Assessment for the February 2019 severe winter storms, OEM reached out to the utilities for their assessments of the effectiveness of the previous mitigation efforts.

This is what they said:

Douglas Electric Cooperative	*"The mitigation done absolutely helped shorten the outage to that portion of DEC's transmission that was moved closer to the road. If the line would have been in the old location on the bluff, trees would have taken it out, it would have been considerably longer getting the Scottsburg community back on, our estimates one to two weeks longer. We had a couple trees in the new line and some wire down, but in general that section was quick to repair. In addition, we would have needed a helicopter to fly-in poles to the old location. The old line was in an area that was not accessible by equipment at all, you needed ropes to secure yourself while working due to the steepness of the terrain, and trying to put wire or a pole up with a few feet of snow in those conditions would have been difficult. I heard the comment several times in the storm:* ***Thank goodness that project was done. That work has paid for itself many times over and improved power reliability to a rural community."***
Eugene Water and Electric Board	***"40% reduction in power outages*** *in the Laurel Hill area due to past mitigation work"*
Springfield Utility Board	*"**Yes, the [Underground Emerald Circuit] project reduced losses from the February snow storm.** The portion of line that was converted from overhead to underground as a part of this project is in a heavily wooded area that experienced significant snow accumulation and damage to limbs/branches/trees. It's a difficult area to access in ideal conditions, and would have been much more difficult with the snow and damaged trees."*
Emerald People's Utility District	*"Our Operations Manager stated that the mitigation projects that we had completed at both the Harness Mountain site as well as the Badger Mountain site, having both of those locations underground **saved us seven days' worth of work for three crews** during the February 2019 Winter Storm."*

3.4 Capability Assessment

Requirement 44 CFR §201.4(c), To be effective the plan must include the following elements:

(3) A Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment. This section shall include:

(ii) A discussion of the State's pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas; a discussion of State funding capabilities for hazard mitigation projects; and a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.

3.4.1 State Capability Assessment

3.4.1.1 State Capability Changes Since Approval of the 2015 Oregon NHMP

One of the most visible and important changes in state capability since 2014 is the establishment of the Governor's Resilience Policy Office and hiring of a State Resilience Officer in 2016. These actions directly implement a mitigation action in the 2015 Oregon NHMP and recommendations in the 2013 Oregon Resilience Plan (ORP). Following publication of the ORP, the Oregon legislature appointed a Resilience Task Force to suggest which of the ORP's mitigation actions should be undertaken first. The Task Force reported to the legislature on October 1, 2014 that establishment of long-term, statewide oversight was essential for resilience, and a resilience policy advisor appointed by and reporting directly to the Governor was the top priority.

Another very visible and important effort championed by Governor Brown was the establishment of the Governor's Council on Wildfire Response in January 2019. The Council was "tasked with reviewing Oregon's current model for wildfire prevention, preparedness and response, and analyzing the sustainability of the current model to provide recommendations to strengthen, improve, or replace existing systems." The Council undertook a very intense, multi-faceted process and issued its final report and recommendations in November 2019 (https://www.oregon.gov/gov/policy/Documents/FullWFCReport_2019.pdf). A bill to fund some of the recommended foundational work was supported but left unfunded with the early end of the 2019 legislative session. Efforts to fund that work are continuing and it is anticipated that the State Legislature will consider legislation addressing wildfire risks and land use planning, including creation of stakeholder advisory committee. DLCD will incorporate any legislative direction in its work.

In May 2012, the Oregon Department of Transportation completed the Oregon Seismic Lifeline Routes (OSLR) Identification project. The OSLR project study recommends a specific list of highways and bridges that comprise the seismic lifeline network; and establishes a three-tiered system of seismic lifelines to help prioritize investment in seismic retrofits on state-owned highways and bridges. In May 2013 ODOT released the Oregon Seismic Options Report that presents options for mitigation against damage to roadways and bridges that may be caused by seismic events. In September 2014, the Resilience Task Force recommended that additional revenue be identified to complete the most critical backbone routes identified in ODOT's Seismic Options Report within a decade, and the complete program by 2060.

In October 2014, ODOT completed a prioritization of these options in the Oregon Highways Seismic Plus Report. Phase I of the Oregon Highways Seismic Plus Report received funding in 2017 that has allowed scoping for seismic work on I-5 near Eugene for the 2021-2024 State Transportation Improvement Program (STIP). Phase I also includes portions of I-84 that are planned for to be retrofitted moving from east to west. The 2021-2024 STIP funding includes $31M to address ODOT bridge seismic needs.

After taking on lead responsibility for coordinating update and maintenance of the Oregon NHMP in 2012, DLCD stepped up to fill a need for directly assisting local governments with NHMP updates. That effort started with the Pre-Disaster Mitigation grant cycle for federal fiscal year 2014 (PDM 14). At that time, FEMA notified OEM and DLCD that special districts also need NHMPs to establish funding eligibility. DLCD began reaching out to special districts and inviting them to participate in multi-jurisdictional NHMP updates, develop or update stand-alone NHMPs. In February 2018, OEM and DLCD delivered a presentation on mitigation planning to the Special Districts Association of Oregon. It generated a lot of interest and was well-attended.

The work on PDM 14 was delayed for administrative reasons and began in earnest in 2016. Since then, DLCD hired one additional natural hazards planner in 2016 and two in 2018. DLCD has worked with 13 counties on multi-jurisdictional plan updates covering about 36 cities, some for the first time, and a similarly large number of special districts; one stand-alone city plan update; and one tribal plan update. This is the first time tribe in Oregon has worked with the state rather than directly with FEMA. DLCD has applied for PDM 18 and 19 funds to assist with five multi-jurisdictional plan updates and three stand-alone city plan updates, and intends to continue to assist local governments in this way with the transition to FEMA's new program, Building Resilient Infrastructure and Communities (BRIC).

In addition, DLCD's Ocean and Coastal Management Division devotes significant resources to natural hazards mitigation in coastal communities through the work of its Coastal Specialist. In particular during this period, efforts have focused on assisting local governments with planning for tsunami mitigation including adoption of tsunami overlay zones and development of vertical evacuation structures using its 2014 publication Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities. The Coastal Specialist has also assisted coastal communities with adopting or updating other natural hazard mitigation-related codes.

In 2012 and 2013 respectively, DOGAMI developed a lidar-based method for mapping shallow and deep landslide susceptibility. Building on that work, in 2016 DOGAMI published a statewide landslide susceptibility map. It contains generalized, regional-scale information that provides a broad understanding of relative risk and highlights areas where more detailed mapping is needed. Following this, DOGAMI and DLCD partnered to produce Preparing for Landslide Hazards: A Land Use Guide for Oregon Communities, published in October, 2019. The effort was funded by a FEMA CTP grant.

DOGAMI and DLCD have continued to partner on coordinating multi-hazard risk assessments with local NHMP updates. These assessments are a product of work along the Risk MAP multi-hazard track "decoupled" from the flood mapping track. DLCD suggested this pathway and FEMA agreed several years ago. These assessments are invaluable to the NHMP updates and we have made a lot of progress in coordinating their schedules. Because lidar needs to be collected and geologic mapping completed before the risk assessment work can begin, and because the two efforts are generally funded through two different grants on two different schedules, we need to look years ahead to ensure that the risk assessment schedule lines up with the NHMP update schedule. Grant funding priorities are not always aligned with the timing of needed NHMP updates so the reality is that there will always be some efforts that won't synchronize. Nevertheless, we are coordinating and collaborating well for the benefit of the Oregon's local governments and residents.

DLCD continues to encourage local governments to integrate NHMPs with comprehensive plans. Following approval of its NHMP (with which DLCD directly assisted) in 2017, the City of Medford fully integrated the NHMP into its comprehensive plan. Between 2016 and 2019, the following coastal jurisdictions adopted Tsunami Hazard Overlay Zones into their comprehensive plans: Coos County, Douglas County, Reedsport, Florence, North Bend, Rockaway Beach, Gearhart, Port Orford, and Tillamook County. Most of those jurisdictions have also completed Tsunami Evacuation Facilities Improvement Plans to identify evacuation routes and improvement projects. Coos County also adopted new and updated provisions to their Natural Hazard Overlay Zone, which addressed mitigation actions identified in their NHMP. DLCD and ODF continue to encourage local governments to update Community Wildfire Protection Plans and integrate them with local NHMPs and comprehensive plans.

ODF has also developed and rolled out an online interactive web application called the Oregon Wildfire Risk Explorer, an integral part of the Oregon Explorer, maintained under contract with OSU's Institute for Natural Resources. It employs a new wildfire risk assessment model, the Quantitative Wildfire Risk Assessment prepared by Pyrologix for the US Forest Service in 2018.

Since working with the Oregon Climate Change Research Institute (OCCRI) to introduce climate change into the 2015 Oregon NHMP, DLCD has engaged OCCRI to develop downscaled, county-level future projection reports for the local NHMP updates with which it is assisting directly. The reports provide information on how climate change is likely to influence hazards a county faces. They have been very well received and very helpful in assessing risk. DLCD and OCCRI plan to continue this work as funding is available with the goal of eventually producing a report for every county.

OCCRI also played a very important role in this 2020 Oregon NHMP update by reviewing and revising the Introduction to Climate Change section; addressing the ways in which climate change can be expected to influence hazards at the state level and updating the climate-related sections in the regional risk assessments; taking the lead in developing the new Extreme Heat chapter as well as assisting in updating other climate-related hazard chapters.

Further, OCCRI and DLCD have reprised their partnership on the 2010 Climate Change Adaptation Framework (CCAF) to produce an update. DLCD is the lead with OCCRI playing an essential supporting role. In August 2019, OCCRI hosted an event entitled Oregon Climate Change Effects, Likelihood, and Consequences Workshop during which subject matter experts convened and discussed these topics relative to both the CCAF and Oregon NHMP updates. The outcomes of this workshop were captured in a report of the same title and used for both efforts (http://www.occri.net/media/1115/oregonclimatechangeworkshopsummaryreport_fall2019.pdf). Acknowledging the interrelationship between climate change adaptation and natural hazards mitigation, and because the two efforts were on similar schedules, the intent was to integrate the two updated documents. However, the CCAF document and project scope have evolved significantly over this period and the timeline has evolved as well. Therefore, the two documents could not be fully integrated. A climate change goal and mitigation/adaptation actions have been incorporated into the 2020 Oregon NHMP. NHMP maintenance will provide opportunities for further integration. This deepening relationship with OCCRI is a very important and exciting enhancement of the State's natural hazard mitigation capability.

DAS's Chief Financial Office with DOGAMI's assistance in 2015 issued DAS CFO Facility Planning Guidelines for Development with Natural Hazards. DAS-CFO and DOGAMI also partnered to address seismic issues with state buildings and developed a plan (currently on hold) to build two new buildings that would house state government core functions and continue to be operational during and after a Cascadia subduction zone event.

DLCD's initiative to establish and support two Community Rating System Users Groups (northern and southern Oregon) to encourage current participants to maintain their participation and increase their ratings, and to encourage non-participating communities to join the CRS Program had to be tabled due to turnover, capacity, and NFIP funding priorities. It has since been supported primarily by FEMA's insurance specialist with DLCD providing advocacy and encouragement to local governments to join the program during every CAV and CAC.

The Office of Emergency Management is the proud recipient of an Esri 2020 Special Achievement in GIS award for its GIS system (https://oregon-oem-geo.hub.arcgis.com/) that provides data and information to emergency managers and decision makers about current and anticipated hazard events.

While the state has made great progress and improved capability in a number of ways during the life of the 2015 Oregon NHMP, a few events have hampered advancement of several hazard mitigation-related initiatives of late. There has been a lot of turnover in state agencies involved in hazard mitigation. In some cases positions have remained vacant and in others there has been a lag in filling them. Both cases have meant a decrease in capacity that has affected the 2020 update. By agreement with FEMA, Oregon no longer has a Risk MAP Coordinator, and FEMA Region X staff is filling that role.

The unexpected early termination of the 2019 and 2020 legislative sessions resulted in a number of hazard mitigation and resilience-related bills not having been acted upon and therefore remaining unfunded.

In between the two sessions, the novel coronavirus pandemic took hold, and in March 2020 schools, businesses, and state offices closed and state employees began working virtually. This has required major adjustments in how business is conducted which in many ways has slowed progress. The shutdown has also caused a sharp decline in state revenues with deepening shortfalls expected over the next several years. Lawmakers are in the process of cutting agency budgets, including personnel and services, statewide. We have yet to learn what this will mean specifically for hazard mitigation programs and activities in the State of Oregon.

3.4.1.2 Policies, Programs, and Capabilities

Pre-Disaster Hazard Mitigation Policy Framework

Oregon maintains a robust pre-disaster natural hazard mitigation policy framework. The foundation of this framework is rooted in the Oregon statewide land use planning requirements passed in 1973. Goal 7, the natural hazard planning component of a community's comprehensive land use plan, provided an incentive for all of Oregon's flood-prone communities to participate in the National Flood Insurance Program. A number of Oregon communities have chosen to participate in the Community Rating System Program as well. Oregon updated Goal 7 in 2002, largely driven by the flooding and landslides of the February 1996 major disaster declaration (DR-1099). In its current form, Goal 7 directs communities to regulate development in hazard-prone areas through local comprehensive plans and implementing ordinances. At minimum, local comprehensive plans in Oregon must address floods (coastal and riverine), landslides, earthquakes and related hazards, tsunamis, coastal erosion, and wildfires where applicable. Accordingly, all of Oregon's cities and counties are required to plan for Oregon's major natural hazard events and to mitigate impacts through regulatory controls.

Table 3-7 provides an overview of the various policies and federal programs related to specific natural hazards in Oregon.

Table 3-7. Policies and Federal Programs Related to Specific Natural Hazards in Oregon

Hazard	Oregon Statewide Planning Goals & Policies	Federal Programs & National Resources
Multi-Hazard	Local Comprehensive Plans	Pre-disaster mitigation planning grants (FEMA)
	Goal 2: Land Use Planning	
	Goal 7 Natural Hazards	American Planning Association (Resources on landslides, flooding, and post-disaster recovery)
	Oregon Building Codes	
Coastal Hazards	Goal 17: Coastal Shorelands	National Flood Insurance Program (NFIP)
	Goal 18: Beaches and Dunes	NFIP V-Zone Construction
	Ocean Shore Regulation	Army Corps of Engineers Permit Program
	Tsunamis — ORS 336.071, ORS 455.446, and ORS 455.448	
Flood	Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces	National Flood Insurance Program (NFIP)
	Division of State Lands (DSL) Fill and Removal Permit Program	NFIP Community Rating System Flood Mitigation Assistance Programs (includes Severe Repetitive Loss and Repetitive Flood Claims Programs as of 2013)
	The Oregon Plan for Salmon and Watersheds	FEMA Region X's Policy on Fish Enhancement Structures in the Floodway
	Oregon's Wetlands Protection Program	Army Corps of Engineers Permit Program
Landslide	Goal 17: Coastal Shorelands	American Planning Association: Landslide Hazards and Planning
	The Oregon Plan for Salmon and Watersheds	
	1997 Senate Bill 12: Rapidly Moving Landslides	
Seismic	2005 Senate Bill 2: Statewide seismic needs assessment for schools and emergency facilities	USGS Earthquake Hazards Program
	2005 Senate Bill 3: Seismic earthquake rehabilitation grant program	
	2005 Senate Bill 4 and 5: State bond authorization	
	2001 Senate Bill 13: Seismic Event Preparation	
	2001 Senate Bill 14: Seismic Surveys for School Buildings	
	2001 Senate Bill 15: Seismic Surveys for Hospital Buildings	
	1991 Senate Bill 96: Seismic Hazard Investigation	
	Tsunamis — ORS 336.071, ORS 455.446, and ORS 455.448	
Fire–WUI	1997 Senate Bill 360: Wildland-Urban Interface	National Fire Protection Agency Firewise Program
	Additional Criteria for Forestland Dwellings — ORS 215.730	
	Urban Interface Fire Protection — ORS 477.015-061	

Source: OPDR

State Pre-Disaster Hazard Management Policies

Multi-Hazards

Statewide Land Use Planning Goals Related to Natural Hazards

In Oregon, every city and county has a comprehensive plan that includes inventories, policies, and implementation measures (e.g., laws and ordinances) to guide community land use decisions. Comprehensive plans are required to address local concerns and issues raised by each of the state's 19 land use planning goals. While all of the goals have some connection to natural hazards mitigation, a few are highlighted here.

GOAL 2: LAND USE PLANNING

Statewide Land Use Planning Goal 2 establishes a planning process and policy framework as a basis for decisions and actions related to use of land. It also assures that an adequate factual base exists for such decisions and actions.

GOAL 5: NATURAL RESOURCES, SCENIC AND HISTORIC AREAS, AND OPEN SPACES

Statewide Land Use Planning Goal 5 requires local governments to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. Conservation of resources promotes a healthy environment and natural landscape that contributes to Oregon's livability.

GOAL 7: AREAS SUBJECT TO NATURAL HAZARDS

Statewide Land Use Planning Goal 7 aims to protect people and property from natural hazards. Local governments are required to adopt comprehensive plans (inventories, policies and implementing measures) to reduce risk to people and property from natural hazards. Natural hazards for the purpose of this goal are: floods (coastal and riverine), landslides (including "rapidly moving landslides" regulated by ORS 195.250-275, 1999 edition), earthquakes and related hazards, tsunamis, coastal erosion, and wildfires. Local governments may also identify and plan for other natural hazards.

GOAL 15: WILLAMETTE RIVER GREENWAY

The purpose of Goal 15 is to protect, conserve, enhance, and maintain the natural, scenic, historical, agricultural, economic and recreational qualities of lands along the Willamette River as the Willamette River Greenway.

Oregon Building Codes

With the adoption of the 2019 Oregon Structural Specialty Code (OSSC) on October 1, 2019, building designs in Oregon must now comply with latest building and construction science available. This includes lateral force resisting elements to address; wind, earthquake, flood and where adopted locally, tsunami. It also captures the best science available for establishing ground snow loads.

While HB 3309, 2019 session removed the prohibition of constructing essential facilities and other defined structures in the tsunami inundation zone, the state adopted an Appendix O in the 2019 Oregon Structural Specialty Code addressing tsunami loading which is available for local adoption.

In addition, a new section, R327 Wildfire Hazard Mitigation was adopted as part of the Oregon Residential Specialty Code effective January 24, 2019. These amendments provide additional wildfire hazard mitigation provisions that are available for local adoption.

Oregon's Wetlands Protection Program

Oregon's Wetlands Program was created in 1989 to integrate federal and state rules concerning wetlands protection with the Oregon Land Use Planning Program. The Wetlands Program has a mandate to work closely with local governments and the Division of State Lands (DSL) to improve land use planning approaches to wetlands conservation. A Local Wetlands Inventory (LWI) is one component of that program. DSL also develops technical manuals, conducts wetlands workshops for planners, provides grant funds for wetlands planning, and works directly with local governments on wetlands planning tasks.

The Oregon Plan for Salmon and Watersheds

"The Oregon Plan" is the state's program to restore native salmon and trout populations and to improve water quality. The overall goal of the Oregon Plan is to restore fish populations to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits.

Division of State Lands Fill and Removal Permit Program (ORS 196.800-990)

The Division of State Lands (DSL) Fill and Removal Permit Program (ORS 196.800-990) requires individuals who remove or fill 50 cubic yards or more in "waters of the state" to obtain a permit from the DSL. In State Scenic Waterways or areas designated by DSL as essential indigenous anadromous salmonid habitat, most removal-fill activities require a permit, regardless of the number of cubic yards affected. In addition, the Oregon Department of Environmental Quality is responsible for water quality certification under section 401(a) of the Clear Water Act. This certification is required as part of the DSL permitting process.

In addition, the Removal/Fill Law and implementing regulations contain specific standards and requirements for riprap and other bank and shore stabilization projects in areas that extend from the Pacific Ocean shore to the line of established upland vegetation or the highest measured tide, whichever is greater. The Oregon Parks and Recreation Department (OPRD) administers the removal/fill regulations jointly with the Ocean Shore Permit Authority. Activities permitted under these regulations are required to comply with the Statewide Planning Goals and be compatible with corresponding provisions of local comprehensive plans. Permits for shoreline protective structures may be issued only when development existed prior to January 1, 1977, as required under Goal 18. Foredune management plans, often implemented as hazard mitigation strategies, require a permit from OPRD because these strategies affect the structure of the shoreline. Other hazard mitigation strategies that require OPRD approval include: natural product (dirt) removal, re-sloping of a vertical bank below the statutory line of vegetation, and mitigating for erosion by altering the course of a stream that flows into the ocean.

Coastal Hazards

Statewide Land Use Planning Goals Related to Natural Hazards

GOAL 16: ESTUARINE RESOURCES

The purpose of Goal 16 is twofold: to recognize and protect the unique environmental, economic, and social values of each estuary and associated wetlands; and to protect, maintain, where appropriate develop, and where appropriate restore the long-term environmental, economic, and social values, diversity, and benefits of Oregon's estuaries. Comprehensive management programs to achieve these objectives are to be developed by appropriate local, state, and federal agencies for all estuaries.

Goal 17: Coastal Shorelands

Statewide Land Use Planning Goal 17 is concerned with conservation and protection, as well as appropriate development of Oregon's coastal shorelands. It aims to reduce the hazard to human life and property, and the adverse effects upon water quality and fish and wildlife habitat resulting from the use and enjoyment of Oregon's coastal shorelands.

Goal 18: Beaches and Dunes

The purpose of Statewide Land Use Planning Goal 18 is to conserve, protect, and where appropriate, to either develop on or restore resources and benefits of coastal beach and dune areas. It is also concerned with reducing the hazard to human life and property from natural or human-induced actions associated with these areas.

Ocean Shore Regulation

The Oregon Parks and Recreation Department (OPRD) is responsible for protecting the scenic, recreational, and natural resource values of the Oregon coast. OPRD accomplishes this through an extensive permitting program for shoreline protection under the authority of The Ocean Shore Law (ORS 390.605-390.770), also known as the "Beach Bill." While not responsible for activities above the statutory vegetation line, the survey line, or the line of established vegetation, OPRD is the permitting authority for actions affecting the ocean shorelands. This distinction can be seen visually at the line of established vegetation that backs the shoreline.

The Division of State Lands (DSL) has co-authority with the OPRD over rocky intertidal areas. The DSL manages the state-owned seabed within three nautical miles of low tide at the ocean shore. Specifically, the DSL regulates removal and filling of seabed and estuaries, including any dredged materials or seabed minerals. DSL may also issue leases for the harvest of Bull Kelp, a large seaweed in rocky areas of Oregon's coast. The Beach Bill requires that a permit be obtained from OPRD for all "beach improvements" west of a surveyed beach zone line. Communities can check their comprehensive plan or contact OPRD to obtain the location of this surveyed line.

Earthquakes/Tsunamis

Tsunamis — ORS 336.071, ORS 455.446, and ORS 455.448

Fourteen earthquake-related bills were introduced during the 1995 session. Several passed, including a new requirement for earthquake education and tsunami drills to be conducted in public schools (ORS 336.071), a requirement for essential and special-occupancy structures to be built outside of tsunami inundation zones (ORS 455.446), provisions for the inspection and entrance of buildings damaged by earthquakes (ORS 455.448) and specific provisions for the abatement of buildings damaged by earthquakes. Senate Bill 1057 created a task force to evaluate the risks impacting existing buildings and make recommendations to the 1997 legislature.

House Bill 3309 (2019)

This bill removed the prohibition of constructing essential facilities and other defined structures in the tsunami inundation zone. However, the state adopted an Appendix O in the 2019 Oregon Structural Specialty Code addressing tsunami loading which is available for local adoption.

Senate Bill 96 (1991): Seismic Hazard Investigation

The legislature passed Senate Bill 96 in 1991. This law requires site-specific seismic hazard investigations before the construction of essential facilities, hazardous facilities, major structures, and special-occupancy structures (e.g., hospitals, schools, utilities and public works, police and fire stations). These requirements were adopted into the State Building Code. The law also provides for the installation of strong-motion sensors in selected major buildings and mandates that school officials in all public schools lead students and staff in earthquake drills.

Senate Bill 13 (2001): Seismic Event Preparation

Senate Bill 13, signed by the Governor on June 14, 2001, requires each state and local agency and persons employing 250 or more full-time employees to develop seismic preparation procedures and inform their employees about the procedures. Further, the bill requires agencies to conduct drills in accordance with Oregon Office of Emergency Management guidelines. These drills must include “familiarization with routes and methods of exiting the building and methods of duck, cover and hold during an earthquake.”

Senate Bill 14 (2001): Seismic Surveys for School Buildings

The Governor signed Senate Bill 14 on July 19, 2001. The bill required the State Board of Higher Education to conduct seismic safety surveys of buildings that have a capacity of 250 or more persons and are routinely used for student activities by public institutions or departments under the control of the board. A seismic safety survey was not required for buildings that had previously undergone seismic safety surveys, or that had been constructed to meet state building code standards. For buildings that were found to pose an undue risk to life and safety during a seismic event, the bill required the State Board of Higher Education to develop plans for seismic rehabilitation or seismic risk reduction. Subject to available funding, all seismic rehabilitation or risk reduction activities must be completed before January 1, 2032.

Senate Bill 15 (2001): Seismic Surveys for Hospital Buildings

The Governor signed Senate Bill 15 on July 19, 2001. The bill required the Health Division to conduct seismic safety surveys of hospital buildings that contain acute inpatient care facilities. Subject to available funding, seismic surveys must also be conducted on fire stations, police stations, sheriffs’ offices, and similar facilities. The surveys were completed in January, 2007.

A seismic survey was not required for buildings that had previously undergone seismic safety surveys, or that had been constructed to meet state building code standards. For buildings that were found to pose an undue risk to life and safety during a seismic event, the bill required building occupants to develop plans for seismic rehabilitation or seismic risk reduction. Subject to available funding, all seismic rehabilitation or risk reduction activities must be completed before January 1, 2022.

Oregon Seismic Safety Policy Advisory Commission (OSSPAC) — ORS 401.337 to 401.353

The Oregon Seismic Safety Policy Advisory Commission (OSSPAC), otherwise known as the Earthquake Commission, is a state advisory commission that was created in February 1990 through an executive order from Governor Neil Goldschmidt. The group is composed of 18 individuals who represent a variety of interests concerned with the formulation of public policy regarding earthquakes. It has six representatives of government, six representatives of the public interest, and six representatives of industries and stakeholders. This variety of interests helps direct the goals of the Commission for the benefit of all Oregon citizens.

The Earthquake Commission has the unique task of promoting earthquake awareness and preparedness through education, research, and legislation. OSSPAC seeks to positively influence decisions and policies regarding pre-disaster mitigation of earthquake and tsunami hazards, and to increase public understanding of hazards, risk, exposure, and vulnerability. In order to fulfill the goals of the commission, OSSPAC members have developed five primary objectives. These objectives are to increase or improve:

- Earthquake awareness, education, and preparedness;
- Earthquake risk information;
- The earthquake safety of buildings and lifelines;
- Geoscience and technical information; and
- Emergency pre-disaster planning, response and recovery efforts.

For information on OSSPAC, contact the Oregon Office of Emergency Management.

Senate Bill 2 (2005): Statewide Seismic Needs Assessment Using Rapid Visual Screening

Oregon Senate Bill 2 directed DOGAMI, in consultation with project partners, to develop a statewide seismic needs assessment that includes seismic safety surveys of K-12 public school buildings and community college buildings that have a capacity of 250 or more persons, hospital buildings with acute inpatient care facilities, fire stations, police stations, sheriffs' offices and other law enforcement agency buildings.

The statewide needs assessment consisted of rapid visual screenings (RVS) of these buildings, information gathering to supplement RVS, and ranking of RVS results into risk categories. The results are posted on DOGAMI's website.

Senate Bill 2 (2005) provided the first step in a pre-disaster mitigation strategy that is further defined in Senate Bills 3-5 (2005).

Wildfires and Wildland-Urban Interface

Oregon Forestland-Urban Interface Fire Protection Act (SB 360)

The Oregon Forestland-Urban Interface Fire Protection Act, often referred to as Senate Bill 360, enlists the aid of property owners toward the goal of turning fire-vulnerable urban and suburban properties into less-volatile zones where firefighters may more safely and effectively defend homes from wildfires. Senate Bill 360 established Oregon's first comprehensive statewide policy regarding mitigation in wildland-urban interface areas. It broadly defined the WUI and set in place a process to identify and classify these areas. The legislation also required the development of standards, which WUI owners are to apply in order to manage and minimize wildfire hazards on their property. When work to implement Senate Bill 360 begins in a county, a committee of local representatives formally identifies and classifies WUI areas. Individual property owners in these areas are then contacted and informed of the standards they are required to meet. They have up to 2 years to bring their property into compliance with the standards and then to certify that they have done so. Owners who fail to certify become subject to a potential liability of up to $100,000 for certain costs of suppressing fires which start on their property.

The Oregon Forestland-Urban Interface Fire Protection Act is fully described in Oregon Revised Statutes 477.015 through 477.061, and Oregon Administrative Rules 629-044-1000 through 629-044-1110.

Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings

ORS 215.730 (County Planning; Zoning, Housing Codes) provides additional criteria for approving dwellings located on lands zoned for forest and mixed agriculture and forest use. Under its provisions, county governments must require, as a condition of approval, that single-family dwellings on lands zoned as forestland meet the following requirements:

1. Dwelling has a fire retardant roof;
2. Dwelling will not be sited on a slope of greater than 40%;
3. Evidence is provided that the domestic water supply is from a source authorized by the Water Resources Department and not from a Class II stream as designated by the State Board of Forestry;
4. Dwelling is located upon a parcel within a fire protection district or is provided with residential fire protection by contract;
5. If dwelling is not within a fire protection district, the applicant provides evidence that the applicant has asked to be included in the nearest such district;
6. If dwelling has a chimney or chimneys, each chimney has a spark arrester; and
7. Dwelling owner provides and maintains a primary fuel-free break and secondary break areas on land surrounding the dwelling that is owned or controlled by the owner. If a governing body determines that meeting the fourth requirement is impractical, local officials can approve an alternative means for protecting the dwelling from fire hazards.

This can include a fire sprinkling system, on-site equipment and water storage, or other methods that are reasonable, given the site conditions. If a water supply is required under this subsection, it must be a swimming pool, pond, lake or similar body of water that at all times contains at least 4,000 gallons or a stream that has a minimum flow of at least one cubic foot per second. Road access must be provided to within 15 feet of the water's edge for fire-fighting pumping units, and the road access must accommodate a turnaround for fire-fighting equipment.

Oregon Revised Statute 477.015-061 Urban Interface Fire Protection

These provisions were established through efforts of the Oregon Department of Forestry, the Office of the State Fire Marshal, fire service agencies from across the state, and the Commissioners of Deschutes, Jefferson, and Jackson Counties. It is innovative legislation designed to address the expanding interface wildfire problem within Oregon Department of Forestry Fire Protection Districts. Full implementation of the statute will occur on or after January 1, 2002. The statute does the following:

1. Directs the State Forester to establish a system of classifying forestland-urban interface areas;
2. Defines forestland-urban interface areas;

3. Provides education to property owners about fire hazards in forestland-urban interface areas;
4. Allows for a forestland-urban interface county committee to establish classification standards;
5. Requires maps identifying classified areas to be made public;
6. Requires public hearings and mailings to affected property owners on proposed classifications;
7. Allows property owners appeal rights;
8. Directs the Board of Forestry to promulgate rules that set minimum acceptable standards to minimize and mitigate fire hazards within forestland-urban interface areas;
9. Creates a certification system for property owners meeting acceptable standards; and
10. Establishes a $100,000 liability limit for cost of suppressing fires, if certification requirements are not met.

Oregon Revised Statute Chapter 478: Rural Fire Protection Districts

ORS 478, Rural Fire Protection Districts, includes the following provisions, among others, related to wildfire hazard mitigation:

478.120 Inclusion of forestland in district. The authority to include forestland within a rural fire protection district pursuant to ORS 478.010 (2)(c) applies to forestland within the exterior boundaries of an existing district and to forestland on which structures subject to damage by fire have been added after July 20, 1973.

478.140 Procedure for adding land to district by consent of owner. Any owner consenting to add the forestland of the owner to the district under ORS 478.010 (2)(c) shall do so on forms supplied by the Department of Revenue. The owner shall file the original with the district. The district shall forward a copy to the assessor of each county in which the land is located, within 20 days of receipt.

478.910 Adoption of fire prevention code. A district board may, in accordance with ORS 198.510 to 198.600, adopt a fire prevention code.

478.920 Scope of fire prevention code. The fire prevention code may provide reasonable regulations relating to:

1. Prevention and suppression of fires.
2. Mobile fire apparatus means of approach to buildings and structures.
3. Providing fire-fighting water supplies and fire detection and suppression apparatus adequate for the protection of buildings and structures.
4. Storage and use of combustibles and explosives.
5. Construction, maintenance, and regulation of fire escapes.
6. Means and adequacy of exit in case of fires and the regulation and maintenance of fire and life safety features in factories, asylums, hospitals, churches, schools, halls, theaters, amphitheaters, all buildings, except private residences, which are occupied for sleeping purposes, and all other places where large numbers of persons work, live, or congregate from time to time for any purpose.
7. Requiring the issuance of permits by the fire chief of the district before burning trash or waste materials.

8. Providing for the inspection of premises by officers designated by the board of directors, and requiring the removal of fire hazards found on premises at such inspections.

478.927 Building permit review for fire prevention code. A district adopting a fire prevention code shall provide plan review at the agency of the city or county responsible for the issuance of building permits for the orderly administration of that portion of the fire prevention code that requires approval prior to the issuance of building permits.

The state adopted a new section, R327 Wildfire Hazard Mitigation as part of the Oregon Residential Specialty Code. These amendments became effective on January 24, 2019 and provide additional wildfire hazard mitigation provisions that are available for local adoption.

Landslides

Senate Bill 12: Rapidly Moving Landslides

Following the flood and landslide events of 1996, legislation was drafted to reduce risk from future landslide hazards. The legislature passed Senate Bill 1211 in 1997, which dealt with rapidly moving landslide issues around steep forestlands, and not in typical urban or community settings. Senate Bill 1211 granted authority to the State Forester to prohibit forest operations in certain landslide-prone locations, and created the Interim Task Force on Landslides and Public Safety. SB 1211 charged the Interim Task Force with developing a comprehensive, practicable, and equitable solution to the problem of risks associated with landslides.

The Interim Task Force developed the legislative concept that resulted in Senate Bill 12 in the 1999 session (ORS 195.250 et seq.). Senate Bill 12 directs state and local governments to protect people from rapidly moving landslides. The bill has three major components affecting local governments: detailed mapping of areas potentially prone to debris flows (i.e., “further review area maps”), local government regulating authority, and funding for a model ordinance. The legislature allocated funding to the Department of Geology and Mineral Industries (DOGAMI) to prepare the “further review area maps,” and provided $50,000 for a grant to a local government to develop a model program to address rapidly moving landslides. Senate Bill 12 applies only to rapidly moving landslides, which are uncommon in many communities, but are very dangerous in areas where they do occur.

Dam Safety

The Oregon Water Resources Department is the state authority for dam safety with specific authorizing laws and implementing regulations.

As of December 2019, there were 945 state regulated dams and another 252 federal regulated dams that met Oregon statutory dam safety criteria (at least ten feet high and storing at least three million gallons). The largest dams are under federal ownership or regulation. An additional 12,000 or so dams have water right permits for storage from the Department but are smaller than Oregon statutory thresholds. In general, the dam safety programs for the large federal dams have significant dam safety staffing while state dam safety staffing is limited.

The Oregon dam safety program has the following responsibilities:

- Review designs for dams proposed to store water and wastewater prior to construction, and required approval before construction and after design safety is demonstrated;
- Maintain design, construction and inspection information in its files (many electronic);
- Conduct dam breach inundation analysis for hazard rating (consequence of failure);
- Inspect dams with a frequency based mostly on hazard but which can also consider the condition of dams;
- Evaluate the general condition of dams;
- Take regulatory action on dams that are unsafe;
- Require an Emergency Action Plan (EAP) for high hazard dams, providing a template for owners to develop these plans;
- Respond to unusual conditions and potential emergencies; and
- Coordinate with federal agencies on emergency inspection and response.

Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law (ORS 540.443-540.491) became operative on July 1, 2020, with rules and guidance under active development. The state dam safety program coordinates on but does not directly regulate dams owned by the United States or most dams used to generate hydropower.

Post-Disaster Hazard Mitigation Policy Framework

Following the Presidential Disaster Declaration for the December 2007 winter storm event (DR-1683), Governor Kulongoski signed Executive Order 08-20 establishing the Governor's Emergency Recovery Framework. The Order established a Recovery Planning Cell (RPC) comprised of emergency recovery advisors, state agency leadership, and others as the situation requires. The RPC directs emergency recovery in Oregon, providing leadership and coordinating private and government sector recovery efforts. It is charged with the development and initial execution of a "day after" plan for recovery efforts. The Order also established the Governor's Recovery Cabinet to coordinate ongoing recovery efforts following the initial emergency response.

State Post-Disaster Hazard Management Policies

Earthquakes/Tsunamis

More recently, the legislature passed House Resolution 3 following the 2011 Great Tohoku Earthquake in Japan and the resulting tsunami that impacted the Oregon coast (DR-1964). HR 3 recognizes risks and susceptibility of Oregon to catastrophic damage and loss of life resulting from megathrust earthquakes and tsunamis associated with Cascadia fault. Furthermore, it directed the creation and legislative consideration of an "Oregon Resilience Plan." The Oregon Seismic Safety Policy Advisory Committee published that Plan in February 2013. The plan identifies the state's vulnerabilities in the event of a Cascadia earthquake and tsunami, and contains mitigation actions. Following publication, the legislature appointed the Resilience Task Force to recommend which mitigation actions to take first. The Resilience Task Force's report (Appendix **9.2.4**) was provided to the legislature on October 1, 2014. Several of its recommendations have been and are being acted upon.

Floods

Substantial Damage Policy

Under the NFIP, a building is considered to be substantially damaged when the total cost of repair equals or exceeds 50% of the pre-damage market value of the structure. A substantial damage determination provides opportunities for mitigation through acquisition, relocation, demolition, and elevation. For NFIP-insured properties, timely determinations of substantial damage are critical for meeting the application period for an **Increased Cost of Compliance (ICC)** mitigation claim. If approved for ICC, the ICC payment of up to $30,000 may be used as the property owner's non-federal cost share. Timely substantial damage determination is a standard protocol for all flood disaster declarations in Oregon.

Repetitive Loss (RL) and Severe Repetitive Loss (SRL) Policy

Repetitive Losses and **Severe Repetitive Losses** properties are defined in the State Risk Assessment.

RL and SRL properties are a top priority for mitigation in Oregon. However, several criteria must generally align for their mitigation to be executable. In addition to meeting the federal statutory criteria for mitigation projects — technically feasible, cost-effective, and environmentally sound — the state will vigorously pursue mitigation of RL and SRL properties if:

- The structure is substantially damaged and eligible for funding under the NFIP's Increased Cost of Compliance provision;
- The structure is located in a community with a FEMA-approved local NHMP;
- The structure is located in a community with ability to manage federal grant funds;
- Elected officials support pursuing flood mitigation projects;
- The structure is located in a declared county (post-disaster) and post-disaster mitigation funding is available; and
- The owners of the structure are interested in mitigation through elevation, flood-proofing, relocation, or demolition.

In addition, geographic distribution of properties and alignment of repetitive loss and severe repetitive loss property mitigation with other mitigation efforts (such as restoring natural and beneficial floodplain functions) may play a role. It is the state's policy to distribute mitigation assistance and funding to impacted communities and repetitive loss and severe repetitive loss properties in different areas of the state whenever practicable.

Pre- and Post-Disaster Hazard Mitigation Programs and Capabilities Framework

Oregon Lidar Consortium

Formed by the Department of Geology and Mineral Industries, the Oregon Lidar Consortium (OLC) develops cooperative agreements for the collection of high-quality lidar that benefits the public at large, the business community, and agencies at all levels of government. The goal of the OLC is to provide high-quality lidar coverage for the entire state. The collection of lidar data can assist governments in better identifying hazardous areas.

Oregon Seismic Safety Policy Advisory Committee

OSSPAC is a state advisory commission created in February 1990 through an executive order from Governor Neil Goldschmidt and established in statute by the 1991 Oregon Legislature (ORS 401.337). The purpose of the 18-member group is to reduce exposure to Oregon's earthquake hazards.

Hazard Mitigation Grant Review Board

The Hazard Mitigation Grant Review Board is an intergovernmental body which, when convened, reviews, discusses, ranks, and recommends projects for funding under Section 404 of the Stafford Act (also known as Hazard Mitigation Grant Program or HMGP).

Drought Council

The Drought Council is responsible for assessing the impact of drought conditions and making recommendations to the Governor's senior advisors.

Numerous additional agency-specific hazard mitigation programs and capabilities also exist or are under development. For example, OPDR is a coalition of public, private, and professional organizations working collectively toward the mission of creating a disaster resilient and sustainable state. Developed and coordinated by the Community Service Center at the University of Oregon, OPDR employs a service learning model to increase community capacity and enhance disaster safety and resilience statewide. Similarly, DLCD is currently working to incorporate the principles of FEMA's Risk Map program into an Oregon-specific initiative called Risk Plan. The Risk Plan program is conceptual at this point, but when implemented will offer an integrated state-wide framework for delivering information, guidance, technical assistance and other resources to local governments.

Agencies/Organizations

State Interagency Hazard Mitigation Team

First convened by Governor Kitzhaber in 1996, the State Interagency Hazard Mitigation Team (IHMT) meets quarterly and provides leadership in addressing natural hazards mitigation in Oregon. The State IHMT is an important state mechanism for interagency coordination. The Team's focus is to understand losses arising from natural hazards, including secondary losses that occur when natural hazard events impact technological systems and critical infrastructure, and to coordinate recommended strategies to mitigate loss of life, property, economic and natural resources by maintaining the FEMA-approved and Governor-adopted *Oregon Natural Hazards Mitigation Plan*.

The State IHMT's goals are:

1. Coordinate hazard mitigation programs and activities at all levels in the state of Oregon.
2. Describe and evaluate the natural hazards to which the state of Oregon is vulnerable.
3. Describe and evaluate state, local government, and private sector hazard mitigation policies, programs, and capabilities, consistent with federal codes and regulations.
4. Identify sources of hazard mitigation funding and the procedures that must be followed to obtain such funding; make this information widely available.

5. Identify and evaluate proposed hazard mitigation strategies, projects, and legislation to ensure consistency and to proactively integrate natural resource goals into mitigation activities.
6. Continue to develop, implement, monitor, evaluate, and update the Oregon Natural Hazards Mitigation Plan.
7. Provide education and information about natural hazards and steps which can be taken to mitigate against their effects.
8. Facilitate integration of hazard mitigation into the activities and programs of state and local government agencies, and to the extent practical, into the activities of private sector organizations.
9. Strive to integrate into natural hazard mitigation: natural resource protection and restoration, stormwater management, ecosystem concerns, floodplain management, and protection of water quality for public use.
10. Promote and facilitate the concept of a disaster resistant economy in Oregon.

OEM houses the State Hazard Mitigation Officer who serves as Chair of the IHMT. In addition, OEM provides overall staff support through routine communication with the membership, agenda development, and meeting logistics. Members of the State IHMT are called upon to assist with various mitigation activities outside of the scheduled State IHMT meetings to include such things as updating the Oregon NHMP and identifying and reviewing projects, particularly following major disaster declarations.

State IHMT meetings are open to the public. Liaison representatives from non-state IHMT agencies and organizations can be added as needed. Descriptions of the State IHMT agencies' hazard mitigation roles, responsibilities, and authorities are provided in **Table 3-8**.

Table 3-8. IHMT Agencies' Hazard Mitigation Roles, Responsibilities, and Authorities

State IHMT Agency	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Department of Administrative Services (DAS), Chief Financial Office	Works to prepare state government offices for emergency evacuation planning using the State of Oregon's *Sound the Alarm RisKey* guide. DAS works to improve safety among the workplace by identifying risks and developing tools to manage risks. DAS also works to protect state-owned property and buildings, and sets standards for leasing and constructing state buildings.	No legal authority for natural hazards mitigation, except that which may arise from a claim under self-insurance property coverage.
Oregon Department of Agriculture (ODA)	Works to exclude or eradicate certain insect pests from becoming established in the state. Using the Insect Pest Prevention and Management program (IPPM), the ODA works to protect Oregon's agriculture, horticulture and timber resources from damaging insect pests, thus preventing the defoliation of vast acreage of trees and reducing fire and erosion hazards; works with soil and water conservation districts to help landowners implement best management practices to reduce erosion, thereby preventing slides, floods, and erosion-related problems; actively involved in watershed health and maintaining natural resources through education, technical assistance, and regulatory programs for landowners.	ORS, Chapter 568 provides authority for water quality and soil conservation measures, and Chapter 570 provides authority for pest and disease control programs.
Department of Consumer and Business Services (DCBS), Building Codes Division (DCBS-BCD)	Works to implement statewide building codes through a permitting program. BCD has adopted construction standards that help create disaster resistant buildings. BCD administers the post-earthquake inspection program for damaged buildings and provides technical assistance and training for building inspectors, plans examiners, designers, and contractors. A post-earthquake inspector carries out post-earthquake habitability assessments for all structures affected by an earthquake. BCD has compiled an active list of certified post-earthquake inspectors. BCD generally adopts nationally recognized model codes that include various standards to ensure building safety. Technical assistance is provided to designers, contractors, building officials, and the public through its code specialists, its web page, regular mailings to interested parties and local building officials, and its quarterly publication *Codelink*.	ORS, Chapter 455 provides legal authority for the Building Codes Division's (BCD) natural hazard mitigation activities including 455.020 (code adoption), .725 (training), .440 (site soil analysis), .446 (construction in tsunami zones), .447 (seismic site hazard analysis), and .448-.449 (entry and inspection of earthquake damaged buildings).
DCBS - Department of Financial Regulation (DCBS-DFR)	Works to perform a major balancing role, protecting the public's interests through ensuring the financial soundness of insurers, the availability and affordability of insurance, and the fair treatment of policyholders and claimants while maintaining a positive business climate. DCBS-DFR helps home and business owners prepare for natural hazards through the provision of insurance-related educational material and trainings. DCBS-DFR also works to help ensure insurance compensation to insurance holders in the wake of a natural disaster.	ORS Chapter 731 provides authority to DCBS-DFR. House Bill 3605 allows the director of the Department of Consumer and Business Services (DCBS) to modify insurance policy terms in times of emergency.
Business Oregon, Infrastructure Finance Authority (BusOR-IFA)	Works with the Governor and all state agencies to prioritize programs and modify services that help those affected by natural disasters. Works with current loan customers to address needs during recovery from a natural disaster. Works with communities to prioritize infrastructure needs resulting from a natural disaster, which is used to develop state and federal funding solutions for Oregon communities. Offers Emergency Response Funding Programs. Also supports hazard mitigation by promoting development of new facilities and infrastructure in appropriate locations. As of January 1, 2014, administers the Seismic Rehabilitation Grant Program.	ORS Chapter 285A-C provides authority to Oregon Business, including 285B.020 (infrastructure).

State IHMT Agency	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Oregon Climate Change Research Institute (OCCRI) and the Oregon Climate Service (OCS)	OCCRI, housed at Oregon State University, is authorized to: 1. Facilitate research by Oregon University System faculty on climate change and its effects on natural and human systems in Oregon 2. Serve as a clearinghouse for climate change information 3. Provide climate change information to the public in integrated and accessible formats 4. Support the Oregon Global Warming Commission in developing strategies to prepare for and to mitigate the effects of climate change on natural and human systems 5. Provide technical assistance to local governments to assist them in developing climate change policies, practices and programs In addition, at least once each biennium, OCCRI assesses the state of climate change science as it relates to the state of Oregon, and the likely effects of climate change on the state and delivers the assessment to the Governor’s Office and the Legislative Assembly. OCS is part of the College of Earth, Ocean, and Atmospheric Sciences at OSU, and has been absorbed by OCCRI. OCS: 1. Collects, maintains and distributes Oregon weather and climate data; 2. Educates Oregonians on current and emerging climate issues; and 3. Performs research related to climate issues.	HB 3543 (2007)
Department of Environmental Quality (DEQ)	Works to protect and maintain waters of the state for public health and safety as well as for all future beneficial uses under EPA delegated programs from the Clean Water Act and Safe Drinking Water Act. Emergency actions related to natural hazards must meet environmental protection requirements. If a natural hazard were to result in hazardous materials being released into the environment, DEQ’s Emergency Response Program is designed to respond. DEQ’s Environmental Cleanup Division takes action should a release occur or the threat of a release. DEQ assists OEM, DLCD, and FEMA in conducting environmental assessments related to watershed restoration, hazard mitigation projects, and provides matching grants for projects under the Clean Water Act. DEQ plays a central role in the disposal of disaster debris. DEQ also works with Oregon Natural Events Action Plan for Wildfire Smoke. DEQ offers the Wildfire Air Quality Rating to monitor air pollution throughout the state to ensure that air quality standards are being met.	ORS, Chapter 468, water pollution control, enables DEQ to protect all future beneficial uses of waters of the state (surface and groundwater), and allows DEQ to act should there be a threat of release or a spill. ORS, Chapter 468a, enables the DEQ to regulate and monitor air quality. ORS, Chapters 465 and 466 enables the DEQ to respond to hazardous waste and materials that have been released into the environment.
Oregon Department of Fish and Wildlife (ODFW)	Has a primary role in determining the effects of potential hazard mitigation projects on fish and wildlife habitats and recommending measures that enhance or at least do not degrade such habitats; administers the state’s Riparian Tax Incentive Program and Restoration and Enhancement Program, and can provide cost-share funding, grants and technical assistance.	ORS, Chapter 496 (application, administration, and enforcement of wildlife laws), Chapter 497 (licenses and permits), Chapter 498 (hunting, angling and trapping) and Chapter 501 (refuges and closures).

State IHMT Agency	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Oregon Department of Forestry (ODF)	Works to protect communities from wildfires through the implementation of the Communities at Risk Assessment Program. ODF Identifies communities and assigns each a low, moderate, or high risk rating for the following categories: risk, hazard, protection, capability, value, and overall. ODF works with communities to create Community Wildfire Protection Plans (CWPP): a process involving collaboration between communities and agencies interested in reducing wildfire risk. ODF is responsible for all aspects of wildland fire protection on private, state and BLM forestlands. ODF administers regulations, including landslide mitigation, on non-federal lands. ODF does all of the following things which advance natural hazards mitigation: requires landowners to control fires on their lands; controls fires that other landowners cannot control; administers the industrial fire prevention program; investigates wildfires; administers the Forest Practices Act; coordinates with other agencies; maintains technical expertise on wildfire sciences, geosciences, and hydrology; completes debris flow hazard mapping for Western Oregon; and leads many aspects of the *Oregon Plan for Salmon and Watersheds.*	ORS, Chapter 477 addresses the fire protection of forests and vegetation, including sections on urban interface fire protection, hazard abatement, fire abatement, fire prevention, and related sections. Chapter 527 contains provisions which pertain to timber harvest and road construction regulations in landslide areas.
Department of Geology and Mineral Industries (DOGAMI)	Works to develop geologic maps and data to enable Oregonians to understand geology and to mitigate the hazards resulting from earthquakes, tsunamis, landslides, and other hazards; works with project partners, to develop a statewide seismic needs assessment; focuses much effort on risk reduction, often in partnership with other federal, state, and local agencies, and the private sector; provides information which leads to the construction of safer buildings; works on siting of natural gas cogeneration power plants, correctional facilities, gas pipelines using policy decisions related to geologic, seismic and coastal hazards; also works with local partners to develop systematic evaluations of risk to people and property so mitigation efforts can be prioritized.	ORS, Chapter 516 creates and defines the duties; Section 516.030(3) directs DOGAMI to administer on a cooperative basis studies and programs that will reduce the loss of life and property by understanding and mitigating geological hazards.
Oregon Health Authority — Public Health Division (OHA)	The Oregon Health Authority's Health Security, Preparedness and Response (HSPR) Program develops public health systems to prepare for and respond to major, acute threats and emergencies that impact the health of people in Oregon. The Program addresses eight of the 11 natural hazards in the Oregon NHMP, extreme heat, and bioterrorism. The Oregon Health Authority's Climate and Health Program Oregon's Climate and Health Program is working with partners to study, prevent, and plan for the health effects of climate change.	ORS 431 provides authority for state and local administration and enforcement of health laws including public health emergency planning and response.
Department of Land Conservation and Development (DLCD)	Manages the statewide land use planning program; Goal 7 of which addresses development in places subject to natural hazards, requiring that jurisdictions apply "appropriate safeguards" when planning for development there. The goal requires local comprehensive plans to include inventories, policies, and ordinances which will reduce losses. DLCD supports local government's and tribe's efforts to address natural hazards through technical assistance during periodic plan review, comprehensive plan and zoning code updates, and development and updates of NHMPs; provides workshops and responds to local government requests for information. As of 2013, DLCD is responsible for facilitating updates of the Oregon Natural Hazards Mitigation Plan. DLCD manages the National Flood Insurance Program (NFIP) in the State of Oregon through an agreement with FEMA. DLCD also manages the Oregon Coastal Management Program, which implements a coastal hazards and assessment program.	ORS, Chapter 197 provides the basis for comprehensive land use planning in the State of Oregon, including provisions governing development in floodplains and in other areas subject to natural hazards, which are intended to mitigate the effects of such hazards. ORS, Chapter 476 provides the basis for the Conflagration Act.

State IHMT Agency	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Department of State Lands (DSL)	Responsible for a variety of service-related functions relating to land management and implementation of state removal-fill law. DSL's role in hazard mitigation is in the issuing of removal and fill permits or enforcement actions on wetlands waters of the state.	ORS 196 and 390 address wetlands, removal and fill permits or enforcement actions on the beds and banks of the waters of this state. Many of these provisions have a tangential effect on floodplain management and flood hazard mitigation.
Oregon Military Department, Office of Emergency Management (OEM)	Convenes the IHMT and provides overall coordination of natural hazards mitigation in the State of Oregon. The State Hazard Mitigation Officer (SHMO) is on the staff of the Oregon Office of Emergency Management. Among OEM's related responsibilities are chairing the Oregon Emergency Response System (OERS) Council, staffing the Oregon Seismic Safety Policy Advisory Commission (OSSPAC), developing and maintaining the State *Emergency Management Plan* and related documents, managing the Chemical Stockpile Emergency Preparedness Program and providing training and other assistance which help mitigate hazards.	ORS, Chapter 401 Includes many of the state's emergency management statutes one section of which states that the general purpose of the law is to reduce the vulnerability of the State of Oregon to loss of life, injury to persons or property, human suffering, and financial loss resulting from emergencies.
Oregon State Police, Office of State Fire Marshal (OSFM)	Develop, promote, and maintain protection of life, property, and the environment from fire and other perils through leadership, direct action, and coordination of public safety resources; provides hazard mitigation through programs to educate, inspect, survey, investigate, respond to emergency incidents, and communicate with the public and emergency responders. The Conflagration Act and the State Fire Services Mobilization Plan are coordinated at all levels of state, county, and city government and they foster cooperation in responding to fires and emergency incidents. OSFM employs Regional HazMat Emergency Response Teams to help ensure public safety regarding hazardous materials incidents occurring throughout the state. OSFM provides education and programs, inspections, information, reports, data and brochures, training programs, and emergency responses to incidents for the schools, governments, and the public.	ORS, Chapters 453 and 476-480 authorize the State Fire Marshal to perform a wide variety of education and training programs, inspections, investigative and information reports and other activities related to fire prevention, safety, and management.
Public Utility Commission (OPUC)	A regulatory agency for certain electric, gas, telecommunication, and water utility companies; enforces the National Electrical Safety Code and the Federal Gas Pipeline Safety Regulations, which address utility operations under both normal and emergency conditions; monitors utilities' actions and infrastructure under a wide variety of conditions, including natural hazards, to ensure code compliance and prudent practices. OPUC promotes effective vegetation management practices to improve system safety and reliable service delivery by its ongoing enforcement of Oregon statutes and administrative rules, specifically in Chapter 860, Division 024.	ORS, Chapters 756-759, 772, and 774 authorize the PUC to carry out its purpose.

