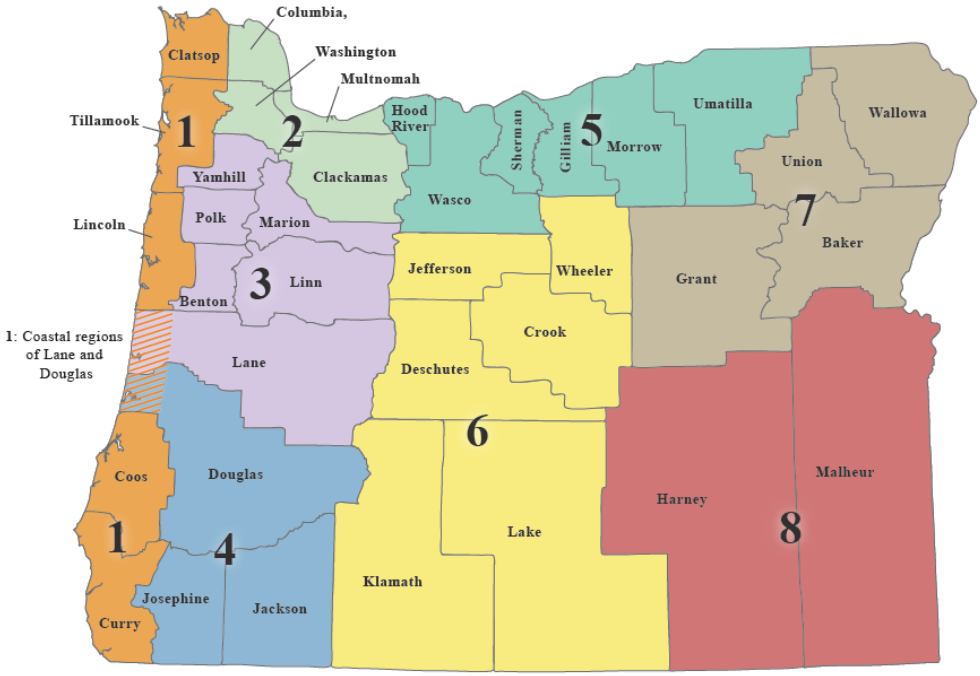
2.3 Regional Risk Assessments

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).

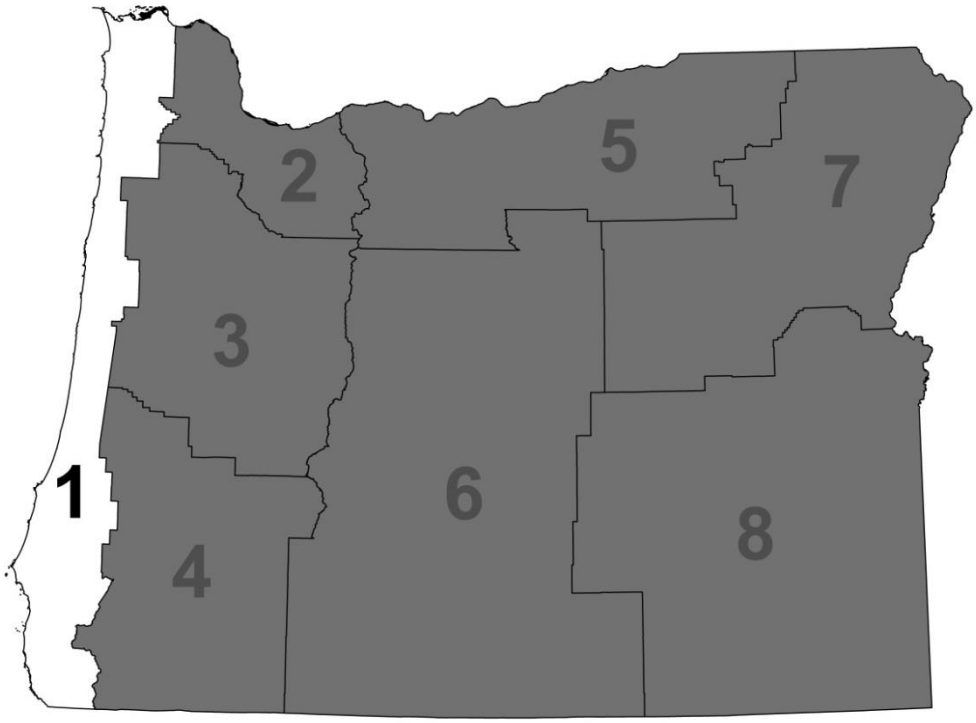
3. The **Hazards and Vulnerability** section first identifies each hazard and its characteristics in the region. Then, the historical events that have impacted the region are listed. Lastly, probabilities and vulnerabilities are discussed as identified by local and state risk assessments. Vulnerabilities

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 90th 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…

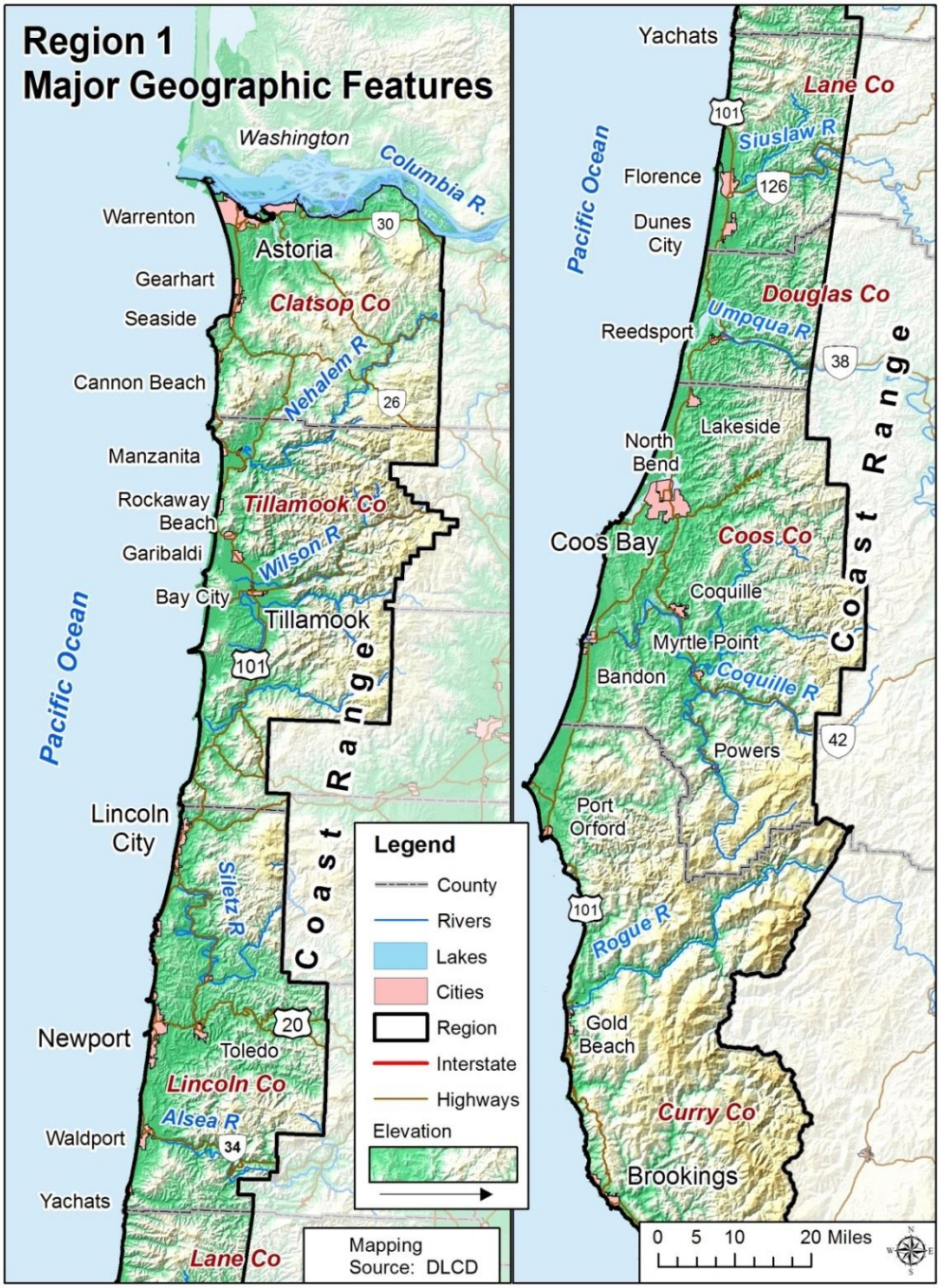
Natural Environment

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.

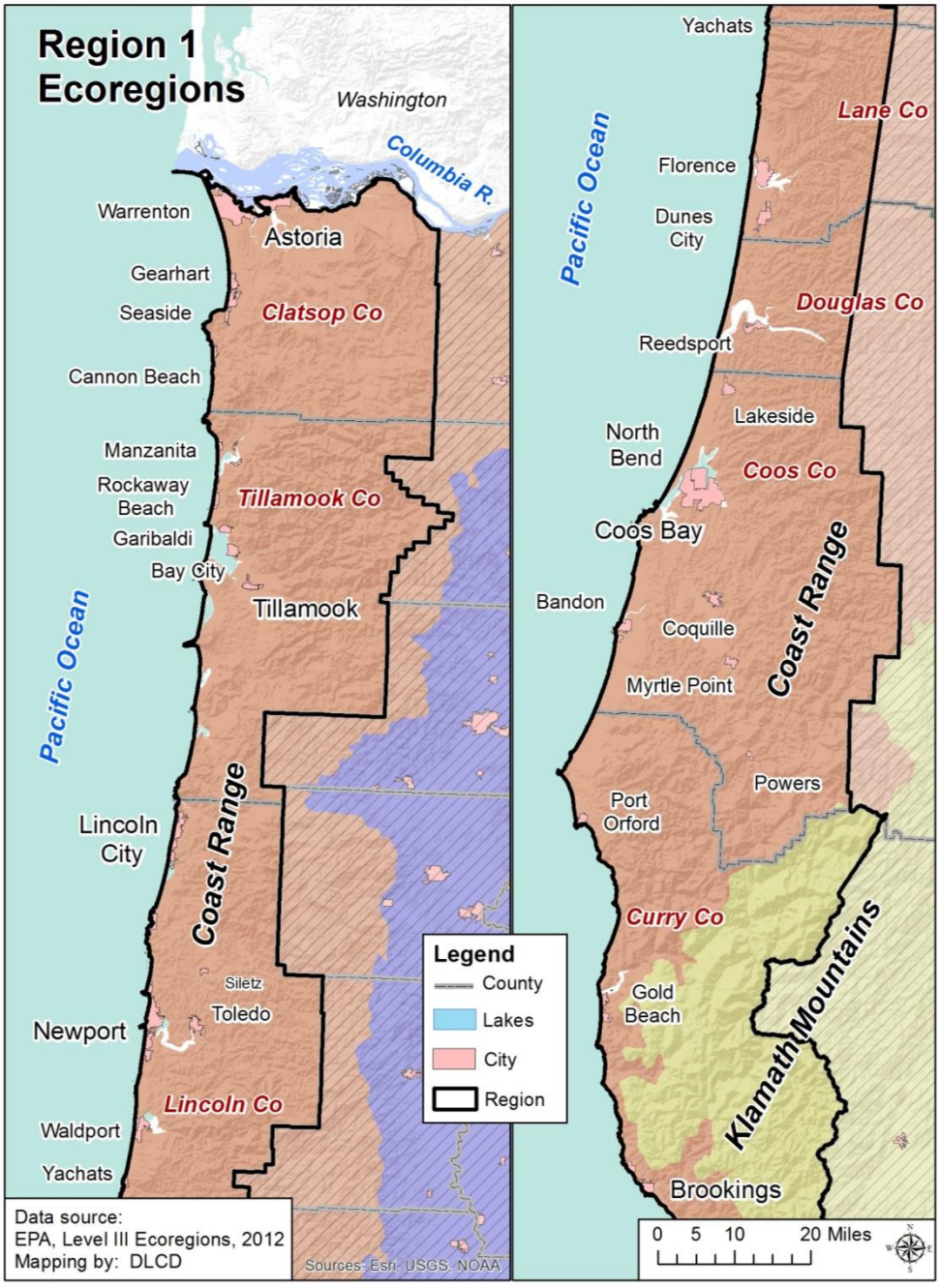
The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 1 comprises two ecoregions: the Coast Range and a smaller area of the Klamath Mountains (**Figure 2-117**).

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.

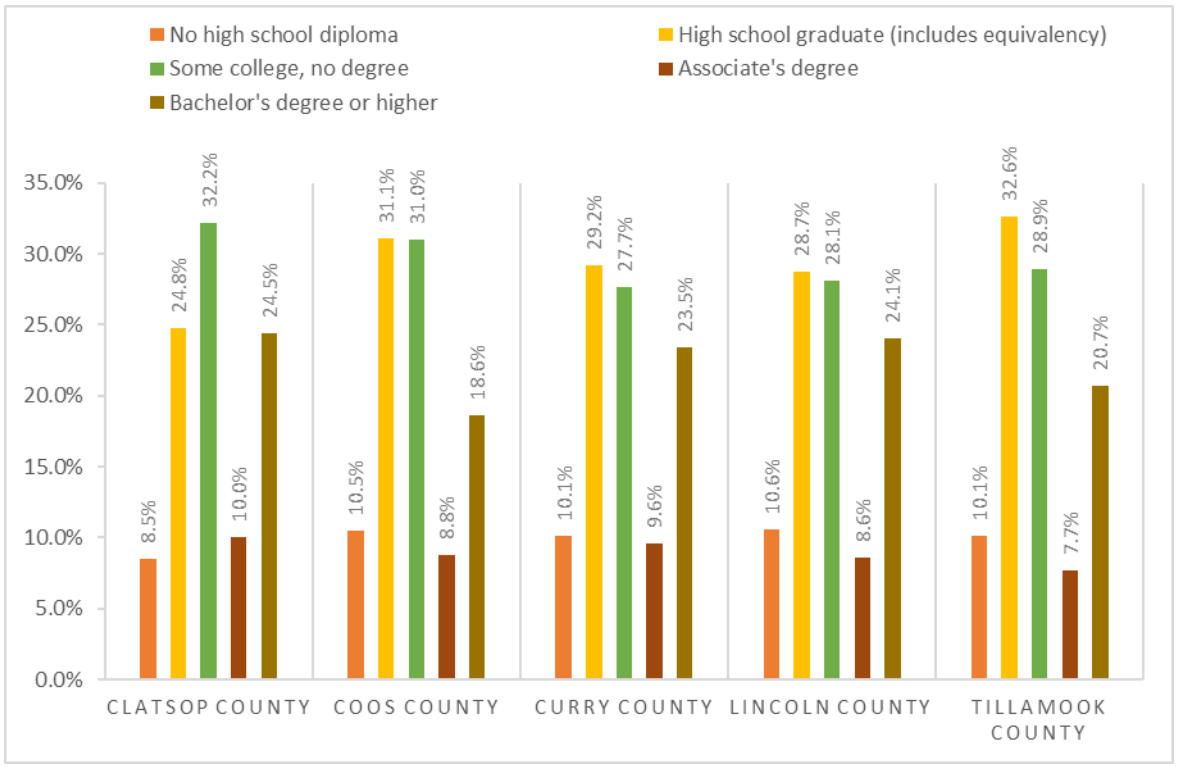
Source: U.S. Census Bureau, 20013–2017 American Community Survey 5-Year Estimates, Table DP02

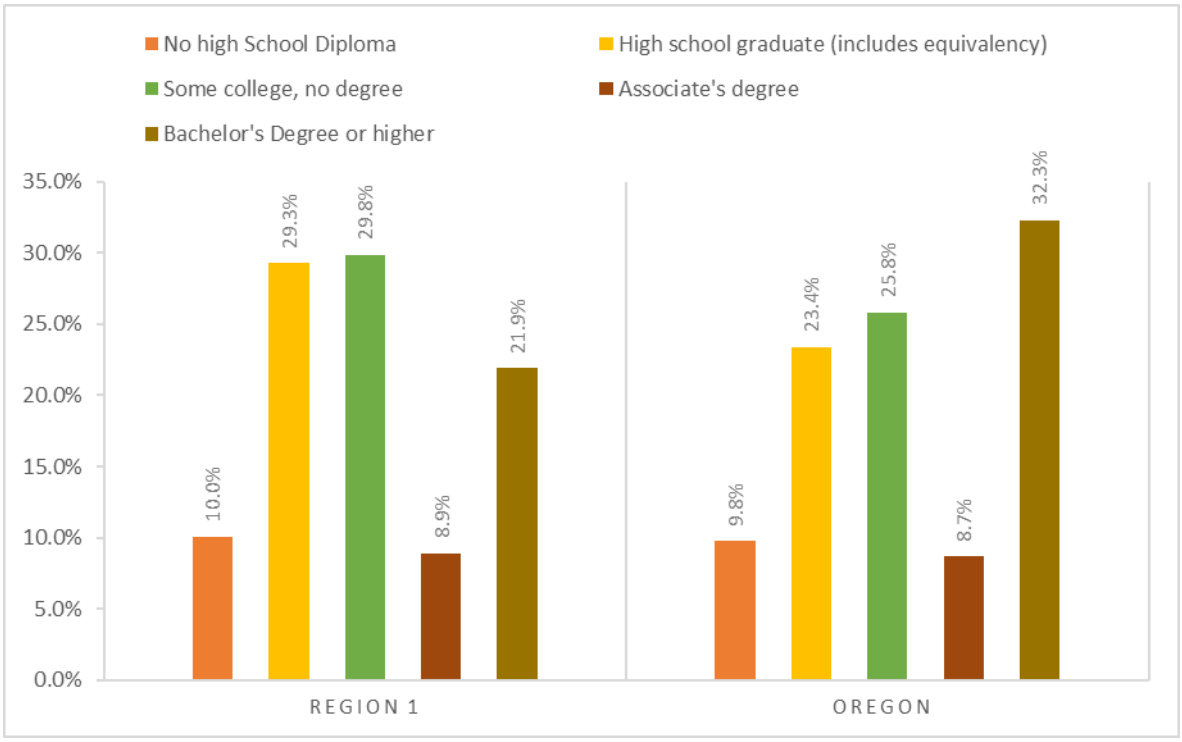
Education Level

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.

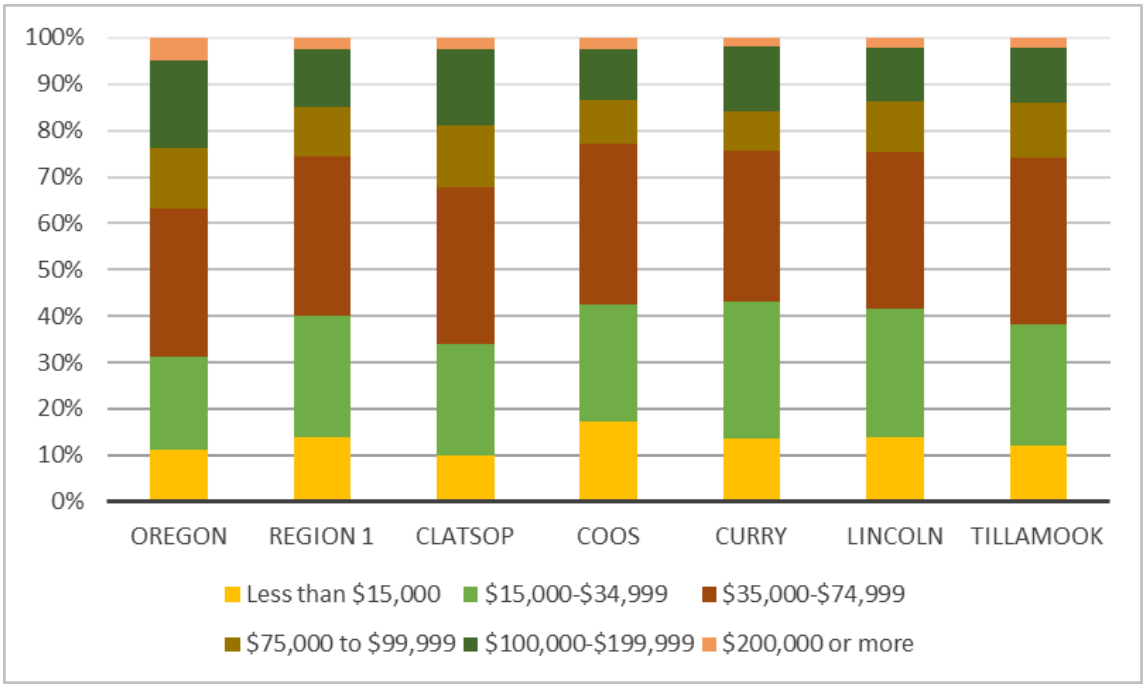
*Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**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.

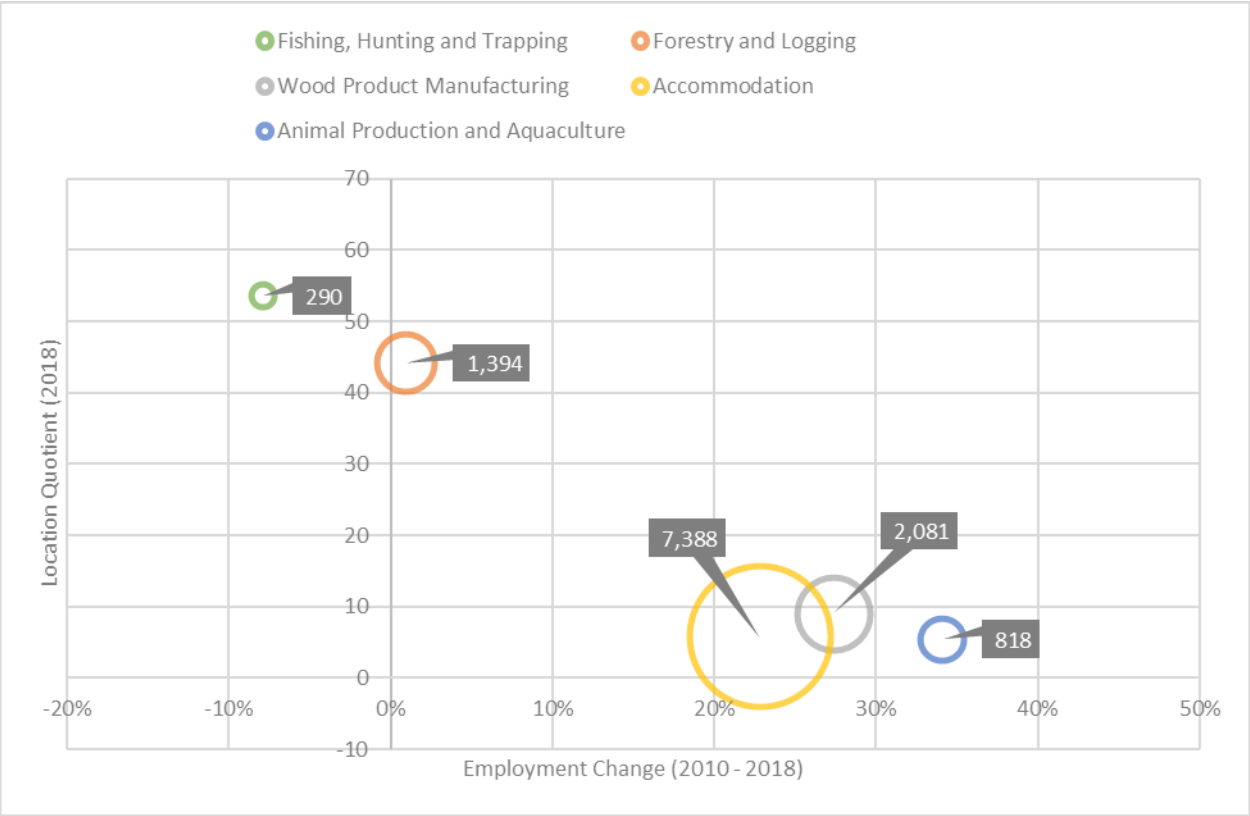
Table 2-95. Most Concentrated Industries and Employment Change in Region 1, 2018

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

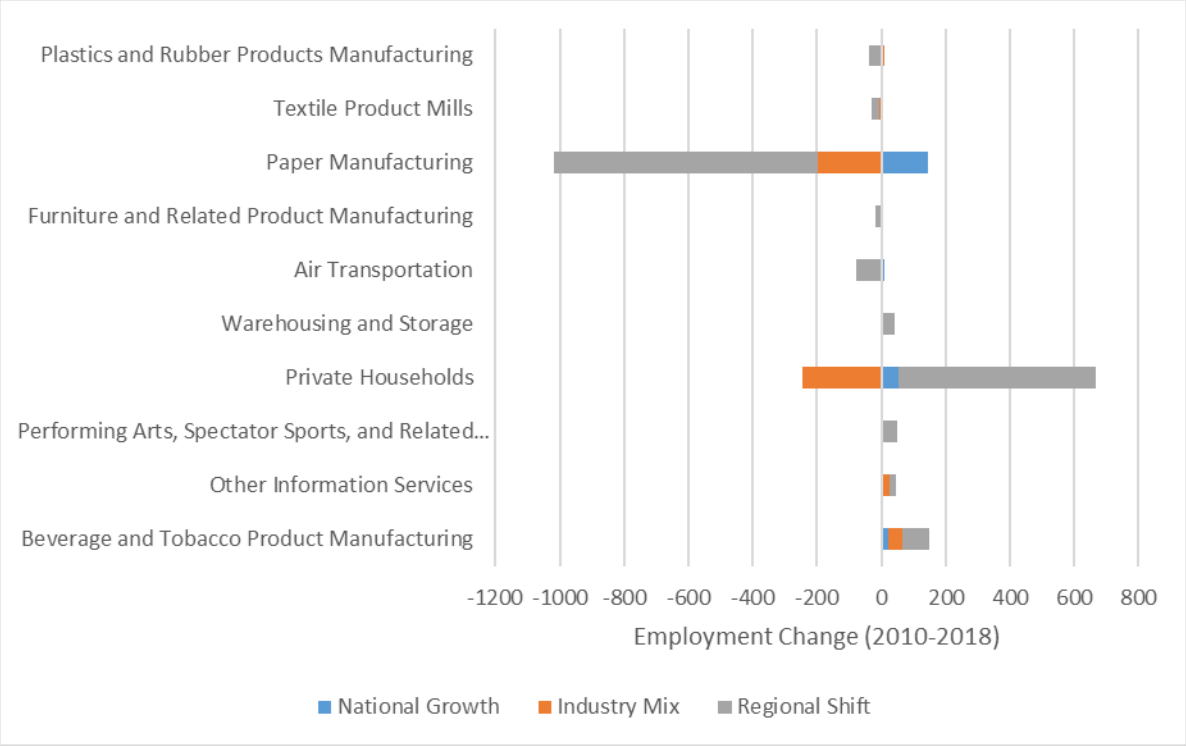
U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for average annual employment, and employment change by DLCD

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%

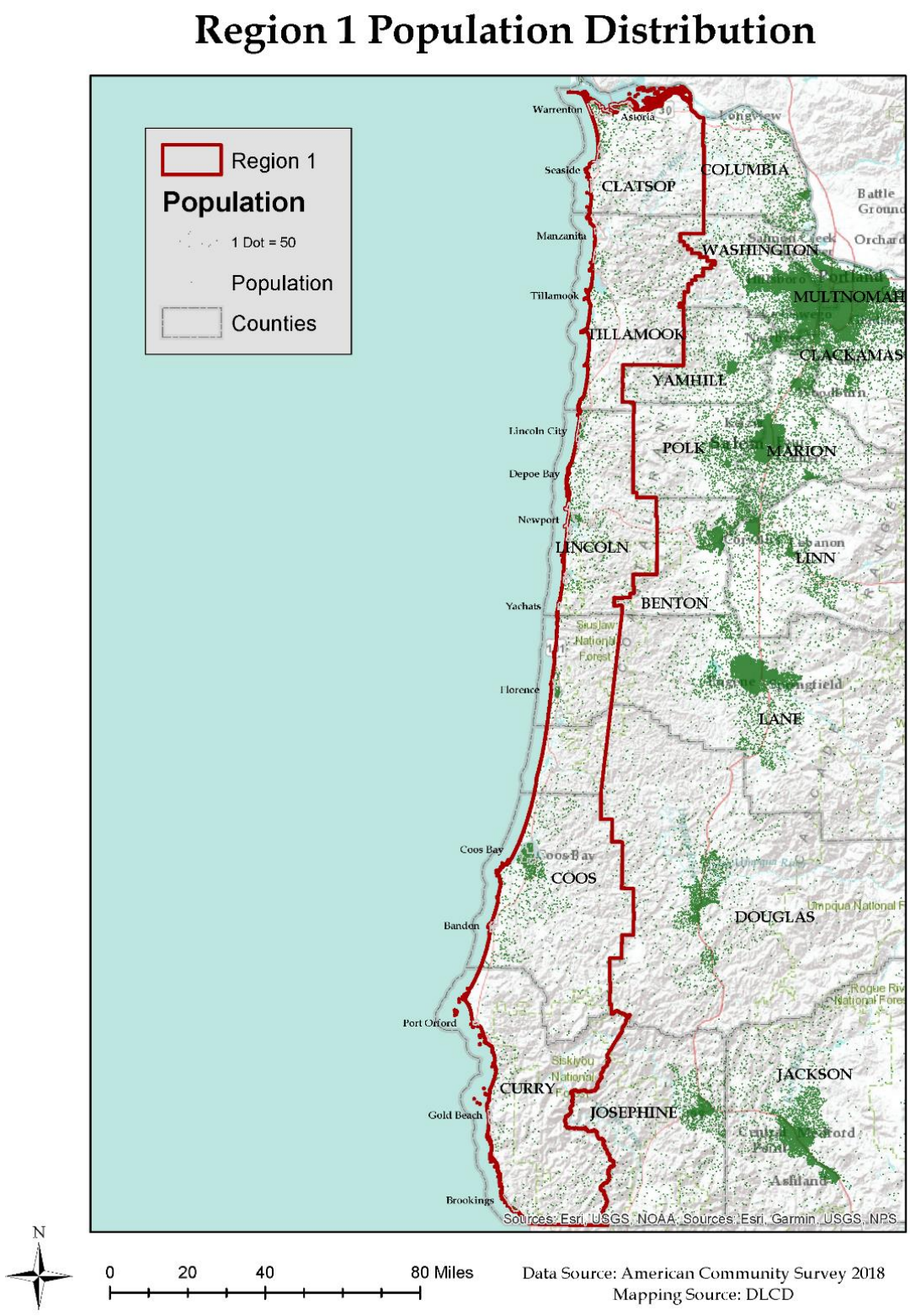
U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2

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

	Total Housing Units	Vacant^		
		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).

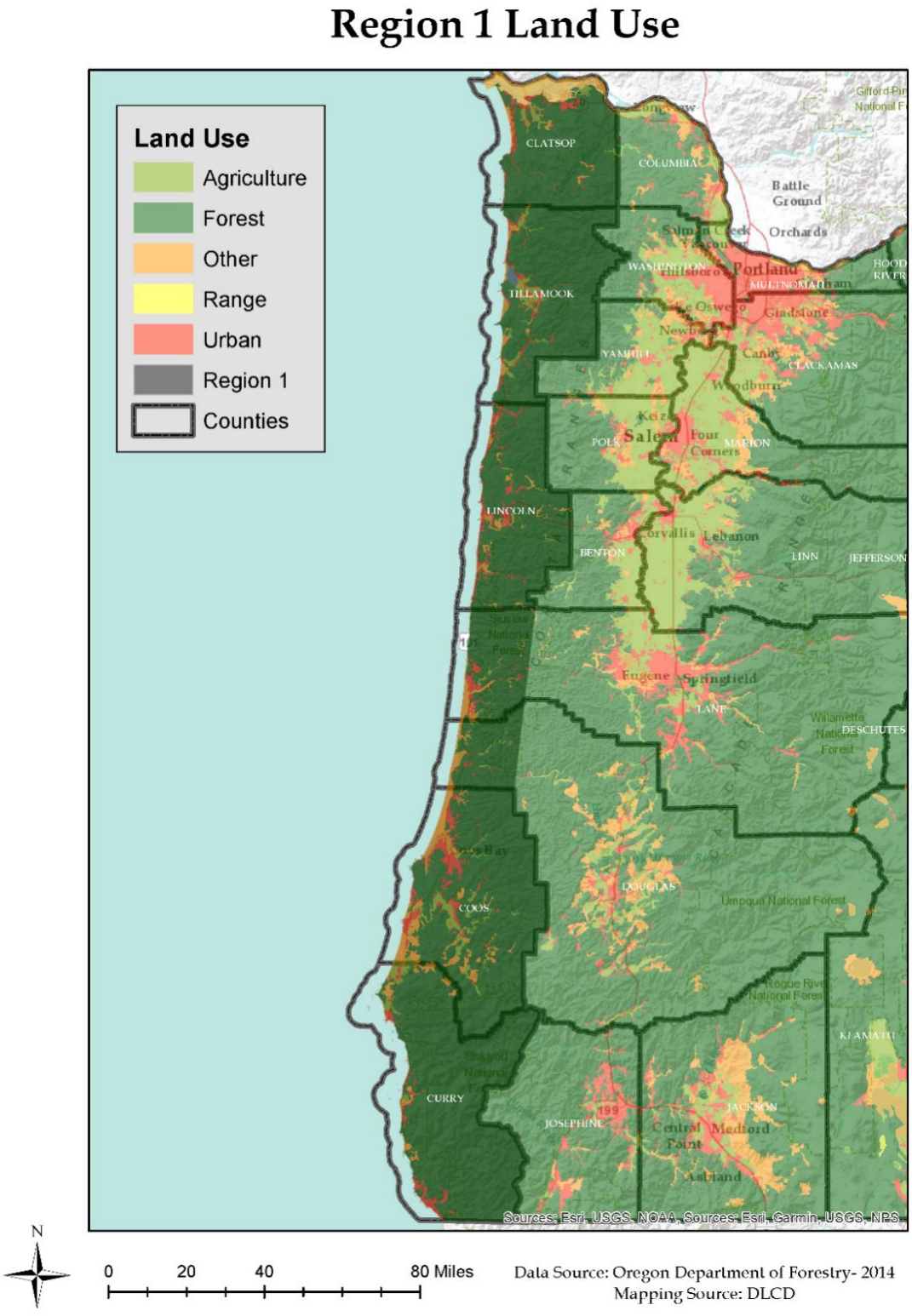
During 2012-2013, the Department of Geology and Mineral Industries released tsunami inundation maps displaying five scenarios of a potential impact of a Cascadia Subduction Zone tsunami, reflecting the full range of what was experienced in the past and is projected for the future. Then in January, 2014, 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



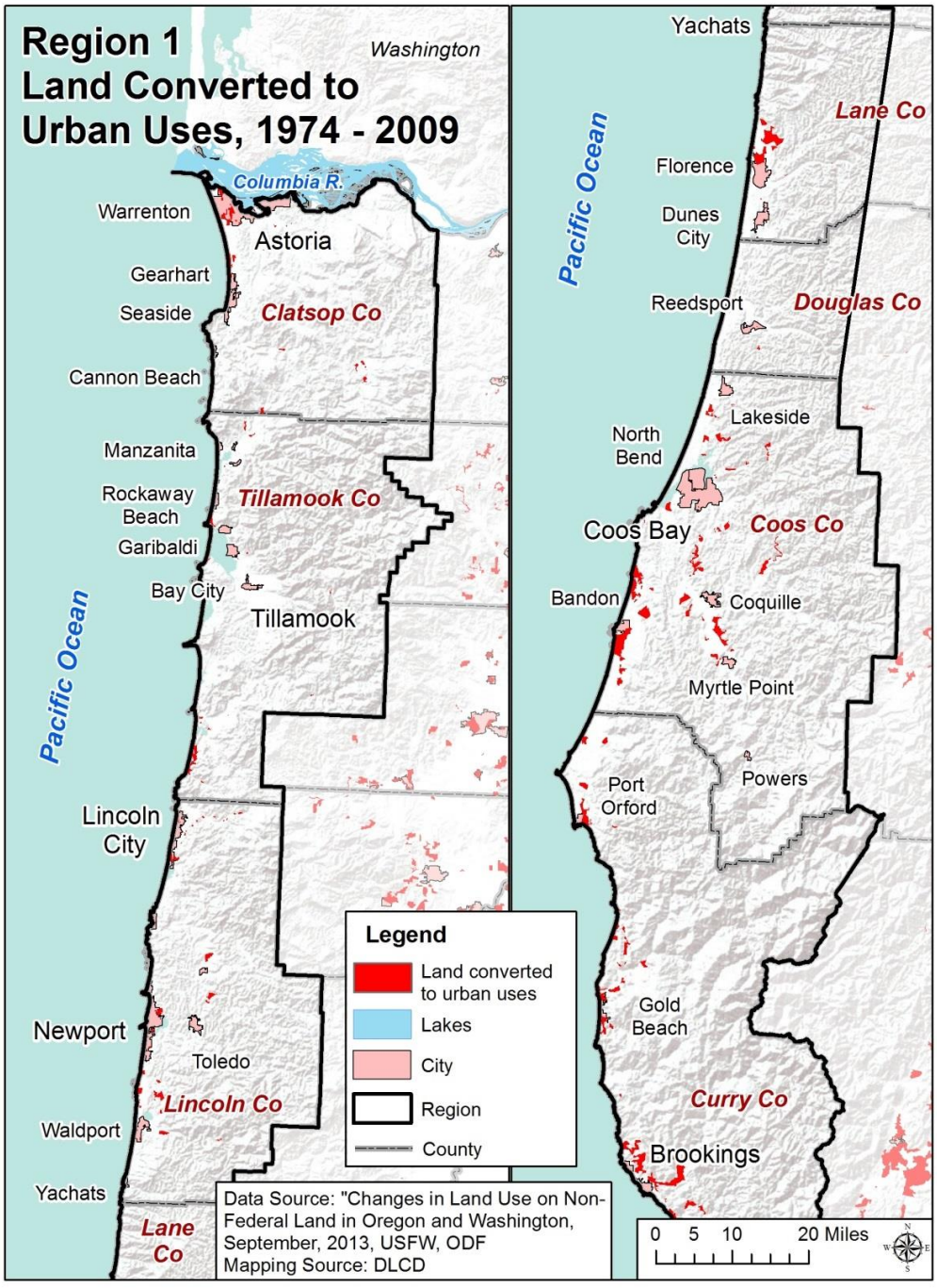
that during the six-year period, the percentage of resource lands converted in each county in Region 1 was less than one percent.

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

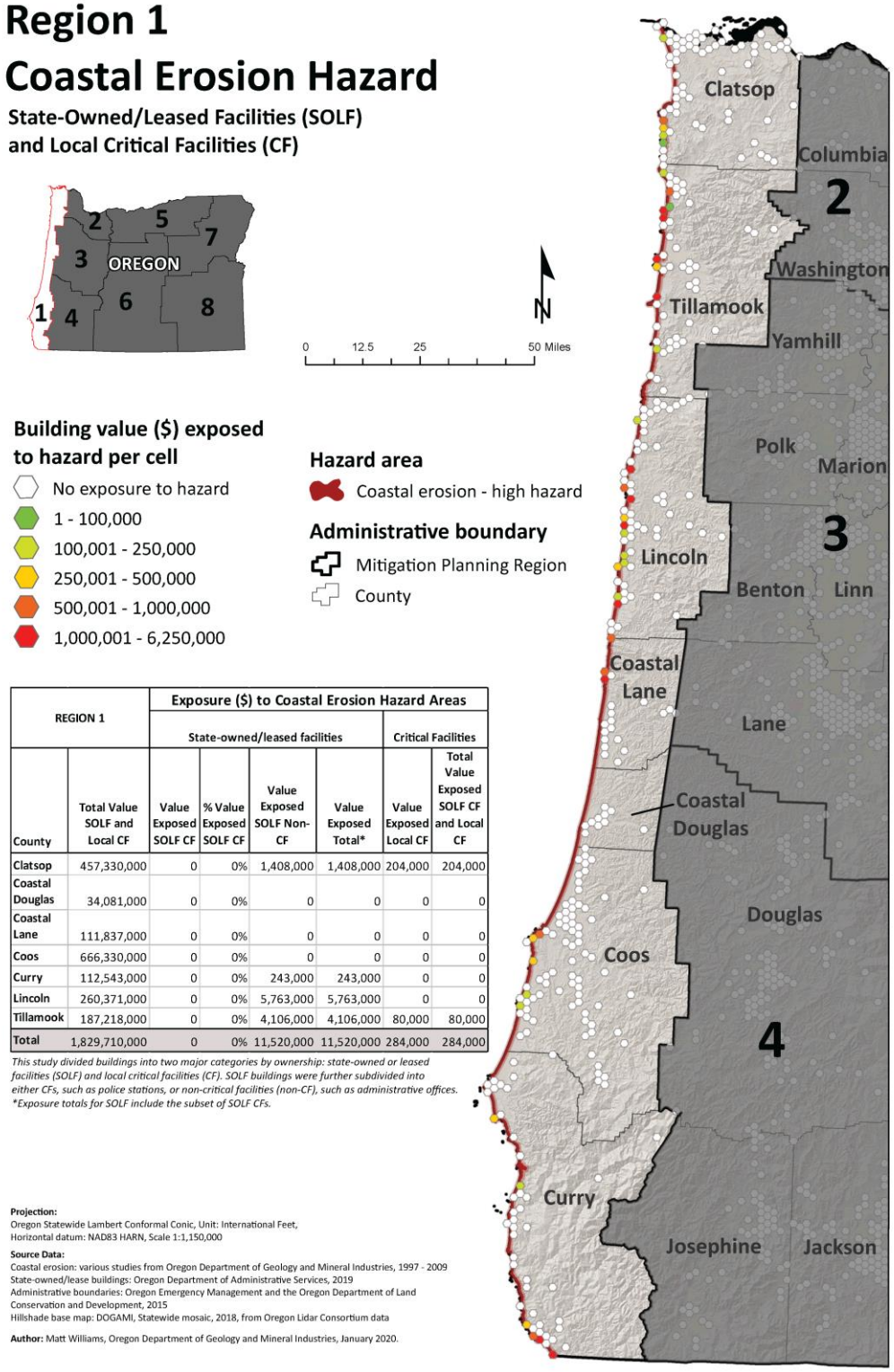
Chronic hazards are clearly evident along Oregon's shores, including beach, dune, and bluff erosion, landslides, slumps, gradual weathering of sea cliffs, and flooding of low-lying coastal lands during major storms. The damage caused by chronic hazards is usually gradual and cumulative. The regional, 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.

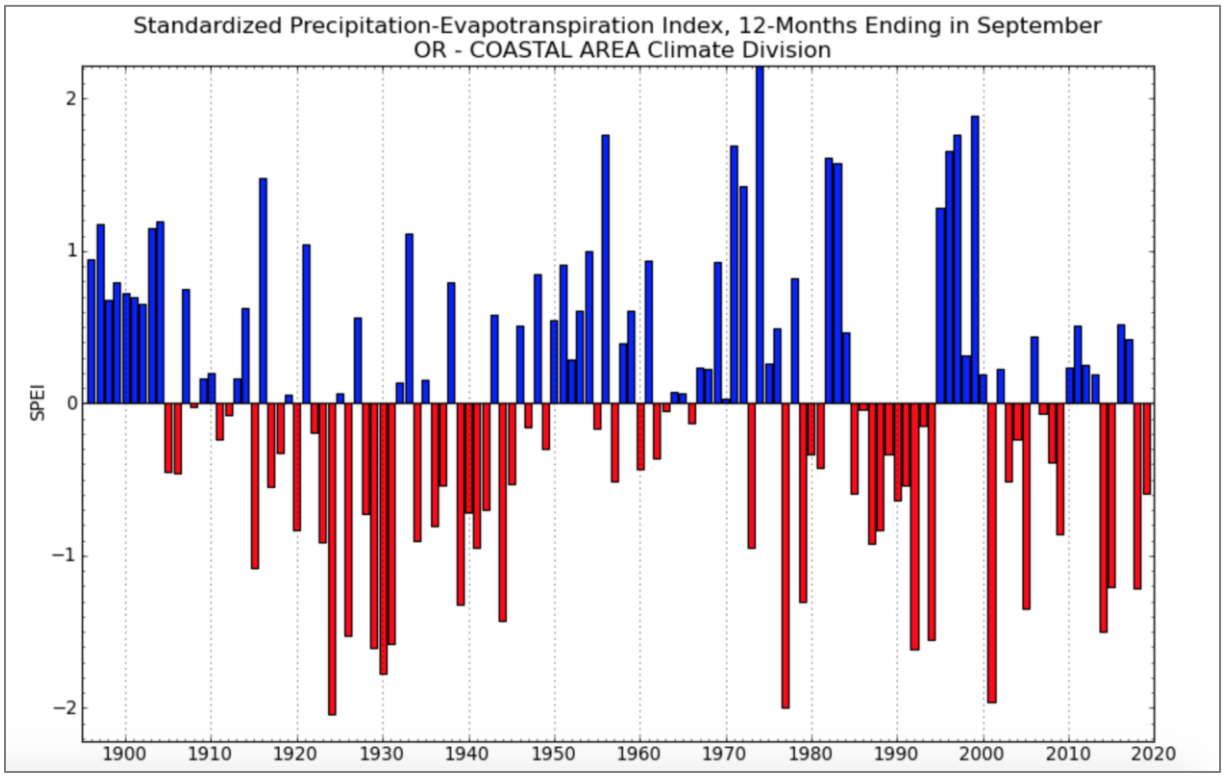
Sources: Taylor and Hatton (1999); NOAA's Climate at a Glance. Western Regional Climate Center's Westwide Drought Tracker, http://www.wrcc.dri.edu/wwdt; personal communication, Kathie Dello, Oregon Climate Service, Oregon State University; Governor-declared drought declarations obtained from the Oregon 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.

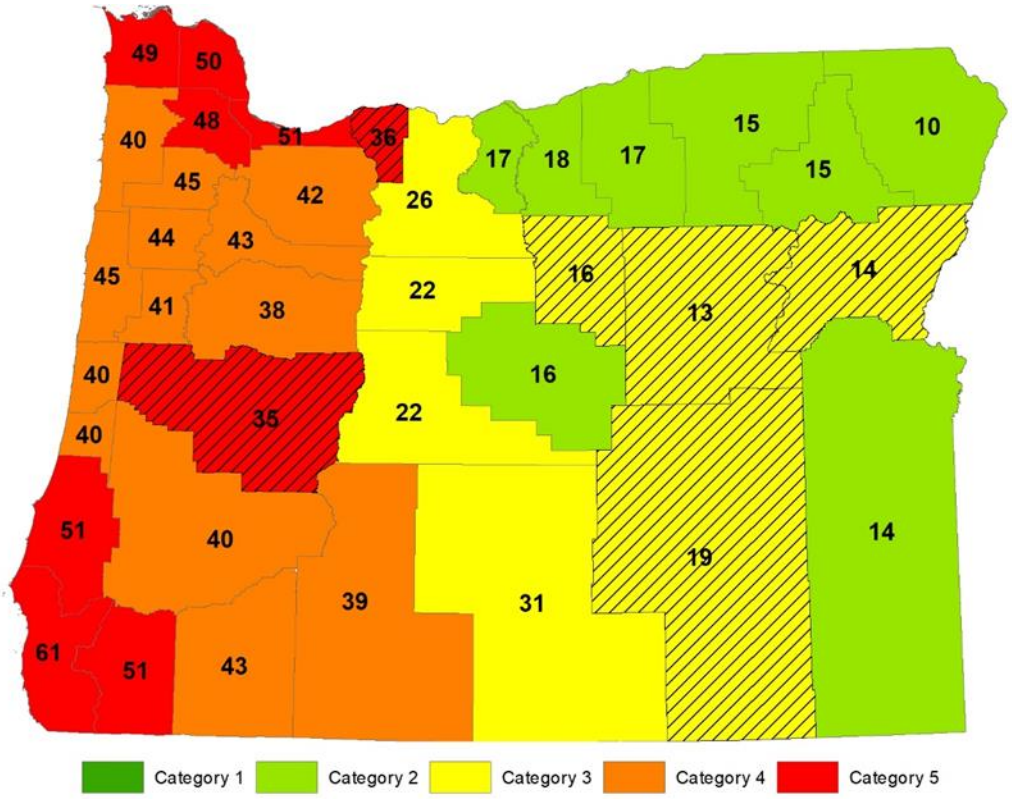
DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by

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)

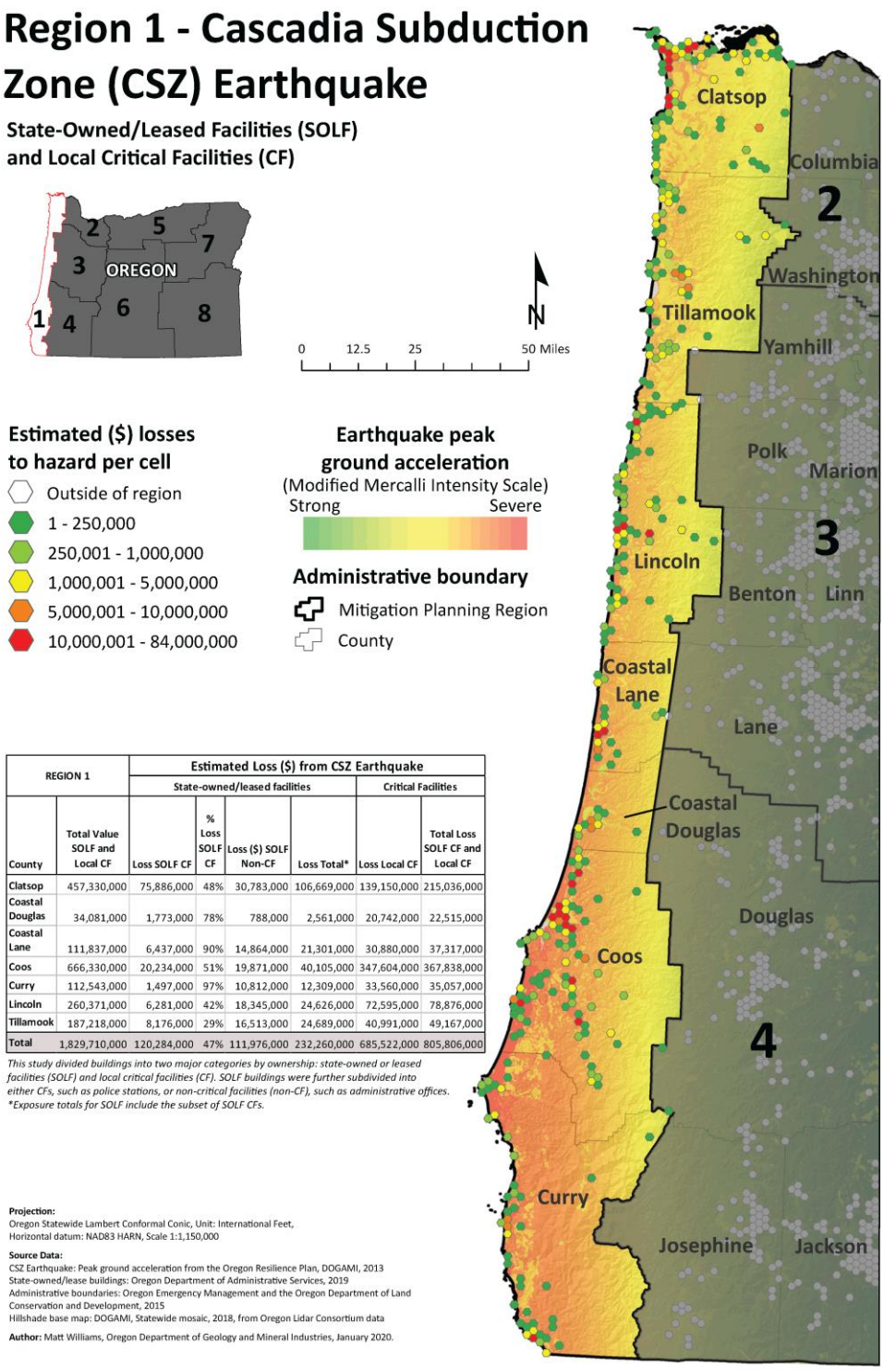
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

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.*

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

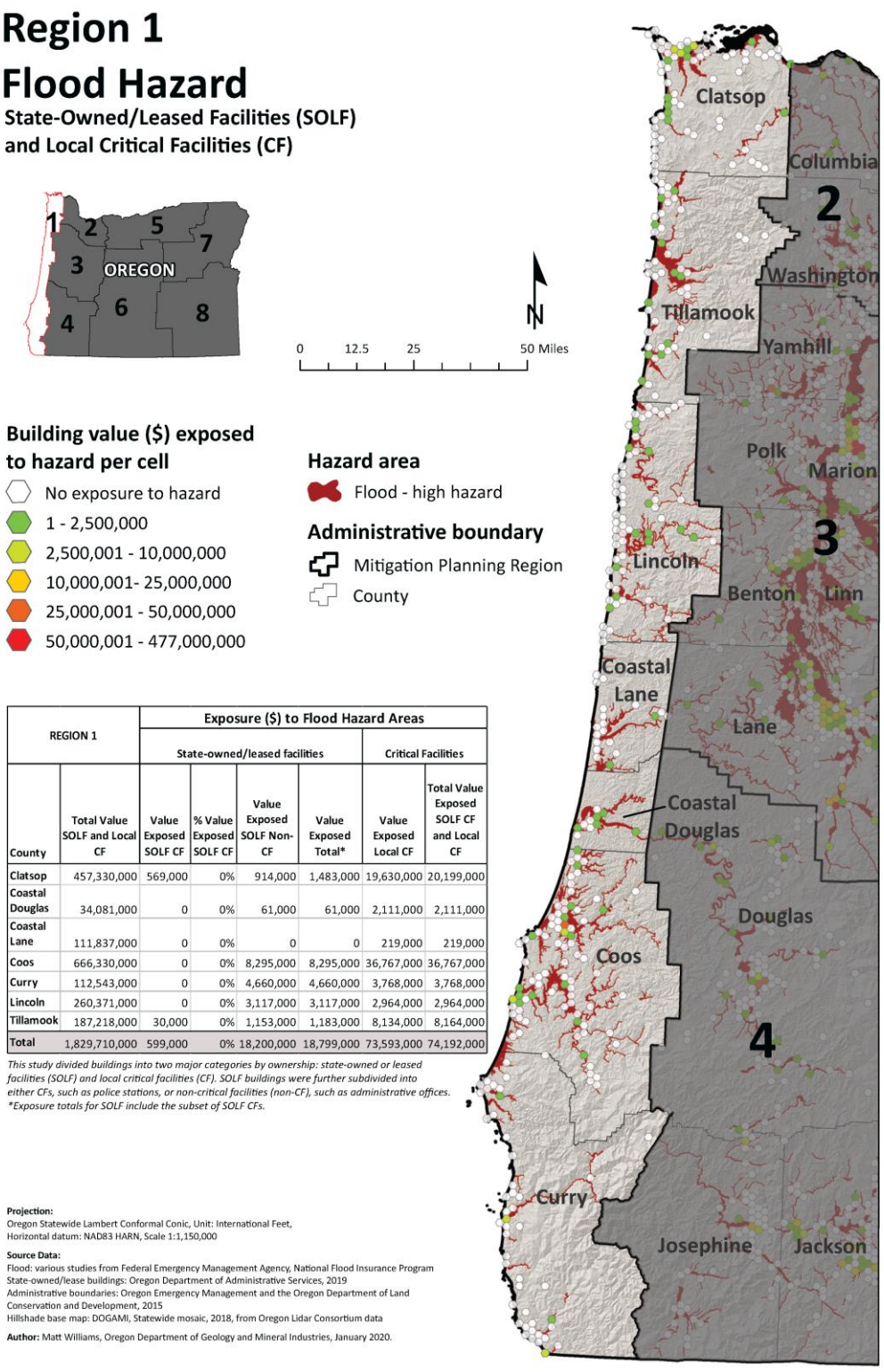
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. Lane 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.*

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:1,150,000

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 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

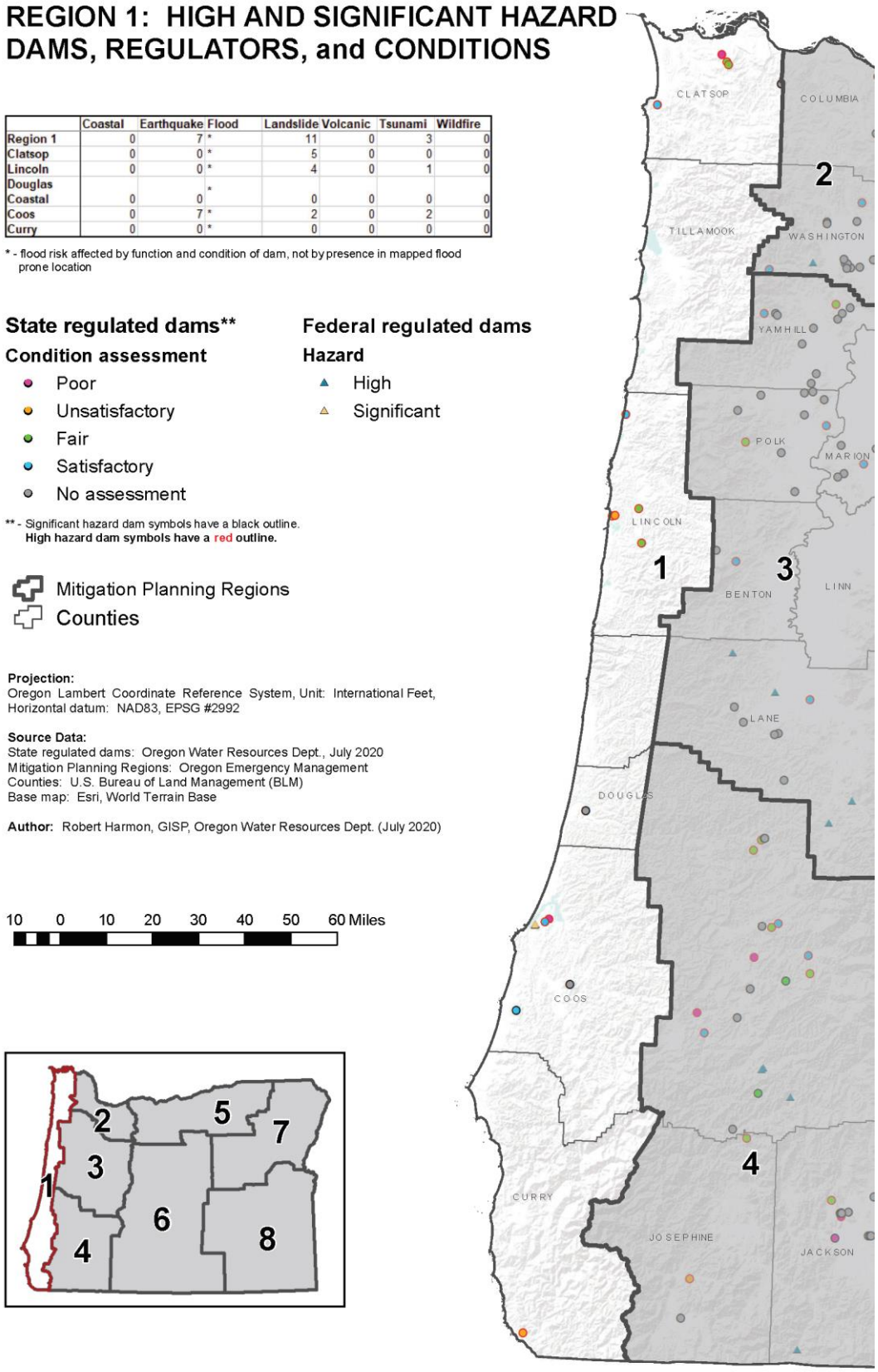
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Bear Creek (Astoria)	OR00449	POOR	20	57	Clatsop
Pony Creek Lower	OR00070	POOR	687	408	Coos
Ferry Creek	OR00437	UNSAT	84	25	Curry
Big Creek Reservoir #1 (Lower)	OR00225	UNSAT	16	35	Lincoln
Big Creek Reservoir #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



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

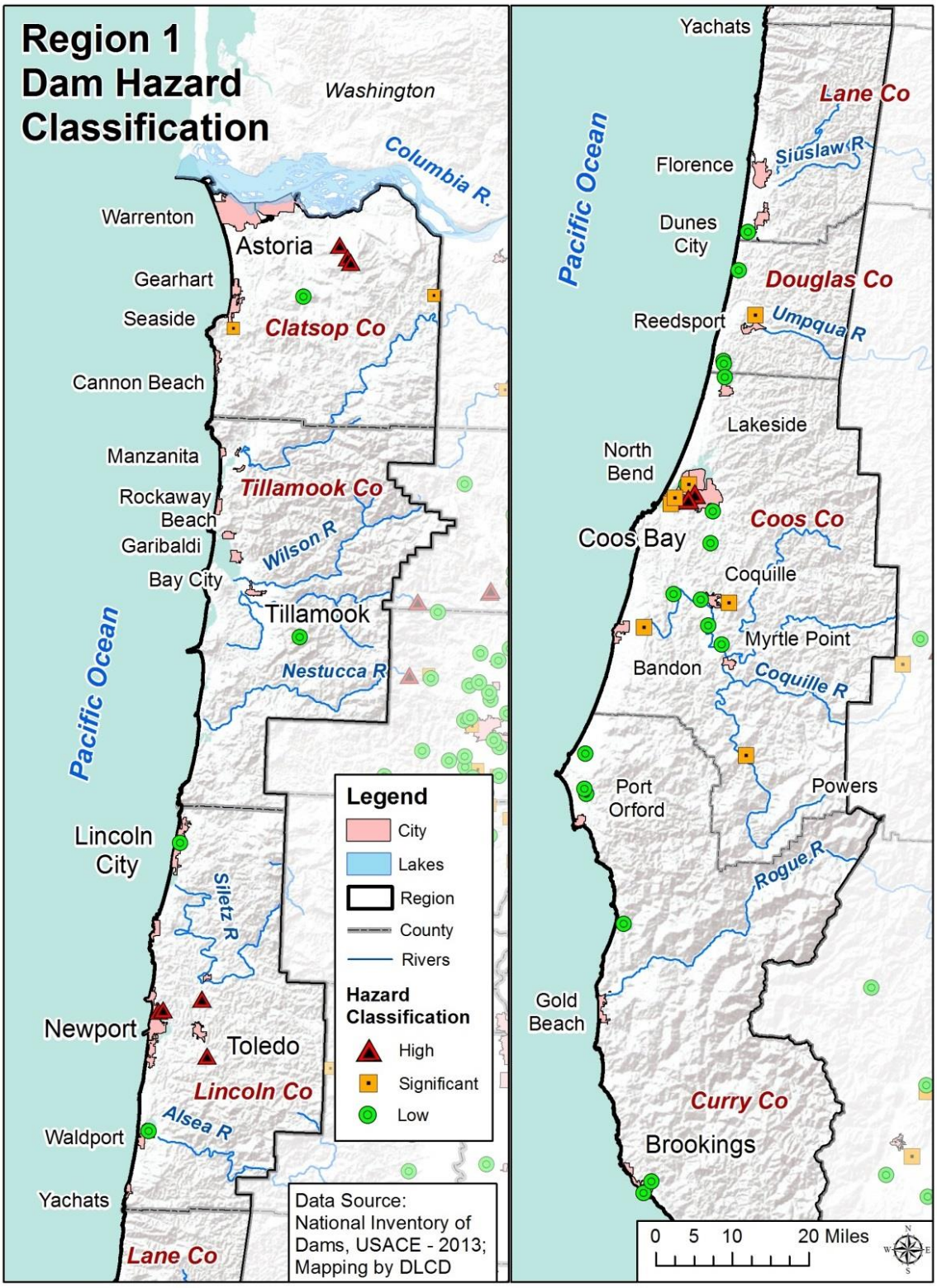
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), the counties in Region 1 with high hazard dams in 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

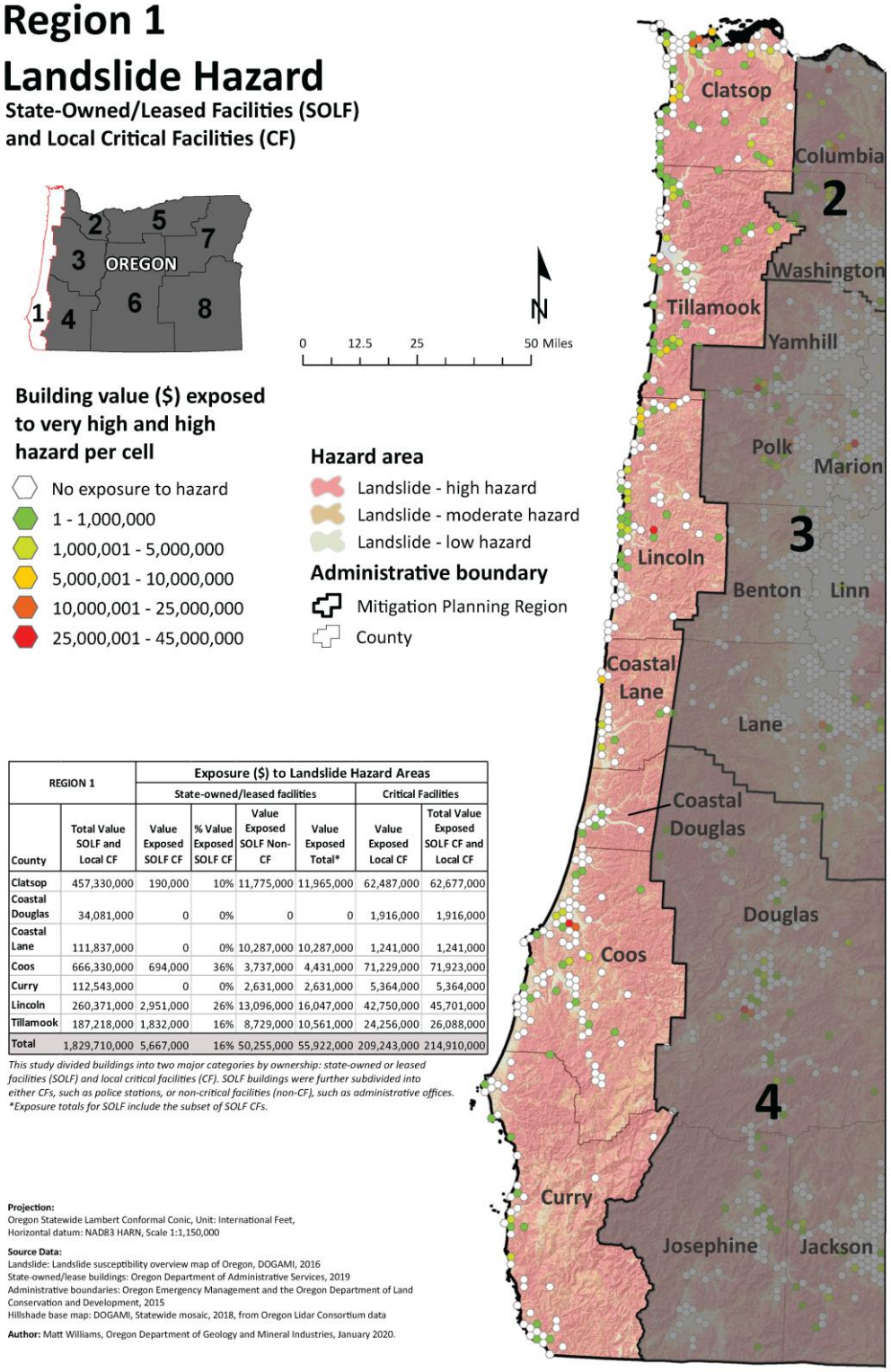
Rain-induced landslides and debris flows can potentially occur during any winter in this region. This area is also subject to future very large earthquakes, which will trigger landslides. Many of the communities in Region 1 have a high exposure to the landslide hazard, for example Astoria. A study of 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.

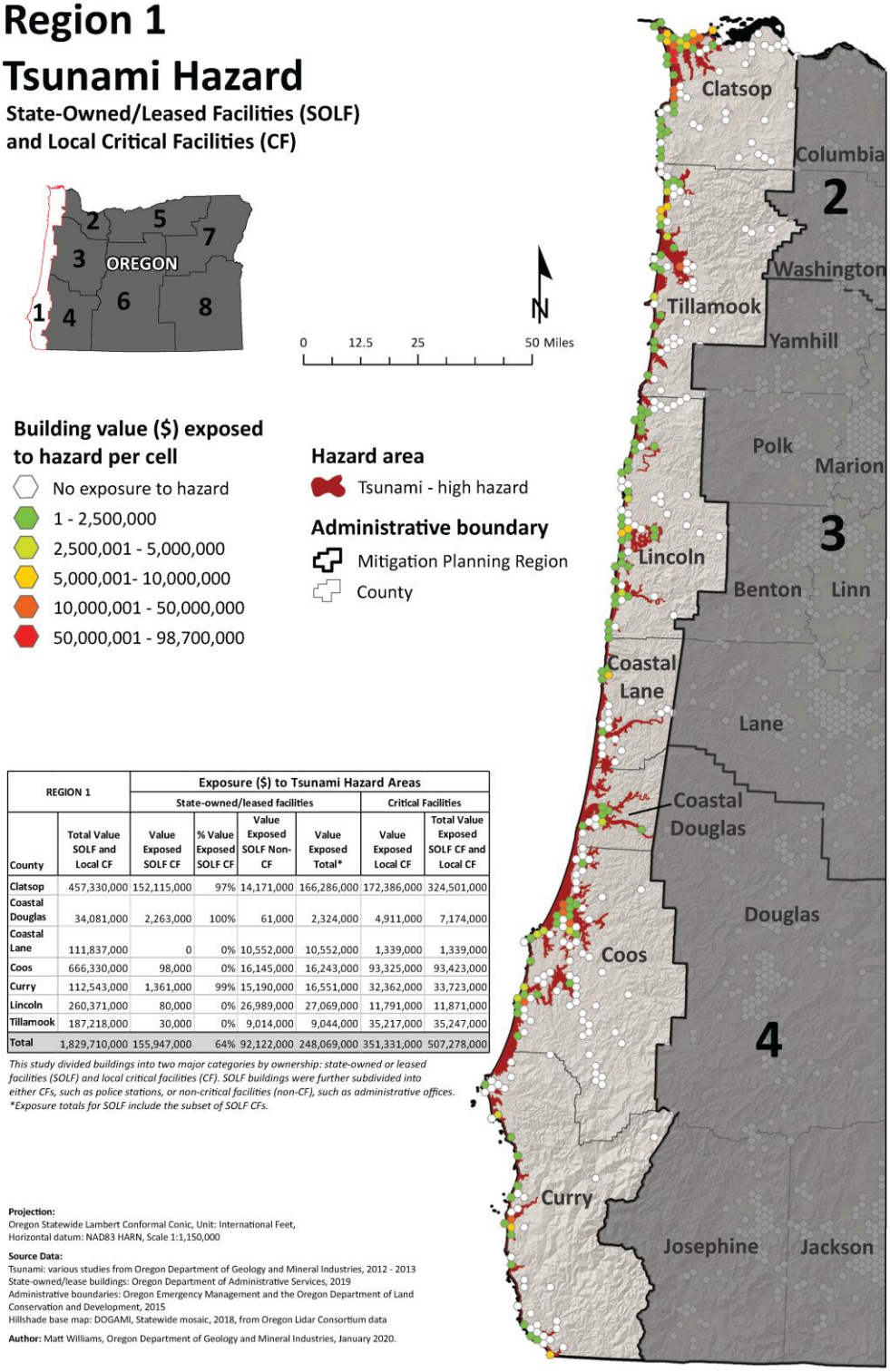
Most Vulnerable Jurisdictions

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.



REGION 1		Exposure ($) to Tsunami 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	152,115,000	97%	14,171,000	166,286,000	172,386,000	324,501,000
Coastal Douglas	34,081,000	2,263,000	100%	61,000	2,324,000	4,911,000	7,174,000
Coastal Lane	111,837,000	0	0%	10,552,000	10,552,000	1,339,000	1,339,000
Coos	666,330,000	98,000	0%	16,145,000	16,243,000	93,325,000	93,423,000
Curry	112,543,000	1,361,000	99%	15,190,000	16,551,000	32,362,000	33,723,000
Lincoln	260,371,000	80,000	0%	26,989,000	27,069,000	11,791,000	11,871,000
Tillamook	187,218,000	30,000	0%	9,014,000	9,044,000	35,217,000	35,247,000
Total	1,829,710,000	155,947,000	64%	92,122,000	248,069,000	351,331,000	507,278,000

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:
Tsunami: various studies from Oregon Department of Geology and Mineral Industries, 2012 - 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 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)

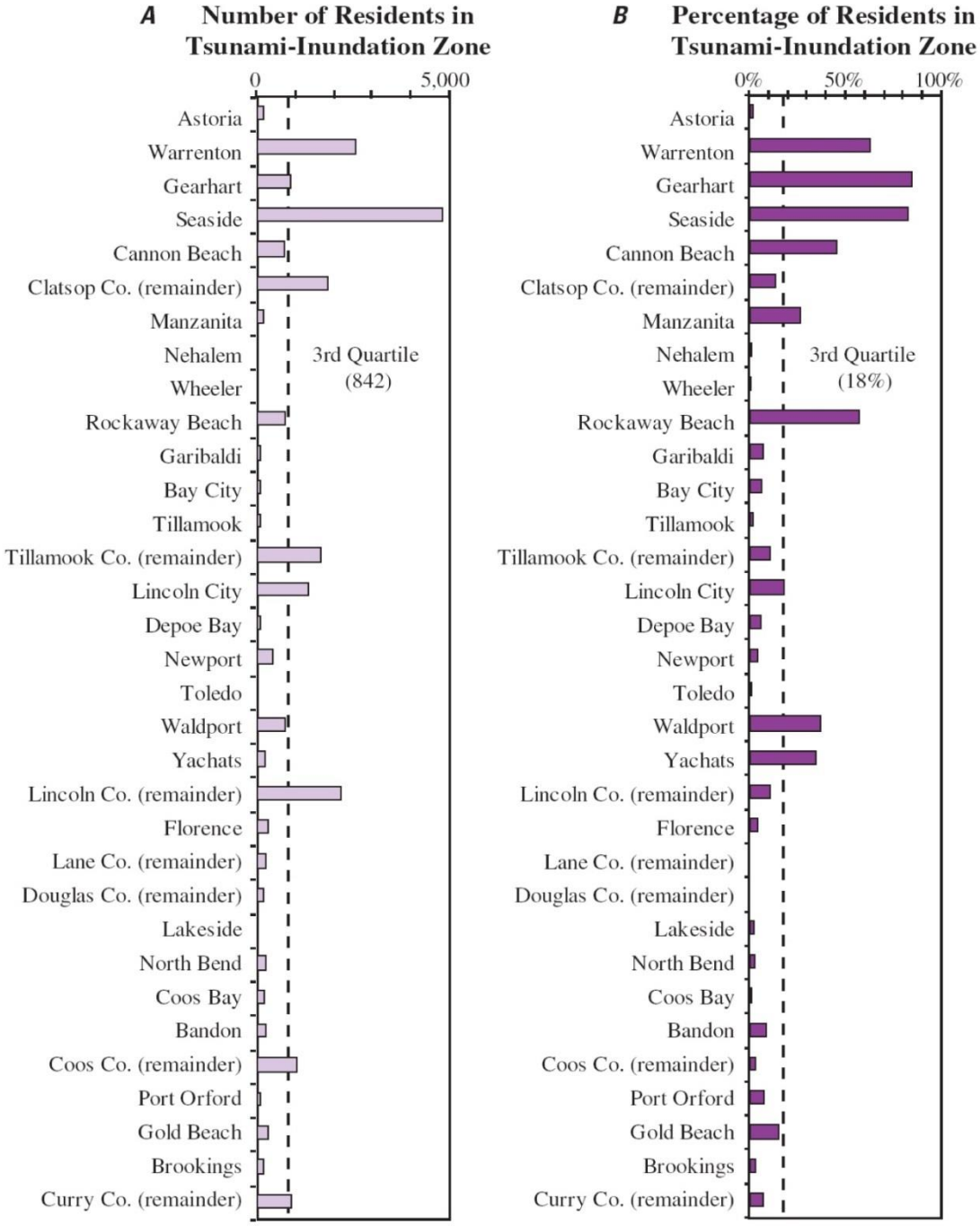


Figure 2-137. Number (A) and Percentage (B) of Residents in the Oregon Regulatory Tsunami Inundation Zone (data from Wood and others, 2015)





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).

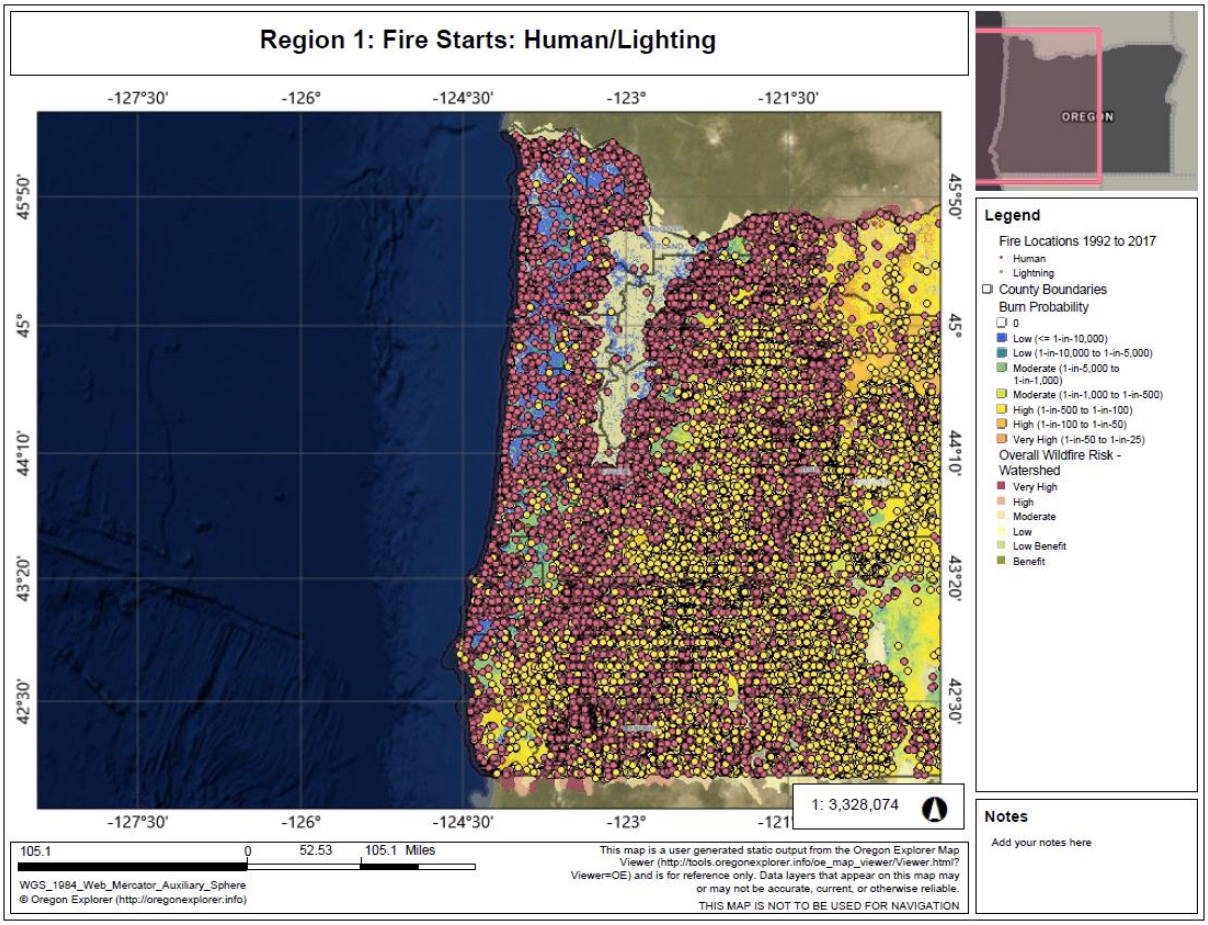
Wildfires

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

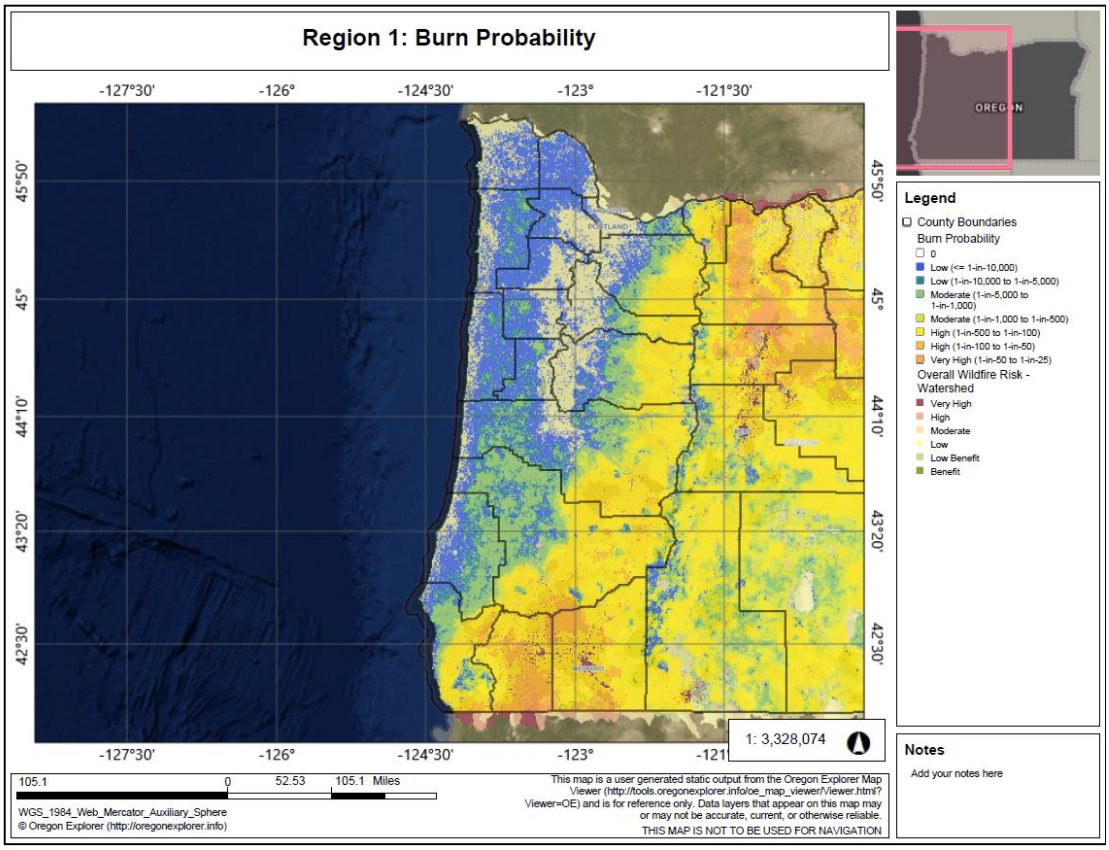
	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	L	L	H	M	L	L	L

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

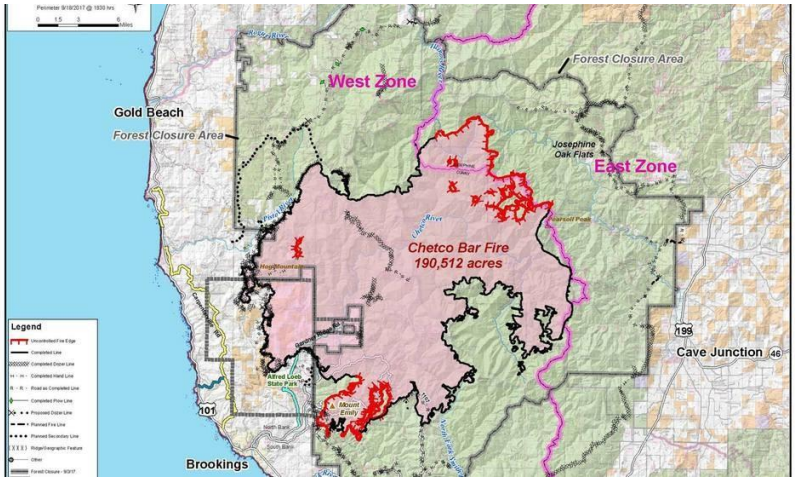


Source: Oregon Wildfire Risk Explorer, March 2020

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			

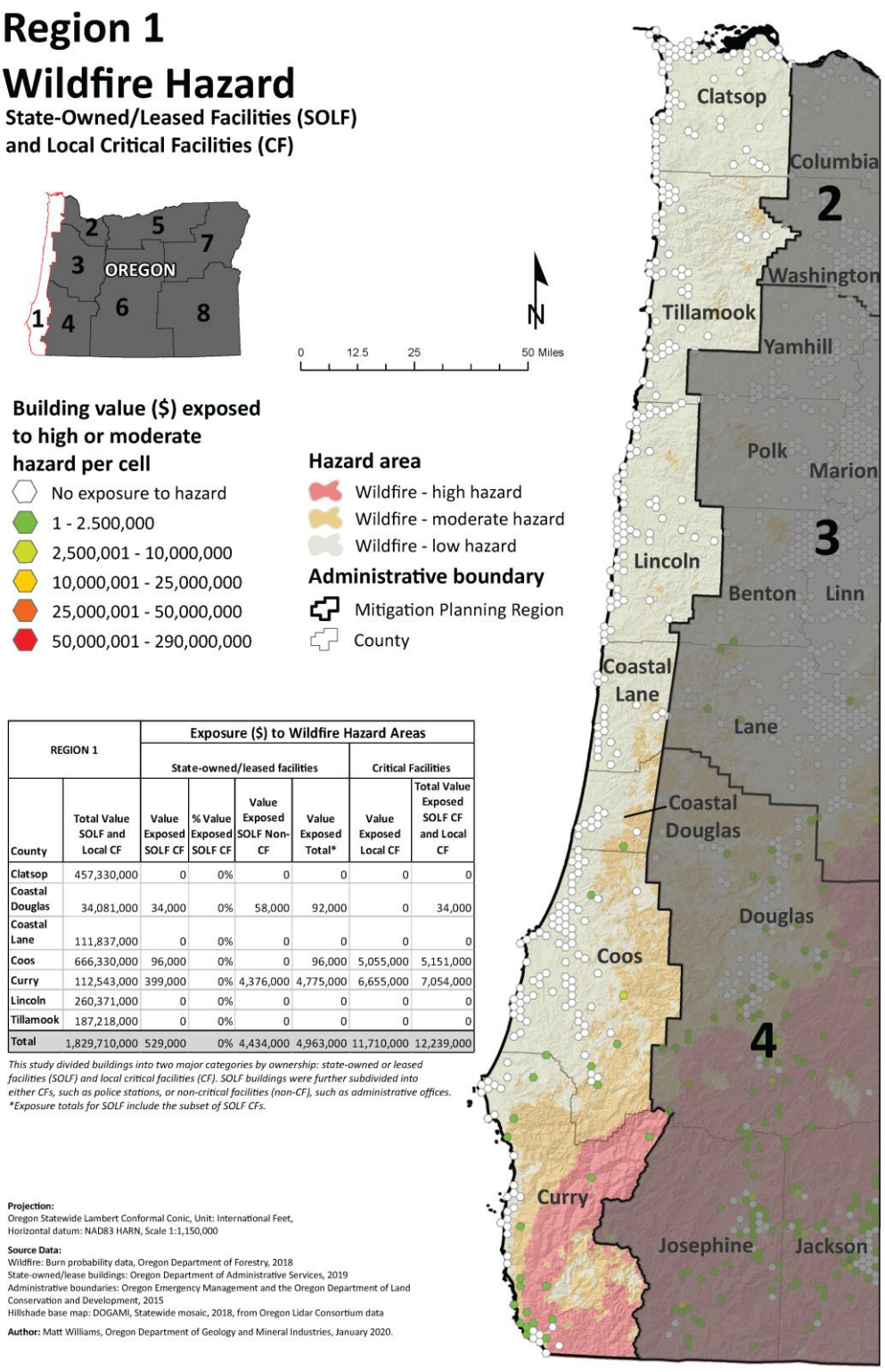
Source: Oregon Dept. of Forestry Statewide Forest Assessment September, 2006

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

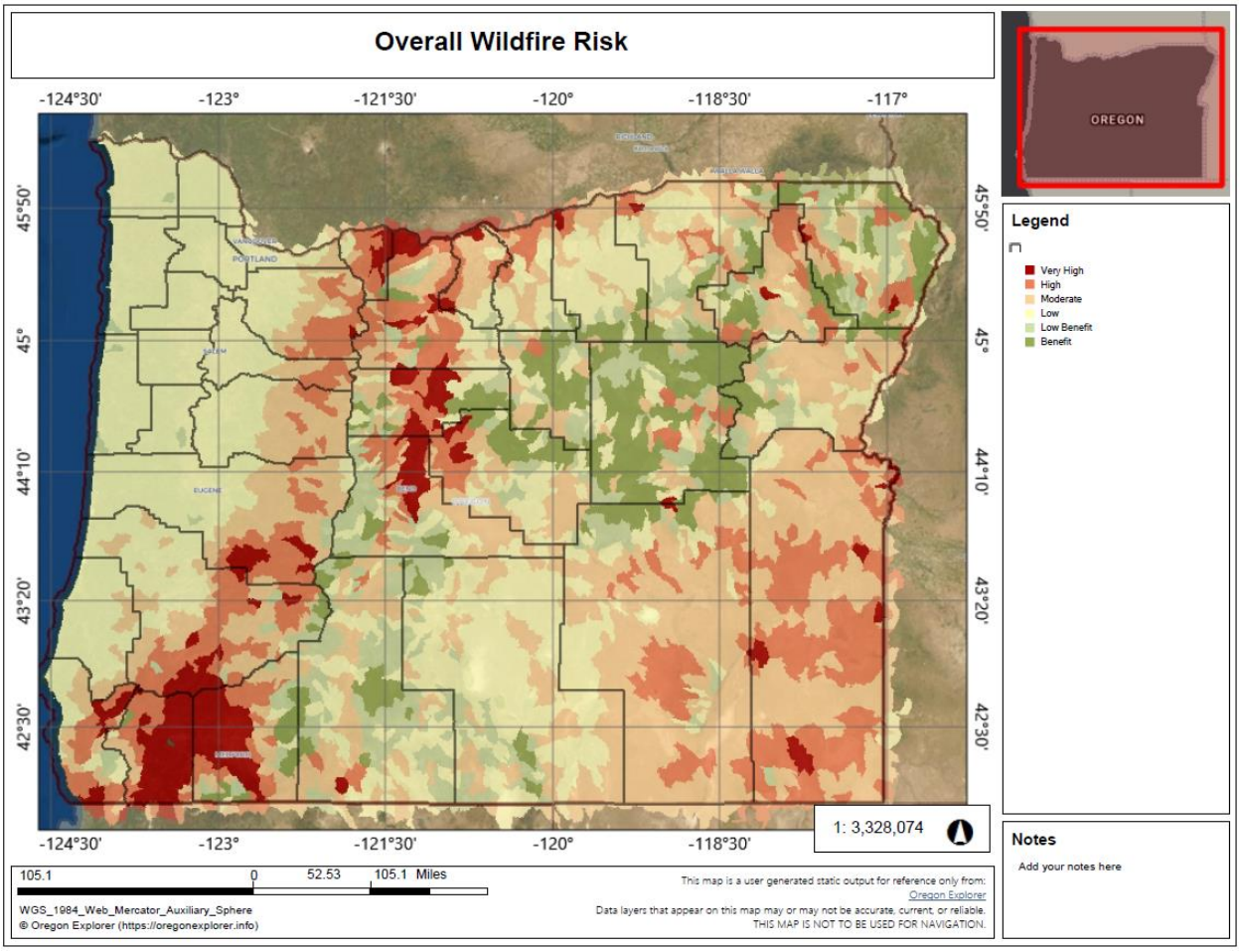
	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Risk	L	H	L	H	H	L	L

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.

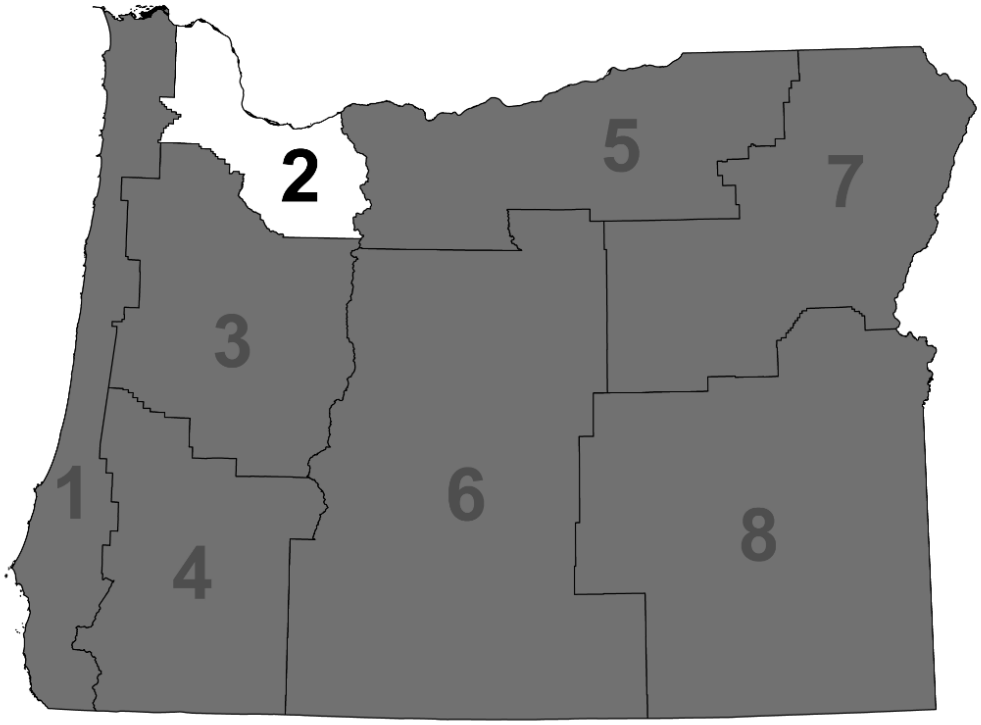
Risk

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

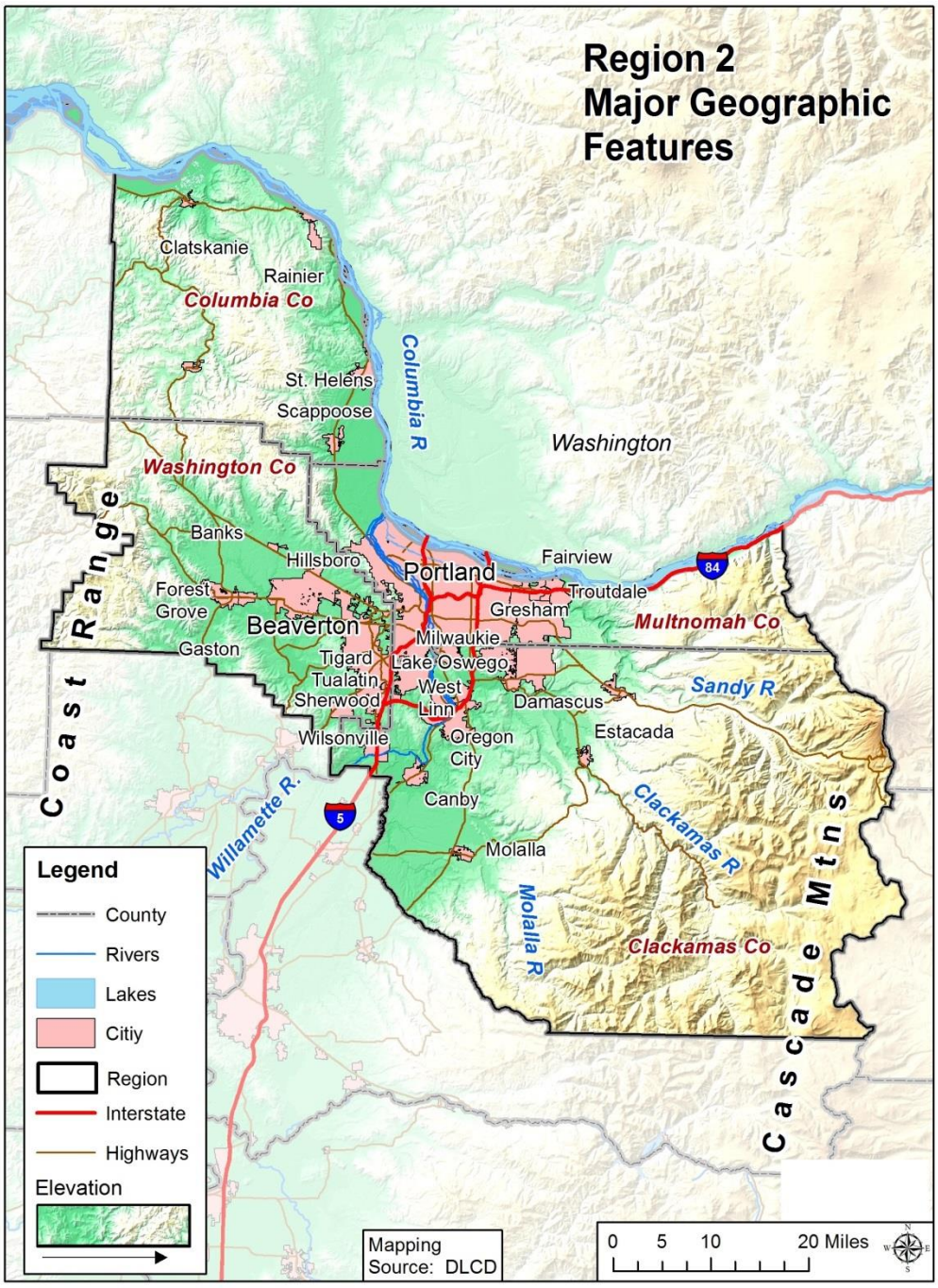
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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.