State IHMT Agency	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Oregon Department of Transportation (ODOT)	Is the road authority for all state highways in Oregon, including interstate highways; works to maintain drainage, open culverts, clean ditches, and perform hydraulic studies; helps prevent or reduce damage to the state highway system caused by floods or landslides. ODOT invites and works with local public works agencies to become participating parties in the Oregon Public Works Emergency Response Cooperative Assistance Agreement. ODOT and local agencies completed a seismic retrofit prioritization study of Oregon's bridges in 1997. As of January 1999, ODOT completed seismic retrofit projects on 124 state bridges.	ORS, Chapter 810 designates ODOT as the road authority for all state highways and specifies a wide range of maintenance, operations, and analysis activities related to hazard mitigation, for example: drainage maintenance, culvert inventory, and the bridge seismic retrofit program.
Water Resources Department (OWRD)	Responsible for allocation of the water that is produced by watersheds each year; quantifies and provides public notification of flows throughout the state, and insures safe operation of certain dams and other hydraulic structures.	ORS Chapter 540 provides OWRD statutory authorities for dam safety and a statewide hydrographic program for measuring river and stream flows.
Oregon Parks & Recreation Department (OPRD)	Works to provide and protect outstanding natural, scenic, cultural, historic, and recreational sites for the enjoyment and education of present and future generations. OPRD is responsible for land stewardship, marine conservation , rocky shores, several permit programs, department-wide resource policies, and park plants and animals. OPRD strives to provide a safe environment while maintaining the natural beauty and historic importance of our parks. In certain areas providing a safe environment for park users involves planning for natural disasters.	ORS Chapter 390 provides deals with the role of OPRD in dealing with state and local parks, recreation programs, scenic waterways and recreation trails
Oregon Partnership for Disaster Resilience (OPDR)	OPDR is a coalition of public, private, and professional organizations working collectively toward the mission of creating a disaster resilient and sustainable state. Developed and coordinated by the Community Service Center at the University of Oregon, OPDR employs a service learning model to increase community capacity and enhance disaster safety and resilience statewide. Primary activities include community plan and project development support; applied research and technical resource development; training programs and capacity building; and the development of strategic alliances.	N/A
University of Oregon, Emergency Management and Continuity	The Emergency Management & Continuity Program protects the University's ability to meet its mission of teaching, research and public service that is vulnerable to any emergency resulting in the loss of vital resources such as buildings, equipment, infrastructure, technology, or personnel. The emergency management team manages, coordinates, and supports planning, training and exercises to enable the university to protect against, respond to, continue during, and recover from natural and human-caused emergencies.	N/A

Cascadia Regional Earthquake Workgroup

The Cascadia Region Earthquake Workgroup (CREW) is a coalition of private and public representatives working together to improve the ability of Cascadia Region communities to reduce the effects of earthquake events.

CREW's goals include the following:

- Promote efforts to reduce the loss of life and property damage from earthquakes.
- Educate and motivate decision makers, managers, and the general public to reduce risks associated with earthquakes.
- Foster productive linkages between scientists, critical infrastructure providers, businesses, and governmental agencies in order to improve the viability of communities after an earthquake event.

Drought Council

The Drought Council is responsible for assessing the impact of drought conditions and making recommendations to the Governor's senior advisors. The Drought Council is, in turn, advised by the Water Availability Committee, a sub-committee of technical people who monitor conditions throughout the state and report these conditions monthly. In this manner the Drought Council keeps up-to-date on water conditions. Members combine this knowledge with information they bring from their organizations and differing geographic areas of the state in order to make recommendations for policy, response, and mitigation.

The Drought Council is chaired and facilitated by the Oregon Office of Emergency Management. Members of the Council include state and federal agencies, and private organizations involved in drought forecasting, assessment, response, or recovery. The goal of the Drought Council is to "strive to reduce the effects of an impending drought through a coordinated federal, state, local, and voluntary effort, consisting of the development of drought plans, policies, and procedures, and through coordinated state response." (Oregon Office of Emergency Management, 2014 rev.)

Specific tasks of the Drought Council include:

- Monitoring meteorological and hydrological conditions to determine the current and future severity of a drought;
- Estimating the severity of a drought and its impact on electric power consumption and generation, agricultural production, essential human needs, industrial output, fish and wildlife, state forests, and other areas as appropriate;
- Developing an inventory of physical, economic, or other resources available for responding to anticipated drought impacts;
- Determining potential conflicts between water users and electric power users, and initiating actions to minimize these conflicts;
- Coordinating drought response and recovery efforts;
- Acting as a clearinghouse for questions and requests for state and federal drought declarations;
- Assisting the Governor and the Oregon Office of Emergency Management in determining the need for various federal disaster declarations and other federal assistance;
- Reporting to the Governor's Natural Resource Advisor;

- Facilitating and coordinating development of water and power conservation plans; and
- Facilitating and coordinating public information processes that encourage voluntary conservation measures.

Energy Facility Siting Council

The Energy Facility Siting Council reviews proposed energy facilities for seismic vulnerability through its structural standard, Oregon Administrative Rule (OAR) 345-022-0020. This standard is a safety standard rather than a reliability standard. It ensures that structural failure at an energy facility will not endanger workers or the public. It does not require that energy facilities be proven to remain operable in a seismic event because the Council assumes that key safety facilities such as hospitals will have backup electricity.

The standard requires that:

- The applicant, through appropriate site-specific study, has adequately characterized the site as to appropriate seismic design category and expected ground motion and ground failure, taking into account amplification during the maximum credible and maximum probable seismic events;
- The applicant can design, engineer, and construct the facility to avoid dangers to human safety presented by seismic hazards affecting the site that are expected to result from all maximum probable seismic events (as used in the rule, "seismic hazard" includes ground shaking, landslide, liquefaction, lateral spreading, tsunami inundation, fault displacement, and subsidence);
- The applicant, through appropriate site-specific study, has adequately characterized the potential geological and soils hazards of the site and its vicinity that could, in the absence of a seismic event, adversely affect, or be aggravated by, the construction and operation of the proposed facility; and
- The applicant can design, engineer and construct the facility to avoid dangers to human safety presented by the hazards identified.

The Council reviews proposed energy facilities such as power plants, major electric transmission lines, major gas pipelines (greater than 16 inch diameter) for compliance with this standard. They do so in consultation with Oregon Department of Geology and Mineral Industries under an interagency agreement.

In response to an electricity shortage, the 2001 Oregon Legislature created an expedited review process for certain qualifying power plants. These power plants are generally not required to meet the structural standard; however, the Oregon Office of Energy, in consultation with Oregon Department of Geology and Mineral Industries, can still impose conditions on these plants related to the structural standard.

Hazard Mitigation Grant Review Board

The Hazard Mitigation Grant Review Board is an intergovernmental body which when convened reviews, discusses, ranks, and recommends project selections for funding under Section 404 of the Stafford Act (also known as the Hazard Mitigation Grant Program — HMGP).

With requirements for FEMA-compliant (201.6) local mitigation plans to be eligible for Section 404 grants, the need to convene the Hazard Mitigation Grant Review Board has been largely replaced by project actions and priorities identified in those local mitigation plans. In order to expedite the Section 404 grant offering early in the post-disaster recovery process, HMGP project funding is first prioritized to the disaster-declared counties (and all eligible applicant entities therein) on a pro rata share basis of their Public Assistance and Individual Assistance eligible costs as initially determined during the Preliminary Damage Assessment. The pro rata applicant share can be further refined at either the 12-month or 18-month HMGP lock-in. HMGP planning grant funding is available statewide from the onset of the program's availability.

During the PA and HMGP Applicant Briefing, the state promulgates broad priorities and project categories for Section 404 project pre-applications that tend to focus on the nature of the disaster and related mitigation opportunities. Representatives from the Hazard Mitigation Grant Review Board and the State IHMT are encouraged to provide their input into establishing the broad priorities and project categories for Section 404 project pre-applications early in the process. The Hazard Mitigation Grant Review Board plays a key role in selecting state 5% initiative projects as there are often many more "5%" projects than available funding.

Board membership includes:

- Director of the Oregon Office of Emergency Management or designee (most usually the Section Director, Mitigation and Recovery Services who is also the State Coordinating Officer for major disaster declarations), who chairs the Board;
- State NFIP Coordinator of the Department of Land Conservation and Development (DLCD) or designee;
- President of the Oregon Emergency Management Association (OEMA) or designee;
- A representative of the Association of Oregon Counties (AOC) and/or the League of Oregon Cities (LOC); and
- For flood disasters and related projects, Chief of the Emergency Management Branch, Portland District, U.S. Army Corps of Engineers (USACE) or designee.

The State Hazard Mitigation Officer (SHMO) of the Oregon Office of Emergency Management provides staff and technical assistance and presents hazard mitigation projects to the Board, but is not a voting member.

Oregon Board of Geologist Examiners

In 1990 the Oregon Board of Geologist Examiners adopted guidelines to assist professionals in preparing engineering geologic reports in the state. Then in 1996, the Board adopted additional guidelines for site-specific seismic hazard reports for essential and hazardous facilities, major structures, and special occupancy structures as provided in ORS 455.447. A complete listing of all report elements is included in Section 1802.6.1 of the *Oregon Structural Specialty Code.* In 2001, the Board established a Memorandum of Understanding with the Engineering & Land Surveying Examiners Board to clarify the roles of Certified Engineering Geologists and Geotechnical Engineers.

Oregon Emergency Management Association

Oregon Emergency Management Association (OEMA) is the association for Oregon's emergency management professionals. OEMA provides over 200 public, private, and non-profit members with the following:

- A network for training, education, and preparedness information and professional development;
- A forum for the sharing of knowledge, ideas, processes and building partnerships; and
- A collective and unified voice for emergency management issues in Oregon.

OEMA promotes the efforts of Oregon's communities to plan for all natural and human caused hazards through improved mitigation, preparedness, response, and recovery capabilities.

Oregon Lidar Consortium

Formed by the Department of Geology and Mineral Industries, the Oregon Lidar Consortium (OLC) develops cooperative agreements for the collection of high-quality lidar that benefits the public at large, the business community, and agencies at all levels of government. The goal of the OLC is to provide high-quality lidar coverage for the entire state. The collection of lidar data can assist governments in better identifying hazardous areas.

Oregon Seismic Safety Policy Advisory Committee

OSSPAC is a state advisory commission created in February 1990 through an executive order from Governor Neil Goldschmidt and established in statute by the 1991 Oregon Legislature (ORS 401.337).

It is made up of 18 members with interests in earthquake safety: Building Codes Division, Oregon Office of Emergency Management, Department of Geology and Mineral Industries, Department of Land Conservation and Development, Oregon Department of Transportation, two representatives from the Oregon Legislature, one local government representative, one member from education, three from the general public and six members from affected industries, such as homebuilders and banking industries.

The purpose of the work of OSSPAC is to reduce exposure to Oregon's earthquake hazards by:

- Developing and influencing policy at the federal, state, and local government levels;
- Facilitating improved public understanding and encouraging identification of earthquake risk; and
- Supporting research and special studies, appropriate mitigation, response, and recovery.

The Commission has proposed concepts to the Oregon Legislature on improving seismic safety in Oregon. They have prepared a document entitled *Oregon at Risk,* which outlines seismic hazards in the state. In 2004 the Commission provided a venue to the General Obligation (GO) Bond Task Force to develop policy recommendations for implementation of SB 14 & 15 (2001). These bills and general obligation bonds for funding of the grant program would improve the earthquake safety of public schools and emergency response facilities across the state.

Oregon Sea Grant Extension

The Oregon State University Extension Service conveys research-based knowledge to a variety of businesses owners, growers, foresters, youth and community leaders in an effort to improve their lives, their homes, their businesses and their communities. The Oregon Sea Grant program provides education regarding watershed health and creating hazard resilient coastal communities with particular attention placed to earthquake and tsunami hazards.

Pacific Northwest Seismograph Network

The Pacific Northwest Seismograph Network operates seismograph stations and locates earthquakes in Oregon and Washington. They are funded by the U.S. Geologic Survey, the Department of Energy, and the State of Washington. The PNSN website provides information on Pacific Northwest earthquake activity and hazards.

Pacific Northwest Wildfire Coordinating Group

The Pacific Northwest Wildfire Coordinating Group provides leadership in interface and wildland fire management for local, tribal, state, and federal agencies. The PNWCG is comprised of USDA-Forest Service, USDOI-Bureau of Land Management, Bureau of Indian Affairs, National Park Service, Fish and Wildlife Service, Oregon Department of Forestry, Washington Department of Natural Resources, Washington Association of Fire Chiefs, Oregon Fire Chiefs Association, the Oregon State Fire Marshal, and the Washington State Fire Marshal.

State Pre-Disaster Hazard Mitigation Programs

Conservation Reserve Program (CRP)

CRP retires eligible cropland from agricultural production and plants the land to permanent grass cover that reduces erosion and benefits wildlife populations. CRP does a very good job of providing cover that reduces windblown dust and has been effective in reducing soil erosion in the areas most prone to wind erosion. However, silt soils easily stay suspended for long periods of time and can move great distances affecting visibility on roads away from the protected fields. The strategy to encourage a strip of CRP along the freeway has been determined to probably be ineffective at reducing dust storm intensity. Also, the fire hazard could be worse than the dust hazard. In Umatilla County, NRCS has designated an area near I-84 as a wind erosion priority area to influence enrollment into the Conservation Reserve Program.

Community Rating System Users Groups

The NFIP's Community Rating System (CRS) is a voluntary program that rewards communities for engaging in floodplain management activities that exceed the minimum NFIP requirements by discounting flood insurance premium rates to reflect the reduced flood risk resulting from those activities. Other benefits resulting from community participation in the CRS program include:

- Reducing flood damage to insurable property,
- Strengthening and supporting the insurance aspects of the NFIP, and
- Encouraging a comprehensive approach to floodplain management.

Relatively few of Oregon's communities participate in the CRS Program. In 2014, DLCD convened two new CRS Users Groups (northern and southern) to encourage greater participation. The two groups were open to communities already participating in the CRS program and to any other community interested in floodplain management best practices. DLCD was the coordinating body, but the effort had to be tabled for a time due to turnover, capacity, and NFIP funding priorities. It has since been supported primarily by FEMA's insurance specialist with DLCD providing advocacy and encouragement to local governments to join the program during every CAV and CAC.

Oregon Coastal Management Program

The Oregon Coastal Management Program (OCMP) is the combined effort of 32 cities, seven counties, and a host of state agencies to carry out the statewide land use program on the Oregon Coast. OCMP's mission is to work in partnership with coastal local governments, state and federal agencies, and other stakeholders to ensure that Oregon's coastal and ocean resources are managed, conserved, and developed consistent with statewide planning goals.

To accomplish this mission OCMP provides substantial financial and technical assistance to coastal local governments for planning, capacity building, and special projects. OCMP also coordinates and integrates programs of local, state, and federal agencies to support local planning and to protect and restore coastal natural resources, and reviews state and federal permits to ensure compliance with local, state, and federal program requirements. OCMP also uses the Internet to provide coastal data and information to a wide public through the Oregon Coastal Atlas.

DOGAMI Partnership with U.S. Geological Survey National Landslide Hazard Program

DOGAMI has entered into a collaborative partnership with the U.S. Geological Survey National Landslide Hazard Program, centered on three targeted goals for Western Oregon: (a) develop inventory maps and digital databases of existing deep-seated landslides, (b) develop predictive hazard maps of areas prone to rapidly moving landslides, and (c) develop susceptibility maps of deep-seated landslides for targeted developable areas. The second of these incorporates the mandates of Oregon Revised Statutes 195.260 (2003) to produce *further review areas* of rapidly moving landslide hazard. This will be conducted in cooperation with local governments and will provide some technical assistance to local governments to facilitate the use and application of this information. A Landslide Advisory Committee consisting of local government stakeholders and state and federal agencies will aid the agency in prioritizing projects.

DOGAMI Earthquake Hazard Mitigation Program

DOGAMI's enabling statute gives the agency broad responsibility and authority for evaluating all geologic hazards statewide, including earthquake hazards. DOGAMI has published numerous maps and reports on the earthquake hazards of the state. The agency, in partnership with other state and federal agencies, has undertaken a wide-ranging program in Oregon to identify seismic hazards, including active fault identification, bedrock shaking, tsunami inundation zones, ground motion amplification, liquefaction, and earthquake induced landslides.

DOGAMI Tsunami Hazard Mitigation Program

The primary goal of the Oregon Tsunami Hazard Mitigation Program is to reduce loss of life and property damage from tsunamis. Additionally, the program aims to promote community preparedness through development of mitigation products and the implementation of a coastwide, volunteer driven education and outreach initiation to support the National Weather Service's *TsunamiReady*™ program. Funding granted from the National Tsunami Hazards Mitigation Program is being used to complete the next generation of tsunami inundation maps along Oregon's 43 *TsunamiReady*™ communities.

ODF National Fire Plan Implementation in Oregon

Under the National Fire Plan (NFP), funding opportunities for local wildland-urban interface (WUI) planning, prevention and mitigation projects first became available in 2000. Since that time, Oregon has aggressively sought funding for a wide variety of projects, including fuels reduction work, education and prevention projects, community planning, and alternative uses of fuels. The majority of these monies have been used to fund fuels reduction projects on individual properties and to establish community fuel breaks in the most wildfire prone portions of the state. NFP funds have also been used to expand fire prevention efforts, to educate local officials about how they may help address the WUI situation, to implement Senate Bill 360, to improve public awareness about the wildfire problem, and to better identify areas especially exposed to wildland fire.

ODFW Habitat Resources Program — Riparian Lands Tax Incentive

The Riparian Tax Incentive Program, authorized by ORS 308A.350 through 308A.383, offers a property tax incentive to property owners for improving or maintaining qualifying riparian lands. Under this program, property owners receive complete property tax exemption for their riparian property. This can include land up to 100 feet from a stream.

When the Riparian Tax Incentive law was passed in 1981, the Oregon Legislative Assembly declared that "it is in the best interest of the state to maintain, preserve, conserve, and rehabilitate riparian lands to assure the protection of the soil, water, fish, and wildlife resources of the state for the economic and social well-being of the state and its citizens." Healthy riparian zones are important to the resource by providing cooler water due to shading resulting in better habitat for salmon, trout, and steelhead; more and better varieties of habitat for wildlife; increased water during summer low flow periods; erosion control by stabilizing stream banks with protective vegetation; and flood control.

ODFW Fisheries Restoration and Enhancement Program

The Fisheries Restoration and Enhancement Program is a comprehensive program to restore state-owned hatcheries, enhance natural fish production, expand hatchery production, and provide additional public access to fishing waters. The R&E Program provides increased sport fishing opportunities, and also supports and improves the commercial salmon fishery.

The program was authorized by the Oregon Fisheries and Enhancement Act of 1989 and was renewed in 2009. The program focuses on projects that increase fish production (either hatchery or natural production), increase recreational or commercial opportunities or access to the fish resources, or improve fish management capabilities. Restoration projects that facilitate fish passage may also provide flood-control benefits.

OEM Pre-Disaster Mitigation Planning and Project Activities

State pre-disaster mitigation planning and project activities are an integral component of OEM's mission. OEM's Mitigation and Recovery Services Section provides oversight and administration of financial services and related funding that is sub-granted to local governments. Specifically, the Section Director, SHMO, Alternate SHMO, Facilities Engineer (Public Assistance Officer), Seismic Grants Coordinator, and financial support staff work together closely on pre-disaster mitigation grant programs and project activities. Although OEM has limited staff support available for mitigation planning and project implementation activities, the state is able to effectively secure and manage FEMA's PDM and FMA grants.

The success of mitigation planning activities statewide combines Oregon's past history of land use planning and goals with the integration of resources from FEMA's mitigation grants leveraged through the Oregon Partnership for Disaster Resilience. The concept of aggregating regional, jurisdictional mitigation planning needs that leverage and target financial and technical resources to geographic areas around the state has proven to be successful in securing funding and completing local mitigation plans.

OPDR Pre-Disaster Mitigation Planning Program

Despite the growing recognition of the need for long-term coordination to reduce risk from natural disasters, many communities in Oregon continue to experience difficulty in developing and implementing natural hazard risk reduction plans, policies and activities. Communities regularly suffer from a lack of technical and funding assistance, as well as insufficient coordination among public, private, and non-profit sectors at the local, regional, and statewide levels. OPDR works to address these challenges and offers a model of how increased communication, coordination, and collaboration between diverse partners can assist communities in reducing their risk from natural hazards. The Pre-Disaster Mitigation (PDM) program is completely funded by nationally competitive federal grants with in-kind match coming from local communities and the University of Oregon. Mitigation planning occurs in partnership with the Oregon Office of Emergency Management, the Department of Land Conservation and Development, Department of Geology and Mineral Industries, FEMA Region X, and local governments throughout Oregon.

OPDR Disaster Resilient University Initiative

The Oregon Disaster Resilient University (Oregon-DRU) is a new initiative between University of Oregon Emergency Management, Oregon Partnership for Disaster Resilience and Oregon's post-secondary institutions. The concept is to build a collaborative service center model between campuses in Oregon to link the skills, expertise, resources, and innovation of post-secondary education, federal agencies, professional and trade organizations, and state agencies to reduce risk on Oregon campuses. The Oregon-DRU has five specific service areas geared to enhance and support emergency management and risk reduction efforts within post-secondary institutions in Oregon.

ODF Community Wildfire Protection Plans

A Community Wildfire Protection Plan (CWPP) is developed by a community in an area at-risk from wildfire. CWPs have three primary requirements: (a) they must be developed collaboratively between local and state government representatives in consultation with federal agencies and other interested parties, (b) they must identify and prioritize areas for hazardous fuels reduction treatments while also recommending methods for treatments that will protect at-risk communities and essential infrastructure, and (c) they must recommend measures that homeowners and communities can take to reduce ignitability of structure throughout the plan area. The statutory definition of a CWPP appears in Title I of the Healthy Forest Restoration Act of 2003. Oregon has 35 County CWPPs and 26 additional community CWPPs.

Oregon Plan for Salmon and Watersheds — Covered in Policies

"The Oregon Plan" is the state's program to restore native salmon and trout populations and to improve water quality. The overall goal of the Oregon Plan is to restore fish populations to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits.

Statewide Land Use Planning Program

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of that program is a set of 19 statewide planning goals. The goals express the State's policies on land use and related topics, such as citizen involvement, housing, and natural resources. Oregon Statewide Planning Goal 7- *Areas Subject to Natural Hazards* was developed to protect people and property from natural hazards in Oregon. Goal 7 provides guidelines for local government planning officials to follow that can reduce their vulnerability to natural hazards. These guidelines include what factors local governments can consider in adopting policies and measures to protect people and property from natural hazards, and several ways in which local governments can implement mitigation measures more effectively.

DLCD's Natural Hazards Mitigation Planning Program facilitates the update and maintenance of Oregon's NHMP, assists local governments and tribes directly with developing and updating NHMPs, and undertakes other activities to implement Goal 7. This Program, the NFIP staff and the Ocean and Coastal Management Program staff work together to promote intra-departmental awareness of and action on hazard mitigation issues and opportunities in land use planning as well as working directly with communities to advance hazard mitigation statewide.

NFIP and Cooperating Technical Partners

NFIP: The Oregon Department of Land Conservation and Development serves as the state NFIP coordinating agency, partnering with DCBS-BCD, DOGAMI, and OEM. These agencies are responsible for existing flood mitigation strategies and programs. In addition to state programs, the NFIP is designed to help minimize flood losses through local floodplain management. The NFIP relies on flood hazard mapping, flood insurance, and floodplain development standards implemented at the local level to reduce flood losses. In Oregon, 259 cities and counties and two tribal nations participate in the NFIP (total of 259 "NFIP" communities) and thus play a key role in flood mitigation.

Cooperating Technical Partners: FEMA's Risk MAP Program's partnership mechanism provides the opportunity to pool resources and extend the productivity of limited public funds. Risk MAP partners include State or regional agencies and federally recognized tribes that serve communities participating in the National Flood Insurance Program (NFIP). Risk MAP partner activities include, but are not limited to, assessing mapping needs, reviewing hydrologic and hydraulic studies prepared for flood map revisions, and providing an inventory of base maps.

FEMA partners with State and regional organizations in the management of Risk MAP activities for the following reasons:

- Management participation will help ensure that the products resulting from Risk MAP do not conflict and are complementary, not duplicative;

- Risk MAP provides a means to interject a tailored, local focus into a national program. Where unique conditions may exist, special approaches to communication, coordination, and compliance that may be necessary can be taken; and
- The Risk MAP partnership mechanism provides the opportunity to combine resources and extend the productivity of limited public funds.

Oregon Coastal Management Program

Oregon's Coastal Management Program (OCMP) is the combined effort of 32 cities, seven counties, and a host of state agencies to carry out the statewide land use program on the Oregon coast. All statewide planning goals apply to the coast, but the OCMP emphasizes four coastal-related goals: Goal 16, Estuarine Resources; Goal 17, Coastal Shorelands; Goal 18, Beaches and Dunes; and Goal 19, Ocean Resources. The Department of Land Conservation and Development is the state's Coastal Management Agency and provides overall program administration and coordination. The OCMP assists coastal planners to identify and plan for costal hazards to prevent property damage and avoid loss of life. The OCMP also works with the Oregon Department of Geology and Mineral Industries and Oregon Sea Grant to identify and communicate natural hazards such as shoreline erosion and tsunami inundation.

Oregon Emergency Response System

Oregon's Emergency Response System coordinates and manages state resources in response to natural and technological emergencies and civil unrest involving multijurisdictional cooperation between all levels of government and the private sector. Established in 1972, OERS was the first state plan of its kind, it serves as the primary point of contact by which any public agency reports the state with notice of an emergency or disaster or from which they can request access to state or federal resources.

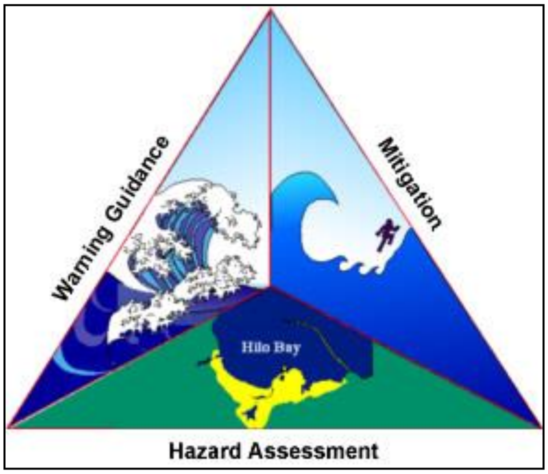
Oregon's Wetlands Protection Program

Oregon's Wetlands Program was created in 1989 to integrate federal and state rules concerning wetlands protection with the Oregon Land Use Planning Program. The Wetlands Program has a mandate to work closely with local governments and the Division of State Lands (DSL) to improve land use planning approaches to wetlands conservation. A Local Wetlands Inventory (LWI) is one component of that program. DSL also develops technical manuals, conducts wetlands workshops for planners, provides grant funds for wetlands planning, and works directly with local governments on wetlands planning tasks.

National Tsunami Hazard Mitigation Program

The National Tsunami Hazard Mitigation Program (NTHMP) is a state and federal partnership. The program's Coordinating Committee includes emergency management and geoscience representatives from the original five Pacific states (Alaska, California, Hawaii, Oregon, and Washington), emergency management representatives from the Atlantic and Gulf Coast states, the United States Geological Survey (USGS), the Federal Emergency Management Agency (FEMA), National Oceanographic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). Funds to administer the program are provided by NOAA and have been available every fiscal year since federal FY 1997.

Figure 3-1. Tsunami Hazard Mitigation Program



The 2006 *Tsunami Warning and Education Act* (PL 109-424) called for a Forecasting and Warning Program, a Tsunami Hazard Mitigation Program, and a Tsunami Research Program. These programs include the upgrade of seismic networks and installation of open ocean tsunami detection equipment designed to reduce the number of false alarms; development of tsunami inundation models and maps; and education, preparedness, and mitigation work, including an implementation plan to ensure that the goals of the program were met.

Water Resources Department Dam Safety Program

The Water Resources Department Dam Safety Program reviews design plans, reports and specifications and approves for construction, modification, or enlargement all hydraulic structures greater than or equal to 10 feet height and 3,000,000 gallons reservoir capacity. Design approval for High Hazard hydraulic structures typically includes a satisfactory review of Emergency Action Plans and inundation maps.

The Dam Safety Program maintains for the National Inventory of Dams, a database of all Oregon dams and reservoirs that exceed statutory size criteria regardless of ownership. The program also performs regular inspections of all existing non-federal dams statewide. The OWRD dam safety program participates cooperatively with existing established federal dam safety programs such as U.S. Army Corps Engineers, U.S. Bureau Reclamation, Federal Energy Regulatory Commission and others in their design review and inspection of federal project dams, reservoirs, and appurtenant works.

OWRD is the designated state agency and the Hydroelectric Licensing Program is the lead for review and license permitting for new and existing hydroelectric projects. OWRD's licensing program collects data and requests from other state agencies, negotiates settlements, and assembles the state's criteria for power development and operation. When the process is completed, the conditions and requirements are incorporated into and apply concurrently with issuance of the federal license for all regulated hydroelectric projects statewide.

Wildfire Awareness Week

Since 2001, when Governor John Kitzhaber proclaimed Oregon's first Wildfire Awareness Week, this interagency effort has grown with each passing year. That year, a coalition led by the Office of State Fire Marshal, and including the Department of Forestry, structural fire agencies, insurance industry representatives, and others developed and distributed a campaign tool kit with model proclamations and recorded public service announcements designed for distribution to media outlets. In 2008, the Keep Oregon Green Association became the caretaker of the annual campaign.

OEM Statewide Earthquake and Tsunami Drills

Earthquake and tsunami drills are conducted annually by OEM. On January 25, 2011 the first annual Great Oregon Shake Out occurred throughout Oregon with over 39,000 participants. In partnership with DOGAMI, OEM also conducts voluntary tsunami evacuation drills. The community-wide drills incorporate aircraft public address systems in addition to the tsunami warning issued by the National Weather Service in areas where sirens have limited coverage.

ODOT Winter Maintenance Practices

ODOT's winter maintenance practices include plowing, sanding, and applying anti-icing liquids in order to increase efficiency of snow removal and to reduce motor vehicle crashes. To increase motorist safety in collaboration with local media, ODOT Region 5 publishes a special multi-page flyer known as the Winter Roadway Guide. Additionally, ODOT publishes winter driving tips and information on its website and readerboards geared to motorists and bicyclists.

Public Health Mitigation Planning

The Oregon Public Health Emergency Preparedness Program is an effort to anticipate, detect, assess, and understand health risks associated with an emergency. The mitigation aspect focuses on long-term measures for reducing or eliminating risk including technological and policy changes. The department promotes guidance from the National Health Security Strategy, Interim Implementation Guides, and Community Mitigation Strategies.

Oregon Seismic Safety Policy Advisory Commission

The Oregon Seismic Safety Policy Advisory Commission has the unique task of promoting earthquake awareness and preparedness through education, research, and legislation. The mission of OSSPAC positively influence decisions and policies regarding pre-disaster mitigation of earthquake and tsunami hazards, increase public understanding of hazard, risk, exposure, and vulnerability through education seminars, etc., and be responsive to the new studies and or issues raised around earthquakes and tsunamis.

As a result of the Loma Prieta Earthquake in the Bay Area of California in 1989, Oregon residents wanted the State to address the earthquake hazard and preparedness. As a result, the Interagency Seismic Task Force recommended that a new state commission be formed in response to this need. OSSPAC was formed as a result of Senate Bill 96 in 1991. Since this time, OSSPAC has continued to increase Oregon's awareness to earthquake hazards by supporting earthquake education, research, and legislation. Every 2 years, OSSPAC provides a summary report to the Governor of the Commission's activities. OSSPAC has also formed relationships with the Western States Seismic Policy Council (WSSPC) and the California Seismic Safety Commission which provides a persuasive advantage to affect federal policy for the West Coast.

National Programs & Organizations

American Planning Association (APA)

The APA's Hazards Planning Research Center brings together solutions from multiple disciplines into a single source. The center provides original and applied research to identify best practices that that protect communities from natural and man-made hazards. APA's efforts are accomplished through its Hazard Mitigation and Disaster Recovery Planning Division, research, outreach, education, policy and resource guides and other publications.

Firewise

Firewise is a program developed within the National Wildland-Urban Interface Fire Protection Program, and it is the primary federal program addressing interface fire. It is administered through the National Wildfire Coordinating Group whose extensive list of participants includes a wide range of federal agencies. The program is intended to empower planners and decision makers at the local level. Through conferences and information dissemination, Firewise increases support for interface wildfire mitigation by educating professionals and the general public about hazard evaluation and policy implementation techniques. Firewise offers online wildfire protection information and checklists, as well as listings of other publications, videos, and conferences.

FireFree Program — Bend, Oregon

FireFree is a unique private/public program for interface wildfire mitigation involving partnerships between an insurance company and local government agencies. It is an example of an effective non-regulatory approach to hazard mitigation. Originating in Bend, the program was developed in response to the city's "Skeleton Fire" of 1996, which burned over 17,000 acres and damaged or destroyed 30 homes and structures. Bend sought to create a new kind of public education initiative that emphasized local involvement. Safeco Insurance Corporation was a willing collaborator in this effort. Bend's pilot program included:

- A short video production featuring local citizens as actors, made available at local video stores, libraries, and fire stations
- Two city-wide yard debris removal events
- A 30-minute program on a model FireFree home, aired on a local cable television station
- Distribution of brochures, featuring a property owner's evaluation checklist and a listing of fire-resistant indigenous plants

The program continues to provide educational materials on fire risk reduction strategies and fire resistant plants.

National Flood Insurance Program (NFIP)

The function of the NFIP is to provide flood insurance to homes and businesses located in floodplains at a reasonable cost, and to encourage the location of new development away from the floodplain. The program is based upon mapping areas of flood risk, and requiring local implementation to reduce that risk, primarily through restrictions on new development in floodplains. Elevation Certificates are forms published by FEMA required to be maintained by communities participating in the NFIP. New development is required to be elevated or otherwise designed to protect against flooding. The NFIP requires local governments to obtain certificates for all new construction in floodplains and to keep the certificates on file. Local governments must insure that elevation certificates are filled out correctly for structures built in floodplains.

V-ZONE CONSTRUCTION

In many of Oregon's coastal communities, FEMA has mapped "V zones" (velocity zones), areas of special flood hazard that are subject to high velocity wave action from storm surges or seismic events. Because of the potential force associated with this wave action, special regulations apply for new construction and substantial improvements in "V zones."

COMMUNITY RATING SYSTEM (CRS)

Community Rating System (CRS) is a program operated by the NFIP that recognizes communities who go beyond the minimum requirements of the NFIP. CRS offers reduced flood insurance premiums for communities who adopt higher standards and encourages community activities that reduce flood losses, facilitate accurate insurance rating, and promote flood insurance awareness.

FEMA Region 10 Policy on Fish Enhancement Structures in the Floodway

Local communities regulate development in the floodway. The regulations require that a community prohibit encroachments (including fill, new construction, and other development) within the floodway unless it is demonstrated by engineering analysis that the proposed encroachment will not result in any increase in flood levels during the occurrence of a 100-year flood event. The recent designation of several northwest salmon and steelhead runs as threatened or endangered has resulted in an increased effort to restore fish habitat. Restoring habitat often involves placing structures in stream.

Army Corps of Engineers Permit Program

The U.S. Army Corps of Engineers is responsible for the protection and development of the nation's water resources, including navigation, flood control, energy production through hydropower management, water supply storage, and recreation. The Corps administers a permit program to ensure that the nation's waters are used in the public interest, and requires any person, firm, or agency planning work in the waters of the United States to first obtain a permit from the Corps. Permits are required even when land next to or under the water is privately owned. It is a violation of federal law to begin work before a permit is obtained and penalties of fines and/or imprisonment may apply. Examples of activities in waters that may require a permit include: construction of a pier, placement of intake and outfall pipes, dredging, excavation, and depositing of fill. Permits are generally issued only if the activity is found to be in the public interest. In Oregon, the Division of State Lands (DSL) and the U.S. Army Corps of Engineers jointly issue permits for development of these activities. As mentioned in the discussion of DSL permits, local planning agencies are required to sign off on any permits issued by DSL and the U.S. Army Corps of Engineers and water quality certification is required by the Department of Environmental Quality.

Pre-Disaster Hazard Mitigation Projects

Tsunami Evacuation Signs

The Oregon Department of Transportation (ODOT) collaborated with DOGAMI, OEM, and coastal counties to develop signs denoting tsunami hazard zones, evacuation routes, and evacuation sites. ODOT manufactures the signs and makes them available to local governments at cost. The signs also have been used in California, Washington, Alaska, the Philippines, and Japan.

A project started in 2003 with OEM, DOGAMI, and coastal counties involved the development of signs that tell motorists when they are entering or leaving a tsunami hazard zone. The new signs are placed on US-101, the Pacific Coast Highway, when local communities establish the locations of their tsunami evacuation routes.

As local tsunami evacuation plans are developed, ODOT will work with communities to develop corresponding alternate route plans for U.S. 101 and other state highways.

Wind Erosion Control Practices

The Natural Resources Conservation Service (NRCS) and local soil and water conservation districts (SWCD) have long sought to reduce wind erosion of cropland. Farming practices commonly used in dryland cropping areas, such as reduced tillage and residue management, reflect this interest. However, occasionally after long periods with little or no precipitation any activities that disturb soil or reduce vegetation can lead to conditions conducive to dust storms.

Nationally, NRCS has developed quality criteria for wind erosion control practices and use a wind erosion equation model for predicting potential wind erosion under various farming systems.

Since 1985, to maintain eligibility for USDA Farm Program benefits, landowners have been required to meet minimum standards for control of erosion, both from water and wind. Participating farmers have developed and are responsible for implementing conservation plans for all farmland designated as highly erodible. Plans address practices such as residue management, tillage methods, and irrigation management.

At this time, wind erosion control is a requirement under the Federal Farm Bill for certain commodities such as wheat and corn, but depending on the rotation, may not be a requirement for other commodities such as potatoes or vegetables. USDA-NRCS is generally responsible for these programs.

Wind erosion is ranked high among concerns for funding under the Environmental Quality Incentive Program, the current USDA cost-share program available to landowners.

No-Till Cropping

SWCDs have been actively promoting, through education and incentives, direct seeding methods. Direct seeding or no-till cropping systems use technology that places seed and fertilizer into undisturbed soil and residue from the previous crop. This results in minimal soil disturbance and reduced potential for wind and water erosion.

Research funded by the Cooperative State Research, Education, and Extension Service (CSREES) research on the Columbia Plateau has demonstrated that no-till cropping can reduce predicted dust emissions by 94% during severe wind events, compared to conventional wheat-fallow. Research continues on measuring dust emissions from fields on the Columbia Plateau, a 50,000 square-mile region in Washington, Oregon, and Idaho containing one of the driest, yet most productive, rain-fed wheat regions in the world. No-till only works for some crops under certain conditions, however, and even in situations where it does work, some farmers find that they need to till the soil periodically to reduce diseases and redistribute soil moisture.

Trip Check

TripCheck is an online travel planning resource, developed by the Oregon Department of Transportation (ODOT) to provide travelers with the latest travel conditions and information via road cameras, continuous winter travel updates, year-round highway construction details, and other valuable tips. Several projects were included in providing the public with this resource, including installation of closed circuit television cameras on remote state highways, installation of Road Weather Information Systems (RWIS) on state highways. The RWIS's are used to make winter road maintenance decisions, and data is shared with the public. Installation of Wind Warning Systems on state highways to alert drivers to hazardous wind conditions at bridge crossings and along coastal highways.

Highway Advisory Radio

ODOT has coordinated the installation of Highway Advisor Radio transmitters for Highway Advisory Radio in select travel corridors. Locations include; installation of radio transmitters along I-84 in Morrow and Umatilla Counties for, and along the full length of US-101.

When an emergency occurs, the ODOT District 12 office selects the appropriate pre-recorded message on the system and transmits it via radio. At the same time, ODOT activates yellow flashing beacons. Motorists seeing the signs and flashing lights should tune to 1610 AM and comply with any messages. In the case of a dust storm, motorists are advised to slow down and exit the freeway as soon as possible. ODOT worked with OEM's Chemical Stockpile Emergency Preparedness Program office in Pendleton and local emergency management personnel on this project.

Also installed in the system is the ability to re-broadcast National Weather Service (NWS) weather information. NOAA Weather Radio is re-broadcast on a continuous basis unless there is an emergency. An emergency broadcast then overrides the NOAA Weather Radio service

ODOT Mitigation Efforts

ODOT has several implemented several hazard mitigation measures and increase motorists' safety, including:

- Installation of debris flow warning signs at designated locations on three at-risk highways: OR-38, OR-6, and I-84;
- Installation of automated flood warning systems on some state highways to monitor water levels and to notify maintenance crews and the public of potentially hazardous conditions;
- Installation of snow zone signs on state highways notifying motorists of chain and traction tire requirements ahead;
- Installation of tsunami zone signs on state highways; and
- Establishment of a 511 statewide toll-free telephone number allowing drivers to hear road and weather information by phone.

Publications/Studies

Energy Assurance Plan

As the designated State Energy Office, the Oregon Department of Energy (ODOE) is responsible for developing and maintaining the State Energy Emergency Plan under the State Energy Program. ODOE was required to review and update the State Energy Emergency Plan annually for submission to USDOE as the state energy Plan of Record.

The September 2009 Oregon Energy Emergency Response Plan was revised and renamed the Oregon State Energy Assurance Plan as a result of a grant awarded to ODOE by the USDOE's Office of Electricity Delivery and Energy Reliability (USDOE-OE) to enhance state government energy assurance resiliency. As a result, new information was added to the state's 2009 plan.

The Plan includes information on seismic vulnerabilities and earthquake impacts on the critical energy infrastructure in Oregon from a magnitude nine Cascadia Subduction Zone earthquake. Furthermore, the state is considering the integration of new energy portfolios like alternative fuels as well as smart grid technologies into Oregon's response strategies to energy emergencies to improve energy assurance resiliency.

"Resiliency" is defined as the ability of critical infrastructure to absorb, adapt to, and rapidly recover from a potentially severe and disruptive event. "Critical infrastructure" includes energy lifelines that, if disrupted, could significantly impact public health and safety, the economy, or national security. Any prolonged interruption of the supply of basic energy — whether it is petroleum products, electricity, or natural gas — could do considerable harm. As a result, improving energy assurance and resiliency in Oregon's energy infrastructure is intended to help mitigate the impacts of an energy supply interruption and help the state return to normal conditions as quickly as possible, regardless of the cause of the interruption.

Oregon's energy assurance and resiliency planning takes into account four key components: (a) understanding the energy infrastructure, Oregon's Energy Profile, and system interdependencies; (b) assessing potential risks and hazards threatening the state's critical energy infrastructure and considering short- and long-term mitigation measures to reduce risk and vulnerability; (c) developing effective plans and procedures to help minimize the impacts of an energy supply interruption and rapidly restore the energy infrastructure should an emergency occur; and (d) increasing public awareness. The Oregon State Energy Assurance Plan is designed to provide an overview of the first three components to help achieve the fourth component, which is to increase general awareness of the energy infrastructure, risks to the state energy lifelines, and the state's approach to restore fuel, power, and natural gas should an emergency occur.

The Oregon State Energy Assurance Plan is an introduction to how Oregon prepares for, responds to, and recovers from energy emergencies. The Oregon State Energy Assurance Plan complies with the National Association of State Energy Officials (NASEO) guidelines, the NASEO Energy Assurance Planning Framework, the National Response Framework, the National Infrastructure Protection Plan, and the National Incident Management System. The Oregon Energy Assurance Plan is also consistent with the Oregon Emergency Management Plan and Oregon Revised Statute (ORS) 401 to "coordinate the activities of all public and private organizations providing emergency services within this state." ODOE will review and update the

Oregon State Energy Assurance Plan annually or as needed to reflect changing response trends and strategies and to incorporate

Oregon Resilience Plan

Directed by the Oregon Legislative Assembly, The Oregon Resilience Plan was completed and published in February, 2013 by the Oregon Seismic Safety Policy Advisory Commission (OSSPAC). The plan reviews policy options, summarizes relevant reports and studies by state agencies, and makes recommendations on policy direction to protect lives and keep commerce flowing during and after a Cascadia earthquake and tsunami. The plan includes a specific section addressing the unique risks faced by Oregon's coast.
https://www.oregon.gov/oem/documents/oregon_resilience_plan_final.pdf

Resiliency 2025: Improving Our Readiness for the Cascadia Earthquake and Tsunami

In 2018, an assessment of the accomplishments and progress toward achieving the goals within The Oregon Resilience Plan was completed.
https://www.oregon.gov/gov/policy/orr/pages/index.aspx#

In response to The Oregon Resilience Plan and the five-year assessment, the State of Oregon developed and published Resiliency 2025: Improving Our Readiness for the Cascadia Earthquake and Tsunami. The purpose of Resiliency 2025 is to build upon the success of the 2013 Oregon Resilience Plan and provides six key strategies for moving the state forward, the last of which will be to update the Oregon Resilience Plan in 2021 to reflect current best practices, community input, academic research, and a specific plan for the Oregon Coast.
https://www.oregon.gov/gov/policy/Documents/resiliency-policy-agenda.pdf

Oregon Climate Change Adaptation Framework (2010)

This document provides a framework for state agencies to identify authorities, actions, research, and resources needed to increase Oregon's capacity to address the likely effects of a changing climate.

Given the broad range of expected changes to Oregon's climate in the coming decades, the breadth of state-level responsibilities, authorities, and programs that will likely need to respond to the effects of future climate conditions, and limited time, it has only been possible to begin the development of a climate change adaptation strategy for Oregon. This report constitutes a *framework* for the continued development of strategies and plans to address future climate conditions. This Climate Change Adaptation Framework (CCAF) provides context, identifies risks, lays out short-term priorities, and provides momentum and direction for Oregon to prepare for future climate change. The framework has been developed in parallel with the Oregon Climate Assessment Report (OCAR) by the Oregon Climate Change Research Institute (OCCRI). The OCAR and this framework are intended to complement each other. The OCAR identifies the most likely impacts from climate change, which will help the state prioritize resources to prepare for and adapt to a changing and variable climate. OCCRI assisted in the development of this Framework.

This Framework lays out expected climate-related risks, the basic adaptive capacity to deal with those risks, short-term priority actions, and several steps that will evolve into a long-term process to improve Oregon's capacity to adapt to variable and changing climate conditions.

The 2010 CCAF is currently being updated and evolving into a foundation for a statewide, interagency, climate adaptation program under the auspices of the Governor's Office. This update and the 2020 Oregon NHMP update are being coordinate to the extent feasible given the evolution of the CCAF and the timelines of the two efforts.

Oregon Climate Assessment Report (2010)

In 2007, the Oregon State Legislature charged the Oregon Climate Change Research Institute, via HB 3543, with assessing the state of climate change science including biological, physical, and social science as it relates to Oregon and the likely effects of climate change on the state. This inaugural assessment report is meant to act as a compendium of the relevant research on climate change and its impacts on the state of Oregon. This report, published December 2010, draws on a large body of work on climate change impacts in the western United States from the Climate Impacts Group at the University of Washington and the California Climate Action Team. The report continues to be updated regularly, most recently in 2019, and published on OCCRI's website.

State Emergency Management Plan

This Natural Hazards Mitigation Plan is a document within Volume I, Preparedness and Mitigation, of the State Emergency Management Plan, administered by the Oregon Office of Emergency Management. The other volumes of the Emergency Management Plan are: Volume II, Emergency Operations Plan, and Volume III, Relief and Recovery.

Volume I: "Preparedness and Mitigation" includes the plans and guidance necessary for the state to prepare and mitigate the effects of a disaster. It includes the state disaster hazard assessment, exercise, and training programs, and plans to lessen the physical effects of a disaster to citizens, the environment, and property. Volume I also includes this natural hazards mitigation plan.

Volume II: "Emergency Operations Plan," which is also referred to as the Basic Plan, describes in broad terms the organization used by the state to respond to emergencies and disasters. The EOP is supplemented by emergency Support Function Annexes, Support Annexes, and Incident Annexes. It describes common management functions including areas common to most major emergencies or disasters such as communications, public information, and others.

Volume III: "Relief and Recovery" gives guidance, process, and rules for assisting Oregonians with recovering from the effects of a disaster. It includes procedures to be used by government, business, and citizens.

State Fire Services Mobilization Plan

The State Fire Services Mobilization Plan is an all-hazard based plan used to mobilize fire resources to any incident beyond local fire service capabilities that are necessary to protect life, property, and the environment. It assumes the prior existence of mutual aid agreements that organize district and regional firefighting forces to cope with local emergencies.

The primary purpose of mutual aid is to supplement resources of a fire agency during a time of critical need. Mutual aid is based on reciprocal, non-reimbursed contributions for services rendered and is contingent upon a responding fire chief's approval. Mutual aid is given only when equipment and resources are available and dispatch will not jeopardize local firefighting capabilities.

Under the Emergency Conflagration Act, local firefighting forces will be mobilized when the state fire marshal believes that a fire or emergency is causing, or may cause, undue jeopardy to life or property and the Act is invoked by the governor.

For purposes of this Plan, Oregon has been divided into fire defense districts. The Emergency Conflagration Act fire suppression resources of each fire defense district include the county, city, and rural fire protection departments and districts, as well as any other resources available through mutual aid agreements.

The Mobilization Plan may be used separately from the Conflagration Act to mobilize local structural fire agencies for any emergency situation exceeding local mutual aid resources. However, reimbursement for responding resources is assured only when the governor invokes the Conflagration Act. Federal or state disaster assistance reimbursement may or may not apply to emergency services mobilizations.

The objectives of the Oregon Fire Service Mobilization Plan are:

- To provide organizational structure and operating guidelines for the expeditious mobilization and direction of Oregon fire service forces;
- To promote effective communication among agencies during the preparation for, progress of, and demobilization from a fire suppression operation or other emergency response activity;
- To effectively cooperate and coordinate the efforts of various participating agencies through the use of a common command structure and terminology;
- To ensure prompt, accurate and equitable apportionment of fiscal responsibility for fire suppression or other emergency response activity; and
- To provide an OSFM Incident Management Team for effective support to local agencies and fire defense districts during major operations.

Oregon's Communities at Risk Assessment

A statewide task force was formed in February 2004 as part of the Oregon Department of Forestry's Fire Program Review to develop a statewide assessment of *Communities at Risk*. The assessment was used to develop a statewide fuels strategy, and to help set large-scale priorities across geographic areas. A *Community at* Risk is a "geographic area within and surrounding permanent dwellings with basic infrastructure and services, under a common fire protection jurisdiction, government, or tribal trust or allotment, for which there is significant threat due to wildfire." The assessment identifies communities and assigns each a *low, moderate,* or *high* risk rating for *Risk, Hazard, Protection, Capability, Value,* and *Overall*. The *Communities at Risk* assessment was updated and published in January 2020.

The Water Quality Model Code and Guidebook is a companion to the Model Development Code and User's Guide for Small Cities. These documents were developed by the Department of Land Conservation and Development and the Department of Transportation under the Transportation and Growth Management Program (TGM). This guidebook integrates many of the "smart development" inspired code recommendations of the TGM project with recommended code language to achieve water quality objectives. The goal of this guidebook is to provide local communities, both small cities and counties, with a practical guide to protecting and enhancing water quality through improved land use regulations. The guidebook includes both model zoning code ordinances and comprehensive plan policies that are ready for implementation. It also provides references to other publications and resources which provide background information on the link between development activity and water quality.

While Goal 7 does not point specifically toward the issue of water quality, Goal 7 compliance entails measures that will help improve water quality. This goal notes that comprehensive plans “should consider as a major detriment, the carrying capacity of the air, land, and water resources… (and) should not exceed the carrying capacity of such resources.” In protecting against floods and other natural disasters, local governments may jointly address issues of water quality, such as limiting development within floodways and reducing impervious surfaces that increase runoff and flooding.

DOGAMI Tsunami Evacuation Maps

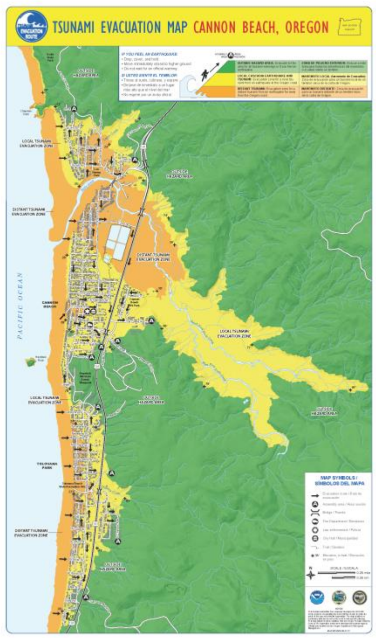
The Department of Geology and Mineral Industries has statutory authority to take a lead role in the mitigation of geologic hazards statewide and assists the BCD in administering ORS 455.446 and .447. Tsunamis can potentially cause the most loss of life of any geologic hazard in the state, so mitigation and assessment of these hazards has a high priority in the agency.

DOGAMI’s Newport Coastal Field Office, in collaboration with OEM and DLCD, has developed tsunami evacuation maps for every coastal population center. These maps and evacuation routes have been compiled into an online Geographic Information System developed for the coast by DLCD. Strong ground shaking at the coast should trigger evacuation of the Cascadia zone, whereas the NOAA warning system will trigger evacuation of the distant tsunami zone.

DOGAMI, in collaboration with the Oregon Health and Science University and NOAA, has developed detailed tsunami inundation maps for several areas on the coast, including Gold Beach, Coos Bay, Siletz Bay (southern Lincoln City), Alsea Bay (Waldport), Yaquina Bay (Newport), Cannon Beach, Seaside-Gearhart, and Warrenton/Astoria.

The Cascadia Subduction Zone earthquake sources developed for maps produced prior to 2008 were also used as standards for similar mapping in Washington State. These sources for the northern Oregon coast and Washington were updated in a 2008 pilot study of Cannon Beach by DOGAMI (**Figure 3-2**).

Figure 3-2. Cannon Beach Tsunami Evacuation Map, 2013



Source: DOGAMI website, http://www.oregongeology.org/tsuclearinghouse/pubs-evacbro.htm

These more detailed maps are used as guides for emergency response planning. DOGAMI plans to develop detailed inundation maps for other areas according to a priority list. Local steering groups established for each map project ensure that maps meet local needs. Local emergency officials review inundation and evacuation maps in the field to ensure that the boundaries are accurate and meet the practical necessities of local government.

DLCD Tsunami Land Use Guide

DLCD released *Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities* (http://www.oregon.gov/lcd/ocmp/docs/publications/tsunamiguide20140108.pdf) on January 15, 2014. Its purpose is to assist vulnerable communities as they incorporate tsunami resilience measures into their local land use programs. The guide can be tailored by communities for their individual risk and location. It includes information on map amendments, sample tsunami related comprehensive plan text and policies, a model tsunami hazard overlay zone, financing and incentive concepts, evacuation route planning assistance, and web links to other helpful information. The guide is designed to be used with the Department of Geology and Mineral Industries' Tsunami Inundation Maps (TIMs).

DLCD/DOGAMI Landslide Guide

In October 2019, DLCD and DOGAMI released *Preparing for Landslide Hazards: A Land Use Guide for Oregon Communities*. The project was funded by a Risk MAP CTP grant. Its goal was to address questions from communities receiving new lidar-based shallow and deep landslide susceptibility maps about how best to use the maps to reduce the newly identified risk from landslide hazards. The *Landslide Guide* provides examples of comprehensive plan language and development code provisions allowing communities to tailor land use policies and regulations to their individual circumstances.

DLCD Water Quality Model Code and Guidebook

In Oregon it is no longer possible to ignore the connection between urban development and degraded water quality. Extensive findings demonstrate that our urban streams do not meet state water quality standards, and do not adequately support native salmon populations. The best way to reverse these trends is to think differently about land use planning at the local level. Local governments are already rethinking the connection between land use and transportation as it relates to air quality. The new challenge is to amend local plans and codes to protect water quality.

Incorporating Green Infrastructure and Low Impact Development into the Ashland Hazard Mitigation Plan

The University of Oregon's Community Service Center (CSC) worked with Ashland, Oregon stakeholders, and state and regional partners to develop and workshop proposed natural hazard mitigation plan (NHMP) action items that utilize green infrastructure (GI) and low impact development (LID) best management practice (BMPs). These proposed action items not only reduce risk from natural hazards, but also provide important water quality, habitat, and community benefits. The report contains two recommended action items for adoption by the Ashland NHMP committee. The CSC incorporated a final project recommendations report (Appendix **9.2.6**) as an appendix to the City of Ashland 2017 Natural Hazard Mitigation Plan.

The project was one of two national pilot projects that emerged from a unique collaboration between the Federal Emergency Management Agency (FEMA) and the Environmental Protection Agency (EPA). The purpose of the project was to:

- Expand the range of tools used to mitigate flood and other natural hazard risks;
- Institutionalize GI/LID into natural hazard mitigation planning;
- Enable FEMA funds to be directed to GI/LID projects; and
- Promote the understanding of the co-benefits of GI/LID including improved water quality, hydrology, climate mitigation, air quality and quality of life.

The Ashland project presented a unique opportunity to analyze the intersecting goals of FEMA and EPA. Specifically, the team assessed the co-benefits of using GI and LID best management practices (BMPs) to achieve both environmental and community risk reduction benefits. The assessment, along with a community profile, provided the framework for the pilot project process. The CSC engaged a technical advisory team of city, regional, and state stakeholders in small meetings and at two large workshops to develop and review proposed NHMP action items. A GIS assessment, ecosystem service evaluation, and ordinance review were performed to develop and strengthen the action items. The project includes a set of ecosystem service overview sheets that explicitly identify co-benefit opportunities in Ashland.

Mount Hood Coordination Plan

The Mount Hood Coordination Plan provides vital Mount Hood volcanic event response information for the areas that will be most affected by a volcanic event. The purpose of the Mount Hood Coordination Plan is to coordinate the actions that various agencies must take to minimize the loss of life and damage to property before, during, and after hazardous geologic events at Mount Hood volcano. The plan strives to ensure timely and accurate dissemination of warnings and public information.

Planning for Natural Hazards: Oregon Technical Resource Guide, 2000

Developed for DLCD by the Community Service Center's Oregon Natural Hazards Workgroup at the University of Oregon, the Technical Resource Guide (TRG) provides contacts, documents, and internet resources to assist planners, emergency managers, and citizens in mitigating earthquake hazards along with several other hazards.

Natural Hazards Mitigation in Oregon: An Evaluation of Natural Hazards Mitigation Planning and Implementation in Oregon

In January 2010, the Oregon Partnership for Disaster Resilience (OPDR) at the University of Oregon's Community Service Center received a grant from the Hazard Mitigation Grant Program (HMGP) to facilitate and document the State's Enhanced Natural Hazards Mitigation Plan update process. As part of the plan update process, OPDR and the Department of Land Conservation and Development (DLCD) were tasked with conducting a survey of natural hazards mitigation planning in Oregon. This report is a summary of the findings of the natural hazards mitigation planning survey.

The survey assessed (a) the extent to which natural hazards mitigation strategies were being implemented at the local level and (b) the availability and applicability of technical resources designed to assist jurisdictions in planning for or mitigating the effects of natural hazards. Additionally, the survey asked for suggestions on how to make hazards planning and mitigation more effective at both the state and local levels.

Where applicable, results are compared to a similar survey that was conducted by DLCD and the University of Oregon's Community Planning Workshop (CPW) in 1998. Survey results will be used to inform content within the State's Enhanced Natural Hazards Mitigation Plan and to develop more effective long-term statewide mitigation efforts.

Seismic Transportation Lifelines

The Oregon Department of Transportation has been engaged for several decades in data collection on highway and bridge conditions (Oregon Seismic Lifelines Identification Project, May 2012; https://www.oregon.gov/ODOT/Planning/Documents/Seismic-Lifelines-Evaluation-Vulnerability-Synthese-Identification.pdf), development of options for mitigation against damage to roadways and bridges that may be caused by seismic events (Oregon Seismic Options Report, May 2013; ftp://ftp.odot.state.or.us/bridge/bridge_website_chittirat/Oregon_Highways_Seismic_Options_Report_3_2013.pdf) and in 2014 completed a prioritization of these options in the Oregon Highways Seismic Plus Report (https://www.oregon.gov/ODOT/Bridge/Docs_Seismic/Seismic-Plus-Report_2014.pdf) published in October 2014. These bodies of work are currently being implemented.

Oregon Transportation Plan

A sound transportation network is what enables Oregonians to reach jobs and recreation access goods and services, and meet daily needs. Due to the extent of the existing transportation infrastructure, and the importance of sustaining that infrastructure, there are numerous ways in which Oregon's transportation system could be adversely affected by any of Oregon's natural hazards. Just as other critical infrastructure can be vulnerable to natural hazards, so too can Oregon's transportation system. The Oregon Transportation Plan addresses the risk and vulnerability to natural hazards by outlining strategies for reducing risk, such as "Evaluate the impacts of geological hazards and natural disasters including earthquakes, floods, landslides and rockfalls, on the efficiency and sustainability of the location and design of new or improved transportation facilities as appropriate."

Oregon Highway Plan

Oregon's state highways are a critical component of the state's transportation network. Oregonians rely on highways to go between the state's widespread cities, towns, parks, forests, and businesses. Oregon's industries, including agriculture, timber, tourism, and technology, all depend on highways.

The Oregon Department of Transportation owns, operates, and maintains 7,483 miles (12,040 kilometers) of roads in every corner of Oregon. The state highway system is as diverse as Oregon itself–ranging from six-lane, limited access freeways with metered ramp entrances in the Portland area to the gravel road from Prineville to Brothers. The challenge facing Oregon is to efficiently and effectively guide this diverse highway system into the next millennium. Oregon will continue to grow. Forecasts predict that the state will have 1.2 million new residents by 2020. With limited funding, intelligent investment strategies must be devised to help Oregon meet its long-term goals. Intelligent investments include planning for, and reduce vulnerability to natural hazards. The Oregon Highway Plan addresses this issue by recommending actions and policy elements that include identifying hazards, and improving the safety of potentially hazardous sites and corridors. Mitigation measures listed within the recommended actions include advance maintenance, structural reinforcement, flood proofing, emergency response planning, and development of emergency alternative routes. These risk reduction efforts can also bolster the State of Oregon's emergency response and post-disaster recovery efforts.

Drought Annex to the State Emergency Operations Plan

Droughts occur within drainage basins (watersheds) that usually involve more than one city or county. Some cities and counties benefit by planning on a regional level. The state Drought Annex provides information to facilitate regional planning efforts, model water curtailment measures for water utilities, and other strategies. It describes the state system for addressing drought emergencies, but it does not carry the force of law. Its purpose is to coordinate local, state, and federal agency response to drought emergencies and to provide water supplies for human consumption and use under conditions of inadequate supply.

Post-Disaster Hazard Mitigation Programs and Capabilities

Hazard Mitigation Grant Program

The state and local communities integrate mitigation into post-disaster recovery operations by taking advantage of Hazard Mitigation Grant Program (HMGP) dollars that become available after presidentially declared disasters.

OEM Disaster Recovery and Post-Disaster Mitigation

State post-disaster mitigation planning and project activities following disasters are an integral component of OEM's mission. OEM's Mitigation and Recovery Services Section provides oversight and administration of financial services and related funding that is passed through to local governments. Additionally, the Mitigation and Recovery Services Section manages disaster recovery activities for state and local governments in the event of a devastating emergency or disaster. Specifically, the Section Director, SHMO, Alternate SHMO, Facilities Engineer (Public Assistance Officer), Seismic Grants Coordinator, and financial support staff work together closely post-disaster mitigation grant programs and project activities. Although OEM has limited staff support available for post-disaster mitigation planning and project implementation activities, the state is able to effectively secure and manage FEMA's HMGP grants.

OEM also staffs county liaisons that are assigned specific counties to support operations both during and after disasters. By working closely with the state's Public Assistance Officer, the state is able to identify early mitigation opportunities immediately following a disaster declaration that can frequently be implemented quickly as a component of Section 406 disaster assistance.

DCBS-BCD Post-Earthquake Inspection Program

DCBS-BCD supports training to inspectors, architects, engineers, contractors and post-earthquake inspectors by providing funding to agencies that provide training. Various classes in seismic design and construction techniques have been sponsored by the division during the last several years Other classes covering subjects such as soils classification, excavation and grading and landslides, which are often related to earthquakes, have also been sponsored.

DCBS-BCD maintains a roster of persons qualified to inspect buildings following an earthquake. As part of this program, the division adopted rules establishing qualifications and training required to be registered as a post-earthquake damage inspector.

DEQ Emergency Response Program

DEQ's Emergency Response Program is designed to carry out legislative direction to work with other agencies and industry to prevent and respond to spills of oil and hazardous materials. Oil and hazardous material spills pose a major potential threat to Oregon's waters, air, land, and wildlife. Large volumes of oil move along the Columbia River and along the coast. Hazardous materials are shipped along the highways and by rail. DEQ works with other agencies and industry to prevent and respond to spills of these materials. The program also coordinates removal of drug lab materials which would otherwise present a risk to the public.

Office of State Fire Marshal — Conflagration Act

OSFM works in a collaborative role in helping to respond to WUI fire issues. As part of its fire prevention program, OSFM provides statewide standardization and technical assistance to local fire agencies and to communities with no structural fire protection. Coordination of structural firefighting resources occurs pursuant to the *Conflagration Act.* When directed by the Governor, the Act allows the State Fire Marshal to mobilize structural firefighting personnel and equipment, when a significant number of structures or lives are threatened by fire, and the local capacity to provide structural protection has been exhausted.

The *Conflagration Act* was established as a civil defense measure to provide a mechanism to mobilize structural fire suppression resources for massive urban fires. It was first used in 1959 to coordinate aid resulting from the explosion of a dynamite filled truck in downtown Roseburg. The Act was not invoked again until 1972, when a wildland fire in Yamhill County exceeded the capacity of local structural agencies to protect isolated structures and agricultural lands. Since then, the Act has been invoked more and more frequently — and nearly always for lightning caused wildfires threatening structures in the WUI. In the decade after 1977, the average number of declared conflagrations was about one per year. In the decade after 1987 (a record year) the average number of declarations per year more than doubled. Since 1998, the average has doubled again.

Under this law, only the Governor may invoke the Act to mobilize fire suppression resources from the across the state, but only if local resources, including what is available under mutual aid agreements, has first been fully committed. The increasing frequency of *Conflagration Act* utilization has caused funding concerns and challenges because no dedicated funds are set aside for this purpose. Especially troubling is the increasing frequency and public expectation to use the Act to protect structures in communities having minimal or nonexistent structural protection. Since 2002, with onset of stronger mitigation efforts, *Community Wildfire Protection Plans* along with ODF's surge in initial attacks on wildfires threatening structures, the use of the Act has dropped significantly.

OPDR Post-Disaster Recovery Planning for Catastrophic Disasters

In collaboration with the Cascadia Region Earthquake Workgroup (CREW), the United States Geological Survey (USGS), the City of Cannon Beach, and the Oregon Office of Emergency Management, OPDR developed a pilot long-term catastrophic post-disaster recovery planning process in the City of Cannon Beach. [2006]

OPDR developed a Post-Disaster Recovery Planning Forum: How-To Guide for communities desiring a framework to identify redevelopment issues they will face after a disaster. [2007]

OPDR assisted Douglas County in obtaining over $250,000 in grant funding from the Federal Emergency Management Agency to develop long-term, catastrophic post-disaster recovery plans for Coos, Curry, Douglas, and Lane Counties. [2009–2011]

3.4.1.3 Funding Sources

Funding Overview

Oregon uses a number of local, state, and federal funding sources to support natural hazard mitigation projects and planning. In general, FEMA Hazard Mitigation Assistance (HMA) grants figure prominently in the state's funding strategy. Several of the grant programs are available "pre-disaster" while others are available only after a federally declared disaster has occurred.

State funding to support hazard mitigation and risk reduction remains limited. However, Oregon has an excellent track record of leveraging limited local resources to successfully complete mitigation planning and projects throughout the state. State funding often consists of "General Fund" money that pays for the labor costs of state officials who are working to support local and statewide hazard mitigation activities. These labor costs are often used as non-federal cost-share for projects that are otherwise federally funded. For example, all of OEM's mitigation staff are funded in part by state dollars that are used to match other federal, homeland security based funding sources. Notably, the majority of state-level staff positions dedicated to hazard mitigation planning and implementation (and a growing number of those at the local level) are funded through federal programs or grants.

Chief among the federal funding sources used to support local mitigation planning in Oregon is FEMA's Pre-Disaster Mitigation Grant Program (PDM). PDM funds generally support one or more local mitigation projects each year as well. The Flood Mitigation Assistance Program (FMA) provides federal funds for flood mitigation projects. FEMA's Risk MAP Program also provides funding for hazard studies, flood mapping products, risk assessment tools, mitigation, and planning and outreach support.

Post-disaster, the Hazard Mitigation Grant Program (HMGP), Public Assistance (PA) Program, and Small Business Association's (SBA) Physical Disaster Loan Program each support varying levels and types of mitigation planning and projects. Oregon is experiencing presidentially declared disasters more often in recent years. Each of these disaster declarations has opened up funds through HMGP that Oregon has used to support local and statewide hazard mitigation planning as well as numerous local mitigation projects.

The Oregon Water Resources Department (OWRD) has heard from the owners of dams – both public and private – that lack of funding sources to address dam deficiencies is a significant barrier. Oregon is not the only state that faces this challenge; many other states have also identified funding for dam safety as a challenge. Funding sources for private dam owners to repair, rehabilitate, or remove dams are limited. There are a few more options for publicly owned dams; however, even for public entities, the costs may still be prohibitive. Overall, funding for the repair, replacement, rehabilitation, or removal of dams is limited and inadequate to address the need. OWRD is continuing to try to identify potential sources of funding for dam rehabilitation.

In addition, cities, counties, and special districts use a variety of funding mechanisms to support local mitigation projects. Capital improvement funds, service fees, general funds, levies, and local grants are used to support mitigation projects across Oregon. For example, Lincoln County voters have approved several bond measures that specifically supported the relocation of schools outside the tsunami inundation zone. In one case, local bond funds leveraged the first FEMA supported (PDM) tsunami school buy-out in the nation. These examples reflect the creative, innovative and proactive methods communities in Oregon are using to support risk reduction.

Federal Funding Sources Pre-Disaster

Unified Hazard Mitigation Assistance (HMA)

According to the 2013 HMA Program Guidance, U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) HMA programs present a "...critical opportunity to reduce the risk to individuals and property from natural hazards while simultaneously reducing reliance on Federal disaster funds." HMA programs include the (a) Pre-Disaster Mitigation Grant Program, (b) Flood Mitigation Assistance Program, and (c) Hazard Mitigation Grant Program. Together, they fund hazard mitigation plans and projects and span pre- and post-disaster environments. HMA programs are intended to reduce community vulnerability to disasters. Specific information about each HMA grant program is presented below.

Pre-Disaster Mitigation Grant Program

The annual Pre-disaster Mitigation Program grants funds for:

- Mitigation planning,
- Non-flood mitigation projects, and
- Flood mitigation projects.

PDM funds support several local mitigation plan updates in Oregon each year. Over the life of the 2015 Oregon NHMP at least seven planning subawards have been issued supporting multi-jurisdictional plans for more than 12 counties, their cities and special districts and one federally recognized tribe. In addition, PDM funding was awarded for seismic retrofitting of a pump station in the City of Reedsport and the seismic retrofitting of a reservoir and pipeline in the City of Gresham. Like FMA, PDM is administered by OEM as the applicant (grantee when funded), who works with eligible sub-applicants and then as sub-grantees to implement their funded projects. The State IHMT has a long-standing relationship with the University of Oregon's Partnership for Disaster Resilience, which has facilitated the creation and update of the majority of Oregon's local plans using PDM grants. OPDR will continue in this role into the future. PDM grants have sometimes been sub-awarded to individual cities and counties to complete their mitigation plans. Sub-awards to cities will continue to be made on a case-by-case basis. Sub-awards also have been made to DLCD for local plan updates. As the state's regulatory land-use planning agency, DLCD not only assists jurisdictions with their hazard mitigation plan maintenance, but also facilitates integration of plan action items into local comprehensive plans.

FEMA's Risk MAP program supplements these hazard mitigation plan efforts by providing funding for hazard studies, flood mapping products, risk assessment tools, mitigation, and planning and outreach support. DLCD was Oregon's Risk MAP coordinating agency; that responsibility has shifted to FEMA by mutual agreement. FEMA also has awarded Risk MAP funds to OPDR and the Department of Geology and Mineral Industries to complete specialized studies.

PDM can also be used to fund flood and non-flood mitigation projects. The state generally uses FMA to fund flood mitigation projects and PDM for non-flood hazard mitigation projects. However, the State may reconsider this position because of a FEMA Mitigation Policy Directive dated June 18, 2014 (FP 204-078-112-1) that allows PDM to be used for projects related to the construction, demolition, or improvement of dams, dikes, levees, floodwalls, seawalls, groins, jetties, breakwaters, and certain erosion control projects.

Building Resilient Infrastructure and Communities (BRIC)

At this time the PDM grant program is being phased out and replaced by a new program, *Building Resilient Infrastructure and Communities* or *BRIC*. FEMA anticipates that this new program will generally be more well-funded than the PDM grant program. However, the funding is focused on projects rather than planning; funding for planning and planning-related activities is limited to $300,000 federal share per state per offering through the state allocation only. Planning will not be permitted to compete with projects for funding through the national competition. Nevertheless, state and local governments will still be required to have FEMA-approved NHMPs at the time of application and at the time of obligation. This set of circumstances will make it very difficult for the state and for local governments to maintain effective NHMPs and therefore eligibility for planning and project funding, especially as revenue has fallen sharply and is expected to continue to decline even faster in the wake of the novel coronavirus pandemic.

Flood Mitigation Assistance Program

The Flood Mitigation Assistance (FMA) Program was authorized by the National Flood Insurance Reform Act of 1994 and amended by the Biggert-Waters Flood Insurance Reform Act of 2012. Among other provisions, the amendments dissolved the Severe Repetitive Loss and Repetitive Flood Claims Programs, incorporating their provisions into other existing programs. The FMA Program provides Federal grant funds to pay for up to 100% of the cost of eligible mitigation activities, such as acquiring and demolishing, or elevating SRL structures. In some cases, moving a structure out of the floodplain to high ground (relocation) is a practicable alternative. In addition, mitigated properties may qualify for reduced flood insurance rates.

The overall goal of the Flood Mitigation Assistance (FMA) Program is to fund cost-effective measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other National Flood Insurance Program (NFIP) insurable structures. As of this writing FMA prioritizes mitigation projects on SRL and RL properties. Examples include:

- Acquisition or relocation of at-risk structures and conversion of the property to open space,
- Elevation of existing structures,
- Relocation of structures out of the floodplain, and
- Dry floodproofing of historic properties.

The State of Oregon prefers, where possible, to acquire and demolish, or relocate SRL structures and RL structures, especially those located in the floodway.

The Oregon Military Department's Office of Emergency Management (OEM_ is the applicant for FMA Program grants; cities and counties are eligible sub-applicants. OEM submits project subapplications for FEMA's consideration in accordance with FEMA and State priorities for the annual grant offering. FEMA's priorities are set forth each year in the grant solicitation. The State then ranks qualifying projects accordingly to ensure a high likelihood of grant award. OEM, with assistance from DLCD, annually reaches out to communities with FEMA-identified SRL and RL properties before FEMA's formal program announcement to make them aware of the program, to train potential sub-applicants on the application and grants management process, and to collect information necessary to develop projects, including owner's willingness to participate voluntarily. Once FEMA releases a formal program announcement, OEM and DLCD follow up with specific technical assistance to help develop sub-applications for projects that are both ready to proceed and most likely to receive grant funding.

The FMA Program also offers funding for:

- Planning — to prepare flood mitigation plans (as part of a community's natural hazards mitigation plan, and
- Management Cost Funding — for the sub-grantee and grantee to help administer the FMA program and activities.

Although FMA can provide federal funds for flood hazard planning, Oregon generally does not pursue planning grants under FMA because funds can only be used to update the flood hazard chapter of a local mitigation plan and we are generally successful at developing and updating all-hazard mitigation plans through the annual Pre-Disaster Mitigation Program (PDM). Five subrecipients were awarded FMA funding during the life of the 2015 Plan. The funds were used for various property acquisition and demolition projects around the state and a multi-hazard flood resiliency project.

NOAA Coastal Zone Management Program

Coastal Zone Management Program works with coastal states and territories to address a wide range of issues including climate change, coastal hazards, coastal development, public access, habitat protection, water quality, ocean governance and planning, and planning for energy facilities. Key elements of the program include:

- protecting natural resources,
- Managing development in high hazard areas,
- Giving development priority to coastal-dependent uses,
- Providing public access for recreation,
- Prioritizing water-dependent uses, and
- Coordinating state and federal actions.

While the legislation includes basic requirements for state partners, it also allows the flexibility needed to design programs that best address local challenges and work within state and local laws and regulations. By using both federal and state funds, the program strengthens the capabilities of each partner to address coastal issues.

National Fire Plan

Under the National Fire Plan (NFP), funding opportunities for local wildland-urban interface (WUI) planning, prevention and mitigation projects first became available in 2000. Since that time, Oregon has aggressively sought funding for a wide variety of projects, including fuels reduction work, education and prevention projects, community planning, and alternative uses of fuels. As of early 2007 the ODF had received approximately $25 million. The majority of these monies have been used to fund fuels reduction projects on individual properties and to establish community fuel breaks in the most wildfire prone portions of the state. NFP funds have also been used to expand fire prevention efforts, to educate local officials about how they may help address the WUI situation, to implement Senate Bill 360, to improve public awareness about the wildfire problem, and to better identify areas especially exposed to wildland fire.

Dam Safety - Potential Federal Funding Sources

The Federal Government has had limited funding for rehabilitating non-federally regulated dams. In recent years, there have been efforts to increase federal involvement; however, funding for new programs in many cases has been authorized but not appropriated. Funding for the following federal programs is dependent upon Congressional appropriations and applicants meeting the criteria for the program.

FEMA National Dam Rehabilitation Program

Section 5006 of the WIIN Act (P.L. 114-322) authorized a program for rehabilitation of high hazard dams, providing a cost-share of 65 percent federal and 35 percent non-federal. The Act authorized $10 million in appropriations for Fiscal Year (FY) 2019. This grant program is being used to fund risk analysis for the 16 Oregon dams of concern, with the grant award to Oregon of $264 K.

USDA Watershed Rehabilitation Program

The USDA Watershed Rehabilitation Program can provide assistance for the planning, design, and implementation of dam rehabilitation projects; however, dams are only eligible if they were originally built with certain USDA funds. The program may cover up to 65 percent of the total rehabilitation cost. Current projects benefitting from the program are listed online at www.nrcs.usda.gov/wps/portal/nrcs/main/or/programs/planning/wr/.

Federal Funding Sources Post-Disaster

Hazard Mitigation Grant Program

FEMA's Hazard Mitigation Grant Program (HMGP) was created in November 1988 under the authority of the Stafford Act, Section 404. The HMGP assists states and local governments to implement long-term hazard mitigation measures following a Presidential major disaster declaration. Initially, the federal cost-share for projects was established at 50%; however, in 1993 that portion was increased to 75% of a project's total eligible costs. Objectives of HMGP include:

- preventing loss of lives and property due to disasters,
- implementing state and local hazard mitigation plans,
- enabling mitigation measures to be implemented during immediate recovery from a disaster, and
- providing funding for previously identified mitigation measures that benefit the disaster area.

Effective November 2004, the state and its applicants must minimally have a FEMA-approved natural hazards mitigation plan (44 CFR Section 201) to qualify for HMGP funding. Eligible applicants for the HMGP are the same as for the Public Assistance Program (Stafford Act, Section 406):

- state and local governments (including special districts),
- certain private nonprofit organizations or institutions, and
- Native American nations and authorized organizations (in Oregon these entities have a direct relationship with FEMA and do not apply through the state).

Homeowners and businesses whose properties can benefit from hazard mitigation measures cannot apply directly for HMGP funding, but rather must be represented by an eligible applicant, such as the city or county in which their project is located.

HMGP activities are managed by the Oregon Office of Emergency Management as grantee. The state develops a program administrative plan, solicits applicant interest and project applications, establishes priorities and selection criteria, reviews, and selects projects. FEMA reviews all projects submitted by the state, conducts the required environmental reviews and benefit-cost analyses, and approves projects for funding.

The amount of HMGP funding available to the state is calculated at 15% of the federal funds spent on FEMA Public Assistance and Human Services Programs (minus administrative expenses) for each disaster. When a state has a FEMA-approved *enhanced* state hazard mitigation plan (Section 201.5), the calculated amount of HMGP funding increases to 20% of the federal funds spent on FEMA Public Assistance and Human Services Programs.

HMGP allows the state to set-aside up to 5% of the total obligation for projects that are not specifically hazard mitigation, such as warning systems. Another set-aside of 7% of the total HMGP obligation can be earmarked to state and local natural hazards mitigation planning.

Although HMGP project funding is intended for use in the disaster-declared counties, it can be, at the state’s request, used in non-declared counties for eligible hazard mitigation projects.

Oregon experienced eight Presidentially declared disasters between 2015 and 2020. Four qualified for HMGP grants and two for HMGP-Post Fire grants. In addition, six distinct fires were awarded Fire Mitigation Assistance Grants (FMAG), a pilot program that was the precursor to the HMGP-Post Fire Grant Program.

The FMAG grants were used for various projects including installing a fire detection warning system in Josephine County and a fire stabilization and rehabilitation project for the Oregon Parks and Recreation Department. The HMGP and HMGP-Post-Fire grants were awarded for mitigation activities across all four HMGP funding categories: planning, projects, five-percent initiative, and advance assistance.

Local governments including special districts and private non-profits have used project funding to mitigate flooding, winter storms, mudslides, earthquakes, and wildfires among other hazards. Projects included undergrounding wires, relocating powerlines, purchasing and installing generators, improving drainage, creating defensible space, property acquisition and fuels reduction.

The five percent initiative was used to fund backup power projects, fire detection early warning systems and education-related projects.

Advance assistance funded application development, feasibility studies, and other analyses.

Public Assistance Program

The FEMA Public Assistance (PA) Program (Stafford Act, Section 406) provides disaster response and recovery assistance to communities following a Presidential Disaster Declaration. PA primarily supports debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain private non-profit (PNP) organizations. However, PA also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process. Federal assistance is provided at 75% or more of the eligible costs with the balance of funds provided by the grantee or sub-grantee.

Oregon experienced eight Presidentially declared disasters between 2015 and 2020, mainly a result of severe storms with damage from ice, straight-line winds, floods, landslides, mudslides, but also a result of the novel coronavirus pandemic. Damage included blown-out culverts; erosion and washout of public roads, bridges, and engineering channels; statewide power outages; sediment loading of engineered basins; and damage to docks. Public Assistance funding was used for these repairs.

Being self-insured, the State typically does not use PA funding for repairs to damaged state assets.

Physical Disaster Loan Program

When Physical Disaster Loans are made to homeowners and businesses by the U.S. Small Business Administration (SBA) following disaster declarations, up to 20% of the loan amount can be used to take specific measures to protect against recurring damage in similar future disasters.

Increased Cost of Compliance (ICC)

The standard Flood Insurance Policy has a provision that will pay the policy holder to comply with a state or local floodplain management law or ordinance regulating repair or reconstruction of a structure that has suffered flood damage and meets other eligibility criteria, such as receiving a substantial damage or repetitive loss determination from a local official. Mitigation activities eligible for payment are: elevation, floodproofing, relocation, or demolition (or any combination of these activities) of the structure. The private-party premium payments are considered non-federal cost share as long as the claim is made within the timeframes allowed by the NFIP. In addition, if the ICC payment is being used as a sub-applicant's non-federal cost share, the NFIP policy holder must assign the claim to the sub-applicant (city or county). Policyholders may receive up to $30,000 under this coverage.

Federal Funding Sources Pre- and Post-Disaster

Community Assistance Program — State Support Services Element (CAP-SSSE)

The CAP-SSSE program is part of the NFIP. It provides grants to states at 75% with a 25% non-federal match to evaluate local governments' NFIP performance and provide technical assistance to help communities successfully implement the various facets of the NFIP. These funds cover the following activities and more:

- Strategic Planning,
- Ordinance Assistance,
- Community Assistance Visits,
- Outreach, Workshops and Other Training,
- General Technical Assistance,
- Mapping Coordination Assistance, and
- Assistance to Communities in Responding to Disasters.

Secure Rural Schools and Community Self-Determination Act

Title III of the Rural Schools and Community Self-Determination Act (frequently referred to simply as "Title III") funds the Firewise and Community Wildfire Protection Plan Programs by passing federal funding through the State of Oregon to its counties. Counties may also be reimbursed for search and rescue and other emergency services, including firefighting, that are performed in national forests.

State Funding Sources

General Fund

State general fund money pays for the labor costs of state officials who are working on mitigation projects for their agencies; these labor costs can be used as non-federal cost-share for projects that are otherwise federally funded. The state also occasionally contributes cash match through one of several funding mechanisms, such as portions of state agency budgets that are funded by a state source of revenue.

Land Conservation and Development Commission Technical Assistance Grant

The Land Conservation and Development Commission oversees a grant program through which each biennium local governments are awarded general funds for purposes that support the statewide land use planning program. One of the grants in the program is the Technical Assistance Grant or TA Grant. It is a competitive grant that had the following five priorities, in order: (1) promote economic development; (2) advance regulatory streamlining; (3) provide infrastructure financing plans for urbanizing areas; and (4) update comprehensive plans and implementing codes in response to changes in state law; and (5) provide coordinated county-wide population projections. Starting with the 2015-17 biennium, the fifth priority was established as a separate grant and "Natural hazards planning" was added as Priority #3 to assist local governments "with creating local natural hazard mitigation plans and for incorporating new hazards data, and the response to the data, into comprehensive plans and zoning regulations."

This was a very exciting change. Over the next few years it became clear, though, that the scope was too narrow. Beyond supporting mitigation planning and integration with comprehensive plans, there was a need to support mitigation-related efforts for which other funding was not available. DLCD was also beginning to incorporate climate change information into NHMPs and the effort to update the 2010 Climate Change Adaptation Framework was getting started so there was a need to include related climate change adaptation activities. In the 2019-21 biennium, the descriptive language for Priority #3 was revised to acknowledge these needs: "Plan for resilience to natural hazards and climate change adaptation. This priority is for grants that provide assistance with: (a) creating local natural hazard mitigation plans; (b) other studies and activities supporting local resilience to natural hazards and climate adaptation; and (c) incorporating new hazards data, and the response to the data, into comprehensive plans and zoning regulations.

Dam Safety - Potential State Funding Sources

There is no state funding program specific to rehabilitation of dams, and most funding programs are only accessible by public entities. The Oregon Water Resources Department has heard from some dam owners that even low-interest loans may be cost-prohibitive for entities that have a small rate-payer base. In general, the dam safety programs for the large federal dams and state regulated dams in many other states have greater funding for staff and other activities as compared with Oregon dam safety staffing. Some other states have state-funded dam rehabilitation and repair programs. Oregon does have brand new authorities that will allow it to make the most of its limited resources. Addressing the backlog of dams that have not been analyzed for risk, and the dams that are in unsatisfactory or poor conditions will take decades at current resource levels.

Oregon's *Special Public Works Fund* could potentially provide for dam rehabilitation and repairs; however, resources are limited and there are many other competing needs. Eligibility is currently limited to specified public entities.

There are other funding programs that may be able to fund dam rehabilitation, although none are explicitly targeted for this purpose. Examples of funding programs that may be able to provide funding in some circumstances include, but are not limited to:

Water Projects Grants and Loans

This funding source was authorized by the Oregon Legislature in 2013 (SB 839); however, it is generally not an ideal source of funding for dam rehabilitation as it is more targeted at projects that provide new water supplies. Projects are ranked based on public benefits, and projects must provide benefits in three categories: economic, environmental, and social/cultural. In addition, the funding for this program has been around $10-15 million per biennium.

Safe Drinking Water Revolving Loan Fund

The purpose of this loan is to fund drinking water system improvements necessary for compliance with the Federal Safe Drinking Water Act. It may be able to fund dam rehabilitation work in limited instances; however, an EPA waiver is required. Eligibility is limited to owners of water systems that provide service to at least 25 year-round residents or systems that have 15 or more connections.

Clean Water Revolving Loan Fund

In very limited instances, this loan may be able to provide some assistance for dam rehabilitation where it benefits water quality. Eligibility currently is limited to specified public entities.

Seismic Rehabilitation Grant Program

The Seismic Rehabilitation Grant Program (SRGP) provides state funds to strengthen public schools and emergency services buildings so they will be less damaged during an earthquake. Administration of the SRGP was transferred from the Oregon Office of Emergency Management (OEM) to Business Oregon's Infrastructure Finance Authority (BusOR-IFA) on January 1, 2014. The SRGP is a competitive grant program that provides state funds on a reimbursable basis for seismic rehabilitation of critical public buildings:

- Hospital buildings with acute inpatient care facilities;
- Fire stations;
- Police stations;
- Sheriffs' offices; and
- Other facilities used by state, county, or district municipal law enforcement agencies.

In addition, eligible school buildings must (a) have a capacity of 250 or more persons; (b) be routinely used for student activities by K-12 public schools, community colleges, education service districts (ESDs), and higher education institutions; and (c) be owned by the State Board of Higher Education, a school district, an education service district, a community college district, or a community college service district.

The SRGP program is subject to the availability of funding, as well as any directive or restriction made with respect to such funds. SRGP grants are awarded on a competitive basis, and the maximum grant award is $1.5 million.

Table 3-9. SRGP Awarded Projects, 2009-2010

School District/Entity	Project	Award Amount	Project Status
Linn Benton Community College	Science Technology Building	$565,016	complete
Three Rivers School District	Applegate School	$826,018	complete
Beaverton School District	Elmonica Elementary School	$200,200	complete
Beaverton School District	Cooper Mountain Elementary School	$162,640	complete
Beaverton School District	McKay Elementary School	$320,035	complete
Beaverton School District	Oak Hills Elementary School	$120,600	complete
Western Oregon University	Todd Hall	$1,190,895	complete
Lake County School District	Lakeview High School	$589,700	complete
Lake County School District	Fremont Elementary School	$398,100	complete
Medford School District	Washington Elementary School	$271,000	complete
Medford School District	Medford Opportunity High School	$200,926	complete
David Douglas School District	Floyd Light Middle School	$1,489,766	complete
Yamhill Carlton School District	Yamhill Carlton Intermediate School	$76,500	complete
North Clackamas School District	Milwaukie Elementary School	$1,088,604	complete
2009-2010 Schools SRGP Sub-Total		***$7,500,000***	
Emergency Services	**Project**	**Amount Awarded**	**Project Status**
Tuality Healthcare	Tuality Hospital, Building A	$1,380,480	complete
City of Dallas Fire Department	Dallas Fire Station	$887,725	complete
City of Albany Fire Department	Station 12	$280,023	complete
City of Gresham Fire and Emergency Services	Stations 71 (Public Safety Building) and 72	$273,866	complete
Netarts Oceanside Fire District	Station 61	$170,000	complete
City of St. Helens Police Department	St. Helens Police Station	$20,000	complete
Klamath County Fire District No. 1	Station 6	$1,311,704	complete
City of Eugene	Danebo Fire Station Number 8	$66,739	complete
Silverton Fire District	Scotts Mills Station	$131,207	complete
Oregon Health and Science University	University Hospital South	$1,478,256	complete
City of Coos Bay	Coos Bay City Hall	$1,500,000	complete
2009-2010 Emergency Services SRGP Sub-Total		***$7,500,000***	

Source: Business Oregon, Infrastructure Finance Authority

Table 3-10. SRGP Awarded Projects, 2010-2011

	Project	Award Amount	Project Status
School District/Entity			
Greater Albany Public Schools	Central Elementary School	$1,500,000	Open
Klamath Falls City Schools	Mills Elementary School Auditorium	$1,495,212	complete
Tigard-Tualatin School District	Twality Middle School	$835,750	complete
2010-2011 Schools SRGP Sub-Total		***$3,830,962***	
Emergency Services			
Langlois RFPD	Langlois Fire Station	$249,894	complete
City of Garibaldi	Garibaldi Fire Station	$270,000	complete
City of Grants Pass	Hillcrest Public Safety Building	$477,024	complete
City of Astoria	Public Safety Building	$1,500,000	complete
Santa Clara Fire District	Station 1	$570,000	complete
City of Hood River	Hood River Fire Department	$291,225	complete
Woodburn RFPD	Station 22	$310,895	complete
2010-2011 Emergency Services SRGP Sub-Total		***$3,669,038***	

Source: Business Oregon, Infrastructure Finance Authority

Table 3-11. SRGP Awarded Projects, 2011-2012

School District/Entity	Project	Amount Awarded	Project Status
Portland Public Schools	Alameda Elementary School	$1,500,000	complete
Lake County School District	Daly Middle School	$1,186,251	complete
Rogue River School District	Rogue River Elementary School	$1,500,000	complete
Lane Community College	Building 11	$708,718	open
Myrtle Point School District	Myrtle Point High School	$1,470,939	complete
Philomath School District	Philomath Middle School	$284,920	complete
Hillsboro School District	North Plains Elementary School	$593,623	complete
Springfield Public Schools	Walterville Elementary School	$255,549	complete
2011-2012 Schools SRGP Sub-Total		***$7,500,000***	

Source: Business Oregon, Infrastructure Finance Authority

The program is dependent on the legislature allocating funding to Article M (education) and Article N (emergency services) bond sales. In general the funding awarded is broken into two bond sales each spring of the biennium. The following information shows the current awards that have been made for the funding awarded. The 2020 bond sale and the 2021 bond sale each have $50 million allocated for schools and $10 million allocated for emergency services. The awards for those funds will be announced in April/May of each year.

The 2013–2015 state budget includes $30 million in voter-approved bonds that fund this program. No new SRGP projects were funded in 2013. After bond sales in 2014 13 school projects were funded for a total of $14,732,100 and 22 emergency services projects for a total of $13,428,166. All of the projects funded in 2014 are complete.

There were no bond sales for these funds in 2015.

In 2016 there were 41 school projects funded for a total of $50,360,396. There were no bond sale for emergency services buildings in 2016 so there were no emergency services projects funded. All projects funded in 2016 are complete.

In 2017 there were 100 school projects funded for a total of $125,000,000 and 47 emergency services projects for a total of $28,600,000. All projects funded in 2017 are complete.

In 2018 there was a total of 12 school projects funded for a total of $25,000,000 and 8 emergency services projects funded for a total of $10,000,000.

In 2019 there was a total of 34 school projects funded for a total of $75,131,015 and 6 emergency services projects funded for a total of $10,115,416.

Community Development Block Grant

Community Development Block Grants (CDBG) are made available to communities in the State of Oregon, usually via the Infrastructure Finance Authority with funding provided by the U.S. Department of Housing and Urban Development (HUD). While these grants originate with a federal agency, the funding is usually considered non-federal for matching grant purposes (i.e., CDBG can usually be used as non-federal match to other federal funding sources).

In 1981, Congress amended the Housing and Community Development Act of 1974 (HCD Act) to give each state the opportunity to administer CDBG funds for “non-entitlement” areas: local jurisdictions that do not receive CDBG funds directly from HUD through the entitlement program and are (a) cities with populations of less than 50,000 or (b) counties with populations of less than 200,000.

The primary statutory objective of the CDBG Program is to develop viable communities by revitalizing neighborhoods, expanding affordable housing and economic opportunities, and improving community facilities and services, principally for persons of low and moderate income. The state must ensure that a specified percentage of its CDBG grant funds are used for activities that benefit low- and moderate-income persons over a 3-year time period.

However, states may also use their funds to meet other urgent community development needs. A need is considered urgent if it poses a serious and immediate threat to the health or welfare of the community, has arisen in the past 18 months, and the project would serve primarily low- to moderate-income residents. For example, funds can be used as the non-federal match for eligible HMGP, PDM, and FMA Program projects.

Community Development Block Grant — Disaster Recovery

In addition to CDBG funds made available to the state on an annual basis, special HUD funding can become available to the state as a result of natural disasters. This HUD assistance supplements assistance from FEMA and other federal agencies. Traditionally, funds provided via HUD disaster recovery initiatives can be used for long-term recovery efforts, property acquisitions, relocations, and other efforts to reduce future damage. The program is intended to give communities flexibility in meeting local needs quickly. Unless restricted by regulation, these funds can also be used as non-federal, local match for eligible HMGP, PDM, and FMA Program projects.

Congressional supplemental appropriations provide HUD disaster funds. For example, in late 1998, funds were provided to address unmet disaster-related needs in communities affected by recent Presidentially declared disasters. Unmet needs were those that were not addressed by federal disaster relief and recovery programs following these declared disasters. OECDD (now Business Oregon-Infrastructure Finance Authority) was directed to administer these supplemental funds in Oregon for the Crook County and Prineville floods of May and June 1998. These particular HUD funds carried a requirement for other non-federal match.

Oregon Watershed Enhancement Board

Previously known as the Governor's Watershed Enhancement Board (GWEB), the Oregon Watershed Enhancement Board (OWEB) was created by the 1987 Oregon Legislature. OWEB is charged with supporting implementation of *The Oregon Plan for Salmon and Watersheds*, which includes the Oregon Coastal Salmon Restoration Initiative (OCSRI) and the Healthy Streams Partnership.

In 1995 the Legislature directed OWEB to provide support to watershed councils. OWEB directs a grant program through the Natural Resources Division of the Oregon Department of Agriculture by which each of the state's 45 soil and water conservation districts may apply for funds for watershed enhancement projects.

While OWEB's primary responsibilities are implementing projects addressing coastal salmon restoration and improving water quality statewide, these projects can sometimes also benefit efforts to reduce flood and landslide hazards. In addition, OWEB conducts watershed workshops for landowners, watershed councils, educators, and others, and conducts a biennial conference highlighting watershed efforts statewide.

Funding for OWEB programs comes from the general fund, state lottery, timber tax revenues, license plate revenues, angling license fees, and other sources. OWEB awards approximately $20 million in funding annually.

Oregon Local Disaster Assistance Loan and Grant Account

Through the Local Disaster Loan and Grant Account, the Oregon Legislature makes loans to local governments, special districts, and school districts to match federal disaster relief funding for federally declared disasters. It also provides loans and grants to the same entities for paying the costs of responding to disasters whether or not they are federally declared. The Oregon Military Department may use a small percentage of the loan amount to cover the cost of administering the loan. Prior to the 2012 legislative session, this account was a source of loans only. The 2012 Oregon Legislature amended the program to make this account a source of grant funds as well. In 2012, the Account was used to provide grant funds assisting Columbia County with the Vernonia School District Acquisition Project and the City of Salem with financing a flood warning system on the Mill Creek Tributary. It has been activated occasionally since then.

Dam Safety – Potential Local Funding Sources

Public entities, such as municipalities or irrigation districts for example, may be able to utilize revenues from rate payers or patrons to help pay for needed dam repairs or rehabilitation. Some may also be able to raise taxes or issue bonds. However, for many entities these sources by themselves are unlikely to be able to pay for the cost of dam rehabilitation or repair.

Local Funding Sources

Table 3-12. Potential Hazard Mitigation Funding Programs

Program Activity	Type of Assistance	Agency & Contact
Basic and Applied Research/Development		
Community Resilience to Coastal Hazards and Climate Change	Physical and social science **research** aimed at better understanding ocean and coastal processes and the socio-economic barriers to hazard and climate change preparation	**Oregon State University** — Oregon Sea Grant https://seagrant.oregonstate.edu/research
Decision, Risk, and Management Science (DRMS) Program	Funding for **research** and related educational activities on risk, perception, communication, and management (primarily technological hazards)	**NSF —** Division of Social and Economic Sciences, Decision, Risk and Management Sciences (DRMS) http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5423
Disaster Resilience for Rural Communities	Basic **research** in engineering and in the social, behavioral, and economic sciences on enhancing disaster resilience in rural communities	**USDA** — National Institute of Food and Agriculture https://nifa.usda.gov/
Disaster Resilient Oregon	**Coalition** of public, private, and professional organizations working collectively with graduate students and University of Oregon faculty toward the mission of creating a disaster resilient and sustainable state	**University of Oregon** — Oregon Partnership for Disaster Resilience https://opdr.uoregon.edu/
Hazard Mitigation and Structural Engineering (HMSE)	Supports fundamental **research** to mitigate impacts of natural and anthropogenic hazards on civil infrastructure and to advance the reliability, resiliency, and sustainability of buildings and other structures	**National Science Foundation (NSF),** Division of Civil, Mechanical and Manufacturing Innovation (CMMI) https://www.nsf.gov/div/index.jsp?div=CMMI
National Earthquake Hazard Reduction Program (NEHRP) in Earth Sciences	**Research** into basic and applied earth and building sciences	**NSF —** Division of Earth Sciences (EAR) https://www.nsf.gov/dir/index.jsp?org=GEO
Natural Hazards Gateway	**Research** into the natural hazards facing the nation. Additionally, provides education and real-time data on natural hazards	**USDOI —** U.S. Geological Survey (USGS) https://www.usgs.gov/mission-areas/natural-hazards/programs
Societal Dimensions of Engineering, Science, and Technology Program	Funding for **research** and related educational activities on topics such as ethics, values, and the assessment, communication, management and perception of risk	**NSF —** Division of Social and Economic Sciences https://www.nsf.gov/div/index.jsp?div=SES
Science, Technology and Society Program	Funding for **research** into the historical, philosophical, and sociological questions that arise in connection with science, engineering, and technology, and their respective interactions with society	**NSF —** Directorate for Social, Behavioral and Economic Sciences, Science and Technology Studies (STS) http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5324
Technical and Planning Related Assistance		

Program Activity	Type of Assistance	Agency & Contact
Coastal Management Training	Program provides **training** on subjects ranging from coastal hazards to climate adaptation. User selects training format (in-person, on-line, etc.)	**NOAA** Coastal Services Center (CSC) https://coast.noaa.gov/digitalcoast/training/
Community Assistance Grants	Grants to communities in Oregon and Washington for **planning** and projects related to wildfire	**Oregon Department of Forestry** (via National Forest Service and the Pacific Northwest Wildfire Coordinating Group) https://www.fs.fed.us/r6/fire/pnwcg/
Disaster Mitigation Planning and Technical Assistance	**Technical and planning assistance** grants for capacity building and mitigation project activities focusing on creating disaster resistant jobs, workplaces and economies	U.S. Department of Commerce (**USDOC**), U.S. Economic Development Administration (USEDA) https://www.eda.gov/funding-opportunities/ https://eda.uoregon.edu/
Emergency Management/ Mitigation Training	**Training** in disaster mitigation, preparedness, planning	Federal Emergency Management Agency (**FEMA**) Emergency Management Institute (EMI) https://training.fema.gov/emi.aspx
Environmental Quality Incentives Program (EQIP)	**Technical**, educational, and limited **financial assistance** to encourage environmental enhancement	**USDA-NRCS** https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/
National Dam Safety Program	**Technical assistance,** training, and grants to help improve State dam safety programs	**FEMA** https://www.fema.gov/emergency-managers/risk-management/dam-safety#
National Earthquake Hazard Reduction Program	**Technical and planning assistance** for activities associated with earthquake hazards mitigation	**FEMA, USDOI-USGS** Earthquake Program Coordinator: https://www.nehrp.gov/
National Flood Insurance Program	**Formula grants to States** to assist communities to comply with NFIP floodplain management requirements (Community Assistance Program)	**FEMA** https://www.fema.gov/flood-insurance
Risk Mapping, Assessment, and Planning (Risk MAP) Program	Risk MAP provides **technical assistance** aimed at delivering quality data that increases public awareness and leads to action that reduces risk to life and property	**FEMA** http://www.fema.gov/risk-mapping-assessment-planning Department of Land Conservation and Development http://www.oregonriskmap.com/
Silver Jackets (Oregon)	Interagency team dedicated to establish and strengthen **intergovernmental partnerships** at the state level as a catalyst in developing comprehensive and sustainable solutions to state flood hazard challenges	**U.S. Army Corps of Engineers**; **Oregon Interagency Hazard Mitigation Team** https://silverjackets.nfrmp.us/State-Teams/Oregon
Volcano Hazards Program	**Technical assistance**: Volcano hazard warnings and operation of four volcano observatories to monitor and assess volcano hazard risk	**USDOI-USGS** Volcanic Hazards https://volcanoes.usgs.gov/index.html
Watershed Protection and Flood Prevention Program	Watershed and Flood Prevention Operations provides **technical and financial assistance** in authorized watershed projects which have public sponsors	**USDA-NRCS** https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/
Hazard ID and Mapping		
Climate Data, Products and Services	Provides **science and information** for a climate-smart nation	**NOAA** https://www.climate.gov/maps-data

Program Activity	Type of Assistance	Agency & Contact
Conservation Gateway	The Gateway provides information on **conservation planning and adaptive management**, conservation topics and geographic implications. Includes the West Wide Wildfire Risk Assessment in addition to many other tools	**The Nature Conservancy** https://www.conservationgateway.org/Pages/default.aspx https://www.thewflc.org/resources/west-wide-wildfire-risk-assessment-final-report
National Flood Insurance Program: Flood Mapping	**Flood insurance rate maps** and flood plain management maps for all NFIP communities	**FEMA** https://msc.fema.gov/portal/home
National Flood Insurance Program: Technical Mapping Advisory Council	**Technical guidance and advice** to coordinate FEMA's map modernization efforts for the National Flood Insurance Program	**FEMA** https://www.fema.gov/flood-maps/guidance-partners/technical-mapping-advisory-council
National Digital Orthophoto Program	Develops **topographic quadrangles** for use in mapping of flood and other hazards	**USDOI-USGS —** National Mapping Division: https://www.usgs.gov/centers/eros/science/usgs-eros-archive-aerial-photography-digital-orthophoto-quadrangle-doqs?qt-science_center_objects=0#qt-science_center_objects
National Earthquake Hazards Program	**Seismic mapping for U.S.**	**USDOI-USGS** https://www.nehrp.gov/ https://www.usgs.gov/natural-hazards/earthquake-hazards https://earthquake.usgs.gov/earthquakes/map/
National Geophysical Data Center (NGDC)	NGDC provides stewardship, products, and services for **geophysical data** from our Sun to Earth and Earth's sea floor and solid earth environment, including Earth observations from space	https://www.ngdc.noaa.gov/ https://www.ngdc.noaa.gov/hazard/hazards.shtml
Oregon Hazard Mapping	Results of **geologic studies** presented in a variety of formats such as maps, books, open-file reports, special papers and brochures, and interactive maps. Includes the Oregon Lidar Consortium, Oregon HazVu and other mapping resources	**Oregon Department of Geology and Mineral Industries** https://www.oregongeology.org/pubs/index.htm https://www.oregongeology.org/lidar/index.htm https://www.oregongeology.org/hazvu/index.htm
Oregon Explorer	**Information** to help citizens, planners, and policymakers make more informed decisions about Oregon's natural resources and communities	**Oregon State University** — Institute for Natural Resources https://oregonexplorer.info/topics/hazards?ptopic=140
Risk Mapping, Assessment, and Planning (Risk MAP) Program	Risk MAP provides **technical assistance** aimed at delivering quality data that increases public awareness and leads to action that reduces risk to life and property	Federal Emergency Management Agency (**FEMA**) https://www.fema.gov/flood-maps/tools-resources/risk-map Department of Land Conservation and Development https://oregonexplorer.info/content/oregon-risk-map
Sea Level Rise and Coastal Flooding Impacts Viewer	**Tool** visualizes potential impacts from sea level rise	**NOAA** Digital Coast https://coast.noaa.gov/slr/
Soil Survey	**Maintains soil surveys** of counties or other areas to assist with farming, conservation, mitigation or related purposes	**USDA-NRCS** https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
Stream gauging and Flood Monitoring Network	Operation of a **network of over 8,500 stream gaging stations** that provide data on the flood characteristics of rivers	**USDOE, USGS** https://www.usgs.gov/mission-areas/water-resources/science/usgs-streamgaging-network?qt-science_center_objects=0#qt-science_center_objects

Program Activity	Type of Assistance	Agency & Contact
U.S. Drought Monitor	Maintains up to date national and regional **drought map resources**	**Partnership** between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. https://droughtmonitor.unl.edu/
Project Support		
The Agricultural Conservation Easement Program (ACEP)	Provides **financial and technical assistance** to help conserve agricultural lands and wetlands and their related benefits	**USDA-NRCS** https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/
Aquatic Ecosystem Restoration	**Direct support** for carrying out aquatic ecosystem restoration projects that will improve the quality of the environment	**DOD-USACE** http://www.aquatics.org/
Association of State Floodplain Managers	Promotes education, policies, and activities **(information)** that mitigate current and future losses, costs, and human suffering caused by flooding, and to protect the natural and beneficial functions of floodplains - all without causing adverse impacts	**ASFPM** https://www.floods.org/
Beneficial Uses of Dredged Materials	**Direct assistance** for projects that protect, restore, and create aquatic and ecologically related habitats, including wetlands, in connection with dredging an authorized Federal navigation project	**DOD-USACE** https://budm.el.erdc.dren.mil/
Clean Water Act Section 319 Grants	**Grants to States** to implement nonpoint source programs, including support for non-structural watershed resource restoration activities	US Environmental Protection Agency (**EPA**) https://www.epa.gov/nps/319-grant-program-states-and-territories
Coastal Zone Management Program	**Grants** for planning and implementation of non-structural coastal flood and hurricane hazard mitigation projects and coastal wetlands restoration	U.S. Department of Commerce (**USDOC**) National Oceanic and Atmospheric Administration (**NOAA**) https://coast.noaa.gov/
Coastal Services Center Grant Opportunities	**Formula and program enhancement grants** for implementing and enhancing Coastal Zone Management programs that have been approved by the Secretary of Commerce	National Oceanic and Atmospheric Administration (**NOAA**) https://coast.noaa.gov/funding/index.html
Coastal Wetlands Conservation Grant Program	Matching **grants to states** for acquisition, restoration, management, or enhancement of coastal wetlands	U.S. Fish and Wildlife Service (**USFW**) https://www.fws.gov/wsfrprograms/subpages/grantprograms/GrantProgramsIndex.htm
Community Assistance and Protection Program	Mitigation/prevention experts offer mitigation/prevention **support, education, and outreach** that addresses reduction of wildland fire threats and losses to communities and natural resources by taking actions before a fire starts	Bureau of Land Management (**BLM**), Fire and Aviation https://www.blm.gov/programs/fire-and-aviation