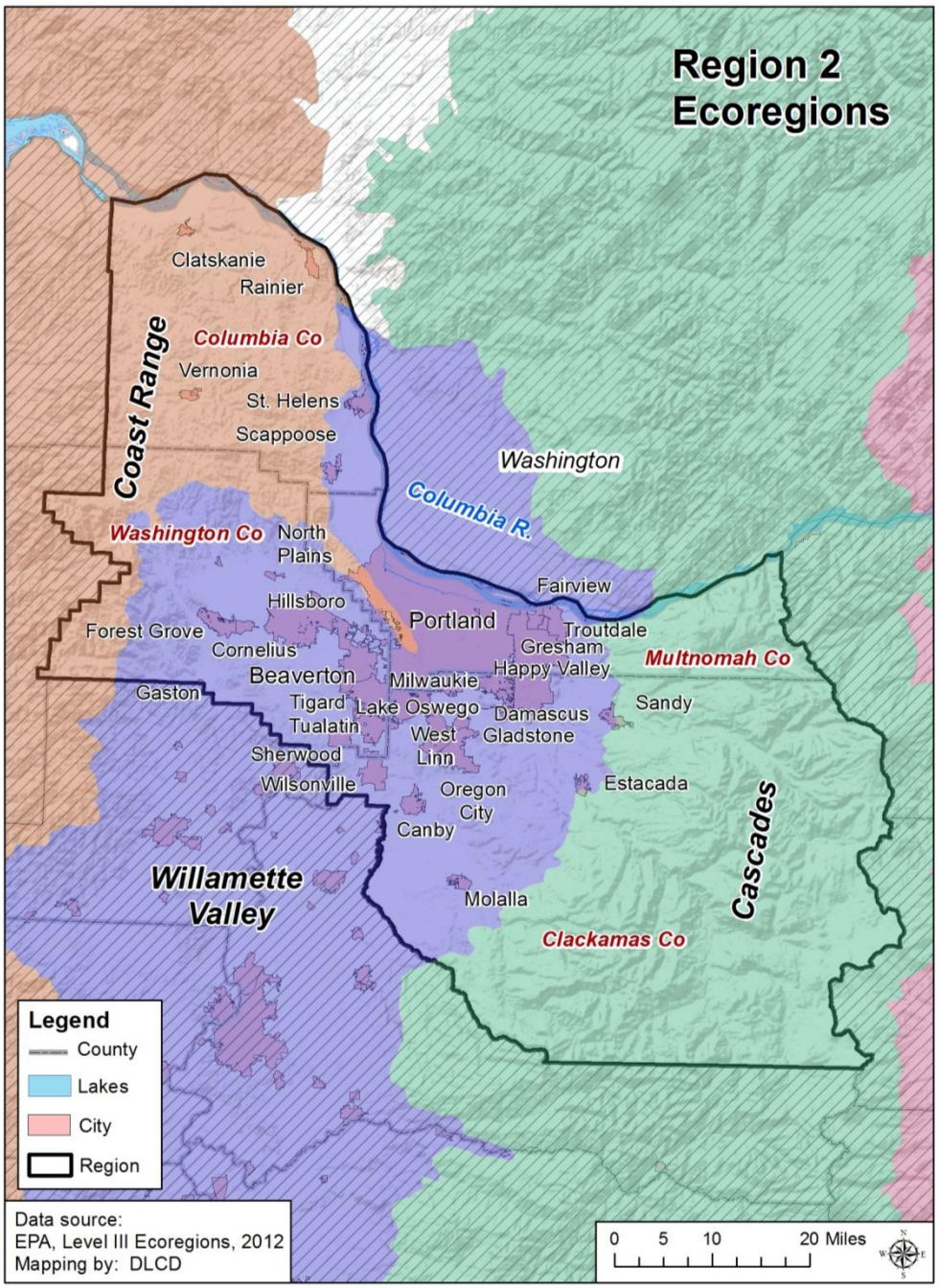
Figure 2-143. Region 2 Major Geographic Features



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

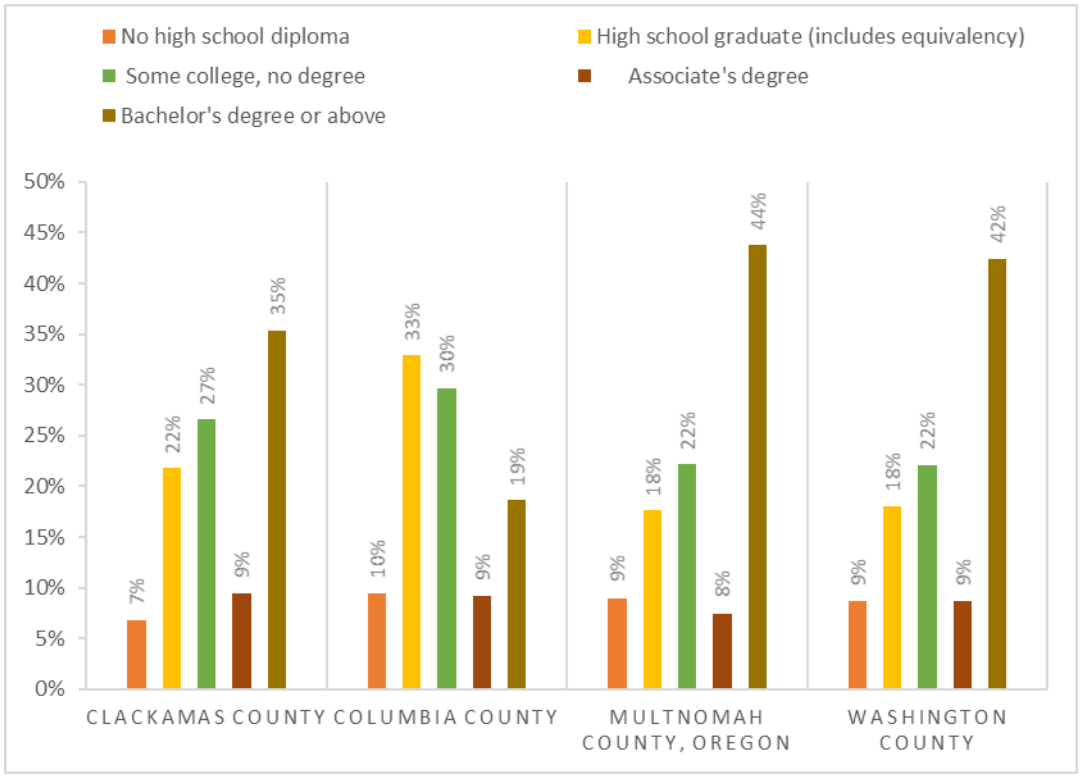


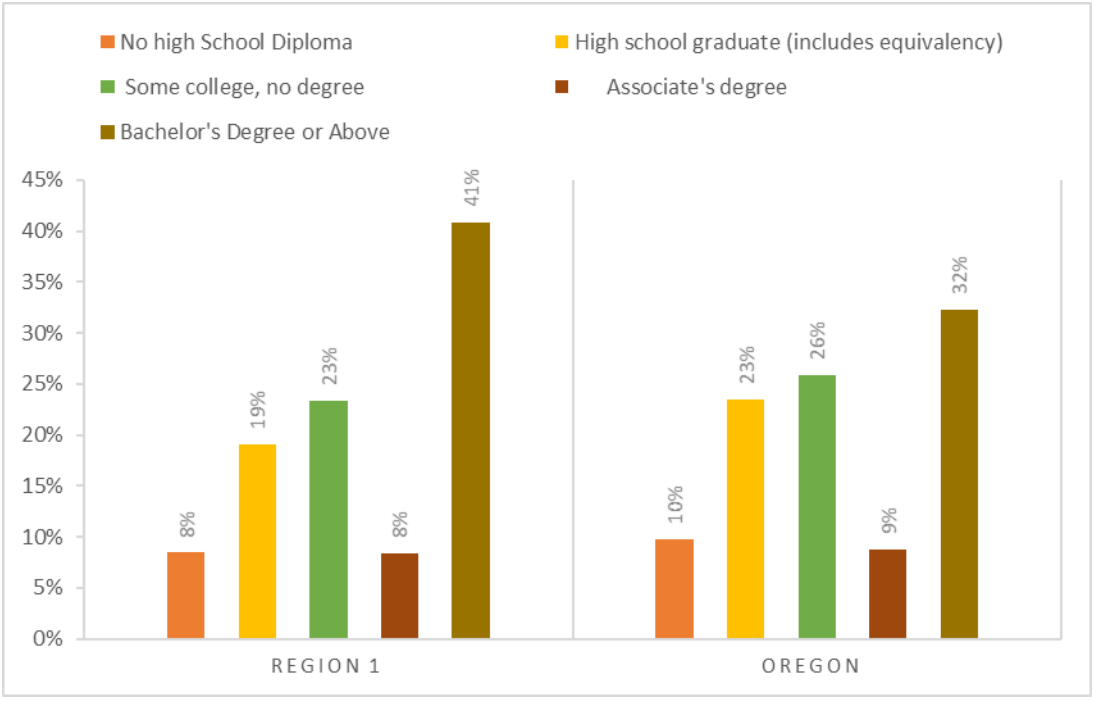
Education Level

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.

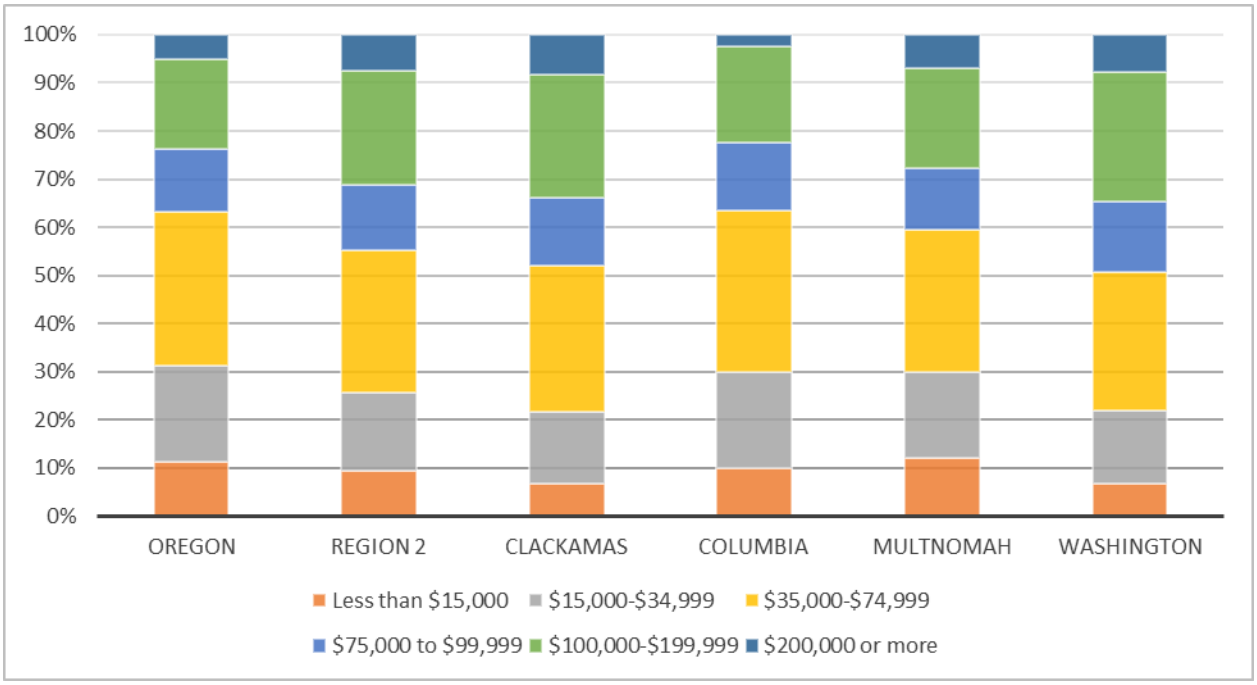
*Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**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.

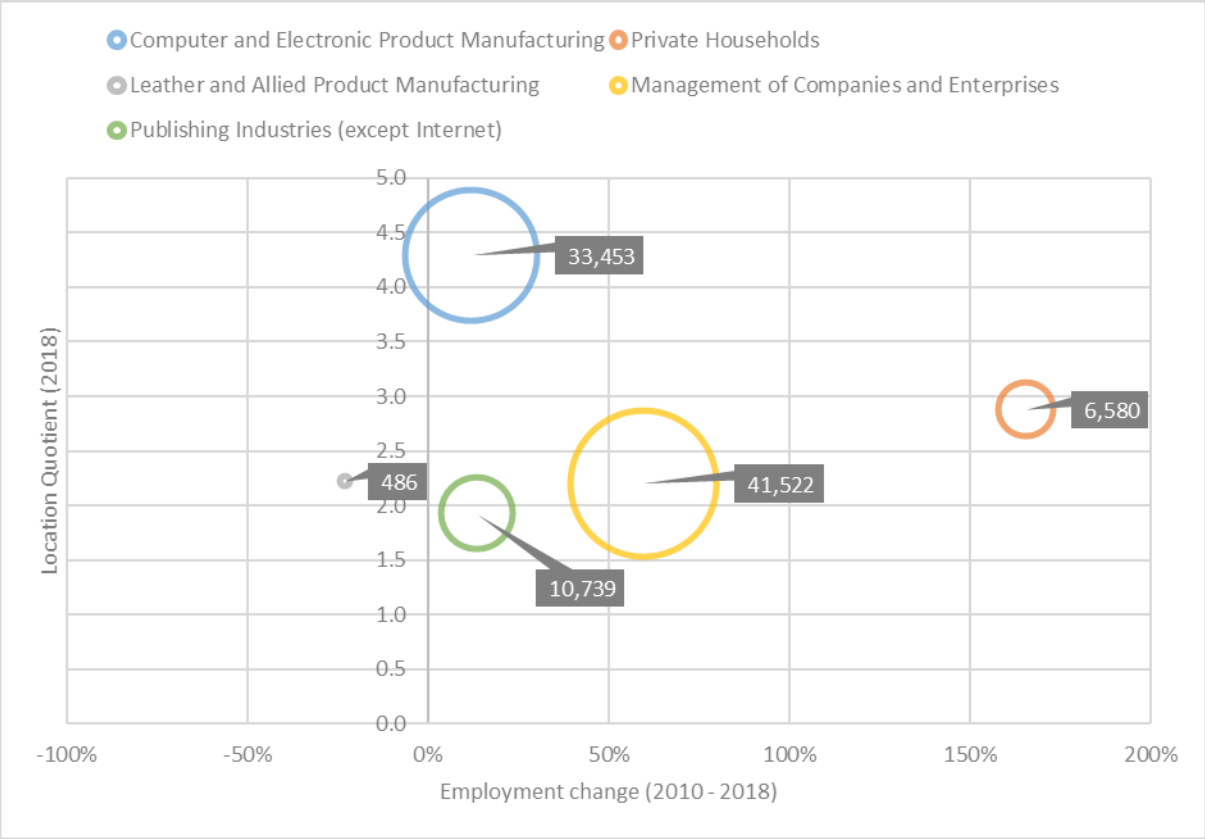
Table 2-201. Most Concentrated Industries and Employment Change in Region 2, 2018

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).

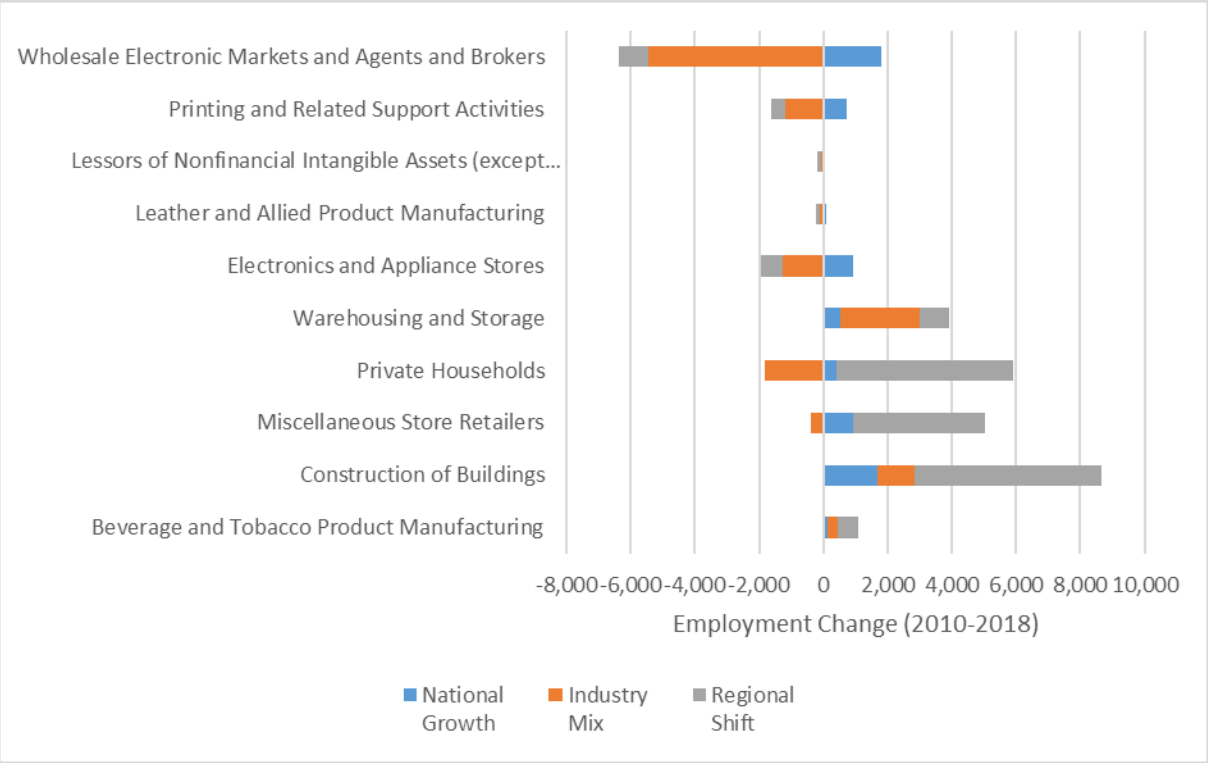
The Private Households industry employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019). The increase in employment in the Private Households industry mirrors a statewide trend (Wallis, 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

Roads

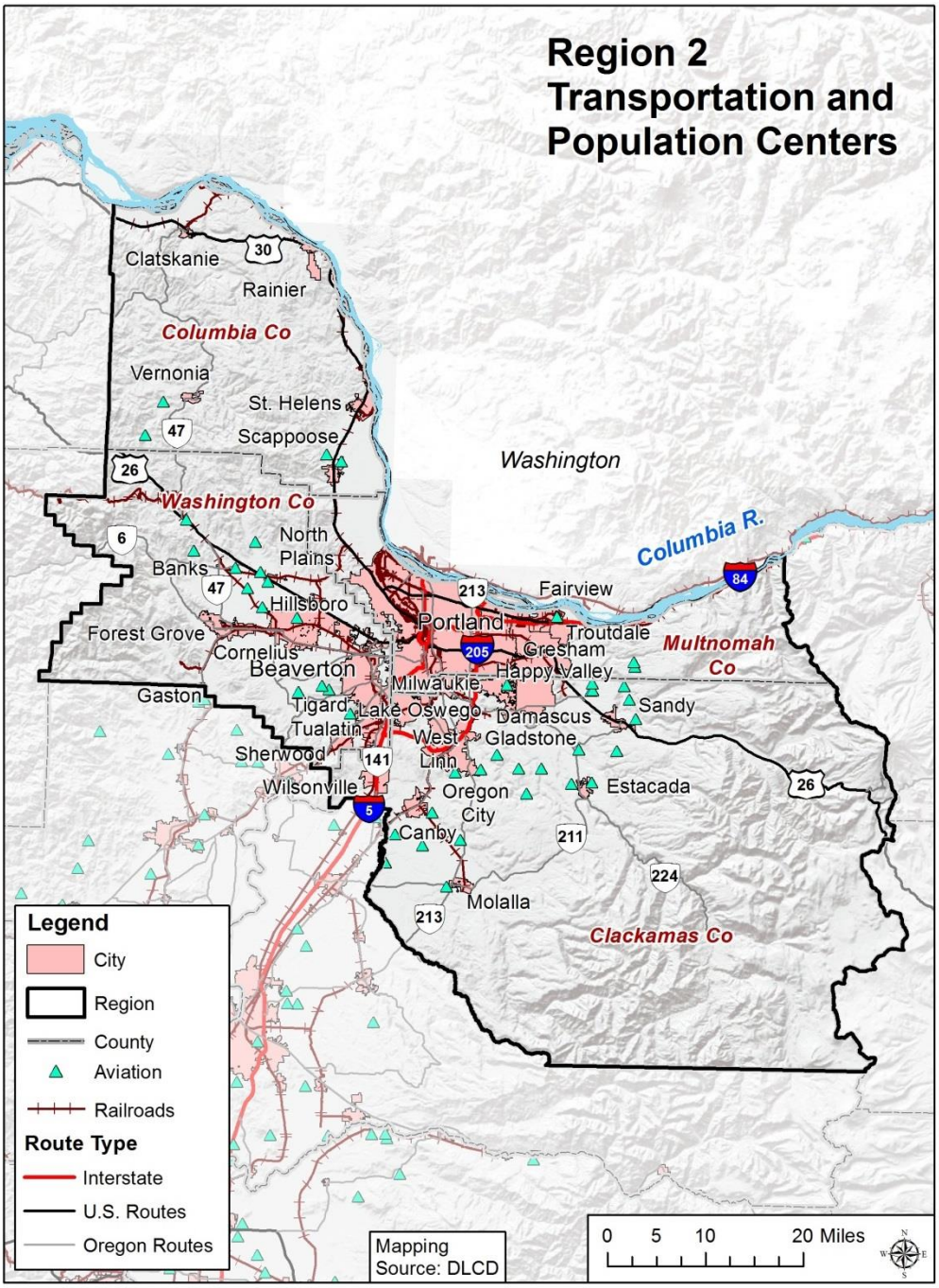
The largest population bases in Region 2 are located along the region's major freeways: I-5, I-205, and I-84. I-5 runs north-south through Region 2 and is the main passage for automobiles and trucks traveling along the West Coast. I-205 is a loop route that serves Portland and Vancouver and provides 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.

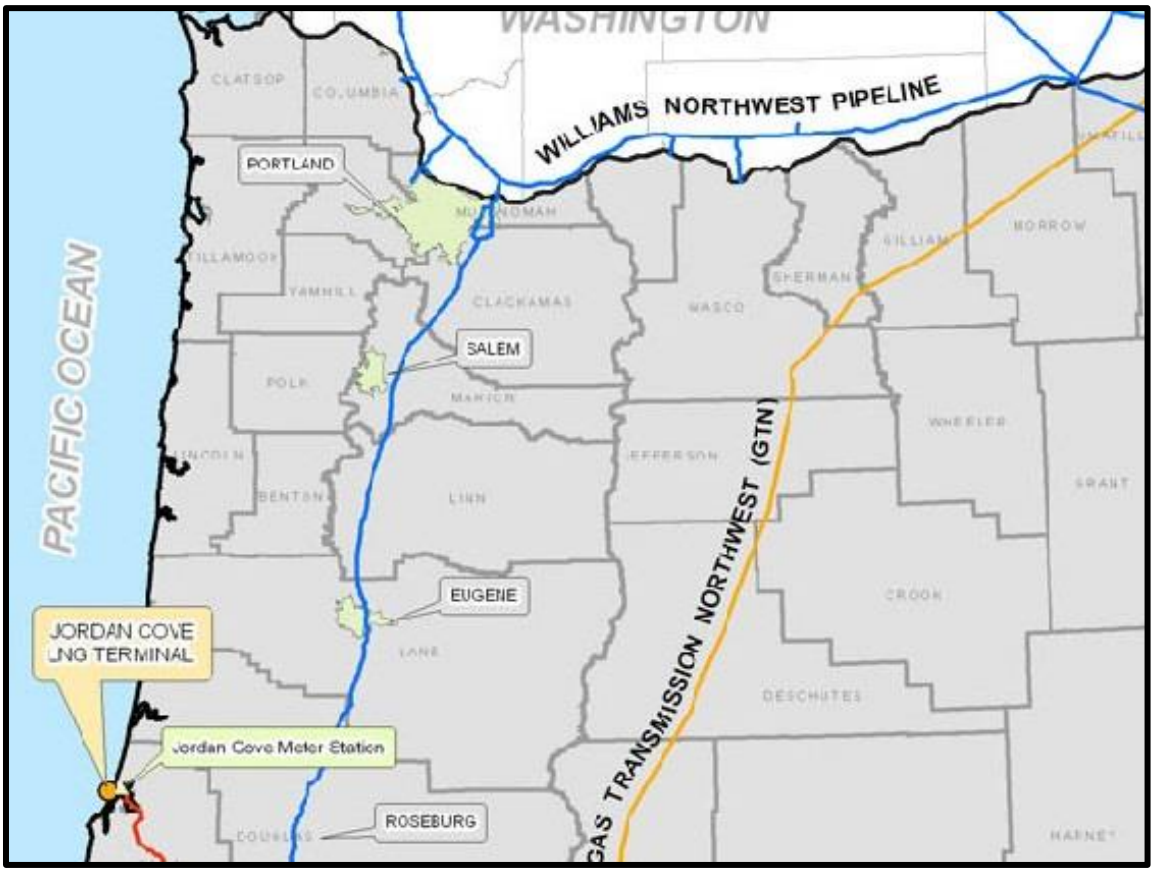
Hydropower

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%

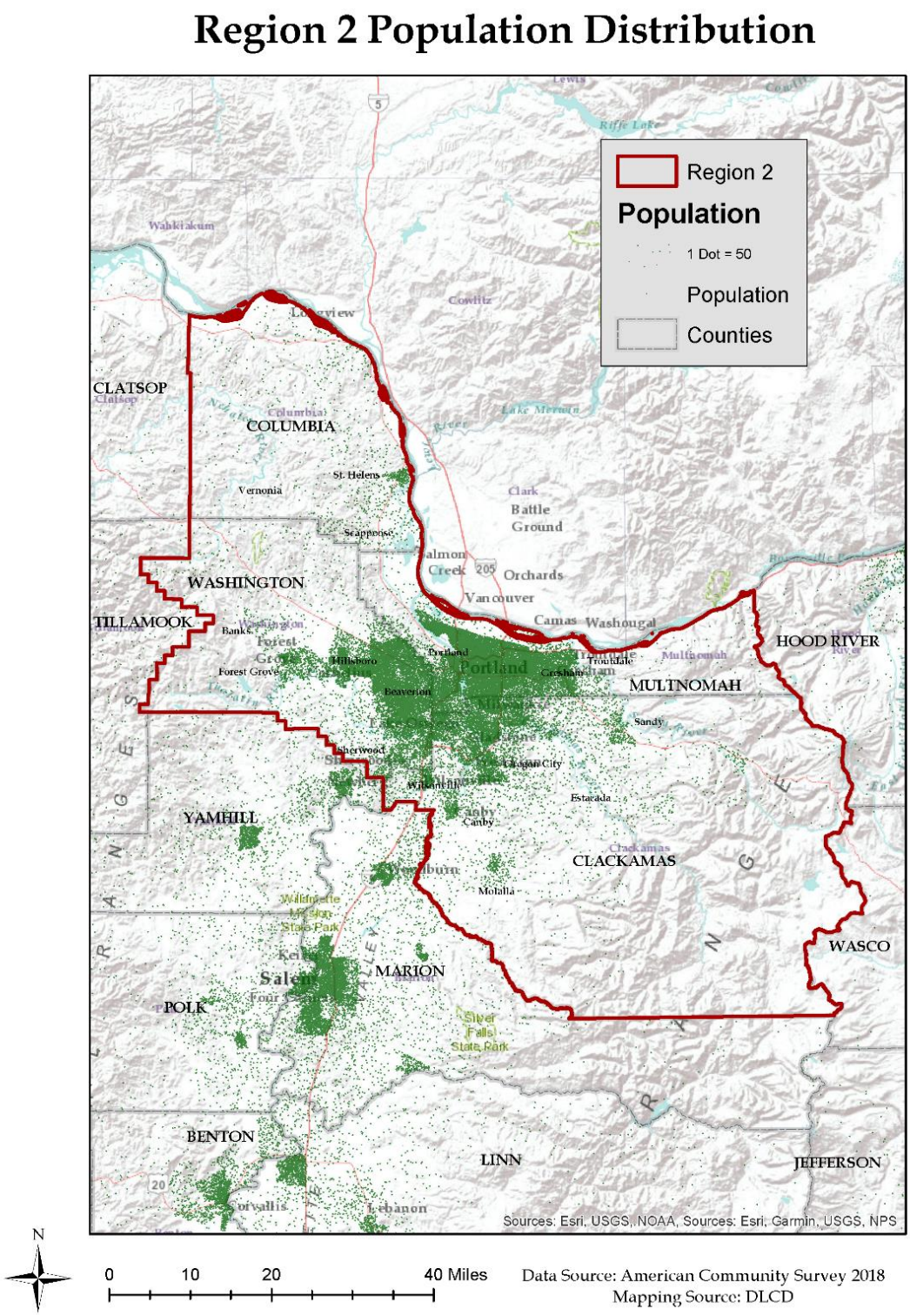
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2

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

	Total Housing Units	Vacant^		
		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).

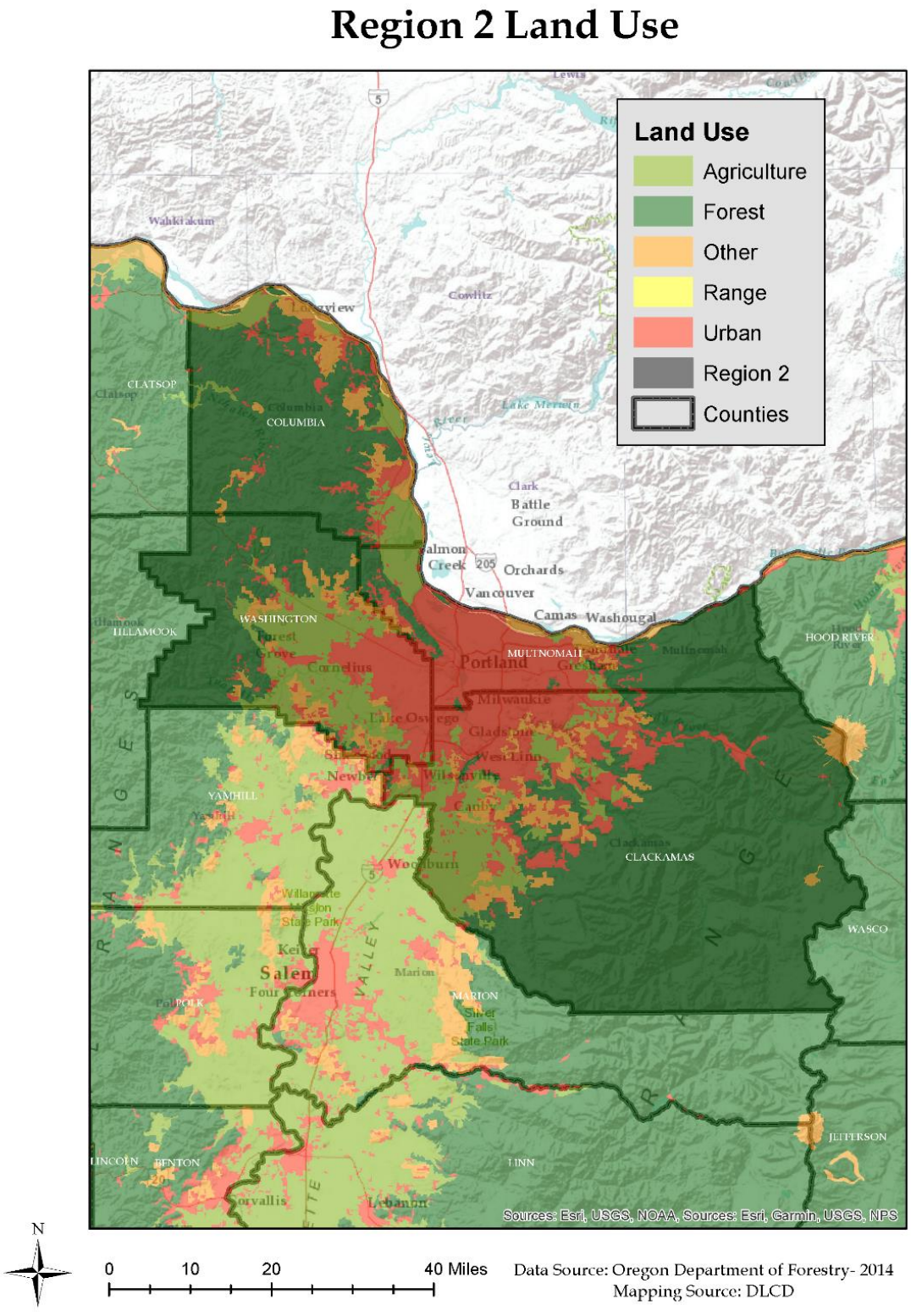
More recently, much of the new residential growth in the Portland area has been either infill or redevelopment. For example, from 2007-2009, 58% of new development in the Portland area fell into one of these two categories (Lettman G. J., 2011). The rest of the residential construction in that time, 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).

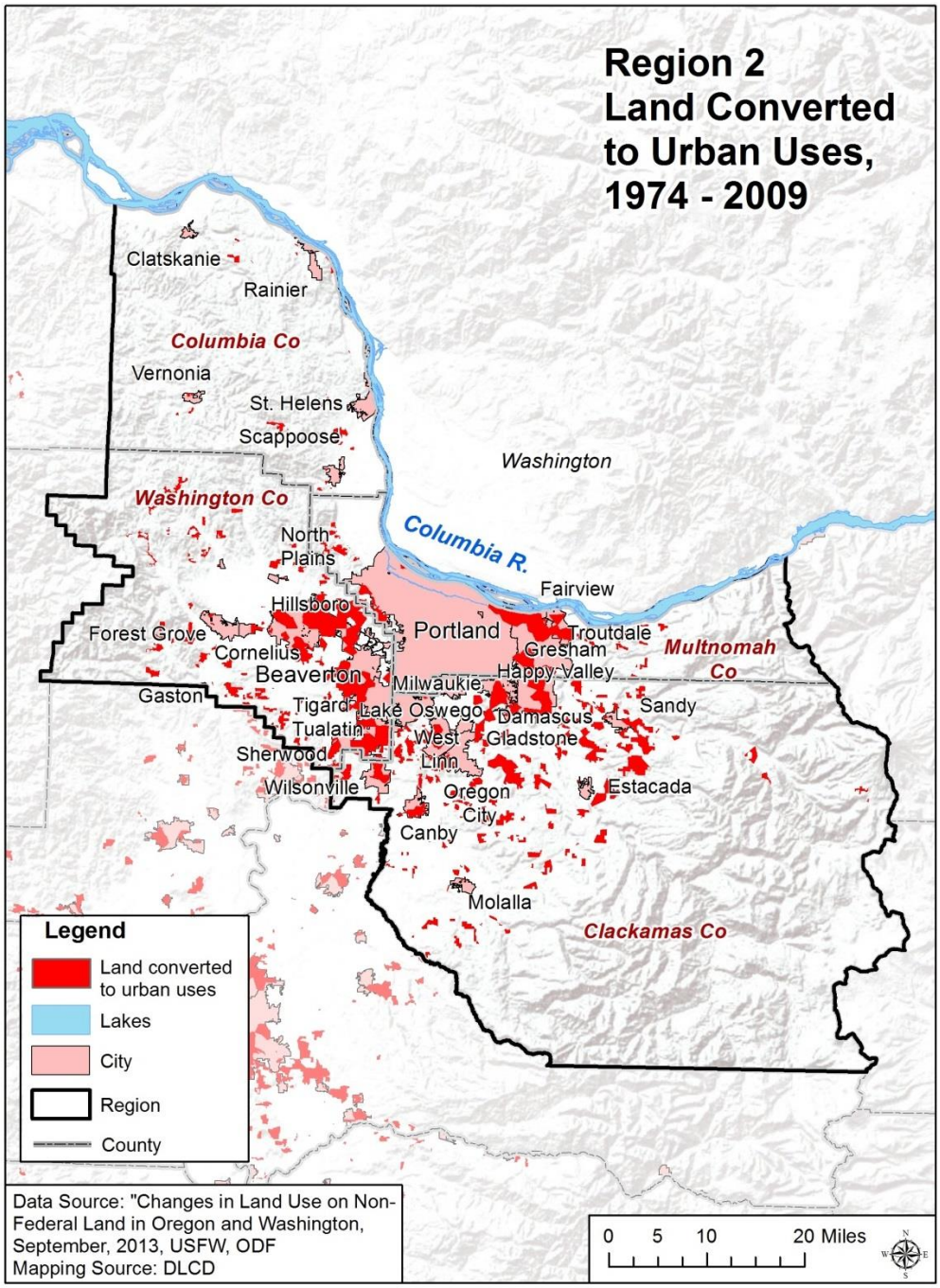
Potential upgrades to the 28 miles of levees that protect the north Portland area from the Columbia River remain a continuing land use issue for the region. As of January 2020, potential costs to the four drainage districts involved were approximately $157 million dollars (U.S. Army Corps of Engineers, 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

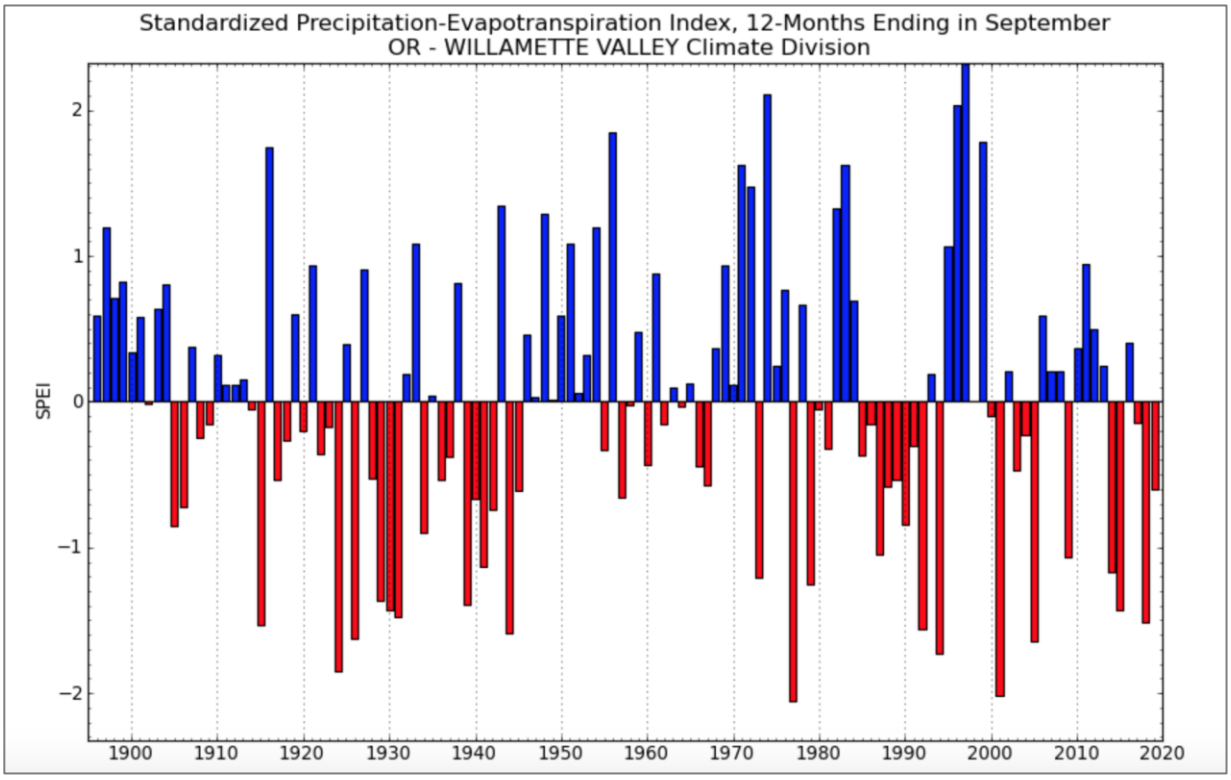
Date	Location	Description
1924	statewide	prolonged statewide drought that caused major problems for agriculture
1930	Regions 1–3, 5–7	moderate to severe drought affected much of the state; the worst years in Region 2 were 1928–1930, which kicked off an era of many drier than normal years
1939	statewide	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

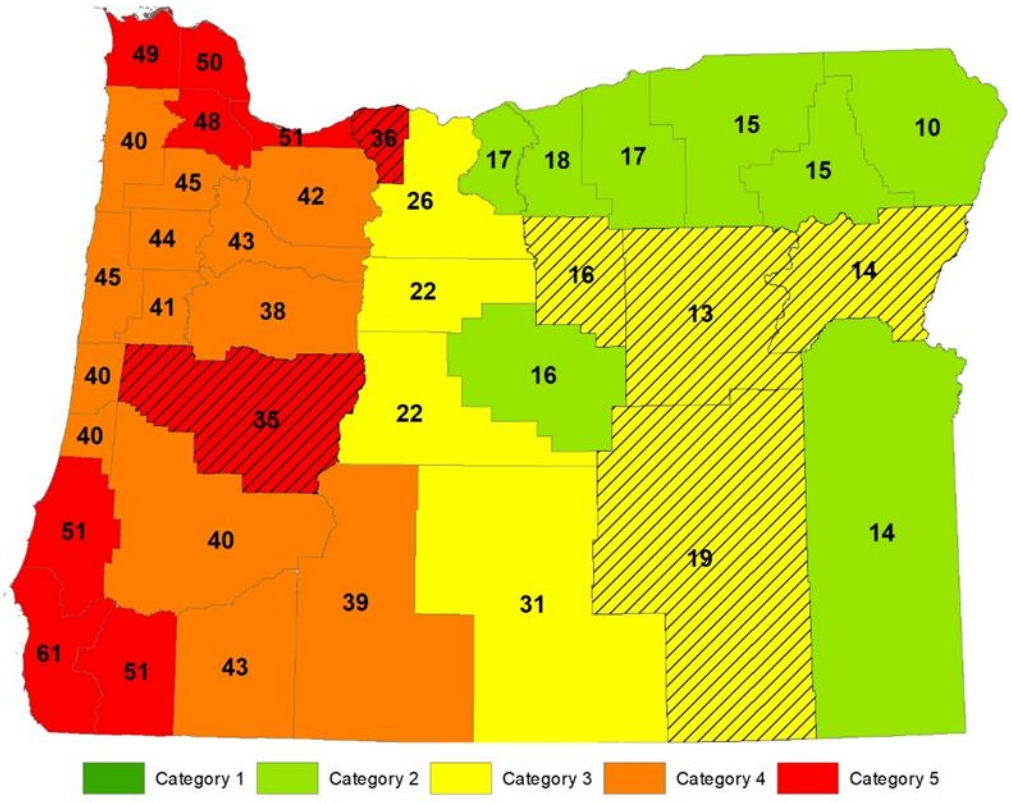
The probability of damaging earthquakes varies widely across the state. In Region 2 the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well-understood recurrence history.

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

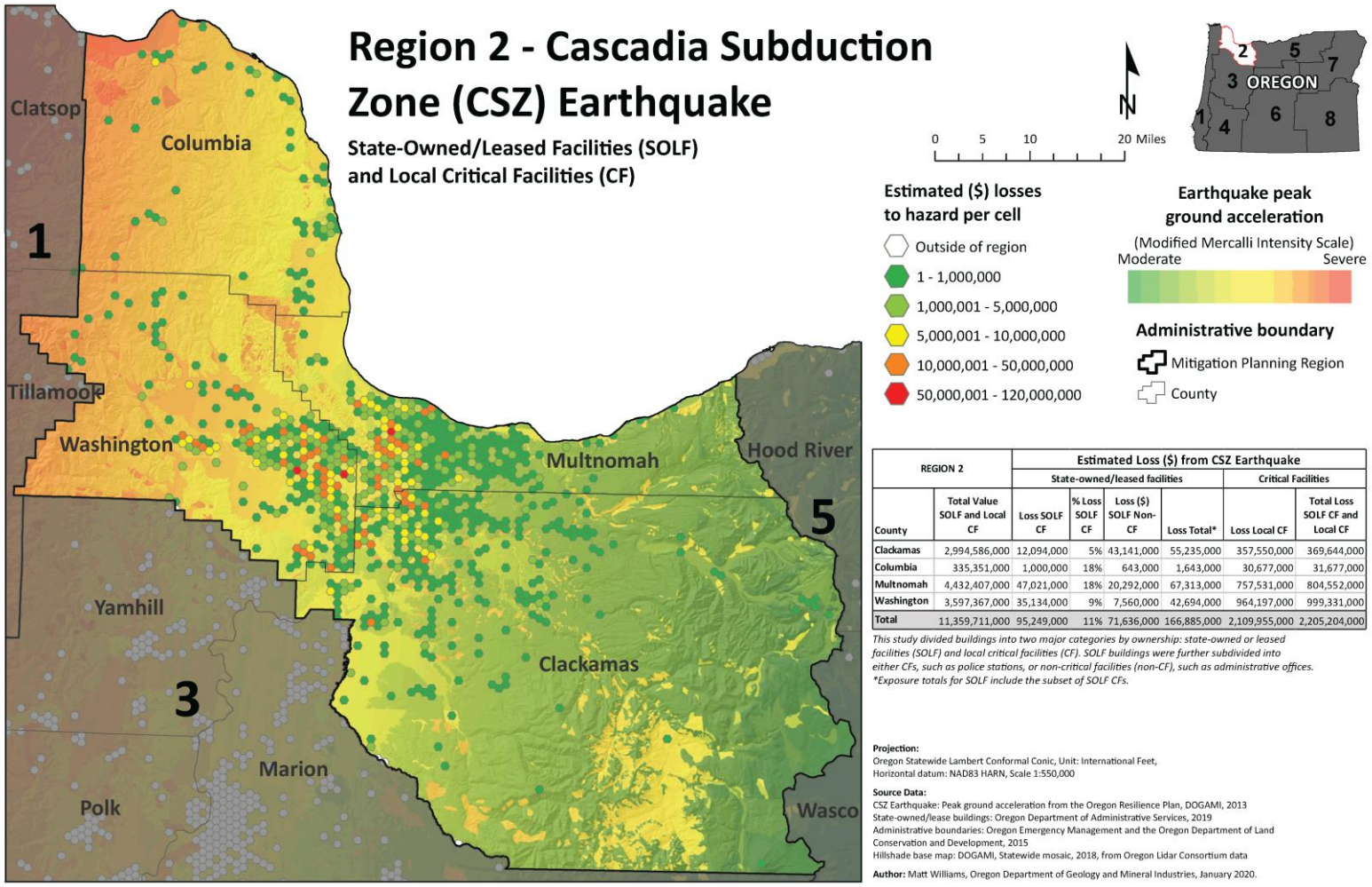
For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a Magnitude 9 Cascadia Subduction Zone (CSZ) event in Region 2. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building 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



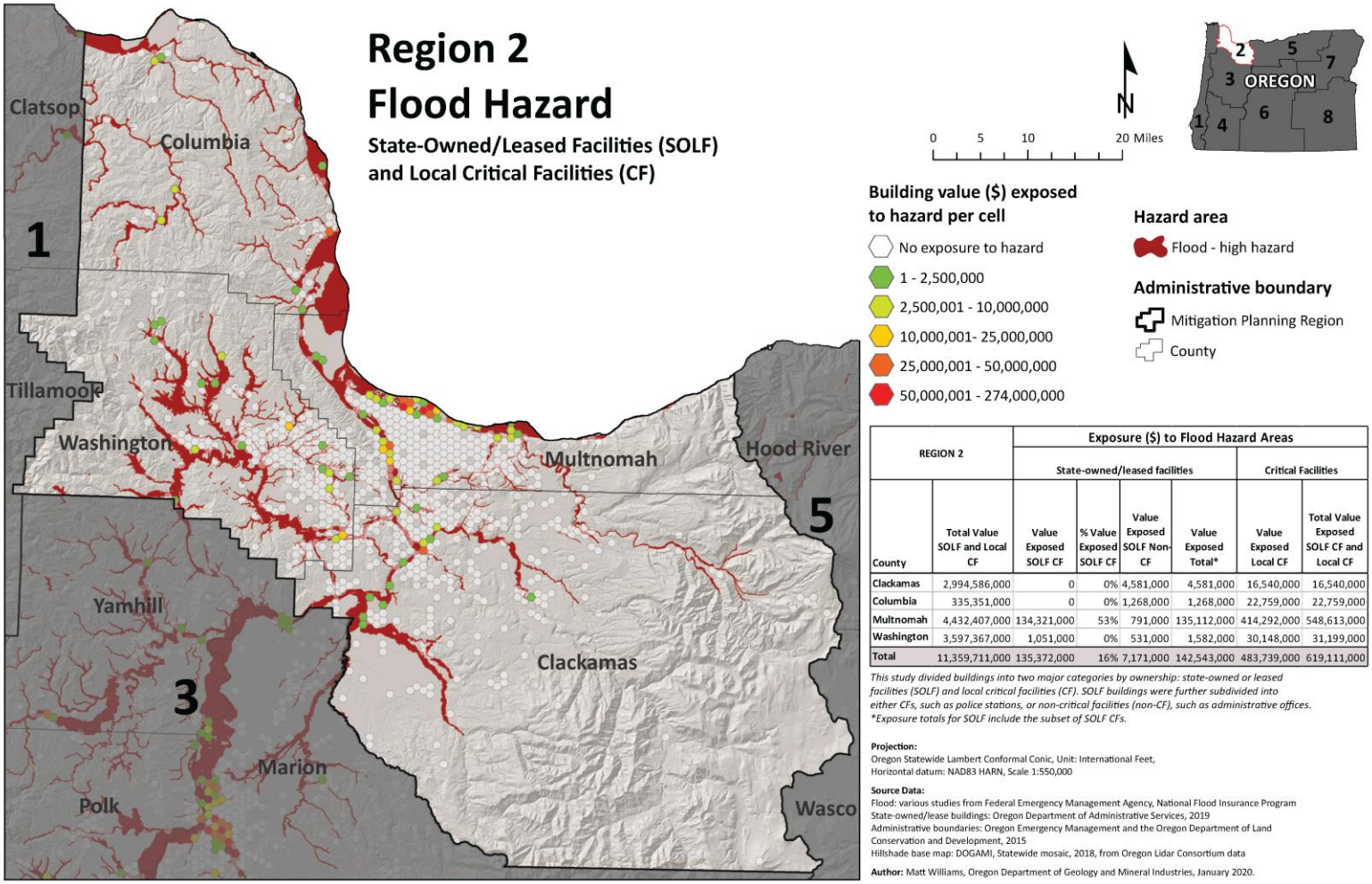
that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. Clackamas County participates in CRS, as do the cities of Oregon City, Portland, Scappoose, and Troutdale.