Program Activity	Type of Assistance	Agency & Contact
Community Development Block Grant (CDBG) State Administered Program	**Grants to States** to develop viable communities (e.g., housing, a suitable living environment, expanded economic opportunities) in non-entitled areas, for low- and moderate income persons. Includes suite of relevant programs including Entitlement Communities, Section 108 Loan Guarantee Program, and Disaster Recovery Assistance	U.S. Department of Housing and Urban Development **(HUD)** https://www.hudexchange.info/programs/cdbg/
Community Development Block Grant (CDBG) Disaster Recovery Assistance	Provides **flexible grants** to help cities, counties, and States recover from Presidentially declared disasters, especially in low-income areas, subject to availability of supplemental appropriations	U.S. Department of Housing and Urban Development (**HUD**) https://www.hudexchange.info/programs/cdbg-dr/
Disaster Assistance for State Units on Aging (SUAs) and Tribal Organizations	Provide **disaster relief funds** to those SUAs and tribal organizations who are currently receiving a grant under Title VI of the Older Americans Act	**Administration for Community Living** https://acl.gov/grants/disaster-assistance-state-units-aging-suas-and-tribal-organizations-national-disasters-1
Economic Administration Grants	EDA provides **support and funds** post disaster (pending congressional approval) to support economic recovery and mitigation in disaster areas	**Economic Development Administration** https://www.eda.gov/disaster-recovery/
Emergency Watershed Protection Support Services	**Funds** for public and private landowners to implement emergency measures in watersheds to relieve imminent hazards to life and property created by a natural disaster	**USDA Natural Resources Conservation Service.** https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/
Farm Service Agency Conservation Programs	Transfers title of certain inventory farm properties owned by FSA to Federal and State agencies for **conservation** purposes (including the restoration of wetlands and floodplain areas to reduce future flood potential)	U.S. Department of Agriculture (**USDA**) –Farm Service Agency (**FSA**) https://www.fsa.usda.gov/programs-and-services/conservation-programs/index
Federal Land to Parks Program	Identifies, assesses, and transfers available Federal real property for **acquisition** for State and local parks and recreation, such as open space	USDOI-National Park Service (**NPS**) https://www.nps.gov/ncrc/programs/flp/index.htm
Firewise Communities Program	To save lives and property from wildfire, NFPA's Firewise Communities program **teaches** people how to adapt to living with wildfire and encourages neighbors to work together and take action now to prevent losses	**Firewise Communities** https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Firewise-USA
Forest Stewardship Program	Helps family forestland owners with hazard reduction **training and funding** to assist with thinning and other actions to reduce wildfire hazard	USDA — U.S. Forest Service (**USFS**) https://www.fs.usda.gov/managing-land/forest-stewardship/program
Hazard Mitigation Assistance	Grant programs designed to provide **funding** to protect life and property from future natural disasters	Federal Emergency Management Agency (FEMA) https://www.fema.gov/grants/mitigation
Highway Bridge Replacement and Rehabilitation	Deficient highway **bridges** on all public roads may be eligible for replacement or rehabilitation	USDOT — Federal Highway Administration (**FHA**) https://www.fhwa.dot.gov/bridge/hbrrp.cfm

Program Activity	Type of Assistance	Agency & Contact
HOME Investment Partnerships Program	Provides **formula grants to States** and localities to fund a wide range of activities including building, buying, and/or rehabilitating affordable housing for rent or homeownership	U.S. Department of Housing and Urban Development (**HUD**) https://www.hud.gov/program_offices/comm_planning/affordablehousing/programs/home/
Indian Housing Assistance (Housing Improvement Program)	**Project grants and technical assistance** to substantially eliminate sub-standard Indian housing	**HUD Office of Public and Indian Housing** https://www.hud.gov/program_offices/public_indian_housing https://www.bia.gov/bia/ois/dhs/housing-improvement-program
Land Trusts	Land trusts assist with the **preservation** of open spaces, scenic vistas, working landscapes and natural areas	**Coalition of Oregon Land Trusts** (for more information) https://oregonlandtrusts.org/
National Flood Insurance Program (NFIP)	Makes available **flood insurance** to residents of communities that adopt and enforce minimum floodplain management requirements	**FEMA** https://www.fema.gov/flood-insurance
National Tsunami Hazard Mitigation Program	Program provides a coordinated, national effort to **assess** tsunami threat, **prepare** community response, issue timely and effective **warnings**, and **mitigate** damage	Coordinated by **NOAA**, **USGS,** and **FEMA**. https://nws.weather.gov/nthmp/
Partners for Fish and Wildlife Program	Provides **financial and technical assistance** to **private landowners** interested in restoring degraded wildlife habitat	U.S. Fish and Wildlife Service (**USFW**) https://www.fws.gov/partners/
Public Assistance Program (Infrastructure)	**Grants to States and communities** to repair damaged infrastructure and public facilities, and help restore government or government-related services. Mitigation funding is available for work related to damaged components of the eligible building or structure	Federal Emergency Management Agency (**FEMA**) https://www.fema.gov/assistance/public
Public Housing Modernization Reserve for Disasters and Emergencies	**Funding** to public housing agencies for modernization needs resulting from natural disasters (including elevation, floodproofing, and retrofit). (24 CFR 968.104)	Housing and Urban Development (**HUD**) https://www.hud.gov/program_offices/public_indian_housing/programs/ph/capfund/emfunding
Rural Fire Assistance and Volunteer Fire Assistance Grants	**Grants** to fund to improve firefighter skills and to purchase needed equipment; priority areas are located in or adjacent to WUI areas	Oregon Department of Forestry (**ODF**) https://www.oregon.gov/odf/aboutodf/Pages/grantsincentives.aspx
Rural Development Assistance — Utilities	USDA Rural Development provides **funding opportunities** in the form of payments, grants, loans, and loan guarantees, for the development and commercialization of vital utility services	**USDA**-Rural Development https://www.rd.usda.gov/programs-services
Rural Development Assistance –Housing	USDA Rural Development provides **funding** for single family homes, apartments for low-income persons or the elderly, housing for farm laborers, childcare centers, fire and police stations, hospitals, libraries, nursing homes, schools, and much more	**USDA**-Rural Development https://www.rd.usda.gov/programs-services

Program Activity	Type of Assistance	Agency & Contact
Title III Funds	The *Secure Rural Schools and Community Self-Determination Act of 2000* (Title III, Section 301(5) of PL 106-393), commonly known as *Title III*) has recently been reauthorized and now includes specific language regarding the Firewise Communities program. Counties seeking funding under Title III must use the **funds** to perform work under the Firewise Communities program	USDA Forest Service (**USFS**) https://www.fs.usda.gov/wps/portal/fsinternet/cs/main/!ut/p/z1/04_Sj9CPykssy0xPLMnMz0vMAfIjo8zijQwgwNHCwN_DI8zPwBcqYKAfDlZggAM4GuhHEaMfj4Io_MaH60dhtSLMB2ECITMKckMjDDIdFQEHHRNG/dz/d5/L2dBISEvZ0FBIS9nQSEh/?position=BROWSEBYSUBJECT&pname=Secure%20Rural%20Schools-%20Home&navtype=BROWSEBYSUBJECT&ss=119985&pnavid=null&navid=091000000000000&ttype=main&cid=FSE_003853
Watershed Protection and Flood Prevention Program	**Funds** for soil conservation; flood prevention; conservation, development, utilization and disposal of water; and conservation and proper utilization of land	USDA-Natural Resources Conservation Service (**NRCS**) https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/
Wetlands Protection — Development Grants	**Grants** support the development and enhancement of State and tribal wetlands protection programs	U.S. Environmental Protection Agency (**EPA**) https://www.epa.gov/wetlands#financial
Financing and Loan Guarantees		
Physical Disaster Loans and Economic Injury Disaster Loans	**Disaster loans** to non-farm, private sector owners of disaster damaged property for uninsured losses. Loans can be increased by up to 20% for mitigation purposes	Small Business Administration (**SBA**) https://disasterloan.sba.gov/ela/Information/Index
Conservation Contracts	**Debt reduction** for delinquent and non-delinquent borrowers in exchange for conservation contracts placed on environmentally sensitive real property that secures FSA loans	USDA-Farm Service Agency (**FSA**) https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2019/conservation-contracts-factsheet-19.pdf https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/index
Clean Water State Revolving Funds	**Loans** at actual or below-market interest rates to help build, repair, relocate, or replace wastewater treatment plants	**EPA Office of Water State Revolving Funds** https://www.epa.gov/cwsrf
Section 108 Loan Guarantee Program	**Loan guarantees** to public entities for community and economic development (including mitigation measures)	**HUD** https://www.hud.gov/hudprograms/section108
Section 504 Loans for Housing	**Repair loans, grants and technical assistance** to very low-income homeowners to repair, improve, or modernize their dwellings or to remove health and safety hazards	U.S. Department of Agriculture (**USDA**) — Rural Housing Service (**RHS**) https://www.rd.usda.gov/sites/default/files/fact-sheet/508_RD_FS_RHS_SFH504HomeRepair.pdf
Single Family Housing Loans and Grants	Provides **loans, loan guarantees, and technical assistance** to low- and moderate-income rural Americans through **several loan, grant, and loan guarantee** programs. The programs also make funding available to individuals to finance vital improvements necessary to make their homes decent, safe, and sanitary	**USDA-Rural Development** https://www.rd.usda.gov/programs-services/single-family-housing-repair-loans-grants

Program Activity	Type of Assistance	Agency & Contact
Community Facilities Direct Loan Program, Guaranteed Loan Program, and Grant Program	**Provide loans, grant and loan guarantee**s for essential community facilities in rural areas. Priority is given to health care, education, and public safety projects. Typical projects are hospitals, health clinics, schools, fire houses, community centers and many other community based initiatives	**USDA — Rural Development** https://www.rd.usda.gov/programs-services/community-facilities-direct-loan-grant-program
Rural Development Assistance –Utilities	Provides funding opportunities in the form of **payments, grants, loans, and loan guarantee**s, for the development and commercialization of vital utility services	USDA-Rural Development https://www.rd.usda.gov/programs-services/programs-services-utilities
Farm Service Agency Disaster Assistance Programs	**Provides assistance for natural disaster losses**, resulting from drought, flood, fire, freeze, tornadoes, pest infestation, and other calamities	**USDA-Farm Service Agency** https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/
Farm Ownership Loans	**Direct loans, guaranteed/insured loans, and technical assistance** to farmers so that they may develop, construct, improve, or repair farm homes, farms, and service buildings, and to make other necessary improvements	**USDA-Farm Service Agency** https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/index

Source: OPDR

3.4.2 Local Capability Assessment

3.4.2.1 Policies, Programs, and Capabilities

Table 3-13. Local Policies, Programs, Capabilities, and Their Effectiveness

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Comprehensive Land Use Planning (ORS 197; OAR 660-003, OAR 660-018) Statewide Land Use Planning Goals (ORS 197.225; OAR 660-015, OAR 660-025) Goal 7, Areas Subject to Natural Hazards (RE: Landslides — ORS195.250-195-275; OAR 629-623	In Oregon, comprehensive planning is directed through 19 statewide land use planning goals. Goal 7 is entitled *Areas Subject to Natural Hazards.* Its stated goal is "To protect people and property from natural hazards." Goal 7 requires local governments to adopt inventories, policies, and implementing measures to reduce risk to people and property from floods, landslides, wildfires, earthquakes and related hazards, tsunamis, and coastal erosion, and allows communities to plan for protection from other natural hazards as well. It encourages local governments to use both regulatory and non-regulatory strategies to achieve risk reduction.	All cities and counties in Oregon must have a comprehensive plan acknowledged by the state as compliant.	Land use plans can be used to guide new development to a community's less hazardous areas. Additionally, they can identify opportunities for redevelopment projects that will improve hazard mitigation by adjusting current land uses, and by requiring up-to-date building codes and standards for rehabilitation of existing structures. Compliance with Goal 7 is dependent on the availability of hazard inventory information. Many jurisdictions have not updated the Goal 7 section of their comprehensive plans in many years. Recently, there has been increased interest in addressing landslide hazards and the much anticipated Cascadia earthquake event and resulting tsunami. Landslide susceptibility maps based on lidar have been produced for a few areas of the state, and funding is being pursued to do additional studies, eventually covering the entire state. As these studies are completed, DLCD will be working with local governments to incorporate the new information into their comprehensive plans, development regulations, and other programs to improve loss reduction. The City of Madras integrated its comprehensive plan and NHMP by update its comprehensive plan Goal 7 section and incorporating within it elements of its NHMP. The City of Medford fully integrated its NHMP into its comprehensive plan. Between 2016 and 2019, the following coastal jurisdictions adopted Tsunami Hazard Overlay Zones into their comprehensive plans: Coos County, Douglas County, Reedsport, Florence, North Bend, Rockaway Beach, Gearhart, Port Orford, and Tillamook County. Most of those jurisdictions have also completed Tsunami Evacuation Facilities Improvement Plans to identify evacuation routes and improvement projects. DLCD and ODF continue to encourage local governments to update Community Wildfire Protection Plans and integrate them with local NHMPs and comprehensive plans.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Zoning (ORS 215, ORS 227)	Zoning consists of a map and text that outlines where and how development is to occur within a jurisdiction. Definitions, general provisions, zoning district regulations, special development standards and administration and enforcement are typical elements of a zoning ordinance.	All cities and counties in Oregon must have a zoning ordinance that implements provisions of the comprehensive plan.	Zoning is used to specify the type and location of development within a jurisdiction. In this respect, zoning is a very effective tool to reduce hazard risk in a community. Hazard overlay zones can prohibit or restrict certain types of development within areas known to contain hazards. Hillside development, flood, tsunami and wildland-urban interface zones are some examples of zoning regulations that can be used to control development on lands subject to natural hazards. Flood zones, which can be found in all of Oregon's NFIP participating jurisdictions, are the most commonly used hazard zone. Other types of local hazard zones found in Oregon include geologic hazard (e.g., Marion County), landslide (e.g., City of Salem), tsunami inundation (e.g., Douglas County), and wildfire safety (e.g., Jackson County) overlay zones. Coos County adopted new and updated provisions to their Natural Hazard Overlay Zone, which addressed mitigation actions identified in their NHMP.
Land Division Ordinances (ORS 92)	Land division ordinances (including partitions and subdivisions) govern the division of land into two or more parcels. Land development ordinances include both standards and procedures that must be followed in order to legally divide land.	All cities and counties in Oregon must have a land division ordinance that implements provisions of the zoning ordinance and comprehensive plan.	Land division ordinances are used to ensure that land is made ready for development in an orderly manner. In addition, the land division process ensures that public improvements are available to serve the area when development occurs. For example, subdivision regulations ensure that emergency service personnel have adequate access and infrastructure in place in order to respond to hazard events or other emergencies. Land division ordinances also provide jurisdictions with the opportunity to require site specific evaluations of potentially hazardous areas to ensure the area is suitable and safe to build on. All jurisdictions in Oregon have adopted land division regulations.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Building Codes (ORS 445; OAR 918)	Oregon building codes establish uniform standards for all residential and commercial buildings in Oregon. The codes prohibit local governments from enacting conflicting regulations. The Oregon Building Codes Division (BCD) provides code development, administration, inspection, plan review, licensing, and permit services to ensure the safe and effective construction of structures in Oregon.	Building codes govern the construction, reconstruction, alteration, and repair of buildings and other structures throughout Oregon.	The mission of the Building Codes Division is to work with Oregonians to ensure safe building construction while promoting a positive business climate. This mission is accomplished through (a) adopting and administering uniform statewide building codes, (b) providing code and rule interpretation, (c) assisting local government building departments and facilitating dispute resolution, (d) enforcing license, code, and permit requirements, (e) certifying inspectors and licensing trade professionals, (f) facilitating economic development efforts around the state, and (g) conducting inspections where local entities do not. At the local level, all jurisdictions have building codes. This allows cities and counties in Oregon to ensure that new construction is built to minimum standards. Certain provisions of the building code apply to the design and construction of buildings located in areas prone to natural hazards. With the adoption of the 2019 Oregon Structural Specialty Code (OSSC) on October 1, 2019, building designs in Oregon must now comply with latest building and construction science available. This includes lateral force resisting elements to address; wind, earthquake, flood and where adopted locally, tsunami. It also captures the best science available for establishing ground snow loads. While HB 3309, 2019 session removed the prohibition of constructing essential facilities and other defined structures in the tsunami inundation zone, the state adopted an Appendix O in the 2019 Oregon Structural Specialty Code addressing tsunami loading which is available for local adoption. In addition, a new section, R327 Wildfire Hazard Mitigation was adopted as part of the Oregon Residential Specialty Code effective January 24, 2019. These amendments provide additional wildfire hazard mitigation provisions that are available for local adoption.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Tsunami Inundation Zone (ORS 455.446 and 455.447; OAR 632-005)	Senate Bill 379 restricted the construction of certain essential facilities, hazardous facilities, major structures, and special occupancy structures in the tsunami inundation zone. House Bill 3309 (2019) removed these restrictions, but provided alternative measures.	All incorporated and unincorporated land in Oregon westward of the statutorily identified building line.	While HB 3309 (2019) removed the prohibition of constructing essential facilities and other defined structures in the tsunami inundation zone, the state adopted an Appendix O in the 2019 Oregon Structural Specialty Code addressing tsunami loading which is available for local adoption. Provisions of the zone are enforced at the local level. Some coastal communities have proactively relocated critical facilities such as schools (e.g., City of Waldport) and fire stations (e.g., city of Cannon Beach) east of the statutory line.
Open Space Preservation (ORS 197; OAR 660-16, 660-023, OAR 660-017, OAR 660-020; OAR 660-034)	In Oregon, comprehensive planning is directed through 19 statewide land use planning goals. Goal 5 is entitled Natural Resources, Scenic and Historic Areas and Open Space. Its stated goal is “To protect natural resources and conserve scenic and historic areas and open spaces.” Goal 5 requires local governments to adopt inventories, policies, and implementing measures to protect natural resources and conserve scenic, historic, and open space resources for present and future generations.	All cities and counties in Oregon must have a comprehensive plan acknowledged by the state as compliant.	Land use plans can be used to ensure communities have adequate supply of and access to resources that promote healthy and safe environments. Resource areas and open spaces offer natural mitigation opportunities by buffering development from or absorbing the impacts of natural hazards. For example, riparian buffers along streams serve multiple functions from flood control and storage to habitat preservation and stormwater filtration. Compliance with Goal 5 requires that communities (a) inventory local occurrences of resources listed in Goal 5 and decide which ones are important; (b) identify potential land uses on or near each resource site and any conflicts that might result; (c) analyze economic, social, environmental, and energy, (ESEE) consequences of such conflicts; (d) decide whether the resource should be fully or partially protected and justify the decision; and (e) adopt measures such as zoning to put that decision into effect. Resources inventoried under Goal 5 number more than a dozen resources, including threatened and endangered species, critical habitats, scenic and historic places and aggregate. Emphasis is placed on wetlands, riparian zones and wildlife habitats. Jurisdictions are required to update Goal 5 under Oregon Administrative Rule 660 during their next “periodic review” of the goal or “when they amend their current land-use plan or ordinances.”

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Local Natural Hazards Mitigation Plans	Many Oregon cities and counties have prepared local NHMPs, in great measure through the state's Pre-Disaster Mitigation (PDM) program. The primary aim of the program is to help communities develop or update local natural hazards mitigation plans. It systematically provides funding and technical assistance targeted annually to local governments in specific planning regions identified by OEM for the purpose of developing or updating existing local natural hazards mitigation plans. The PDM planning program was established by OPDR and OEM in 2004 and is carried out in partnership with DLCD, DOGAMI, FEMA Region X, and local governments with FEMA funding. FEMA is ending the PDM grant program and replacing it with a new program, *Building Resilient Communities and Infrastructure (BRIC)*. The state intends to continue its practice of direct technical assistance to local governments developing or updating NHMPs through the BRIC program.	Oregon cities and counties	Historically, OPDR has offered grant writing support, technical assistance, and human resource capacity to jurisdictions across the state. Recent administrative changes at the University of Oregon, where OPDR is housed, have made it more challenging for OPDR to maintain its current operational structure. As a result, OPDR has decreased the number of communities to which it offers this assistance in recent years. While OPDR has provided the majority of this assistance to local governments, private consulting firms have also assisted local communities. Some jurisdictions undertake development or updates of NHMPs on their own. DLCD has begun to provide direct technical assistance to local governments developing or updating NHMPs. Since 2016, DLCD has assisted 13 counties with multi-jurisdictional plan updates covering about 36 cities and a similar number of special districts, a city and a tribe. DLCD plans to assist five more counties and three cities in the next few years and to continue in this manner after the transition to the new BRIC program. Plans are tracked and inventoried at the county level (36 Oregon counties). **Table 3-14** shows the status of local NHMPs in Oregon. The table is current through December 2019. Since then, several of the expired plans have been updated and approved. Most have included cities and special districts that had not previously participated and therefore have developed plans for the first time. Oregon's efforts to ensure that local NHMPs are updated and to engage more cities and special districts in natural hazards mitigation planning are demonstrably successful.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
LCDC Technical Assistance Grants	The Technical Assistance Grant is a competitive grant with five priority categories. "Plan for resilience to natural hazards and climate change" is Priority #3. Its purpose is: "Plan for resilience to natural hazards and climate change adaptation. This priority is for grants that provide assistance with: (a) creating local natural hazard mitigation plans; (b) other studies and activities supporting local resilience to natural hazards and climate adaptation; and (c) incorporating new hazards data, and the response to the data, into comprehensive plans and zoning regulations."	Local governments (cities, counties, special districts) and tribes	Natural hazards mitigation planning and integration of NHMPs into comprehensive plans and implementing codes was first included as a priority for Technical Assistance Grants for the 2015-17 biennium. A few project proposals were funded and successful. One was unable to be fully completed due to shifts in component timelines. In the 2017-19 biennium, hazards were proposed as elements of a few projects, and none of those projects were funded. In the 2019-21 biennium there are two funded projects that will, among other things, update the Goal 7 element of their comprehensive plans. A number of other proposals include elements that touch on hazards or climate change issues. As DLCD's, OEM's, OPDR's, and DOGAMI's other efforts are raising awareness that natural hazards and climate change adaptation are related to many of the statewide land use planning goals, we anticipate more applications will include these elements, directly or indirectly.
Capital Improvement Plans (ORS Chapter 223; OAR 660-011-0000, OAR 660 — 12-0000, OAR 660-013-0010)	Local jurisdictions maintain capital improvement plans and programs to ensure that infrastructure is developed and maintained at an adequate level to serve the needs of the community.	Oregon Cities, Counties and Special Districts	Many communities are directly or indirectly addressing hazard mitigation through their capital improvement plans. Such plans are generally maintained on a five to six-year basis. Capital Improvement Plans distribute the expense of major capital construction projects over time. Long-range infrastructure improvement projects are implemented annually through the jurisdictions standard budget process. In many cases, bonds are used to finance projects. In recent years, state and federal grants have been used to offset the costs of local infrastructure improvements. The primary opportunity to mitigate projects comes when old infrastructure is improved in ways that eliminate or reduce hazard impacts. For example, bridges can be retrofitted to address seismic impacts; culverts can be upsized to reduce localized flood impacts; electrical lines can be buried to avoid impacts associated with snow, ice, and wind storms. These efforts may not be seen by the community as mitigation, but bringing the infrastructure or facilities up to code reduces the vulnerability of those systems. For example, the Harney Electric Cooperative in south-central Oregon has planned or completed three power line undergrounding projects to offset impacts from winter storm events in that region.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Erosion Control Management Plans (ORS Chapter 568; OAR 340-041, OAR 603-095)	Erosion control aims to reduce soil loss from wind and water through a variety of control techniques including vegetative cover, buffer strips, contour plowing, riparian enhancements, and windbreaks.	Erosion control plans can apply to any lands where erosion is a concern. Wind erosion control is a requirement under the Federal Farm Bill for certain commodities such as wheat and corn, but depending on the rotation, may not be a requirement for other commodities such as potatoes or vegetables.	The Natural Resources Conservation Service (NRCS) and local soil and water conservation districts (SWCD) have long sought to reduce wind erosion of cropland. Specific requirements for erosion control plans apply to certain agricultural lands. Nationally, NRCS has developed quality criteria for wind erosion control practices and use a wind erosion equation model for predicting potential wind erosion under various farming systems. Since 1985, USDA-NRCS has been responsible for agriculture programs that require wind and water erosion control as a requirement under the Federal Farm Bill for certain commodities such as wheat and corn. Participating farmers develop and implement conservation plans for all farmland designated as highly erodible. Plans address practices such as residue management, tillage methods, and irrigation management. The Environmental Quality Incentive Program provides funds and technical assistance to agricultural producers and owners of non-industrial forest lands. Eligibility requires that applicants “be in compliance with the highly erodible land and wetland conservation requirements.” These programs have been so successful that dust storms are no longer a hazard in the Willamette Valley. That is one reason the IHMT chose not to address dust storms as a natural hazard in the 2020 Oregon NHMP update.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Floodplain Management (ORS Chapter 536, ORS Chapter 549)	Floodplain management aims to reduce losses associated with flood events and encourage restoration and protection of natural floodplain function.	Oregon has 258 cities and counties that are subject to flooding, and all participate in the National Flood Insurance Program (NFIP) thereby making flood insurance available to their residents and businesses.	The NFIP has three basic components: flood hazard mapping, floodplain insurance, and floodplain regulations. Does the combination of mapping, regulations, and insurance work to reduce flood damages? Yes! According to FEMA, flood insurance provides an alternative to publicly funded disaster assistance that reduces the ever-escalating costs of repairing damage to buildings and their contents caused by floods. FEMA further reports that flood damages are reduced by nearly $1 billion a year nationally through communities implementing sound floodplain management requirements and property owners purchasing flood insurance. Newer buildings constructed in compliance with floodplain regulations suffer approximately 80% less damage annually than those not built to current standards. Oregonians make use of floodplains for a variety of purposes. Floodplain management involves recognition that our use of floodplains can negatively impact floodplain functions and that communities will be faced with making choices about land uses in the floodplain. Water quality and endangered species benefits also result from proactive floodplain management. Development within floodplains is generally not prohibited. Rather, floodplain management involves regulatory, construction, and public education measures designed to avoid and minimize potential risk to development from flood hazards. Floodplain management also entails implementation of specific actions intended to prevent future damages and threats to human life and public health. Local floodplain programs are built upon statewide requirements for land use planning and implementation of building codes. Local governments implement flood damage prevention ordinances through floodplain development permits, and the state building codes via local building permits. Many local governments in Oregon adopt higher regulatory standards into their flood damage prevention ordinances. For example, some jurisdictions require two or three feet of freeboard (e.g., City of Scio), regulate an area larger than the floodplain shown on FEMA FIRMs, require balanced cut and fill in the floodplain, etc. Table 3-14 shows the status of local jurisdiction participation in the NFIP in Oregon.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Community Rating System (CRS)	The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements.	All NFIP Communities in Oregon are eligible to participate.	The National Flood Insurance Program's (NFIP) Community Rating System (CRS) effectively addresses the flood hazard by discounting flood insurance premium rates. CRS participating communities (a) reduce flood damage to insurable property, (b) strengthen and support the insurance aspects of the NFIP, and (c) encourage a comprehensive approach to floodplain management. Local governments in Oregon are encouraged to join CRS. The CRS provides an important avenue for Oregon's NFIP communities to obtain recognition for their local floodplain programs. With recent NFIP reforms (i.e., Biggert Waters), many communities in Oregon are interested in joining or enhancing their current participation in the CRS program. As of May 2014, 21 cities and seven counties participated in the CRS program. The City of Portland had the highest rating in the state at 5; Eighteen other cities had ratings of 6 or 7 with the remainder falling at 8 or above. As of December 2019, 20 cities and five counties participated, a net loss of three jurisdictions. However, the Cities of Albany and Corvallis strengthened their ratings to 5, joining Portland with the highest ratings in the state. Thirteen are rated at 6 or 7, and the remaining nine at 8 or 9. The distribution approximates a bell curve, with three communities each having the highest and lowest ratings of 5 and 9; ten on the up- and down-slopes with four having a rating of 6 and six a rating of 8; and most communities at the peak with nine communities having a rating of 7. **Table 3-14** shows the status of local jurisdiction participation in the CRS program in Oregon.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
CRS Users Groups	In 2014, DLCD convened two new CRS Users Groups (northern and southern Oregon) to encourage greater participation in the CRS Program. Through CRS Users' Groups, participating CRS communities can obtain assistance in increasing their CRS classifications and new communities can find peer-to-peer support as they join the CRS program. Each CRS Users' Group meets a minimum of three times per year in person or virtually. An online forum allows both groups to share documents, discuss ideas and post projects between meetings.	The CRS Users Groups are open to communities already participating in the CRS program and to any other community interested in floodplain management best practices.	The CRS Users Groups were established in the latter half of 2014, but the effort had to be tabled for a time due to turnover, capacity, and NFIP funding priorities. It has since been supported primarily by FEMA's insurance specialist with DLCD providing advocacy and encouragement to local governments to join the program during every CAV and CAC. The program has not resulted in significant increases in CRS membership or ratings but is highly valued by participants for information sharing, networking, and support.
Mitigation of Repetitive Loss and Severe Repetitive Loss Properties through FEMA's Flood Mitigation Assistance (FMA) Program	FEMA's FMA program provides funds each year for projects to elevate, acquire, or relocate NFIP-insured structures. The State focuses on helping local governments and homeowners or businesses access these funds for mitigation of structures that have been repeatedly damaged by floods.	Local governments may apply for funding on behalf of homeowners or business owners.	While these projects are almost always cost-effective, and FEMA covers 75-100% of the cost, other issues make it very difficult to successfully complete an acquisition or relocation project. First, the FMA grants are reimbursement grants, so the local government or property owner must be willing and able to finance the project and wait for reimbursement from FEMA. The property owner must also be willing to absorb up to 25% of the project cost. Further the local government must have staff with both federal grant management and project management expertise to successfully execute the project.
Leveraging Mitigation of Repetitive Loss and Severe Repetitive Loss Properties through partnerships with Community Action Teams (CATs)	Community Action Teams are non-profit organizations that provide a range of services and resources to address the needs of the economically disadvantaged.	Eligibility varies by program and service.	One of the services that CATs provide is home weatherization. When a Repetitive Loss or Severe Repetitive Loss property will be weatherized, the State and local governments assist the property owner with leveraging this opportunity to also elevate the property above the base flood elevation to avoid future flood damage.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Community Wildfire Protection Planning (Related Statute: ORS 477; OAR 629-042, OAR 629-043; OAR 629-044; OAR 629-048)	A Community Wildfire Protection Plan (CWPP) is developed by a community in an area at-risk from wildfire. The CWPP establishes strategies aimed at reducing wildfire risk.	Primarily counties; plan boundaries may include sub-county regions (e.g., Fire Protection District, unincorporated communities, watersheds, etc.) as well as multi-jurisdictional plans. Certain types of federal funding require the adoption of a CWPP under the provision of the Healthy Forest Restoration Act.	The purpose of a CWPP is to establish a strategic vision (normally five-years in duration) for long-term wildfire risk reduction activities and public outreach. CWPPs outline wildfire mitigation goals, strategies, and activities and highlight other relevant plans and partnerships, including: land use, natural resource, capital improvement, and emergency operation plans. All 36 counties in Oregon have adopted a CWPP; the Oregon Department of Forestry identifies 28 additional sub-county CWPPs. The statutory definition of a CWPP appears in Title I of the Healthy Forest Restoration Act of 2003 (HFRA). The HRFA decrees that communities which have a CWPP in place will be a priority for receiving hazardous fuels reduction funding administrated by the U.S. Forest Service and Bureau of Land Management. Plans developed to address the requirements of the 2003 Healthy Forests Restoration Act (HFRA) must meet three minimum requirements: • Collaboration: Local and state government representatives, in consultation with federal agencies and other interested parties, must collaboratively develop a CWPP. • Prioritized Fuel Reduction: A CWPP must identify and prioritize areas for hazardous fuel reduction treatments and recommend the types and methods of treatment that will protect at-risk communities and essential infrastructure. • Treatment of Structural Ignitability: A CWPP must recommend measures that homeowners and communities can take to reduce the ignitability of structures. The Healthy Forest Restoration Act (HFRA) requires that three decision-makers mutually agree to the final contents of the CWPP. The three are the local government (i.e., counties or cities), the local fire department(s) and the state entity responsible for forest management (ODF). These three are directed to consult with and involve local representatives of the USFS and BLM and other interested parties or persons in the development of the CWPP. ODF, OEM, OPDR, DLCD, and FEMA Region X collaborated on a draft methodology for integrating CWPPs with NHMPs. In particular, ODF, OPDR, and DLCD encourage local governments to pursue opportunities for updating CWPPs prior to or simultaneously with NHMP updates and to use the draft methodology for integrating the two plans. When a community updating its NHMP has an effective CWPP, its information is used in the NHMP.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Local Emergency Planning Committees (OAR 104-040; OAR 837-085, OAR 837-120)	Under the Emergency Planning and Community Right-to-Know Act (EPCRA), Local Emergency Planning Committees (LEPCs) must develop an emergency response plan, review the plan at least annually, and provide information about chemicals in the community to citizens.	All designated emergency planning districts established under 42 U.S.C. 116§11001(c).	In 1986, the federal government established the Emergency Planning and Community Right to Know Act (EPCRA). The intent of this law was to give citizens the right to know what types of hazardous materials were in their communities, so they could be prepared to respond if a release occurred. Part of this law provided states with the opportunity to create Local Emergency Planning Committees (LEPCs). LEPCs work to understand chemical hazards in the community, develop emergency plans in case of an accidental release, and look for ways to prevent chemical accidents. The Office of State Fire Marshal (OSFM) has created a State Emergency Response Commission Advisory Board, to help Oregon communities establish LEPCs and support them in their activities. OSFM currently recognizes 11 LEPCs in the state. In addition, OSFM is actively supporting Community Capability Assessments, a planning approach that “aids emergency responders in evaluating, coordinating and enhancing the cohesiveness of their emergency response plans” in communities with active LEPCs. LEPC members include people from emergency management, police, fire, emergency medical services, transportation, health, broadcast and print media, industry, community groups, colleges, and the public. Notably, many of these organizations are also typically involved in the development of local natural hazards mitigation plans.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Local Fire Prevention Cooperatives (ORS 447)	Fire prevention cooperatives are nonprofit interagency fire service groups engaged in fire prevention and public education within their communities. They promote an exchange of ideas, programs, and resources in both wildland and structural fire prevention and public education. They also promote, coordinate, and actively support interagency participation in fire prevention activities.	Any collective group of agencies interested and engaged in fire prevention and education can form an LFPC.	A wide range of community-based fire prevention efforts exist across Oregon. Many of these efforts are developed and implemented by local fire prevention cooperatives. Since the mid-1970s, fire prevention cooperatives have been highly successful at the creation and delivery of cost-effective fire prevention programs, developed to address specific local situations. Cooperatives multiply the effectiveness of community fire prevention efforts by identifying common needs among neighboring agencies, then developing a single, joint approach to addressing those needs. The cooperative concept recognizes that no single agency usually has the personnel, expertise, community recognition, or financial resources to develop, implement and deliver a comprehensive package of fire awareness, education and public safety needs for a local area. In addition to identifying, designing and implementing unique local programs, fire prevention cooperatives serve as highly effective distributors of materials and programs developed by others. One example is their increasing involvement in Wildfire Awareness Week programs. OSFM lists the following communities on the current LFPC roster (most recently updated 03/16/2018): • Baker County Interagency Fire Prevention Team • Central Oregon Fire Prevention Co-Op • Clackamas County Fire Prevention Cooperative • Douglas County Fire Prevention Cooperative • Grant-Harney Fire Prevention Cooperative • Klamath Fire Prevention Cooperative • Lane County Fire Prevention Cooperative • Mid-Columbia Fire Prevention Cooperative • Northwest Passage Fire Prevention Co-Op • Rogue Valley Fire Prevention Cooperative • Southwestern Oregon Public Safety Association • Wallowa County Fire Prevention Cooperative

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Local Fire Departments and Fire Protection Districts (ORS 476)	City fire departments, rural fire protection districts, county special service districts, and commercial subscription based entities provide both structural and non-structural fire protection.	Authority to establish and maintain LFDs and FPDs is granted in ORS 476.060.	Most structural fire protection in Oregon is provided by city fire departments, rural fire protection districts, county special service districts, and commercial subscription based entities. Specialized agencies also provide structural protection, such as the Portland Airport Fire Department and the National Park Service. A variety of volunteer organizations also exist. In some locations, such as the area immediately west of Portland, structural fire agencies have complete responsibility for the prevention and suppression of all fires, both wildland and structural. Across much of the state, structural fire agencies and the ODF share jurisdiction in Wildland-Urban Interface areas. In some parts of Oregon, property owners may be subject to the protection, assessment and taxation of both a local structural fire agency and ODF. In such areas, the structural fire department and ODF jointly protect properties, with the fire departments focused on protecting improvements and ODF focused on protecting the forest resources. To facilitate this joint responsibility, mutual aid agreements signed by both the structural district or department and ODF typically provide up to 24 hours of non-reimbursed firefighting assistance for fires that threaten each other's protected property and resources. The Oregon State Fire Marshal's office currently lists 301 distinct local fire departments in Oregon.
Rangeland Fire Protection Associations (ORS 477)	Formed under ORS 477.315, RFPAs are nonprofit, locally governed and operated landowner associations organized to provide fire protection on rangeland areas of eastern Oregon which lack both structural and wildland fire protection.	RFPA membership is voluntary.	State law provides for the formation of these RFPAs under the authority of the Oregon Board of Forestry, with assistance from ODF. There are currently 14 RFPAs that collectively protect over 3.2 million acres of private land in Eastern Oregon. The RFPA's also protect approximately a half-million acres of State lands. These lands are primarily Department of State Lands, with lesser amounts of Department of Fish & Wildlife, and Parks & Recreation Department. In 2005, the state established a Rangeland Fire Protection Coordinator position. Since that time, federal grants have supported state program administration. In addition, ODF contributes approximately $30,000 per biennium to support associations and reimburse, primarily to reimburse insurance and administration costs. ORS 477.317(2) limits state funding support for the program to "50 percent of the total of budgeted operating costs and the cash equivalent of in-kind supplies and services of the association in any fiscal year." RFPAs also rely on a variety of additional federal grants for funding support.

Local Policies, Programs, Capabilities and Their Effectiveness			
Policy/Program/Capability	**General Description**	**Applicability**	**Effectiveness**
Dam Safety (ORS 540.443 - 540.491)	Dams may be owned by federal, state, or local governments, or by private parties. Local governments that own dams have primary responsibility for the safety of those dams and for emergency response.	The statute primarily applies to the state, but does address briefly some responsibilities of local governments.	Local governments that own dams have the primary responsibility for safety actions on those dams. They also have the primary role in emergency response and may have a limited dam safety role with some authority determine a dam may be a nuisance. In general, most local governments have the following capabilities: 1. Knowledge of high hazard dam locations 2. Maintenance and understanding of the Emergency Action Plans for the dams within their jurisdiction 3. Understanding and participation in Emergency Action Plan exercises 4. Efficient utilization of limited personnel for emergency response 5. Identification and communication of potential emergency conditions Local government decisions might be improved with the following information: 1. Information on inundation areas and on condition of dams, in some cases for land use decisions 2. Understanding of their authorities to declare some dams a nuisance, which might require an owner to remove a dam at the owners' expense OWRD coordinates with local emergency managers on Emergency Action Plans, and has recently cooperated on exercises of Emergency Action Plans. OWRD engages in extensive coordination with communities that own dams.

3.4.2.2 Local Hazard Mitigation Planning

Table 3-14. Local Jurisdiction NHMP, NFIP, and CRS Participation Status through December 2019

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
1	**Baker**	**Baker County**	NE Oregon - Region 7 HMP	Jun-19	Baker County MJ HMP update underway (DLCD).	**Yes**	—	
2	Baker	Baker City	NE Oregon - Region 7 HMP	Jun-19	Baker County MJ HMP update underway (DLCD).	**Yes**	—	
3	Baker	Greenhorn			Developing plan. Party in Baker County MJ HMP update (DLCD).	**No**	—	Never mapped
4	Baker	Haines			Developing plan. Party in Baker County MJ HMP update (DLCD).	**Yes**	—	
5	Baker	Halfway	NE Oregon - Region 7 HMP	Jun-19	Baker County MJ HMP update underway (DLCD).	**Yes**	—	
6	Baker	Huntington			Developing plan. Party in Baker County MJ HMP update (DLCD).	**Yes**	—	
7	Baker	Richland			Developing plan. Party in Baker County MJ HMP update (DLCD).	**No**	—	Never mapped
8	Baker	Sumpter			Developing plan. Party in Baker County MJ HMP update (DLCD).	**Yes**	—	
9	Baker	Unity			No Plan	**No**	—	Never mapped
10	**Benton**	**Benton County**	Benton County MJ Hazard Mitigation Plan	Aug-21		Yes	**7**	
11	Benton	Adair Village	APA- Benton County MJ Hazard Mitigation Plan	Aug-21		No	—	Has FIRM
12	Benton	Corvallis	Benton County MJ Hazard Mitigation Plan	Aug-21		**Yes**	**5**	
13	Benton	Monroe	APA - Benton County MJ Hazard Mitigation Plan	Aug-21		**Yes**	—	
14	Benton	Philomath	APA - Benton County MJ Hazard Mitigation Plan	Aug-21		**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
15	**Clackamas**	**Clackamas County**	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
16	Clackamas	Barlow			No Plan	**Yes**	**—**	
17	Clackamas	Canby	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
18	Clackamas	Damascus	Clackamas County HMP	Apr-18		**Yes**	**—**	
19	Clackamas	Estacada	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
20	Clackamas	Gladstone	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
21	Clackamas	Happy Valley	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
22	Clackamas	Johnson City	Clackamas County MJHMP	Apr-24		**No**	**—**	All X zone
23	Clackamas	Lake Oswego	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
24	Clackamas	Milwaukie	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
25	Clackamas	Molalla	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
26	Clackamas	Oregon City	Clackamas County MJHMP	Apr-24		**Yes**	**8**	
27	Clackamas	Rivergrove			No Plan	**Yes**	**—**	
28	Clackamas	Sandy	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
29	Clackamas	West Linn	Clackamas County MJHMP	Apr-24		**Yes**	**—**	
30	Clackamas	Wilsonville	Clackamas County MJHMP	Apr-24		**Yes**	**—**	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	County	Jurisdiction	Plan Title	Expiration Date	LNHMP Comments	NFIP?	CRS Level	NFIP Comments
31	**Clatsop**	**Clatsop County**	Clatsop County MJHMP	Jul-20	Clatsop County MJHMP update in progress (DLCD).	**Yes**	—	
32	Clatsop	Astoria	Clatsop County MJHMP	Jul-20	Clatsop County MJHMP update in progress (DLCD).	**Yes**	—	
33	Clatsop	Cannon Beach	Clatsop County MJHMP	Jul-20	Clatsop County MJHMP update in progress (DLCD).	**Yes**	—	
34	Clatsop	Gearhart	Clatsop County MJHMP	Jul-20	Clatsop County MJHMP update in progress (DLCD).	**Yes**	—	
35	Clatsop	Seaside	Clatsop County MJHMP	Jul-20	Clatsop County MJHMP update in progress (DLCD).	**Yes**	—	
36	Clatsop	Warrenton	Clatsop County MJHMP	Jul-20	Clatsop County MJHMP update in progress (DLCD).	**Yes**	—	
37	**Columbia**	**Columbia County**	Columbia County HMP	Oct-19	Columbia County plan update in progress (County).	**Yes**	—	
38	Columbia	Clatskanie	Columbia County HMP	Oct-19	Columbia County plan update in progress (County).	**Yes**	—	
39	Columbia	Columbia City	Columbia County HMP	Oct-19	Columbia County plan update in progress (County).	**Yes**	—	
40	Columbia	Prescott	Columbia County HMP	Oct-19	Columbia County plan update in progress (County).	**Yes**	—	
41	Columbia	Rainier	Columbia County HMP	Oct-19	Columbia County plan update in progress (County).	**Yes**	—	
42	Columbia	Scappoose	Columbia County HMP	Oct-19	Columbia County plan update in progress (County).	**Yes**	**8**	
43	Columbia	St Helens	Columbia County HMP	Oct-19	Columbia County plan update in progress (County).	**Yes**	—	
44	Columbia	Vernonia	Columbia County HMP	Oct-19	Columbia County plan update in progress (County).	**Yes**	—	
45	**Coos**	**Coos County**	Coos County Multi-Jurisdictional HMP	Sept-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
46	Coos	Bandon	Coos County Multi-Jurisdictional HMP	Sept-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
47	Coos	Coos Bay	Coos County Multi-Jurisdictional HMP	Sept-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
48	Coos	Coquille	Coos County 2005 HM Plan	Jul-10	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
49	Coos	Lakeside	Coos County Multi-Jurisdictional HMP	Sept-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
50	Coos	Myrtle Point	Coos County Multi-Jurisdictional NHMP 2010	Aug-15	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
51	Coos	North Bend	Coos County Multi-Jurisdictional HMP	Sept-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
52	Coos	Powers	Coos County Multi-Jurisdictional HMP	Sept-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
53	**Crook**	**Crook County**	Crook County NHMP	May-23		Yes	—	
54	Crook	Prineville	Crook County NHMP	May-23		**Yes**	—	
55	**Curry**	**Curry County**	Curry County Multi-jurisdictional HMP	May-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
56	Curry	Brookings	Curry County Multi-jurisdictional HMP	May-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
57	Curry	Gold Beach	APA - Curry County Multi-jurisdictional HMP	May-21	Current plan Approvable Pending Adoption; Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
58	Curry	Port Orford	Curry County Multi-jurisdictional HMP	May-21	Curry County plan MJHMP update in progress (DLCD).	**Yes**	—	
59	**Deschutes**	**Deschutes County**	Deschutes County NHMP	Jul-20		**Yes**	—	
60	Deschutes	Bend	Deschutes County NHMP	Jul-20		**Yes**	—	
61	Deschutes	La Pine	Deschutes County NHMP	Jul-20		**Yes**	—	
62	Deschutes	Redmond	Deschutes County NHMP	Jul-20		**Yes**	—	
63	Deschutes	Sisters	Deschutes County NHMP	Jul-20		**Yes**	—	
64	**Douglas**	**Douglas County**	Douglas County MJ HMP	Sep-22		**Yes**	—	
65	Douglas	Canyonville	Douglas County MJ HMP	Sep-22		**Yes**	—	
66	Douglas	Drain	Douglas County MJ HMP	Sep-22		**Yes**	—	
67	Douglas	Elkton	Douglas County MJ HMP	Sep-22		**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
68	Douglas	Glendale	Douglas County MJ HMP	Sep-22		**Yes**	—	
69	Douglas	Myrtle Creek	Douglas County MJ HMP	Sep-22		**Yes**	—	
70	Douglas	Oakland	Douglas County MJ HMP	Sep-22		**Yes**	—	
71	Douglas	Reedsport	Douglas County MJ HMP	Sep-22		**Yes**	—	
72	Douglas	Riddle	Douglas County MJ HMP	Sep-22		**Yes**	—	
73	Douglas	Roseburg	Douglas County MJ HMP	Sep-22		**Yes**	**7**	
74	Douglas	Sutherlin	Douglas County MJ HMP	Sep-22		**Yes**	—	
75	Douglas	Winston	Douglas County MJ HMP	Sep-22		**Yes**	—	
76	Douglas	Yoncalla	Douglas County MJ HMP	Sep-22		**Yes**	—	
77	**Gilliam**	**Gilliam County**	Gilliam County MJ HMP	Jan-24		**Yes**	—	
78	Gilliam	Arlington	Gilliam County MJ HMP	Jan-24		**Yes**	—	
79	Gilliam	Condon	Gilliam County MJ HMP	Jan-24		**Yes**	—	
80	Gilliam	Lonerock	Gilliam County MJ HMP	Jan-24		**No**	—	Never mapped
81	**Grant**	**Grant County**	NE Oregon - Region 7 HMP	Jun-19	Grant County MJ HMP underway	**Yes**	—	
82	Grant	Canyon City			No Plan	**Yes**	—	
83	Grant	Dayville			No Plan	**Yes**	—	
84	Grant	Granite			No Plan	**No**	—	Never mapped
85	Grant	John Day	NE Oregon - Region 7 HMP	Jun-19	Grant County MJ HMP underway	**Yes**	—	
86	Grant	Long Creek			No Plan	**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
87	Grant	Monument			No Plan	**Yes**	—	
88	Grant	Mt Vernon			No Plan	**Yes**	—	
89	Grant	Prairie City			No Plan	**Yes**	—	
90	Grant	Seneca			No Plan	**Yes**	—	
91	**Harney**	**Harney County**	Harney County HMP	Jun-18	Harney County MJ HMP in progress	**Yes**	—	
92	Harney	Burns	Harney County HMP	Jun-18	Harney County MJ HMP in progress	**Yes**	—	
93	Harney	Hines	Harney County HMP	Jun-18	Harney County MJ HMP in progress	**Yes**	—	
94	**Hood River**	**Hood River County**	Hood River County MJ Plan	Nov-23		**Yes**	—	
95	Hood River	Cascade Locks	Hood River County MJ Plan	Nov-23		**Yes**	—	
96	Hood River	Hood River (City)	Hood River County MJ Plan	Nov-23		**Yes**	—	
97	Hood River	Port of Cascade Locks	Hood River County MJ Plan	Nov-23				
98	Hood River	Port of Hood River	Hood River County MJ Plan	Nov-23				
99	**Jackson**	**Jackson County**	Jackson County HMP	Jul-23		**Yes**	**7**	
100	Jackson	Ashland	Jackson County HMP	Jul-23		**Yes**	**8**	
101	Jackson	Butte Falls	Jackson County HMP	Jul-23		**Yes**	—	
102	Jackson	Central Point	Central Point HMP	Dec-16	Stand-alone City NHMP	**Yes**	**6**	
103	Jackson	Eagle Point	Jackson County HMP	Jul-23		**Yes**	—	
104	Jackson	Gold Hill			No Plan	**Yes**	—	
105	Jackson	Jacksonville	Jackson County HMP	Jul-23		**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
106	Jackson	Medford	Medford City HMP	Sep-22	Stand-alone City NHMP	**Yes**	**6**	
107	Jackson	Phoenix	Jackson County HMP	Jul-23		**Yes**	**—**	
108	Jackson	Rogue River	Jackson County HMP	Jul-23		**Yes**	**7**	
109	Jackson	Shady Cove	Jackson County HMP	Jul-23		**Yes**	**—**	
110	Jackson	Talent	Jackson County HMP	Jul-23		**Yes**	**8**	
111	**Jefferson**	**Jefferson County**	Jefferson County HMP	Feb-19		**Yes**	**—**	
112	Jefferson	Culver	Jefferson County HMP	Feb-19		**Yes**	**—**	
113	Jefferson	Madras	Jefferson County HMP	Feb-19		**Yes**	**—**	
114	Jefferson	Metolius	Jefferson County HMP	Feb-19		**No**	**—**	Never applied
115	**Josephine**	**Josephine County**	Josephine County HMP	Jul-22		**Yes**	**—**	
116	Josephine	Cave Junction		Oct-09	After partial participation in the 2011-12 process, decided not to finish.	**Yes**	**—**	
117	Josephine	Grants Pass	Josephine County HMP	Jul-22		**Yes**	**8**	
118	**Klamath**	**Klamath County**	Klamath County HMP	Jun-23		**Yes**	**—**	
119	Klamath	Bonanza			No Plan	**Yes**	**—**	
120	Klamath	Chiloquin			No Plan	**Yes**	**—**	
121	Klamath	Klamath Falls	Klamath County HMP	Jun-23		**Yes**	**—**	
122	Klamath	Malin			No Plan	**No**	**—**	No FIRM
123	Klamath	Merrill			No Plan	**No**	**—**	No FIRM
124	Klamath	*Oregon Tech Special District*	Oregon Tech	Mar-18	Stand-alone Special District Plan	N/A	**—**	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
125	**Lake**	**Lake County**	Lake County HMP	Sep-18	Lake County MJ HMP update in progress.	**Yes**	—	
126	Lake	Lakeview	Lake County HMP	Sep-18	Lake County MJ HMP update in progress.	**Yes**	—	
127	Lake	Paisley	Lake County HMP	Sep-18	Lake County MJ HMP update in progress.	**Yes**	—	
128	**Lane**	**Lane County**	Lane County MJ HMP	Oct-23		**Yes**	**7**	
129	Lane	Coburg	Lane County MJ HMP	Oct-23		**Yes**	—	
130	Lane	Cottage Grove	Cottage Grove HMP	Apr-22	Stand-alone City NHMP	**Yes**	**7**	
131	Lane	Creswell	Lane County MJ HMP	Oct-23		**Yes**	—	
132	Lane	Dunes City	Lane County MJ HMP	Oct-23		**Yes**	—	
133	Lane	Eugene	Eugene-Springfield Multi-Jurisdictional NHMP	Feb-20	Stand-alone joint City NHMP - Eugene-Springfield NHMP update under review with FEMA.	**Yes**	**7**	
134	Lane	Florence	Lane County MJ HMP	Oct-23		**Yes**	—	
135	Lane	Junction City			No Plan	**Yes**	—	
136	Lane	Lowell			No Plan	**Yes**	—	
137	Lane	Oakridge	Lane County MJ HMP	Oct-23		**Yes**	—	
138	Lane	Springfield	Eugene-Springfield Multi-Jurisdictional NHMP	Feb-20	Stand-alone joint City NHMP - Eugene-Springfield NHMP update under review with FEMA.	**Yes**	—	
139	Lane	*University of Oregon Special District*	University of Oregon HMP	Sep-22	Stand-alone Special District Plan	**N/A**	—	
140	Lane	Veneta	Lane County MJ HMP	Oct-23		**Yes**	—	
141	Lane	Westfir	Lane County MJ HMP	Oct-23		**Yes**	—	
142	**Lincoln**	**Lincoln County**	Lincoln County MJ HMP	Sep-20	Lincoln County MJ HMP under way.	**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
143	Lincoln	Depoe Bay	Lincoln County MJ HMP	Sep-20		**Yes**	—	
144	Lincoln	Lincoln City	Lincoln County MJ HMP	Sep-20		**Yes**	—	
145	Lincoln	Newport	Lincoln County MJ HMP	Sep-20		**Yes**	—	
146	Lincoln	Siletz	Lincoln County MJ HMP	Sep-20		**Yes**	—	
147	Lincoln	Toledo	Lincoln County MJ HMP	Sep-20		**Yes**	—	
148	Lincoln	Waldport	Lincoln County MJ HMP	Sep-20		**Yes**	—	
149	Lincoln	Yachats	Lincoln County MJ HMP	Sep-20		**Yes**	—	
150	**Linn**	**Linn County**	Linn County MJ HMP	May-23		**Yes**		
151	Linn	Albany	Albany HMP	Oct-21	Stand-alone City NHMP	**Yes**	**5**	
152	Linn	Brownsville	Linn County MJ HMP	May-23		**Yes**	—	
153	Linn	Halsey	Linn County MJ HMP	May-23		**Yes**	—	
154	Linn	Harrisburg	Linn County MJ HMP	May-23		**Yes**	—	
155	Linn	Lebanon	Linn County May-21 MJ HMP	May-23		**Yes**	—	
156	Linn	*Linn-Benton Community College Special District*	Linn-Benton Community College	May-18	Stand-alone Special District Plan	**N/A**	—	
157	Linn	Lyons	Linn County MJ HMP	Dec-15		**Yes**	—	
158	Linn	Millersburg			No Plan	**Yes**	—	
159	Linn	Scio	Linn County MJ HMP	May-23		**Yes**	—	
160	Linn	Sodaville	Linn County MJ HMP	May-23		**No**	—	Has FIRM