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

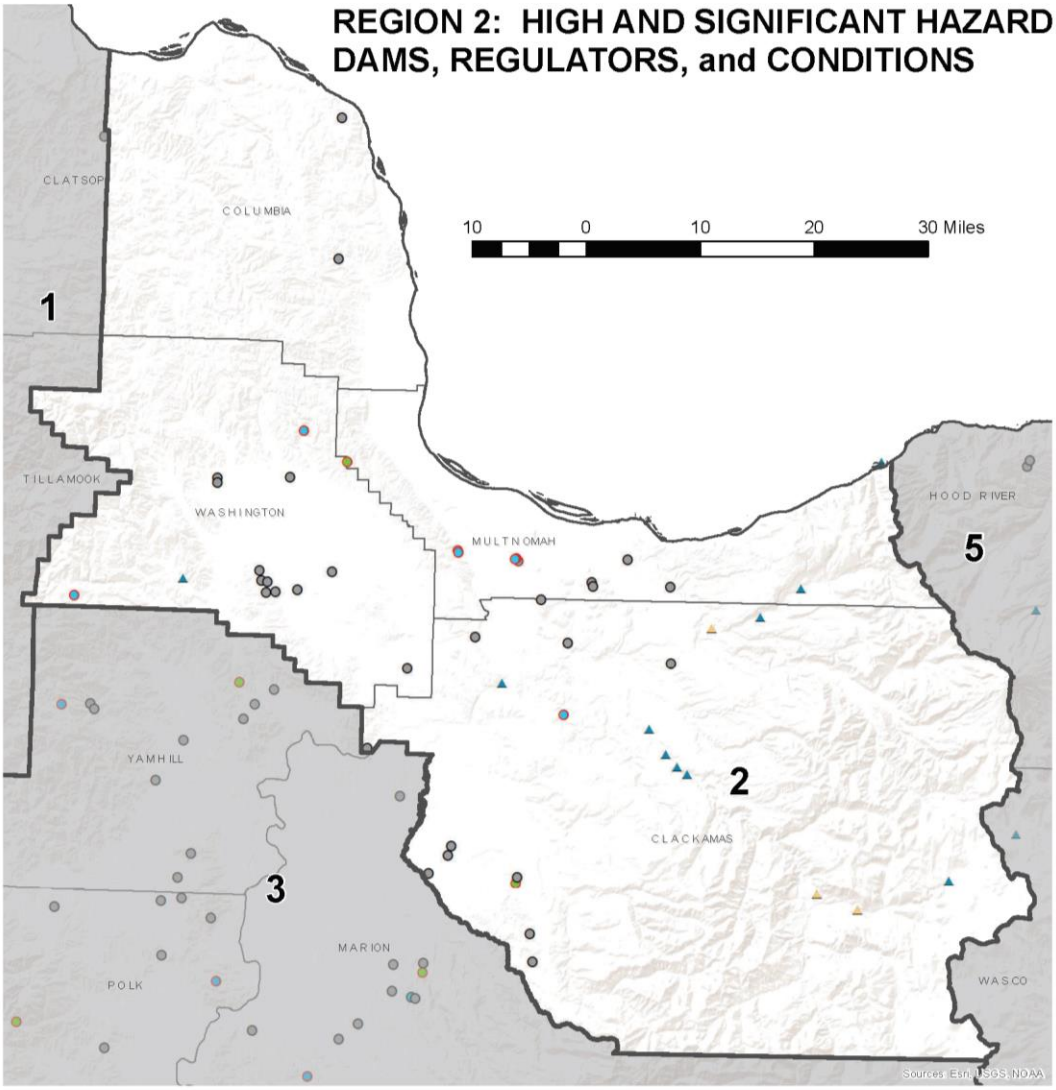
State-Regulated High Hazard Dams not Meeting Safety Standards

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

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)

State regulated dams**

Condition assessment

- Poor
- Unsatisfactory
- Fair
- Satisfactory
- No assessment

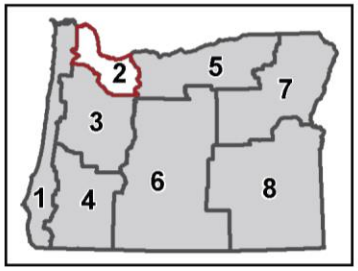
** - Significant hazard dam symbols have a black outline. **High hazard dam symbols have a red outline.**

Federal regulated dams

Hazard

- High
- Significant

Mitigation Planning Regions
Counties



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

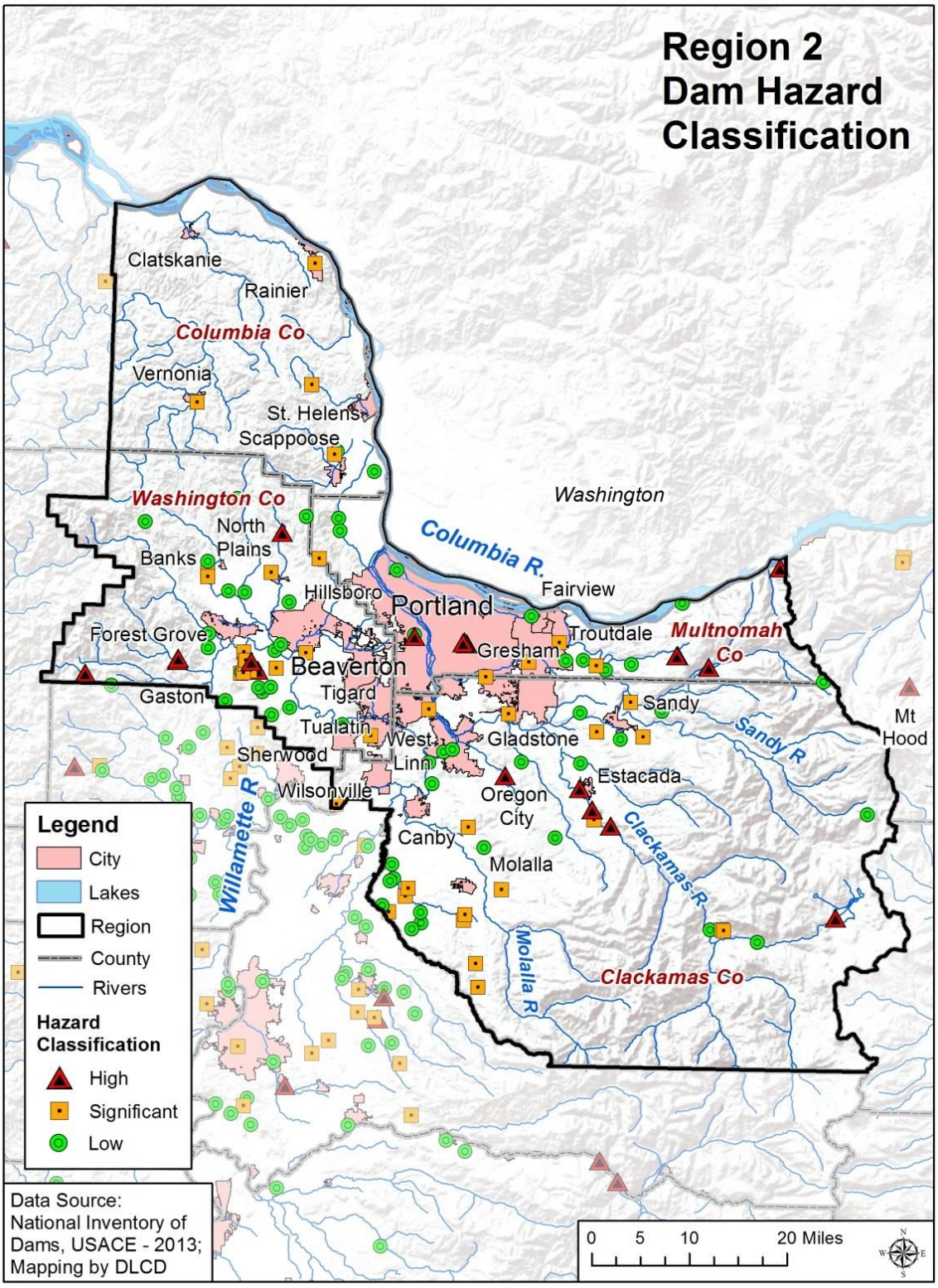
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), no Region 2 counties are considered "most vulnerable 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

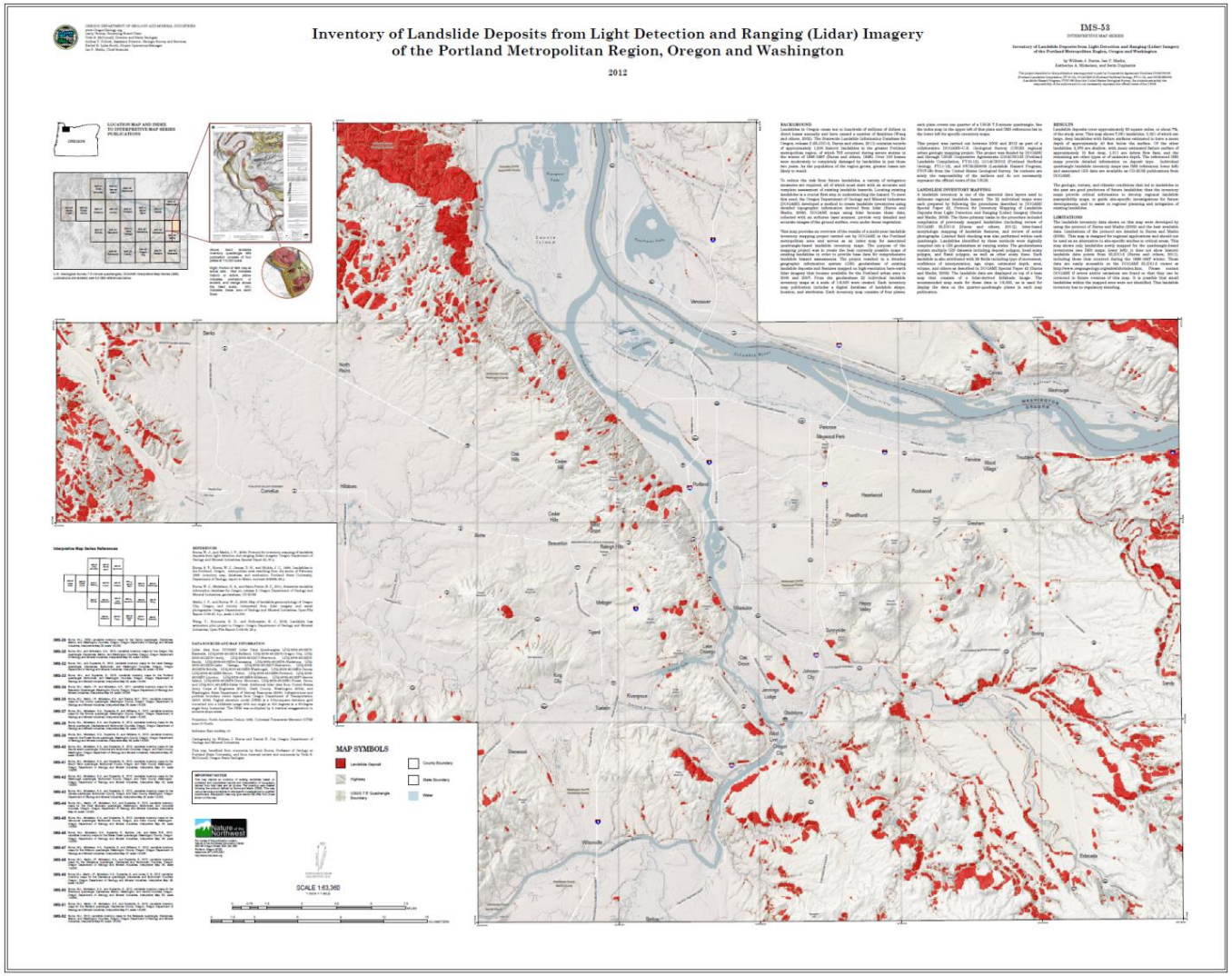
Characteristics

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

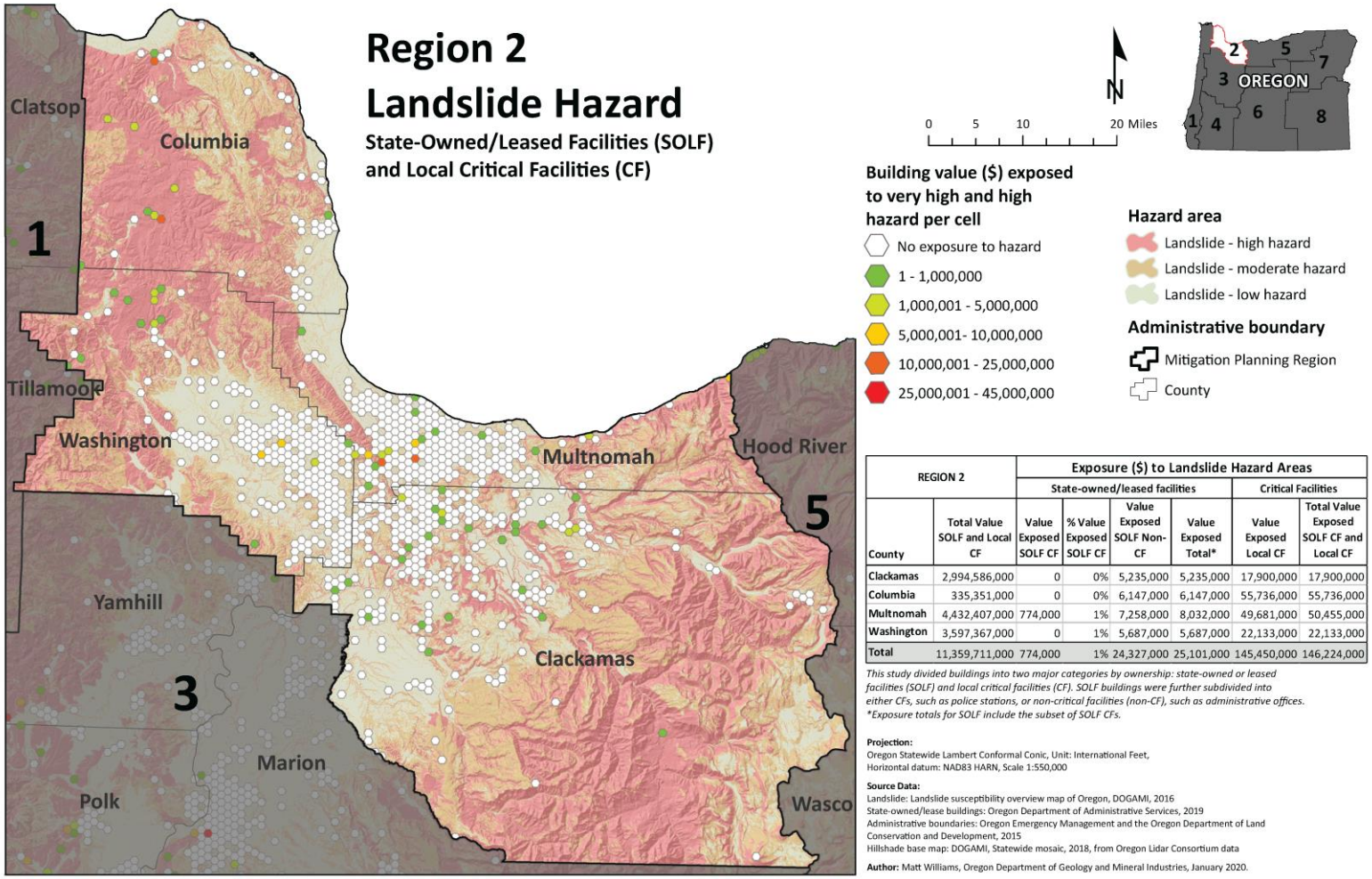
Source: DOGAMI and DLCD, 2020

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

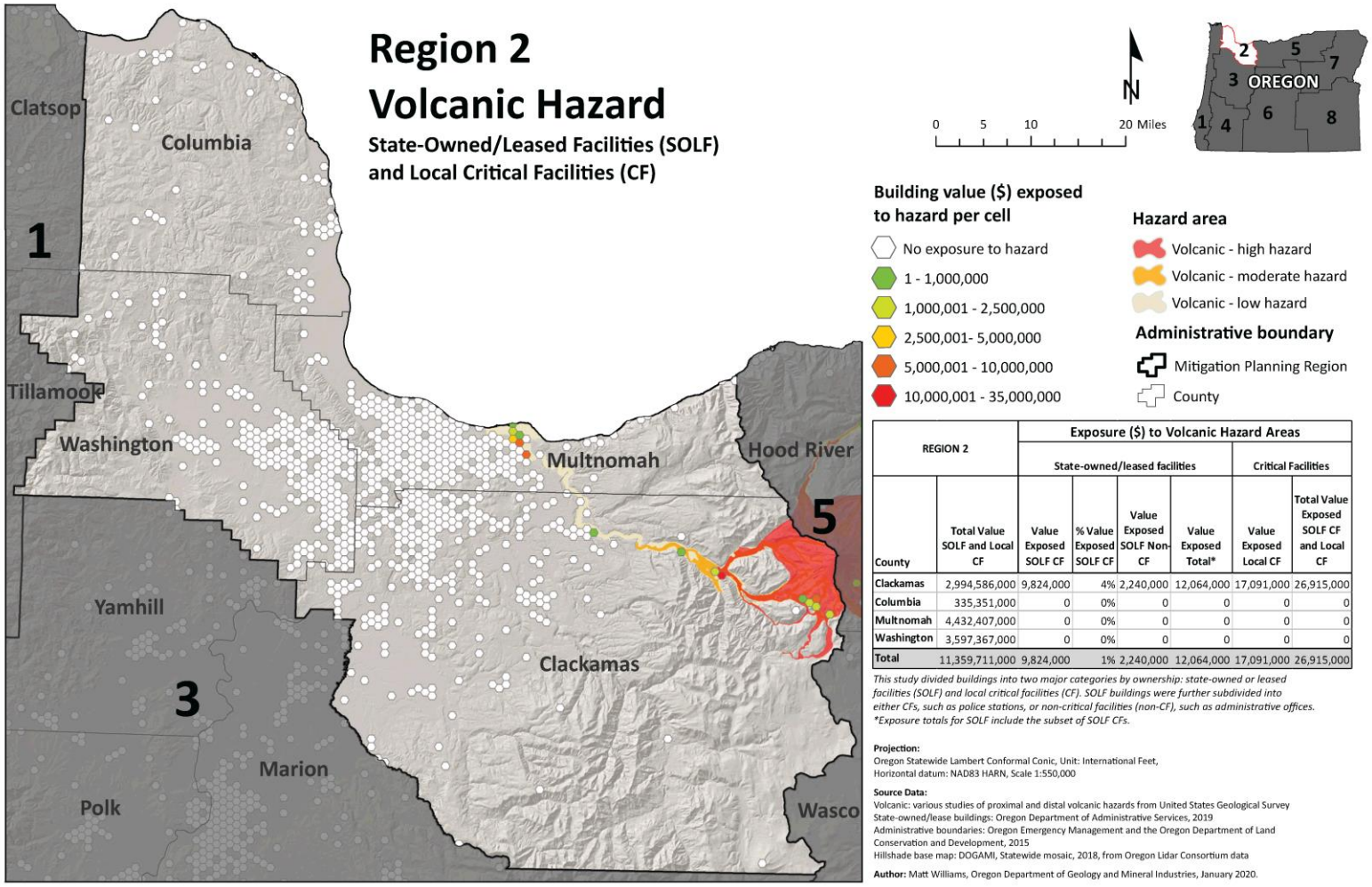
Source: DOGAMI and DLCD, 2020

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

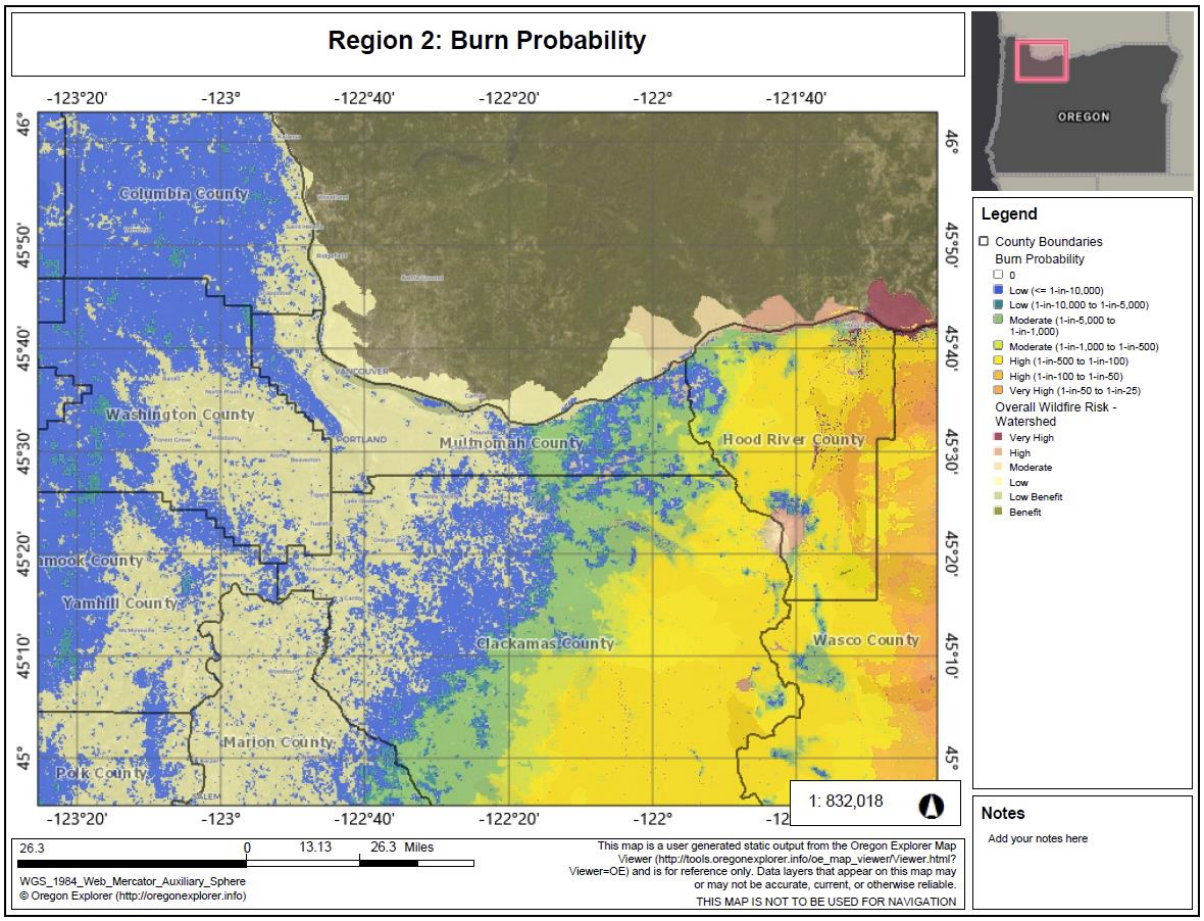
Source: PNW Quantitative Wildfire Risk Assessment and Oregon Explorer, 2020

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.

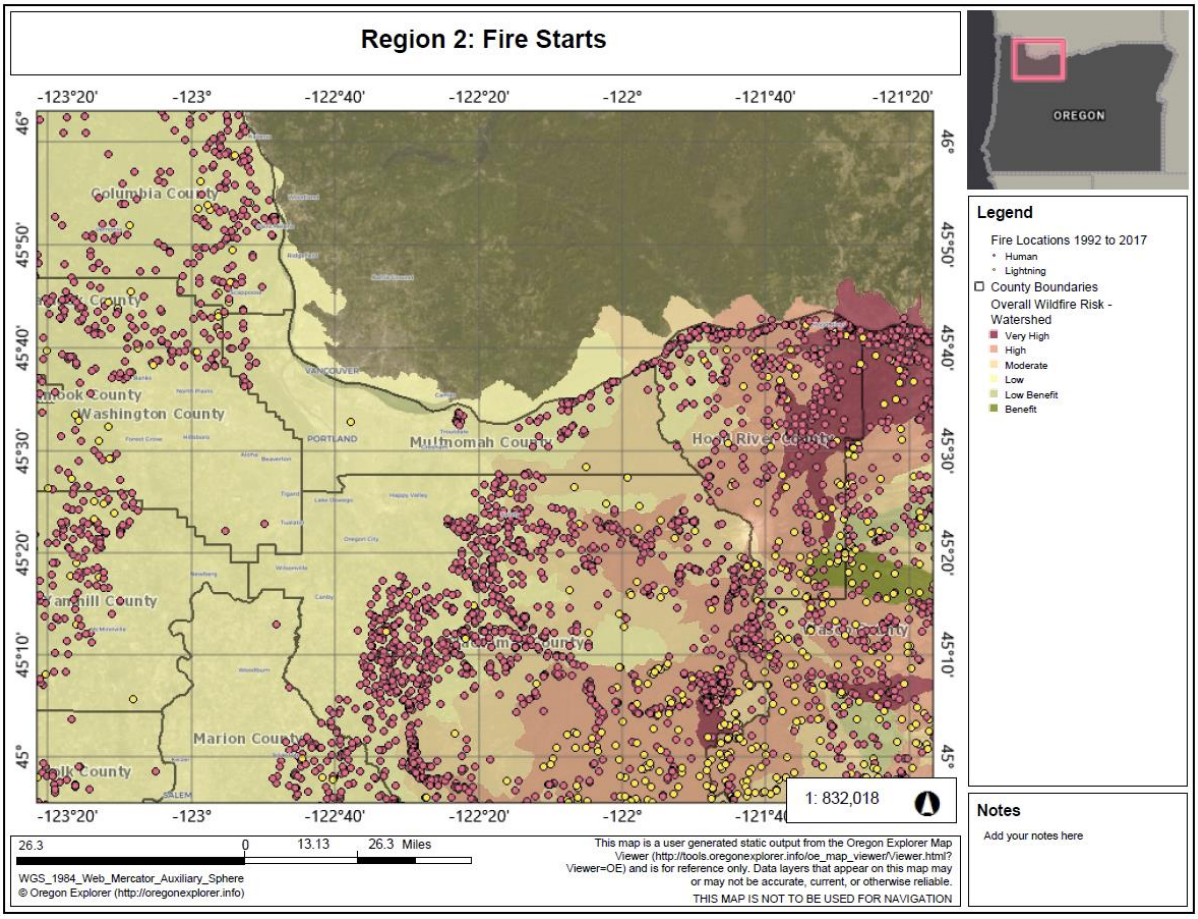
Figure 2-163. Burn Probability



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,"

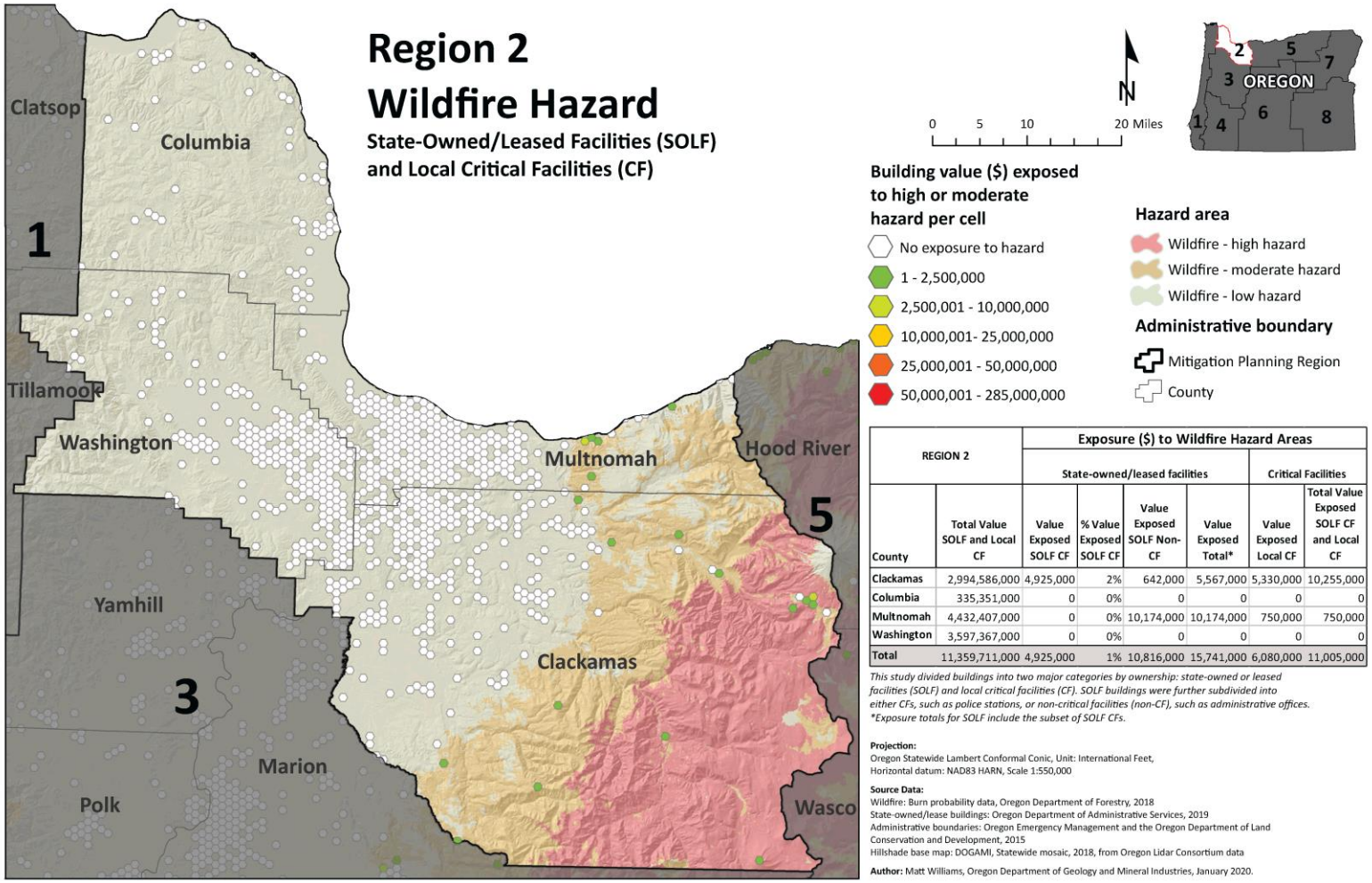


"Moderate," and "Low" categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as "Low."

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

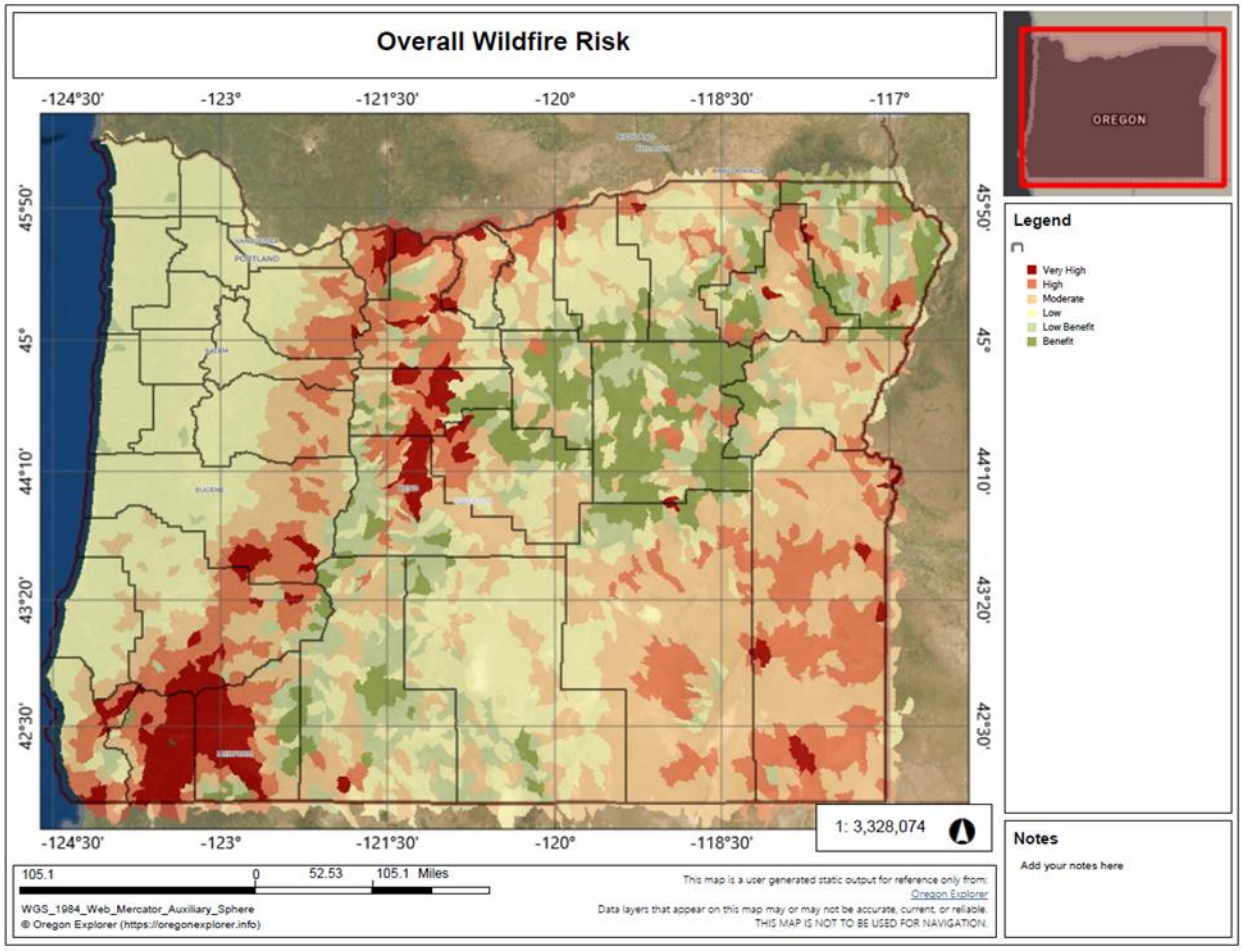
Table 2-265. Risk of Wildfire Hazards in Region 2

	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.

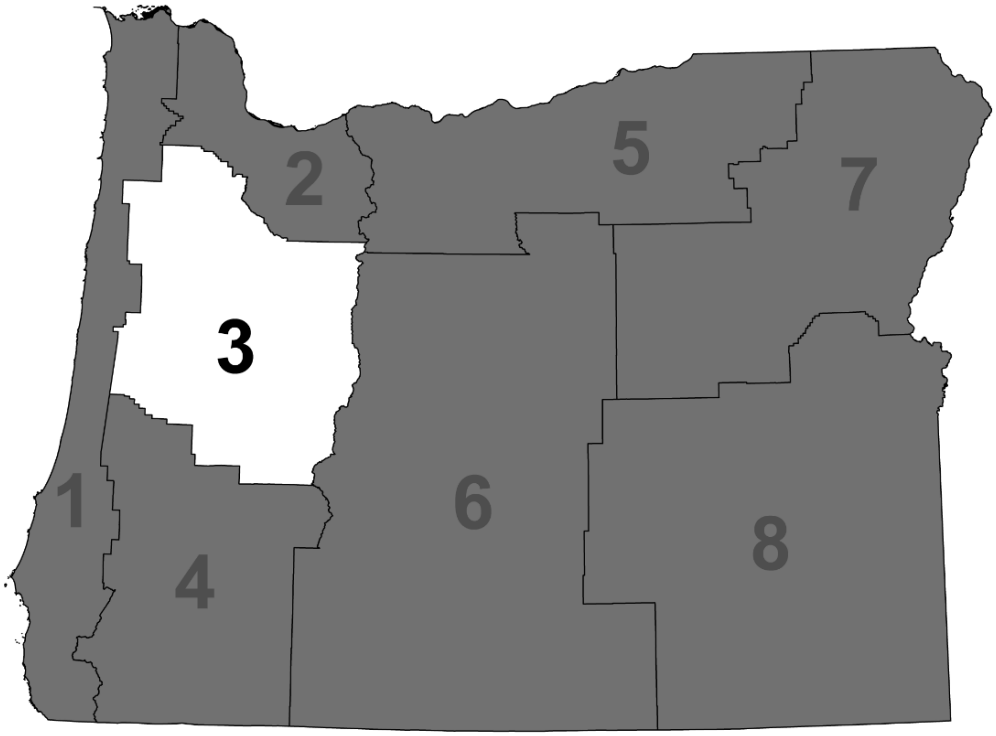
Risk

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

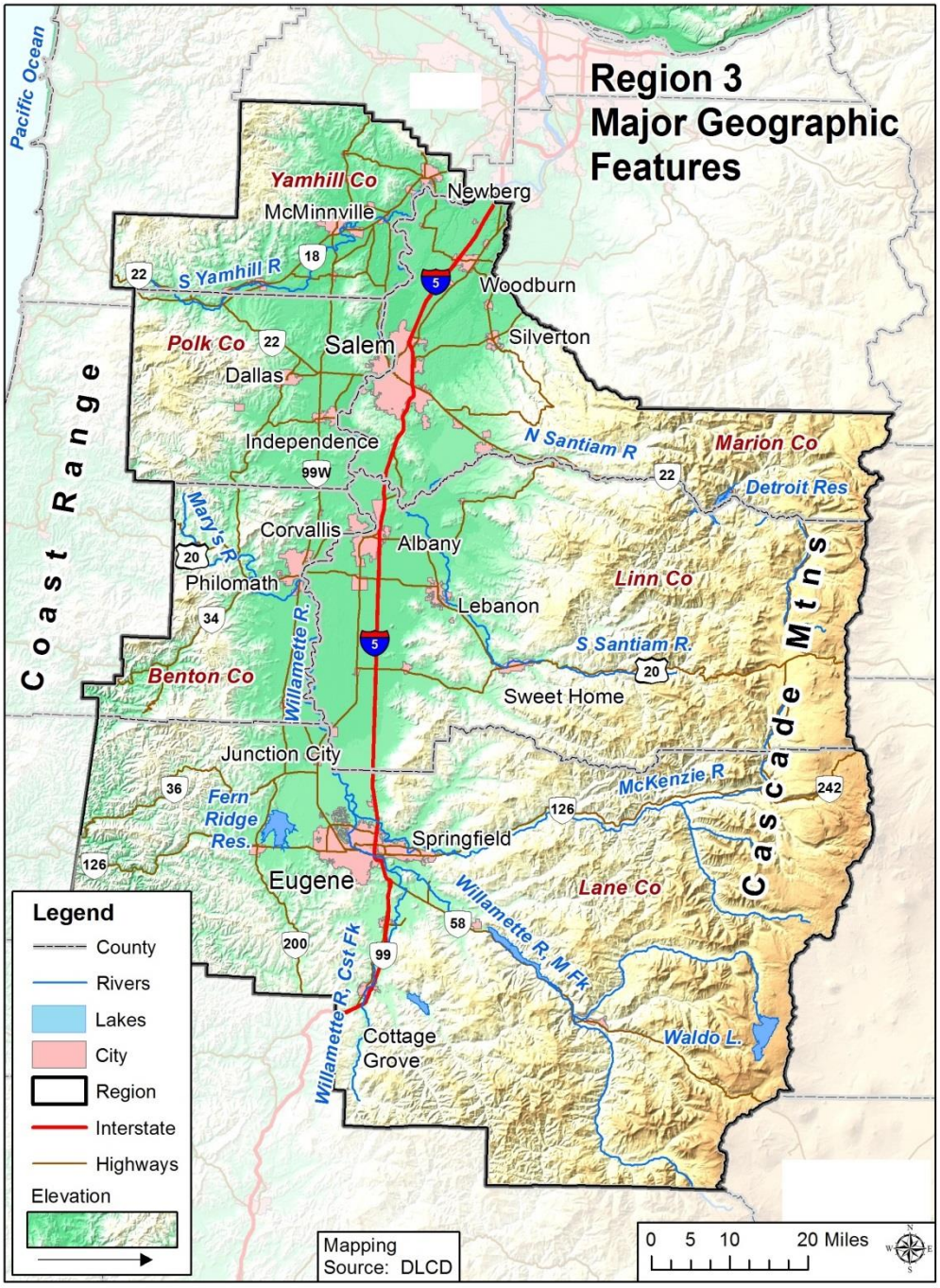
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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.

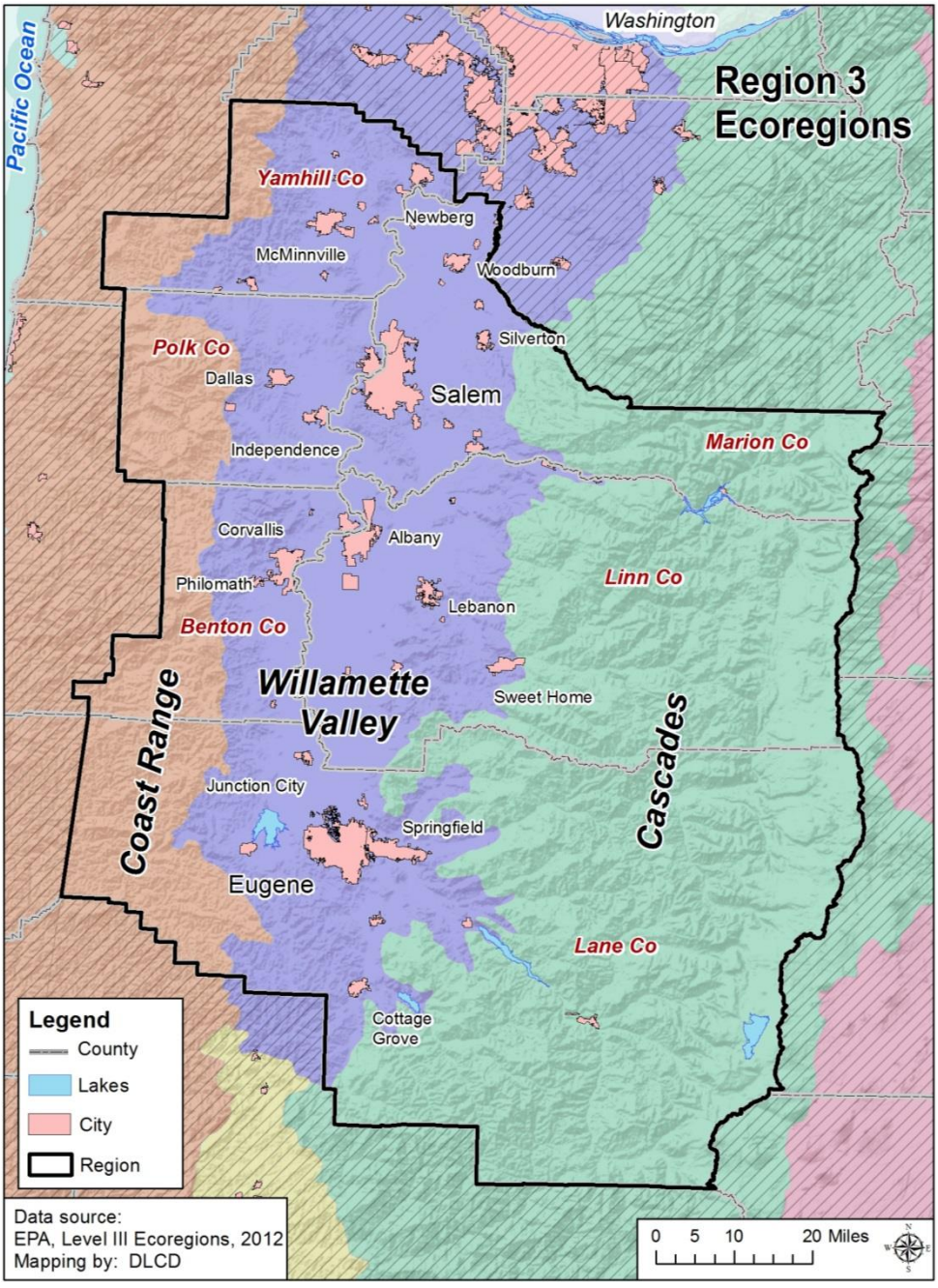
Figure 2-167. Region 3 Major Geographic Features



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

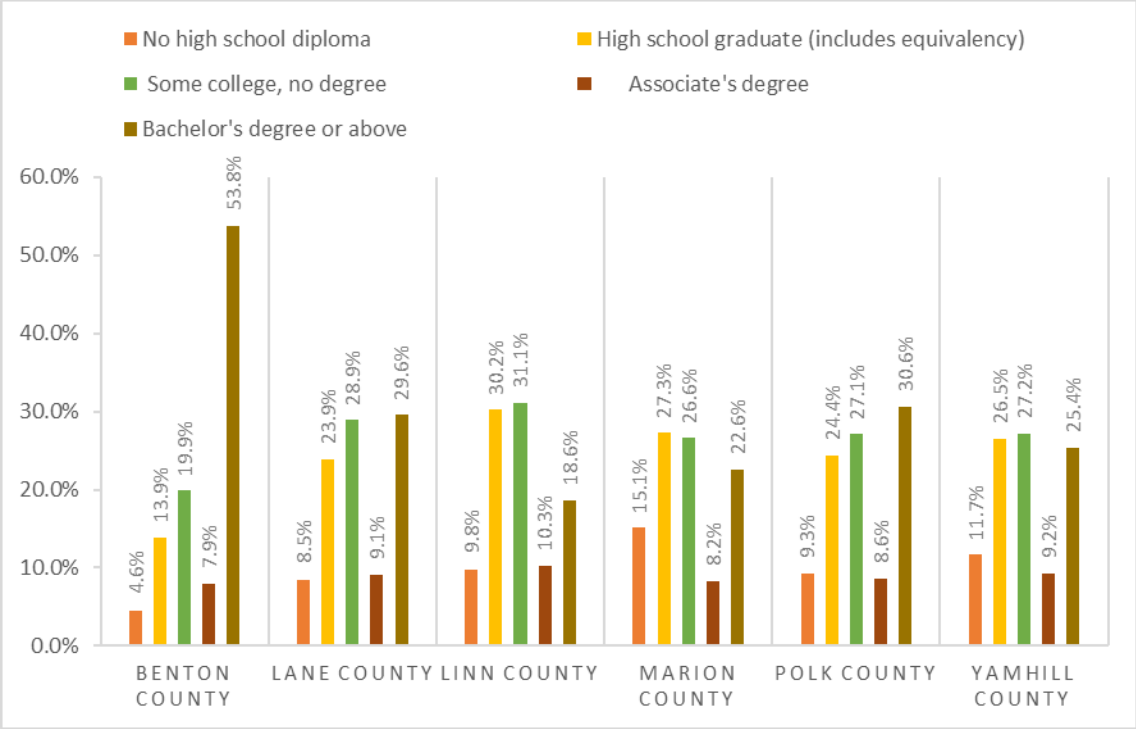
Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual's ability to understand and act on warning information, navigate bureaucratic systems, and to access resources before and after a natural disaster (Masozera, Bailey, & Kerchner, 2007).

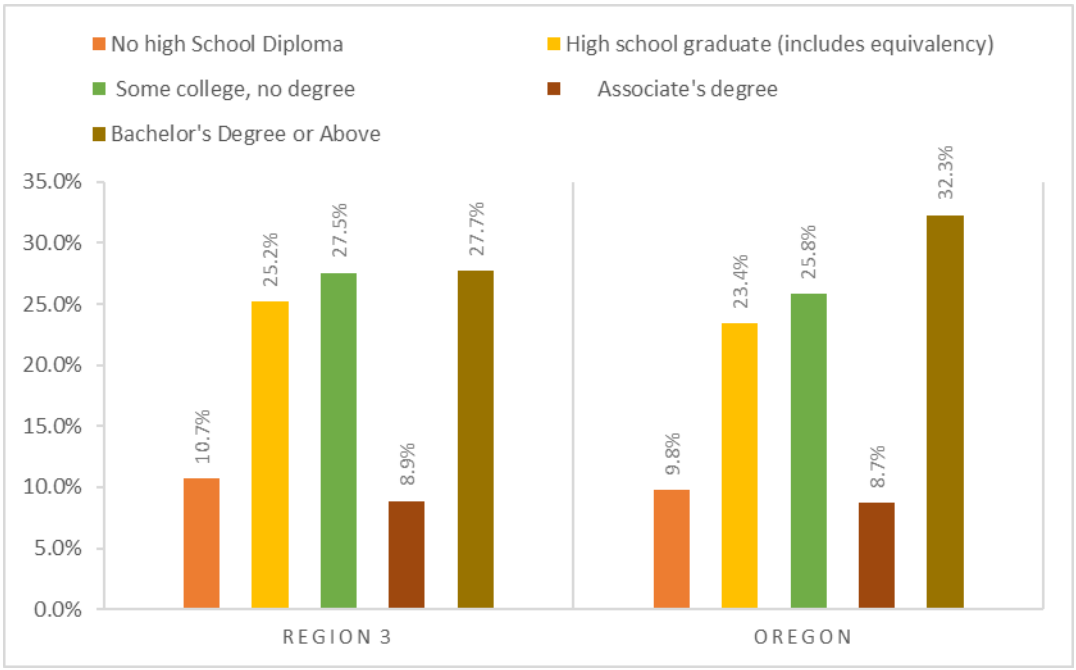
Approximately 28% of residents in Region 3 have a bachelor's degree or higher, which is approximately five percentage points lower than the statewide estimate. One tenth of residents in the region do not have a high school diploma, which is similar to the statewide share. Approximately one-quarter of 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.

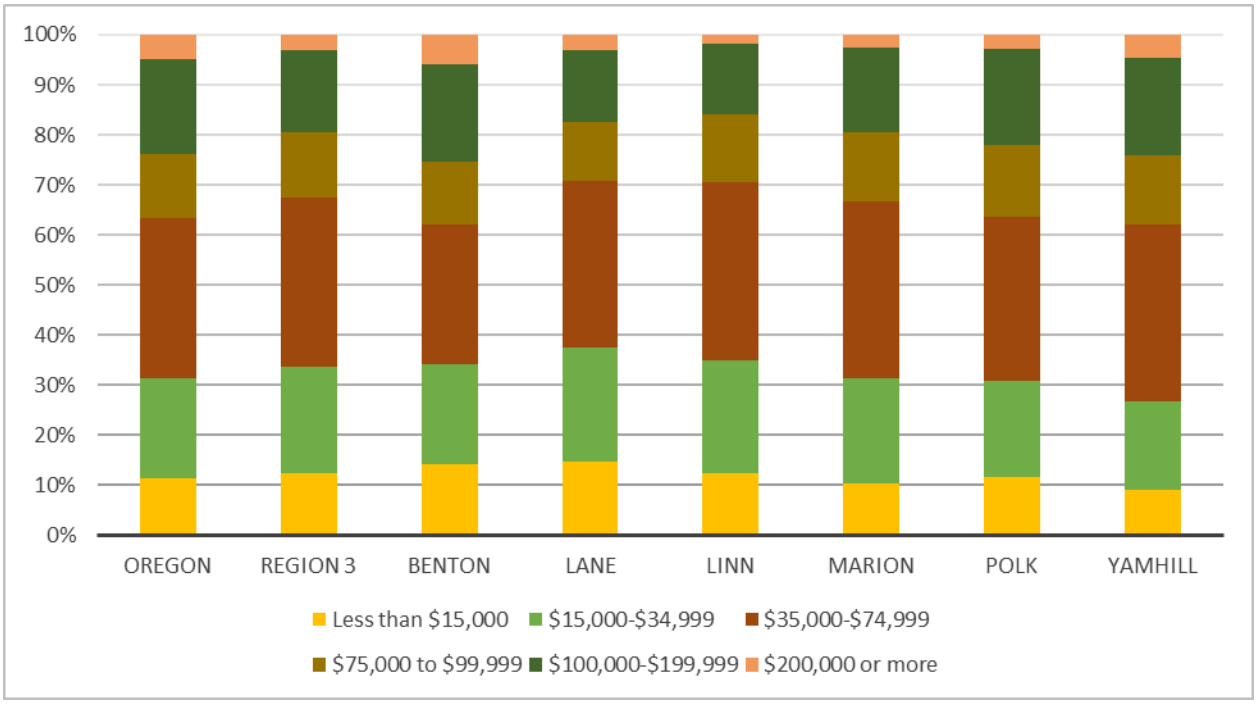
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**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.