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	County	Jurisdiction	Plan Title	Expiration Date	LNHMP Comments	NFIP?	CRS Level	NFIP Comments
161	Linn	Sweet Home	Sweet Home HMP	Oct-20	Stand-alone City - Update in progress (DLCD).	**Yes**	—	
162	Linn	Tangent	Linn County MJ HMP	May-23		**Yes**	—	
163	Linn	Waterloo	Linn County MJ HMP	May-23		**Yes**	—	
164	**Malheur**	**Malheur County**	Malheur County HMP	Jul-24		**Yes**	—	
165	Malheur	Adrian	Malheur County HMP	Sep-13	Did not participate in update	**Yes**	—	
166	Malheur	Jordan Valley	Malheur County HMP	Sep-13	Did not participate in update	**Yes**	—	
167	Malheur	Nyssa	Malheur County HMP	Jul-24		**Yes**	—	
168	Malheur	Ontario	Malheur County HMP	Jul-24		**Yes**	—	
169	Malheur	Vale	Malheur County HMP	Jul-24		**Yes**	—	
170	**Marion**	**Marion County**	Marion County HMP	Aug-22		**Yes**	**6**	
171	Marion	Aumsville	Marion County HMP	Aug-22		**Yes**	—	
172	Marion	Aurora	Marion County HMP	Aug-22		**Yes**	—	
173	Marion	Detroit	Marion County HMP	Aug-22		**Yes**	—	
174	Marion	Donald			No Plan	**No**	—	All X zone
175	Marion	Gates	Marion County HMP	Aug-22		**Yes**	—	
176	Marion	Gervais			No Plan	**Yes**	—	
177	Marion	Hubbard			No Plan	**Yes**	—	
178	Marion	Idanha	Marion County HMP	Aug-22		**Yes**	—	
179	Marion	Jefferson (City)			No Plan	**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
180	Marion	Keizer	Marion County HMP	Aug-22		**Yes**	—	
181	Marion	Mill City	Marion County HMP	Aug-22				
182	Marion	Mt Angel			No Plan	**Yes**	—	
183	Marion	Salem	Salem HMP	Jan-23	Stand-alone City NHMP	**Yes**	**5**	
184	Marion	Scotts Mills			No Plan	**Yes**	—	
185	Marion	Silverton	Marion County HMP	Aug-22		**Yes**	—	
186	Marion	St Paul			No Plan	**Yes**	—	
187	Marion	Stayton	Marion County HMP	Aug-22		**Yes**	—	
188	Marion	Sublimity			No Plan	**Yes**	—	
189	Marion	Turner	Marion County HMP	Aug-22		**Yes**	—	
190	Marion	Woodburn	Marion County HMP	Aug-22		**Yes**	—	
191	**Morrow**	**Morrow County**	Morrow County HMP	Feb-22		**Yes**	—	
192	Morrow	Boardman	Morrow County HMP	Feb-22		**Yes**	—	
193	Morrow	Heppner	Morrow County HMP	Feb-22		**Yes**	**9**	
194	Morrow	Ione	Morrow County HMP	Feb-22		**Yes**	—	
195	Morrow	Irrigon	Morrow County HMP	Feb-22		**Yes**	—	
196	Morrow	Lexington	Morrow County HMP	Feb-22		**Yes**	—	
197	**Multnomah**	**Multnomah County**	Multnomah County HMP	Nov-22		**Yes**	—	
198	Multnomah	Fairview	Multnomah County HMP	Nov-22		**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	County	Jurisdiction	Plan Title	Expiration Date	LNHMP Comments	NFIP?	CRS Level	NFIP Comments
199	Multnomah	Gresham	Multnomah County HMP	Nov-22		**Yes**	—	
200	Multnomah	Maywood Park			No Plan	**N/A**	—	
201	Clackamas, Multnomah, Washington	Metro Region			Not Applicable	**N/A**	—	
202	Clackamas, Multnomah, Washington	Metro Region			Not Applicable	**N/A**	—	
203	Multnomah	Portland	Portland Hazard Mitigation Plan	Nov-21	Stand-alone City NHMP	**Yes**	**6**	
204	Multnomah	Troutdale	Multnomah County HMP	Nov-22		**Yes**	**7**	
205	Multnomah	Wood Village	Multnomah County HMP	Nov-22		**Yes**	—	
206	**Polk**	**Polk County**	Polk County HMP	Feb-23		**Yes**	**8**	
207	Polk	Dallas	Polk County HMP	Feb-23		**Yes**	—	
208	Polk	Falls City	Polk County HMP	Feb-23		**Yes**	—	
209	Polk	Independence	Polk County HMP	Feb-23		**Yes**	—	
210	Polk	Monmouth	Polk County HMP	Feb-23		**Yes**	—	
211	**Sherman**	**Sherman County**	Sherman County HMP	Aug-24		**Yes**	—	
212	Sherman	Grass valley	Sherman County HMP	Aug-24		**Yes**	—	
213	Sherman	Moro	Sherman County HMP	Aug-24		**No**	—	Never mapped
214	Sherman	Rufus	Sherman County HMP	Aug-24		**Yes**	—	
215	Sherman	Wasco (City)	Sherman County HMP	Aug-24		**Yes**	—	
216	**Tillamook**	**Tillamook County**	Tillamook County HMP	Sep-22		**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
217	Tillamook	Bay City	Tillamook County HMP	Sep-22		**Yes**	**—**	
218	Tillamook	Garibaldi	Tillamook County HMP	Sep-22		**Yes**	**—**	
219	Tillamook	Manzanita	Tillamook County HMP	Sep-22		**Yes**	**—**	
220	Tillamook	Nehalem	Tillamook County HMP	Sep-22		**Yes**	**7**	
221	Tillamook	Port of Garibaldi	Tillamook County HMP	Sep-22				
222	Tillamook	Port of Tillamook Bay	Tillamook County HMP	Sep-22				
223	Tillamook	Rockaway Beach	Tillamook County HMP	Sep-22		**Yes**	**—**	
224	Tillamook	Tillamook (City)	Tillamook County HMP	Sep-22		**Yes**	**9**	
225	Tillamook	Wheeler (City)	Tillamook County HMP	Sep-22		**Yes**	**—**	
226	**Umatilla**	**Umatilla County**	Umatilla County HMP	May-19		**Yes**	**—**	
227	Umatilla	Adams	Umatilla County HMP	Jul-14		**Yes**	**—**	
228	Umatilla	Athena	Athena Addendum to Umatilla County Plan	Jul-14		**Yes**	**—**	
229	Umatilla	Echo			No Plan	**Yes**	**—**	
230	Umatilla	Helix			No Plan	**Yes**	**—**	
231	Umatilla	Hermiston			No Plan	**Yes**	**—**	
232	Umatilla	Milton-Freewater			No Plan	**Yes**	**—**	
233	Umatilla	Pendleton			No Plan	**Yes**	**—**	
234	Umatilla	Pilot Rock	Umatilla County HMP	Jul-14		**Yes**	**—**	
235	Umatilla	Stanfield			No Plan	**Yes**	**—**	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
236	Umatilla	Ukiah			No Plan	**Yes**	—	
237	Umatilla	Umatilla (City)	Umatilla County HMP	Jul-14		**Yes**	—	
238	Umatilla	Weston	Weston Addendum to Umatilla County Plan	Jul-14		**Yes**	—	
239	**Union**	**Union County**	NE Oregon - Region 7 HMP	Jun-19		**Yes**	—	
240	Union	Cove			No Plan	**No**	—	Never mapped
241	Union	*Eastern Oregon University Special District*	Eastern Oregon University	May-18	Stand-alone Special District Plan	**N/A**	—	
242	Union	Elgin			No Plan	**Yes**	—	
243	Union	Imbler			No Plan	**No**	—	
244	Union	Island City			No Plan	**Yes**	—	
245	Union	La Grande	NE Oregon - Region 7 HMP	Jun-19		**Yes**	—	
246	Union	North Powder			No Plan	**Yes**	—	
247	Union	Summerville			No Plan	**Yes**	—	
248	Union	Union (City)			No Plan	**Yes**	—	
249	**Wallowa**	**Wallowa County**	NE Oregon - Region 7 HMP	Jun-19	Wallowa County MJHMP update in progress (DLCD).	**Yes**	—	
250	Wallowa	Enterprise	NE Oregon - Region 7 HMP	Jun-19	Wallowa County MJHMP update in progress (DLCD).	**Yes**	—	
251	Wallowa	Joseph			Wallowa County MJHMP update in progress (DLCD).	**Yes**	—	
252	Wallowa	Lostine			Wallowa County MJHMP update in progress (DLCD).	**Yes**	—	
253	Wallowa	Wallowa (City)			Wallowa County MJHMP update in progress (DLCD).	**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
254	**Wasco**	**Wasco County**	Wasco County MJ HMP	May-24		**Yes**	—	
255	Wasco	Antelope			No Plan	**No**	—	Never mapped
256	Wasco	Dufur			No Plan	**Yes**	—	
257	Wasco	Maupin			No Plan	**Yes**	—	
258	Wasco	Mosier			No Plan	**Yes**	—	
259	Wasco	Shaniko			No Plan	**No**	—	Never mapped
260	Wasco	The Dalles	Wasco County MJ HMP	May-24		**Yes**	—	
261	**Washington**	**Washington County**	Washington County MJ HMP	Feb-22		**Yes**	—	
262	Washington	Banks			No Plan	**No**	—	Never mapped
263	Washington	Beaverton	Beaverton HMP	Mar-16	Stand-alone City NHMP	**Yes**	—	
264	Washington	Cornelius	Washington County Hazard Mitigation Plan	Feb-16		**Yes**	—	
265	Washington	Durham			No Plan	**Yes**	—	
266	Washington	Forest Grove	Washington County Hazard Mitigation Plan	Feb-16		**Yes**	—	
267	Washington	Gaston			No Plan	**Yes**	—	
268	Washington	Hillsboro	Washington County MJ HMP	Feb-22		**Yes**	—	
269	Washington	King City			No Plan	**Yes**	—	
270	Washington	North Plains			No Plan	**Yes**	—	
271	Washington	Sherwood			No Plan	**Yes**	—	

Local Jurisdiction NHMP, NFIP, And CRS Status through December 2019								
#	**County**	**Jurisdiction**	**Plan Title**	**Expiration Date**	**LNHMP Comments**	**NFIP?**	**CRS Level**	**NFIP Comments**
272	Washington	Tigard	Washington County MJ HMP	Feb-22		**Yes**	—	
273	Washington	Tualatin			No Plan	**Yes**	—	
274	**Wheeler**	**Wheeler County**	Wheeler County HMP	Dec-24		**Yes**	—	
275	Wheeler	Fossil	Wheeler County HMP	Dec-24		**No**	—	
276	Wheeler	Mitchell	Wheeler County HMP	Dec-24		**Yes**	—	
277	Wheeler	Spray	Wheeler County HMP	Dec-24		**No**	—	
278	**Yamhill**	**Yamhill County**	Yamhill County HMP	Nov-19		**Yes**	—	
279	Yamhill	Amity	Yamhill County HMP	Nov-19		**Yes**	—	
280	Yamhill	Carlton	Yamhill County HMP	Nov-19		**Yes**	—	
281	Yamhill	Dayton	Yamhill County HMP	Nov-19		**Yes**	—	
282	Yamhill	Dundee	Yamhill County HMP	Nov-19		**Yes**	—	
283	Yamhill	Lafayette	Yamhill County HMP	Nov-19		**Yes**	—	
284	Yamhill	McMinnville			No Plan	**Yes**	—	
285	Yamhill	Newberg	Yamhill County HMP	Nov-19		**Yes**	—	
286	Yamhill	Sheridan	Yamhill County HMP	Nov-19		**Yes**	**9**	
287	Yamhill	Willamina	Yamhill County HMP	Nov-19		**Yes**	—	
288	Yamhill	Yamhill (City)	Yamhill County HMP	Nov-19		**Yes**	—	

3.5 Coordinating State and Local Mitigation Planning

(4) A section on the Coordination of Local Mitigation Planning that includes the following:

(i) A description of the State process to support, through funding and technical assistance, the development of local mitigation plans.

(ii) A description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the State Mitigation Plan.

(iii) Criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which should include consideration for communities with the highest risks, repetitive loss properties, and most intense development pressures. Further, that for non-planning grants, a principal criterion for prioritizing grants shall be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.

3.5.1 Funding and Technical Assistance

Direct State technical planning assistance for local NHMPs is provided primarily by OEM, DLCD, and DOGAMI. This assistance is funded by full or partial State support of FTE positions whose duties include providing technical assistance in mitigation planning and project implementation to local communities. Technical assistance is also provided indirectly, in the form of access to products and information.

At OEM, the State Hazard Mitigation Officer (SHMO) assists with mitigation project development, execution, and grant compliance. Others provide oversight of mitigation plans; public information and outreach, particularly for earthquake and tsunami hazards; and tsunami evacuation planning.

DLCD staff provide local governments assistance in complying with Statewide Planning Goal 7 which requires planning for hazard mitigation and integrating local NHMPs with comprehensive plans and implementing programs and regulations. It encourages implementing the NFIP minimum and higher standards. In 2014, DLCD staff began assisting local jurisdictions with updating and developing new NHMPs. DOGAMI continues to develop local risk assessments that underpin local NHMPs through the Risk MAP Program

Together, OEM and DLCD provide technical assistance to property owners and local governments for mitigating repetitive loss (RL) and severe repetitive loss (SRL) properties. DLCD and OEM provide notification and information regarding mitigation grant options and opportunities to local communities. OEM provides assistance, to the degree possible, to communities to help them prepare grant subapplications. The state and communities must have an information sharing agreement with FEMA to obtain RL and SRL data. Since the state is no longer allowed to share RL and SRL data with local communities, DLCD advises communities to request the data from FEMA and execute the data sharing agreement. Once the local communities have obtained the data, DLCD will work with them to identify mitigation options and prioritize mitigation projects for RL and SRL properties.

In addition to the Risk MAP Program's products, specific hazard information, risk, and vulnerability assessment products are provided by DOGAMI on a funding-contingent basis. When State funding is involved, it may come through DOGAMI itself or from other State agencies. One example is DOGAMI's initial study of statewide channel migration zone susceptibility which was fully supported with State funds. This is an important step forward in understanding the state's flood risk, and is expected to pave the way for further state and federal funding to support detailed channel migration zone delineations. Ultimately, these products will help save lives and reduce property damage from flooding. Another example is DOGAMI's recently launched flood hazard webpage, http://www.oregongeology.org/flood/default.htm.

Numerous other agencies — federal (e.g., FEMA, U.S. Geological Survey, U.S. Army Corps, etc.), State (e.g., ODF, ODOT, OHA, etc.) and local (counties, cities, councils of governments, special districts, etc.) — also contribute valuable technical information and support to local mitigation planning efforts.

A critical source of technical hazard mitigation planning assistance in Oregon, the Oregon Partnership for Disaster Resilience at the University of Oregon assists local jurisdictions with grant writing, local plan development, plan update, process facilitation, stakeholder engagement, public outreach, and hazard research services and serves as a liaison between local communities and state, federal and NGO partners during the mitigation planning process. OPDR strives to ensure that local communities: (a) receive the tools and resources to successfully facilitate and document plan development or plan update processes (b) establish regional partnerships to discuss collaborative projects and implementation strategies, and (c) engage with a variety of state and local agencies and organizations that can assist with local risk reduction strategies.

In June 2013, the agencies most actively involved in local mitigation planning and technical assistance (OEM, DLCD, DOGAMI, and OPDR) began meeting between the regularly scheduled State IHMT meetings to foster closer coordination and collaboration on mitigation activities, leverage existing resources, and develop additional resources to support state and local mitigation planning and projects. Topics discussed at these meetings included local mitigation planning project updates and priorities, funding coordination, and agency-level alignment of natural hazard legislation and policy recommendations. The discussions have been successful in improving coordination of (a) funding and technical assistance proposals for supporting local natural hazards mitigation planning and (b) agency legislative and budget proposals, resulting in enhanced funding and technical assistance for local jurisdictions. Over time the frequency of these meetings has decreased, but the relationships and collaboration built through them have lasted. These agencies still meet as necessary and work closely together to achieve the same goals.

Funding for the State's Pre-Disaster Mitigation Planning Program comes primarily from FEMA's PDM and HMGP grants, supplemented by state and local general funds, University of Oregon in-kind match, and other in-kind matching sources (e.g., local stakeholder match). In coastal counties, funding for DLCD's hazards mitigation activities other than NHMP development and updates, and some of DOGAMI's coastal research projects supported through NOAA's Coastal Zone Management Program.

Technical assistance provided by DLCD's Coastal Hazards Program during the life of the 2015 Oregon NHMP resulted in these accomplishments:

- One county and six cities adopted changes to their land use and zoning ordinances to address tsunami hazards and several other jurisdictions are in the process of adoption. DLCD provided technical support through mapping, interpretation of map and modeling products, development of comprehensive plan and development code provisions, and assistance with outreach. DLCD's publication, *Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities,* also known as the *Tsunami Land Use Guide*, was a primary resource for this work.

- Coos County adopted updated land use regulations and maps to address various natural hazards throughout the county, including for tsunami, erosion, earthquake-induced liquefaction, landslide, and wildfire. The County is using the latest natural hazards information and new regulations in their planning to help inform development decisions and make their community more resilient.
- These same coastal communities used DOGAMI's *Tsunami Inundation Maps* as their overlay boundaries for implementing regulations. These map products, which were finalized in 2013, are critical data products for communities looking to understand their tsunami risk. They have now become regulatory maps in these seven communities Using the guidance that OCMP provided through the *Tsunami Land Use Guide* and technical assistance, communities are now able to use the best available science in their land use planning for tsunami hazards.

3.5.1.1 Technical Assistance Grants

The Land Conservation and Development Commission oversees a grant program through which each biennium local governments are awarded general funds for purposes that support the statewide land use planning program. One of the grants in the program is the Technical Assistance Grant or TA Grant. It is a competitive grant that had the following five priorities, in order: (1) promote economic development; (2) advance regulatory streamlining; (3) provide infrastructure financing plans for urbanizing areas; and (4) update comprehensive plans and implementing codes in response to changes in state law; and (5) provide coordinated county-wide population projections.

Starting with the 2015-17 biennium, the fifth priority was established as a separate grant and "Natural hazards planning" was added as Priority #3 to assist local governments "with creating local natural hazard mitigation plans and for incorporating new hazards data, and the response to the data, into comprehensive plans and zoning regulations."

This was a very exciting change. Over the next few years it became clear, though, that the scope was too narrow. Beyond supporting mitigation planning and integration with comprehensive plans, there was a need to support mitigation-related efforts for which other funding was not available. DLCD was also beginning to incorporate climate change information into NHMPs and the effort to update the 2010 Climate Change Adaptation Framework was getting started so there was a need to include related climate change adaptation activities.

In the 2019-21 biennium, the descriptive language for Priority #3 was revised to acknowledge these needs: "Plan for resilience to natural hazards and climate change adaptation. This priority is for grants that provide assistance with: (a) creating local natural hazard mitigation plans; (b) other studies and activities supporting local resilience to natural hazards and climate adaptation; and (c) incorporating new hazards data, and the response to the data, into comprehensive plans and zoning regulations.

The amount of funding allocated to this program has continued to be significantly reduced in recent years. DLCD has repeatedly requested at least increasing if not restoring previous funding levels. It appears this funding will be affected by the budget cuts being contemplated by the legislature in Summer 2020 as a result of the deep revenue losses resulting from the novel coronavirus pandemic.

3.5.1.2 New State Agency Positions

DLCD and OEM have continued to request new funding to support hazard mitigation-related staff positions in their respective agencies. New positions would increase state's capacity to develop data useful for local hazard mitigation planning; provide access for local jurisdictions to that data; provide technical assistance to local jurisdictions for mitigation planning, projects, and integrating local NHMPs with comprehensive plans, implementing programs and regulations.

DLCD added a new natural hazards planner in 2016 and two in 2018. In the February 2020 short legislative session, OEM received funding approval for six positions that would be at least partially assigned to mitigation activities. We do not know whether these positions will be affected by the funding shortfall caused by the novel coronavirus pandemic.

For additional information on funding sources used to support local mitigation planning, please refer to the **Funding Sources** section.

3.5.1.3 Training

Oregon delivers a robust calendar of training classes and events each year that support mitigation planning, project development and implementation, and risk reduction.

Oregon also sponsors the *Oregon Prepared* Conference in the spring of each year which brings together emergency managers and others for a few days of discussion, coordination, and networking around disaster cycle topics.

OEM and DLCD also collaborated on an educational presentation to the Special Districts Association of Oregon in February 2018. The purpose of the presentation was to advise special district representatives about the requirement for having an NHMP to access HMA funding; the return on investment in mitigation; the process for developing NHMPs; and technical assistance available from the state. The presentation was well attended and appreciated.

Table 3-15 documents the numerous trainings the State has delivered over the life of the 2015 Oregon NHMP.

Table 3-15 State-Delivered Training: 2015-2019

STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
1	2015	Statewide	Great Oregon Shakeout	554,814	OEM	
2	2015	Professional Land Surveyors of Oregon annual meeting	NFIP	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
3	2015	Willamette Valley Chapter of Land Surveyors of Oregon	NFIP Elevation Certificate workshop	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
4	2015	North Albany public open house	NFIP flood mapping	Unknown	DLCD	Audience: Public, planners
5	2015	Oregon planners network meeting	NFIP permitting class	Unknown	DLCD	Audience: Planners, floodplain managers. Credit for certified floodplain managers.
6	2015	ReMax Portland	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
7	2015	Living Room Realty Portland	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
8	2015	First American Title Sisters	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
9	2015	Housing Works Redmond	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
10	2015	First American Title Sunriver	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
11	2015	First American Title Bend	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
12	2015	First American Title Eugene	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
13	2015	League of Cities Brownsville	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
14	2015	ReMax Springfield	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
15	2015	First American Tigard	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
16	2015	ReMax Portland	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
17	2015	First American Salem	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
18	February 2, 2015	Monmouth, OR	WOU Emeritus Society	30	Althea Rizzo, OEM	
19	February 27, 2015	Bend, OR	Central Cascades Volcano Coordination	30	Althea Rizzo, OEM	
20	March 31, 2015	Bend, OR	Cascadia @OEM Conference	300	Althea Rizzo, OEM	
21	April 9, 2015	Lake Oswego, OR	Public Workshop	100	Althea Rizzo, OEM	
22	April 9, 2015	lake Oswego, OR	Public workshop	100	Althea Rizzo, OEM	
23	April 14, 2015	Warrenton, OR	Wayfinding charrette	20	Althea Rizzo, OEM	
24	April 29, 2015	Salem	Mitigation Planning Workshop (G0318)	31	Joseph Murray, OEM	2 days, 16 hours
25	May 13, 2015	Portland	Insurance and Risk Management	100	Kevin Jeffries, DCBS-DFR	Host: City of Portland/Public Works Department. Jim Thompson presented to a group about how insurance is a form of risk management. Also discussed consumer advocacy and OID
26	May 13, 2015	Hermiston	Small Business Insurance	15	Kevin Jeffries, DCBS-DFR	Host: Hermiston Chamber. Spoke to the Latino Business Network and handed out partnership packets and the DCBS Small Business Guide to Insurance and worksite safety
27	May 14, 2015	La Grand	Small Business Insurance	5	Kevin Jeffries, DCBS-DFR	Host: Union County Chamber. Kevin spoke to a group of agents and small business owners. He handed out partnership packets and the DCBS Small Business Guide to Insurance and worksite safety
28	May 18, 2015	Portland, OR	Building Code conference	20	Althea Rizzo, OEM	
29	May 20, 2015	Mt. Angel	health care reform	12	Kevin Jeffries, DCBS-DFR	Host: Habitat for Humanity. Kevin spoke with Cover Oregon Rep about health care reform in Oregon and health plan rate review
30	May 21, 2015	Salem, OR	SAIF - State Agency Representative	40	Parmelee, OEM	
31	June 15, 2015	Hood River, OR	Impacts of CSZ on Central and Eastern Oregon	12	Althea Rizzo, OEM	
32	June 16, 2015	the Dalles, OR	Impacts of CSZ on Central and Eastern Oregon	12	Althea Rizzo, OEM	
33	June 17, 2015	Bend, OR	Impacts of CSZ on Central and Eastern Oregon	40	Althea Rizzo, OEM	
34	June 18, 2015	Baker City	Impacts of CSZ on Central and Eastern Oregon	30	Althea Rizzo, OEM	
35	June 19, 2015	Pendleton, OR	Impacts of CSZ on Central and Eastern Oregon	30	Althea Rizzo, OEM	
36	July 30, 2015	Corvallis, OR	Public works and city employees	130	Althea Rizzo, OEM	

STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
37	September 14, 2015	Medford	City Crisis Management team	12	Althea Rizzo, OEM	
38	September 14, 2015	Grants Pass	Earthquake Prep Talk	45	Althea Rizzo, OEM	
39	September 14, 2015	Grants Pass	Earthquake Prep Talk	20	Althea Rizzo, OEM	
40	September 15, 2015	Ashland	City Council	30	Althea Rizzo, OEM	
41	September 15, 2015	Ashland	NBC interview Channel 12	Unknown	Althea Rizzo, OEM	
42	September 16, 2015	Medford	Interview: Channel 10	Unknown	Althea Rizzo, OEM	
43	September 16, 2015	Medford	Earthquake Prep Talk	45	Althea Rizzo, OEM	
44	September 16, 2015	Medford	Earthquake Prep Talk	125	Althea Rizzo, OEM	
45	September 16, 2015	Medford	NBC 2 Interview	Unknown	Althea Rizzo, OEM	
46	September 17, 2015	City of Talent	Earthquake Prep Talk	22	Althea Rizzo, OEM	
47	September 17, 2015	Harry and David	talk with Mgt	24	Althea Rizzo, OEM	
48	September 18, 2015	Green Springs	Earthquake Prep Talk	32	Althea Rizzo, OEM	
49	September 20, 2015	Klamath Falls	Earthquake Prep Talk Anniversary of 1993 EQ	3	Althea Rizzo, OEM	
50	September 20, 2015	Klamath Falls	Earthquake Prep Talk Anniversary of 1993 EQ	16	Althea Rizzo, OEM	
51	October 1, 2015	Pendleton	Earthquake workshop	32	Althea Rizzo, OEM	
52	October 13, 2015	Corvallis	Earthquake workshop	75	Althea Rizzo, OEM	
53	October 14, 2015	McMinnville	homeowners insurance/Long term Care Insurance/ Rate Review	30	Kevin Jeffries, DCBS-DFR	Host: Lions Club of McMinnville.
54	October 15, 2015	PDX	Earthquake workshop	400	Althea Rizzo, OEM	
55	October 21, 2015	John Day	Home owner's insurance	15	Kevin Jeffries, DCBS-DFR	Host: Grant County. Did a live radio show to talk about fire losses and rebuilding times
56	October 22, 2015	Newport	Earthquake workshop	60	Althea Rizzo, OEM	
57	October 22, 2015	Ashland	Ashland is Ready	450	Althea Rizzo, OEM	
58	November 2, 2015	Portland	Consumer Advocacy/Small Business Insurance	300	Kevin Jeffries, DCBS-DFR	Host: BOLI.
59	November 2, 2015	Astoria	Tsunami Safe Presentation	19	Parmelee, OEM	
60	November 3, 2015	Lincoln City	Tsunami Safe Presentation	3	Parmelee, OEM	
61	November 4, 2015	Florence	Tsunami Safe Presentation	16	Parmelee, OEM	
62	November 5, 2015	Coos Bay	Tsunami Safe Presentation	4	Parmelee, OEM	
63	November 6, 2015	Brookings	Tsunami Safe Presentation	1	Parmelee, OEM	
64	November 13, 2015	Springfield	Consumer Advocacy/Small Business Insurance	40	Kevin Jeffries, DCBS-DFR	Host: twin Rivers Rotary.
65	December 17, 2015	Seaside	Presentation about Tsunami Safe	15	Parmelee, OEM	
66	2016	Statewide	Great Oregon Shakeout	500,326	OEM	
67	2016	Professional Land Surveyors of Oregon annual meeting	NFIP presentation	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
68	2016	Oregon planners network meeting	NFIP workshop	Unknown	DLCD	Audience: Planners, floodplain managers. Credit for certified floodplain managers.
69	2016	Washington County Planning Directors meeting	NFIP issues briefing	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
70	2016	Willamette Valley professional land surveyors chapter	NFIP LOMC workshop for surveyors	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
71	2016	Oregon Regional Solutions Center	NFIP issues briefing	Unknown	DLCD	Audience: Elected officials, planners
72	2016	ReMax Gresham	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
73	2016	North Coast Board of Realty	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
74	2016	First American Title Gresham	NFIP presentation	Unknown	DLCD	Audience: Real estate agents

STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
75	2016	First American Title Eugene	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
76	2016	Georgetown Realty Portland	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
77	2016	Inhabit Realty Portland	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
78	2016	First American Title Oregon City	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
79	2016	First American Title Salem	NFIP presentation	Unknown	DLCD	Audience: Real estate agents
80	2016	Jackson County	NFIP interagency riparian and floodplain management	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
81	2016	City of John Day	NFIP revised map adoption process	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
82	2016	Tribal cultural resources cluster (North Bend)	NFIP ESA and the NFIP	Unknown	DLCD	Audience: Tribal officials, planners, floodplain managers
83	2016	City of Florence	NFIP coastal hazard workshop	Unknown	DLCD	Audience: Planners, floodplain managers. Credit for certified floodplain managers.
84	2016	Oregon State Board of Examiners for Engineering and Land Surveying annual conference	NFIP presentation	Unknown	DLCD	Audience: Surveyors, engineers, floodplain managers. Credit for certified floodplain managers.
85	2016	City of Coos Bay	NFIP ESA roundtable	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
86	2016	Willamette Oregon chapter of professional land surveyors	NFIP Elevation Certificate training	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
87	2016	Small cities meeting (Port Orford)	NFIP updates	Unknown	DLCD	Audience: Planners, floodplain managers
88	2016	Yamhill County association of realtors	NFIP training for realtors	Unknown	DLCD	Audience: Real Estate Agents
89	2016	Oregon Board of Geologists	NFIP Intro	Unknown	DLCD	Audience: Geologists
90	2016	Seminar Group in Portland	NFIP ESA	Unknown	DLCD	Audience: Planners, floodplain managers, lawyers
91	January 20, 2016	Mt Angle	Home owners insurance	12	Kevin Jeffries, DCBS-DFR	Host: Habitat for Humanity.
92	January 22, 2016	Roseburg, Ashland, Grants Pass, Medford	Small Business Insurance and Consumer Advocacy	5	Kevin Jeffries, DCBS-DFR	Host: Local Chambers.
93	January 25, 2016	Newport and Tillamook	Consumer Advocacy/ Flood Insurance, Home owners insurance	20	Kevin Jeffries, DCBS-DFR	Host: Rep. Gomburg.
94	January 29, 2016	Salem, OR	Cascadia Presentation at Center for Community Innovation	16	Parmelee, OEM	
95	February 9, 2016	Salem	ASSE Cascadia	24	Althea Rizzo, OEM	
96	February 16, 2016	Eugene	Wells Fargo	12	Althea Rizzo, OEM	
97	February 19, 2016	Salem	Rotary Club	24	Althea Rizzo, OEM	
98	February 22, 2016	Seaside	Tsunami Safe Presentation	2	Parmelee, OEM	
99	February 24, 2016	Florence	Tsunami Safe Presentation	16	Parmelee, OEM	
100	February 25, 2016	Reedsport	Tsunami Safe Presentation	5	Parmelee, OEM	
101	February 26, 2016	Coos Bay	Tsunami Safe Presentation	4	Parmelee, OEM	
102	March 2, 2016	Seaside	Tsunami Safety	12	Althea Rizzo, OEM	
103	March 3, 2016	Cannon Beach	Tsunami Safety	24	Althea Rizzo, OEM	
104	March 15, 2016	Roseburg	Cascadia	200	Althea Rizzo, OEM	
105	March 16, 2016	Gold Beach	Tsunami Safe Presentation	2	Parmelee, OEM	
106	March 17, 2016	Seaside	Small Business Insurance and Consumer Advocacy	25	Kevin Jeffries, DCBS-DFR	Host: Downtown ass..
107	March 17, 2016	Newport	Tsunami Safe Presentation	5	Parmelee, OEM	
108	April 1, 2016	Seaside	Small Business Insurance	35	Kevin Jeffries, DCBS-DFR	Host: Seaside Chamber.
109	April 7, 2016	Beaverton	Business Insurance	200+	Kevin Jeffries, DCBS-DFR	Host: Tektronix. information booth
110	April 20, 2016	Salem	Cascadia @ Willamette Military Officers Assoc.	24	Althea Rizzo, OEM	
111	April 21, 2016	Hood River	Cascadia	200	Althea Rizzo, OEM	
112	April 26, 2016	Pendleton	Cascadia and Tsunami Safe Presentation	45	Parmelee, OEM	

STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
113	April 28, 2016	Salem	Preparedness Presentation - Take your kid to work day @ OMD	40	Parmelee, OEM	
114	May 13, 2016	Sunriver	Cascadia Presentation and Volunteering - Oregon Heating, Cooling, & Plumbing Association	36	Parmelee, OEM	
115	May 26, 2016	Portland	Cascadia Presentation @ USCIS	24	Althea Rizzo, OEM	
116	May 30, 2016	Astoria	Cascadia Presentation @ Liberty Theater	150	Althea Rizzo, OEM	
117	June 1, 2016	Salem	Cascadia Presentation @Chemeketa	24	Althea Rizzo, OEM	
118	July 20, 2016	Portland	Cascadia Presentation/TsunamiSafe @ TravelOregon	29	Parmelee, OEM	
119	August 2, 2016	Salem	OPB Unprepared @ Northern Lights	200	Althea Rizzo, OEM	
120	August 16, 2016	Salem	New Employee Presentation	6	Althea Rizzo, OEM	
121	September 6, 2016	Florence	Tsunami Safe Presentation to Fire Chiefs	20	Parmelee, OEM	
122	September 10, 2016	Ashland	Ashland is Ready	350	Althea Rizzo, OEM	
123	September 15, 2016	Salem	Cascadia Presentation @ SAIF	74	Parmelee, OEM	
124	October 4, 2016	Bend	Cascadia Presentation for APWA	23	Parmelee, OEM	
125	October 6, 2016	Salem	Cascadia Presentation @ Center 50+	45	Althea Rizzo, OEM	
126	October 20, 2016	Wilsonville	Cascadia Presentation/TsunamiSafe @ ORLA	19	Parmelee, OEM	
127	October 31, 2016	Lincoln City	Cascadia Presentation/TsunamiSafe @ SAIF	25	Parmelee, OEM	
128	November 1, 2016	Astoria	TsunamiSafe	10	Parmelee, OEM	
129	November 2, 2016	Florence	TsunamiSafe	3	Parmelee, OEM	
130	November 3, 2016	Coos Bay	TsunamiSafe	6	Parmelee, OEM	
131	November 4, 2016	Gold Beach	TsunamiSafe	1	Parmelee, OEM	
132	November 4, 2016	Salem	Student Day at DLCD	12	Althea Rizzo, OEM	
133	November 5, 2016	Florence	Tsunami Preparedness Activities presentation at WLEOG Emergency Preparedness Expo	49	Parmelee, OEM	
134	November 8, 2016	Lincoln City	TsunamiSafe	15	Parmelee, OEM	
135	November 21, 2016	Portland	Appearance on KGW	Unknown	Althea Rizzo, OEM	
136	December 7, 2016	Florence	Tsunami Conference	127	Althea Rizzo & Karen Layng, OEM	
137	2017	Statewide	Great Oregon Shakeout	585,727	OEM	
138	2017	Professional Land Surveyors of Oregon annual conference	NFIP presentation	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
139	2017	Seminar Group in Portland	NFIP ESA	Unknown	DLCD	Audience: Planners, floodplain managers, lawyers
140	2017	Oregon emergency preparedness workshop	NFIP flood preparedness methodologies	Unknown	DLCD	Audience: Emergency managers, floodplain managers
141	2017	Oregon planners network meeting	NFIP refresher	Unknown	DLCD	Audience: Planners, floodplain managers. Credit for certified floodplain managers.
142	2017	City of Monroe	NFIP overview and flood map updates	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
143	2017	City of Turner	NFIP flood mapping public meeting	Unknown	DLCD	Audience: Public, floodplain managers
144	2017	City of Newport	NFIP for realtors	Unknown	DLCD	Audience: Real estate agents
145	2017	City Keizer	NFIP for realtors	Unknown	DLCD	Audience: Real estate agents
146	2017	Association of Counties	NFIP update and ESA	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
147	February 2, 2017	Ontario, 97914	Home/Farm/Business Insurance	120	Kevin Jeffries, DCBS-DFR	Host: Malheur County. Snow Storm response
148	February 8, 2017	Medford	Mitigation Planning Workshop (G0318)	22	Joseph Murray, OEM	2 days, 16 hours
149	February 8, 2017	Salem	Disaster Behavioral Conference	200	Althea Rizzo, OEM	

STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
150	February 11, 2017	Portland, 97201	Home Owner's Ins	8	Kevin Jeffries, DCBS-DFR	Host: Portland Habitat for Humanity.
151	March 1, 2017	Ontario, 97914	Home/Farm/Business Insurance	20	Kevin Jeffries, DCBS-DFR	Host: Governor's Office.
152	March 7, 2017	Nyssa, 97913	Home/Farm/Business Insurance	6	Kevin Jeffries, DCBS-DFR	Host: City of Nyssa. Town Hall
153	April 19, 2017	the Dalles	The Big One	200	Althea Rizzo, OEM	
154	April 20, 2017	Hood River	The Big One	200	Althea Rizzo, OEM	
155	April 29, 2017	McMinnville, 97128	Insurance for Disaster Prep	200	Kevin Jeffries, DCBS-DFR	Host: LDS Church. gave two classes (8 each) info table, 200+ attended
156	May 2, 2017	Salem, 97301	Insurance for Disaster Prep	15	Kevin Jeffries, DCBS-DFR	Host: Class Act
157	May 24, 2017	Salem, 97301	Insurance for Disaster Prep	80+	Kevin Jeffries, DCBS-DFR	Host: Building Codes (BCD).
158	June 21, 2017	The Dalles	Mitigation Planning Workshop (G0318)	20	Joseph Murray, OEM	2 days, 16 hours
159	September 9, 2017	Wilsonville	Safety fair	75	Althea Rizzo, OEM	
160	September 11, 2017	Troutdale, 97060	Eagle Creek Fire Evacuation: Insurance Help	100	Kevin Jeffries, DCBS-DFR	Host: Multnomah County. Staff an info table
161	September 16, 2017	Corvallis	CPI Safety fair	400	Althea Rizzo, OEM	
162	September 21, 2017	Salem	Cascadia Presentation @ SAIF	28	Karen Layng, OEM	
163	September 23, 2017	Florence	Cascadia Presentation @ Florence Expo	62	Karen Layng, OEM	
164	September 25, 2017	Cascade Locks, 97014	Eagle Creek Fire Evacuation: Insurance Help	15	Kevin Jeffries, DCBS-DFR	Host: Gov. Office. Staff an info table
165	October 6, 2017	Burns, 97720	Emergency Prep	25	Kevin Jeffries, DCBS-DFR	Host: Burns Paiute Tribe. talked to tribal members about home owners and financial planning for disasters
166	October 7, 2017	PDX	KATU & KPAM	12	Althea Rizzo, OEM	
167	October 17, 2017	3225 State Street (Donald N. Anderson-Readiness Center), Salem	HMA Grant Opportunities Workshop: Understanding the Requirements and Responsibilities	21	Angie Lane, OEM	2 days, 16 hours
168	2018	Statewide	Great Oregon Shakeout	668,914	OEM	
169	2018	Professional Land Surveyors of Oregon annual conference	NFIP presentation	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
170	2018	Oregon League of Cities	NFIP and ESA status	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
171	2018	City of North Plains	NFIP overview	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
172	2018	Portland	NFIP L0273 managing floodplain development through the NFIP (4-day course)	Unknown	DLCD	Audience: Planners, floodplain managers, engineers, real estate agents. Credit for certified floodplain managers.
173	2018	Lane County	NFIP training for real estate agents	Unknown	DLCD	Audience: Real estate agents
174	2018	Oregon Coastal Planners meeting	NFIP and CRS	Unknown	DLCD	Audience: Planners, floodplain managers
175	2018	Klamath County	NFIP overview and permitting	Unknown	DLCD	Audience: Planners, floodplain managers
176	2018	City of Scio	NFIP overview and permitting	Unknown	DLCD	Audience: Planners, floodplain managers
177	2018	City of Manzanita	NFIP overview and permitting	Unknown	DLCD	Audience: Planners, floodplain managers
178	2018	City of Brookings	NFIP overview and permitting	Unknown	DLCD	Audience: Planners, floodplain managers
179	2018	The Nature Conservancy	NFIP overview and permitting	Unknown	DLCD	Audience: Conservation specialists
180	2018	Oregon Association of County Planning Directors	NFIP updates	Unknown	DLCD	Audience: Planners, floodplain managers
181	2018	Governor’s Water Core Team meeting	NFIP overview	Unknown	DLCD	Audience: State agency deputy directors, planners
182	2018	Oregon City	NFIP L0273 managing floodplain development through the NFIP (4-day course)	Unknown	DLCD	Audience: Planners, floodplain managers, engineers. Credit for certified floodplain managers.
183	January 17, 2018	Salem	PLSO	100	Althea Rizzo, OEM	
184	January 23, 2018	SALEM	KPAM, AP, KXL	Unknown	Althea Rizzo, OEM	
185	January 24, 2018	Salem, 97301	Disaster Prep. Insurance	75	Kevin Jeffries, DCBS-DFR	Host: State Employment Dept. I spoke to the group and provided printed materials
186	February 8, 2018	Seaside	conference	100	Althea Rizzo, OEM	

STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
187	February 25, 2018	Portland, 97217	Home insurance	200	Ron, DCBS-DFR	Host: NW Home and Garden.
188	February 27, 2018	Cannon Beach	Tsunami	13	Althea Rizzo, OEM	
189	February 28, 2018	Seaside	Tsunami Movie Night	12	Althea Rizzo, OEM	
190	March 2, 2018	Cape Meares	Tsunami	16	Althea Rizzo, OEM	
191	March 5, 2018	Nehalem Bay	Tsunami	21	Althea Rizzo, OEM	
192	March 6, 2018	Albany, 97321	Home Owners Insurance	45	Kevin Jeffries, DCBS-DFR	Host: W. Albany High School. Taught two classes
193	March 6, 2018	Port Orford	Tsunami	14	Althea Rizzo, OEM	
194	March 7, 2018	Bandon	Tsunami	36	Althea Rizzo, OEM	
195	March 8, 2018	Coos bay	Tsunami	13	Althea Rizzo, OEM	
196	March 9, 2018	Brookings	Tsunami	28	Althea Rizzo, OEM	
197	March 13, 2018	Gleneden Beach	Tsunami	15	Althea Rizzo, OEM	
198	March 14, 2018	Newport	Tsunami	13	Althea Rizzo, OEM	
199	March 14, 2018	Waldport	Tsunami	10	Althea Rizzo, OEM	
200	March 14, 2018	Lincoln City	Tsunami	15	Althea Rizzo, OEM	
201	March 16, 2018	Yachats	Tsunami	10	Althea Rizzo, OEM	
202	March 20, 2018	Dunes City	Tsunami	6	Althea Rizzo, OEM	
203	March 20, 2018	Florence	Tsunami	20	Althea Rizzo, OEM	
204	March 22, 2018	Reedsport	Tsunami	9	Althea Rizzo, OEM	
205	April 11, 2018	Umatilla County Justice Center, 4700 NW Pioneer Place, Pendleton	HMA Grant Opportunities Workshop: Understanding the Requirements and Responsibilities	8	Angie Lane, OEM	2 days, 15.5 hours
206	April 19, 2018	Bend, 97701	Risk Management :Insurance	5	Kevin Jeffries, DCBS-DFR	Host: WorkSource.
207	April 19, 2018	Redmond, 97756	Risk Management :Insurance	10	Kevin Jeffries, DCBS-DFR	Host: WorkSource.
208	April 27, 2018	Albany , 97321	Who is DFR? Home Insurance/Home Ownership	350	Karla Martinez, DCBS-DFR	Host: CCB/Linn County Fairgrounds Homeshow.
209	April 27, 2018	Bend, 97701	Auto/Home insurance	8	Kevin Jeffries, DCBS-DFR	Host: Marshall High School.
210	May 1, 2018	Salem, 97301	Disaster Preparedness	30	Ron, DCBS-DFR	Host: Oregon State Fiscal Association.
211	May 4, 2018	Bend , 97701	Who is DFR? Home Insurance/Home Ownership	500	Karla Martinez, DCBS-DFR	Host: CCB/Deschutes County Homeshow.
212	May 8, 2018	Salem, 97301	Disaster Preparedness	30	Ron, DCBS-DFR	Host: Oregon State Fiscal Association.
213	May 9, 2018	Port of Tillamook (Main Conference Room), 4000 Blimp Blvd., Tillamook	HMA Grant Opportunities Workshop: Understanding the Requirements and Responsibilities	29	Angie Lane, OEM	2 days, 15.5 hours
214	May 16, 2018	Josephine County Emergency Management/Search & Rescue Complex, 250 Tech Way, Grants Pass	HMA Grant Opportunities Workshop: Understanding the Requirements and Responsibilities	16	Angie Lane, OEM	2 days, 15.5 hours
215	June 14, 2018	San Francisco, CA	Present at CalOES	20	Althea Rizzo, OEM	
216	June 26, 2018	Pendleton	Mitigation Planning Workshop (G0318)	24	Joseph Murray, OEM	2 days, 16 hours
217	July 11, 2018	Wallowa County, 97828	Agent Training	3	Kevin Jeffries, DCBS-DFR	Host: Wallowa Resource Center. homeowners INS
218	July 14, 2018	Portland, 97211	Home Insurance	12	Ron, DCBS-DFR	Host: Habitat for Humanity.
219	July 17, 2018	Canyon City, 97820	Home Insurance FIRE	2	Kevin Jeffries, DCBS-DFR	Host: Sagart (home Owners). interviewed them and created video
220	July 18, 2018	Canyon City, 97820	Renters Insurance FIRE	2	Kevin Jeffries, DCBS-DFR	Host: Kowing family. interviewed them and created video
221	July 27, 2018	Medford , 97501	Disaster Assistance/Home Insurance	350	Karla Martinez, DCBS-DFR	Host: 2018 Veteran Expo Benefit. Work with the ODVA
222	July 30, 2018	The Dalles, 97058	Insurance for Fires	25	Kevin Jeffries, DCBS-DFR	Host: Wasco County. Staffed a table at a Town hall. Also spoke about DFR to the audience
223	July 31, 2018	Moro, 97039	Insurance for Fires	637	Kevin Jeffries, DCBS-DFR	Host: Sherman County. Staffed a table at a Town hall. Also spoke about DFR to the audience
224	September 18, 2018	McMinnville	Mitigation Planning Workshop (G0318)	20	Joseph Murray, OEM	2 days, 16 hours

STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
225	September 19, 2018	Eugene , 97401	Who is DFR/ Home Insurance/ Disaster Preparedness	350	Karla Martinez, DCBS-DFR	Host: 2018 Oregon Realtors Association Conference. Table Event
226	September 26, 2018	Salem, OR	ODA Conference	200	Althea Rizzo, OEM	
227	October 6, 2018	Portland, 97201	Home Insurance	50	Ron, DCBS-DFR	Host: Portland Home Show.
228	October 9, 2018	Bend, 97701	Insurance and Disaster Awareness (home, Flood, Quake)	200	Kevin Jeffries, DCBS-DFR	Host: Oregon Emergency Managers Association (OEMA). Staffed table, spoke to group
229	October 10, 2018	Bend, 97701	Insurance and Disaster Awareness (home, Flood, Quake)	200	Kevin Jeffries, DCBS-DFR	Host: Oregon Emergency Managers Association (OEMA). Staffed table, spoke to group
230	October 16, 2018	Bend, OR	Central Oregon Community College	45	Althea Rizzo, OEM	
231	October 18, 2018	Salem, OR	CDWG Conference	150	Althea Rizzo, OEM	
232	October 29, 2018	Salem, 97301	Insurance and Disaster Awareness (home, Flood, Quake)	150	Kevin Jeffries, DCBS-DFR	Host: DAS ODOT DCBS. Staffed a table
233	October 29, 2018	Salem, OR	ODOT Safety Day	45	Althea Rizzo, OEM	
234	November 10, 2018	McMinnville, 97128	Emergency preparedness	100	Ron, DCBS-DFR	Host: McMinnville Community Center.
235	December 21, 2018	Salem, 97301	Disaster Preparedness	25	Ron, DCBS-DFR	Host: Climate Change Adaptation Framework.
236	2019	Statewide	Great Oregon Shakeout	744,299	OEM	
237	2019	Klamath County	NFIP flood risk review meeting	Unknown	DLCD	Audience: Planners, floodplain managers, engineers
238	2019	Douglas County	NFIP floodplain mapping open house	Unknown	DLCD	Audience: Public, floodplain managers
239	2019	Lane County	NFIP floodplain mapping update meeting	Unknown	DLCD	Audience: Planners, floodplain managers
240	2019	Professional Land Surveyors of Oregon annual conference	NFIP presentation	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
241	2019	Oregon planners network meeting	NFIP update	Unknown	DLCD	Audience: Planners, floodplain managers
242	2019	Lane County	NFIP Substantial Damage and floodplain manager duties during and after a flood	Unknown	DLCD	Audience: Floodplain managers
243	2019	Benton County	NFIP Substantial Damage and floodplain manager duties during and after a flood	Unknown	DLCD	Audience: Floodplain managers
244	2019	Douglas County	NFIP Substantial Damage and floodplain manager duties during and after a flood	Unknown	DLCD	Audience: Floodplain managers
245	2019	Coos County	NFIP Substantial Damage and floodplain manager duties during and after a flood	Unknown	DLCD	Audience: Floodplain managers
246	2019	Oregon coastal planners meeting	NFIP and floodplain management best practices	Unknown	DLCD	Audience: Planners, floodplain managers. Credit for certified floodplain managers.
247	2019	Central Point - L0273 managing floodplain development through the NFIP	NFIP (4-day course)	Unknown	DLCD	Audience: Planners, floodplain managers, engineers. Credit for certified floodplain managers.
248	2019	Unknown	NFIP Advanced concepts, substantial damage, and floodplain permitting	Unknown	DLCD	Audience: Floodplain managers. Credit for certified floodplain managers.
249	2019	Grant County	NFIP flood mapping update meeting	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
250	2019	Harney County and Burns Paiute Tribe	NFIP flood mapping update meeting	Unknown	DLCD	Audience: Elected officials, planners, floodplain managers
251	2019	City of Turner public open house	NFIP flood mapping update	Unknown	DLCD	Audience: Public, floodplain managers
252	2019	Governor’s Regional Solutions team and PGE	NFIP permitting requirements	Unknown	DLCD	Audience: Planners
253	2019	Oregon Community Rating System user group meeting (Benton County)	NFIP CRS activities	Unknown	DLCD	Audience: Floodplain managers
254	2019	Newport Oregon	NFIP insurance agent training	Unknown	DLCD	Audience: Insurance agents, real estate agents, surveyors. Credit for certified floodplain managers.
255	2019	Seaside Oregon	NFIP EC’s and LOMCs training	Unknown	DLCD	Audience: Elected officials, surveyors, planners. Credit for certified floodplain managers.
256	2019	Northwest Regional Floodplain Management Association	NFIP Oregon updates	Unknown	DLCD	Audience: Floodplain managers
257	2019	Department of Environmental Quality	NFIP EO11988 process	Unknown	DLCD	Audience: Planners
258	2019	Department of State Lands	NFIP overview and permitting	Unknown	DLCD	Audience: Planners

STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
259	2019	Department of Transportation	NFIP overview and permitting	Unknown	DLCD	Audience: Planners, engineers
260	2019	Pew Charitable Trust	NFIP flood mitigation practices in the State of Oregon	Unknown	DLCD	Audience: Planners, floodplain managers
261	2019	Toledo City Council meeting	NFIP standards	Unknown	DLCD	Audience: Elected officials, public, planners
262	2019	Oregon CRS user group (Harrisburg)	NFIP CRS activities	Unknown	DLCD	Audience: Planners, floodplain managers
263	2019	City of John Day	NFIP permitting	Unknown	DLCD	Audience: Planners, floodplain managers
264	2019	Eastern Oregon Chapter Professional Land Surveyors (Pendleton)	NFIP Elevation Certificates and LOMCs	Unknown	DLCD	Audience: Surveyors, floodplain managers. Credit for certified floodplain managers.
265	2019	City of Eugene urban reserve committee meeting	NFIP risks of building within floodplains	Unknown	DLCD	Audience: Planners, public
266	January 11, 2019	Salem, 97302	Who is DFR/Homeowners/Mtg Info	500	Karla Martinez, DCBS-DFR	Host: Mid-Valley Home Show. Both
267	January 31, 2019	Bend, 97702	Insurance for natural disasters	12	Kevin Jeffries, DCBS-DFR	Host: Marshall High School. INS
268	February 5, 2019	Bend, 97702	Insurance for natural disasters	12	Kevin Jeffries, DCBS-DFR	Host: Marshall High School. INS
269	February 6, 2019	Salem	Salem Scottish Rite Center	12	Althea Rizzo, OEM	
270	February 7, 2019	Bend, 97702	Insurance for natural disasters	30	Kevin Jeffries, DCBS-DFR	Host: Realms High School. INS
271	February 8, 2019	Bend, 97702	Insurance for natural disasters	30	Kevin Jeffries, DCBS-DFR	Host: Realms High School. INS
272	February 22, 2019	Portland, 97217	Home buying, insurance	50	Ron, DCBS-DFR	Host: Home and Garden Show. Both
273	February 23, 2019	Portland, 97217	Who is DFR/ Homeowners information	400	Karla Martinez, DCBS-DFR	Host: City of Portland. Both
274	March 5, 2019	Oklahoma City,	Disaster outreach	50	Kevin Jeffries, DCBS-DFR	Host: NAIC. both
275	March 8, 2019	Klamath Falls , 97603	Who is DFR/ Homeowners information	900	Karla Martinez, DCBS-DFR	Host: Klamath Basin Home Builders Association. Both
276	March 20, 2019	Lyons, 97358	Disaster prep; fire INS	4	Kevin Jeffries, DCBS-DFR	Host: City of Lyons. both
277	March 20, 2019	Florence	Florence Prep Fair	100	Althea Rizzo, OEM	
278	March 21, 2019	Salem, 97302	Who is DFR/Small Business Owner Info	800	Karla Martinez, DCBS-DFR	Host: Governors Marketplace. Both
279	April 2, 2019	Wilsonville, 97070	Home owners Insurance	250	Kevin Jeffries, DCBS-DFR	Host: City of Wilsonville. Insurance
280	April 8, 2019	Manzanita	NBEVC	30	Althea Rizzo, OEM	
281	April 23, 2019	Portland	Residential Seismic Retrofit (P-50)	37	BJ Cure, Steve McGuire, Cassie Hibbert	1 day, 6 hours
282	April 26, 2019	Albany, 97321	Homeowners Insurance	80	Karla Martinez, DCBS-DFR	Host: CCB Home Show. Insurance
283	May 3, 2019	Bend, 97701	Homeowners Insurance	90	Karla Martinez, DCBS-DFR	Host: CCB Home Show. Insurance
284	May 7, 2019	Redmond, 97756	Insurance, risk management Natural Disasters	26	Kevin Jeffries, DCBS-DFR	Host: Redmond High School / FBO. Both
285	May 7, 2019	Redmond, 97756	Insurance, risk management Natural Disasters	30	Kevin Jeffries, DCBS-DFR	Host: Redmond High School / FBO. Both
286	May 11, 2019	Bend	Firewise fair	45	Althea Rizzo, OEM	
287	May 16, 2019	Bend, 97701	Risk Management	40	Karla Martinez, DCBS-DFR	Host: Bend High School FBO. Insurance
288	May 18, 2019	Redmond , 97756	Home and Auto Insurance	90	Karla Martinez, DCBS-DFR	Host: Mobile Mexican Consulate. Insurance
289	May 19, 2019	Redmond , 97756	Home and Auto Insurance	90	Karla Martinez, DCBS-DFR	Host: Mobile Mexican counsel ate. Insurance
290	June 5, 2019	La Grande, 97850	Small Business	15	Karla Martinez, DCBS-DFR	Host: CCB CE LAW CLASS. Insurance
291	June 6, 2019	Hermiston , 97838	Small Business	20	Karla Martinez, DCBS-DFR	Host: CCB CE LAW CLASS. Insurance
292	July 12, 2019	Bend, 97701	Who is DFR/ Home Insurance	30	Karla Martinez, DCBS-DFR	Host: Bend Business Showcase. INS
293	July 13, 2019	Bend, 97701	Who is DFR/ Home Insurance	50	Karla Martinez, DCBS-DFR	Host: Bend Business Showcase. INS
294	July 13, 2019	Portland, 97201	Insurance, risk management Natural Disasters	12	Kevin Jeffries, DCBS-DFR	Host: Portland area Habitat for Humanity. INS
295	July 14, 2019	Bend, 97701	Who is DFR/ Home Insurance	60	Karla Martinez, DCBS-DFR	Host: Bend Business Showcase. INS
296	July 22, 2019	Coos Bay, 97420	DFR/Small Business Risk Management	15	Karla Martinez, DCBS-DFR	Host: CCB. INS
297	August 7, 2019	Salem	OLCC Wellness	30	Althea Rizzo, OEM	

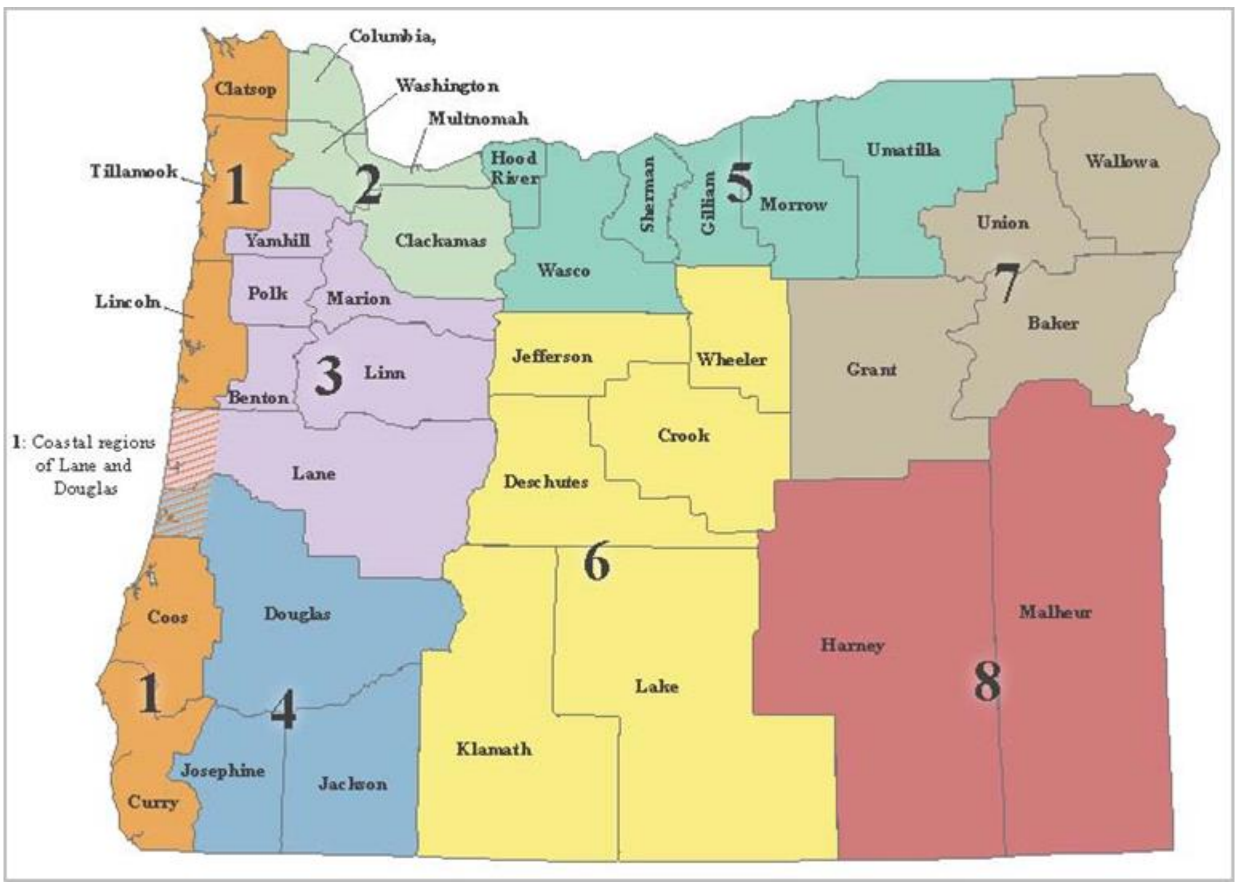
STATE-DELIVERED TRAINING: 2015-2019						
#	**Date**	**Location**	**Topic**	**# Attendees**	**Presenter**	**Notes**
298	August 14, 2019	Salem, 97301	Disaster Prep	55	Kevin Jeffries, DCBS-DFR	Host: DCBS. Both
299	August 14, 2019	Salem	DCBS Disaster Prep	28	Althea Rizzo, OEM	
300	October 7, 2019	Garibaldi	People's coast Conference	14	Althea Rizzo, OEM	
301	October 10, 2019	Eugene, 97405	Small Business Risk Management/Who is DFR	15	Karla Martinez, DCBS-DFR	Host: CCB CE Class. Ins
302	October 10, 2019	Eugene, 97401	Insurance, risk management; Earthquake INS	200	Kevin Jeffries, DCBS-DFR	Host: OEMA. Ins
303	October 24, 2019	Lebanon, 97365	Disaster Preparedness	45	Ron, DCBS-DFR	Host: Oregon Business Education Assoc. Ins
304	October 26, 2019	Medford, 97501	Who is DFR/ Small Business Risk Management	70	Karla Martinez, DCBS-DFR	Host: SOU Rogue Valley Business Resource Forum. Both
305	November 2, 2019	DC, 20036	Insurance for natural disasters	8	Kevin Jeffries, DCBS-DFR	Host: Jump$tart. Ins
306	November 6, 2019	McMinnville	Rotary Club	25	Althea Rizzo, OEM	
307	November 19, 2019	Salem, 97302	Who is DFR/Small Business Risk Management	160	Karla Martinez, DCBS-DFR	Host: OSHA Spanish Conference. Ins
308	November 20, 2019	Madras, 97741	Insurance, risk management	90	Kevin Jeffries, DCBS-DFR	Host: Madras High School. Ins
309	December 3, 2019	Madras and Salem	Pratumm Co-op	200	Althea Rizzo, OEM	
310	December 6, 2019	Pendleton, 97801	Insurance, risk management Natural Disasters	120	Kevin Jeffries, DCBS-DFR	Host: Pendleton High School. Ins

3.5.1.4 Funding and Technical Assistance Process

The State of Oregon continues to build local capacity in developing and implementing risk reduction strategies through plan development support, professional assistance, resource sharing, and technical assistance. Local mitigation planning continues to be accomplished in great measure through the state's Pre-Disaster Mitigation Planning Program, established in 2004 by the Oregon Office of Emergency Management (OEM) in partnership with the Oregon Partnership for Disaster Resilience (OPDR). The program systematically provides funding and technical assistance to local governments for the purpose of developing or updating existing local natural hazards mitigation plans with the goal of ensuring that each county and municipality in the State of Oregon maintains a FEMA-approved natural hazards mitigation plan.

Because local mitigation plans expire after 5 years, the State's strategy is to assist local jurisdictions with plan updates and new plan development on a 5-year rotational basis. OEM has divided the state into eight hazard mitigation regions for mitigation planning and emergency response purposes (**Figure 3-3**). **Table 3-15** presents the model mitigation planning schedule as it rotates through the mitigation planning regions from 2020 through 2030. Note that while some local jurisdictions elect not to participate in the regional planning cycle as scheduled, all 36 counties in Oregon currently participate in the five-year local plan update process.

Figure 3-3. Oregon Natural Hazards Mitigation Planning Regions



Source: OEM

Table 3-15. Model 5-Year Rotational Mitigation Planning Schedule, 2020–2030

Planning Year	OEM Planning Region
2019-20	Regions 1 and 3
2020-21	Regions 2 and 4
2021-22	Region 5
2022-23	Regions 7 and 8
2023-24	Region 6
2024-25	Regions 1 and 3
2025-26	Regions 2 and 4
2026-27	Region 5
2027-28	Regions 7 and 8
2028-29	Region 6
2029-30	Regions 1 and 3

Source: OPDR; updated by DLCD, 2020

In 2014, OEM and OPDR developed a "pre-application" process to screen local communities interested in participating in regional FEMA PDM grant applications. The process consisted of (a) personal communication between the State Hazard Mitigation Officer and local NHMP leads in jurisdictions with plans coming due, (b) an invitation to participate in the pre-application process, and (c) a questionnaire designed to solicit local interest in participating and determine the jurisdiction's capability to participate. The first time through the pre-application process, OEM and OPDR received six completed pre-applications. Because it was so successful, the state intended to continue using the pre-application process.

Now in 2020, with six years of experience; turnover in key staff; the advent of multi-hazard risk assessments and the initiative to coordinate them with NHMP updates; and changes in priorities at federal and local levels, we recognize both the successes and obstacles we have faced with implementing this program. The pre-application process is not as formal as it was at its inception. We track (with the assistance of FEMA's weekly plan status updates and communication among the assisting partners) which jurisdictions to target for assistance to keep the model schedule moving forward and contact them with an offer to assist. Normally we find ourselves ahead of the jurisdictions, preparing to apply for grant funding earlier than they expect because of the grant processing and risk assessment timelines. After discussion, those interested are asked to provide a letter of interest with all the information necessary to support the grant application. This is similar to the purpose of the original pre-application.

We have found that even as we have been successful in continuing to assist jurisdictions with maintaining approved NHMPs, the model plan update cycle has broken down. One of the issues we find is that even the larger jurisdictions have capacity and priority-balancing issues. They cannot ask the same stakeholders to be involved in multiple planning projects simultaneously so must decide which to delay. Others simply don't foresee that they would ever need to apply for mitigation grants and prefer to put their limited capacity to use in other ways. Differences in FEMA's and the State's Risk MAP priorities can put some jurisdictions in a different place in the queue as well.

Further, PDM has been the primary funding source for DLCD and OPDR to assist local jurisdictions with mitigation planning, with HMGP as a secondary funding source. As PDM winds down and BRIC makes its debut, it has become clear that BRIC will not support mitigation planning at the same level as PDM. The financial burden is shifting to states and local governments to finance mitigation planning. We anticipate continuing to fund this successful technical assistance model under BRIC to the extent that we can, and also under HMGP. We will have to find ways to generate additional funding because the amount available under BRIC is insufficient and HMGP funding is inconsistent. With the drastic revenue shortfalls we are having and facing in the future as the result of the novel coronavirus pandemic it will be difficult if not impossible for the state to fill the gap. In addition, Oregon's September 2020 wildfire disaster will surely strain the state's limited budget even further. It has long been the State's goal that Oregon's entire population is covered by current, effective NHMPs.

Acknowledging that it will be more difficult to maintain the current level of service, it will be important to build capacity in local governments for developing and updating NHMPs. Training is one way to do this. The State should focus on providing more G-318 classes and attracting more local government staff and stakeholders to take them. Engaging stakeholders in learning about the planning process and requirements is one way to reach out to the various sectors of the whole community and champion equity, as well as to raise general community awareness. In addition, the State and FEMA should collaborate on creative ways to deliver the G-318 class that will reach the greatest number of jurisdictions and stakeholders in the wake of novel coronavirus travel and gathering restrictions.

Another option for capacity building is to train planning consultants in mitigation planning, creating a pool of talent and expertise from which local governments can draw support. The drawback would be generally higher cost of consulting services. There is potential, however, for developing incentives to keep the cost low.

The Resource Assistance for Rural Environments (RARE) is an AmeriCorps program housed at the University of Oregon's Institute for Policy Research and Engagement. Its mission is "to increase the capacity of rural communities to improve their economic, social, and environmental conditions, through the assistance of trained graduate-level members who live and work in communities for 11 months." The RARE program has successfully provided natural hazards mitigation planning assistance to rural communities and the State could potentially create a relationship with the program to provide ongoing mitigation planning assistance in rural communities.

One way to address the lack of vision and the issue of competing priorities is to develop a risk communication and outreach program that clearly demonstrates to local governments and stakeholders the risks and potential consequences of natural hazards events and the value of mitigation planning. The goal of the program would be for local governments with plans (expired or not) to commit to keeping their plans current and using them. Another goal would be to continue to expand NHMP coverage by encouraging cities and special districts without them develop plans.

On the issue of the divergence of FEMA's and the State's Risk MAP priorities, communication is the key. The State is very grateful that FEMA has funded multi-hazard risk assessments through the CTP program and has found that these risk assessments are vital elements of NHMP updates. Assuming that FEMA will continue to support development of these risk assessments underpinning NHMP updates and new NHMPs, the issue is to agree on the communities for which they will be developed and when. Continuous and effective communication between the involved state agencies and FEMA is the answer.

3.5.2 Prioritizing Local Jurisdictions for Mitigation Funding

3.5.2.1 Eligibility Criteria for Planning Grants

Grant proposals for developing initial local natural hazards mitigation plans or updating existing plans are evaluated on the basis of the following prioritized criteria:

1. The jurisdiction’s plan status:
    - First Priority: Jurisdictions that have never developed a plan;
    - Second Priority: Jurisdictions that have expired plans;
    - Third Priority: Jurisdictions whose plans will expire within 18 months; and
    - Fourth Priority: Jurisdictions whose plans will not expire within 18 months.
2. Jurisdictions located in declared county(ies).
3. Jurisdictions with the required 25% cost-share.
4. Jurisdictions with the highest risks.
5. Jurisdictions with repetitive loss or severe repetitive loss properties.
6. Jurisdictions with the most intense development pressures.
7. Jurisdictions that:
    - Have a local champion to ensure the process moves forward and the plan is completed, and
    - Can spend the grant funds quickly.
8. Jurisdictions located outside the declared county(ies) and geographically diverse with respect to the Oregon NHMP Natural Hazard Regions (**Figure 3-3**).

3.5.2.2 Eligibility Criteria and Ranking System for Project Grants

Proposed hazard mitigation projects, including those proposed under Section 404 of the Stafford Act, are evaluated for FEMA funding eligibility on the basis of the following federal and State criteria:

1. Be consistent with, support, and help implement the goals and objectives of the state's natural hazards mitigation plan developed under Sections (standard plan) 201.4 or (enhanced plan) 201.5 of the Stafford Act;
2. Be consistent with, support, and help implement the goals, objectives, and mitigation actions of local hazard mitigation plans in place for the geographic area in question developed under Section 201.6 of the Stafford Act;
3. Have significant potential to reduce damages to public and/or private property to reduce the cost of recovering from future disasters;
4. Be the most practical, cost-effective, and environmentally sound alternative after a consideration of a range of alternatives;
5. For federally funded projects, meet federal requirements for benefit-cost requirements by having a benefit-cost ratio ≥ 1.0;
6. Address a repetitive loss or substantial damage problem, or one that has the potential to have a major impact on an area, by reducing the potential for loss of life, loss of essential services or personal property, damage to critical facilities, economic loss, hardship, or suffering;
7. Solve a problem independently, or constitute a portion of a solution where there is a likelihood that the project as a whole will be completed;
8. Conform with 44 CFR Part 9, Floodplain Management and Protection of Wetlands, and not contribute to or encourage development in wetlands or in floodplains;
9. Conform with 44 CFR Part 10, Environmental Considerations;
10. Be based on a hazard vulnerability analysis of the geographic area in question;
11. Be feasible (both technically and within an approved scope of work and budget) and be ready to proceed when approved and funded;
12. Meet applicable permit requirements;
13. Not encourage new development in hazardous areas;
14. Contribute to a permanent or long-term solution to the problem, and have manageable maintenance and modification costs;
15. Whenever possible, be designed to accomplish multiple objectives, including damage reduction, environmental enhancement, and economic development or recovery;
16. Whenever possible, use existing agencies or programs to implement the project;
17. Have the support of local community officials; and
18. The community has adequate local grant management capacity.

Mitigation of repetitive loss properties (those with an NFIP insurance history of flood losses) have been identified by FEMA as a top priority for mitigation by elevation, relocation, or acquisition. FEMA preferentially supports these properties for mitigation funding through the NFIP-ICC claims process, benefit-cost waiver for substantial damage by flooding, and by baseline cost-effectiveness determinations that expedite project identification, selection, and approval. NFIP loss data report that one third of all NFIP flood loss claims can be attributed to repetitive loss properties.

Oregon is just beginning to explore the options for prioritizing funding for dams based on risk and other factors. As we get results from the risk assessment work done for the first year of the HHPD grant we will explore use of this information with dam owners and with state and federal grant programs.

Significant state and federal funding will be needed for additional analysis and repair work for at least three dams: Wallowa dam (OR00465), Big Creek # 1 dam (OR00225) and Big Creek # 2 dam (OR00473).

Based on the work that will be conducted for the FEMA High Hazard Potential Dam grant, Oregon will be considering how it might prioritize funding based on:

- Results of the formal risk assessment protocol and the risk assessment on the 16 dams.
- Review of the two floodplain management plans developed using HHPD FY 19 grant funds.
- Possible results from a legislatively directed dam safety task force proposed to deal with funding for dam safety actions.

The quantification of dam risks and affected people, property and infrastructure will be essential for prioritization of funding. The scheduled completion date for this work is April 1, 2022. This information will be available for future updates of the State and the local natural hazards mitigation plans, as will progress on funding opportunities and prioritization of dams for that funding have progressed. More work is needed to address funding for rehabilitation of state regulated dams in Oregon. The dam safety program will support this work consistent with its staffing and its legally mandated duties.

3.5.2.3 Ranking System

Oregon implements a pre-application process through which information used to determine eligibility is collected. Eligible projects are ranked based on the policy framework developed by the State Interagency Hazard Mitigation Team (IHMT) to ensure that post-disaster implementation strategies accomplish those projects that address repetitive losses, are the most cost-effective, and have the potential to quickly demonstrate success by reducing future disaster losses. In addition, communities with FEMA-approved, current 44 CFR Section 201.6 natural hazards mitigation plans will take precedence over those communities who do not have a FEMA-approved NHMP. For flood losses, structures that sustain substantial damage (whether insured through the NFIP or not) as well any structures damaged in any Presidentially declared disaster or in any wet winter in Oregon present high priority mitigation opportunities.

When convened (generally only for larger disaster declarations), the **Hazard Mitigation Grant Review Board** reviews, ranks, and determines which project applications are selected for FEMA's funding consideration.

For flood hazard mitigation proposals when the Hazard Mitigation Grant Review Board is not convened, the State Hazard Mitigation Officer and the State NFIP Coordinator (along with other relevant parties) work together to review and rank proposals using aforementioned eligibility criteria, and prioritization policy framework.

After state ranking and selection for FEMA consideration, FEMA reviews, considers, and approves (or disapproves) all FEMA-funded mitigation projects submitted by the state. Projects are first reviewed to determine if they meet all of the criteria (or could with minimal additional effort). Any projects that do not meet the eligibility criteria are set aside and not considered for funding. Eligible projects are then ranked based on priorities identified through the disaster-specific FEMA-State Hazard Mitigation Strategy report, State, and local hazard mitigation plans, and policy direction from the State IHMT. If there are more projects than dollars, the Board will select the most highly ranked projects up to 90% of the limit of the Federal Hazard Mitigation Grant Program (HMGP) lock-in. In addition, the Board may also consider the level of interest and commitment shown by sub-applicant to hazard mitigation activities and programs. Past success in mitigation does carry weight when evaluating equal projects.

3.5.3 Benefit-Cost Analysis of Natural Hazard Mitigation Projects

Mitigation activities reduce the cost of disasters by minimizing property damage, injuries, and the potential for loss of life, and by reducing emergency response costs which would otherwise be incurred. Other mitigation benefits include those of an economic nature such as maintaining utility services (for example electricity and water) when there is a loss of function as a result of the disaster. Evaluating possible natural hazard mitigation activities provides decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects. An objective benefit-cost analysis is a tool used to determine mitigation project eligibility when Federal funds come into play.

Benefit-Cost Analysis (BCA) is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs. The end result is a Benefit-Cost Ratio (BCR), which is calculated by a project’s total benefits divided by its total costs. The BCR is a numerical expression of the "cost-effectiveness" of a project. A project is considered to be cost effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs.

FEMA requires a BCA to validate cost effectiveness of proposed hazard mitigation projects prior to funding. There are two drivers behind this requirement: (1) the Office of Management and Budget’s (OMB) Circular A-94 Revised, “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs” and (2) the Stafford Act.

The goal of Circular A-94 is to promote efficient resource allocation through well-informed decision-making by the Federal Government. FEMA’s BCA Toolkit has been developed to meet the guidelines published in Circular A-94.

Applicants and subapplicants must use FEMA-approved methodologies and tools to demonstrate the cost-effectiveness of their projects. FEMA has developed the BCA Toolkit to facilitate the process of preparing a BCA. Using the BCA Toolkit will ensure that the calculations are prepared in accordance with OMB Circular A-94 and FEMA's standardized methodologies. It is imperative to conduct a BCA early in the project development process to ensure the likelihood of meeting the cost-effectiveness eligibility requirement.

The BCA Toolkit consists of modules for a range of major natural hazards and project types including:

- Flood
- Tornado Safe Room
- Hurricane Wind
- Hurricane Safe Room
- Earthquake
- Wildfire

- Drought
- Landslide

On July 23, 2019, FEMA released the BCA Toolkit Version 6.0. Version 6.0 replaces previous versions of the BCA Toolkit with the exception of the seismic building retrofit BCAs (see note below).
Some major features of Version 6.0 include:

- Excel-based platform
- Compatible with both Windows and Macintosh operating systems
- Streamlined user interface and improved user experience
- Reduction in the number of manual-input data fields
- Improved help content
- Improved report formatting

A non-FEMA BCA methodology may only be used when it addresses a non-correctable flaw in the FEMA-approved BCA methodology or it proposes a new approach that is unavailable using the FEMA BCA Toolkit. The non-FEMA methodology must be approved by FEMA in writing prior to submission of the project application to FEMA.

The Greatest Savings to the Fund (GSTF) approach is no longer allowed to determine cost-effectiveness for Severe Repetitive Loss (SRL) properties.

3.5.3.1 Oregon Seismic Rehabilitation Grant Program: Oregon BCA Tool

Because Federal funding is not incorporated into the state-funded seismic retrofit program, the state is not obligated to use either the FEMA-prescribed BCA software or explicitly meet the requirements of OMB Circular A-94. However, standard methodologies and refinements to the FEMA BCA software provided a basis for the development of the Oregon BCA Tool.

The Oregon Office of Emergency Management created the Oregon BCA Tool for use by local jurisdictions when applying for state-sponsored mitigation funding through OEM programs such as the Seismic Rehabilitation Grant Program (SRGP). The Oregon BCA Tool uses detailed, USGS data specific to Oregon. The SRGP-based BCA tool was developed using methodologies from the FEMA BCA Tool at the time but with an emphasis on being tailored for Oregon projects (seismology, soil conditions, and building types) and an improved user interface. DOGAMI completed a Statewide Seismic Needs Assessment in June 2007, a key component in developing the Oregon SRGP BCA Tool. This assessment of school buildings and public safety facilities included a rapid visual screening (RVS) of such buildings and a ranking of these screenings based on need and risk. With the legislative authority to develop and implement the Oregon SRGP in 2009, BCA’s were required to be performed as prescribed by OEM. A draft Oregon BCA Tool was completed in October 2009 and a finalized public version released in June 2010, which was the first year the applications were solicited and funded. Seismic benefits calculated by FEMA’s most current BCA tool (4.8 and now 5.0) still seem to be undervalued, making it difficult for most seismic mitigation projects to meet the Federal BCA eligibility test. The SRGP will continue to use the Oregon-specific BCA tool for seismic projects.

For the Oregon Seismic Rehabilitation Grant Program, the following categories of damages and losses are considered:

- building damages,
- contents damages,
- displacement costs for temporary quarters,
- loss of public services, and
- casualties (deaths and injuries).

Benefit-cost analysis requires several types of input data, which requires quantitative assessments of the following factors:

- level of seismic hazard at the building's location,
- vulnerability of the building and contents to damage in future earthquakes,
- values of the building and contents,
- costs for temporary quarters if the building must be vacated for repair of future earthquake damage,
- value and importance of the public services provided from the building, and
- number of occupants in the building.

To compare future benefits with the present costs of seismic retrofits, the calculated future benefits of retrofitting are adjusted to net present value, taking into account the time-value of money. These calculations are done automatically by the Oregon BCA Tool, based on standardized assumptions about the useful lifetime of the project and the "discount rate" which reflects the time-value of money.

For benefit-cost analyses of seismic mitigation projects for the Oregon Seismic Rehabilitation Grant Program, a standard useful lifetime of 50-years and a discount rate of 2% are built into the Oregon BCA Tool. The Oregon BCA Tool does all of the many complicated calculations necessary for benefit-cost analysis automatically. The user must only enter the specified building-specific information in the designated cells in the spreadsheet.

For the Oregon Seismic Rehabilitation Grant Program, benefit-cost results are an important part of the evaluation and ranking process, but are not the sole determinant of whether or not a given project will be selected for funding. In some cases where other non-BCA factors are more important in final project selection, projects with benefit-cost ratios below 1.0 may be considered for funding.

3.6 Local Plan Integration

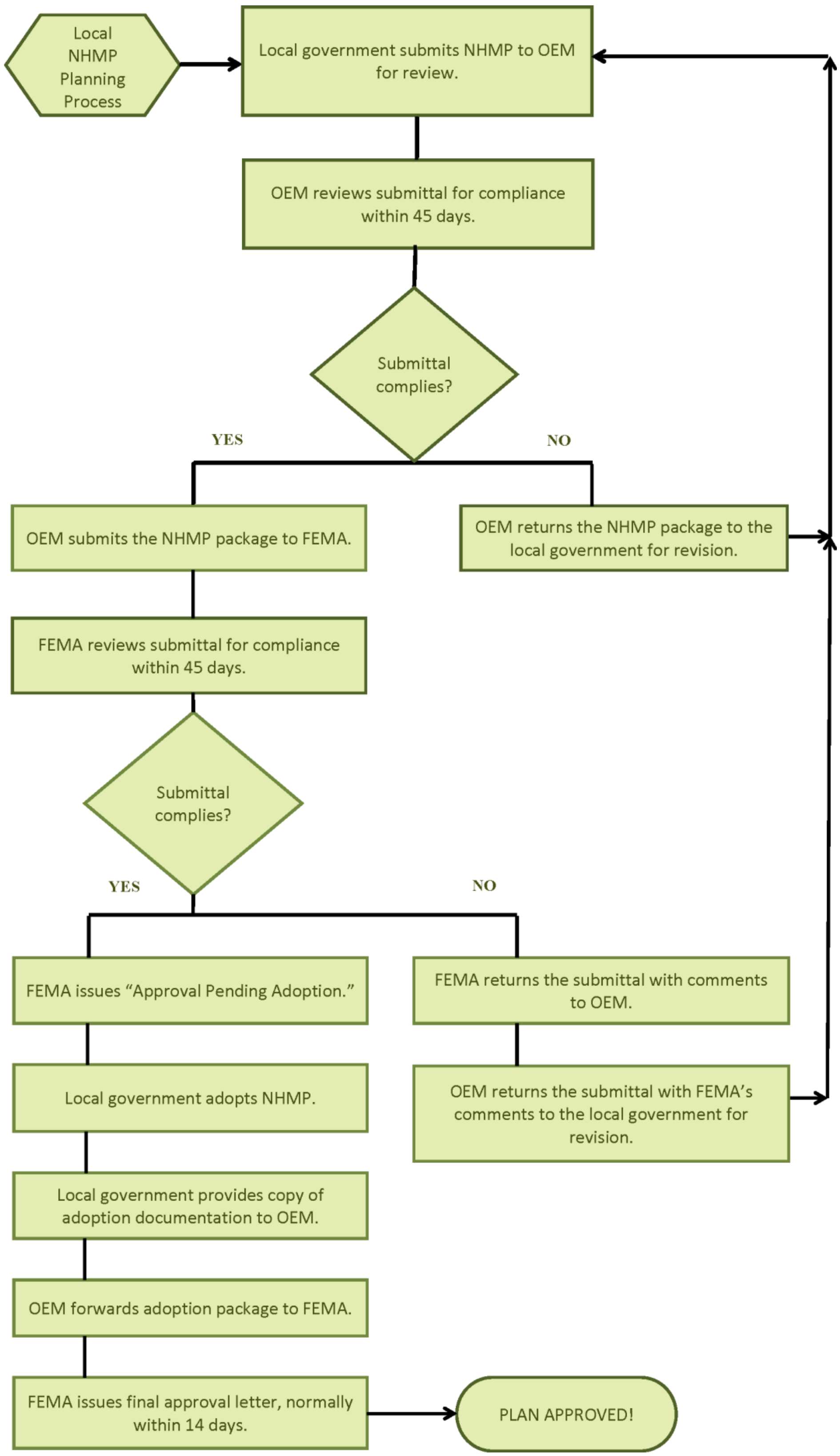
3.6.1 State Review of Local Mitigation Plans

Oregon is responsible for reviewing local jurisdictions' NHMPs prior to submittal to FEMA for review and approval (**Figure 3-4**). Once a local jurisdiction has completed a draft plan, it submits the plan to the OEM for review. If OEM finds that the draft plan does not meet all FEMA requirements, it returns the draft to the local jurisdiction for revision. Once OEM is satisfied that the draft plan is approvable, it forwards the draft to FEMA for review. Because of OPDR's extensive experience assisting local jurisdictions with developing NHMPs, the State delegates its review function to OPDR for those plans with which it assisted, and OPDR forwards approvable plans directly to FEMA for review.

If FEMA finds deficiencies, it returns the draft to OEM or OPDR which in turn returns it to the jurisdiction for revision. Once OEM or OPDR and FEMA are satisfied that the draft is approvable, FEMA issues *Approved Pending Adoption* (APA) status by letter to the highest elected official of the local jurisdiction. At this point, the local jurisdiction adopts its NHMP, usually by resolution, and sends a copy of the resolution and adopted NHMP to OEM or OPDR. OEM or OPDR verifies that the NHMP has not changed substantively since APA status was conferred, and forwards the adopted NHMP and resolution to FEMA. Upon receipt and verification that the NHMP has not changed substantively, FEMA issues final approval, again by letter to the highest elected official of the local jurisdiction.

In many cases, two or more local jurisdictions collaborate to develop a multi-jurisdictional NHMP. Most often this collaboration is among a county and some or all of its cities. In these cases, the county plan is primary, and the cities' plans are addenda to the county plan. The same process is followed, but the county adopts and receives final approval from FEMA first, then the cities follow suit. All jurisdictions that are parties to the plan receive the same effective date as the county.

Figure 3-4. State Process for Reviewing Local Mitigation Plans



3.6.2 Linking State and Local NHMPs

Since the 2015 Oregon NHMP update, DLCD has taken the lead role in assisting local governments (and one tribe to date) with developing and updating NHMPs and OPDR has stepped back, taking on fewer. OEM still assists special districts that are not part of a multi-jurisdictional planning effort, but not in quite the same manner. In addition, some local governments develop and update their plans in-house, occasionally a Council of Governments assists, and occasionally a consultant or consulting firm is retained. Approach, data availability, and planning and analytical expertise vary widely. Gathering, analyzing, and coalescing this disparate collection of risk assessments, goals, and mitigation actions into a coherent statewide mitigation strategy embodied by the Oregon NHMP is a challenge indeed, and the State has begun advancing toward this goal.

During the 2015 update, the State determined that the first step toward coordinating state and local mitigation planning would be to assess the general degree to which state and local mitigation goals were aligned or divergent. To that end, Oregon's 36 county-level NHMPs were reviewed to:

- Discern, if possible, whether the state NHMP goals were considered in developing local NHMP goals;
- Determine to what extent local and state NHMP goals are correlated; and
- Identify county-level goals that are not reflected in the Oregon NHMP.

We found that counties usually do review the State's goals to inform their own. However, county NHMPs do not consistently reference their review of the State goals in an explicit manner. In some cases two or more State goals are combined into one local goal.

Further, we found that about half of the State's goals at the time were reflected in local goals, and that several goals that appeared in a number of local NHMPs were not reflected in the State's NHMP. The State added three goals to enhance coordination.

As a result, when assisting local governments with NHMPs, DLCD, OPDR, and OEM have made it a point to review not only the Oregon NHMP's goals, but also mitigation actions and other information for incorporation into local plans.

Most jurisdictions in Oregon use data available from state and federal agencies and in some cases universities as well as any local data sources for their risk assessments. In recent years, FEMA has supported development of local risk assessments of the seven mapped hazards (coastal erosion, earthquakes, floods, landslides, tsunamis, volcanic hazards, and wildfires) through the Risk MAP program. We have been mostly successful in coordinating the funding cycles and preliminary studies to be able to have the risk assessments done for the jurisdictions next in line for NHMP updates and ready at or near the beginning of the mitigation planning process. This work is foundational for these jurisdictions' risk assessments providing a level of data and analysis that is otherwise unavailable. The State's vision is for this partnership to continue in a manner similar to the NHMP update cycle, so that over time all local jurisdictions have the benefit of this work for their NHMP updates. Then the cycle would renew and continue, bringing new and enhanced data to each update.

Similarly, the State has been using a small portion of FEMA planning grants to contract with OCCRI to provide assessments of the impacts of climate change on natural hazards at the county level for local NHMPs. This work has been very well received by local NHMP Steering Committee members and has been valuable in assessing changing future conditions. Because the climate change assessments are more easily tailored to each county, they address not only the seven mapped hazards but others as well. Again, the State's vision is for this partnership to endure, continuing to enhance our understanding of the effects of climate change on the frequency, intensity, and emergence of natural hazards.

Chapter 2.1.2 discusses the history of the Oregon NHMP's risk assessment and describes the attempt with this 2020 update to analyze the hazards together with the vulnerabilities to arrive at an assessment of risk. This pilot effort, although narrow and imperfect, was useful. It confirmed that we need a more sophisticated and robust methodology, and we need to close our data gaps to have the information necessary to produce solid results.

To coordinate and integrate local risk assessments into the state risk assessment, especially as the State continues to advance its risk assessment methodology and fill data gaps, is complex. FEMA continuing to support the State's production of local risk assessments through the Risk MAP program is key because the data sources and methodology used are the same as or closely aligned with those available for the state's risk assessment. Right now, there are not enough state-produced local risk assessments to meaningfully inform the state risk assessment, but as more and more of them are produced, we will be able to create a statewide picture of risk at a fine-grained local scale.

The first step is to collect all local NHMPs with their existing state-produced and locally produced risk assessments. DOGAMI is in possession of the state-produced risk assessments. The locally produced risk assessments would need to be analyzed for data sources, methodology, and compatibility with each other and with the state's data sources and methodology to determine how best to incorporate them into the state risk assessment.

Collecting the latest NHMPs, finalizing them with a cover, effective dates, and approval letters, storing them in a repository where they will be readily available to the public is a project the state is anticipating to return to and complete in Fall 2020. This aligns with the first step of coordinating state and local risk assessments.

Completed NHMPs and state-produced risk assessments will be collected quarterly in conjunction with the plan maintenance process described in Section 4.3.2; tracked by OEM and DLCD; and analyzed by DLCD with assistance from other IHMT members. As the state further develops its risk assessment methodology, we will determine how best to incorporate the locally produced risk assessment information. The goal is to have an improved state risk assessment methodology incorporating all state-produced local risk assessments and the information that can be incorporated from locally produced risk assessments at the three-year mark in the life of the 2020 Oregon NHMP. We will begin the 2025 update with this information.

As NHMPs are collected, the mitigation goals along with attributes (to be determined) will be entered in a database. The database will be available to local governments and will yield useful information about characteristics and trends of local NHMP goals statewide. This will help the IHMT determine whether local mitigation goals are connected to local risk assessments; the degree of similarity or disparity among them; and the degree of alignment with state mitigation goals. That information can be used to work with local governments to improve local NHMPs as well as more closely connecting state and local mitigation goals.

It has long been the State's desire to develop a mitigation action tracker for use by state and local governments to better coordinate mitigation planning. With the systematic collection of NHMPs, a database of mitigation actions can become a reality. It can be joined with or separate from that for mitigation goals. With access to the database, local governments can glean ideas for actions; coordinate their local actions with the State's actions; or identify potential intergovernmental partnerships. The State can gain an understanding of local governments' mitigation priorities and more closely connect local and state mitigation activities. This would also be a way to identify potential mitigation projects for grant applications.

Further, the mitigation action database could be designed to include relevant information from related programs and projects, for example the Climate Change Adaptation Framework, advancing integration with statewide plans and initiatives, encouraging local integration as well, and supporting the State's eventual return to enhanced plan status.

At the three-year mark in the life of the 2020 Oregon NHMP, the IHMT will discuss what we have learned from the databases and apply that knowledge to the 2025 update. The IHMT will also share that information and how the State is using it with local governments.

Chapter 4 PLANNING PROCESS

In This Chapter

The Oregon NHMP Planning Process is divided into three sections: (a) Introduction, (b) Developing the 2020 Plan, and (c) Maintaining the 2020 Plan.

1. **Introduction:** States the purpose of this chapter.
2. **Developing the 2020 Plan:** Describes the participants and details the 2020 Plan development process. Demonstrates how the 2020 Oregon NHMP is integrated with other State, regional, and federal initiatives. Includes a table identifying changes from the 2015 Plan.
3. **Maintaining the 2020 Plan:** Analyzes the efficacy of the method and schedule for monitoring, evaluating, and updating the 2015 Oregon NHMP and establishes a method and schedule for monitoring, evaluating, and updating the 2020 Oregon NHMP. Summarizes how mitigation measures and project closeouts will be monitored. Identifies a system for reviewing progress toward achieving Plan goals and mitigation actions. Describes how the mitigation action tables are used to show whether mitigation actions in the 2015 Oregon NHMP were implemented as planned.

4.1 Introduction

44 CFR §201.4(b), Planning process. An effective planning process is essential in developing and maintaining a good plan. The mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, interested groups, and be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.

The Disaster Mitigation Act of 2000 (44 CFR 201) had required that states update their multi-hazard mitigation plans every 3 years to maintain eligibility for federal disaster assistance. Effective May 27, 2014, amendments to 44 CFR 201 changed the state mitigation planning update cycle from 3 to 5 years. Oregon first completed a Natural Hazards Mitigation Plan (Oregon NHMP or Plan) in 1992 with subsequent updates occurring in 2000, 2004, 2006, 2009, 2012, 2015, and now 2020. The purpose of this chapter is threefold:

- To describe the process used to develop the 2020 Oregon NHMP,
- To describe the process to be used for tracking progress on mitigation activity and goal achievement during the life of the 2020 Plan, and
- To describe the method and schedule for monitoring, evaluating, and updating the 2020 Plan.

4.2 Developing the 2020 Plan

Requirement 44 CFR §201.4(c), Plan content. To be effective the plan must include the following elements:

Requirement 44 CFR §201.4(c)(1) Description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.

The purpose of this section is to describe the process used to develop the 2020 Oregon NHMP. Key meetings, participants, decision points, interagency coordination, and public outreach efforts are described. In addition, other state and federal planning efforts with which the 2020 Plan is integrated are identified, as are the sections of the 2015 Plan that were revised.

4.2.1 Participants and Coordination

The State Interagency Hazard Mitigation Team (IHMT)

Prior to the spring of 1996, what is today the State IHMT was an informal group of state agencies whose representatives met on an ad hoc basis following Presidentially declared disasters. On March 4, 1997, in response to the floods and landslides of the autumn and winter of 1996-1997, Governor Kitzhaber directed OEM to make the State Interagency Hazard Mitigation Team a permanent body with regular meetings. The State Hazard Mitigation Officer, housed in OEM, chairs the State IHMT. Today the State IHMT meets quarterly to understand losses arising from natural hazards; to recommend and coordinate strategies to mitigate loss of life, property, and natural resources; and to maintain the Oregon NHMP.

State IHMT member agencies:

- Business Oregon — Infrastructure Finance Authority
- Oregon Climate Change Research Institute and Oregon Climate Service
- Oregon Department of Administrative Services — Chief Financial Office
- Oregon Department of Administrative Services — Enterprise Asset Management
- Oregon Department of Administrative Services — Geospatial Enterprise Office
- Oregon Department of Agriculture
- Oregon Department of Consumer and Business Services — Building Codes Division
- Oregon Department of Consumer and Business Services — Division of Financial Regulation
- Oregon Department of Energy
- Oregon Department of Environmental Quality
- Oregon Department of Fish and Wildlife
- Oregon Department of Forestry
- Oregon Department of Geology and Mineral Industries
- Oregon Department of Land Conservation and Development
- Oregon Department of State Lands
- Oregon Department of Transportation
- Oregon Health Authority — Health, Security, Prevention, and Response Program
- Oregon Health Authority — Public Health Division
- Oregon Military Department — Office of Emergency Management
- Oregon Parks and Recreation Department – Stewardship Division

- Oregon Parks and Recreation Department – Heritage Programs Division
- Oregon Public Utility Commission
- Oregon State Police — Office of State Fire Marshal
- Oregon Water Resources Department
- Oregon Water Resources Department – Dam Safety Program
- Oregon Watershed Enhancement Board
- University of Oregon — Emergency Management and Continuity
- University of Oregon — Oregon Partnership for Disaster Resilience

State IHMT meetings are open to the public, and representatives from non-state IHMT agencies and organizations are added as needed. Representatives of several interested federal agencies (including FEMA) are invited to participate. In particular, the Army Corps of Engineers sponsors the Silver Jackets which is an officially recognized sub-committee of the State IHMT. Each IHMT meeting includes a standing agenda item for topics related to the Oregon NHMP.

State IHMT agencies provided staff and other resources to accomplish the update. State IHMT agency Hazard Leads are listed in **Table 4-1**.-DLCD managed and facilitated the update process with oversight from the State IHMT, guidance from FEMA, and in close cooperation with OEM and the State Hazard Mitigation Officer, and DOGAMI. Other state agencies also contributed substantively and substantially to the update.

Table 4-1. State IHMT Hazard Lead Agencies

Hazard	Lead Agency	Support Agency
Climate Change	Oregon Climate Change Research Institute	Department of Land Conservation and Development
Coastal Hazards	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Droughts	Oregon Water Resources Department	Oregon Climate Change Research Institute
Earthquakes	Department of Geology and Mineral Industries	Oregon Office of Emergency Management
Extreme Heat	Oregon Climate Change Research Institute	Oregon Health Authority
Floods ▫ Dam Safety	Department of Geology and Mineral Industries Oregon Water Resources Department Dam Safety Program	Department of Land Conservation and Development
Landslides	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Tsunamis	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Volcanoes	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Wildfires	Oregon Department of Forestry	Oregon Department of Forestry Oregon State Police, Office of the Fire Marshal
Windstorms	Oregon Public Utility Commission	Oregon Climate Change Resource Institute
Winter Storms	Oregon Department of Land Conservation and Development	Oregon Climate Change Research Institute

Source: DLCD

While not an exhaustive recitation of all the contributions by all who participated, the following provides some highlights of the coordination, cooperation, and collaboration that resulted in the 2020 Oregon NHMP.

The hazard characterizations and probability and vulnerability assessments were reviewed and revised by subject matter experts (SMEs) from State IHMT agencies and the Oregon Climate Change Research

Institute (OCCRI). The coastal hazards, earthquakes, landslides, tsunamis, and volcanic hazards chapters were all reviewed and updated by DOGAMI. The flood hazard chapter was reviewed and updated collaboratively by DOGAMI and DLCD. The new Dam Safety portion of the flood hazard chapter was authored by OWRD. OCCRI and OWRD collaboratively reviewed and updated the drought chapter. OCCRI authored the new extreme heat chapter and OHA contributed context, the public health perspective, and additional content. ODF reviewed and updated the wildfire chapter. OPUC and OCCRI both reviewed and updated windstorms chapter. The winter storms chapter was reviewed and updated by DLCD and OCCRI.

The probability analyses in particular were approached differently for this update to facilitate incorporation into the 2020 risk assessment methodology. ODF provided the wildfire probability analysis for the 2020 risk assessment and the wildfire hazard data that DOGAMI used to perform the wildfire exposure analysis. DLCD provided the CDC's social vulnerability index that was used for one element of vulnerability in the 2020 risk assessment.

Information about state-owned and leased buildings and critical/essential facilities as well as impacts of hazard events on them was provided by DAS. The former was analyzed for potential loss and reported by DOGAMI; the latter was analyzed by DLCD for additional vulnerability information. DOGAMI and DLCD established a list of local critical facility types that DOGAMI located and analyzed for potential loss. These analyses were used together with the Center for Disease Control's social vulnerability index to as the vulnerability element of the 2020 risk assessment methodology.

OPRD performed an exposure analysis of archaeological resources with respect to coastal erosion, earthquakes, floods, and landslides; technical difficulties precluded analysis with respect to tsunamis, volcanic hazards, and wildfires. These are the first analyses of exposure of cultural and historic resources to natural hazards to be included in the Oregon NHMP.

OCCRI updated the Introduction to Climate Change section that it debuted in the 2015 Oregon NHMP and in addition to the contributions previously described, lent expertise in the areas of climate (Community Profiles), coastal hazards, drought, extreme heat, floods, wildfires, windstorms, and winter storms – all hazards influenced by climate change. OHA contributed to the extreme heat chapter and to questions of extreme heat impacts, for the first time bringing the public health perspective to the Oregon NHMP.

ODOT provided information about seismic lifelines and climate change impacts to transportation infrastructure. The Local Capability Assessment, Coordination of Local Mitigation Planning, and Funding sections were reviewed and revised by OEM and DLCD using information provided by their own and other agencies. The Regional Profiles were updated by DLCD, with particular attention to and enhanced analysis of the demographic, economic, and built environment sections. Housing is addressed in the demographic and built environment sections. Goals and mitigation actions were reviewed, evaluated, revised, and prioritized by State IHMT agency representatives.

The State applied for and received a FEMA High Hazard Potential Dams grant to undertake risk assessments and related work concerning state-regulated dams. The grant required that high hazard potential dams be addressed the same way the eleven recognized natural hazards are addressed. As the State has not to date considered dam safety a natural hazard, and as it is primarily associated with flood hazards, the State has met this requirement by incorporating dam safety into the state and regional flood hazard risk assessment sections and into other relevant chapters of the Oregon NHMP. The Dam

Safety risk assessments mimic the structure of the eleven state-recognized natural hazard risk assessments, effectively treating it as a twelfth natural hazard, but without a discrete chapter.

The Oregon Dam Safety Program (DSP) is housed in the Oregon Water Resources Department (OWRD). OWRD-DSP participated in the 2020 Oregon NHMP update as lead author of the sections related to dams, providing expertise, data, studies, and other information on Oregon's dams. Data used for these sections included the National Inventory of Dams and the State dam safety database and files, including design and inspection documentation and history. OWRD-DSP also participated in development, review, and prioritization of mitigation goals and actions.

The Silver Jackets, a U.S. Army Corps of Engineers program is implemented in Oregon as a sub-committee of the State IHMT. It brings together a number of federal and State agencies and has been instrumental in moving flood hazard mitigation forward during this update cycle. This is an active, successful, ongoing forum for federal and State collaboration and coordination.

A new initiative during this period is the establishment of another officially recognized sub-committee of the IHMT, the Oregon Landslide Risk Reduction Team (OLRRT) led by DOGAMI. The OLRRT facilitates collaboration between the many entities with a role in reducing landslide risk in Oregon – state and federal agencies, university researchers, cities, counties, private consultants, and others – to protect natural resources and water quality, land use, transportation, and public safety.

During the 2015 Oregon NHMP update, DLCD found that the state does not have a system to track changes in land use over time, and began an initiative to develop one. With funding from DAS-GEO, one of the state's Framework Implementation Teams, comprising GIS staff and users across all levels of government who develop datasets to an adopted standard and share and maintain them, launched a pilot. The Team found that there was broad support and need for this information, but the result was that the methodology tested did not work well for both urban and rural areas. Two years later, a second pilot was funded through the same program, and this time the tested methodology had a more promising outcome. DAS-GEO provided a third grant which is currently funding development of a land use GIS layer that can be used with other Framework GIS data to analyze land use for a wide variety of use cases, not least of which is Oregon NHMP updates. This work builds on what we have learned from the first two pilots and implements the project statewide. We are hoping that this effort will be successful in establishing an initial, baseline GIS land use layer and that we will have the means to update it and identify changes to land use for the 2025 Oregon NHMP.

4.2.2 The Planning Process

The primary focus of this plan update was to improve the risk assessment by developing a single methodology to assess risk across all hazards statewide and use the results to inform and guide mitigation goals and actions. The goal was to connect hazard and vulnerability assessments to describe risk in a way that would identify the where and on which hazards the state should focus its mitigation efforts. During the 2015 Plan update process, the IHMT working with the University of Oregon Infographics Lab had developed such a concept methodology, but several attempts to fund development were unsuccessful. Therefore, to move forward the State needed to identify a simpler methodology that would be able to be implemented with a limited budget. A fair amount of time and effort was spent during the early part of the update process on researching and discussing what could be done. A full description of the 2020 Risk Assessment methodology pilot is located in Section **2.1.2**.

Another focus of the 2020 update was to coordinate with the simultaneous update of Oregon's 2010 Climate Change Adaptation Framework (CCAF) and integrate the two documents to the extent possible. Both efforts were led by DLCD, facilitating coordination. Similar to the Oregon NHMP update, the CCAF update was a collaborative effort by a large number of state agencies. In fact, all but a few state agencies participating in both efforts were the same, and some staff were assigned to both projects. The Oregon Climate Change Research Institute was involved in both efforts, and sponsored a workshop in August 2019 to ensure that both projects had the same access to the same best available science. Due to the organic nature of the planning process and the project's political sensitivity, the original vision for the updated CCAF has been modified several times over the course of the project and the project schedules have diverged. Therefore, the CCAF is not yet ready for full integration with the Oregon NHMP. The Oregon NHMP does include a goal addressing climate change adaptation and several mitigation actions from the CCAF, and the current review draft is provided in Appendix **9.1.23**. The State's intention is still to integrate the two documents when the CCAF update is complete.

Another benefit of the coordination with the CCAF update is the incorporation of an equity lens in the Oregon NHMP goals. Governor Brown has brought the issue of equity to the fore, and all state agencies are working to incorporate it into their work. OHA's Climate and Health Program staff, who also contributed to the Oregon NHMP, led the equity work for the CCAF update. This link further underscores the relationship between the CCAF and the NHMP and has nourished the working relationships among DLCD's SMEs and OHA's.

Further, social vulnerability is central to OHA's public health work, including that of the Climate and Health Program. Social vulnerability is also a core element of vulnerability to natural hazards. The IHMT's interest in social vulnerability was addressed in the 2020 risk assessment for the first time. The University of South Carolina is the national leader in social vulnerability research and has developed a social vulnerability index. The Centers for Disease Control has used the University's work to develop its own index. Both are based on the Census Bureau's data. OHA uses the CDC's index. Therefore, in the spirit of coordination, integration, and collaboration, DLCD chose to use the CDC's index in the 2020 risk assessment. This will facilitate interagency coordination around issues of social vulnerability and equity.

During the 2015 Plan update, DLCD engaged staff at OEM and OPRD who were working on historic and cultural resource issues and invited their participation in the Oregon NHMP update. At the time, both agencies were actively engaged in and had requested additional funding for advancing mitigation of potential damage to cultural and historic resources. Together they penned a vision for the program located in the section of the 2015 Oregon NHMP entitled "Future Enhancements." The funding was not received and both staff moved on. OEM determined not to continue that position, but OWRD has, and has taken on the leadership role. For the 2020 update, DLCD approached not only that staff, but also the historic preservation lead and a staff archaeologist to try to incorporate historic and archaeological resources into the risk assessment. The result was that the first exposure analyses for these resources was performed for this update.

The 2020 Oregon NHMP update officially began with DLCD presenting the project, timeline, and next steps at the IHMT meeting of October 2017. During the 2015 Plan update, DLCD not only discovered issues with the risk assessment methodology, but also heard participants' ideas about changing the hazards that are addressed in the Plan and how they are addressed, potentially emphasizing some hazards over others. In November 2017, DLCD followed up with a survey to find out where the IHMT members stood on these issues and how willing or able they were to engage in the effort to develop a new risk assessment methodology. Meetings in January and February 2018 culminated in these decisions presented at the April 2018 IHMT meeting:

- **Dust Storms** would be dropped from the Plan as it has been well addressed largely through implementation of best practices in land tilling techniques. While dust storms still do occur and do result in fatalities, they are far fewer and are no longer considered a major hazard. In addition, there is very little data available about dust storms with which to develop a risk analysis or mitigation goals and actions.
- **Extreme Heat** would be added to the Plan. As temperatures, drought and wildfire are increasingly experienced across the state, and several local governments have included it in their plans, the participants felt it was time to include extreme heat in the State Plan.
- **Climate Change** would not be included as a discrete hazard in the 2020 Plan, but would be addressed as an influence on other hazards. As concern about climate change is rising, data is evolving, and the state is experiencing changes in the frequency, duration, and intensity of coastal hazards, droughts, floods, wildfires, windstorms, and winter storms, the participants felt that it was important to address how climate change affects the presentation of these hazards across the state.
- **Dam Failure** would be addressed as a type of flood hazard, but not in great detail as it is not a natural hazard.
- **Channel Migration** would also be discussed as a type of flood hazard. The State has developed data about channel migration susceptibility statewide, but the participants felt that there was not yet enough information to treat it as a separate hazard. As the state develops more information about channel migration, this decision will be revisited.
- **Other Hazards.** Radon, sea level rise, ocean acidification, high surf, extreme cold, and air quality were other natural hazards considered for treatment as discrete hazards in the Plan, but ultimately determined to be best addressed under other hazards, addressed outside of the NHMP, or not addressed.
- **Prioritizing Hazards.** Emphasizing or prioritizing some hazards over others was fraught with questions and tabled for further, future discussion.

The State Resilience Officer assisted DLCD by sponsoring a meeting for the directors of the IHMT state agencies. The purpose of the meeting was to explain the 2020 Oregon NHMP update – its purpose and benefits, the work required, and the timeline – and to gain their support by assigning staff and budgeting for participation in the update. The meeting was held at the end of June 2018, good timing in the state's biennial budget process. The State Resilience Officer, OEM and DLCD leadership, management, and staff all presented and participated in the discussion. It appeared to have been a successful meeting. DLCD reported on it at the IHMT's July meeting.

Over the next number of months, DLCD spent time researching options for a new risk assessment methodology. Finally settling on a very simple method, DLCD approached DOGAMI for assistance with the necessary analyses (including the loss estimation which would be used in the vulnerability part of the method). DOGAMI is equipped to do hazard analyses for geologic hazards: coastal erosion, earthquakes, floods, landslides, tsunamis, and volcanic hazards. Using wildfire data provided by ODF DOGAMI is able to perform the same analyses for wildfire hazards. Because we do not have mapped hazard areas or sufficient data for drought, extreme heat, windstorms, or winter storms, the method was not able to be used to evaluate them. However, at the end of the process, we did add a qualitative assessment of these four hazards to see how it might affect the risk assessment overall.

Also during this time, DLCD presented about the 2020 Oregon NHMP update at a meeting of the Intergovernmental Cultural Resource Council in November 2018. DLCD's agency representative to the Tribes Cultural Resource Cluster and the Government to Government Natural Resources Working Group presented on it to those groups at meetings in February 2019.

Due to administrative issues, DOGAMI was unable to engage when approached for several months. Other participants were also very busy and it was difficult to schedule large meetings to address elements of the plan together. DLCD determined that it would be best to work with participants individually. As could be expected, some were more available and engaged than others and we moved forward slowly in gathering the data and information needed for the portions of the plan outside of the risk assessment and mitigation goals and actions. DOGAMI did provide a data sharing platform to facilitate the update and participants were given access and the materials they needed to provide assistance in their areas of expertise. This worked very well.

DOGAMI was finally able to engage at what would normally have been the final months of the process. This meant that all the risk assessment work and dependent mitigation goals and action reviews and prioritization had to be accomplished very quickly. At the same time, the state suffered several disasters that were severe enough to warrant Presidential declarations and usurped participants' ability to engage and produce documentation. One of these Presidential declarations was for the novel coronavirus pandemic. In the middle of March 2020 all executive branch offices closed and staff pivoted to working from home and using electronic meeting platforms to conduct business. All of this greatly strained the plan update process and timeline.