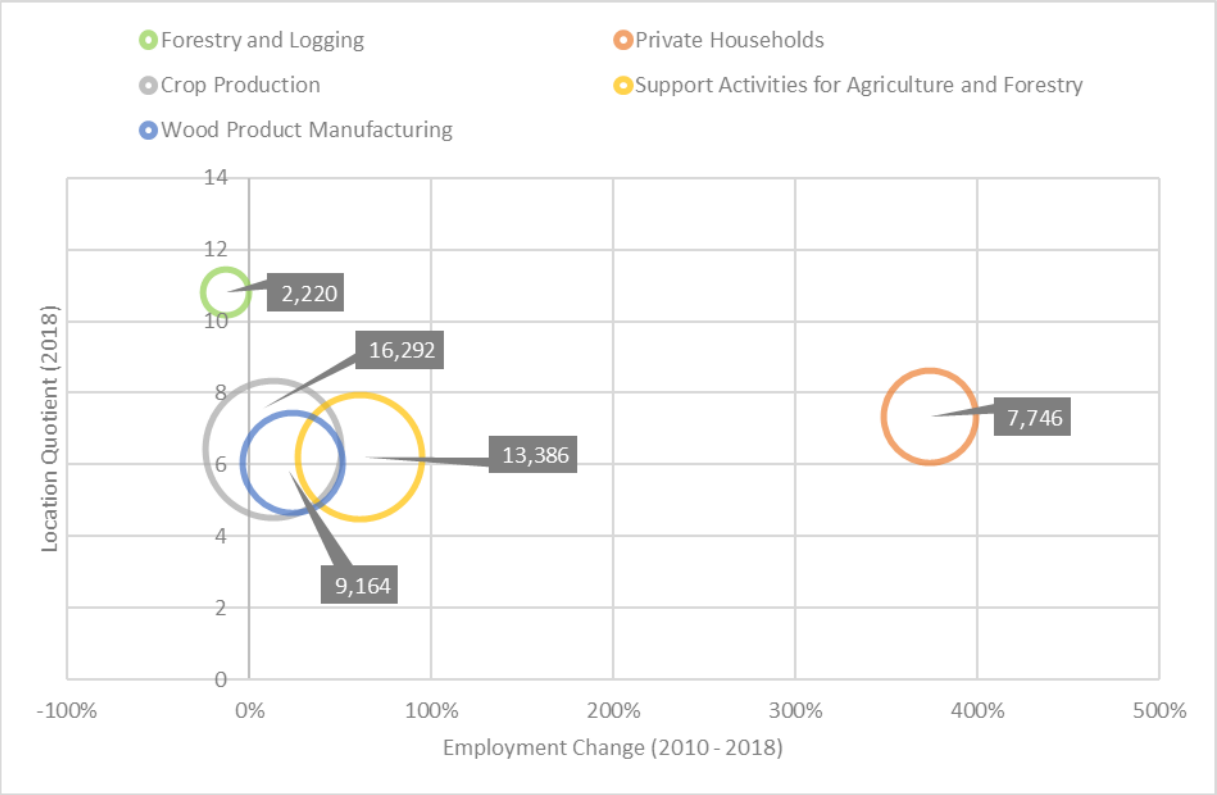
Table 2-291. Most Concentrated Industries and Employment Change in Region 3, 2018

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).

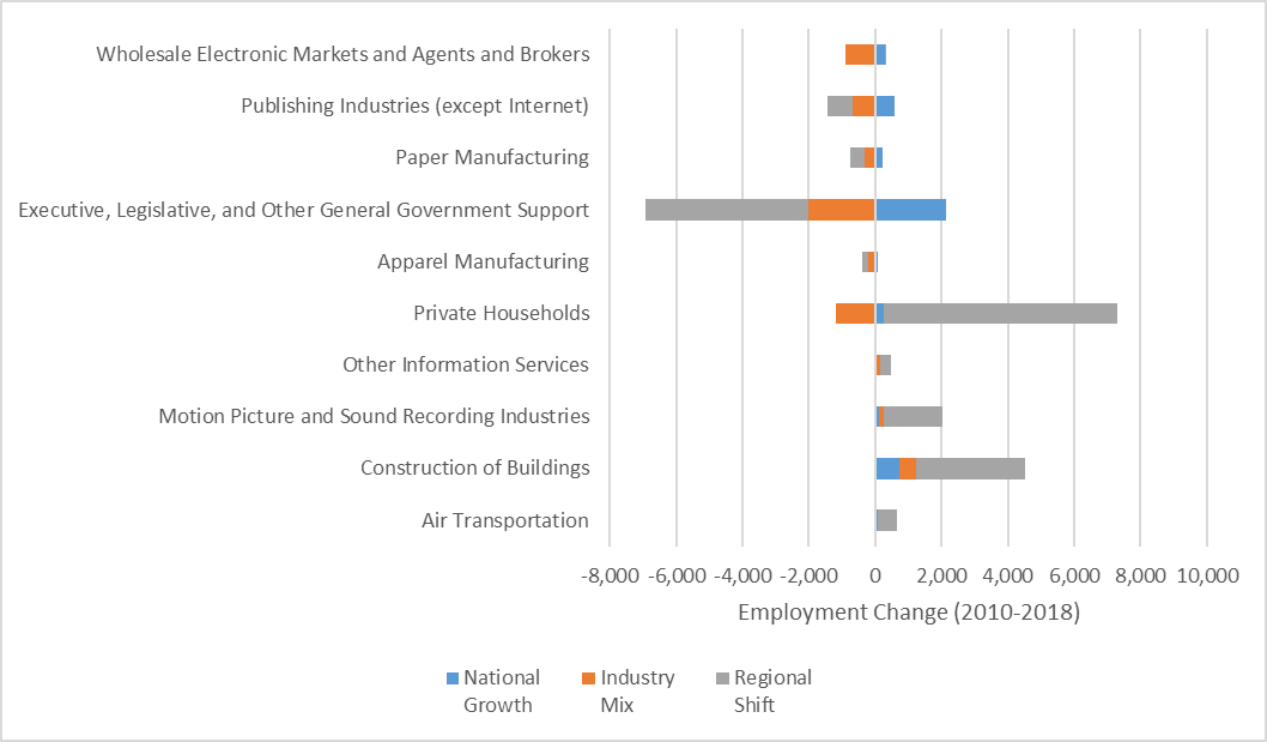
The Air Transportation and Other Information Services subsectors also experienced strong growth during the period. Growth in the Air Transportation subsector was likely drive in part by increased service and passenger travel in Eugene. According to the shift-share analysis, most of the growth in both 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

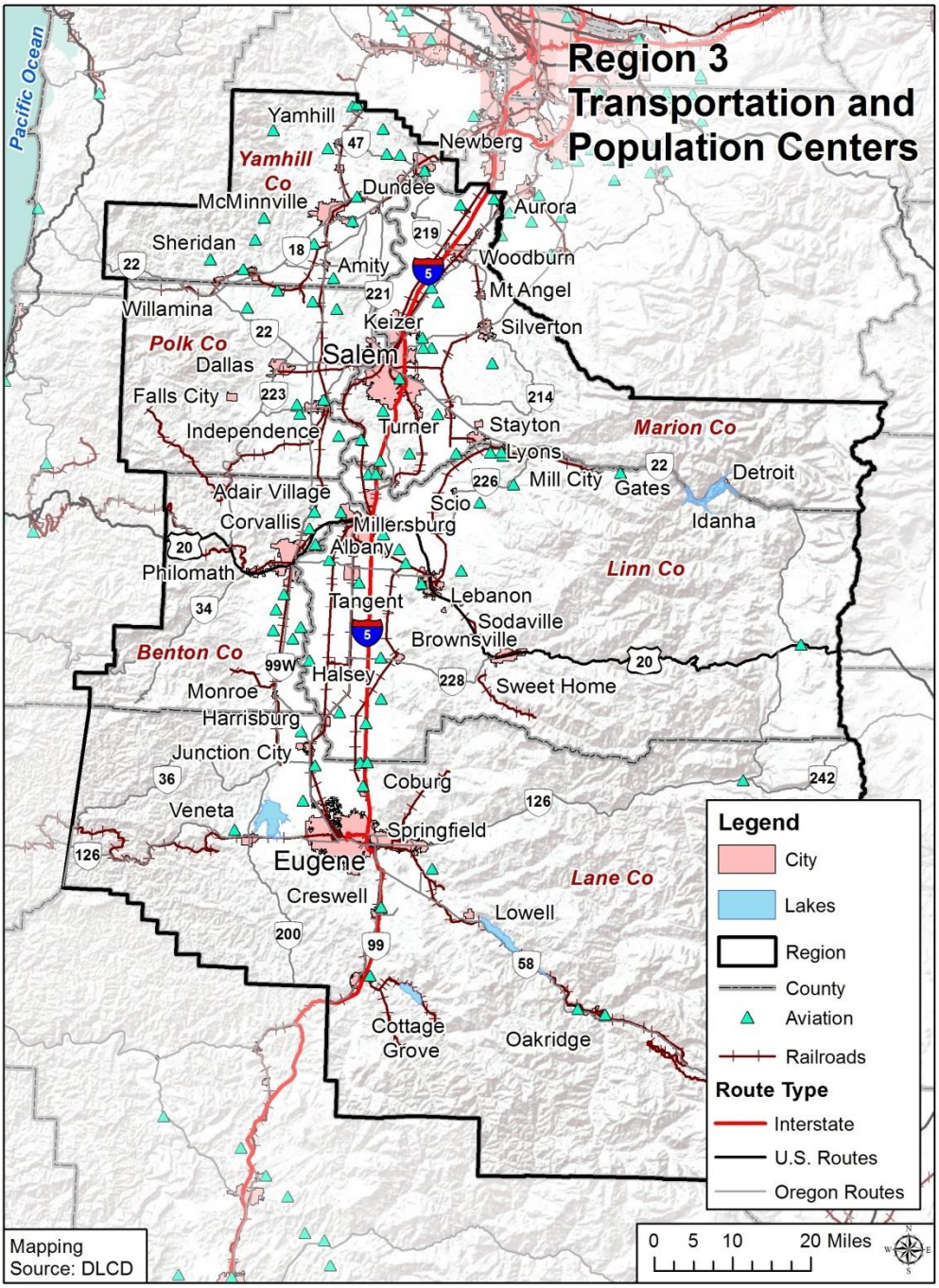
The highway system in the Region 3 centers on I-5 and the major east-west highways that intersect it. Recent population growth in the region has increased the number of vehicles on the roads. Many trips through the region originate outside the region in the Portland Metropolitan Area. Portland drivers 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.

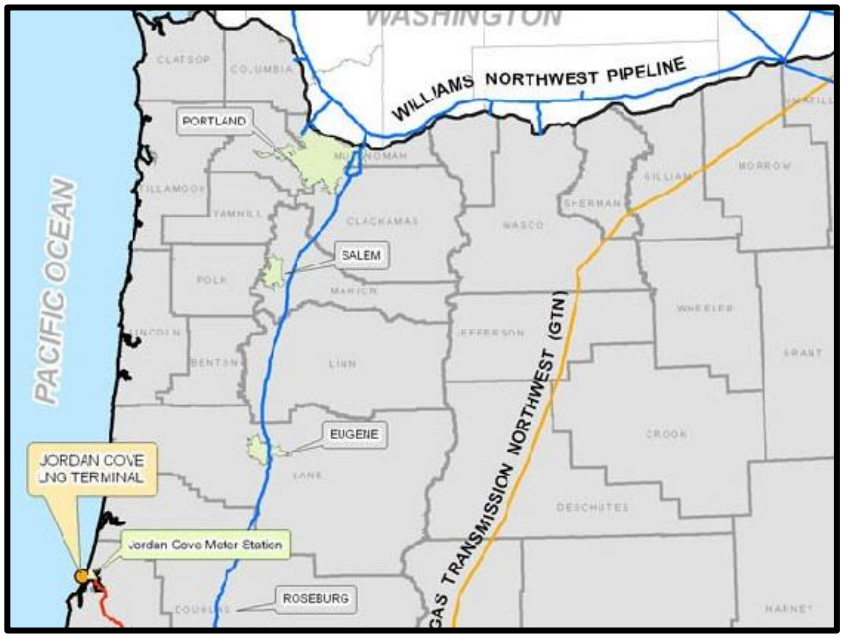
Hydropower

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%

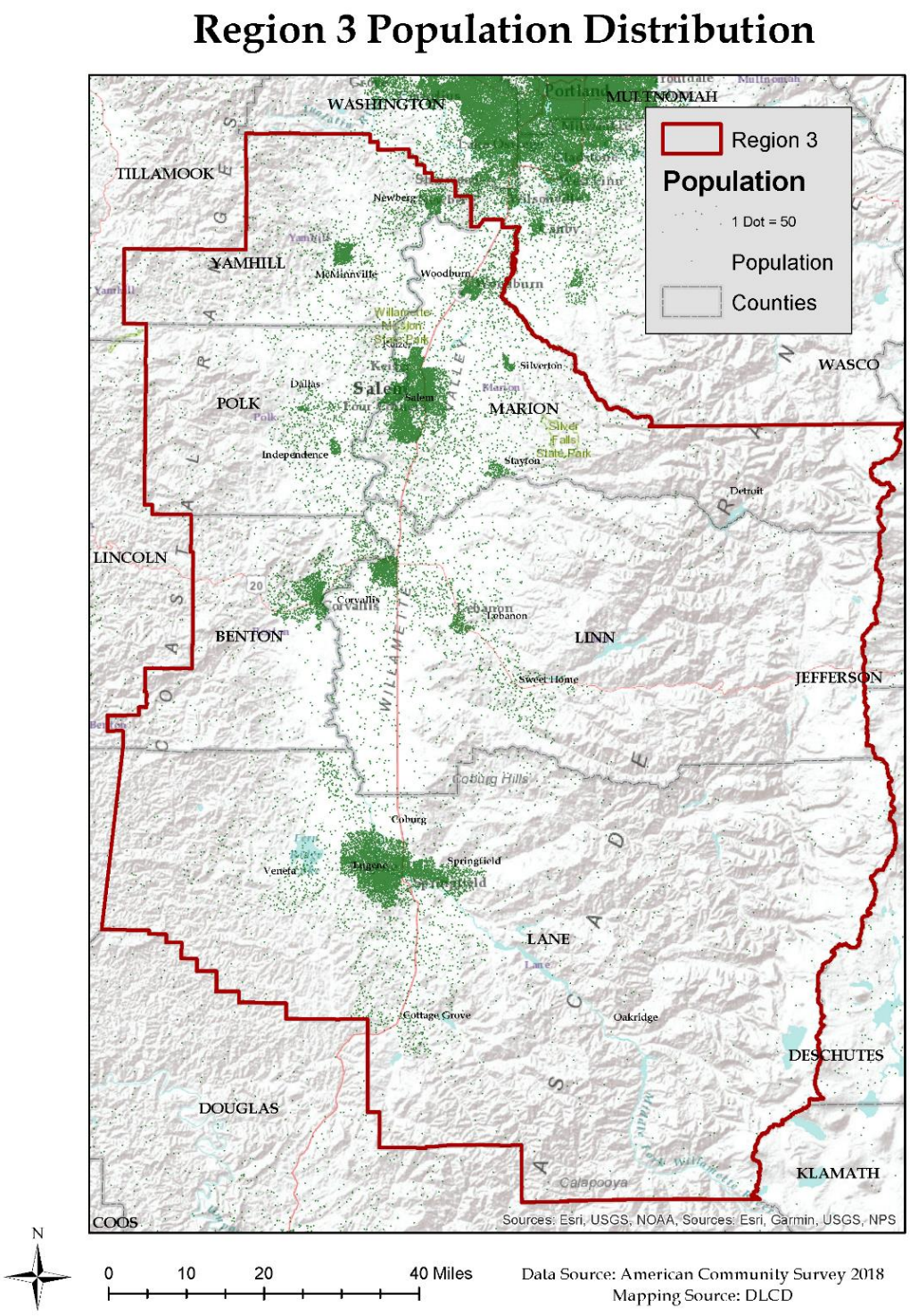
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2

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

	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 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

	Initial FIRM	Current FIRM
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.

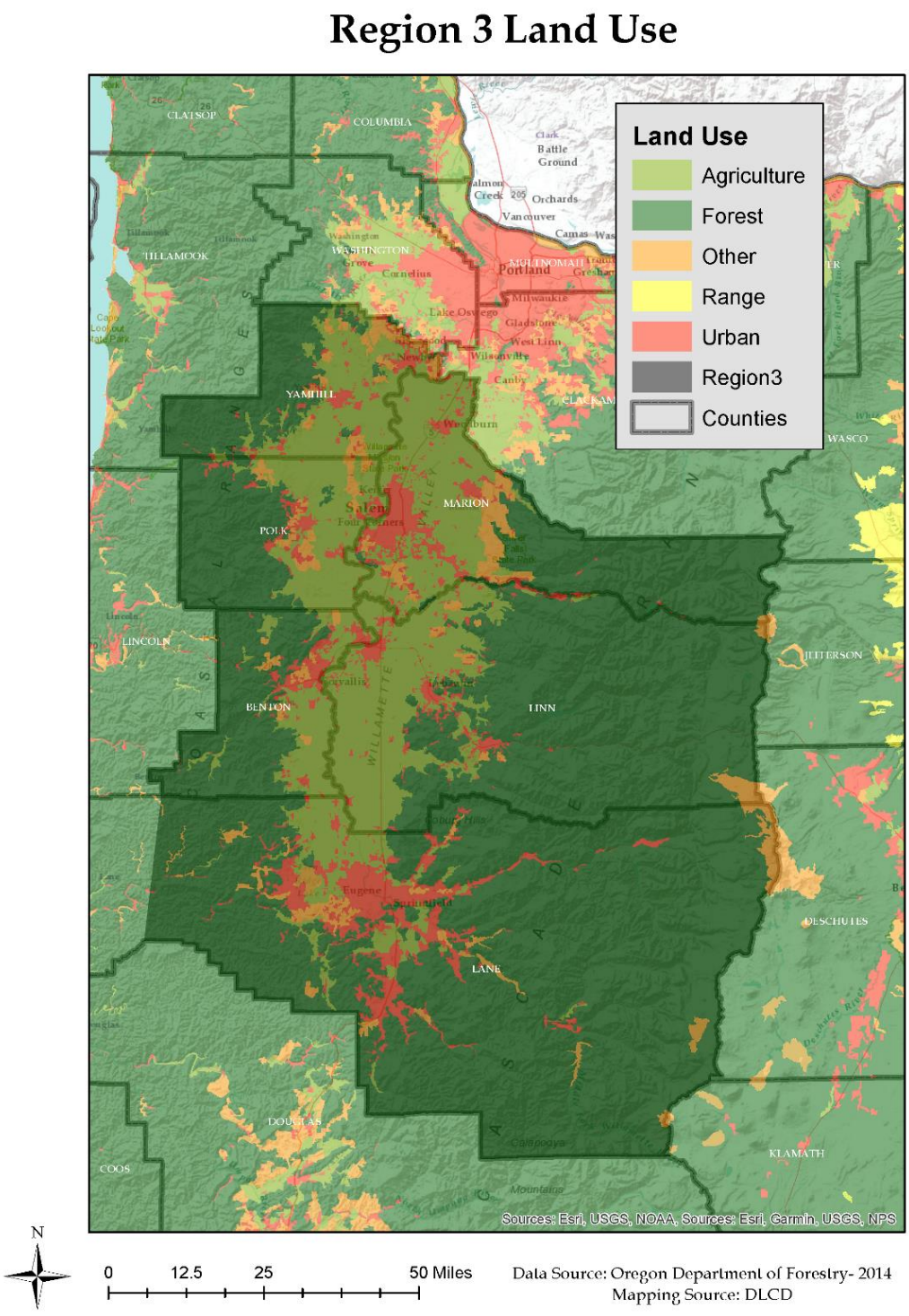
Oregon Department of Forestry data show that in the 25-year period between 1984 and 2009, approximately 147,000 acres of farm and range land in the state transitioned from land use classes more conducive to commercial farm or forest practices into more developed land classes. Almost half of all farm 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.

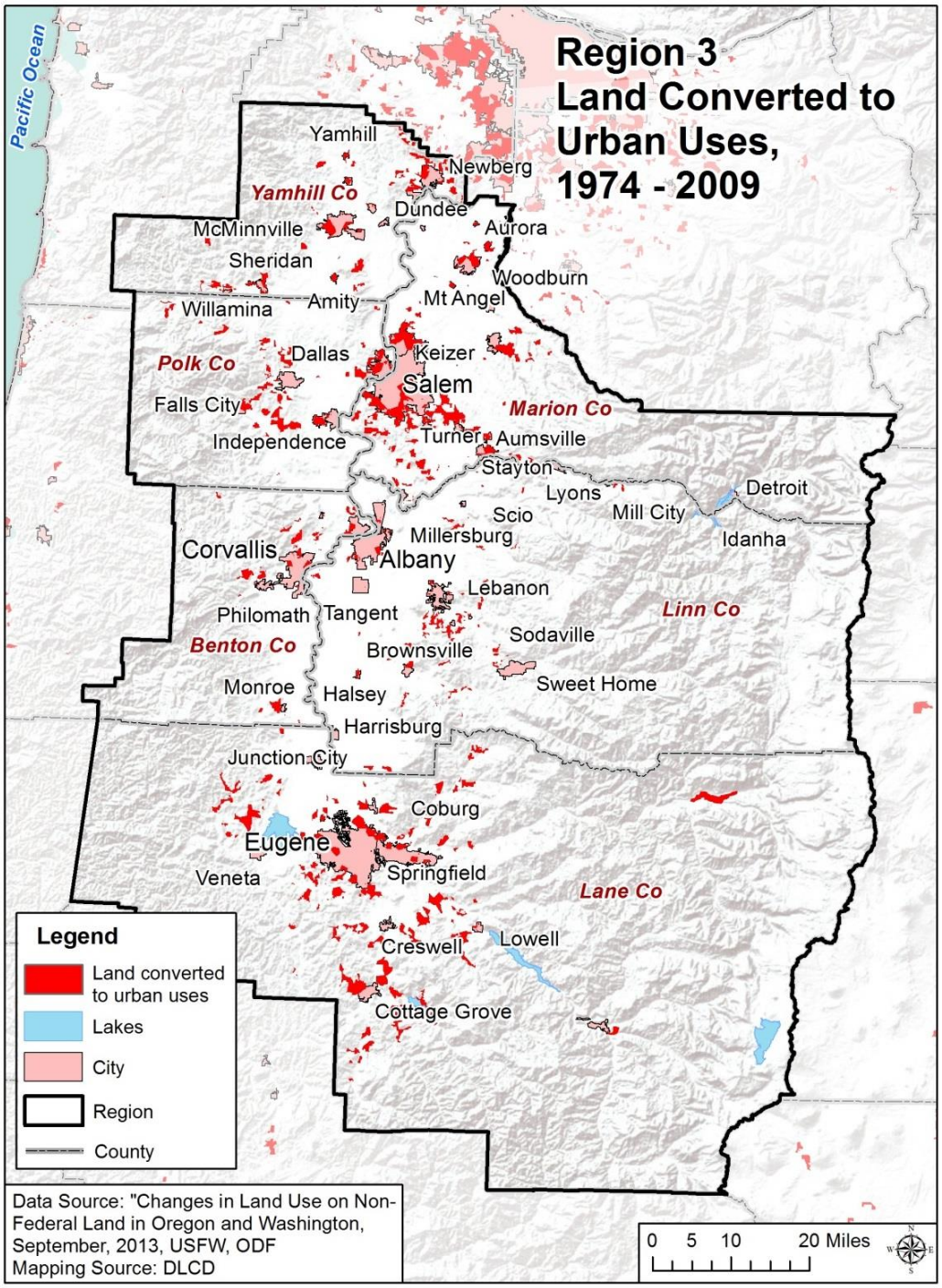
Eugene-Springfield is the third largest metropolitan area in Oregon, but expansion options are restricted by potential landslide and flood hazard areas. These communities are doing what they can to accommodate growth inside existing UGBs while minimizing encroachment into known hazard areas. One strategy 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

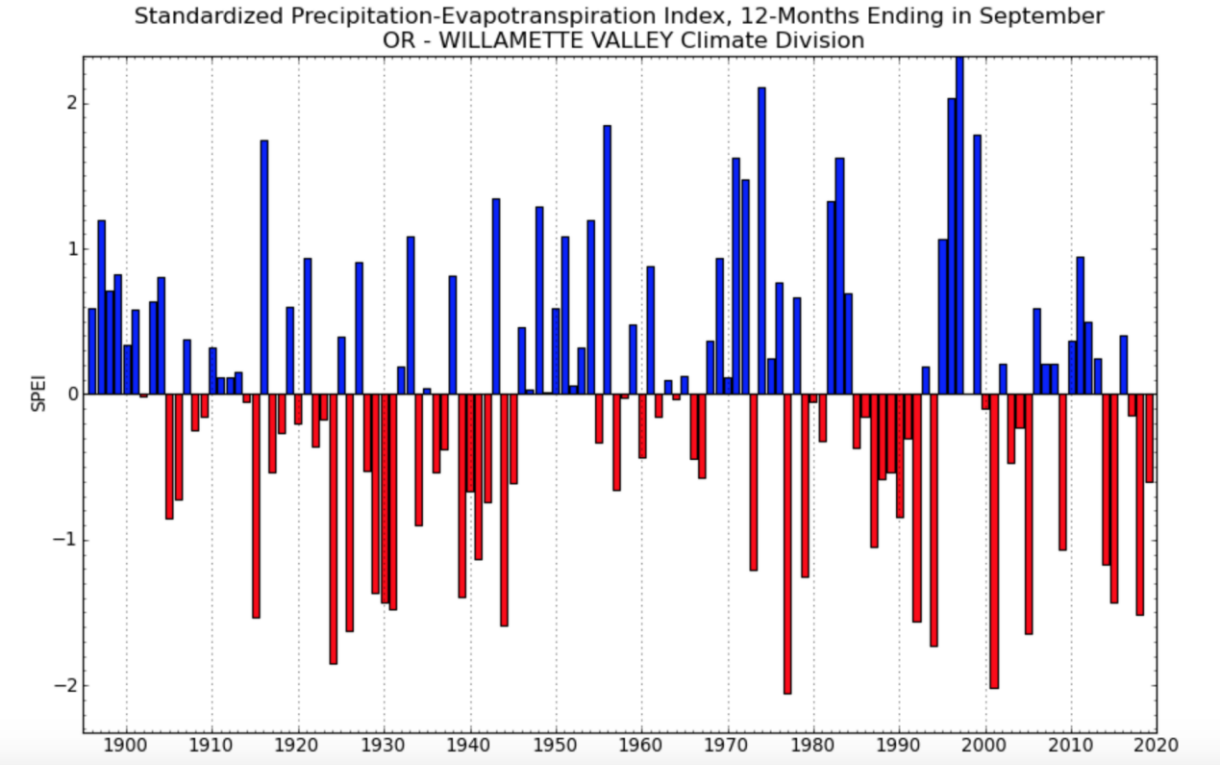
Date	Location	Description
1923-1924	statewide	prolonged statewide drought that caused major problems for agriculture
1928-1930	Regions 1–3, 5–7	moderate to severe drought affected much of the state; the worst years in Region 2 were 1928–1930, which initiated an era of many drier than normal years
1938-1939	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

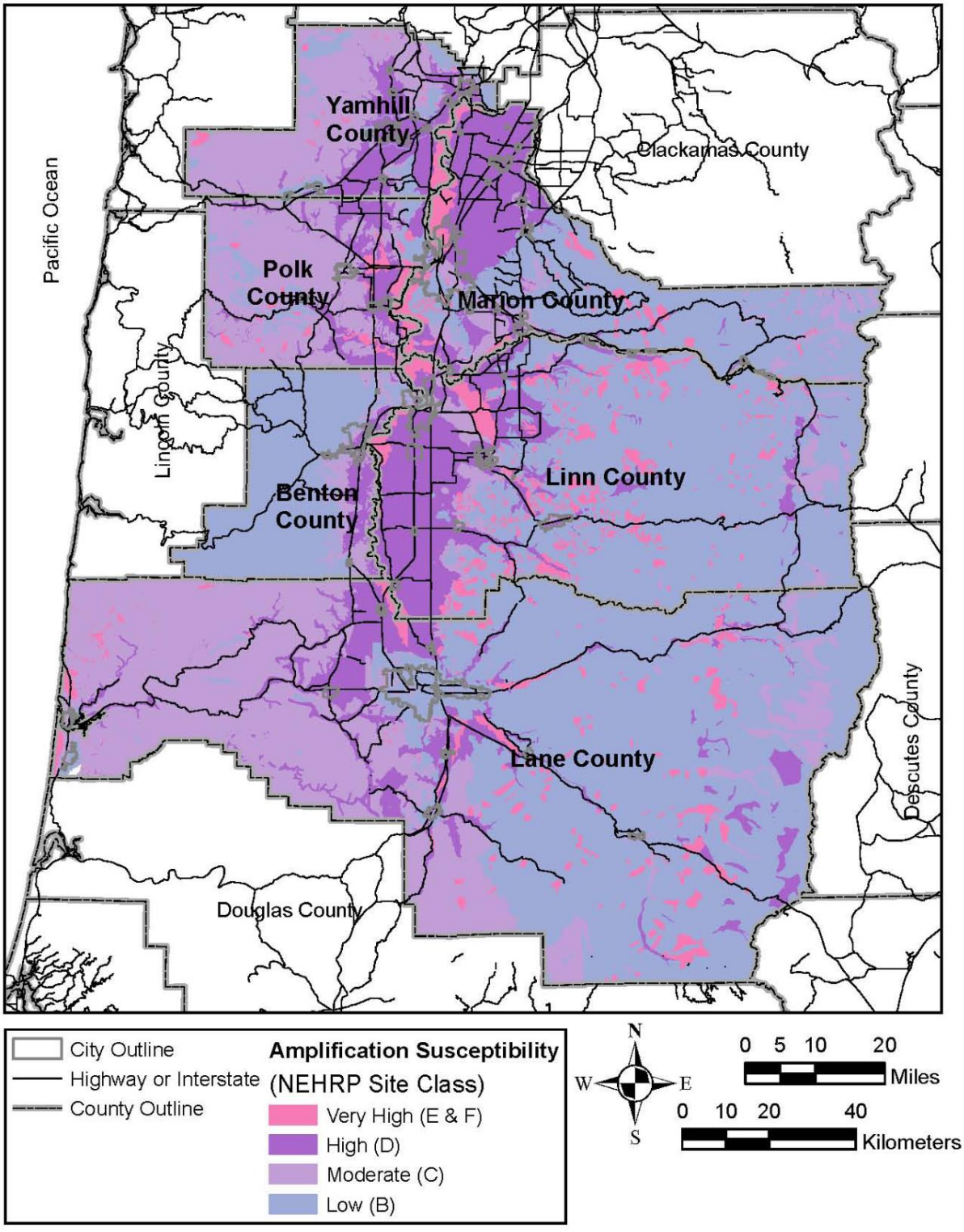
The geographic position of Region 3 makes it susceptible to earthquakes from four sources: (a) the off-shore Cascadia Fault Zone, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) shallow crustal events within the North America Plate, and (d) earthquakes associated with renewed 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.

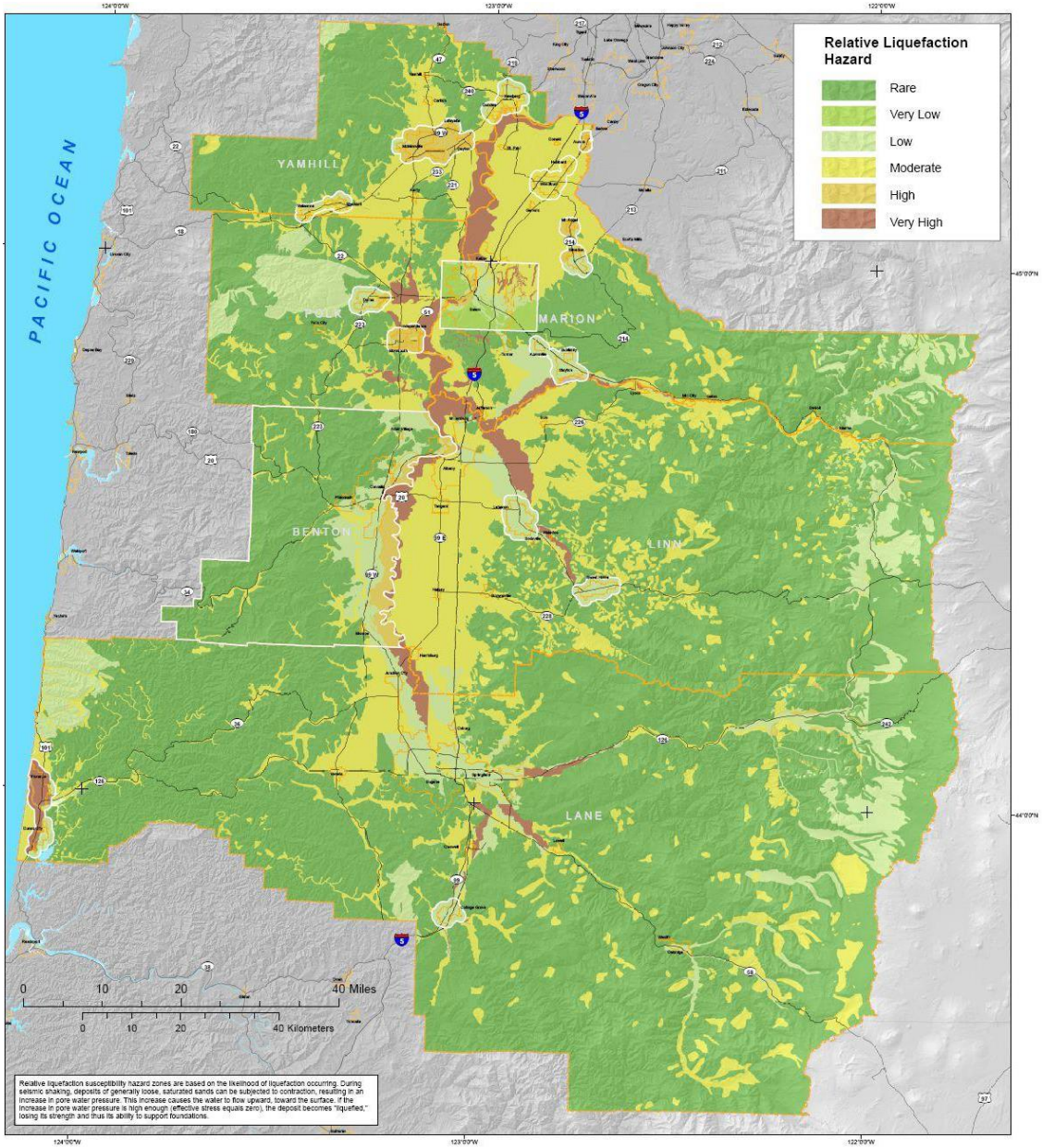
Figure 2-179. Amplification Susceptibility for Region 3



Source: Burns, et al. (2008)

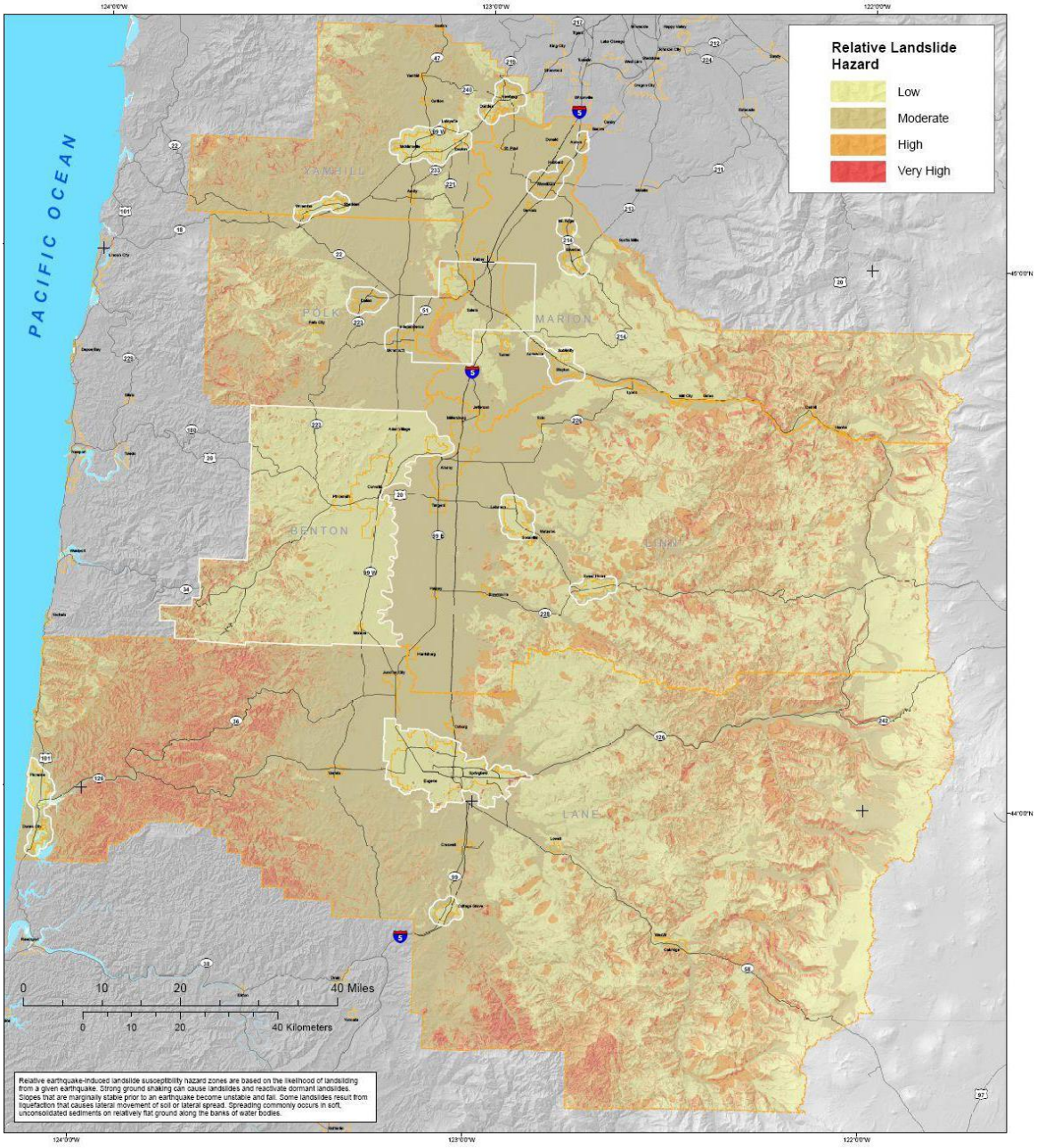
During seismic shaking, deposits of loose saturated sands can be subjected to contraction resulting in an increase in pore water pressure. If the increase in pore water pressure is high enough, the deposit becomes "liquefied," losing its strength and thus its ability to hold and support loads. **Figure 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

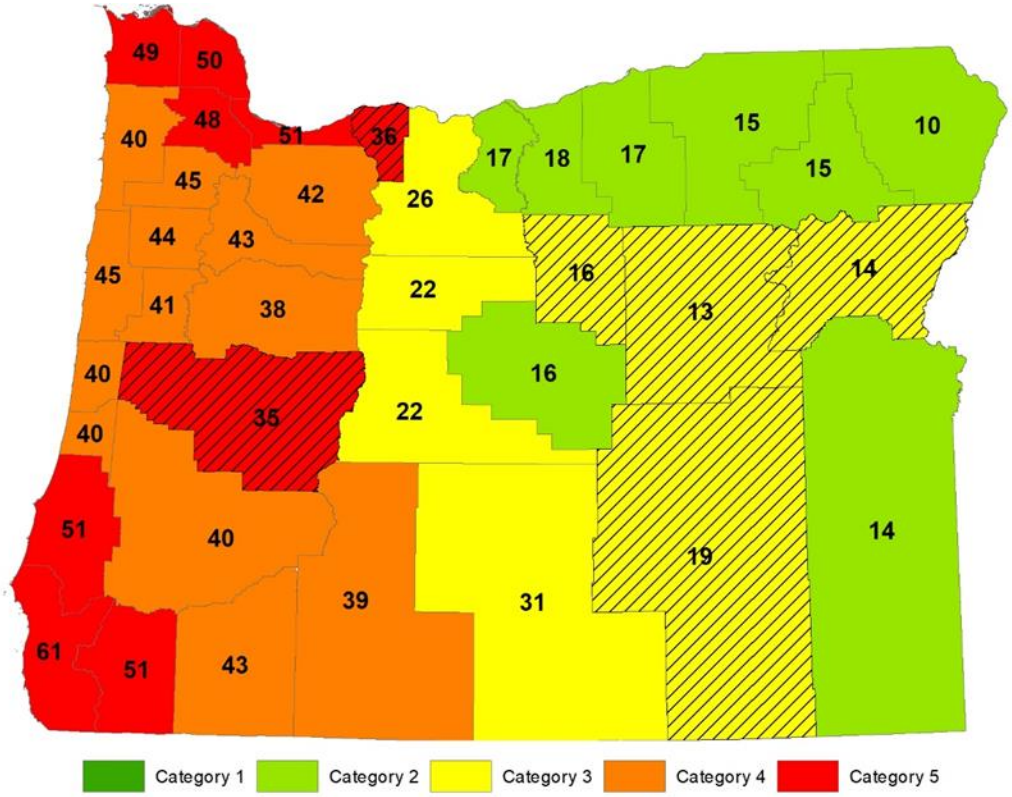
The probability of damaging earthquakes varies widely across the state. In Region 3 the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well-understood recurrence history.

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)

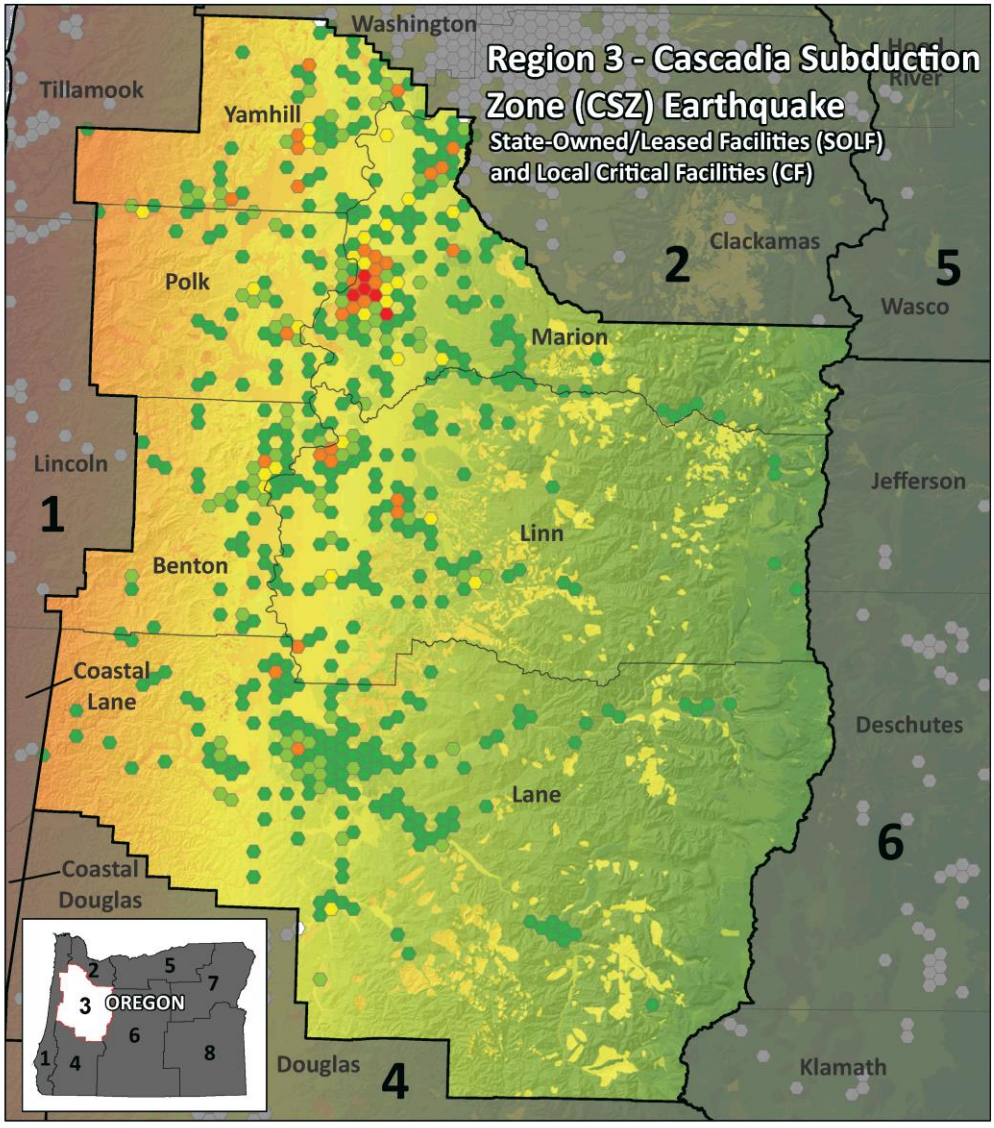
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

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

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.

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.*

0 10 20 40 Miles

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 house-less.

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: Marys River Newton Creek Mill Race Frazier Creek Soap Creek Oak Creek Jackson Creek	Willamette River and tributaries, especially: Amazon Creek Berkshire Slough Blue River Cedar Creek Coast Fork Dedrick Slough Fall Creek Long Tom River McKenzie River Mohawk River Oxley Slough Row River Salmon Creek Silk Creek	Willamette River and tributaries, especially: Calapooia River Santiam (N and S) Thomas Creek Ames Creek Oak Creek Peters Ditch Truax Creek	Willamette River and tributaries, especially: Santiam River Pudding River Battle Creek Butte Creek Beaver Creek Claggett Creek Croisan Creek Gibson Creek Lake Labish Creek Mill Creek Pringle Creek Senecal Creek Silver Creek Shelton Ditch	Willamette River and tributaries, especially: S. Yamhill River Ash Creek (all forks) Agency Creek Ellendale Creek Gibson Creek Rickreall Creek Rock Creek Rowell Creek	Willamette River and tributaries, especially: Yamhill River Yamhill Creek Baker Creek Chehalem Creek Cozine Creek Hess Creek Palmer Creek

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

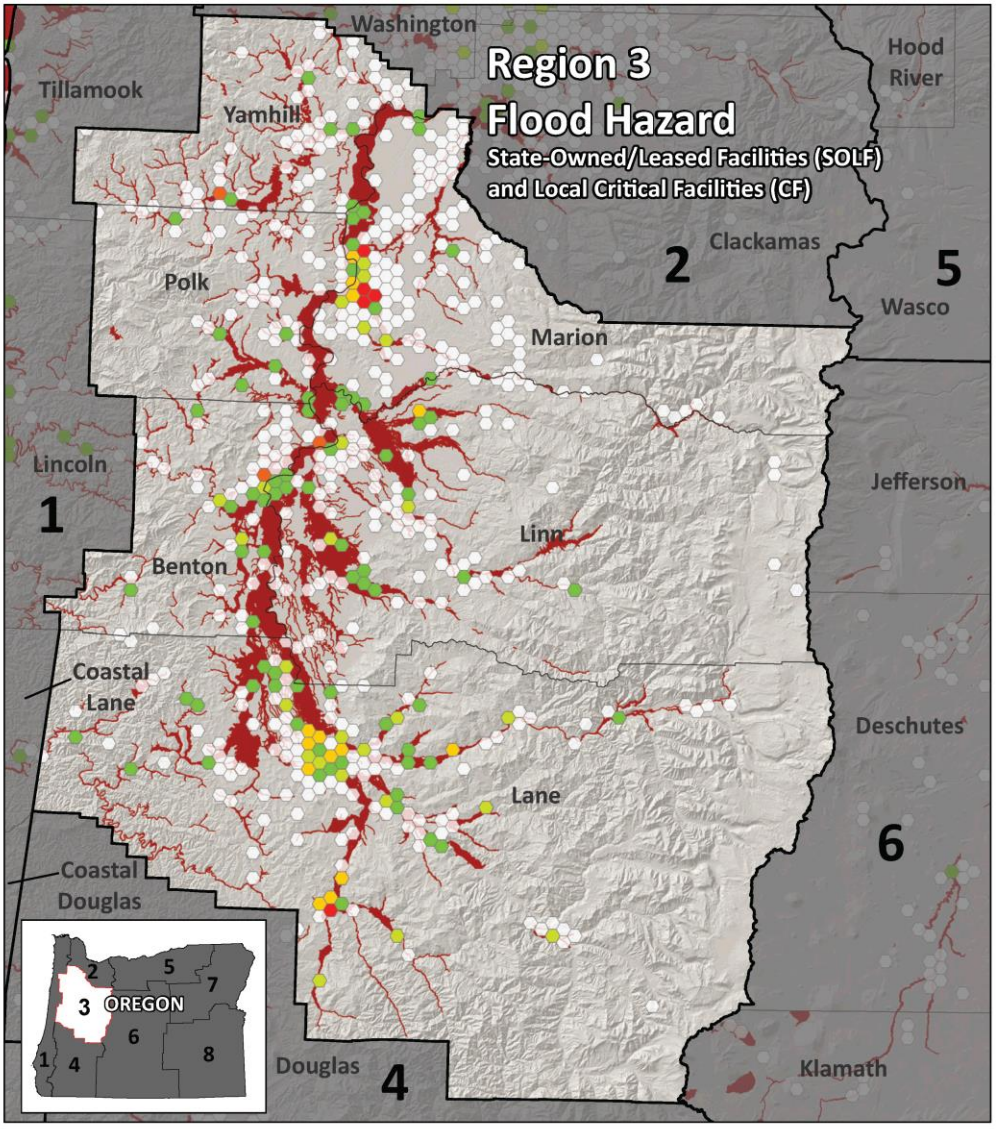
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. Benton, 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

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

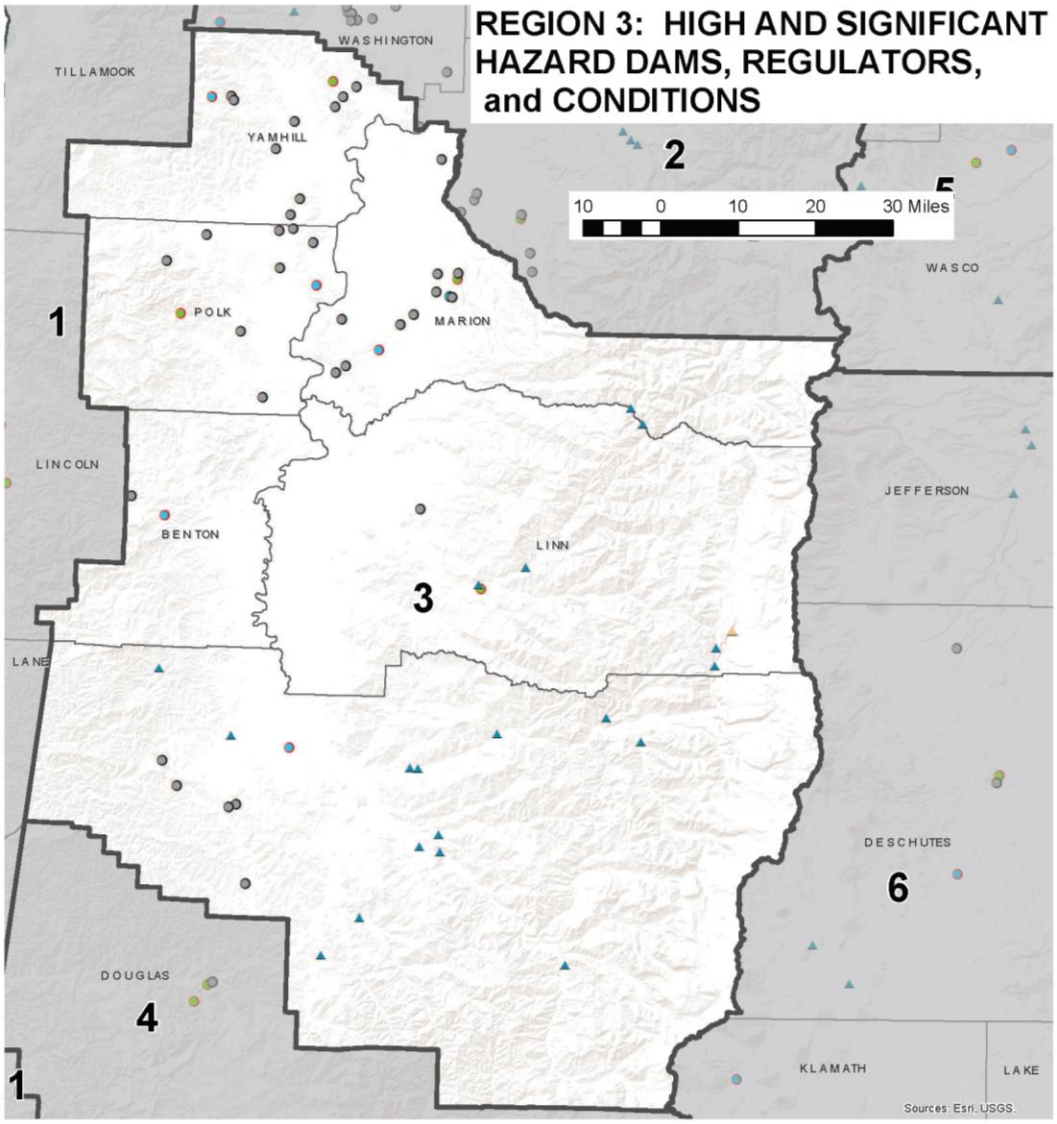
State-Regulated High Hazard Dams not Meeting Safety Standards

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

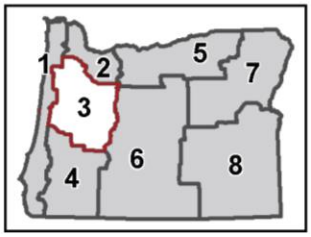
Mitigation Planning Regions
Counties

** - 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

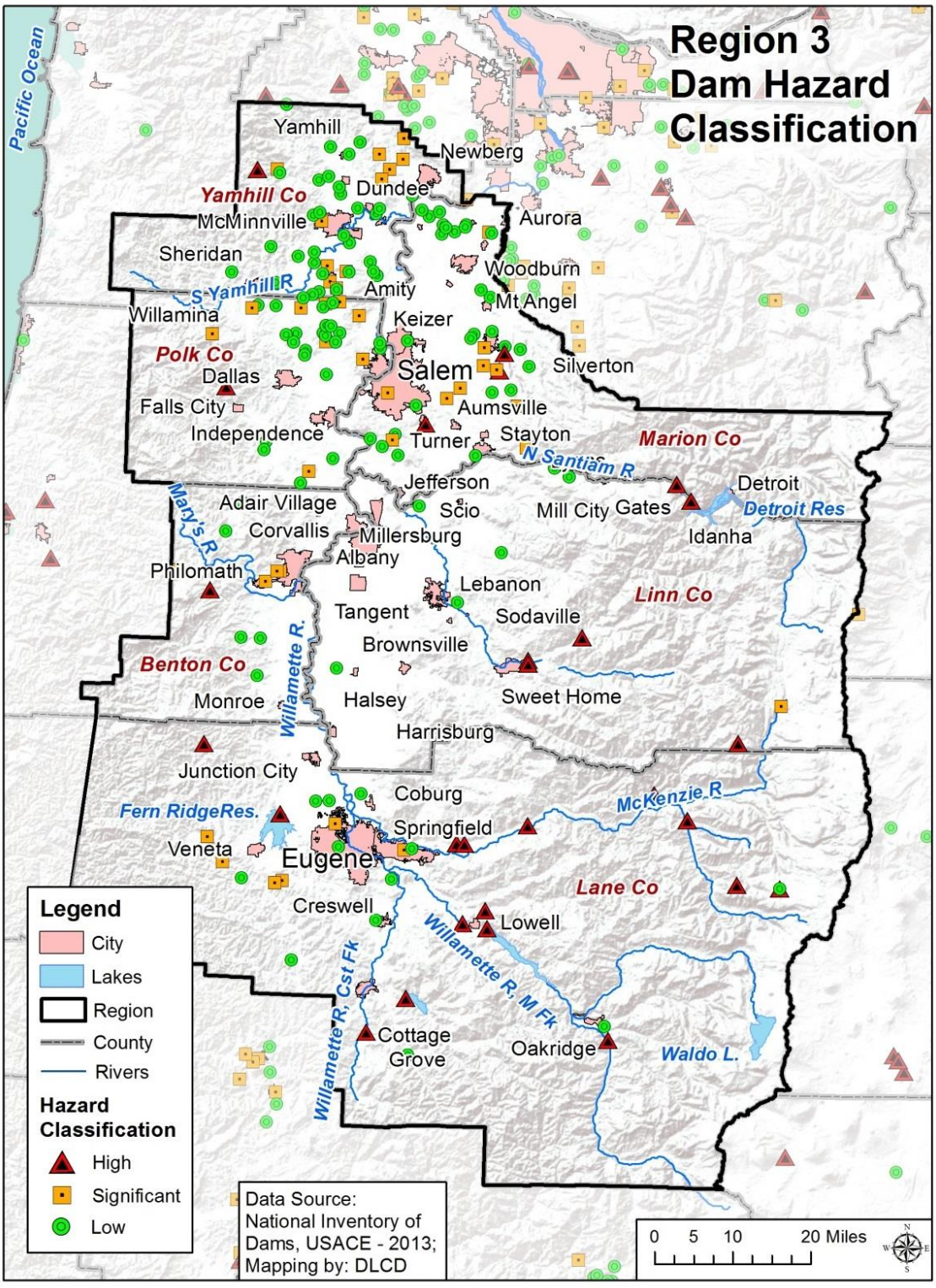
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), no Region 3 counties are considered "most vulnerable 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

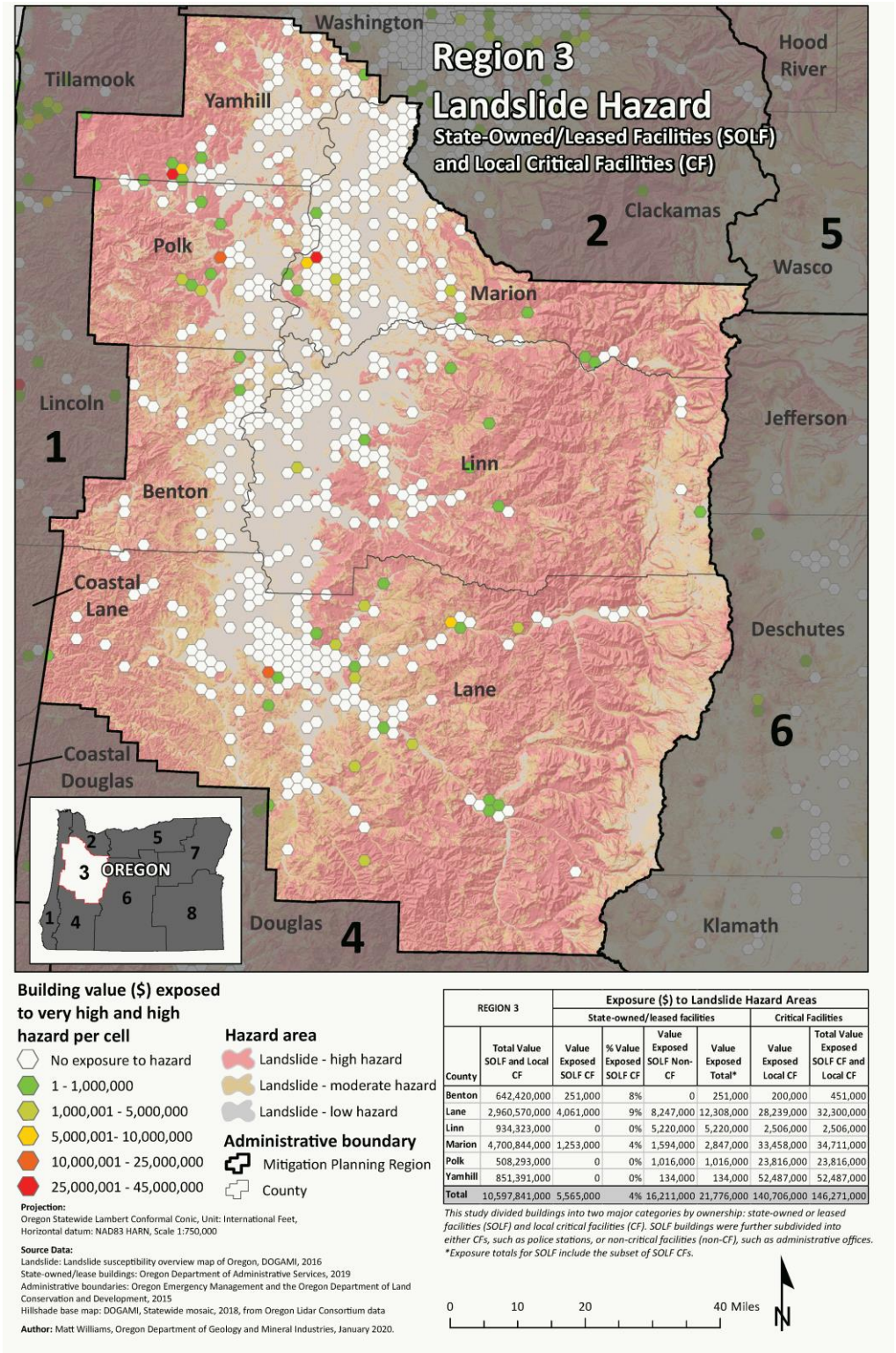
Many of the communities in this region are vulnerable to landslides; for example, the cities of Salem, Corvallis, and Eugene all have moderate exposure to landslides. As previously mentioned, the Vineyard Mountain area near Corvallis had landslides during the January 2009 storm. Many of these landslides 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

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

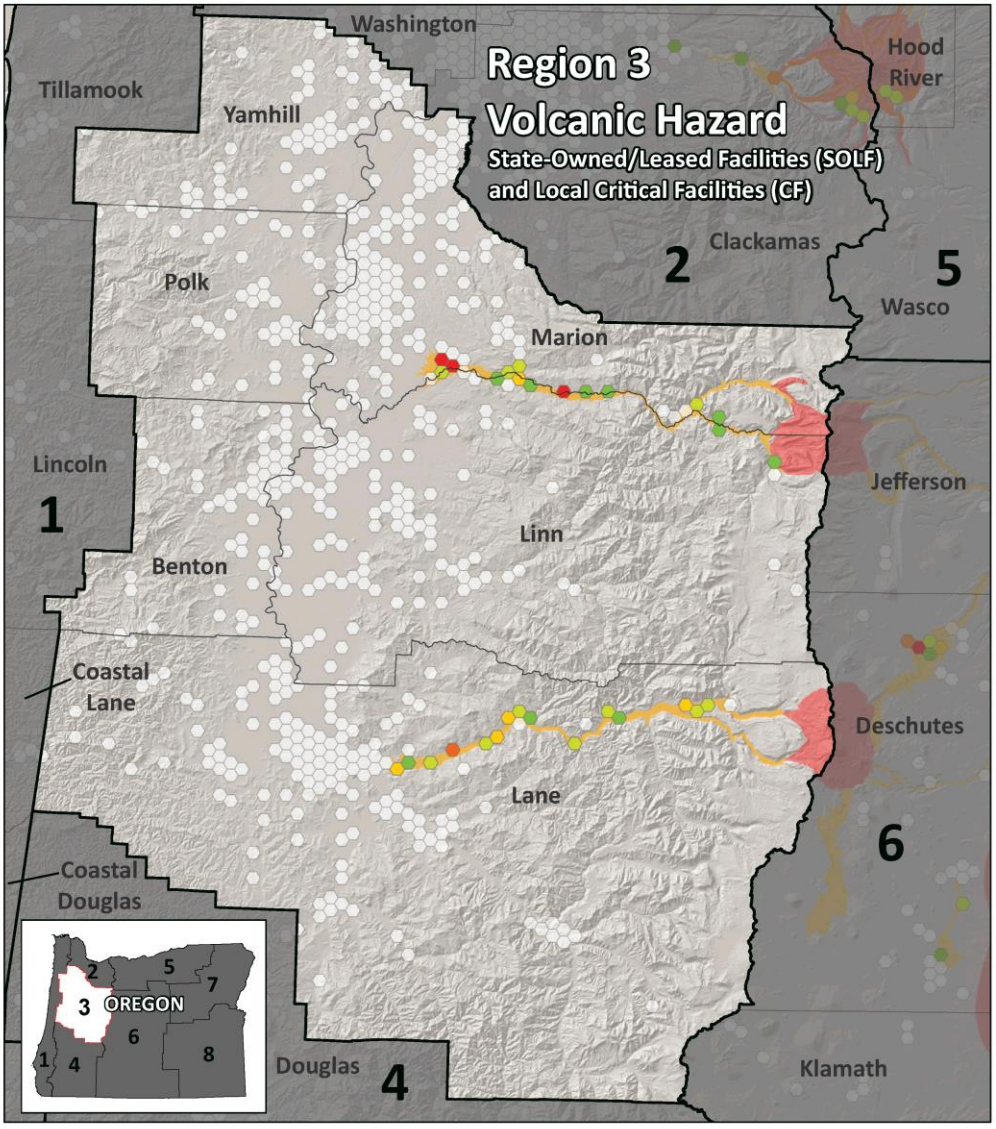
Source: DOGAMI and DLCD, 2020

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.



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.*

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

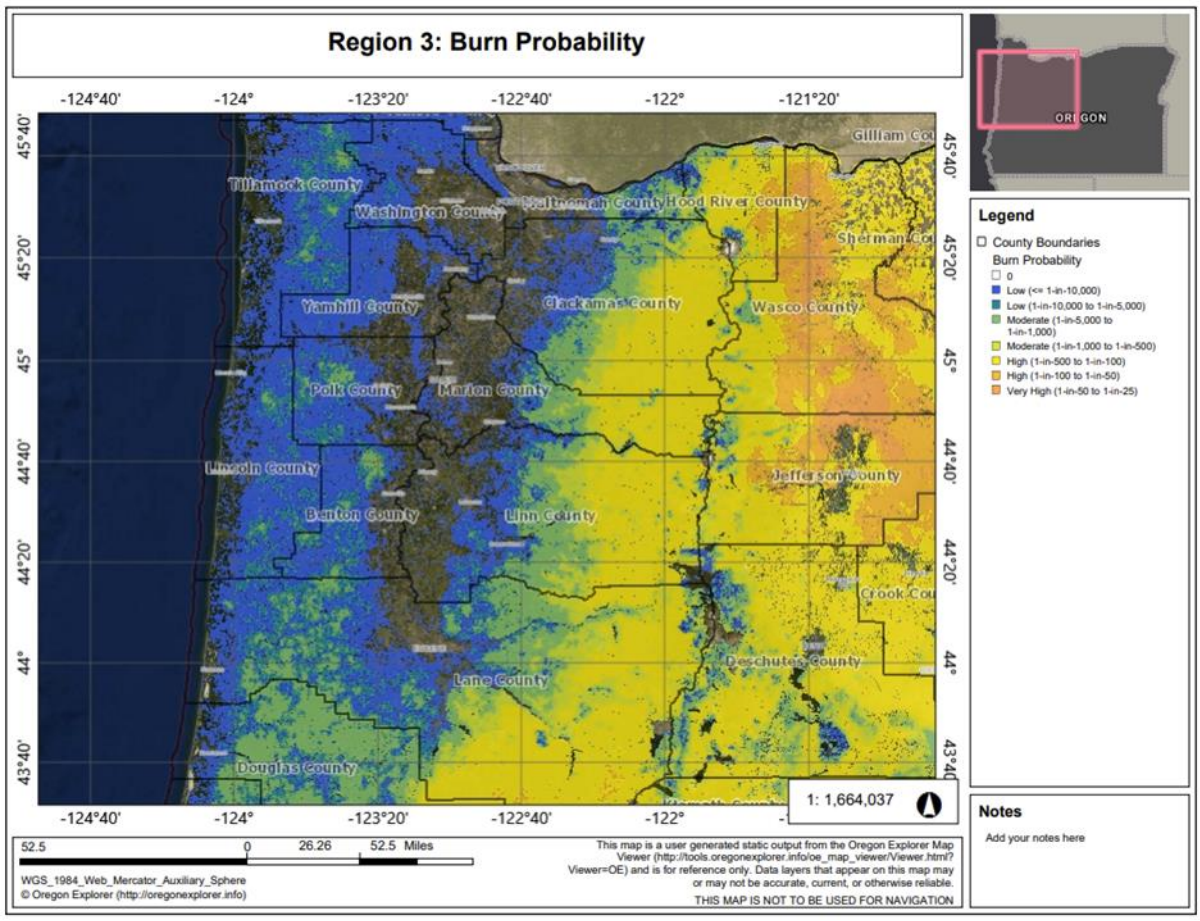
Source: PNW Quantitative Wildfire Risk Assessment and Oregon Wildfire Risk Explorer, 2020

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.

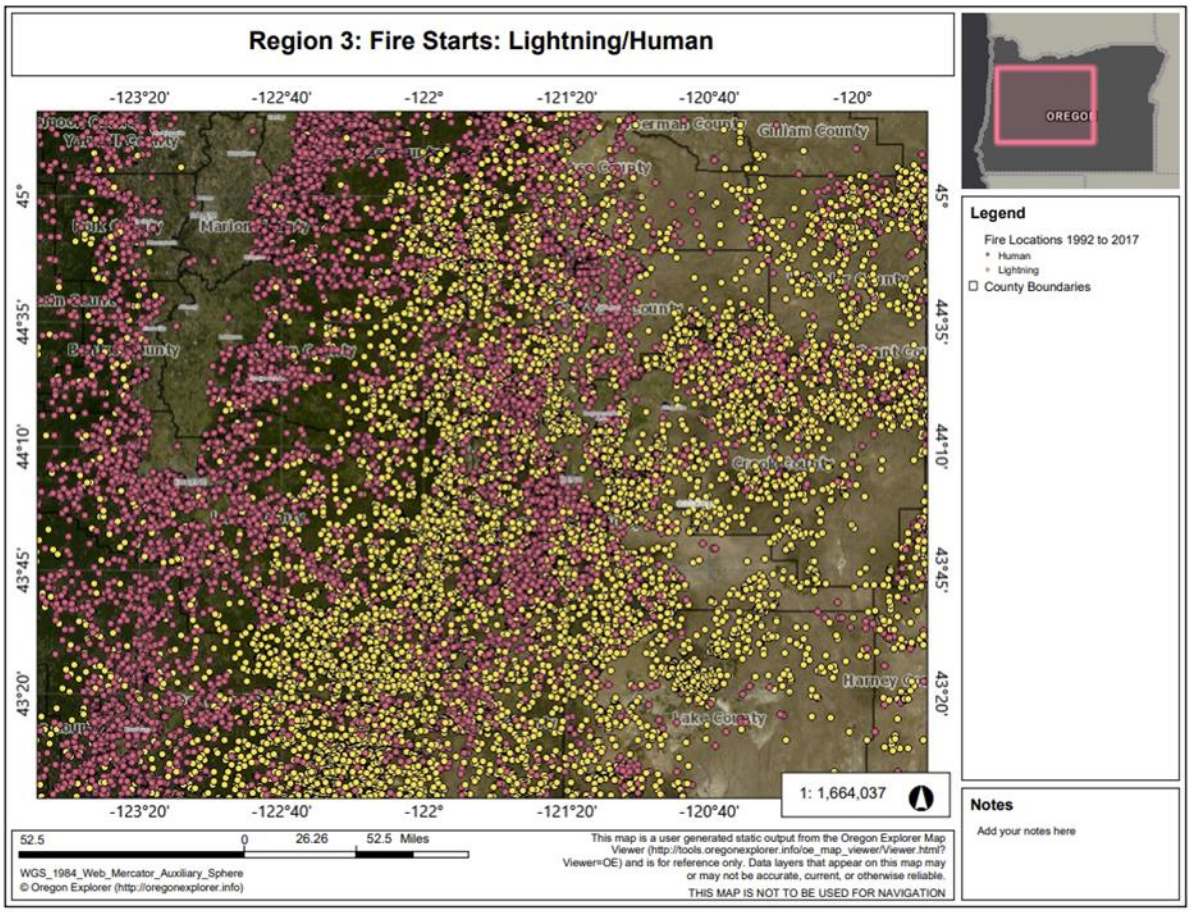
Figure 2-189. Burn Probability



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

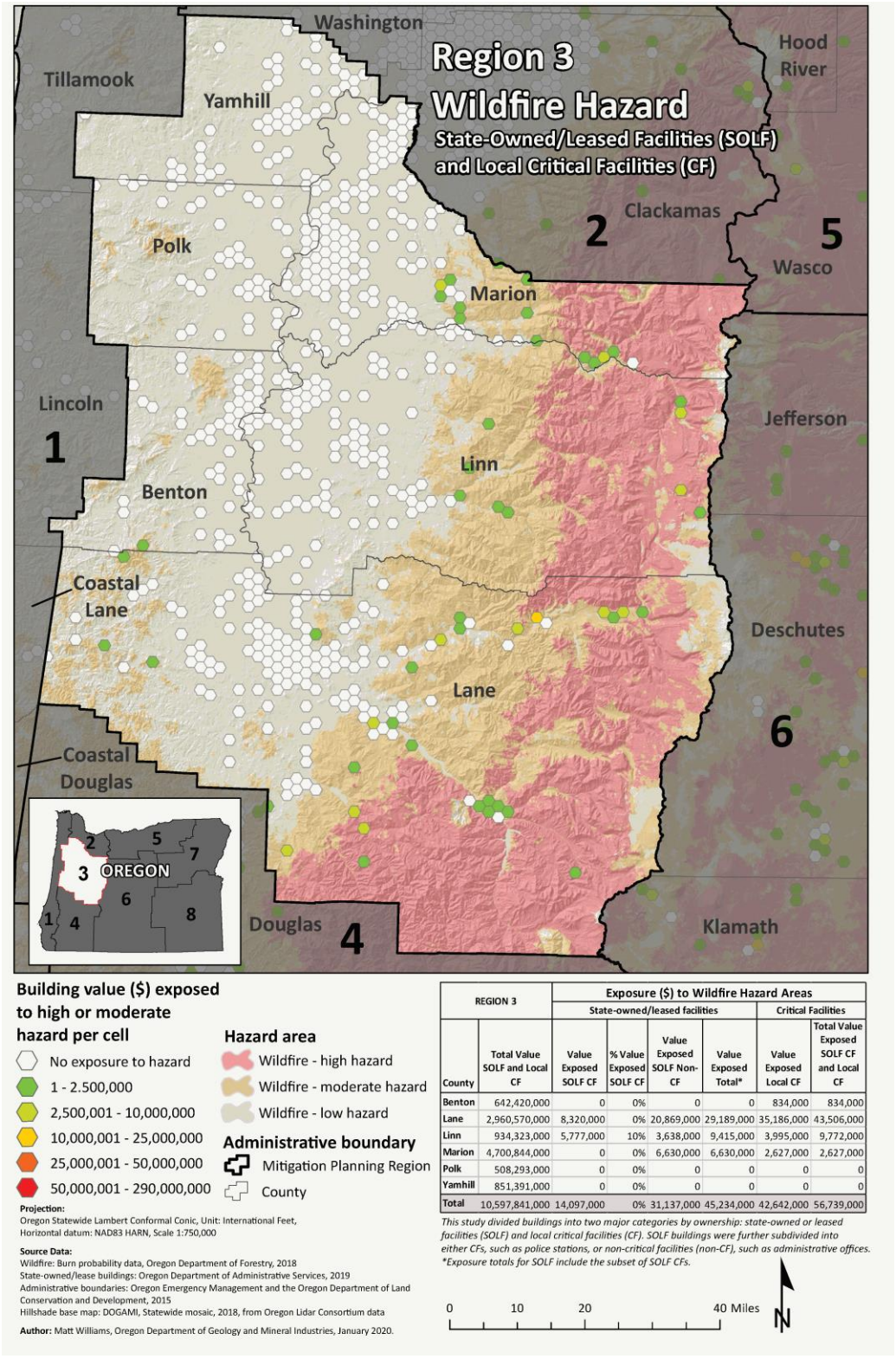
For the 2020 vulnerability assessment, DOGAMI followed ODF guidance and evaluated building exposure to wildfire using the Burn Probability dataset which was classified by ODF in "High," "Moderate," and "Low" categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications 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

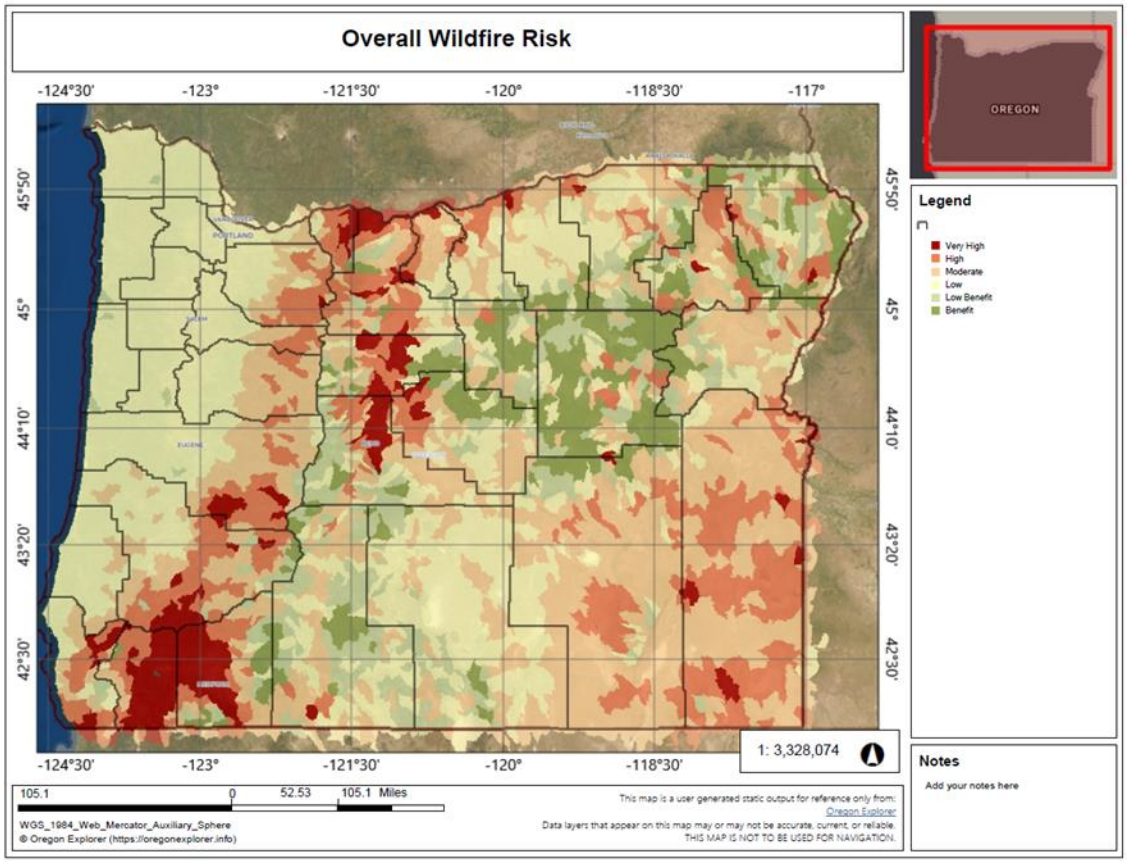
	Benton	Lane	Linn	Marion	Polk	Yamhill
Risk	VL	M	M	M	VL	M

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

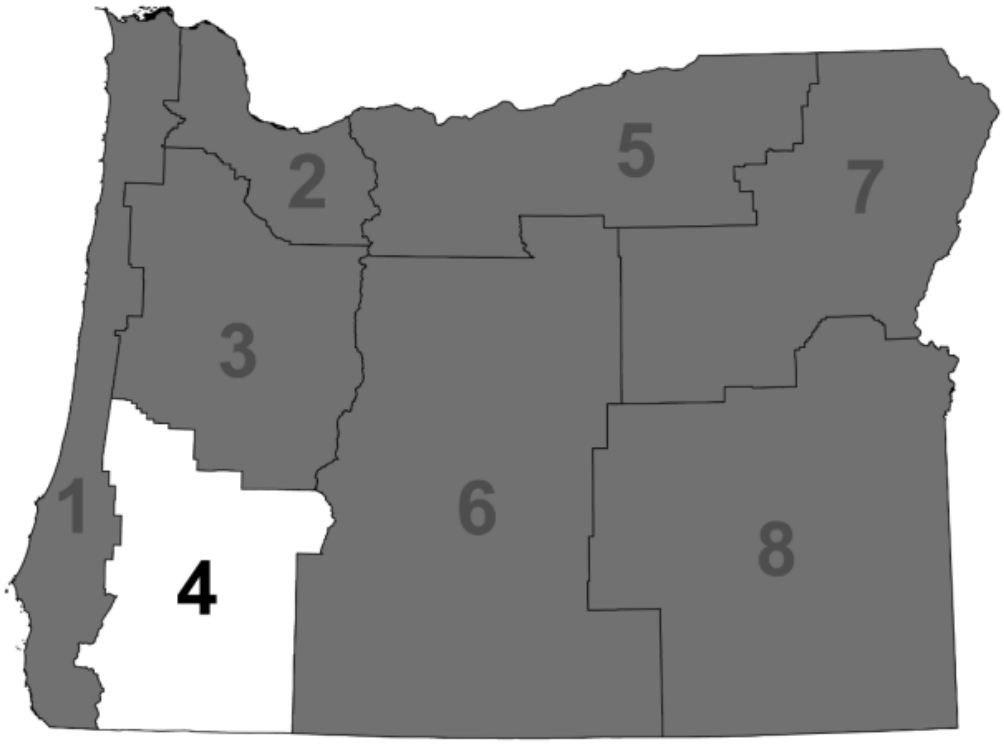
With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life.



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

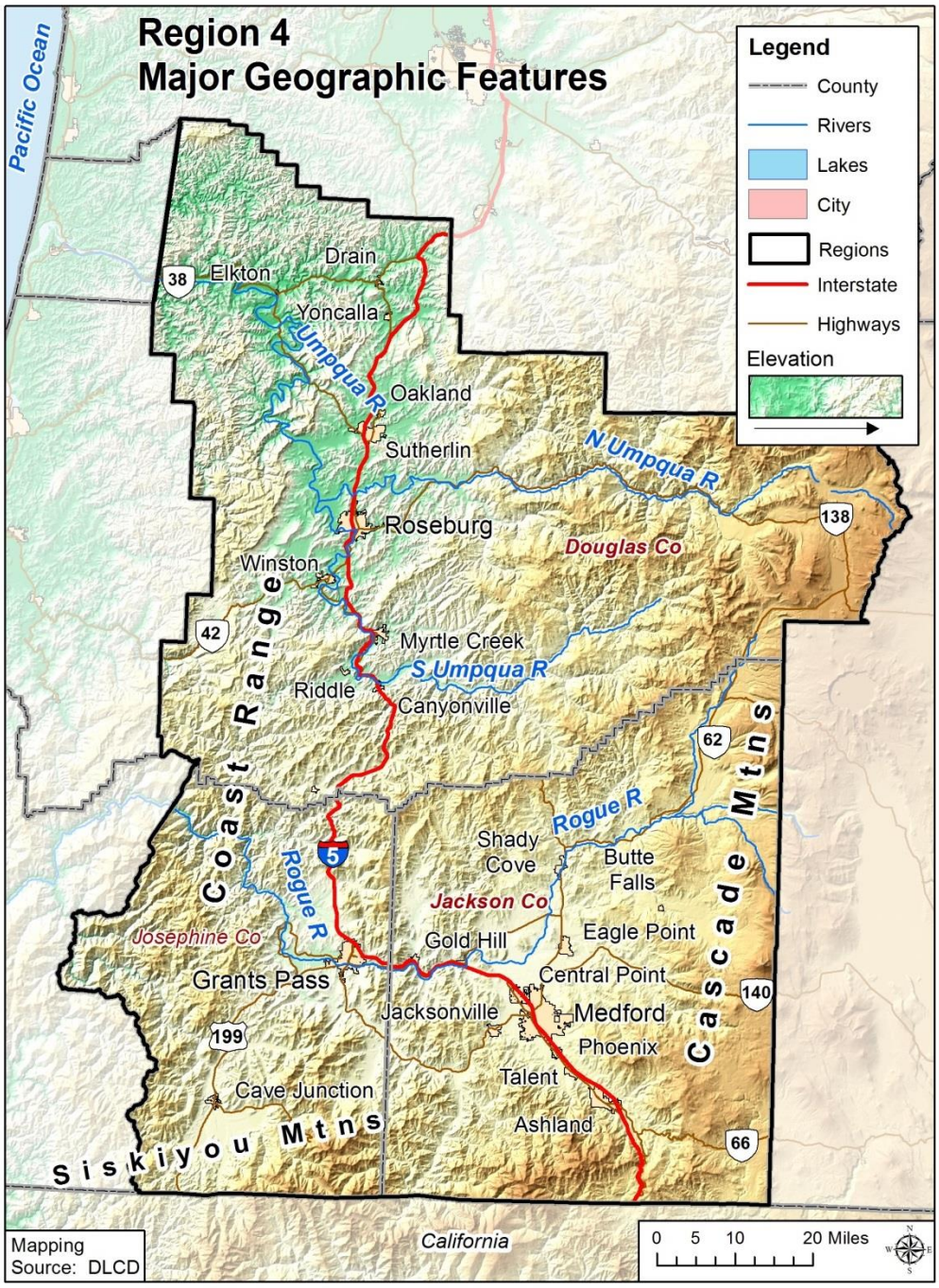
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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).

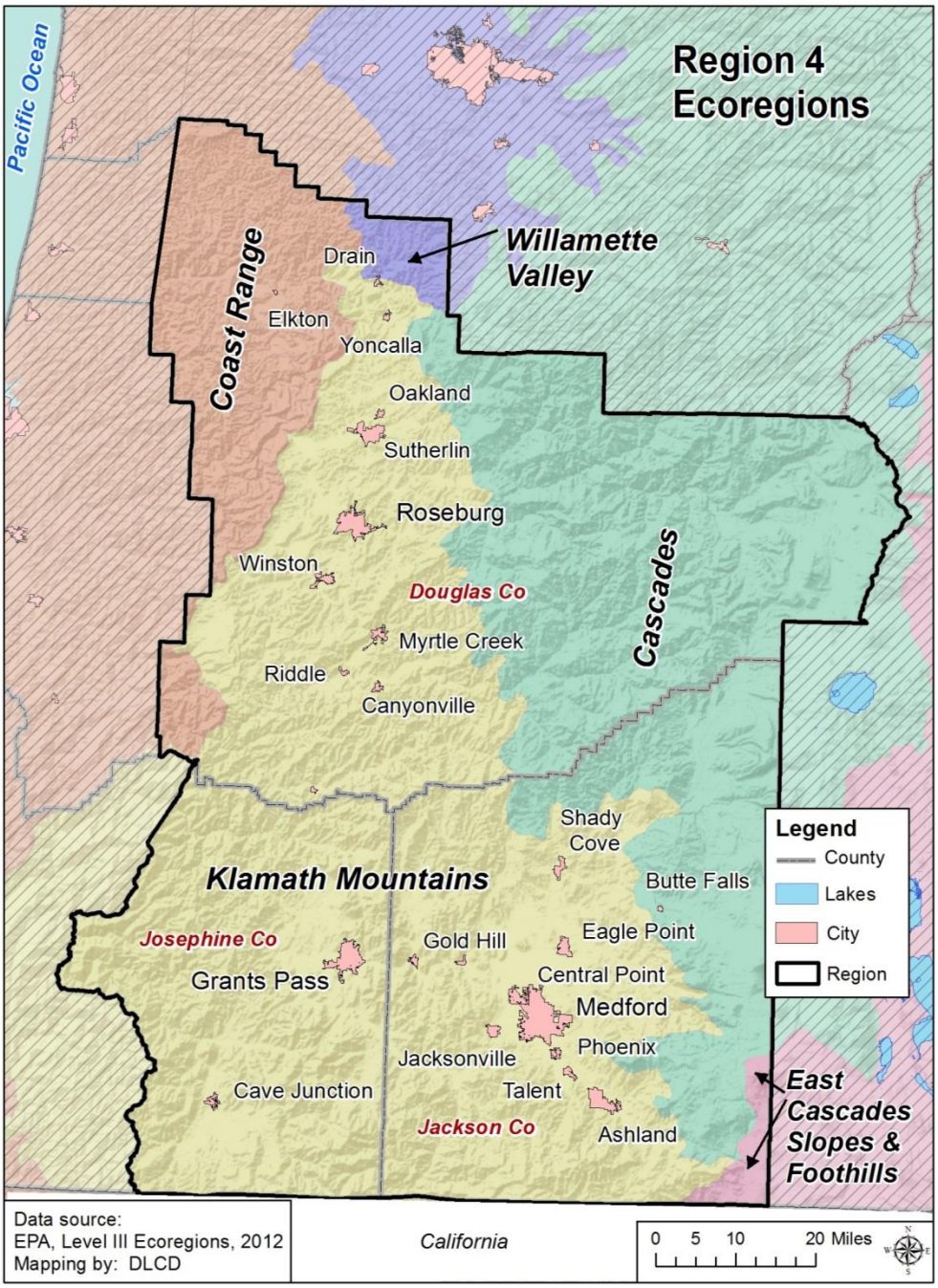
Figure 2-193. Region 4 Major Geographic Features



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%

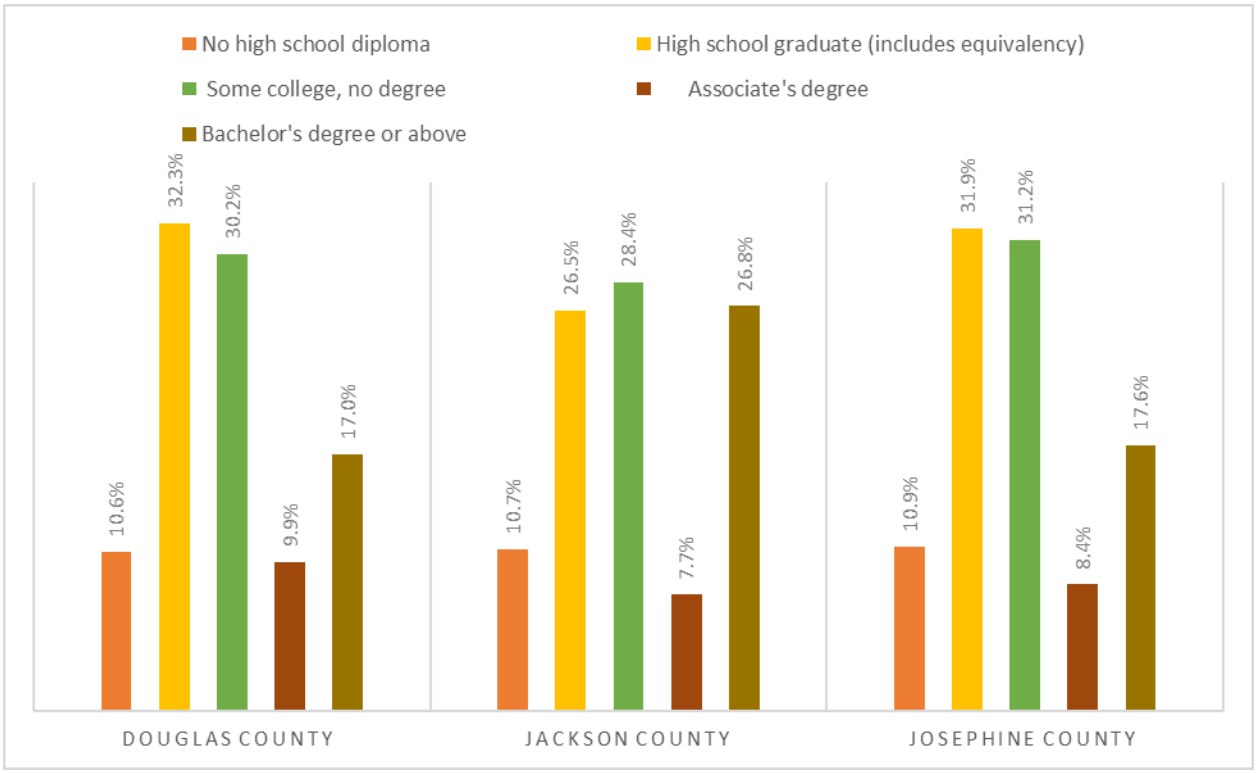
Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

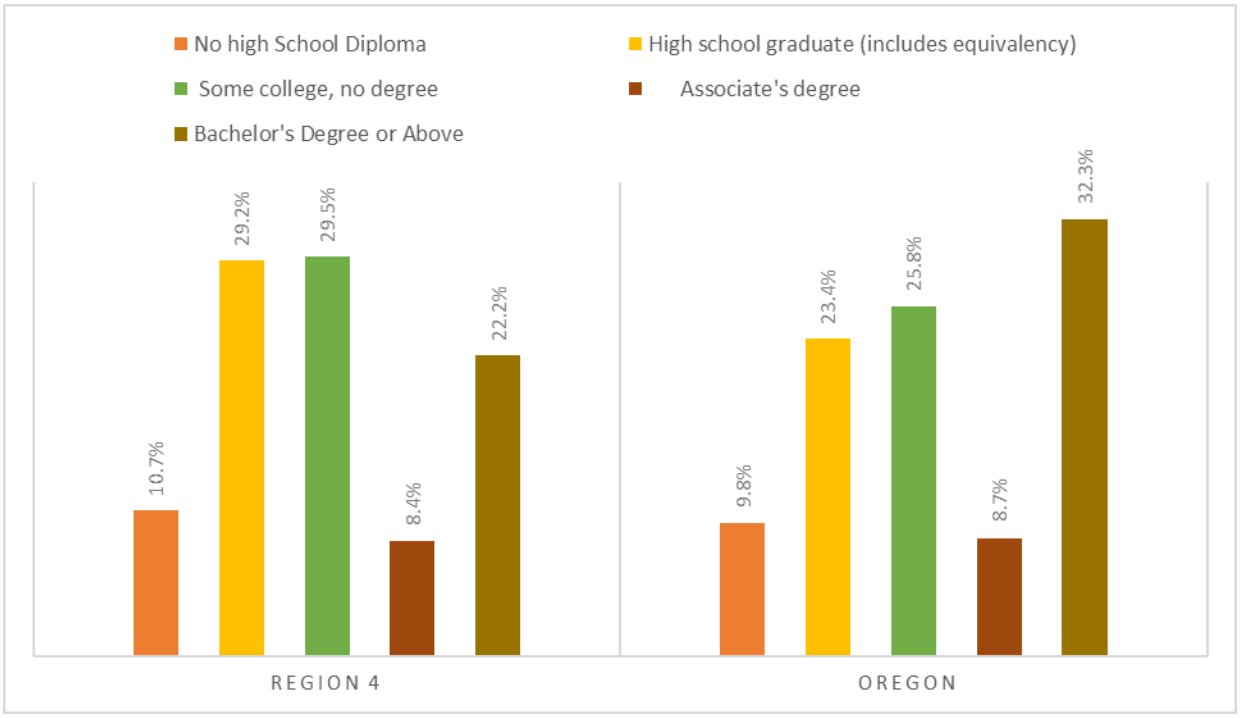
Education Level

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.

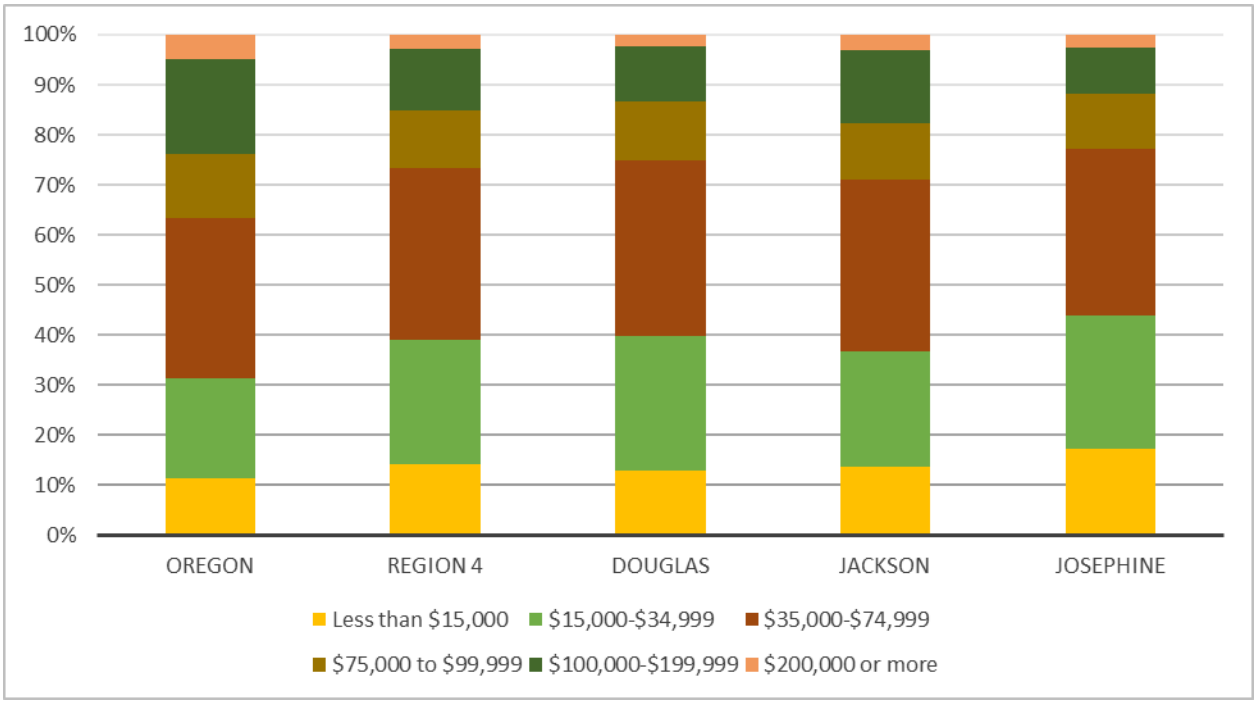
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**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.

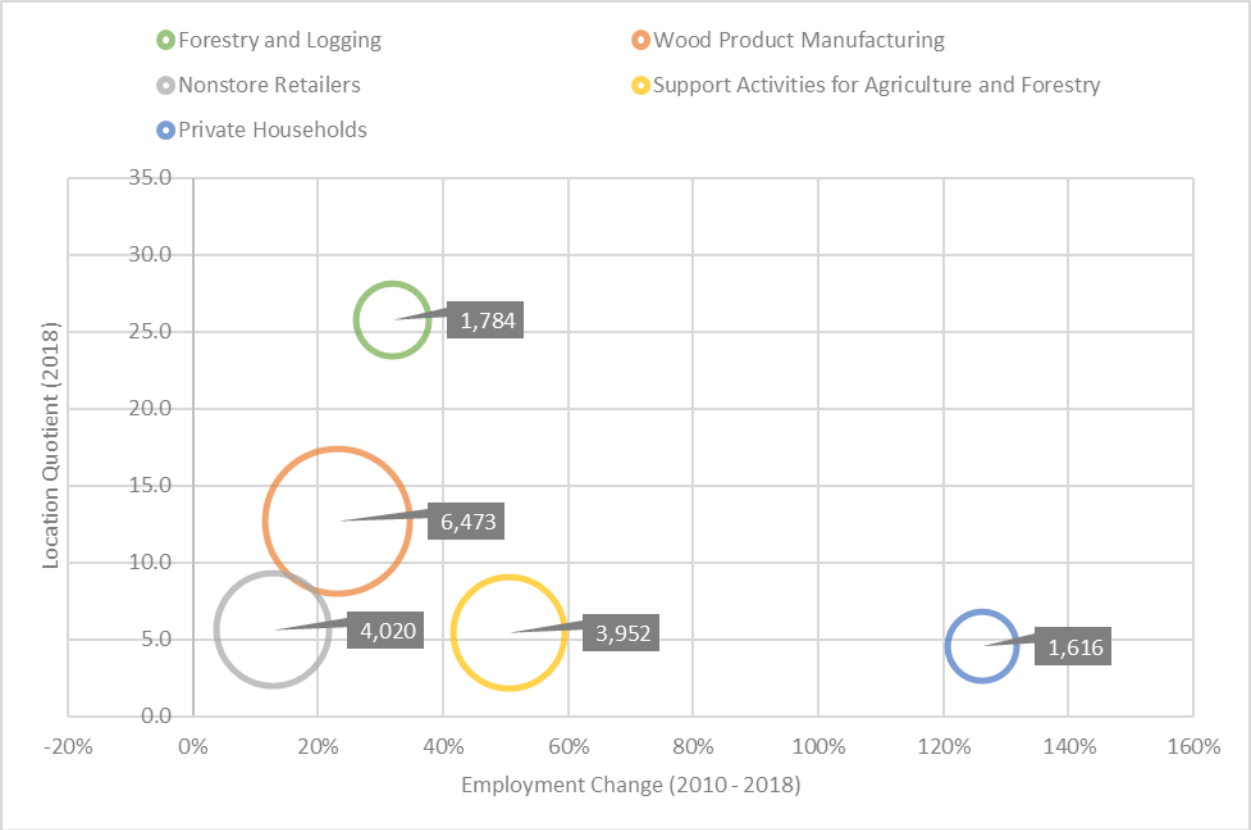
Table 2-386. Most Concentrated Industries and Employment Change in Region 4, 2018

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.