The state and regional risk assessment sections of the 2020 Oregon NHMP were posted for public review on DLCD's website in June 2020. During the public review period, the IHMT participated in an online survey to review, revise, and prioritize mitigation goals and actions. Results are discussed in Section **3.3.1**. Following that, the mitigation strategy was posted for public review on DLCD's website in July 2020. DLCD advertised both public comment periods far and wide using a variety of tools. DLCD sent emails to the planning and emergency management directors of our neighboring states, Washington, Idaho, and California. DLCD emailed Oregon emergency managers including those of the nine federally recognized tribes in Oregon, county commissioners and judges. The Association of Oregon Counties notified county planning directors. DLCD also emailed the CCAF update participants, IHMT members and interested parties, the Resilience Mitigation Advisory Committee led by the State Resilience Officer, and other staff engaged in hazard-related internal efforts. DLCD notified the Silver Jackets and requested their review. DLCD also sent notices via listservs maintained of people interested in natural hazards issues including the Plan update and floodplain managers. In addition, the League of Oregon Cities notified city mayors and planning directors, and included notice of the comment periods in their weekly newsletters that reach over 6,500 people. Letters were mailed to the nine federally recognized tribes in Oregon, advising them of opportunity to consult with DLCD. DLCD received a number of comments, each of which has received a response. Comment and response matrices are included in Appendix **9.3.1**and Appendix **9.3.2**, respectively.

In reviewing these drafts, FEMA alerted DLCD to an oversight: mitigation actions were not evaluated against the required criteria of cost-effectiveness, environmental soundness, and technical feasibility. Because the mitigation actions held over from the 2015 Plan had been evaluated according to these criteria, only the new, priority actions were subjected to this review by IHMT members in a second online survey. Results are noted in Section **3.3.1**.

In the summer of 2019, DLCD became aware that OWRD was applying for FEMA's High Hazard Potential Dams grant and toward the end of the summer more aware of the fact that a Dam Safety chapter would be required to be included in the 2020 Oregon NHMP. This was a new, unanticipated workload and the NHMP requirements, their breadth and depth, were new to OWRD Dam Safety Program staff. Also the deadline for incorporating the new work into the Oregon NHMP was about a week prior to the deadline for completing the NHMP update. During the summer of 2020, FEMA determined that incorporating the dam safety material into the still current 2015 Oregon NHMP would meet the grant requirement, and we chose to pursue that avenue. Dam Safety Program staff rose to the challenge, developing the data, information, and mapping necessary for the plan; developing mitigation goals and actions pertinent to dam safety; participating in the review and revision of mitigation goals and actions; assisting with answers to FEMA's and the public's comments pertaining to dam safety in the risk assessment and mitigation strategy sections; and being generally responsive to DLCD's questions and requests.

Another issue that affected the 2020 Plan update was FEMA's decision that the 2020 Oregon NHMP would not be approved as an enhanced plan. Whether the Plan would still be submitted as an enhanced plan was an open question until toward the end of the planning process when it was determined that it would be submitted as a standard plan. This eased the pressure a bit by eliminating some requirements. However, this was balanced by the need to develop the Dam Safety section in the 2020 Oregon NHMP and have it incorporated into the 2015 NHMP prior to the NHMP update deadline.

With tremendous patience, understanding, and flexibility, FEMA worked with DLCD and OEM to complete the plan update in a timely manner.

4.2.3 Revisions to the 2015 Oregon Natural Hazards Mitigation Plan

Table 4-2. Revisions to the 2015 Oregon Natural Hazards Mitigation Plan

2015	2020	Explanation
Chapter 1: Introduction to the Plan	**Chapter 1: Introduction to the Plan**	Reviewed and revised. Enhanced Plan section explains that Chapter 5, Enhanced Plan is retained in placeholder status since Oregon intends to regain enhanced plan status during the life of the 2020 Oregon NHMP.
Chapter 2: Risk Assessment	**Chapter 2: Risk Assessment**	
2.1 Introduction	2.1 Introduction	Expanded to include seven sections that have been reviewed and revised from the 2015 Plan: • Overview; • 2020 Risk Assessment Methodology; • Social Vulnerability; • Introduction to Climate Change; • State-Owned/Leased Facilities, State Critical Facilities, and Local Critical Facilities Potential Loss Assessment; • Seismic Transportation Lifeline Vulnerabilities; • Cultural Resources

2015	2020	Explanation
2.2 State Risk Assessment 2.2.1 Oregon Hazards 2.2.2 Oregon Vulnerabilities 2.2.3 Future Enhancements to the State Risk Assessment	2.2 State Risk Assessment 2.2.1 Coastal Hazards 2.2.2 Droughts 2.2.3 Earthquakes 2.2.4 Extreme Heat 2.2.5 Floods 2.2.6 Landslides 2.2.7 Tsunamis 2.2.8 Volcanoes 2.2.9 Wildfires 2.2.10 Windstorms 2.2.11 Winter Storms	The 2015 sections on hazards and vulnerabilities have been brought together and another section called "Risk" has been added. The content of the Future Enhancements section has been reviewed, updated, included in other sections, or deleted. A new section on Dam Safety has been added to the Flood Chapter. Dust Storms has been dropped. Extreme Heat has been added. Information on climate change influences on hazards has been updated. Information on exposure of historic resources has been added. Information on exposure of archaeological resources has been added. Information on social vulnerability has been added.
2.3 Regional Risk Assessments	2.3 Regional Risk Assessments	These sections have been reorganized in parallel to the State Risk Assessment chapters with sections on hazards, vulnerability, and risk. New sections on Dam Safety have been added to the Flood sections. Similarly vulnerability information has been added parallel to the state risk assessment.
Chapter 3: Mitigation Strategy	**Chapter 3: Mitigation Strategy**	All sections have been reviewed and updated. Several new mitigation goals have been added. Many new mitigation actions have been added. Mitigation action tables have been reorganized according to hazard to reflect the results of the 2020 risk assessment. Added Dam Safety goals, actions, capability.
Chapter 4: Planning Process	**Chapter 4: Planning Process**	All sections have been reviewed and updated
Chapter 5: Enhanced Plan		The 2020 Plan is being submitted as a standard plan. Therefore, the content of the Enhanced Plan chapter has been removed. A placeholder has been retained as the State intends to earn enhanced plan status again prior to the 2025 update.
Chapter 6: Acronyms and Abbreviations	**Chapter 6: Acronyms and Abbreviations**	Acronyms and abbreviations have been reviewed and updated as necessary.
Chapter 7: Glossary	**Chapter 7: Glossary**	The Glossary has been reviewed and updated as necessary.
Chapter 8: References	**Chapter 8: References**	References have been updated as necessary.
Chapter 9: Appendices	**Chapter 9: Appendices**	Appendices have been reviewed and updated as necessary.

Source: DLCD

4.3 Maintaining the Plan

Requirement 44 CFR §201.4(c), Plan content. To be effective the plan must include the following elements:

Requirement 44 CFR §201.4(c)(5)(i-iii), A Plan Maintenance Process that includes: (i) An established method and schedule for monitoring, evaluating, and updating the plan; (ii) A system for monitoring implementation of mitigation measures and project closeouts; and (iii) A system for reviewing progress on achieving goals as well as activities and projects identified in the Mitigation Strategy.

The purpose of this section is to describe procedures for maintaining the Oregon NHMP. Plan maintenance involves monitoring progress in achieving mitigation actions and Plan goals as well as monitoring, evaluating, and updating the Oregon NHMP itself.

The procedures described in this section are informed by analyses of previous Plan maintenance methods and schedules and the State's current and projected capabilities. Because this Plan and the State's capabilities are ever-evolving, the systems and processes described herein are subject to change. The information collected and documented through the Plan maintenance process will serve as the basis for the next Plan update. The process of updating the Plan provides the state with an opportunity to review its progress in achieving mitigation goals and chart its course for the next mitigation planning cycle.

4.3.1 Analysis of the 2015 Plan Maintenance Process

The Oregon NHMP was last updated and formally adopted by Governor Brown on July 1, 2015 and approved by FEMA on September 24, 2015. The plan monitoring process set forth in the 2015 Plan was followed in general, but not in full. As with all planning processes, circumstances change or do not unfold as anticipated and adjustments are made.

DLCD established a system by which IHMT members would use a detailed reporting form to report on progress on mitigation actions as well as on hazard events, mitigation successes, other new and exciting mitigation activities, and other data required for the plan update either quarterly, semi-annually, or annually as they individually chose. Most chose to report annually. The detailed reporting form provided all the information and guidance one would need to fill it out, and it was meant to be tailored by each respondent to their own areas of mitigation expertise and activity. However, the reporting form turned out to be overwhelming instead of helpful, and getting it completed with the appropriate level of detail and clarity became a workload in itself for DLCD. Nevertheless, DLCD collected the information to the best of everyone's ability, and produced an annual report covering the year 2015. The annual report was provided to FEMA at the July consultation meeting and very well received. DLCD continued to collect information on the detailed reporting forms over the next two years, but it seemed to become more difficult over time. While data was collected, DLCD never produced annual reports covering the years 2016 and 2017. This method also proved not to be useful as a way to funnel the collected data into the plan to keep it updated. It will be necessary to change the approach for 2020 Oregon NHMP maintenance.

The vision for the 2020 plan update was that it would focus on improving the risk assessment such that it could drive the mitigation goals and actions, and much less effort would be expended on updating the remainder of the Plan. In the end much more effort than anticipated was spent updating the remainder of the Plan. The 2015 Plan was also reorganized for 2020, to make a clear connection between the hazard and vulnerability assessments and showing how together they result in an assessment of risk. See Section **4.2.3** for details. Whether mitigation actions were implemented as anticipated is indicated by their status on **Table 3-5**, Mitigation Action Status. 2015 actions that appear on the 2020 *Priority* table have not yet been accomplished. Those in the *Ongoing* table are being implemented. Those that are done, not being done, replaced or covered by another action appear on the *Removed* table with the reason for removal. **Table 3-6** shows the disposition of the 2015 mitigation actions in the 2020 Plan. Section **3.3.2** discusses the changes in mitigation action priorities from 2015 to 2020.

In 2020, Oregon will lose enhanced plan status. Therefore, the 2020 Plan is being submitted as a standard plan. Oregon intends to make the changes necessary to regain enhanced plan status as quickly as possible.

4.3.2 Monitoring, Evaluating, and Updating the 2020 Plan

4.3.2.1 Monitoring the 2020 Plan

DLCD will work with the State Hazard Mitigation Officer to conduct plan monitoring activities during and associated with each quarterly meeting of the IHMT. An expectation for IHMT members to participate in quarterly plan monitoring will be established. Plan monitoring activities will be guided by the mitigation goals and other evaluation criteria in Section **4.3.2.2**. DLCD will update the 2020 Plan after each IHMT meeting with the information gleaned through that quarter's monitoring activities and IHMT members will review the changes for accuracy. In this way the 2020 Oregon NHMP will become a living document, and the effort needed to perform the 5-year update will be reduced.

Further, at a regular quarterly meeting as soon as feasible following a declared disaster event in Oregon, the State IHMT will discuss the event in the context of the Oregon NHMP and provide any necessary direction for updating the Plan. OEM will document this discussion as usual in IHMT meeting minutes and following the meeting DLCD will make any directed plan revisions.

4.3.2.2 Evaluating the 2020 Plan

DLCD will manage and facilitate the plan update process, beginning with review and evaluation of the 2020 Oregon NHMP. The 2020 Plan's mitigation goals will serve as the benchmarks for evaluating the Plan, and the following more specific criteria will be assessed as well:

- Accuracy and utility of the State and Regional Risk Assessments in the context of any Presidentially declared or Governor-declared disasters that may have occurred during the update cycle;
- Progress in applying the lessons learned from the 2020 risk assessment methodology to enhance it further for 2025 or fund an altogether new and better methodology;
- Progress in developing data for currently data-poor hazards or deciding to and how to de-emphasize planning for them or deciding not to plan for them;
- Continued progress in developing data statewide for the data-richer hazards and for channel migration;
- Progress in developing vulnerability data and making choices about the most important vulnerability indicators for the state overall and for the various regions or individual counties;
- Progress toward completion of mitigation actions;

- Progress toward refining the mitigation actions to more clearly address the greatest hazards and vulnerabilities statewide and establish the foundation for eligibility for project funding under FEMA grant programs;
- Progress in coordinating State and local mitigation planning;
- Progress in coordinating FEMA Region X's Risk MAP and State mitigation planning priorities, in particular working toward seamless coordination of funding and the timing of the funding for the State to produce multi-hazard risk assessments as the foundation for new local NHMPs and NHMP updates;
- Progress in solidifying continued funding for OCCRI to produce Future Projection Reports for new local NHMPs and NHMP updates;
- Progress in building local government capacity to develop and update NHMPs and CWPPs; integrate them with each other and with comprehensive or strategic and other plans; implement those plans; track changes in development; and develop project applications.
- Progress in tracking changes in development at the state level;
- Progress in mitigating flood hazards, particularly for repetitive and severe repetitive loss properties;
- Progress in assessing risk of high hazard potential dams and mitigating potential loss of life, property, and state and local critical/essential facilities;
- Progress in diversifying funding sources;
- Progress in building state capacity to a level that:
    - allows the State to regain and easily retain enhanced plan status;
    - supports the State's current cutting-edge approach to and work in natural hazards mitigation;
    - supports a comprehensive statewide natural hazards mitigation program; and
    - supports integration of natural hazards mitigation into other state programs and initiatives;
    - supports the state in coordinating state with local mitigation planning;
    - provides reliable funding to state agencies to participate in the IHMT and Oregon NHMP monitoring, evaluation, and update activities and to participate in coordination, cooperation, collaboration and integration activities with related state programs and initiatives; and
    - provides reliable funding to state agencies and local governments for mitigation planning; capacity building activities; leveraging federal funding programs; and filling gaps in federal funding programs.

Results of the evaluation will be documented and serve as the basis for updating the Plan.

4.3.2.3 Updating the 2020 Plan

DLCD will manage the update of the 2015 Oregon NHMP for 2020. The process will begin ideally with the first, but may begin with the second IHMT meeting following FEMA approval of the 2020 Oregon NHMP. The information from the plan maintenance activity at and associated with the IHMT meeting will be used to update the Plan, beginning to turn it into a living document.

About two-and-a-half years before the 2025 update is due, DLCD will compare the status of the Plan against its 2020 baseline and present the results and alternative approaches and a recommendation for how to proceed with the update to the State IHMT. Once the approach is agreed upon, DLCD will develop a scope of work and timeline, present it to the State IHMT for review and approval, and then discuss the approved scope and timeline with FEMA Region X.

IHMT members will be expected to participate in the update according to their expertise and roles in natural hazards mitigation. Subject matter experts and skilled technical professionals will again be called upon to take the lead on hazard chapters and other elements of the plan, such as vulnerabilities and GIS analyses, and provide other resources as required.

During the 2015 update process, the suite of natural hazards the State is addressing in its NHMP was questioned. The State IHMT also became aware of substantial differences in the amount and availability of data and technical expertise for certain hazards. During the 2020 update the State IHMT re-evaluated the established suite of hazards, considered including other hazards, and decided not to address dust storms any longer, but to address extreme heat. During the 2025 update, the IHMT will have a similar conversation and determine if any changes to the suite of hazards addressed is necessary. During the life of the 2020 Plan, the IHMT will consider whether and if so, how to prioritize the final suite of hazards to address data and expertise availability issues and make optimum use of resources. The decisions on which hazards to address and to what extent (or whether to not address some) will have a profound effect on the approach to and scope of work for the 2025 Oregon NHMP update.

Other issues that would affect 2025 plan update approach and scope of work include:

- The extent of progress on enhancing the 2020 risk assessment or funding and implementing a more sophisticated risk assessment methodology;
- The availability of new or updated hazard, probability, and vulnerability data;
- The extent of progress on enhancing state and local natural hazards mitigation planning and coordination; and
- Any new requirements included in FEMA's revised state NHMP guidance currently being updated.

One goal of the 2020 plan maintenance process is to transform the Oregon NHMP into a living document, updated by DLCD after each IHMT meeting, but also available for IHMT members to update during its life, while maintaining a static version for public use. If that goal is achieved and implemented effectively, it would lessen the burden of the 2025 update.

4.3.2.4 Monitoring Mitigation Actions and Project Closeouts

Progress on state mitigation actions will be monitored through the IHMT's quarterly maintenance activities. DLCD coordinate with OEM and will lead the monitoring activities. Progress of "Priority" mitigation actions will be noted; completed actions or those that will not be completed will be deleted from the "Priority" list and entered on the "Removed" list with a brief explanation. Progress of "Ongoing" mitigation actions will be noted. Mitigation action monitoring over the life of the 2015 Plan was attempted through data gathering for annual reports, but was not met with the same degree of success across all IHMT member agencies. Mitigation status was ascertained for each mitigation action during the 2020 plan update process. Undertaking quarterly maintenance activities at IHMT meetings will not be a foolproof method of obtaining 100% of the necessary data or 100% participation – additional follow-up will be necessary – but the group dynamic holds more possibility of success and fosters coordination and collaboration.

In addition, OEM will continue systematically monitoring the implementation of FEMA-funded mitigation actions and projects for which it is the grantee at both state and local levels using required sub-grantee quarterly reporting; telephone and e-mail communications; and project site visits as required. Successful project implementation requires open communication between the grantee and sub-grantee to ensure schedules, budget, and deliverable requirements are met. While project closeouts have always been conducted on site allowing the grantee and sub-grantee to certify completion of the project activity (performance component) and that all eligible expenses have been submitted, reviewed for eligibility and reimbursed (financial component), during the novel coronavirus pandemic and perhaps afterward, these meetings will necessarily take place virtually. OEM documents project closeout by summary performance and financial reports making sure the sub-grantee is aware of documentation retention requirements, audit requirements and maintenance schedule (if required) to ensure the performance of the mitigation over the life of the project. The State Hazard Mitigation Officer is responsible for reporting this information to the State IHMT for projects funded by the Hazard Mitigation Grant, Pre-Disaster Mitigation and Flood Mitigation Assistance programs.

Outside of the traditional FEMA mitigation grant programs, state and local governments identify and often implement mitigation actions and projects using their own capabilities and resources. At the local level, this may include the development and adoption of local ordinances and regulations that have a hazard mitigation component; mitigation codes and standards as part of ongoing transportation and public works programs; hazard-related components of local comprehensive land use plans; and so forth. While it may not be possible to track and report on every mitigation accomplishment in local mitigation plans, communities will see the positive cumulative impacts of these efforts in reduced disaster losses. The state encourages the seamless integration of mitigation activities into the planning efforts and day-to-day operations of state and local government programs.

Chapter 5 ENHANCED PLAN

In This Chapter

- Placeholder

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The 2020 Oregon NHMP is being submitted as a standard plan.

The Enhanced Plan chapter's framework is being retained in the standard plan because the State intends to take action to regain enhanced plan status during the effective life of this Plan.

The Enhanced Plan chapter's framework identifies the content that would be documented in a future enhanced plan chapter.

5.1 Introduction

Requirement 44 CFR §201.5, Enhanced State Mitigation Plans. (a) A State with a FEMA approved Enhanced State Mitigation Plan at the time of a disaster declaration is eligible to receive increased funds under the HMGP, based on twenty percent of the total estimated eligible Stafford Act disaster assistance. The Enhanced State Mitigation Plan must demonstrate that a State has developed a comprehensive mitigation program, that the State effectively uses available mitigation funding, and that it is capable of managing the increased funding. In order for the State to be eligible for the 20 percent HMGP funding, FEMA must have approved the plan within three years prior to the disaster declaration.

Placeholder

5.2 Compliance with Standard Plan

Placeholder

5.3 Integration with Other Planning Initiatives

Requirement 44 CFR §201.5(b)(1), Demonstration that the plan is integrated to the extent practicable with other State and/or regional planning initiatives (comprehensive, growth management, economic development, capital improvement, land development, and/or emergency management plans) and FEMA mitigation programs and initiatives that provide guidance to State and regional agencies.

Placeholder

5.4 Project Implementation Capability

Requirement 44 CFR §201.5(b)(2), Documentation of the State's project implementation capability, identifying and demonstrating the ability to implement the plan, including:

Requirement 44 CFR §201.5(b)(2)(i), Established eligibility criteria for multi-hazard mitigation measures.

Requirement 44 CFR §201.5(b)(2)(ii), A system to determine the cost effectiveness of mitigation measures, consistent with OMB Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, and to rank the measures according to the State's eligibility criteria.

Placeholder

5.4.1 Established Eligibility Criteria & Ranking System for Multi-Hazard Mitigation Measures

5.4.1.1 Eligibility Criteria

Placeholder

5.4.1.2 Ranking System

Placeholder

5.4.2 Benefit-Cost Analysis of Natural Hazard Mitigation Projects

Placeholder

5.4.2.1 Oregon Seismic Rehabilitation Grant Program: Oregon BCA Tool

Placeholder

5.4.3 Program Management Capability

Requirement 44 CFR §201.5(b)(2)(iii), Demonstration that the State has the capability to effectively manage the HMGP as well as other mitigation grant programs, including a record of the following:

(A) Meeting HMGP and other mitigation grant application timeframes and submitting complete, technically feasible, and eligible project applications with appropriate supporting documentation;

(B) Preparing and submitting accurate environmental reviews and benefit-cost analyses;

(C) Submitting complete and accurate quarterly progress and financial reports on time; and

(D) Completing HMGP and other mitigation grant projects within established performance periods, including financial reconciliation.

Placeholder

5.4.3.1 Hazard Mitigation Grant Review Board

Placeholder

5.4.4 Monitoring Mitigation Measures and Project Closeouts

Placeholder

5.5 Mitigation Action Assessment

Requirement 44 CFR §201.5(b)(2)(iv), A system and strategy by which the State will conduct an assessment of the completed mitigation actions and include a record of the effectiveness (actual cost avoidance) of each mitigation action.

Placeholder

5.6 Effective Use of Available Mitigation Funding

Requirement 44 CFR §201.5(b)(3), Demonstration that the State effectively uses existing mitigation programs to achieve its mitigation goals.

5.6.1 Current and Potential Funding

Placeholder

5.6.2 Funding Used to Implement Mitigation Actions

Placeholder

5.6.2.1 Hazard Mitigation Grant Program (HMGP)

Placeholder

5.6.2.2 Flood Mitigation Assistance (FMA) Program

Placeholder

5.6.2.3 Pre-Disaster Mitigation (PDM) Competitive Grant Program

Placeholder

5.6.2.4 HMGP, FMA, PDM Grants Management Summary

Placeholder

5.6.2.5 Oregon's Seismic Rehabilitation Grant Program (SRGP)

Placeholder

5.6.2.6 Oregon Watershed Enhancement Board (OWEB)

Placeholder

5.7 Commitment to a Comprehensive Mitigation Program

Requirement 44 CFR §201.5(b)(4)(i-vi), Demonstration that the State effectively uses existing mitigation programs to achieve its mitigation goals.

Placeholder

5.7.1 Capacity Building

44 CFR §201.5(b)(4)(i), A commitment to support local mitigation planning by providing workshops and training, state planning grants, or coordinated capability development of local officials, including Emergency Management and Floodplain Management certifications.

Placeholder

5.7.2 Executive Actions

44 CFR §201.5(b)(4)(ii), A statewide program of hazard mitigation through the development of legislative initiatives, mitigation councils, formation of public/private partnerships, and/or other executive actions that promote hazard mitigation.

Placeholder

5.7.3 Non-Federal Match

44 CFR §201.5(b)(4)(iii), The state provides a portion of the non-federal match for HMGP and/or other mitigation projects.

Placeholder

5.7.4 Building Code

44 CFR §201.5(b)(4)(iv), To the extent allowed by state law, the state requires or encourages local governments to use a current version of a nationally applicable model building code or standard that addresses natural hazards as a basis for design and construction of state sponsored mitigation projects.

Placeholder

5.7.4.1 Retrofitting and Rehabilitation

Placeholder

5.7.4.2 Removing Buildings from Harm's Way

Placeholder

5.7.4.3 Structural Projects

Placeholder

5.7.5 Critical/Essential Facilities

44 CFR §201.5(b)(4)(v), A comprehensive, multi-year plan to mitigate the risks posed to the existing buildings that have been identified as necessary for post-disaster response and recovery operations.

Placeholder

5.7.6 Integration with Post-Disaster Recovery Operations

44 CFR §201.5(b)(4)(vi), A comprehensive description of how the state integrates mitigation into its post-disaster recovery operations.

Placeholder

5.7.6.1 Expediting the HMGP Process

Placeholder

5.7.6.2 Exemplary Projects

Placeholder

Chapter 6 ACRONYMS and ABBREVIATIONS

A300	ANSI A300, Tree Care Operations Standards
AASHTO	American Association of State Highway and Transportation Officials
ACEP	Agricultural Conservation Easement Program
AH	Flood Insurance Rate Map (FIRM) zone: Areas subject to inundation by 1%-annual-chance shallow flooding (usually areas of ponding) where average depths are between one and three feet. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown in this zone. Mandatory flood insurance purchase requirements and floodplain management standards apply.
AHPS	Advanced Hydrologic Prediction Service
AHZ	Active Hazard Zone
AIA	American Institute of Architects
AKmax	hypothetical maximum Alaska tsunami
AM	Amplitude Modulation (AM)
ANSI	American National Standards Institute
ANSS	Advanced National Seismic System
AO	Flood Insurance Rate Map (FIRM) zone: areas subject to inundation by 1%-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet. Average flood depths derived from detailed hydraulic analyses are shown in this zone. Mandatory flood insurance purchase requirements and floodplain management standards apply. Some Zone AO have been designated in areas with high flood velocities such as alluvial fans and washes. Communities are encouraged to adopt more restrictive requirements for these areas.
AOC	Association of Oregon Counties
APA	American Planning Association
APCO	Association of Public Safety Communications Officials
ARES	Amateur Radio Emergency Service
ARRA	American Recovery and Reinvestment Act
ARRL	Amateur Radio Relay League
ASCE	American Society of Civil Engineers
ASFPM	Association of State Floodplain Managers
ATC	Applied Technology Council
BCA	Benefit-Cost Analysis
BCD	Building Codes Division (State of Oregon, Department of Consumer and Business Services)
BCE	Before Common Era

BCR	Benefit-Cost Ratio
BFE	Base Flood Elevation
BLM	Bureau of Land Management (United States Department of the Interior)
BMP	Best Management Practice
BNSF	Burlington Northern-Santa Fe Railway
BPA	Bonneville Power Administration
BusOR-IFA	Business Oregon, Infrastructure Finance Authority
CAP	Community Assistance Program (NFIP)
CAP-SSSE	Community Assistance Program — State Support Services Element (NFIP)
CAV	Community Assistance Visit (NFIP)
CB	Coquille Bank
CBRL	Coos Bay Rail Link
CCA	Climate Change Adaptation
CDBG	Community Development Block Grant
CD-ROM	Compact Disc Read-Only Memory
CEI	Critical Energy Infrastructure
CERT	Community Emergency Response Team
CFR	Code of Federal Regulations
CGIAR	Formerly “Consultative Group on International Agricultural Research.” Since 2008, known simply as CGIAR, a global partnership that unites organizations engaged in research for a food secure future
CI	Critical Infrastructure/Essential Public Facilities
CMIP	Coupled Model Intercomparison Project
CMIP5	Coupled Model Intercomparison Project, 5th phase
CMZ	Channel Migration Zone
CNN	Cable News Network
CPO	Climate Program Office
CPW	Community Planning Workshop (University of Oregon)
CREP	Conservation Reserve Enhancement Program
CREW	Cascadia Region Earthquake Workgroup
CRP	Conservation Reserve Program
CRS	Community Rating System (National Flood Insurance Program)
CSC	Community Service Center (University of Oregon)
CSEPP	Chemical Stockpile Emergency Preparedness Program
CSO	combined sewer overflow
CSREES	Cooperative State Research, Education, and Extension Service

CST	Community Solutions Team
CSZ	Cascadia Subduction Zone
CTP	Cooperating Technical Partner (NFIP)
CVO	Cascades Volcano Observatory
CWPP	Community Wildfire Protection Plan
DAS	Department of Administrative Services (State of Oregon)
DAS-CFO	Department of Administrative Services-Chief Financial Office (State of Oregon)
DAS-CIO	Department of Administrative Services-Chief Information Office (State of Oregon)
DAS-EAM	Department of Administrative Services-Enterprise Asset Management (State of Oregon)
DAS-RM	Department of Administrative Services-Risk Management Division (State of Oregon)
DAS-GEO	Department of Administrative Services-Geospatial Enterprise Office (State of Oregon)
DCBS	Department of Consumer and Business Services (State of Oregon)
DCBS-DFR	Department of Consumer and Business-Department of Financial Regulation (State of Oregon)
DEI	Diversity, Equity, and Inclusion
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality (State of Oregon)
DLCD	Department of Land Conservation and Development (State of Oregon)
DMA	Disaster Mitigation Act of 2000 (federal)
DMA2K	Disaster Mitigation Act of 2000
DMV	Department of Motor Vehicles (State of Oregon)
DNR	Department of Natural Resources (Washington State)
DOD-USACE	United States Department of Defense-U.S. Army Corps of Engineers
DOGAMI	Department of Geology and Mineral Industries (State of Oregon)
DP	Demographic Profile
DPSST	Department of Public Safety Standards and Training (State of Oregon)
DR	Alphabetic designation or precursor for Disaster Declaration Number
DRMS	Decision, Risk, and Management Science
DRU	Disaster Resilient University
DSL	Department of State Lands (State of Oregon)
DTM	Digital Terrain Model
EAM	Enterprise Asset Management (State of Oregon Department of Administrative Services)
EAP	Emergency Action Plan
EAS	Emergency Alert System
ECC	Emergency Coordination Center
EDA	Economic Development Administration (U.S.)

EHP	Environmental and Historic Preservation
EIS	Environmental Impact Statement
EMI	Emergency Management Institute (FEMA)
EMPG	Emergency Management Performance Grant (State of Oregon)
ENSO	El Niño Southern Oscillation
EO	Education/Outreach
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
EPA	Environmental Protection Agency (U.S.)
EPCRA	Emergency Planning and Community Right-to-Know Act
EQIP	Environmental Quality Incentives Program
ER	Emergency Relief
ESA	Endangered Species Act
ESD	Education Service District
ESEE	Economic, Social, Environmental, and Energy
EWP	Emergency Watershed Protection (NRCS Program)
FAA	Federal Aviation Administration
FAS	Federal Aid System (U.S. Highway Administration)
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FF	Flash Flood
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FM	Frequency Modulation
FMA	Flood Mitigation Assistance
FMAGP	Fire Management Assistance Grant Program
FPD	Fire Protection District
FSA/FMAGP	Fire Suppression Assistance/Fire Management Assistance Grant Program
FTA	Federal Transit Administration
FTE	Full Time Equivalent
FY	Fiscal Year
GCM	Global Climate Models
GED	General Education Development
GEO	Geospatial Enterprise Office (State of Oregon, DAS)

GIS	Geographic Information System
GNRO	Governor's Natural Resources Office (State of Oregon)
GO	General Obligation
GPS	Global Positioning System
GSA	General Services Administration (U.S.)
GSTF	Greatest-Savings-to-the-Fund (FEMA)
GTN	Gas Transmission Northwest
GWEB	Governor's Watershed Enhancement Board
H	High
Hazus	Hazards U.S.
HB	House Bill (State of Oregon)
HCD	Housing and Community Development Act of 1974
HFRA	Healthy Forest Restoration Act of 2003
HHZ	High Hazard Zone
HM	Hazard Mitigation
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HMSE	Hazard Mitigation and Structural Engineering
HMST	Hazard Mitigation Survey Team
HMTAP	Hazard Mitigation Technical Assistance Program (FEMA)
HR	House Resolution (State of Oregon legislature)
HRFA	Healthy Forest Restoration Act of 2003
HSPR	Health Security, Preparedness, and Response (Oregon Health Authority)
HUD	Housing and Urban Development (U.S.)
HWM	High Water Mark
ICBO	International Conference of Building Officials
ICC	Increased Cost of Compliance (NFIP)
ID	Insurance Division (Oregon Department of Consumer and Business Services)
IDA	Initial Damage Assessment
IEBC	International Existing Building Code
IFA	Infrastructure Finance Authority (Business Oregon)
IHMT	Interagency Hazard Mitigation Team
IMS	Interpretive Map Series (DOGAMI)
IPCC	Intergovernmental Panel on Climate Change

IPPM	Insect Pest Prevention and Management
IR	Indian Reservation
IRIS	Incident Response Information System
ISA	International Society of Arboriculture
ISO	Insurance Services Office
JFO	Joint Field Office (FEMA)
KOG	Keep Oregon Green
KPM	Key Performance Measure
L	Low
LCDC	Land Conservation and Development Commission (State of Oregon)
LEPC	Local Emergency Planning Committee
LFD	Local Fire Department
LFPC	Local Fire Prevention Cooperative
LHZ	Low Hazard Zone (coastal erosion)
LID	Low Impact Development
LLC	Limited Liability Company
LNG	Liquefied Natural Gas
LNHMP	Local Natural Hazards Mitigation Plan
LOC	League of Oregon Cities
LP	Legislative/Policy
LPA	Landowner Preferred Alternative
LU	Land Use/Development
LWI	Local Wetlands Inventory
M	Moderate
MAX	Metropolitan Area Express light rail, operated by Tri-County Metropolitan Transportation District of Oregon (TriMet)
MH	Multi-Hazard
MHHW	Mean High Water
MJO	Madden Julian Oscillation
MLLW	Mean Lower Low Water
MMI	Modified Mercalli Index
MMMS	Map Modernization Management Support (FEMA)
MP	Mile Post or Maintenance/Planning
MV	Most Vulnerable
MVC	Motor Vehicle Collision
M_W	Moment earthquake magnitude scale

N/A	Not Available / Not Applicable
NARCCAP	North American Regional Climate Change Assessment Program
NASA	National Aeronautics and Space Administration
NASEO	National Association of State Energy Officials
NB	Nehalem Bank
NCC	Northwest Coordination Center
NCHR	Natural, Cultural, and Historical Resources
NDBC	National Data Buoy Center
NDWS	Native Database Web Service (Oracle)
NEHRP	National Earthquake Hazards Reduction Program
NEMIS	National Emergency Management Information System
NENA	National Emergency Number Association
NERC	North American Electric Reliability Corporation
NFIP	National Flood Insurance Program
NFP	National Fire Plan
NFPA	National Fire Protection Association
NGA	National Geospatial-Intelligence Agency
NGDC	National Geophysical Data Center
NGO	Non-Governmental Organization
NHMP	Natural Hazards Mitigation Plan
NID	National Inventory of Dams
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRC	National Resource Council
NRCS	Natural Resources Conservation Service (U.S.)
NSF	National Science Foundation
NSFHA	No Special Flood Hazard Area
NTHMP	National Tsunami Hazard Mitigation Program
NVEWS	National Volcano Early Warning System
NWAC	Northwest Weather and Avalanche Center
NWN	Northwest (NW) Natural Gas
NWRFC	Northwest River Forecast Center (National Weather Service)
NWS	National Weather Service
OAIRS	Oregon All Incident Reporting System (State Fire Marshal)

OAR	Oregon Administrative Rule
OBSMAP	Oregon Beach and Shoreline Mapping and Analysis Program
OCAR	Oregon Climate Assessment Report
OCCRI	Oregon Climate Change Research Institute
OCMP	Oregon Coastal Management Program
OCS	Oregon Climate Service
OCSRI	Oregon Coastal Salmon Restoration Initiative
ODA	Oregon Department of Agriculture
ODE	Oregon Department of Education
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOE	Oregon Department of Energy
ODOT	Oregon Department of Transportation
ODR	Oregon Department of Revenue
ODTWG	Oregon Distant Tsunami Working Group
OE	Office of Electricity Delivery and Energy Reliability (U.S. Department of Energy)
OECDD	Oregon Economic and Community Development Department (now Business Oregon-IFA)
OEM	Oregon Office of Emergency Management
OEMA	Oregon Emergency Management Association
OERS	Oregon Emergency Response System
OFR	Open File Report
OGDC	Oregon Geologic Data Compilation
OGIC	Oregon Geographic Information Council
OHA	Oregon Health Authority
OHD	Oregon Health Division
OHIRA	Oregon Hazard Identification and Risk Assessment
OHP	Oregon Highway Plan
OIG	Office of Inspector General (U.S.)
OLC	Oregon Lidar Consortium
OMB	Office of Management and Budget (U.S.)
OMD	Oregon Military Department
OPDR	Oregon Partnership for Disaster Resilience
OPH	Oregon Public Health
OPRD	Oregon Parks and Recreation Department
OPUC	Oregon Public Utility Commission

OR-OSHA	Oregon Occupational Safety and Health Administration
ORP	Oregon Resilience Plan
ORS	Oregon Revised Statutes
OSBEELS	Oregon State Board of Examiners for Engineering and Land Surveying
OSBGE	Oregon State Board of Geologist Examiners
OSFM	Office of State Fire Marshal
OSG	Oregon Sea Grant (Oregon State University)
OSHA	Occupational Safety and Health Administration
OSLR	Oregon Seismic Lifeline Report
OSMB	Oregon State Marine Board
OSP	Oregon State Police
OSSPAC	Oregon Seismic Safety Policy Advisory Commission
OSU	Oregon State University
OUNS	Oregon Utility Notification System
OUS	Oregon University System
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
PA	Public Assistance
PAS	Planning Advisory Service (American Planning Association)
PDA	Preliminary Damage Assessment
PDF	Portable Document Format
PDM	Pre-Disaster Mitigation
PDSI	Palmer Drought Severity Index
PGE	Portland General Electric
PL	Public Law
PM_{10}	Particulate Matter less than 10 micrometers in diameter
PMT	Project Management Team
PNP	Private Non-Profit organization
PNW	Pacific Northwest
PNWCG	Pacific Northwest Wildfire Coordinating Group
PNWR	Portland & Western Railroad
POTB	Port of Tillamook Bay Railroad
PRISM	Parameter-elevation Relationships on Independent Slopes Model, an interpolation method and name of associated climate group at Oregon State University
PSA	Public Service Announcement
PSAP	Public Safety Answering Point

PSU	Portland State University
PUC	Public Utility Commission (State of Oregon)
PUD	People's Utility District
PVC	Polyvinyl Chloride
RACES	Radio Amateur Civil Emergency Services
RAFT	Rapid Assessment of Flooding Tool
RAPTOR	Real-Time Assessment and Planning Tool for Oregon
RARE	Resource Assistance for Rural Environments (University of Oregon)
RAS-C	Risk Assessment Sub-Committee (State of Oregon IHMT)
RCP	Representative Concentration Pathway
REDARS2	Risks from Earthquake Damage to Roadway Systems
RFC	Repetitive Flood Claim (NFIP)
RFPA	Rangeland Fire Protection Association
RFPD	Rural Fire Protection District
RGP	Regional General Permit (Oregon Department of State Lands)
RHS	Rural Housing Service (U.S. Department of Agriculture (USDA))
Risk MAP	Risk Mapping, Assessment, and Planning Program (FEMA)
RL	Repetitive Loss
RM	Risk Management Division (State of Oregon, Department of Administrative Services)
ROS	Rain on Snow
ROW	Right of Way
RPC	Recovery Planning Cell (State of Oregon Executive Order 08-20)
RVS	Rapid Visual Screening
RWIS	Road Weather Information System
SB	Senate Bill (Oregon Legislature)
SBA	Small Business Administration (U.S.)
SC	Steering Committee (OSLR)
SD	Substantial Damage
SEAO	Structural Engineers Association of Oregon
SFC-LPA	Southern Flow Corridor — Landowner Preferred Alternative
SFHA	Special Flood Hazard Area
SHMO	State Hazard Mitigation Officer
SI	Substantial Improvement
SJR	Senate Joint Resolution
SLIDO	Statewide Landslide Inventory Database for Oregon

SM	Snowmelt
SMART	Specific, Measurable, Achievable, Realistic, Time-oriented
SMC	State Management Cost
SNHMP	State Natural Hazards Mitigation Plan
SNOTEL	Snow Telemetry site; part of an automated system of snowpack and related climate sensors operated by the USDA NRCS.
SOI	Southern Oscillation Index
SoVI	Social Vulnerability Index
SRGP	Seismic Rehabilitation Grant Program (State of Oregon)
SRIA	Sandy Recovery Improvement Act of 2013
SRL	Severe Repetitive Loss (NFIP)
SRS	Self-Determination Act
SSF	State Support Function
SUA	State Unit on Aging
SUB	Springfield Utility Board
SWCD	Soil and Water Conservation District
TAG	Technical Assistance Grant (Land Conservation and Development Commission)
TDD	Transportation Development Division (ODOT)
TDR	Transfer of Development Rights
TGM	Transportation and Growth Management Program (Department of Transportation)
THIRA	Threat and Hazard Identification and Risk Assessment
TIM	Tsunami Inundation Map (DOGAMI)
TNC	The Nature Conservancy
TRG	Technical Resource Guide
U.S.C.	United States Code
UASI	Urban Area Security Initiative
UGB	Urban Growth Boundary
UO	University of Oregon
UP	Union Pacific (railroad)
URM	Unreinforced Masonry
US	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDOC	United States Department of Commerce
USDOE	United States Department of Energy
USDOI	United States Department of the Interior

USDOT	United States Department of Transportation
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
V	Vulnerable
VE	Flood Insurance Rate Map (FIRM) zone: an area inundated by 1% annual chance flooding with velocity hazard (wave action); base flood elevations have been determined.
WACO	Water Availability Committee of Oregon
WHZ	Wildfire Hazard Zone
WRD	Water Resources Department (State of Oregon)
WREP	Wetlands Reserve Enhancement Program
WRH	Western Region Headquarters (NOAA National Weather Service)
WRP	Wetlands Reserve Program
WSSPC	Western States Seismic Policy Council
WSU	Washington State University
WUI	Wildland-Urban Interface
WWRA	West Wide Risk Assessment
WWTP	Wastewater Treatment Plant
YBP	Years Before Present

Chapter 7 GLOSSARY

100-year flood means a flooding condition which has a 1% chance of occurring each year. The 100-year flood is the benchmark upon which the National Flood Insurance Program (NFIP) is based.

Amplification is the modification of frequency or strength of seismic earth movement at a location due to thickness, topography, and physical properties of soft surface sediments.

Ash is composed of fine particles of volcanic rock and glass blown into the atmosphere by a volcanic eruption.

Bombs are fragments of tephra (particles ejected into the air during volcanic eruptions) larger than 2.5 inches.

Bedrock shaking is expected earth movement at a location due to seismic activity without considering soft sediment effects such as amplification and liquefaction.

Caldera is a large, generally circular, fault-bounded depression caused by the withdrawal of magma from below a volcano or volcanoes.

Cascadia Subduction Zone is the area where the seafloor plate (the Juan de Fuca or Gorda) is sliding down and below the North American plate.

Cinder is a bubbly (vesicular) volcanic rock fragment that forms when molten, gas-filled lava is thrown into the air, then solidifies as it falls.

Conflagration Act is state legal authority established as a civil defense measure to mobilize structural fire suppression resources for massive urban fires. It must be authorized by the Governor. The act includes authorization for OSFM to assign firefighting forces and equipment beyond mutual aid agreements. It also designates reimbursement for aid to those departments participating.

Conflagration, in the context of this Plan, means Governor-declared fires with an imminent threat to life or structures that have exhausted local and mutual aid suppression resources.

Disaster Mitigation Act of 2000 (DMA2K) amended the Stafford Act, establishing a national program for pre-disaster mitigation; streamlining the administration of disaster relief; changing FEMA’s post-disaster programs for individuals and families; establishing minimum standards for public and private structures; requiring local and state natural hazards mitigation plans that meet a FEMA standard (Section 322); revising FEMA funding for the repair, restoration, and replacement of damaged facilities (Section 406); revising FEMA’s participation in the costs of WUI fire suppression through an expanded and renamed Fire Management Assistance Grant Program (Section 420); removing the requirement for post-disaster IHMT or HMST meetings and reports; and other amendments.

El Niño-Southern Oscillation is a cycle in the Pacific Basin involving water and air temperatures that has a profound effect on weather patterns around the world; events typically last 6-18 months.

FireFree is an Oregon and national model developed in Oregon that predates the more recent nationally known Firewise. http://www.firefree.org/

Firewise is a program developed by the National Fire Protection Association (NFPA) featuring templates to help communities reduce risk and protect property from the dangers of wildland fires; an interactive, resource-rich website; and training programs throughout the nation. http://www.firewise.org/

Floodplain is a land area adjacent to a river, stream, lake, estuary, or other water body that is subject to flooding. These areas, if left undisturbed, act to store excess flood water.

Floodway is the channel of a river or other watercourse and adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.

Flows are rapid to slow mass movement of saturated material moving down a slope. *Debris flows* occur when a landslide moves rapidly downslope as a semi-fluid mass scouring or partially scouring soils from the slope along its path. Other *flow* types include earthflows, mudflows, lahars, debris torrents, and creep.

Foredune is a dune lying parallel to the ocean, occurring at the landward edge of the beach or at the landward limit of the highest tide, which has been stabilized by vegetation.

Goal 7 of the Oregon Statewide Land Use Planning Program calls for local comprehensive plans to include inventories, policies, and implementing measures to guide development in hazard areas with the goal of reducing losses from flooding, landslides, earthquakes, tsunamis, coastal erosion, and wildfires.

Hazard is any situation that has the potential of causing damage to people, property, or the environment.

Hazard Mitigation Grant Program means the program authorized under Section 404 of the Stafford Act and implemented at 44 CFR Part 206, Subpart N, which authorizes funding for certain mitigation measures identified through the evaluation of natural hazards conducted under Section 322 of the Stafford Act. (44 CFR 201.2)

Hazard mitigation means any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards. (44 CFR 201.2)

Hazus (**HAZ**ards **U**nited **S**tates) is a loss estimation methodology that is a FEMA software program using mathematical formulas and information about building stock, local geology, and the location and size of potential earthquakes, economic data, and other information to estimate losses from potential earthquakes.

Hazus-MH (Hazus **M**ulti-**H**azards) is a methodology that expands on Hazus (cf.) by estimating potential losses from earthquakes, hurricane winds, and floods.

Lahar is a type of mudflow that originates on the slopes of volcanoes when volcanic ash and debris become saturated with water and flows rapidly downslope.

Lava is magma that reaches the Earth's surface through a volcanic eruption and when cooled and solidified, forms igneous rock.

Landslide is any detached mass of soil, rock, or debris that moves down a slope or a stream channel.

Lateral spreading is failure on very gentle slopes or flat terrain. The failure is usually associated with water-saturated, loose sediment spreading laterally due to liquefaction during earthquakes or human-caused rapid ground motion.

Lidar (Light Detection and Ranging) is an optical remote sensing technology that can measure the distance to, or other properties of a target by illuminating the target with light, often using pulses from a laser.

Liquefaction is the reaction of saturated soil to seismic earth movement causing the soil to behave like a liquid.

Littoral cells are beaches composed of sand, gravel, or both that may be bounded by prominent headlands limiting sand exchange.

Magma is molten rock that may be completely liquid or a mixture of liquid rock, dissolved gases and crystals.

Pyroclastic flow is an extremely hot mixture of gas, ash and pumice fragments that travels down the flanks of a volcano or along the surface of the ground at speeds of up to 150 miles per hour and tends to flow down valleys.

Magnitude (M) is a measure of the amount of energy released by an earthquake.

Major disaster means any natural catastrophe including any hurricane, tornado, storm, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm or drought, or, regardless of cause, any fire, flood, or explosion in any part of the United States, which in the determination of the President causes damage of sufficient severity and magnitude to warrant major disaster assistance to supplement the efforts and available resources of states, local governments, and disaster relief organizations in alleviating the damage, loss, hardship, or suffering caused thereby. (44 CFR 206.2)

Megathrust is both the giant fault that separates the two plates in a subduction zone and the giant earthquake that occurs when that fault moves.

National Fire Plan is a federal program that helps manage the impact of wildfire on communities. It has five main components: (a) firefighting, (b) rehabilitation and restoration, (c) hazardous fuel reduction, (d) community assistance, and (e) accountability.

National Flood Insurance Program is the program run by the federal government to improve floodplain management, reduce flood-related disaster costs, and provide flood insurance for residents of flood-prone communities.

Natural Hazards Mitigation Plan means a plan meeting the requirements of 44 CFR 201.4, 201.5, or 201.6.

Senate Bill 360 in 1997 established the policy and framework for meeting the fire protection needs of the wildland-urban interface.

Pacific Decadal Oscillation is a similar but longer-term cycle than the El Niño-Southern Oscillation with typical events lasting 20-30 years.

Public Assistance is that part of the disaster assistance program in which the federal government supplements the efforts and available resources of state and local governments to restore certain public facilities or services. Public Assistance includes emergency assistance, debris removal, community disaster loans, and the permanent repair, restoration, or replacement of public and designated private nonprofit facilities damaged or destroyed by a major disaster and is further described under Section 406 of the Stafford Act.

Pyroclastic surge is a dilute version of a pyroclastic flow, which can move even more rapidly and easily moves up and over ridges.

Shield volcano is a gently sloping volcano in the shape of a flattened dome and built almost exclusively of lava flows.

Rock falls are masses of rock fragments that break away from a steep slope and travel mostly by free fall, coming to rest at the base of a slope as talus debris.

Slides have a distinct zone of weakness that separates the overlying failed material from more stable underlying material. Types of slides include rotational (movement along a curved surface) and translational (movement along a flat surface).

Special Flood Hazard Area is the land in the floodplain within a community subject to a 1% or greater chance of flooding in any given year. (44 CFR 59.1)

Stafford Act means the Robert T. Stafford Disaster Relief and Emergency Assistance Act (PL 100-707, which amended PL 91-606 and PL 93-288; then was further amended by PL 106-390, the Disaster Mitigation Act of 2000; and PL 109-295, the Post-Katrina Emergency Reform Act).

State Hazard Mitigation Officer is the official representative of state government who is the primary point of contact with FEMA, other federal agencies, and local governments in mitigation planning and implementation of mitigation programs and activities required under the Stafford Act. In Oregon, the State Hazard Mitigation Officer position resides in the Oregon Military Department's Office of Emergency Management.

State Interagency Hazard Mitigation Team is a permanent body of state agency officials established in 1997 to understand losses arising from natural hazards and coordinate recommended strategies to mitigate loss of life, property, and natural resources.

Stratovolcano is a relatively long-lived volcano built up of both lava flows and pyroclastic material.

Structural fire protection is protection of structures by established municipal fire departments and rural fire protection districts with specific equipment and training.

Subduction zone is the area between two converging plates, one of which is sliding down and below the other.

Subduction zone earthquake is an earthquake along a subduction zone. In Oregon, usually refers to the Cascadia Subduction Zone (CSZ), which lies off shore of the Oregon coast.

Subduction is the process of one crustal plate sliding down and below another crustal plate as the two converge.

Surface fault is a fault that ruptures to the Earth's surface.

Tectonic refers to large-scale vertical or horizontal movement of the earth's crust.

Tectonic plate is a slab of rigid lithosphere (crust and uppermost mantle) that moves over the asthenosphere.

Tephra is a general term for all sizes of particles ejected into the air during volcanic eruptions. Tephra includes particles as tiny as volcanic ash and as large as bombs.

Tsunami is a series of waves generated by undersea earthquakes or landslides.

Vulnerability is the susceptibility of life, property, or the environment to damage if a hazard manifests to potential.

Wave runup is the swash of a broken wave as it travels up the beach face.

Wildfire hazard zone means the portion of a local government jurisdiction that has been determined to be at risk of a catastrophic wildfire.

Wildland-urban interface (also known as wildland interface, forestland-urban interface, interface) is an area where structures are adjacent to or are intermingled with natural vegetative fuels which is prone to the occurrence of wildland fires.

Chapter 8 REFERENCES

Reference note: Many non-specific reference citations and sources listed in the main text are inherited from earlier Plans.

Allan, J. C., & Hart, R. (2007). *Assessing the temporal and spatial variability of coastal change in the Neskowin littoral cell: Developing a comprehensive monitoring program for Oregon beaches (Open-File Report O-07-01).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Allan, J. C., & Hart, R. (2008). *Oregon beach and shoreline mapping and analysis program: 2007-2008 beach monitoring report (Open-File Report O-08-15).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Allan, J. C., & Komar, P. D. (2002). Extreme storms on the Pacific Northwest coast during the 1997-98 El Niño and 1998-99 La Niña. *Journal of Coastal Research, 18*(1), 175-193.

Allan, J. C., & Priest, G. R. (2001). *Evaluation of coastal erosion hazard zones along dune and bluff backed shorelines in Tillamook County, Oregon: Cascade Head to Cape Falcon (Open-File Report O-01-03).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Allan, J. C., & Stimely, L. (2013). *Oregon Beach Shoreline Mapping and Analysis Program: quantifying short to long-term beach and shoreline changes in the Gold Beach, Nesika, and Netarts littoral cells (Open File Report O-13-07).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Allan, J. C., Hart, R., & Tranquilli, V. (2006). The use of Passive Integrated Transponder tags (PIT-tags) to trace cobble transport in a mixed sand-and-gravel beach on the high-energy Oregon coast, USA. *Marine Geology, 232*(1-2), 63–86.

Allan, J. C., Komar, P. D., & Priest, G. R. (2003). Shoreline variability on the high-energy Oregon coast and its usefulness in erosion-hazard assessments. In M. R. Byrnes, M. Crowell, & C. Fowler, *horeline mapping and change analysis: Technical considerations and management implications* (pp. 83–105). West Palm Beach, FL: Coastal Education & Research Foundation, Inc. (CERF).

Allan, J. C., O'Brien, F. E., & Gabel, L. L. (2018). *Beach and shoreline dynamics in the Cannon Beach littoral cell: Implications for dune management (Special Paper 49).* Oregon Department of Geology and Mineral Industries. Retrieved from https://www.oregongeology.org/pubs/sp/p-SP-49.htm

Allan, J. C., Ruggiero, P., & Roberts, J. T. (2012). *Coastal Flood Insurance Study, Coos County, Oregon (Special Paper 44).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Allan, J. C., Witter, R. C., Ruggiero, P., & Hawkes, A. D. (2009). Coastal geomorphology, hazards, and management issues along the Pacific Northwest coast of Oregon and Washington. In J. E. O'Connor, R. J. Dorsey, & I. P. Madin, *Volcanoes to vineyards: geologic field trips through the dynamic landscape of the Pacific Northwest (Geological Society of America Field Guide 15)* (pp. 495–519). Boulder, CO: The Geological Society of America.

Allan, J., Ruggiero, P., Cohn, N., Garcia, G., O'Brien, F., Serafin, K., . . . Roberts, J. (2015c). *Coastal Flood Hazard Study, Lincoln County, Oregon (Open-File Report O-15-06).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Allan, J., Ruggiero, P., Cohn, N., O'Brien, F., Serafin, K., Roberts, J., & Gabel, L. (2017). *Coastal Flood Hazard Study, Lane and Douglas Counties, Oregon (Open-File Report O-17-05).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Allan, J., Ruggiero, P., Cohn, N., O'Brien, F., Serafin, K., Roberts, J., & Stimely, L. (2015d). *Coastal Flood Hazard Study, Curry County, Oregon (Open-File Report O-15-07).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Allan, J., Ruggiero, P., Garcia, G., Harris, E., Roberts, J., & Stimely, L. (2015a). *Coastal Flood Hazard Study, Clatsop County, Oregon (Open-File Report O-15-05).* Portland,OR: Oregon Department of Geology and Mineral Industries.

Allan, J., Ruggiero, P., Garcia, G., O'Brien, F., Stimely, L., & Roberts, J. (2015b). *Coastal Flood Hazard Study, Tillamook County, Oregon (Special Paper 47).* Portland, OR: Oregon Department of Geology and Mineral Industries.

American Red Cross. (2007). *Talking about disaster: guide for standard messages.* Retrieved from https://www.weather.gov/media/bis/AmericanRedCross_TalkingAboutDisaster.pdf

Bacon, C. R., Mastin, L. G., Scott, K., & Nathenson, M. (1997). *Volcano and earthquake hazards in the Crater Lake region, Oregon (Open-File Report 97-487).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.er.usgs.gov/publication/ofr97487

Bauer, J. M., Burns, W. J., & Madin, I. P. (2018). *Earthquake regional impact analysis for Clackamas, Multnomah, and Washington counties, Oregon (Open-File Report O-18-02).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Bauer, J. M., Cakir, R., Allen, C., Mickelson, K., Contreras, T., Hairston-Porter, R., & Wang, Y. (2020). *Earhquake Regional Impact Analysis for Columbia County, Oregon and Clark County, Washington.* Portland: Oregon Department of Geology and Mineral Industries.

Beaulieu, J. D. (1977). *Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon (Bulletin 91).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Beaulieu, J. D., & Olmstead, D. L. (1999a). *Mitigating geologic hazards in Oregon: a technical reference manual (Special Paper 31).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Beaulieu, J. D., & Olmstead, D. L. (1999b). *Geologic hazards: reducing Oregon's losses (Special Paper 32).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Benson, C., & Bishaw, A. (2017, December 7). *Examining the Effect of Off-Campus College Students on Poverty Rates*. Retrieved from census.gov: https://www.census.gov/newsroom/blogs/random-samplings/2017/12/off-campus.html

Bott, J. D., & Wong, I. G. (1993). Historical earthquakes in and around Portland, Oregon. Oregon Geology. *55*(5), 116–122.

Burns, S. F., Burns, W. J., James, D. H., & Hinkle, J. C. (1998). *Landslides in Portland, Oregon Metropolitan area resulting from the storm of February 1996: Inventory map, database, and evaluation (Metro contract 905828).* Portland, OR: Portland State University Dept. of Geology. Retrieved from http://nwdata.geol.pdx.edu/Landslides/PDX-Landslide/metrosld.pdf

Burns, W. J. (2007). Comparison of remote sensing datasets for the establishment of a landslide mapping protocol in Oregon (AEG Special Publication 23). *Conference Presentations,, 1st North American Landslide Conference.* Vail, CO: Association for Engineering Geologists.

Burns, W. J., & Lindsey, K. O. (2017). *Landslide Inventory of Eastern Multnomah County (Open-File Report O-17-03).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., & Madin, I. P. (2009). *Protocol for inventory mapping of landslide deposits from light detection and ranging (lidar) imagery (Special Paper 42).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., & Mickelson, K. A. (2010). *Landslide inventory maps for the Oregon City quadrangle, Clackamas County, Oregon (Interpretive Map 30).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., & Mickelson, K. A. (2013). *Landslide inventory, susceptibility maps, and risk analysis for the City of Astoria, Clatsop County, Oregon (Open-File Report O-13-05).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., Calhoun, N. C., Franczyk, J. J., Lindsey, K. O., & Ma, L. (2018). *Landslide hazard and risk study of central and western Multnomah County, Oregon (IMS-57).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., Hofmeister, R. J., & Wang, Y. (2008). *Geologic hazards, earthquake and landslide hazard maps, and future earthquake damage estimates for six counties in the Mid/Southern Willamette Valley including Yamhill, Marion, Polk, Benton, Linn, and Lane Counties, and the City of Albany, Oregon (Interpr.* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., Hughes, K. L., Olson, K. V., McClaughry, J. A., Mickelson, K. A., Coe, D. E., . . . Madin, I. P. (2011c). *Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon.* Portland, OR: Oregon Department of Geology and Mineral Industries. Retrieved from https://www.oregongeology.org/pubs/ofr/p-O-11-16.htm

Burns, W. J., Hughes, K. L., Olson, K. V., McClaughry, J. D., Mickelson, K. A., Coe, D. E., . . . Madin, I. P. (2011b). *Multi-hazard and risk study for the Mount Hood region, Multnomah, Clackamas, and Hood River Counties, Oregon (Open-File Report O-11-16).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., Madin, I. P., Mickelson, K. A., & Duplantis, S. (2012b). *Inventory of landslide deposits from light detection and ranging (lidar) imagery of the Portland metropolitan region, Oregon and Washington (Interpretive Map Series IMS-53).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., Mickelson, K. A., & Madin, I. P. (2016). *Landslide susceptibility overview map of Oregon (Open-File Report O-16-02).* Portland, OR: Oregon Department of Geology and Mineral Industries. Retrieved from https://www.oregongeology.org/pubs/ofr/p-O-16-02.htm

Burns, W. J., Mickelson, K. A., & Saint-Pierre, E. C. (2011a). *Statewide landslide information database for Oregon, release 2.* Portland, OR: Oregon Department of Geology and Mineral Industries.

Burns, W. J., Mickelson, K. A., Jones, C. B., Pickner, S. G., Hughes, K. L., & Sleeter, R. (2013b). *Landslide hazard and risk study of northwestern Clackamas County, Oregon (Open-File Report O-13-08).* Portland, OR: Oregon Department of Geology and Mineral Industries.

California Governor's Office of Emergency Services. (1997). *Emergency plans for mobilehome parks; completed in compliance with the Flood Emergency Action Team (FEAT): Initiative Number 5.* Retrieved from https://adacounty.id.gov/Portals/Accem/Doc/PDF/mobilehomeparkplan.pdf. Updated version: http://www.caloes.ca.gov/PlanningPreparednessSite/Documents/FEAT_5-EmergencyPlansforMobile%20Home%20Parks%28FEAT%20doc%29.pdf

Cambridge Systematics. (2014). *Oregon State Rail Plan: freight and passenger rail inventory. Prepared for Oregon Department of Transportation.* Retrieved from http://www.oregon.gov/ODOT/TD/TP/RailPlan/Oregon_Rail_System_Inventory_Apr2014_Draft.pdf

Centers for Disease Control and Prevention / Agency for Toxic Substances and Disease Registry / Geospatial Research, Analysis, and Services Program. (2016, May 19). *CDC SVI 2016 Documentation*. Retrieved from https://svi.cdc.gov/data-and-tools-download.html (Agency for Toxis Substances and Disease Registry)

Clarke, L., Nichols, L., Vallario, R., Hejazi, M., Horing, J., Janetos, A. C., . . . White, D. D. (2018). Sector interactions, multiple stressors, and complex systems. In D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. Lewis, T. K. Maycock, & B. C. Stewart (Eds.), *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment* (Vol. II, pp. 638–668). Washington, DC: U.S. Global Change Research Program.

Climate Central. (2020). *Coos County, Oregon, USA*. Retrieved from Surging Seas Risk Finder: https://riskfinder.climatecentral.org/county/coos-county.or.us?comparisonType=county&forecastName=Basic&forecastType=NOAA2017_inthi_p50&level=4&unit=ft&zillowPlaceType=postal-code

Coastal Oregon Marine Experiment Station. (n.d.). *About our ports*. Retrieved from http://marineresearch.oregonstate.edu/about-our-ports

Cooke, D. (2019, December 2). *Oregon Construction Employment at Record Highs.* Retrieved from State of Oregon Employment Department: https://www.qualityinfo.org/-/oregon-construction-employment-at-record-highs

Cutter, S. L. (2006). *Hazards, vulnerability and environmental justice.* New York: Routledge.

Cutter, S., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. *Social Science Quarterly 28(2)*, 242-261.

Dalton, M. M. (2020). *Future Climate Projections: Clatsop County.* Oregon Climate Change Research Institute, College of Earth, Ocean and Atmospheric Sciences, Oregon State University.

Dalton, M. M. (2020). *Future Climate Projections: Lincoln County.* Oregon Climate Change Research Institute, College of Earth, Ocean and Atmospheric Sciences, Oregon State University.

Dalton, M. M., Dello, K. D., Hawkins, L., Mote, P. W., & Rupp, D. E. (2017). *The Third Oregon Climate Assessment Report.* Corvallis, OR: Oregon State University, College of Earth, Ocean and Atmospheric Sciences, Oregon Climate Change Research Institute.

Dalton, M. M., Mote, P. W., & Snover, A. K. (Eds.). (2013). *Climate change in the Northwest: implications for our landscapes, waters, and communities.* Washington, D.C.: Island Press. Retrieved from http://cses.washington.edu/db/pdf/daltonetal678.pdf

Dean Runyan Associates. (2019). *Oregon Travel Impacts Statewide Estimates 1992-2018p.* Portland: Dean Runyan Associates. Retrieved from http://www.deanrunyan.com/doc_library/ORImp.pdf

Dello, K. D., & Mote, P. W. (Eds.). (2010). *Oregon climate assessment report.* Corvallis, OR: Oregon State University, College of Oceanic and Atmospheric Sciences, Oregon Climate Change Research Institute.

Dewey, J. W. (1993). Damages from the 20 September earthquakes near Klamath Falls, Oregon. *Earthquakes & Volcanoes, 24*(3), 121.

Downing, J. A. (2012). Global abundance and size distribution of streams and rivers. *Inland Waters, 2*(4), 229–236.

Easterling, D. R., Kunkel, K. E., Arnold, J. R., Knutson, T., LeGrande, A. N., Leung, L. R., . . . Wehner, M. F. (2017). Precipitation change in the United States. Climate science special report. In D. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, & T. K. Maycock (Eds.), *Fourth National Climate Assessment* (Vol. I, pp. 207–230). Washington, D.C.: U.S. Global Change Research Program.

Ebi, K., Balbus, J., Luber, G., Bole, A., Crimmins, A., Glass, G., . . . White-Newsome, J. L. (2018). Human Health. In D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, & T. K. Maycock (Eds.), *Impacts, Risks, and Adaptation in the United States, Fourth National Climate Assessment* (Vol. II, pp. 539–571). Washington, D.C.: U.S. Global Change Research Program.

Enarson, E. (2017). Gender and Disaster: Foundations and New Directions for Research and Practice. In H. Rodriguez, W. Donner, & J. Trainor, *Handbook of Disaster Research* (pp. 205-223). Springer International.

Energy Trust of Oregon. (2017, March). *Air Conditioning Research—Phase II Final Report (prepared by The Cadmus Group LLC).* Retrieved from https://www.energytrust.org/wp-content/uploads/2018/06/AC-Research_PhaseII_9MAR2018_Final.pdf

Ewart, J. W., Diefenbach, A. K., & Ramsey, D. W. (2018). *Update to the U.S. Geological Survey National Volcanic Threat Assessment (Scientific Investigations Report 2018–5140).* Retrieved from U.S. Geological Survey: https://doi.org/10.3133/sir20185140

Federal Aviation Administration [FAA]. (2012). *CY 2012 Passenger boarding and all-cargo data.* Retrieved March 5, 2014, from Federal Aviation Administration [FAA]: lcargo_stats/passenger/media/cy11_primary_enplanements.pdf

Federal Aviation Administration [FAA]. (2014). *Airport master record (Form 5010).* Retrieved from Federal Aviation Administartion: http://www.faa.gov/airports/resources/forms/?sect=airportmaster

Federal Emergency Management Agency [FEMA]. (1989). *Alluvial fans: hazards and management (FEMA-165).* Retrieved from Federal Emergency Management Agency, Office of Loss Reduction: https://www.fema.gov/media-library/assets/documents/2955

Federal Emergency Management Agency. (2015). *Federal Guidelines for Dam Safety Risk Management (P-1025).* Retrieved from https://www.fema.gov/sites/default/files/2020-08/fema_dam-safety_risk-management_P-1025.pdf

Federal Emergency Management Agency. (2019). *Community Status Book Report, Oregon.* Retrieved from https://www.fema.gov/cis/OR.pdf

FEMA. (2012). *Hazus®-MH 2.1 User manual, Flood model.* Washington, DC: Federal Emergency Management Agency. Retrieved from https://www.fema.gov/media-library-data/20130726-1820-25045-8814/hzmh2_

Ferguson, S. A. (2000). The spatial and temporal variability of rain-on-snow. *Proceedings of the International Snow Science Workshop, 1-6 October 2000, Big Sky, Montana* (pp. 178-183). Victor, ID: American Avalanche Association. Retrieved from http://www.fs.fed.us/pnw/fera/publications/fulltext/ferguson2000.pdf

Flanagan, B. E., Gregory, W. E., Hallisey, E. J., Heitgerd, J. L., & Lewis, B. (2011). A social vulnerability index for disaster management. *Journal of Homeland Security and Emergency Management, 8*(1). doi:10.2202/1547-7355.1792

Franczyk, J. J., Burns, W. J., & Calhoun, N. C. (2019). *Statewide Landslide Information Database for Oregon, release 4.0 (SLIDO-4.0).* Portland, OR: Oregon Department of Geology and Mineral Industries. Retrieved from https://www.oregongeology.org/pubs/dds/p-slido4.htm

Goldfinger, C., Galer, S., Beeson, J., Hamilton, T., Black, B., Romsos, C., . . . Morey, A. (2017). The importance of site selection, sediment supply, and hydrodynamics: A case study of submarine paleoseismology on the Northern Cascadia margin, Washington USA. *Marine Geology, 384*, 4-16, 17, 25-46.

Goldfinger, C., Nelson, C. H., Morey, A. E., Johnson, J. E., Patton, J. R., Karabanov, E., . . . Vallier, T. (2012). *Turbidite event history — methods and implications for Holocene paleoseismicity of the Cascadia subduction zone (Professional Paper 1661–F).* Reston, VA: U..S. Geological Survey. Retrieved from http://pubs.usgs.gov/pp/pp1661f/

Governor's Task Force on Resilience Plan Implementation. (2014). *Report to the 77th Oregon Legislative Assembly, October 1, 2014.* Retrieved from http://library.state.or.us/repository/2014/201410011038023/

IPCC. (2013). Summary for Policymakers. In T. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, . . . P. Midgley (Eds.), *Climate Change 2013: The Physical Science Basis (Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change).* New York, NY: Cambridge University Press.

Jacobs, J. M., Culp, M., Cattaneo, L., Chinowsky, P., Choate, A., DesRoches, S., . . . Miller, R. (2018). Transportation. In D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. Lewis, T. K. Maycock, & B. C. Stewart (Eds.), *Impacts, Risks, and Adaptation in the United States: Fourth*

National Climate Assessment (Vol. II, pp. 479–511). Washington, DC: U.S. Global Change Research Program.

Jordan Cove Energy Project, L.P. (n.d.). Retrieved from http://www.jordancoveenergy.com/

Judson, S. (2012, February 12). *Earthquake design history: a summary of requirements in the State of Oregon.* Retrieved from http://www.oregon.gov/OMD/OEM/osspac/docs/history_seismic_codes_or.pdf

Jurjevich, J. R., Griffin, A., Spielman, S., Folch, D., Merrick, M., & Nagle, N. N. (2018). Navigating statistical uncertainty: How urban and regional planners understand and work with American Community Survey (ACS) data for guiding policy. *Journal of the American Planning Association, 84*(2), 112-126.

Karoly, L., & Zissimopoulos, J. (2010). *The Workforce and Economic Recovery: Effects of Hurricane Katrina.* Retrieved from https://www.rand.org/content/dam/rand/pubs/research_briefs/2010/RAND_RB9531.pdf

Klinenberg, E. (2016). Social isolation, loneliness, and living alone: Identifying the risks for public health. *American Journal of Public Health, 106*(5), 786–787.

Knoder, E. (2018, December 6). *Paper cuts: Oregon's declining paper industry.* Salem: State of Oregon Employment Deaprtment. Retrieved from https://www.qualityinfo.org/-/paper-cuts-oregon-s-declining-paper-industry

Knoder, E. (2019, May 29). *Central and southern Oregon coast economy for 2018.* State of Oregon Employment Department. Retrieved from https://www.qualityinfo.org/-/central-and-southern-oregon-coast-economy-for-2018

Komar, P. D. (1986). The 1982-83 El Niño and erosion on the coast of Oregon. *Shore & Beach, 54*(2), 3–12.

Komar, P. D. (1987). Erosional changes at Alsea Spit, Waldport, Oregon. *Oregon Geology, 49*(5), 55–59.

Komar, P. D. (1997). *The Pacific Northwest Coast: living with the shores of Oregon and Washington.* Durham, NC: Duke University Press.

Komar, P. D. (1998). The 1997-98 El Niño and erosion on the Oregon coast. *Shore & Beach, 66*(3), 33–41.

Komar, P. D., & Allan, J. C. (2010). “Design with Nature” strategies for shore protection — the construction of a cobble berm and artificial dune in an Oregon State Park. In H. Shipman, M. N. Dethier, G. Gelfenbaum, K. L. Fresh, & R. S. Dinicola (Ed.), *Puget Sound Shorelines and the Impacts of Armoring — Proceedings of a State of the Science Workshop, May 2009 (Scientific Investigations Report 2010-5254)* (pp. 117–126). Reston, VA: U.S. Geological Survey.

Komar, P. D., & McKinney, B. A. (1977). *The spring 1976 erosion of Siletz Spit, Oregon: with an analysis of the causative wave and tide conditions.* Corvallis, OR: Oregon State University School of Oceanography.

Komar, P. D., & Rea, C. C. (1976). Erosion of Siletz Spit, Oregon. *Shore & Beach, 44*(1), 9–15.

Konrad, C. P., & Dettinger, M. D. (2017). Flood runoff in relation to water vapor transport by atmospheric rivers over the Western United States, 1949–2015. *Geophysical Research Letters, 44*(22), 11,456-11,462. Retrieved from https://doi.org/10.1002/2017GL075399

Kopp, R. E., Hayhoe, K., Easterling, D. R., Hall, T., Horton, R., Kunkel, K. E., & LeGrande, A. N. (2017). Chapter 15: Potential surprises – compound extremes and tipping elements. In D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, & T. K. Maycock (Eds.), *Climate Science Special Report: Fourth National Climate Assessment* (pp. 411–429). Washington, DC: US Global Change Research Program.

Kossin, J. P., Hall, T., Knutson, T., Kunkel, K. E., Trapp, R. J., Waliser, D. E., & Wehner, M. F. (2017). Chapter 9: Extreme Storms. In D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, & T. K. Maycock (Eds.), *Climate Science Special Report: Fourth National Climate Assessment* (Vol. I). Washington, DC: US Global Change Research Program.

Lander, J. F., Lockridge, P. A., & Kozuch, M. J. (1993). *Tsunamis affecting the west coast of the United States 1806–1992 (NGDC Key to Geophysical Records Documentation No. 29).* NOAA National Geophysical Data Center. Retrieved from ftp://ftp.ngdc.noaa.gov/hazards/publications/Kgrd-29.pdf

Lee, J. Y., & Van Zandt, S. (2019). Housing tenure and social vulnerability to disasters: A review of the evidence. *Journal of Planning Literature, 34*(2), 156-170.

Lehner, J. (2016, April 21). *Oregon High-Tech (and Intel).* Retrieved from State of Oregon Office of Economic Analysis: https://oregoneconomicanalysis.com/2016/04/21/oregon-high-tech-and-intel/

Lehner, J. (2017, October 6). *Oregon's Shifting Retail Landscape.* Retrieved from State of Oregon Office of Economic Analysis: https://oregoneconomicanalysis.com/2017/10/06/oregons-shifting-retail-landscape-graph-of-the-week/

Lehner, J. (2017, September 28). *Portland in Transition.* Retrieved from State of Oregon Office of Economic Analysis: https://oregoneconomicanalysis.com/2017/09/28/report-portland-in-transition/

Lehner, J. (2020, January 9). *Friday Beer Thoughts and One Last 2020s Prediction: Closures.* Retrieved from State of Oregon Office of Economic Analysis: https://oregoneconomicanalysis.com/2020/01/09/friday-beer-thoughts-and-one-last-2020s-prediction-closures/

Lettman , G. J., Gray , A., Hubner , D., McKay, N., & Thompson , J. (2016). *Forests, Farms, & People: Land Use Change on Non-Federal Land in Oregon 1974-2014.* Salem : Oregon Department of Forestry .

Lettman, G. J. (2011). *Forests, farms and people: Land use change on non-federal land in Oregon, 1974–2009.* Oregon Department of Forestry and USDA Forest Service Pacific Northwest Research Station. Salem : Oregon Department of Forestry . Retrieved from http://www.oregon.gov/odf/state_forests/frp/docs/forestfarmspeople2009.pdf

Lettman, G. J. (2011). *Forests, farms and people: Land use change on non-federal land in Oregon, 1974–2009.* Oregon Department of Forestry and USDA Forest Service Pacific Northwest Research

Station, Salem, OR. Retrieved from http://www.oregon.gov/odf/state_forests/frp/docs/forestfarmspeople2009.pdf

Lettman, G. J. (2013). *Land use change on non-federal land in Oregon and Washington.* USDA Forest Service and Oregon Department of Forestry. Retrieved from http://www.oregon.gov/odf/RESOURCE_PLANNING/land_use_in_OR_WA_web_edited.pdf

Lettman, G. J., Gray, A., Hubner, D., McKay, N., & Thompson, J. (2016). *Forests, Farms, & People: Land Use Change on Non-Federal Land in Oregon 1974-2014.* Salem, OR: Oregon Department of Forestry.

Lewis, D. (2007). *Statewide seismic needs assessment: implementation of Oregon 2005 Senate Bill 2 relating to public safety, earthquakes, and seismic rehabilitation of public buildings (Open-File Report O-07-02).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Longwoods International. (2017a). *Oregon Coast Overnight Travel Study.* Retrieved from Travel Oregon: https://industry.traveloregon.com/wp-content/uploads/2018/10/OR-2017-Coast-Region-Visitor-Report.pdf

Longwoods International. (2017b). *Portland Oregon Overnight Travel Study.* Retrieved from Travel Oregon: https://industry.traveloregon.com/resources/research/portland-region-overnight-travel-study-2017-longwoods-international/

Longwoods International. (2017c). *Willamette Valley Oregon Overnight Travel Study.* Retrieved from Travel Oregon: https://industry.traveloregon.com/resources/research/willamette-valley-oregon-overnight-travel-study-2017-longwoods-international/

Longwoods International. (2017d). *Southern Oregon Overnight Travel Study.* Retrieved from Travel Oregon: https://industry.traveloregon.com/wp-content/uploads/2018/10/OR-2017-Southern-Region-Visitor-Report.pdf

Longwoods International. (2017e). *Mt. Hood/Gorge Oregon Overnight Travel Study.* Retrieved from Travel Oregon: https://industry.traveloregon.com/wp-content/uploads/2018/10/OR-2017-Mt-Hood-Columbia-River-Gorge-Region-Visitor-Report.pdf

Longwoods International. (2017f). *Central Oregon Overnight Travel Study.* Retrieved from Travel Oregon: https://industry.traveloregon.com/wp-content/uploads/2018/10/OR-2017-Central-Region-Visitor-Report.pdf

Longwoods International. (2017g). *Eastern Oregon Overnight Travel Study.* Retrieved from Travel Oregon: https://industry.traveloregon.com/wp-content/uploads/2018/10/OR-2017-Eastern-Region-Visitor-Report.pdf

Loy, W. G. (2001). *Atlas of Oregon* (2nd ed.). Eugene, OR: University of Oregon Press.

Loy, W. G., Allan, S., & Patton, C. P. (1976). *Atlas of Oregon.* Eugene, OR: University of Oregon and Economic Development for Central Oregon. Retrieved from http://www.edcoinfo.com/business-resources/utilities/natural-gas/default.aspx

Madin, I. P., & Burns, W. J. (2013). *Ground motion, ground deformation, tsunami inundation, coseismic subsidence, and damage potential maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone earthquakes.* Portland: Oregon Department of Geology and Mineral Industries.

Masozera, M., Bailey, M., & Kerchner, C. (2007, August). Distribution of impacts of natural disasters across income. *Ecological Economics, 63*(1-2), 299-306. Retrieved from https://doi.org/10.1016/j.ecolecon.2006.06.013

May, C., Luce, C. H., Casola, J., Chang, M., Cuhaciyan, J. E., Dalton, M. M., . . . York, E. (2018). Northwest. In D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. Lewis, T. K. Maycock, & B. C. Stewart (Eds.), *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment* (Vol. II, pp. 1036–1100). Washington, DC: U.S. Global Change Research Program.

McClaughry, J. D., Wiley, T. J., Conrey, R. M., Jones, C. B., & Lite, K. E. (2012). *Digital geologic map of the Hood River Valley, Hood River and Wasco Counties, Oregon (Open-File Report O-12-03).* Portland, OR: Oregon Department of Geology and Mineral Industries. Retrieved from https://www.oregongeology.org/pubs/ofr/p-O-12-03.htm

MDC Consultants. (n.d.). *When disaster Strikes - Promising Practices.* MDC Consultants. Retrieved from https://www.mdcinc.org/wp-content/uploads/2017/11/When-Disaster-Strikes-Promising-Practices-Toursts-and-Newcomers.pdf

Meadows, D. H. (2008). *Thinking in systems: a primer.* White River Junction, VT: Chelsea Green Publishing.

Metro. (2020, July 28). *Urban growth boundary*. Retrieved from oregonmetro.gov: https://www.oregonmetro.gov/urban-growth-boundary

Metz, C. (2011, December 1). *Welcome to Prineville, Oregon: Population, 800 Million.* Retrieved from Wired: https://www.wired.com/2011/12/facebook-data-center/

Morrow, B. H. (1999). Identifying and mapping community vulnerability. *Disasters, 23(1)*, 1-18. doi:10.1111/1467-7717.00102

Mote, P. W., Abatzoglou, J. T., Dello, K. D., Hegewisch, K., & Rupp, D. E. (2019). *Fourth Oregon Climate Assessment Report.* Corvallis, OR: Climate Change Research Institute.

Mote, P. W., Lettenmaier, D. P., Xiao, M., & Engel, R. (2018). Dramatic declines in snowpack in the western US. *Climate and Atmospheric Science, 1*(1), 1-6. Retrieved from https://doi.org/10.1038/s41612-018-0012-1

Mote, P. W., Rupp, D. E., Li, S., Sharp, D. J., Otto, F., Uhe, P. F., . . . Allen, M. R. (2016). Perspectives on the causes of exceptionally low 2015 snowpack. *Geophysical Research Letters, 43*(20). Retrieved from https://doi.org/10.1002/2016GL069965

National Research Council. (2012). *Sea-level rise for the coasts of California, Oregon, and Washington: past, present, and future.* Washington, DC: National Academies Press.

NEEA. (2019, April). *Residential Building Stock Assessment II: Single-Family Homes Report 2016-2017.* Retrieved from Northwest Energy Efficiency Alliance: https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf

Niewendorp, C. A., & Neuhaus, M. E. (2003). *Map of selected earthquakes for Oregon, 1841-2002 (Open-File Report O-03-02).* Portland, OR: Oregon Department of Geology and Mineral Industries.

NOAA. (2020). *Climate at a Glance | National Centers for Environmental Information (NCEI)*. Retrieved March 2020, from https://www.ncdc.noaa.gov/cag/statewide/time-series

NTIA. (n.d., May 10). *Oregon Broadband Mapping Project. Interactive Map [National Telecommunications and Information Administration].* Retrieved May 10, 2014, from National Telecommunications and Information Administration: https://broadband.oregon.gov/StateMap/ [Note: This site is no longer available. According to the website, version of the information formerly displayed on this site is available on the National Broadband Map web site, http://www.broadbandmap.gov.]

Office of Management and Budget. (n.d.). *North American Industry Classification System*. Retrieved February 26 2020, from https://www.census.gov/eos/www/naics/2017NAICS/2017_NAICS_Manual.pdf

Omundson, P. (2019, November 5). BLUECHIP: Solid Lane County tourism numbers. *The Register Guard*. Eugene, OR: Gannett Co., Inc. Retrieved from Register Guard .

Oregon Department of Energy. (n.d.a). *Power plants in Oregon*. Retrieved July 1, 2014, from http://www.oregon.gov/energy/siting/pages/power.aspx

Oregon Department of Energy. (n.d.b, May 5). *Oregon's power mix*. Retrieved 2014, from http://www.oregon.gov/energy/pages/oregons_electric_power_mix.aspx

Oregon Department of Environmental Quality. (2014). *Jordan Cove Energy Project*. Retrieved February 19, 2014, from http://www.deq.state.or.us/wr/localprojects/jordancove/index.htm

Oregon Department of Forestry. (2008). *Drought and conifer mortality in the Willamette Valley.* Retrieved September 2014, from http://www.oregon.gov/odf/privateforests/docs/Forest%20Health/droughtconifermortalitywv.pdf

Oregon Department of Transportation. (2014, October). *Oregon highways Seismic Plus report.* Oregon Department of Transportation, Bridge and Geo-Environmental Sections, Technical Services Branch.

Oregon Department of Transportation. (2019). *2019 Bridge Condition Report and Tunnel Data.* Retrieved from Oregon Department of Transportation: https://www.oregon.gov/odot/Bridge/Documents/Bridge-Condition-Report-2019.pdf. Available from https://www.oregon.gov/odot/Bridge/Pages/BCR.aspx

Oregon Housing and Community Services. (2019, Nov. 21, November 21). *2019 Point-in-Time County Brief.* Retrieved from oregon.gov: https://www.oregon.gov/ohcs/DO/docs/11-21-2019-PIT-Brief.pdf

Oregon Office of Emergency Management. (2013). *The 2013 Oregon State Emergency Alert System Plan (12.0).* Retrieved from State of Oregon: http://www.oregon.gov/OMD/OEM/tech_resp/EAS/EAS_Plan.pdf

Oregon Office of Emergency Management. (2014 rev.). *State of Oregon Emergency Operations Plan: Drought Annex, September 2002.* Retrieved from http://www.oregon.gov/OMD/OEM/Pages/plans_train/EOP.aspx; http://www.oregon.gov/owrd/WR/docs/eop_ia_1_drought_complete.pdf

Oregon Office of Emergency Management. (n.d.). *Amateur radio unit - W7OEM*. Retrieved March 15, 2014, from http://www.oregon.gov/OMD/OEM/Pages/tech_resp/amateur_radio.aspx

Parker, L. E., & Abatzoglou, J. T. (2016). Spatial coherence of extreme precipitation events in the Northwestern United States. *International Journal of Climatology, 36*(6), 2451–2460. Retrieved from https://doi.org/10.1002/joc.4504

Peacock, W. G., Dash, N., Zhang, Y., & Van Zandt, S. (2017). Post-disaster sheltering, Temporary housing and permanent housing recovery. In H. Rodriguez, W. Donner, & J. E. Trainor, *Handbook of DIsaster Research.* New York: Springer.

Personius, S. F., Dart, R. L., Bradley, L.-A., & Haller, K. M. (2003). *Map and data for Quaternary faults and folds in Oregon (Open-File Report 03-095).* Reston: U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/of/2003/ofr-03-095/

Petersen, M., Moschetti, M., Powers, P., Mueller, C., Haller, K., Frankel, A., . . . Olsen, A. (2014). *Documentation for the 2014 update of the United States national seismic hazard maps (Open-File Report 2014–1091).* U.S. Geological Survey. Retrieved from https://pubs.usgs.gov/of/2015/1070/pdf/ofr2015-1070.pdf

Peterson, C. D., Jackson, P. L., O'Neil, D. J., Rosenfeld, C. L., & Kimerling, A. J. (1990). Littoral cell response to interannual climatic forcing 1983–1987 on the central Oregon coast, USA. *Journal of Coastal Research, 6*(1), 87–110.

Pipelines International. (2009, December 22). *Pacific Connector and Jordon Cove clear approval hurdle.* Retrieved from http://pipelinesinternational.com/news/pacific_connector_and_jordon_cove_clear_approval_hurdle/009283/

Pitzer, P. C. (1988). The atmosphere tasted like turnips: the Pacific Northwest dust storm of 1931. *Pacific Northwest Quarterly, 79*(2), 50–55.

Population Research Center, Portland State University . (2017 & 2018). *Coordinated Population Forecast 2017-2067 & 2018-2068*. Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/opfp

Population Research Center, Portland State University. (2017). *Coordinated Population Forecast 2017-2067*. Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/opfp

Population Research Center, Portland State University. (2018 [Deschutes County], June 30). *Coordinated Population Forecast, Deschutes County, 2018-2068.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Deschutes_Report_Final.pdf

Population Research Center, Portland State University. (2018 [Harney County], June 30). *Coordinated Population Forecast, Harney County, 2018-2068.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Harney_Report_Final.pdf

Population Research Center, Portland State University. (2018 [Jefferson County], June 30). *Coordinated Population Forecast, Jefferson County, 2018-2068.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Jefferson_Report_Final.pdf

Population Research Center, Portland State University. (2018 [Klamath County], June 30). *Coordinated Population Forecast, Klamath County, 2018-2068.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Klamath_Report_Final.pdf

Population Research Center, Portland State University. (2018 [Lake County], June 30). *Coordinated Population Forecast, Lake County, 2018-2068.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Deschutes_Report_Final.pdf

Population Research Center, Portland State University. (2019 [Baker County], June 30). *Coordinated Population Forecast, Baker County, 2019-2069.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Baker_Report_Final.pdf

Population Research Center, Portland State University. (2019 [Douglas, Jackson, Josephine Counties]). *Coordinated Population Forecast, Douglas County, Jackson County, Josephine County 2018-2069*. Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/current-documents-and-presentations

Population Research Center, Portland State University. (2019 [GIlliam and Sherman Counties]). *Coordinated Population Forecast, GIlliam and Sherman Counties, 2019-2069.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/current-documents-and-presentations

Population Research Center, Portland State University. (2019 [Grant County], June 30). *Coordinated Population Forecast, Grant County, 2019-2069.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Grant_Report_Final.pdf

Population Research Center, Portland State University. (2019 [Lane County], June 30). *Coordinated Population Forecast, Lane County 2019-2069.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Lane_Report_Final.pdf

Population Research Center, Portland State University. (2019 [Malheur County], June 30). *Coordinated Population Forecast, Malheur County, 2019-2069.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Malheur_Report_Final.pdf

Population Research Center, Portland State University. (2019 [Morrow County]). *Cooridnated Population Forecasts, Morrow County, 2019-2069.* Retrieved from https://www.pdx.edu/prc/current-documents-and-presentations

Population Research Center, Portland State University. (2019 [Union County], June 30). *Coordinated Population Forecast, Union County, 2019-2069.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Union_Report_Final.pdf

Population Research Center, Portland State University. (2019 [Wallowa County], June 30). *Coordinated Population Forecast, Wallowa County, 2019-2069.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Wallowa_Report_Final.pdf

Population Research Center, Portland State University. (2019 [Wheeler County], June 30). *Coordinated Population Forecast, Wheeler County, 2019-2069.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/Wheeler_Report_Final.pdf

Population Research Center, Portland State University. (2020 [Hood River], March 31). *Proposed Coordinated Forecasts for Hood River County, its Urban Growth Boundaries, and the Area outside UGBs.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/R3_Hood%20River_Proposed.pdf

Population Research Center, Portland State University. (2020 [Wasco], March 31). *Proposed Coordinated Forecasts for Wasco County, its Urban Growth Boundaries, and the Area Outside UGBs.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/R3_Wasco_Proposed.pdf

Population Research Center, Portland State University. (2020, Mar. 31, March 31). *Proposed Coordinated Population Forecast for Yamhill County, its Urban Growth Boundaries (UGB's), and the area outside the UGBs.* Retrieved from pdx.edu/prc/: https://www.pdx.edu/prc/sites/www.pdx.edu.prc/files/R3_Yamhill_Proposed.pdf

Portland International Airport. (2014). *Monthly traffic report, December, 2013: Calendar year report.* Retrieved from http://www.portofportland.com/Aviation_Stat.aspx

Priest, G. R. (1999). Coastal shoreline change study northern and central Lincoln County, Oregon. In M. Crowell, & S. P. Leatherman (Eds.), *Coastal Erosion Mapping and Management, Journal of Coastal Research. Special Issue 28* (pp. 140–157).

Priest, G. R., Goldfinger, C., Wang, K., Witter, R. C., Zhang, Y., & Baptista, A. M. (2009). *Tsunami hazard assessment of the northern Oregon coast: A multi-deterministic approach tested at Cannon Beach, Clatsop County, Oregon (Special Paper 41).* Retrieved from https://www.oregongeology.org/pubs/sp/SP-41.zip

Priest, G. R., Witter, R. C., Zhang, Y. J., Wang, K., Goldfinger, C., Stimely, L. L., . . . Smith, R. L. (2013). *Tsunami inundation scenarios for Oregon (Open-File Report O-13-19).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Priest, G., Zhang, Y., Witter, R., Wang, K., Goldfinger, C., & Stimely, L. (2014). Tsunami impact to Washington and northern Oregon from segment ruptures on the southern Cascadia subduction zone. *Natural Hazards, 72*(849–870). Retrieved from https://doi.org/10.1007/s11069-014-1041-7

Pyrologix LLC. (2018). *Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results.* prepared for U.S. Forest Service.

QCEW. (2018). *Employment and Wages by Industry.* Retrieved from Oregon Employment Department: qualityinfo.org

Quinterno, J. (2014). *Running the Numbers: A Practical Guide to Regional Economic and Social Analysis.* Armonk: M.E. Sharpe, Inc.

Redmond, K. (2002). The depiction of drought: a commentary. *Bulletin of the American Meteorological Society, 83*(8), 1143–1147.

Redmond, K. T., & Koch, R. W. (1991). Surface climate and streamflow variability in the western United States and their relationship to large-scale circulation indices. *Water Resour. Res., 27*, 2381–2399. Retrieved from https://doi.org/10.1029/91WR00690

Revell, D., Komar, P. D., & Sallenger, A. H. (2002). An application of LIDAR to analyses of El Niño erosion in the Netarts littoral cell, Oregon. *Journal of Coastal Research, 18*(4), 792–801.

Roberts, J. T., & Anthony, L. H. (2017). *Statewide subbasin-level channel migration screening for Oregon (IMS-56).* Portland: Oregon Deparment of Geolooy and Mineral Industries. Retrieved from https://www.oregongeology.org/pubs/ims/p-ims-056.htm

Rooney, B. (2019, August 27). *Professional and Business Services: "What's in that Industry?".* Retrieved from State of Oregon Employment Department: https://www.qualityinfo.org/-/professional-and-business-services-what-s-in-that-industry-

Ruggiero, P., Kratzmann, M. G., Himmelstoss, E. A., Reid, D., Allan, J. C., & Kaminsky, G. M. (2013). *ational assessment of shoreline change: historical shoreline change along the Pacific Northwest coast (Oregon and Washington) (Open-File Report 2012-1007).* Reston: U.S. Geological Survey.

Satake K., Shimazaki K., Tsuji Y., & Ueda K. (1996). Time and size of a giant earthquake in Cascadia inferred from Japanese tsunami records of January 1700. *Nature, 370*, pp. 246–249.

Schilling, S. P. (1996). *Digital data set of volcano hazards for active Cascade Volcanoes, Washington (Open-File Report 96-178).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/of/1996/0178/

Schilling, S. P., Doelger, S., Scott, W. E., & Iverson, R. (2008c). *Digital data for volcano hazards of the Three Sisters Region, Oregon (Open-File Report, 2007-1221).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/of/2007/1221/

Schilling, S. P., Doelger, S., Scott, W. E., Pierson, T., Costa, J., Gardner, C., . . . Major, J. (2008a). *Digital data for volcano hazards of the Mount Hood region, Oregon (Open-File Report 2007-1222).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.er.usgs.gov/publication/ofr20071222

Schilling, S. P., Doelger, S., Sherrod, D. R., Mastin, L. G., & Scott, W. E. (2008b). *Digital data for volcano hazards at Newberry Volcano, Oregon (Open-File Report 2007-1225).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/of/2007/1225/

Schilling, S. P., Doelger, S., Walder, J. S., Gardner, C., Conrey, R. M., & Fisher, B. J. (2007). *Digital data for volcano hazards in the Mount Jefferson region, Oregon (Open-File Report 1224).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/of/2007/1224/intro.html

Schlicker, H. G., Deacon, R. J., Beaulieu, J. D., & Olcott, G. W. (1972). *Environmental geology of the coastal region of Tillamook and Clatsop Counties, Oregon. (Bulletin 74).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Schlicker, H. G., Deacon, R. J., Olcott, G. W., & Beaulieu, J. D. (1973). *Environmental geology of Lincoln County, Oregon (Bulletin 81).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Scott, W. E., Gardner, C. A., Sherrod, D. R., Tilling, R. I., Lanphere, M. A., & Conrey, R. M. (1997b). *Geologic history of Mount Hood Volcano, Oregon; a field-trip guidebook (Open-File Report 97-263).* Reston, VA: U.S. Geological Survey.

Scott, W. E., Iverson, R., Schilling, S. P., & Fisher, B. J. (2001). *Volcano hazards in the Three Sisters region, Oregon (Open-File Report 99-437).* Reston, VA: U.S. Geological Survey.

Scott, W. E., Iverson, R., Vallance, J. W., & Hildreth, W. (1995). *Volcano hazards in the Mount Adams region, Washington (Open-File Report 95-492).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.er.usgs.gov/publication/ofr95492

Scott, W. E., Pierson, T., Schilling, S. P., Costa, J., Gardner, C., Vallance, J. W., & Major, J. (1997a). *Volcano hazards in the Mount Hood region, Oregon (Open-File Report 97-89).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.er.usgs.gov/publication/ofr9789

Sherrod, D. R. (1993). Historic and prehistoric earthquakes near Klamath Falls, Oregon. *Earthquakes & Volcanoes, 24*(3), p. 106.

Sherrod, D. R., Mastin, L. G., Scott, W. E., & Schilling, S. P. (1997). *Volcano hazards at Newberry Volcano, Oregon (Open-File Report 97-513).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.er.usgs.gov/publication/ofr97513

Southwest Oregon Regional Airport. (n.d.). *Master plan documents*. Retrieved from http://www.flyoth.com/mp_documents.php

Stahl, P. (2000). Session Summary #16. Disasters, Diversity, and Equity. *Annual Hazards Workshop.* Boulder: FEMA.

Stahl, P., Mitchell, J., Campbell, P., Enarson, E., Peterson, K., & Edwards, B. (2000). Session S00-16, Disasters, diversity, and equity. *25th Annual Hazards Research and Applications Workshop.* Boulder, CO: Natural Hazards Center, University of Colorado.

Starbuck, E. (2016, December 2). *Multimedia Artists and Animators – An Emerging Occupation in Oregon.* Retrieved from Oregon Workforce and Economic Information Blog: https://oregonemployment.blogspot.com/2016/12/multimedia-artists-and-animators.html

Stembridge, J. E. (1975). *Shoreline changes and physiographic hazards on the Oregon coast.* Unpublished doctoral dissertation, Unpublished doctoral dissertation, University of Oregon, Eugene.

Sweet, W. V., Horton, R., Kopp, R. E., LeGrande, A. N., & Romanou, A. (2017a). Sea level rise. In D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, & T. K. (Eds.), *Climate Science Special Report: Fourth National Climate Assessment, Volume I* (pp. 333–363). U.S. Global Change Research Program. doi:10.7930/J0VM49F2

Sweet, W. V., Kopp, R. E., Weaver, C. P., Obeysekera, J., Horton, R. M., Thieler, E. R., & Zervas, C. (2017b). *Global and Regional Sea Level Rise Scenarios for the United States (NOAA Technical Report NOS CO-OPS 083).* NOAA National Ocean Service. Retrieved from https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

Tauer, G. (2019, August 15). *Oregon's Wholesale Trade Industry.* Retrieved from State of Oregon Employment Department: https://www.qualityinfo.org/-/oregon-s-wholesale-trade-industry

Taylor, G. H., & Hannan, C. (1999). *The climate of Oregon: from rain forest to desert.* Corvallis, OR: Oregon State University Press.

Taylor, G. H., & Hatton, R. (1999). *The Oregon weather book: a state of extremes.* Corvallis, OR: Oregon State University Press.

Terich, T. A., & Komar, P. D. (1974). Bayocean Spit, Oregon: History of development and erosional destruction. *Shore & Beach, 42*(2), 3-10.

Thomas, G. C., Crosson, R. S., Carver, D. L., & Yelin, T. S. (1996). The 25 March 1993 Scotts Mills, Oregon, earthquake and aftershock sequence: spatial distribution, focal mechanisms, and the Mount Angel Fault. *Seismological Society of America, 86*(4), 925–935.

Thorson, T. D., Bryce, S. A., Lammers, D. A., Woods, A. J., Omernik, J. M., Kagan, J., . . . Comstock, J. A. (2003). *Ecoregions of Oregon (color poster with map, descriptive text, summary tables, and photographs; map scale 1:1,500,000).* Retrieved March 8, 2014, from http://www.epa.gov/wed/pages/ecoregions/or_eco.htm

Trentadue, J. A., & Alcock, T. Z. (2020). *Communities at Risk Report.* Retrieved from Oregon Department of Forestry: https://www.oregon.gov/odf/Documents/Fire/Communities-at-risk-report.pdf

U.S. Army Corps of Engineers. (2020). *Portland Metro Levee System Feasibility Study.* Portland: U.S. Army Corps of Engineers.

U.S. Bureau of Labor Statistics. (2019, Dec. 20, December 20). *QCEW Supersectors, High-Level Industry Titles, and NAICS Crosswalk*. Retrieved from bls.gov: https://www.bls.gov/cew/classifications/industry/industry-supersectors.htm

U.S. Bureau of Labor Statistics. (2019, Sept. 4, September 4). *Quarterly Census of Employment and Wages*. Retrieved from bls.gov: https://www.bls.gov/cew/publications/employment-and-wages-annual-averages/current/home.htm#establishments

U.S. Bureau of Labor Statistics. (2020, April 17, April 17). *Miscellaneous Store Retailers: NAICS 453*. Retrieved from Industries at a Glance, bls.gov: https://www.bls.gov/iag/tgs/iag453.htm

U.S. Census Bureau. (2018). *American Community Survey and Puerto Rico Community Survey 2018 Subject Definitions.* Retrieved from census.gov: https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html

U.S. Census Bureau. (2018). Understanding Error and Determining Statistical Significance. In *Understanding and Using American Community Survey Data: What All Data Users Need to Know* (pp. 44-50). Washington, D.C.: U.S. Government Printing Office.

U.S. Census Bureau. (2019, Apr. 3, April 3). *Topics; population; age-and-sex; about*. Retrieved from census.gov: https://www.census.gov/topics/population/age-and-sex/about.html

U.S. Census Bureau. (2019, Mar. 31, March 31). Table S0101, Age and Sex. *American Community Survey (2014-2018, 5yr)*. U.S. Census Bureau.

U.S. Department of Housing and Urban Development. (2016). *Send Red, Not Blue: The Homeless Resident.* Washington, D.C.: U.S. Department of Housing and Urban Development.

USDA. (2020, April 14). *Components of Population Change*. Retrieved from United States Department of Agriculture: https://www.ers.usda.gov/topics/rural-economy-population/population-migration/components-of-population-change/

Valdovinos, K. (2020, March 31). *Most Oregon employers have fewer than 20 employees.* Retrieved from https://www.qualityinfo.org/-/most-oregon-employers-have-fewer-than-20-employees?inheritRedirect=true&redirect=%2Fbi

Van Heeswijk, M., Kimball, J., & Marks, D. (1996). *Simulation of water available for runoff in clearcut forest openings during rain-onsnow events in the western Cascade Range of Oregon and Washington (Water Resources Investigations Report 95-4219).* Tacoma, WA: U.S. Geological Survey.

Vose, R., Easterling, D., Kunkel, K., LeGrande, A., & Wehner, M. (2017). Temperature changes in the United States. In D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, & T. K. Maycock (Eds.), *Climate Science Special Report: Fourth National Climate Assessment* (Vol. I, pp. 185–206). Washington, D.C.: U.S. Global Change Research Program.

Walder, J. S., Gardner, C. A., Conrey, R. M., Fisher, B. J., & Schilling, S. P. (1999). *Volcano hazards in the Mount Jefferson region, Oregon (Open-File Report 99-24).* Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/of/1999/0024/

Wallis, L. (2018). *Couriers and Messengers: From Pony Express to Future Drones.* Retrieved from State of Oregon Employment Department: https://qualityinfo.org

Wallis, L. (2019, March 12). *Private Households: Employing the Nation's Invisible Workforce.* Retrieved from State of Oregon Employment Department: https://www.qualityinfo.org/-/private-households-employing-the-nation-s-invisible-workforce

Wang, Y. (1998). *Earthquake damage and loss estimate for Oregon (DOGAMI Open-File Report O-98-03).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Wang, Y., & Chaker, A. (2004). *Geologic hazards study for the Columbia River transportation corridor (Open-File Report O-04-08).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Wang, Y., & Clark, J. L. (1999). *Earthquake damage in Oregon: preliminary estimates of future earthquake losses (Special Paper 29).* Portland, OR: Oregon Department of Geology and Mineral Industries. Retrieved from http://www.oregongeology.org/pubs/sp/SP-29.pdf

Wang, Y., Bartlett, S. F., & Miles, S. B. (2013). *Earthquake risk study for Oregon's critical energy infrastructure hub (DOGAMI Open-File Report O-13-09).* Oregon Department of Geology and Mineral Industries. Retrieved from http://www.oregongeology.org/sub/earthquakes/cei-hub-report.pdf

Wang, Y., Summers, R. D., & Hofmeister, R. (2002). *Landslide loss estimation pilot project in Oregon (Open-File Report O-02-05).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Wiley, T. J., McClaughry, J. D., & D'Allura, J. A. (2011). *Geologic database and generalized geologic map of Bear Creek Valley, Jackson County (Open-File Report O-11-11).* Oregon Department of Geology and Mineral Industries.

Witter, R. C., Zhang, Y., Wang, K., Priest, G. R., Goldfinger, C., Stimely, L. L., . . . Ferro, P. A. (2011). *Simulating tsunami inundation at Bandon, Coos County, Oregon, using hypothetical Cascadia and Alaska earthquake scenario (Special Paper 43).* Portland, OR: Oregon Department of Geology and Mineral Industries.

Wolfe, E. W., & Pierson, T. (1995). *Volcanic-hazard zonation for Mount St. Helens, Washington, 1995 (Open-File Report, 95-497).* U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/of/1995/0497/

Wong, I. G., & Bott, J. D. (1995). A look back at Oregon’s earthquake history, 1841–1994. *57*(6), 125–139.

Wood, N. (2007). *Variations in city exposure and sensitivity to tsunami hazards in Oregon.* Scientific Investigations Report 2007-5283, U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/sir/2007/5283

Wood, N. (2011). *Understanding risk and resilience to natural hazards.* Fact Sheet 2011-3008, U.S. Geological Survey. Retrieved from https://pubs.usgs.gov/fs/2011/3008/

Wood, N. J., & Schmidtlein, M. C. (2011, June 01). Anisotropic path modeling to assess pedestrian-evacuation potential from Cascadia-related tsunamis in the US Pacific Northwest. *Natural Hazards*, 275–300. doi:10.1007/s11069-011-9994-2

Zhang, Y., Lindell, M., & Prater, C. (2009). Vulnerability of community businesses to environmental disasters. *Disasters, 33*(1), 38-57.

Chapter 9 APPENDICES

The following links will open in a new window. Linked files are PDFs or Excel files.

9.1 Risk Assessment

9.1.1 Wildfire: Conflagration Fires 2015–2019

9.1.2 Wildfire: West Wide Wildfire Risk Assessment Project Summary Statistics of Published Results by State: Oregon

9.1.3 Wildfire: West Wide Wildfire Risk Assessment Final Report–Addendum VI, County Risk Summaries: Oregon

9.1.4 Windstorm: Information on 1931 Dust Storm

9.1.5 Recognizing Tree Risk

9.1.6 Average Observed Snowfall at Various Oregon Weather Stations

9.1.7 Winter Storm: Reducing Ice Storm Damage to Trees

9.1.8 2020 Statewide Loss Estimates: State-Owned/Leased Facilities and Critical Facilities Table (Excel)

9.1.9 2020 Statewide Loss Estimates: Local Critical Facilities Table (Excel)

9.1.10 Statewide Loss Estimates: State-owned Critical and Essential Facilities Loss Estimates Table (PDF)

9.1.11 Statewide Loss Estimates: Local Critical and Essential Facilities Loss Estimates Table

9.1.12 Statewide Loss Estimates: Historic Resources

9.1.13 Statewide Loss Estimates: Archaeological Resources

9.1.14 Oregon Highways Seismic Plus Report, Oregon DOT October 2014

9.1.15 Statewide Loss Estimates: Oregon Highways Seismic Options Report

9.1.16 Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification

9.1.17 2019 Threat and Hazard Identification and Risk Assessment (THIRA) Executive Summary

9.1.18 Oregon Risk Assessment: A New Model, Final Report

9.1.19 OEM Hazard Analysis Methodology

9.1.20 Oregon Climate Assessment Report

9.1.21 Fourth Oregon Climate Assessment Report (2019)

9.1.22 2013 Northwest Climate Assessment Report

9.1.23 2020 Climate Change Adaptation Framework, Review Draft, August 12, 2020: Do not cite or quote.

9.1.24 Oregon Climate Change Workshop Summary Report (Fall 2019)

9.1.25 2013 CREW Cascadia Subduction Zone Scenario

9.1.26 High-Resolution Natural Hazard Maps Showing State-Owned/Leased Facilities and Critical/Essential Facilities

Page-size version of these maps are included in the main text. High resolution, large-file-size, tabloid-page-sized map PDFs external to this document are linked below.

In-Text	Hazard Map	Linked Tabloid-Size PDF
Statewide		
Figure 2-23	State-Owned/Leased & Critical Facilities	Map
Figure 2-24	Local Critical Facilities	Map
Region 1		
Figure 2-127	Coastal Erosion Zone	Map
Figure 2-130	Cascadia Subduction Zone Earthquake Hazard Zone	Map
Figure 2-131	Flood Zone	Map
Figure 2-134	Landslide Hazard Zone	Map
Figure 2-135	Tsunami Hazard Zone	Map
Figure 2-141	Wildfire Zone	Map
Region 2		
Figure 2-156	Cascadia Subduction Zone Earthquake Hazard Zone	Map
Figure 2-157	Flood Zone	Map
Figure 2-161	Landslide Zone	Map
Figure 2-162	Volcanic Hazard Zone	Map
Figure 2-165	Wildfire Hazard Zone	Map
Region 3		
Figure 2-183	Cascadia Subduction Zone Earthquake Hazard Zone	Map
Figure 2-184	Flood Zone	Map
Figure 2-187	Landslide Zone	Map
Figure 2-188	Volcanic Hazard Zone	Map
Figure 2-191	Wildfire Hazard Zone	Map
Region 4		
Figure 2-206	Cascadia Subduction Zone Earthquake Hazard Zone	Map
Figure 2-207	Flood Zone	Map
Figure 2-211	Landslide Hazard Zone	Map
Figure 2-212	Volcanic Hazard Zone	Map
Figure 2-215	Wildfire Zone	Map

In-Text	Hazard Map	Linked Tabloid-Size PDF
Region 5		
Figure 2-236	Earthquake Zone	Map
Figure 2-237	Flood Hazard Zone	Map
Figure 2-242	Landslide Hazard Zone	Map
Figure 2-243	Volcanic Hazard Zone	Map
Figure 2-246	Wildfire Hazard Zone	Map
Region 6		
Figure 2-261	Earthquake Zone	Map
Figure 2-262	Flood Hazard Zone	Map
Figure 2-265	Landslide Hazard Zone	Map
Figure 2-266	Volcanic Hazard Zone	Map
Figure 2-269	Wildfire Hazard Zone	Map
Region 7		
Figure 2-285	Earthquake Zone	Map
Figure 2-286	Flood Hazard Area	Map
Figure 2-289	Landslide Hazard Zone	Map
Figure 2-292	Wildfire Hazard Zone	Map
Region 8		
Figure 2-313	Earthquake Zone	Map
Figure 2-314	Flood Hazard Zone	Map
Figure 2-317	Landslide Hazard Zone	Map
Figure 2-322	Wildfire Hazard Zone	Map

9.2 Mitigation Strategy

9.2.1 Mitigation Action Prioritization Survey #1 – Results

9.2.2 Mitigation Action Prioritization Survey #2 – Results

9.2.3 Oregon Resilience Plan

9.2.4 Resilience Task Force Report to the Oregon Legislature

9.2.5 Resiliency 2025: Improving Our Readiness for the Cascadia Earthquake and Tsunami

9.2.6 Incorporating Green Infrastructure and Low Impact Development into the Ashland Hazard Mitigation Plan

9.3 Planning Process

9.3.1 Comments and Responses: Draft Risk Assessment, June 2020

9.3.2 Comments and Responses: Draft Mitigation Strategy, July 2020