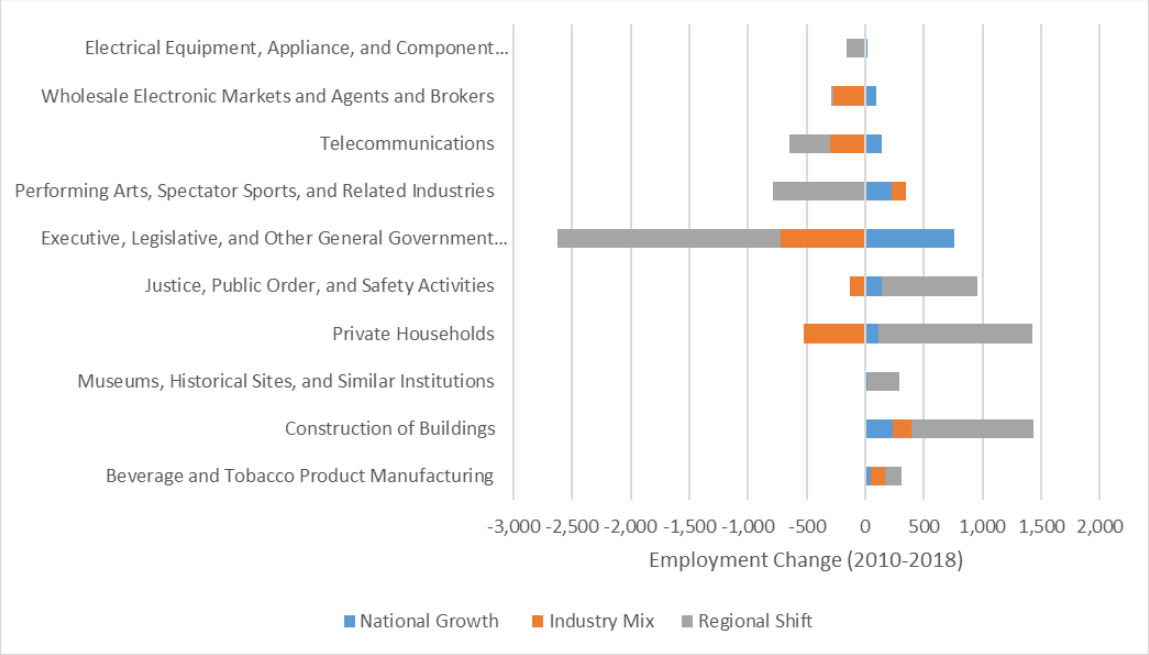
According to the shift-share analysis, the growth was mostly driven by regional factors. One reason for strong growth through the period, however, is that the subsector was severely impacted by the housing-bubble that led to the Great Recession. The decline in employment began around 2007 and was at 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

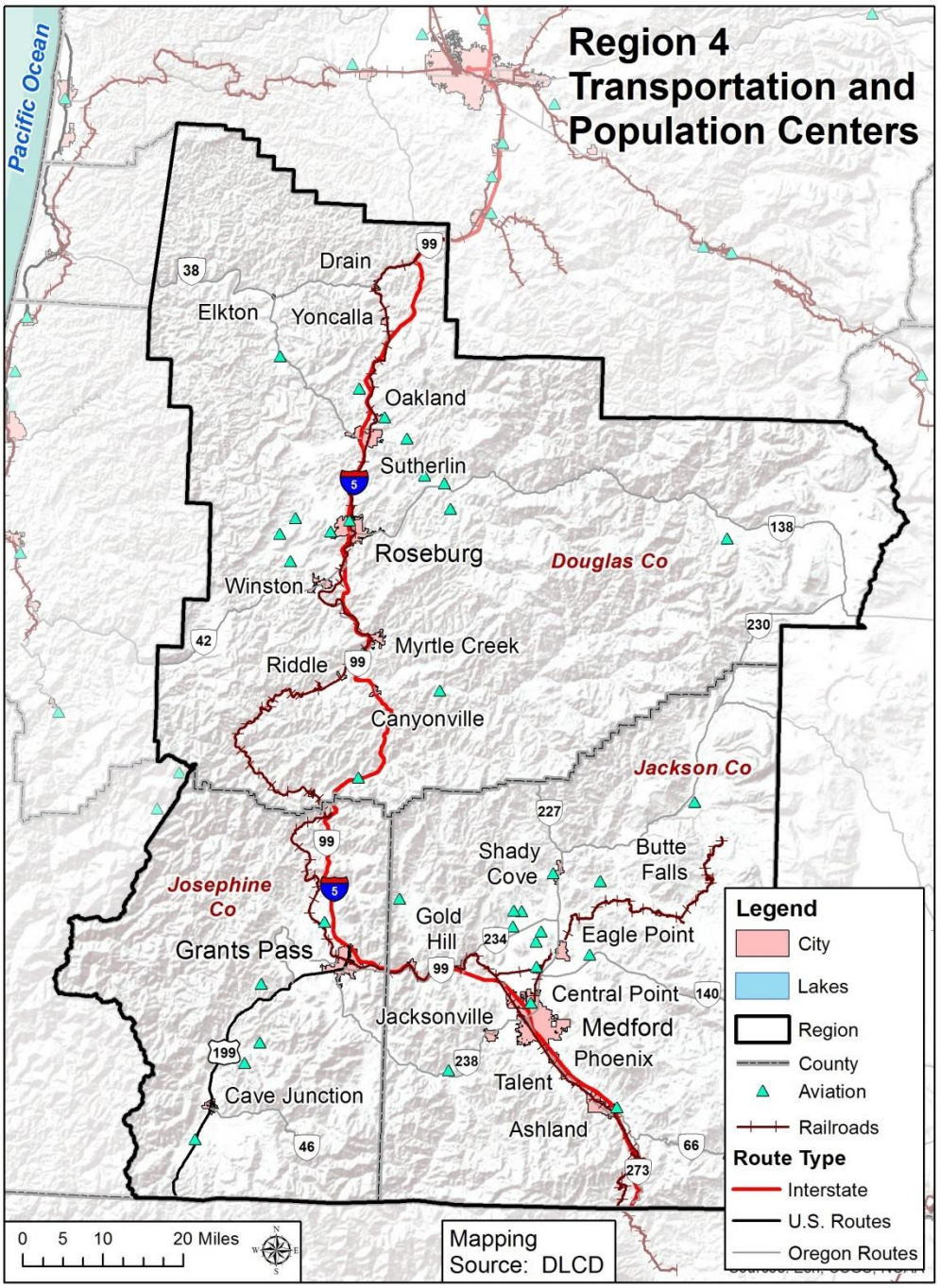
Roads

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.

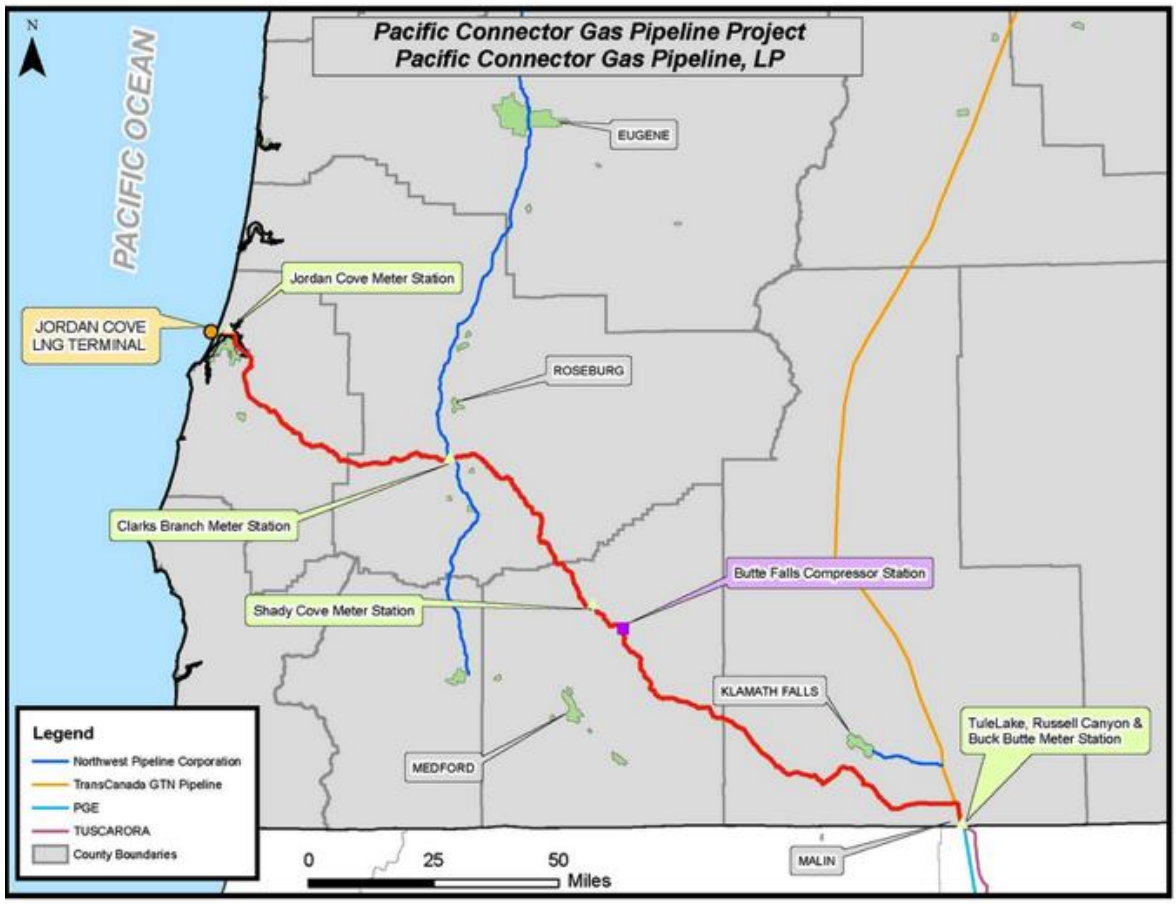
Hydropower

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%

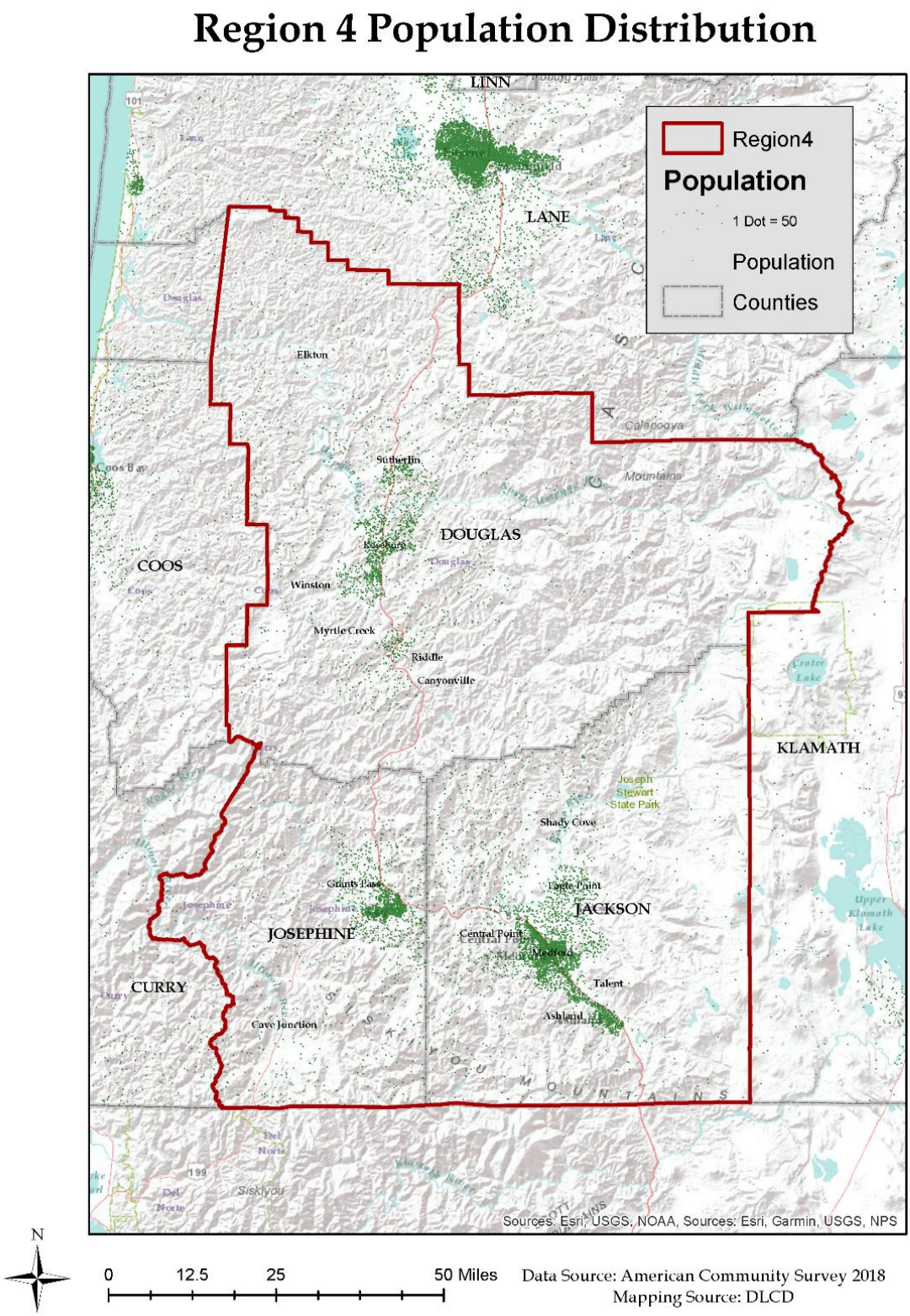
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

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).

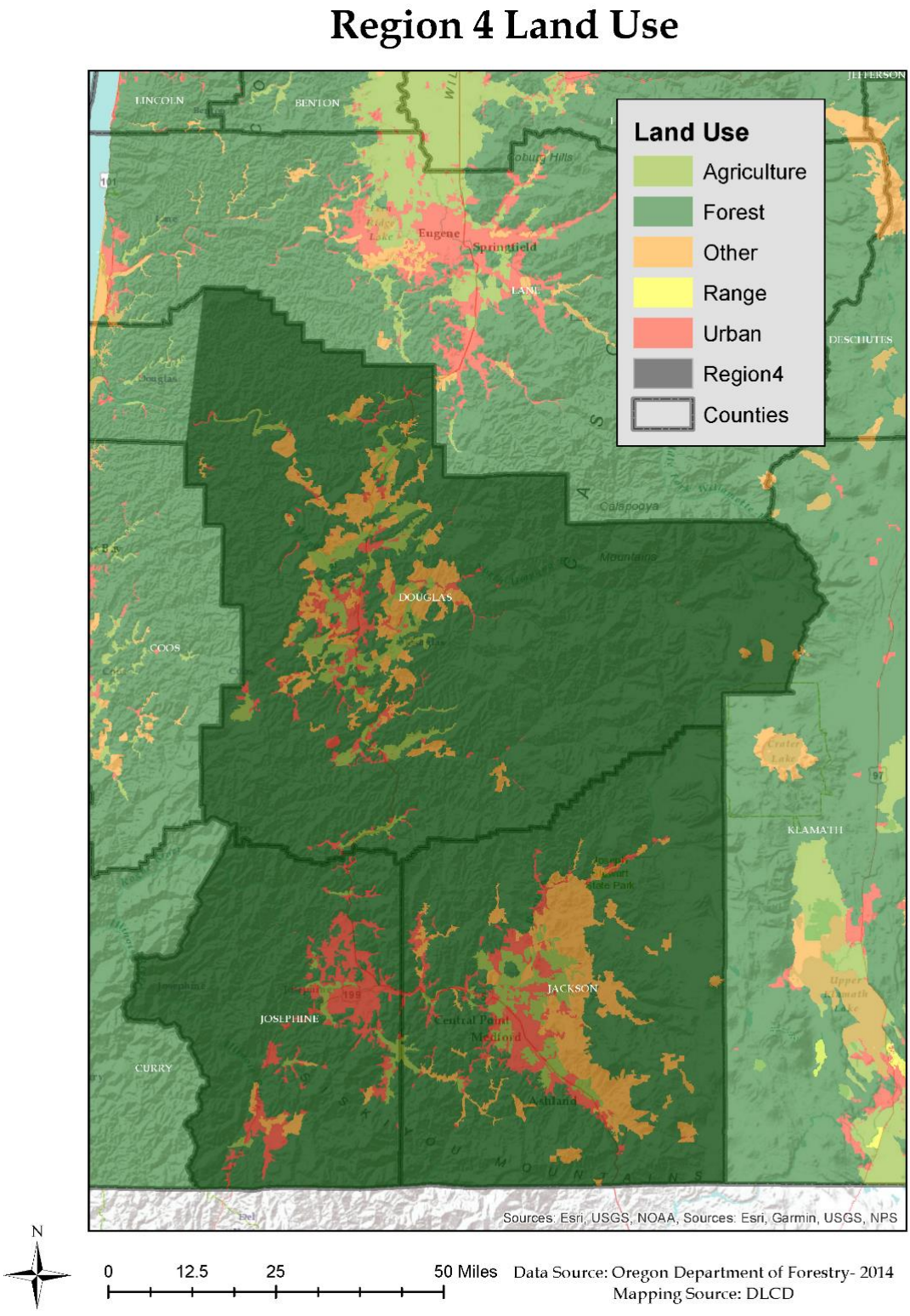
According to the Oregon Department of Forestry's most recent land-use study, "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of

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.

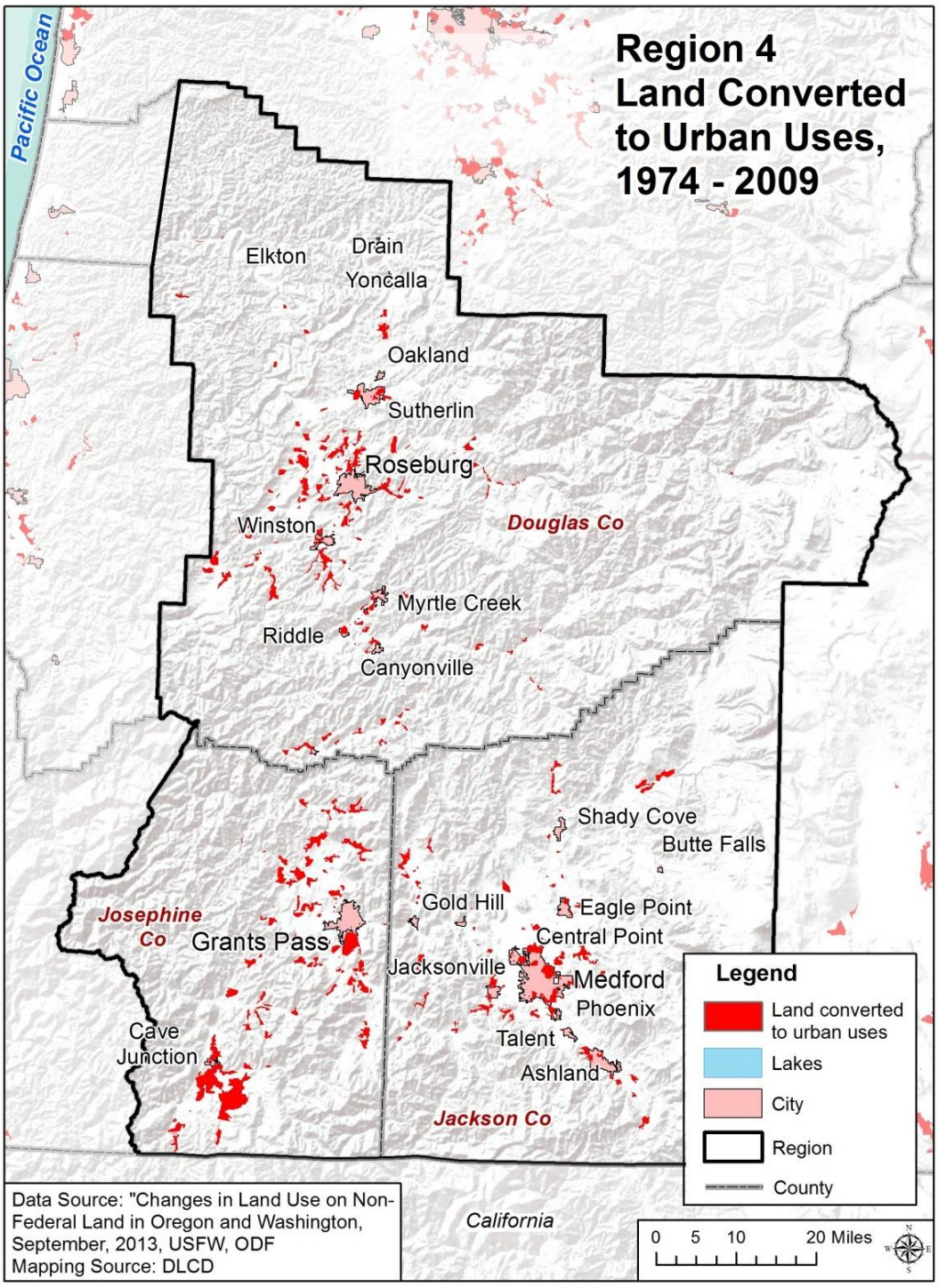
Regional problem solving activities are also addressing land use and development issues and how to guide growth. The "Greater Bear Creek Valley Regional Problem Solving Project" involves Jackson County and six cities in the Rogue Valley in guiding urban growth and development, while preserving priority 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

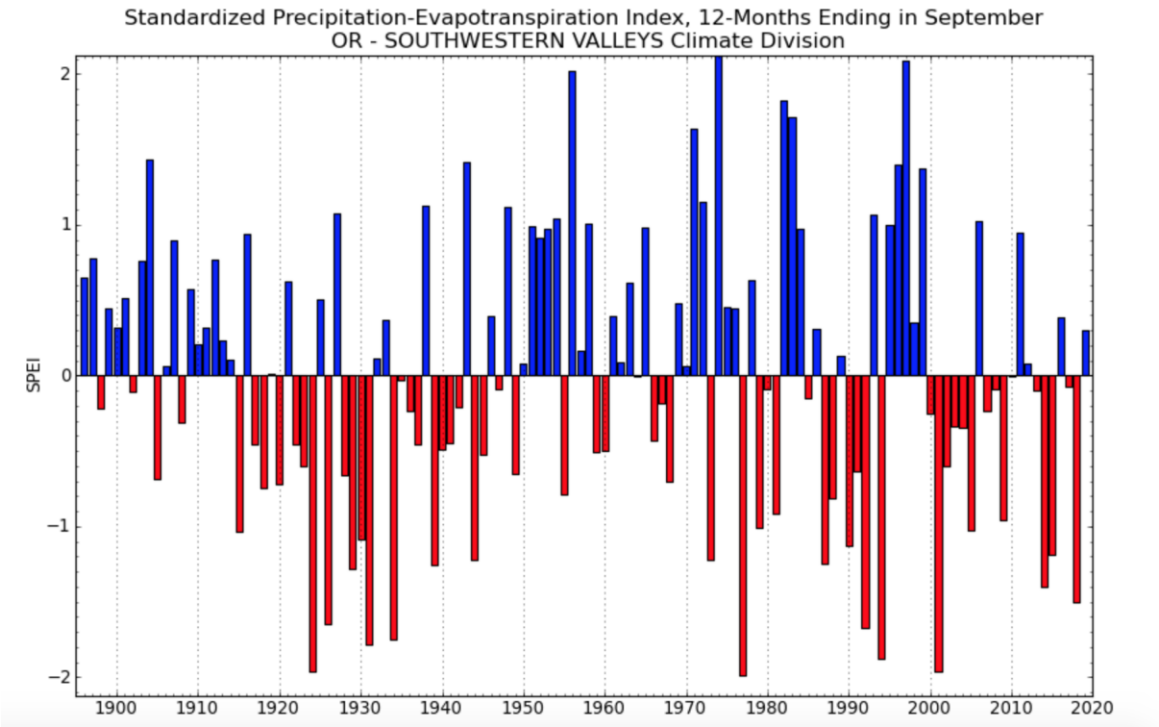
Date	Location	Description
1939	statewide	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country; water year 1939 was one of the more significant drought years in Region 4 during that period
1976-77	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**).



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

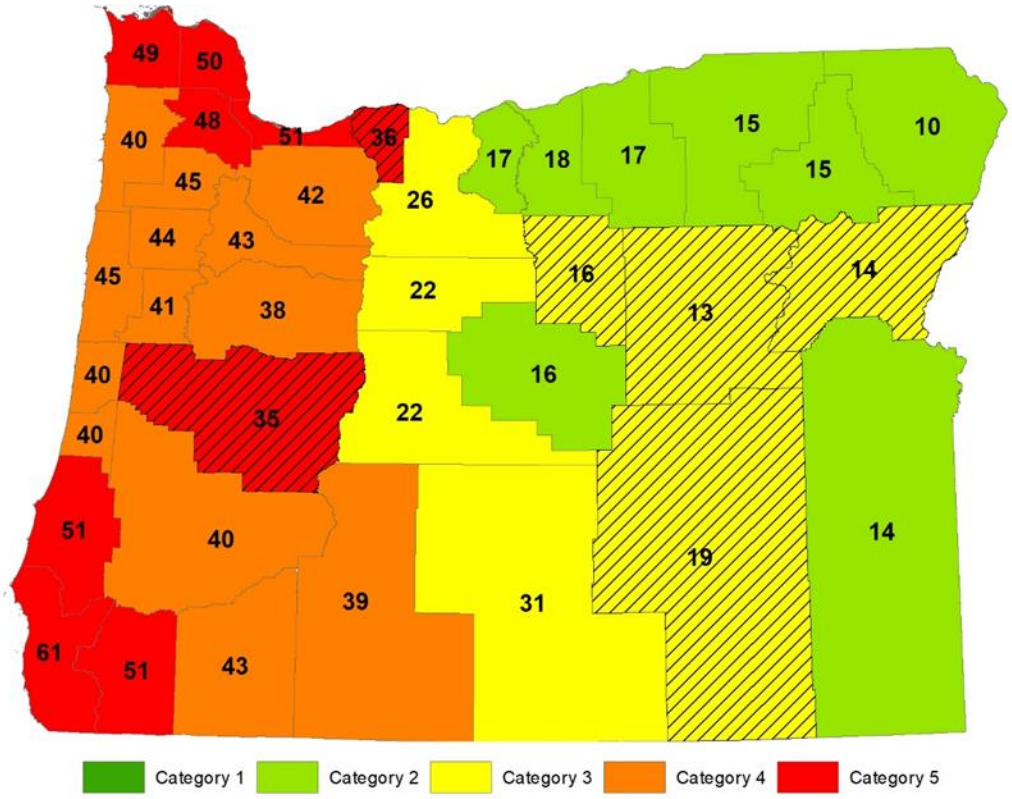
Source: DOGAMI, 2020

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

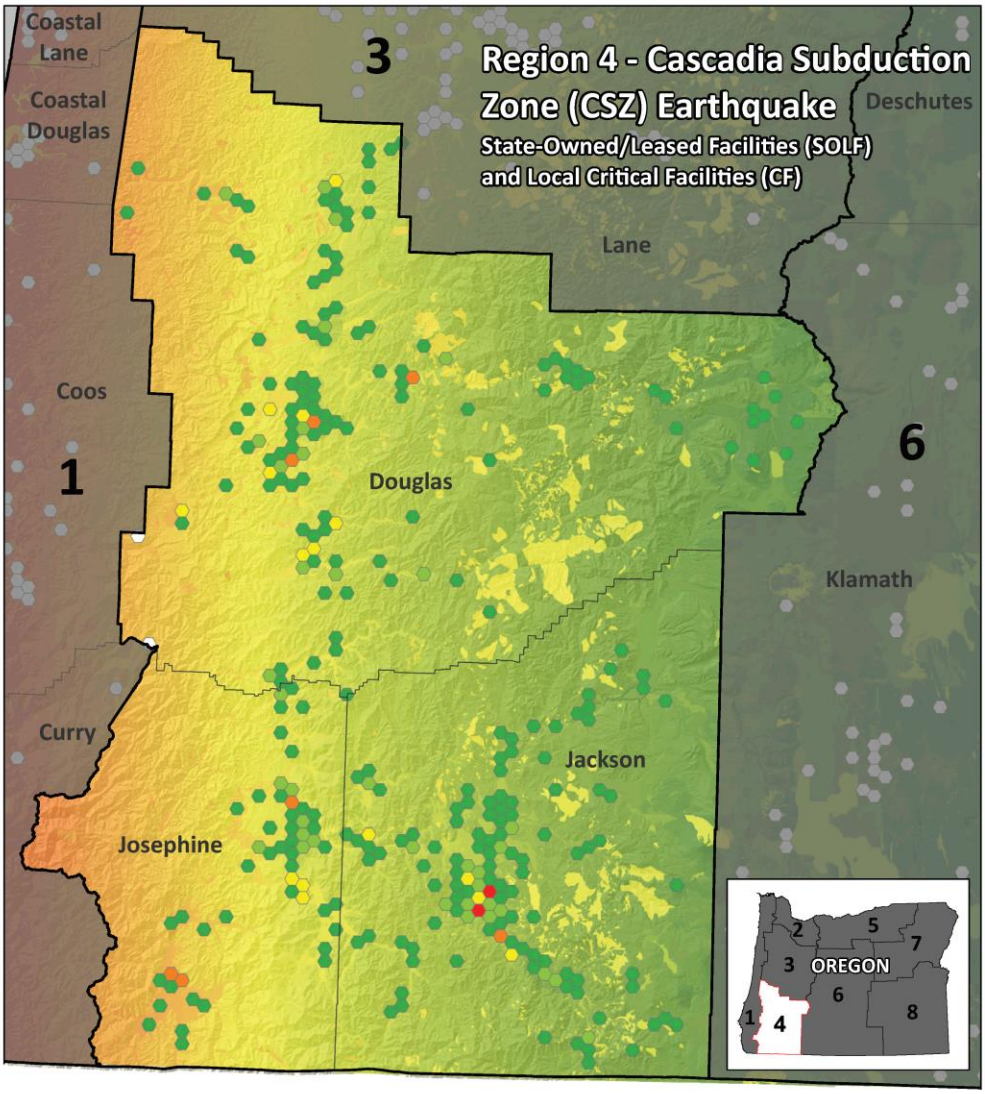
For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a Magnitude 9 Cascadia Subduction Zone (CSZ) event in Region 4. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide

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.



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 - 20,000,000
- 20,000,001 - 42,000,000

Earthquake peak ground acceleration
(Modified Mercalli Intensity Scale)
Moderate — Severe

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:
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.

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.*

0 10 20 40 Miles
N

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

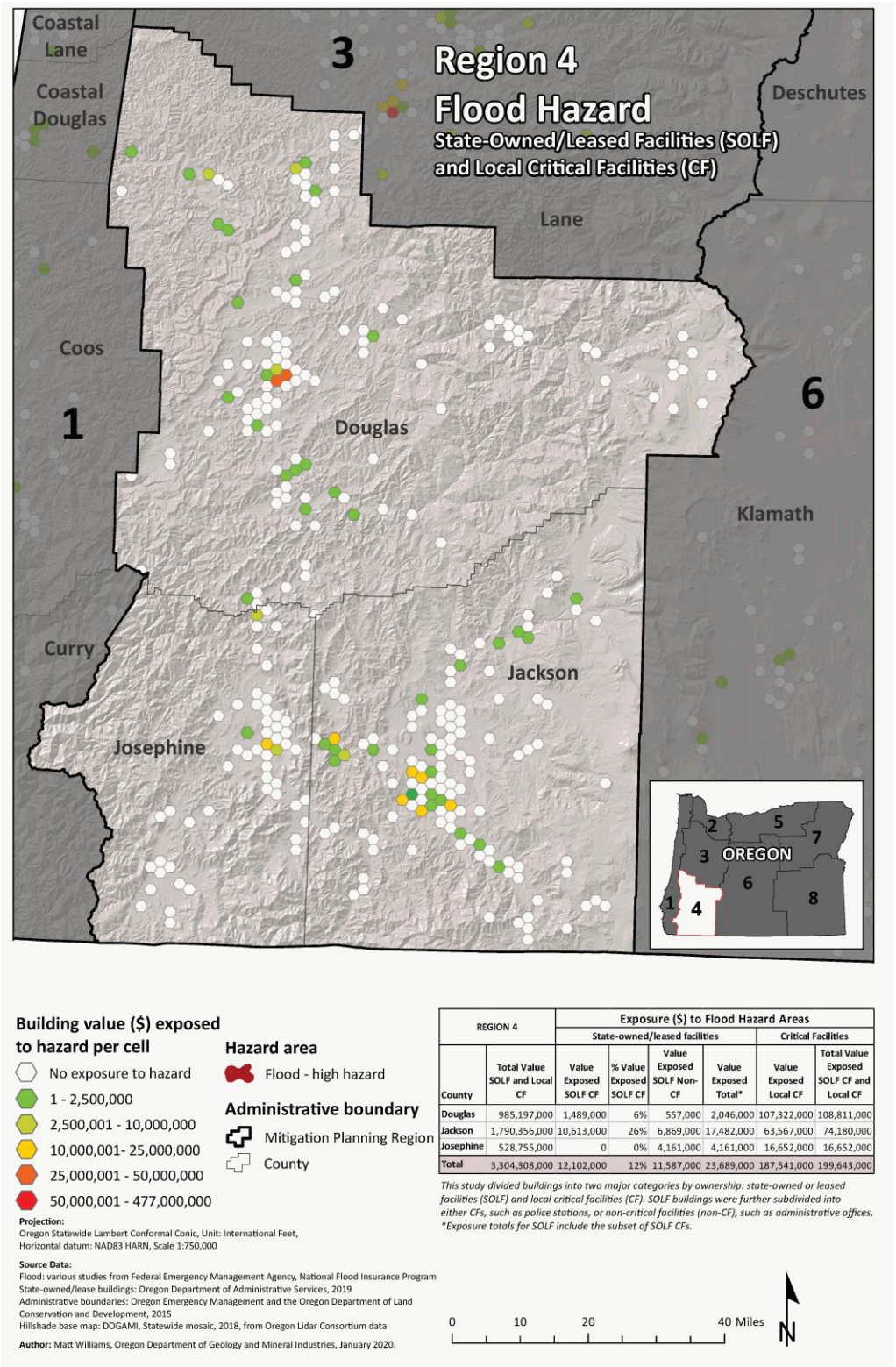
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs.

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

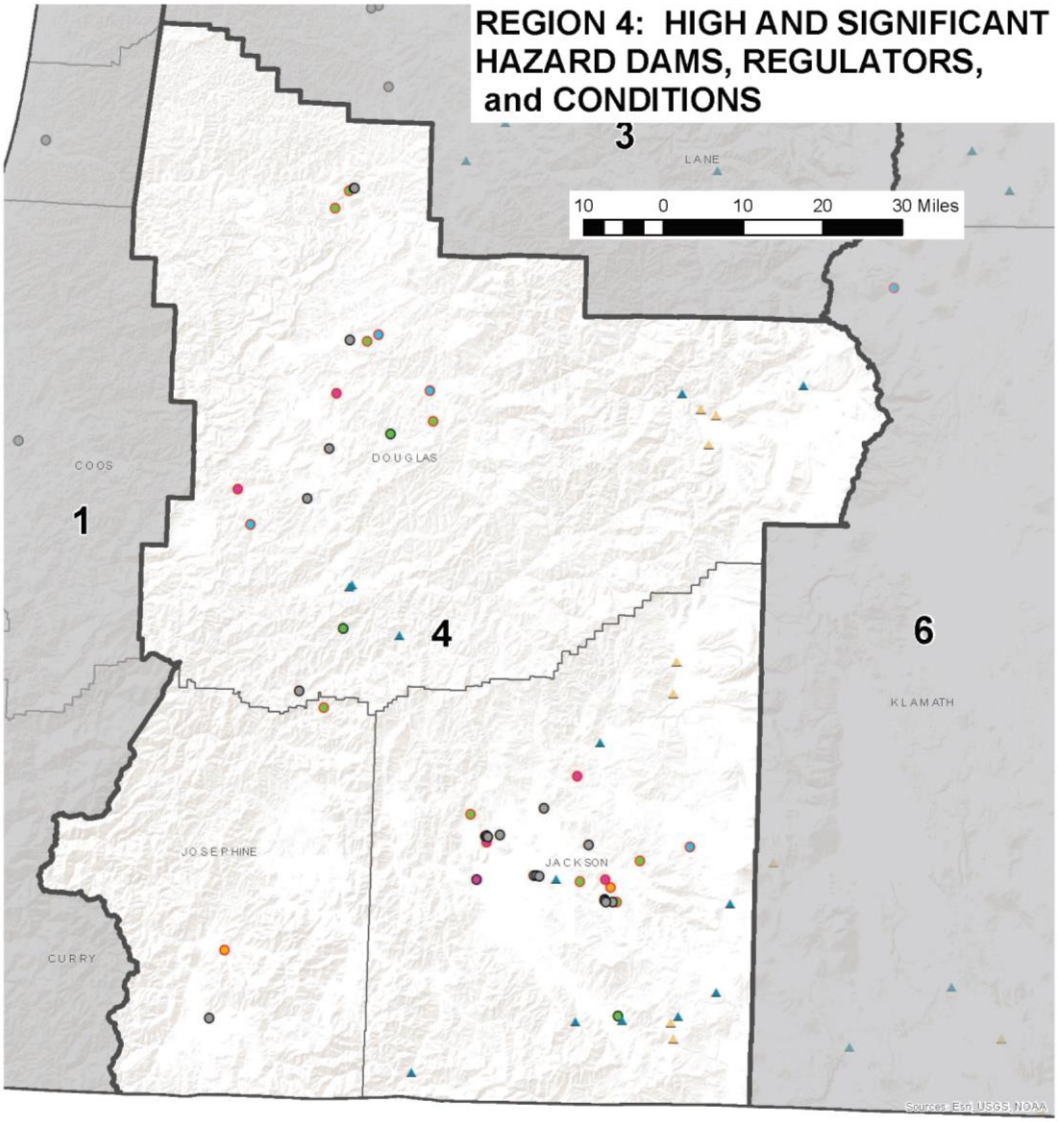
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Wageman	OR00496	POOR	6	12	Douglas
Winchester		POOR	Small	Small	Douglas
Duggan Dam	OR00475	POOR	6	11	Jackson
Osborne Creek Dam	OR00401	POOR	227	500	Jackson
Walch Dam		POOR	Small	Small	Jackson
Woodrat Knob	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

Federal regulated dams

Hazard

- High
- Significant

Mitigation Planning Regions

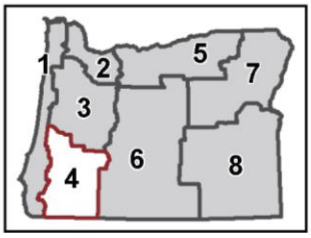
Counties

** - 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 2-434, 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.

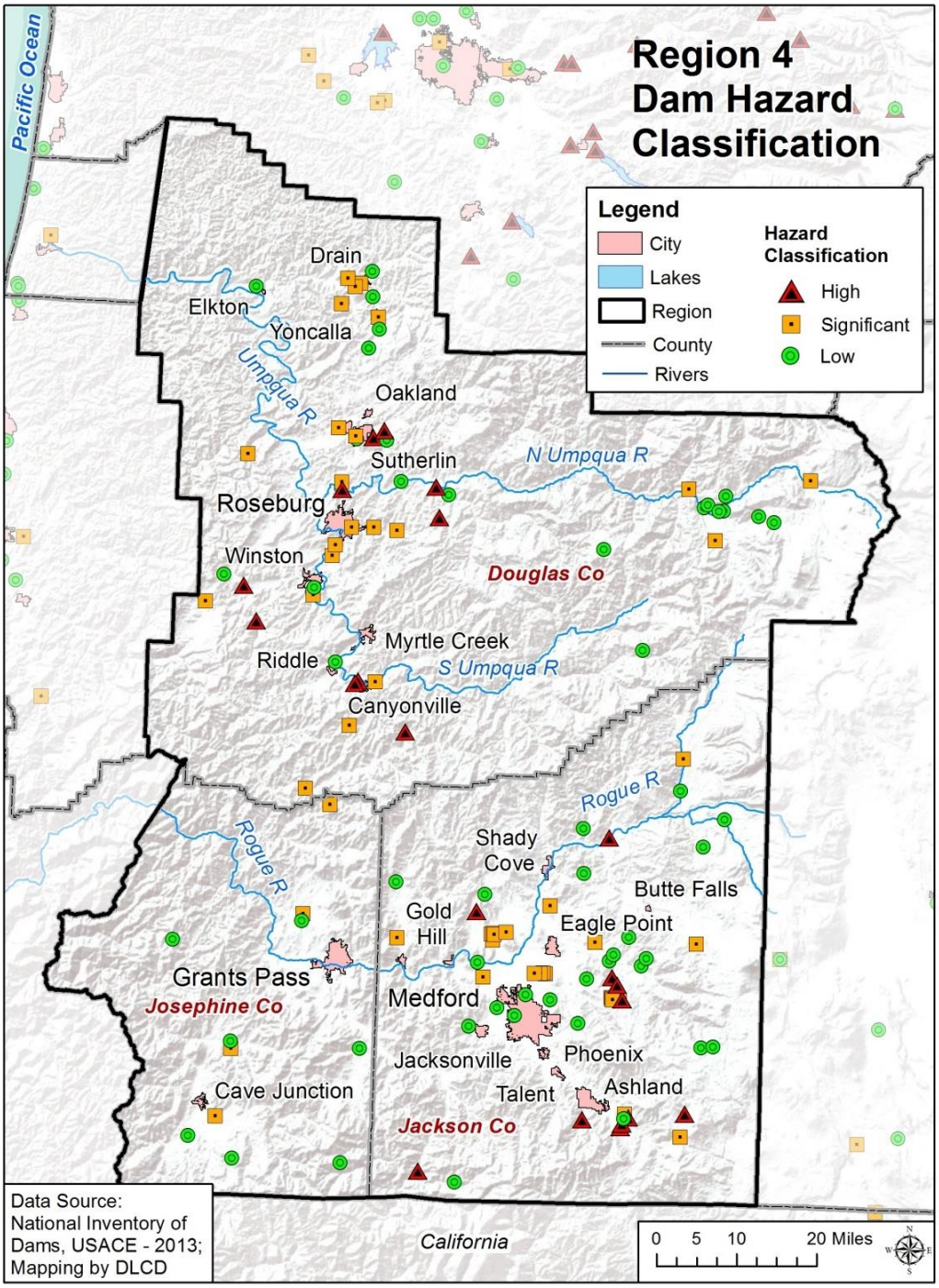
As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable jurisdictions” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The 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

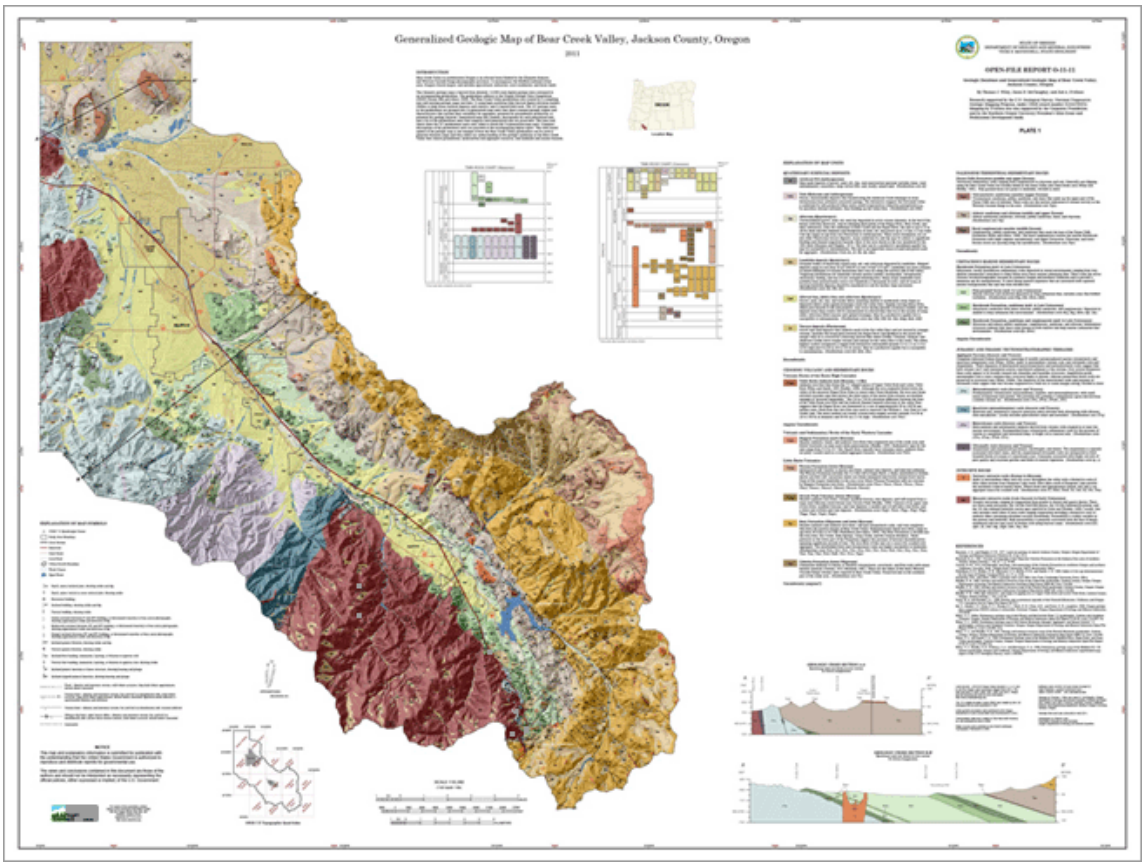
Note: Federally regulated significant hazard dams are not shown.

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

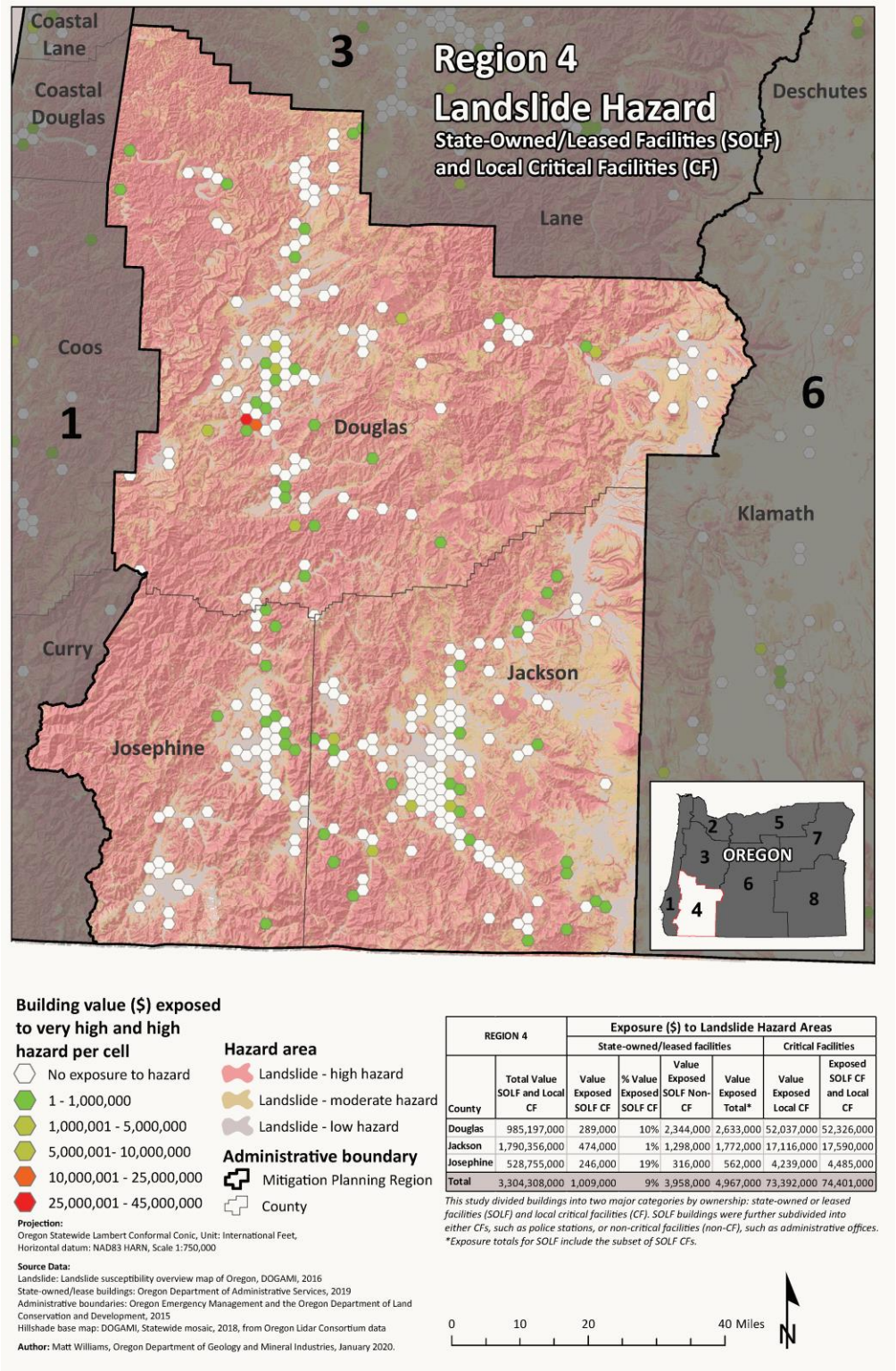
Many of the communities in this region are vulnerable to landslides; for example, the cities of Medford and Ashland have a moderate exposure to landslides.

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

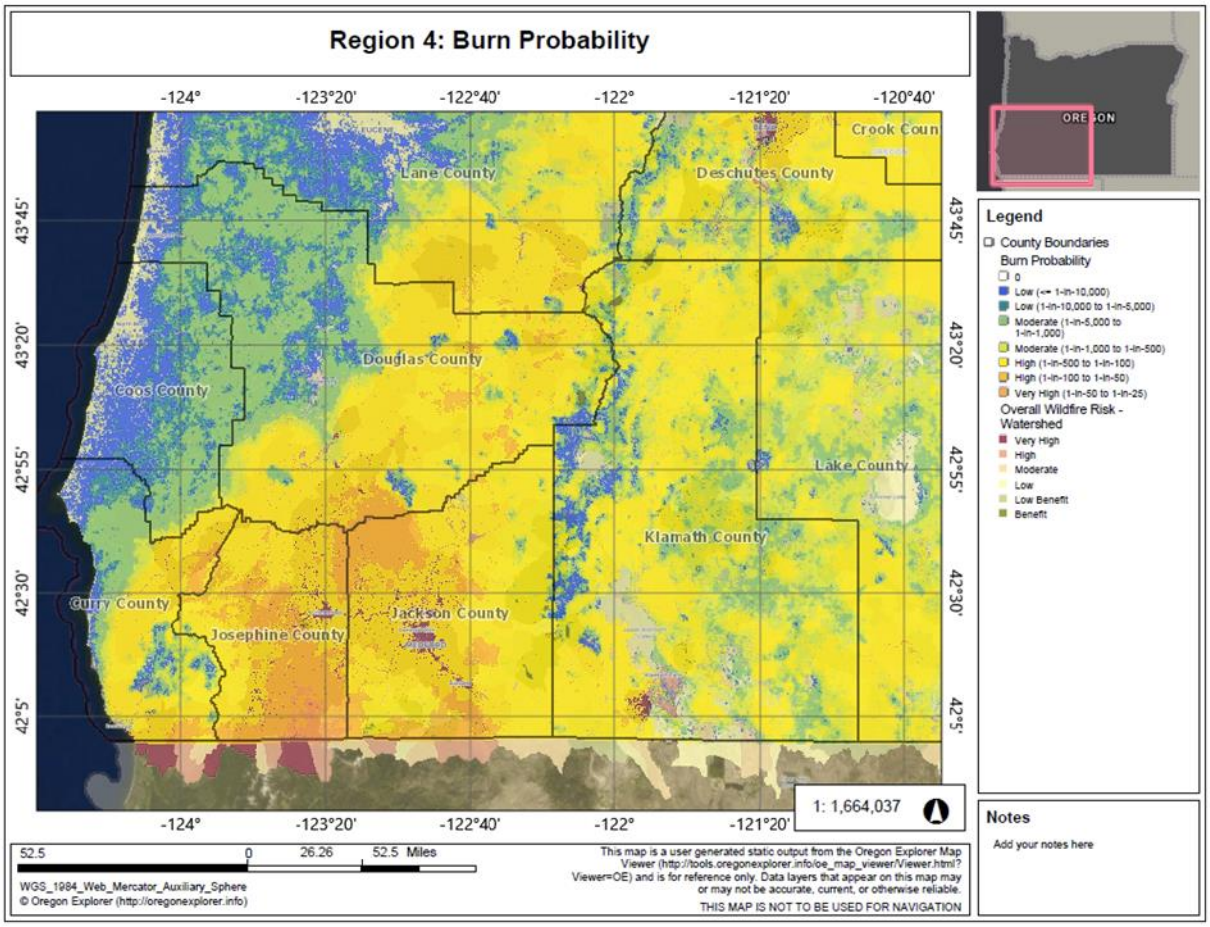
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

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

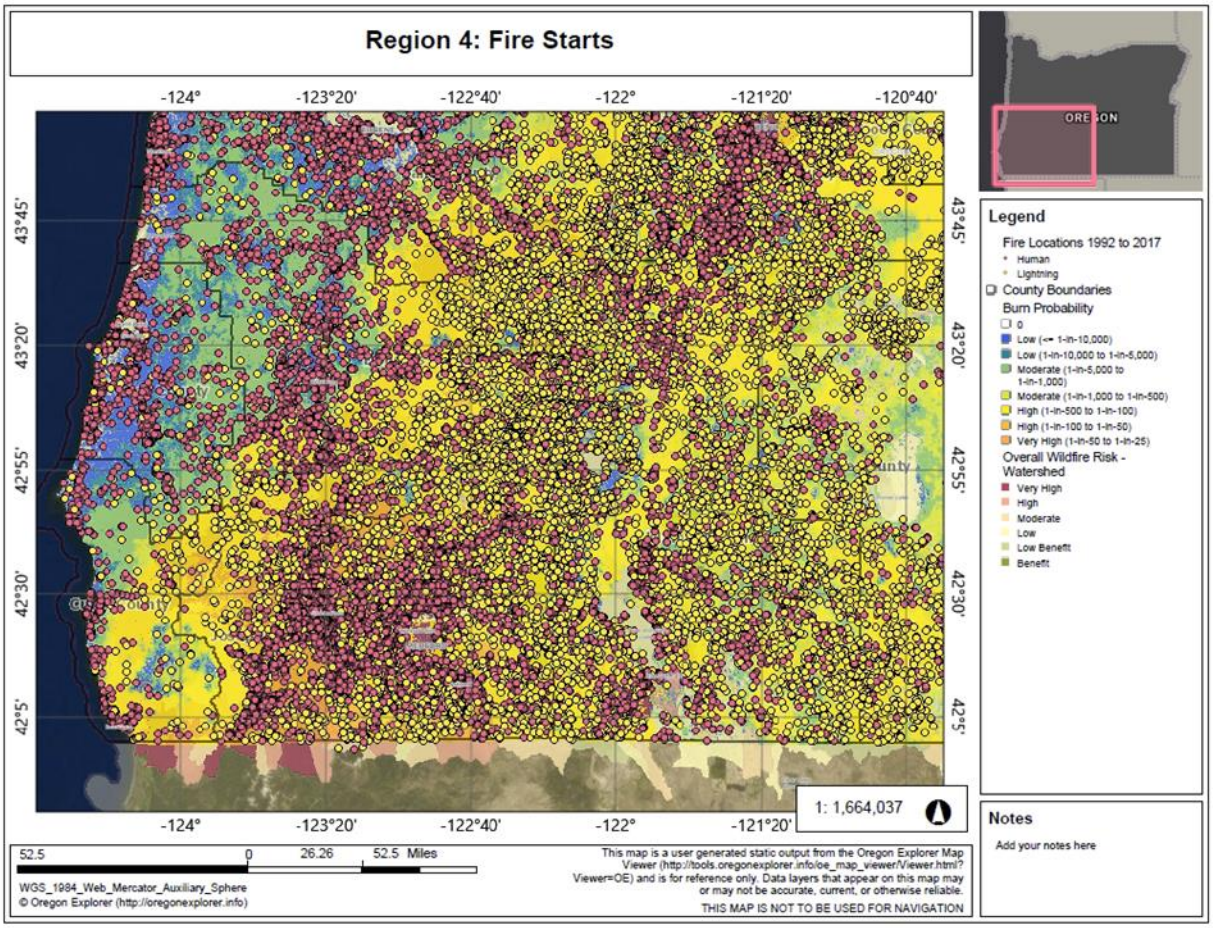


Source: Oregon Wildfire Risk Explorer, March 2020

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			

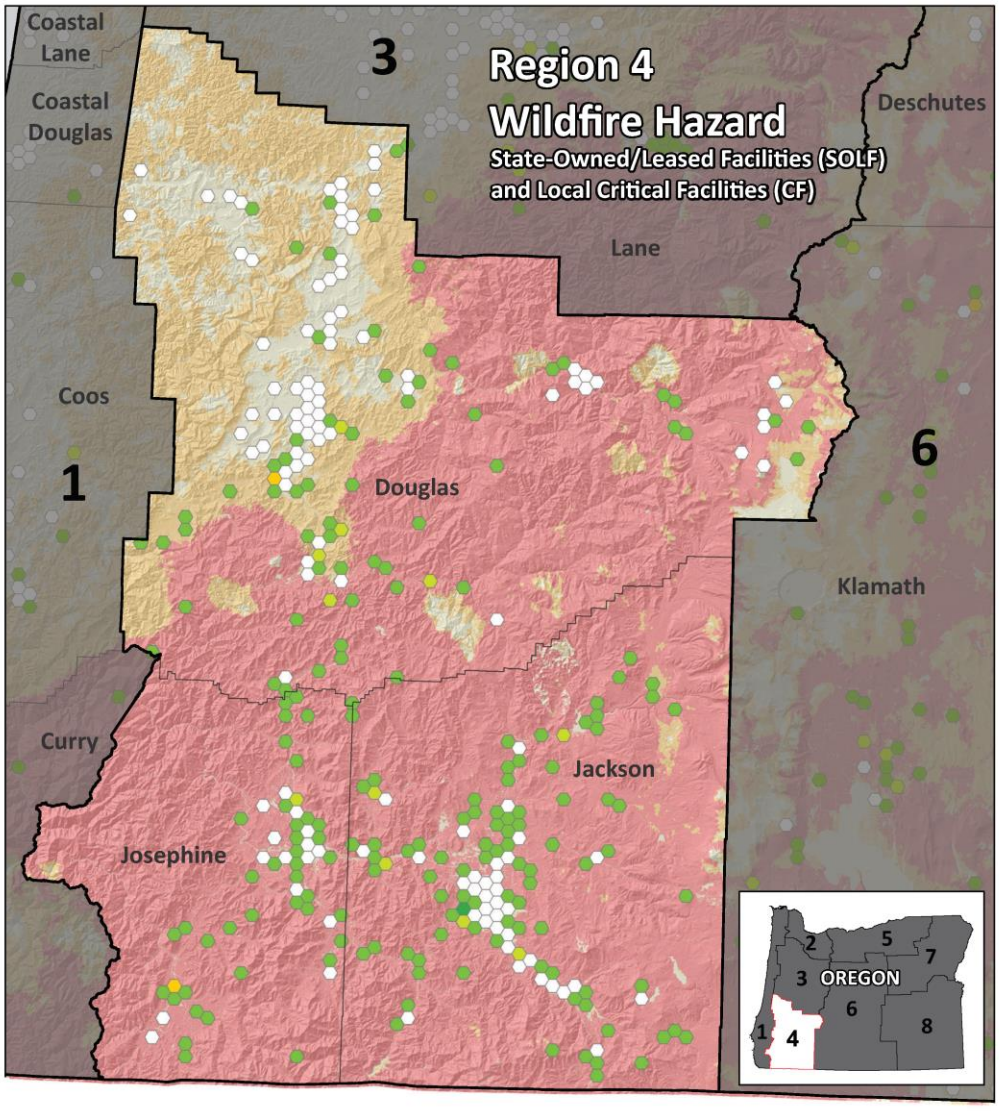
Source: ODF Communities at Risk Report, 2020

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.



Building value ($) exposed to high or moderate 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 - 290,000,000

Hazard area

- Wildfire - high hazard
- Wildfire - moderate hazard
- Wildfire - 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:
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.*

0 10 20 40 Miles

N

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

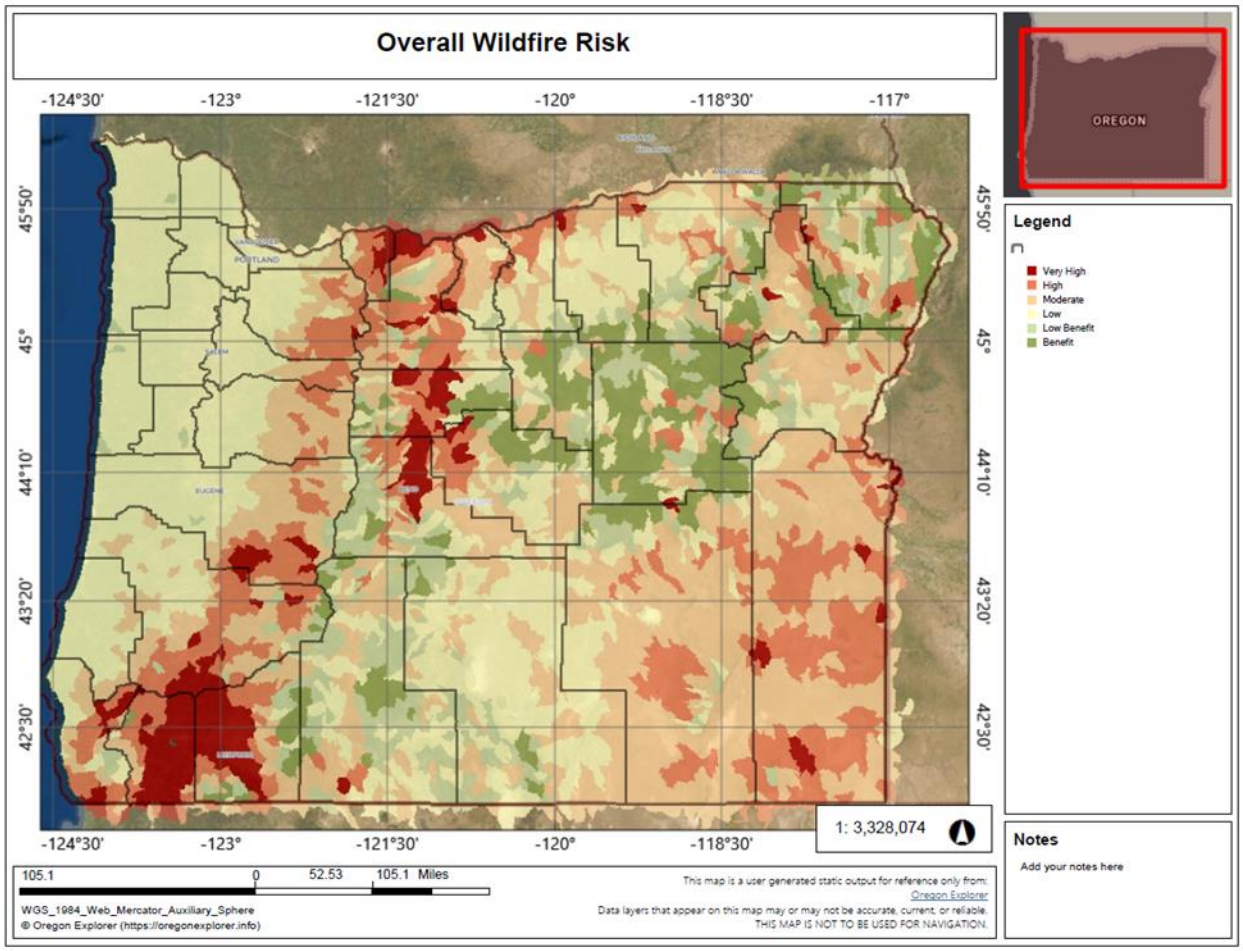
Table 2-453. Risk of Wildfire Hazards in Region 4

	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.

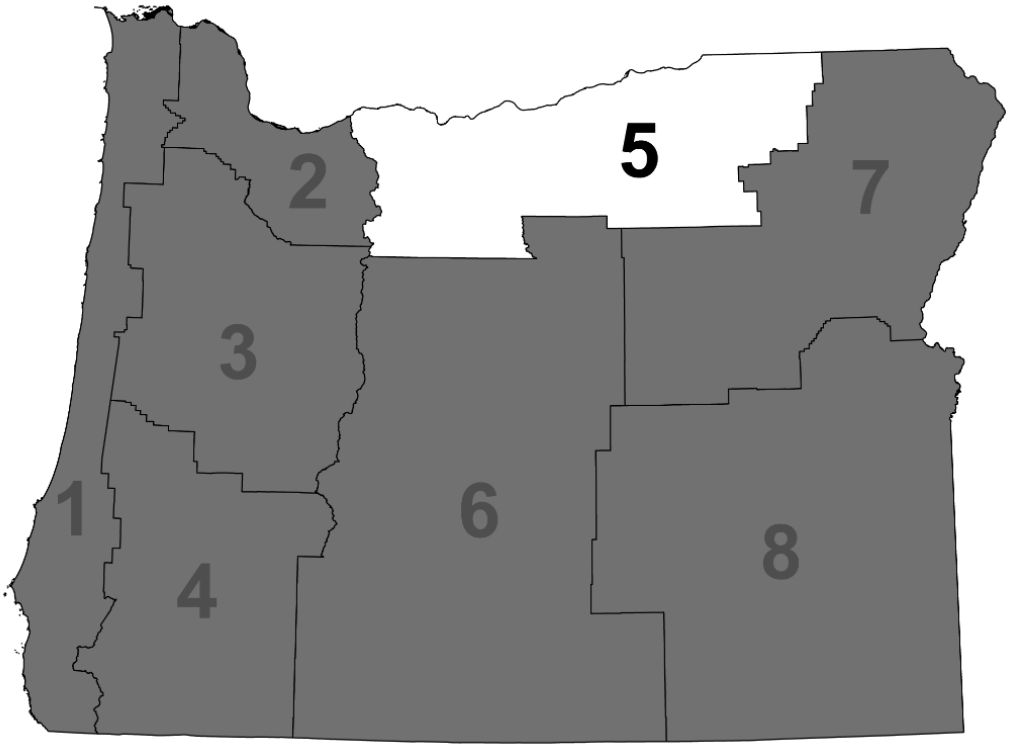
Risk

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

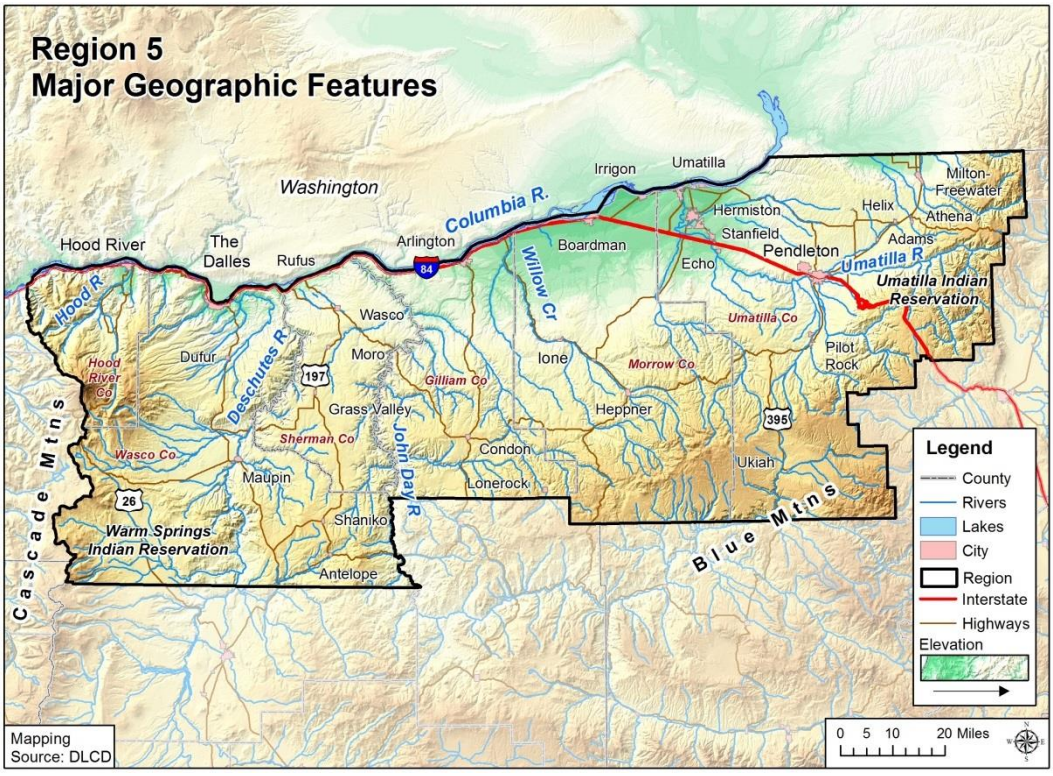
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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.

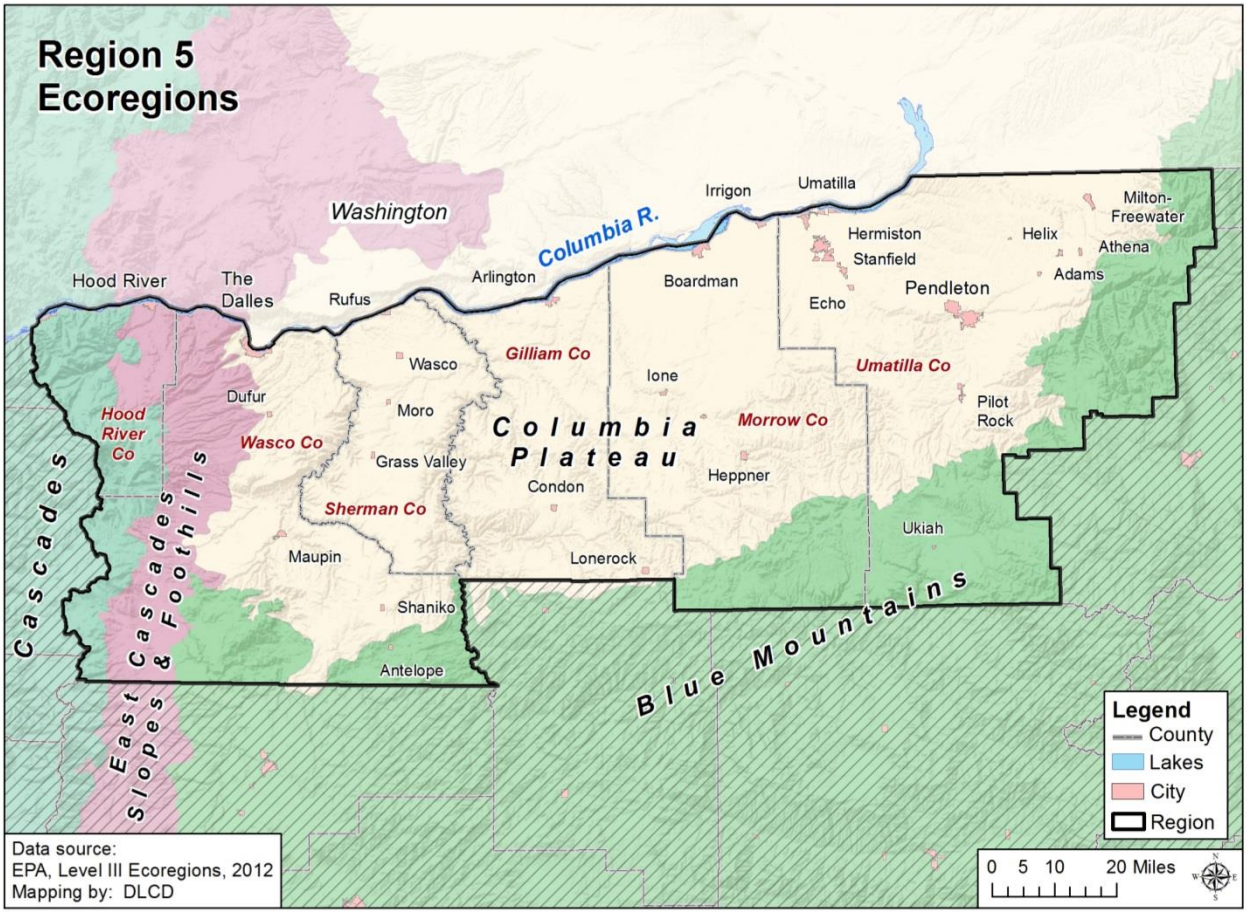
Figure 2-217. Region 5 Major Geographic Features



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/

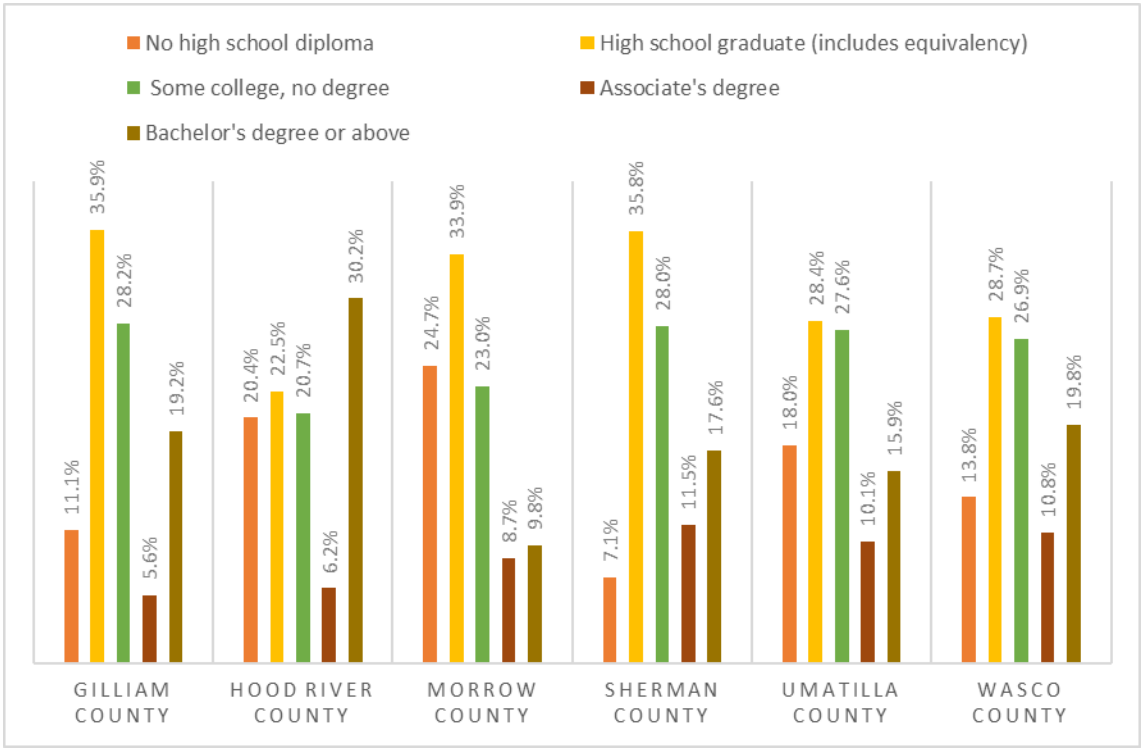


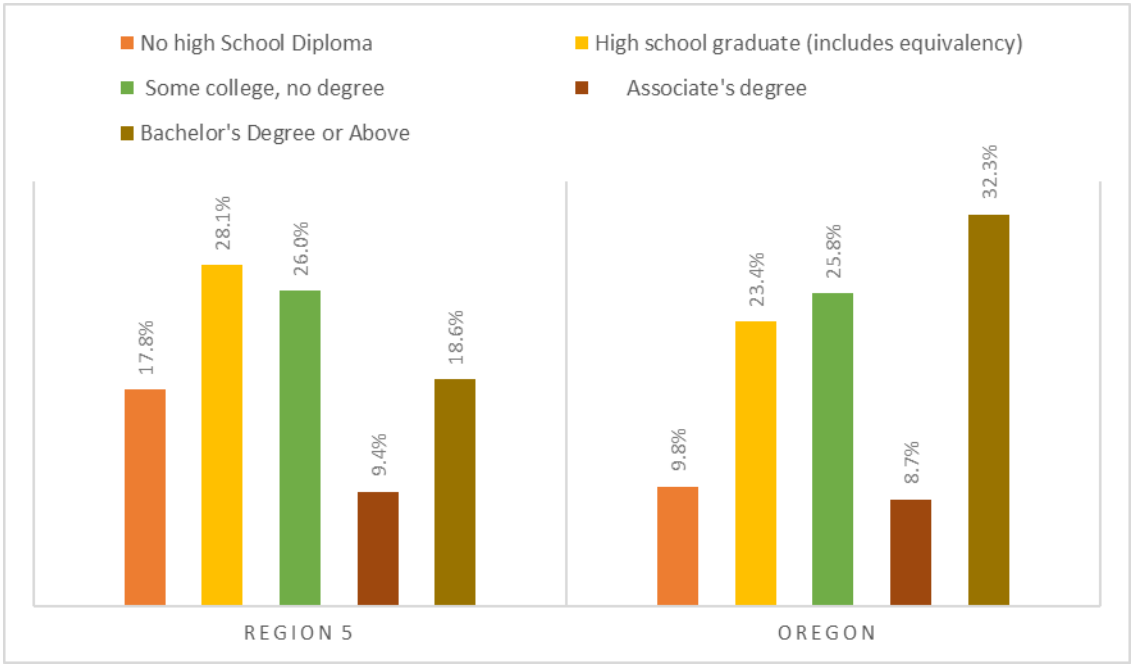
Education Level

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.

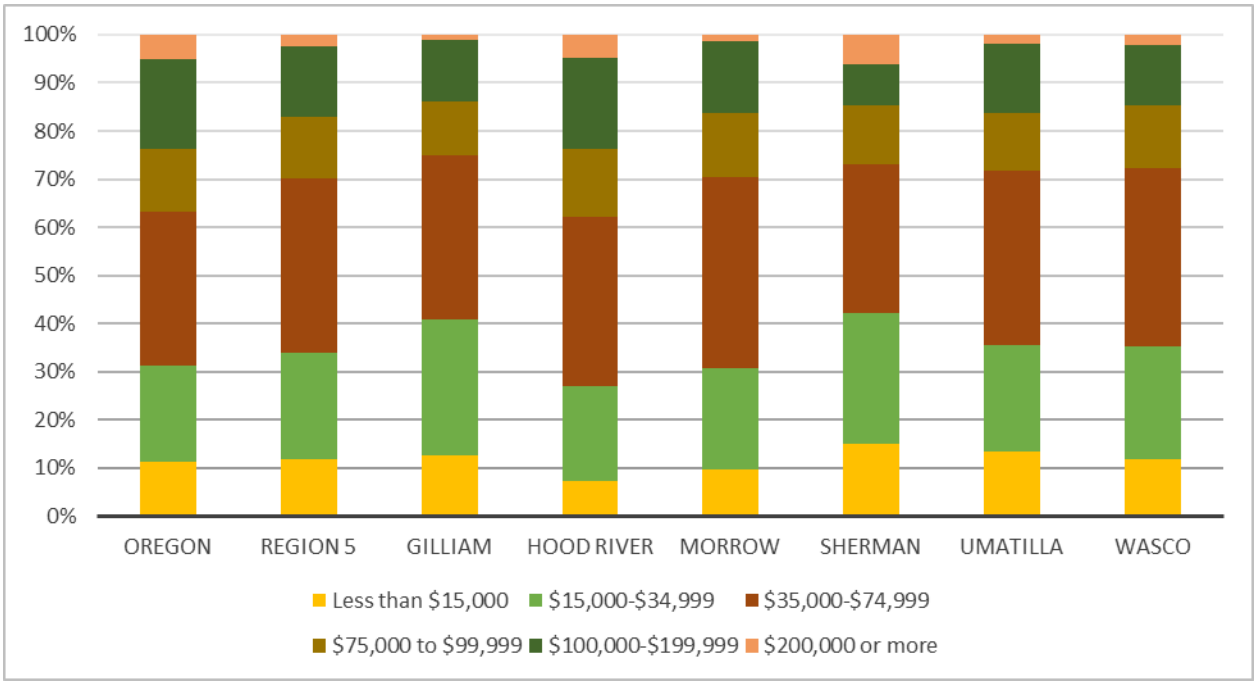
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

**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			
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Statistically Different*
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			
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Statistically Different*
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.

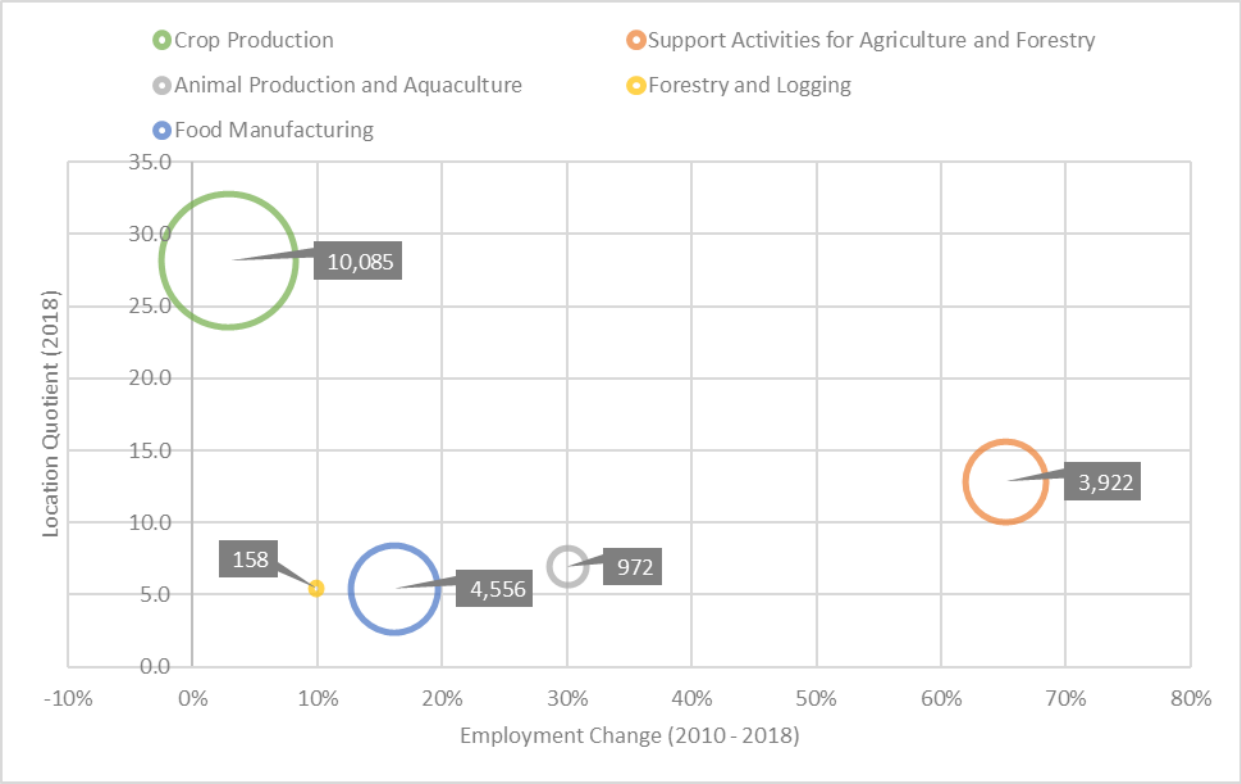
Table 2-479. Most Concentrated Industries and Employment Change in Region 4, 2018

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

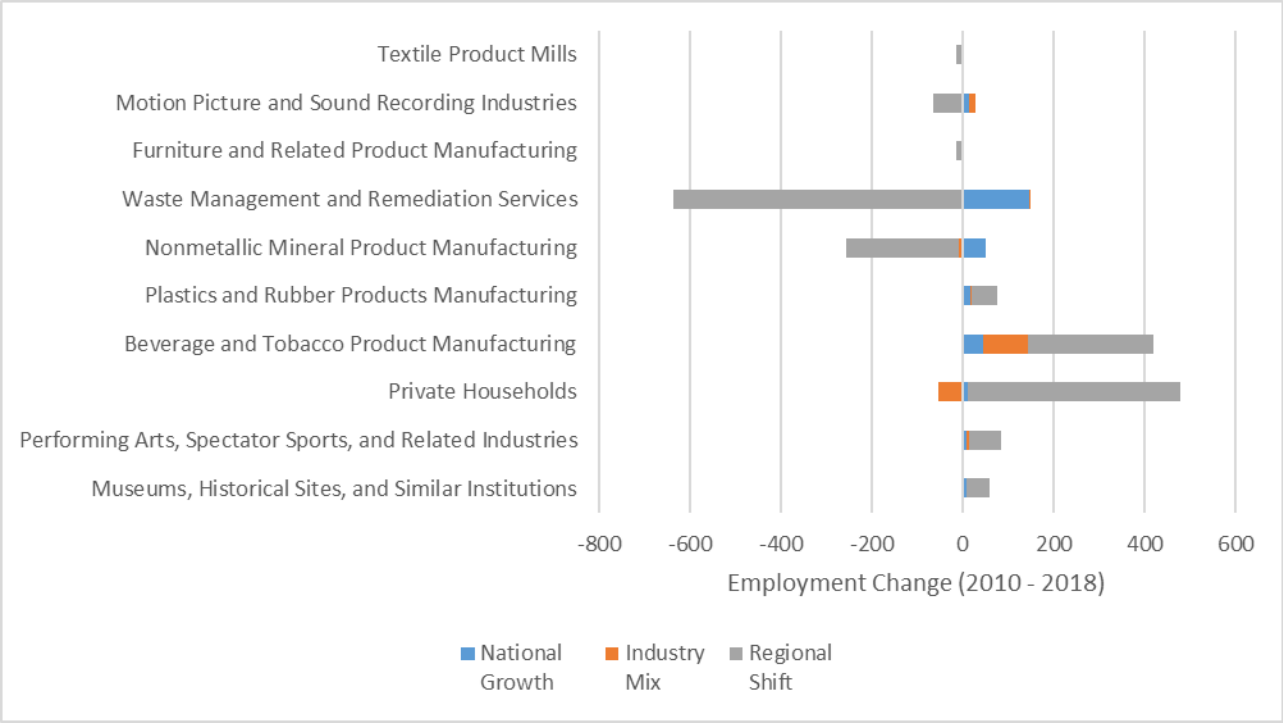
The Private Households industry experienced significant growth from 2010-2018. This sector employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019). The increase in employment in the Private 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

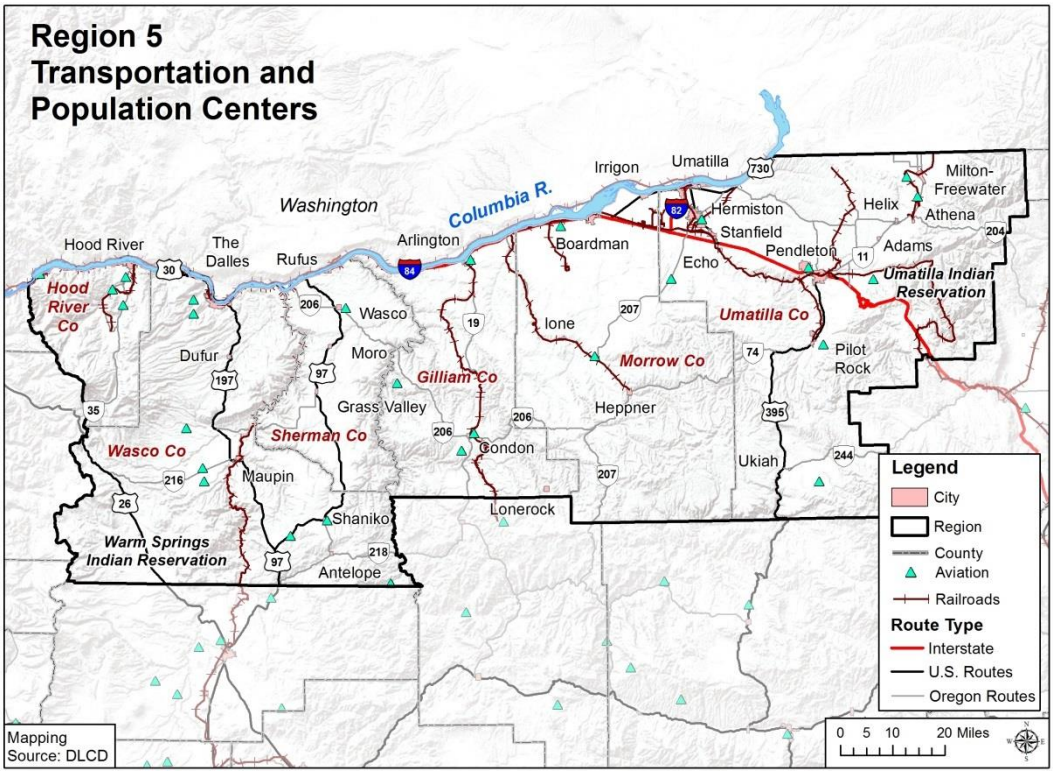
The largest population bases in Region 5 are located along the region's major freeways, I-84. I 84 is the main east-west passage for automobiles and trucks traveling between the northwest and states to the east.

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.

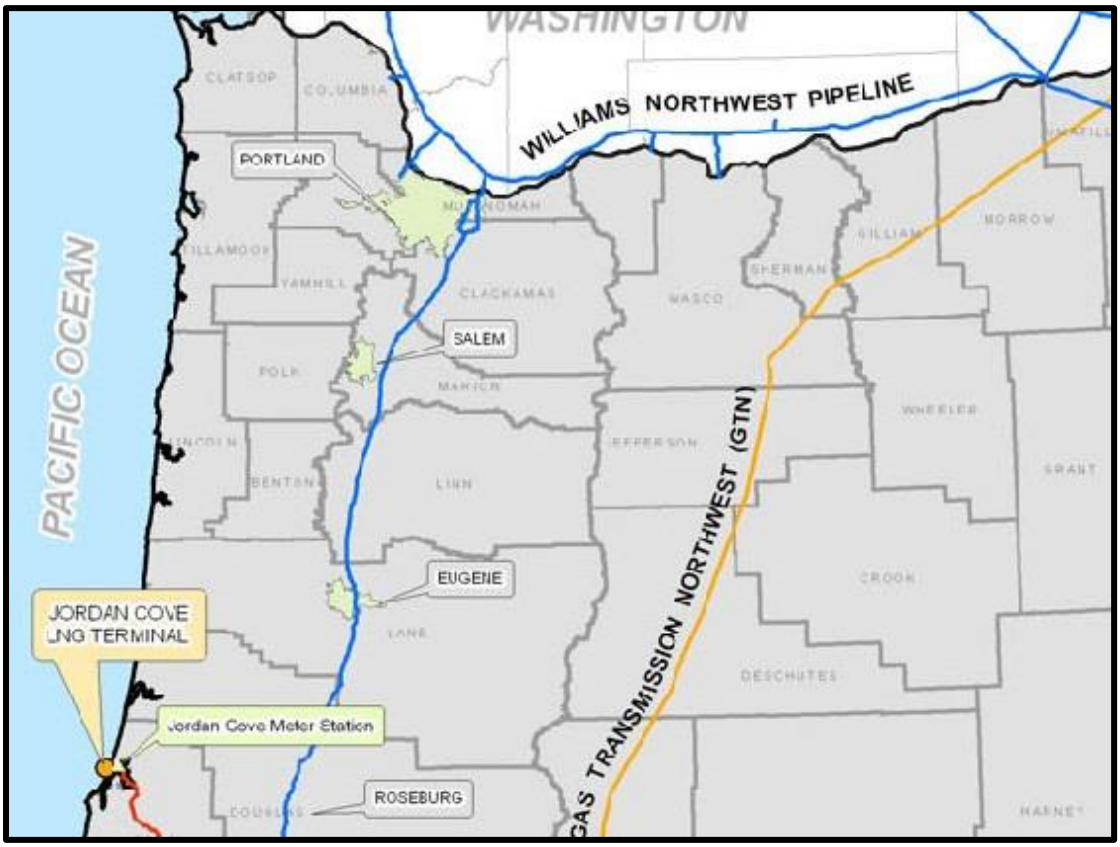
Hydropower

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%

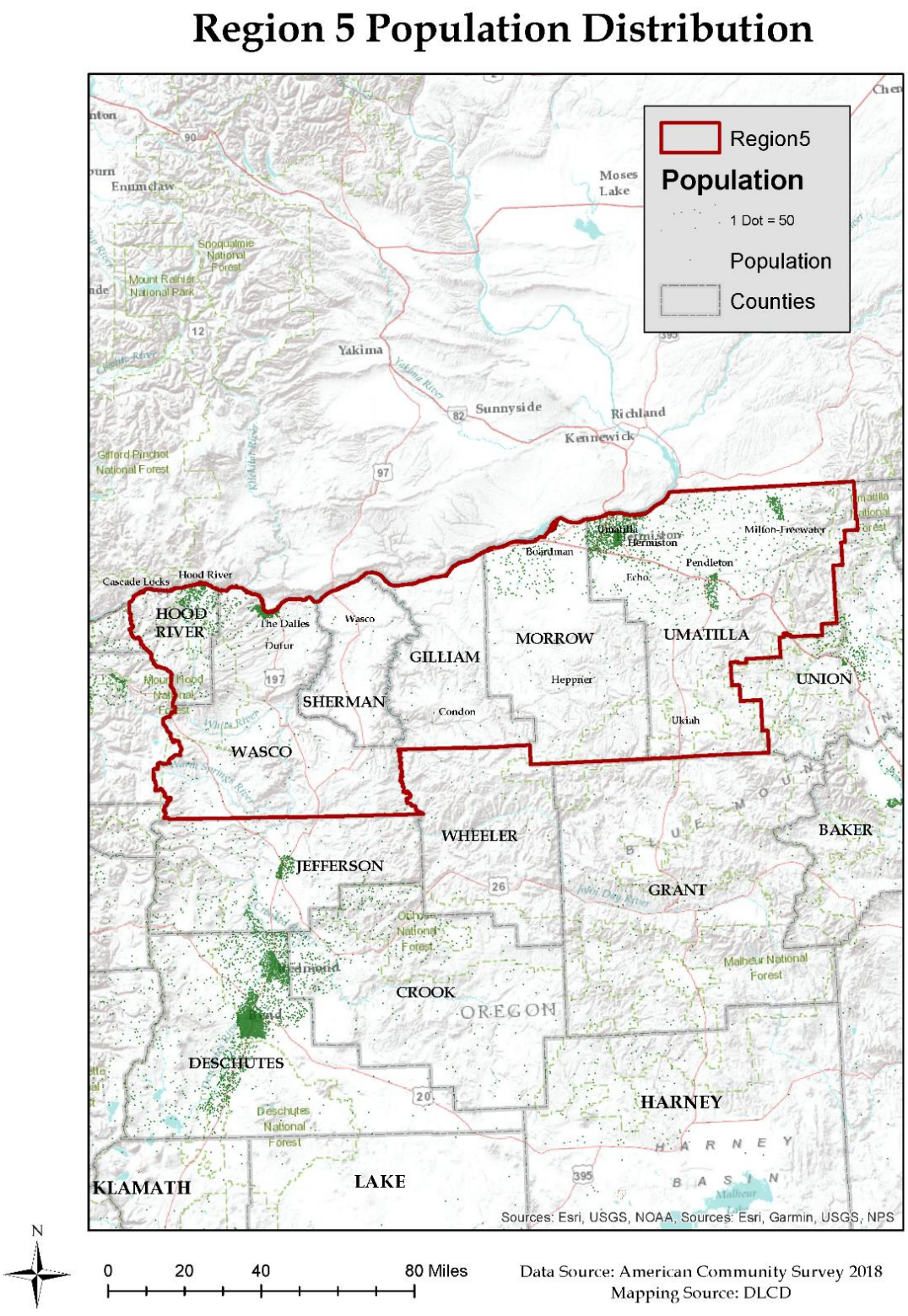
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

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).

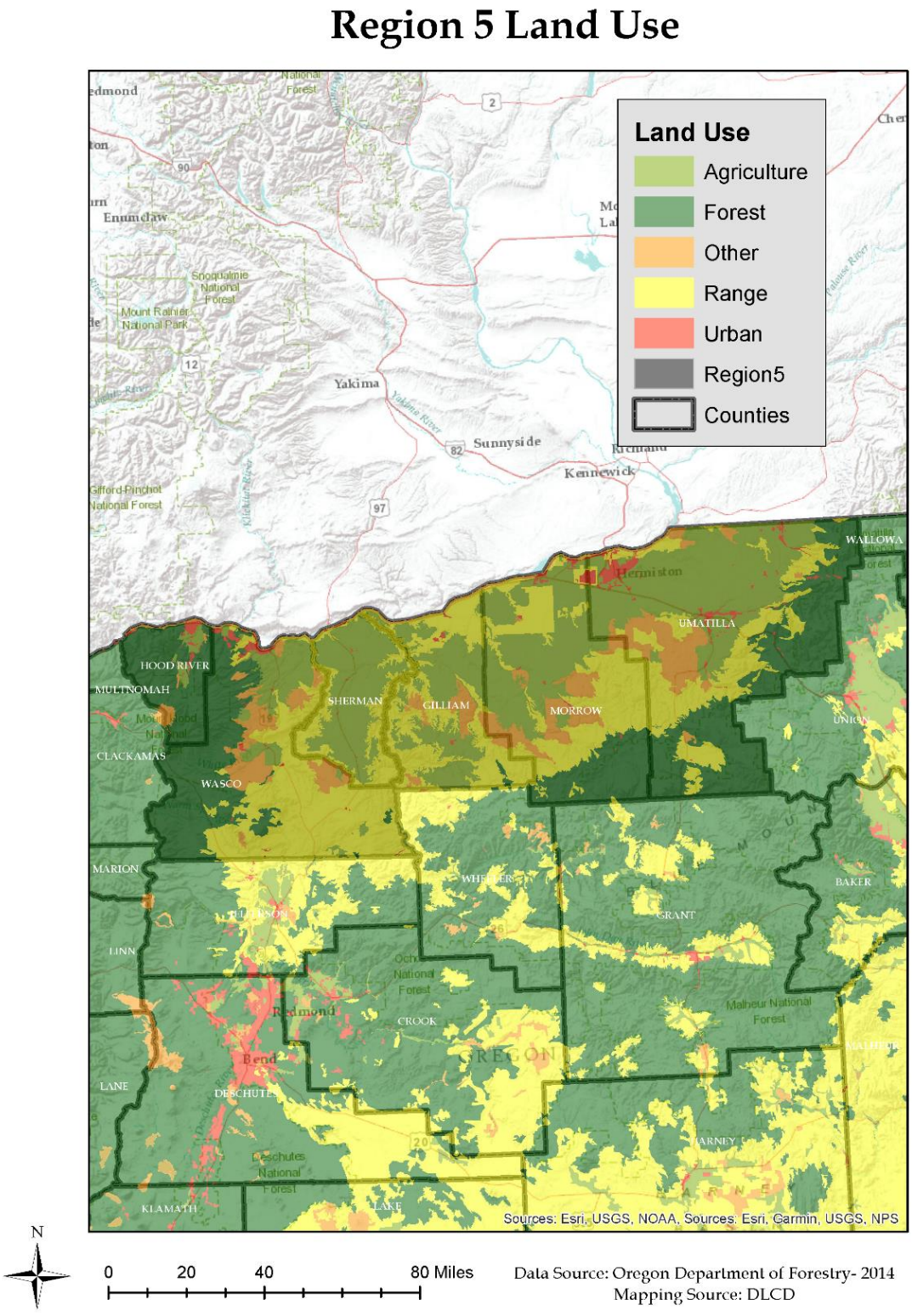
According to the Oregon Department of Forestry's most recent land-use study, "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray , Hubner , 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.

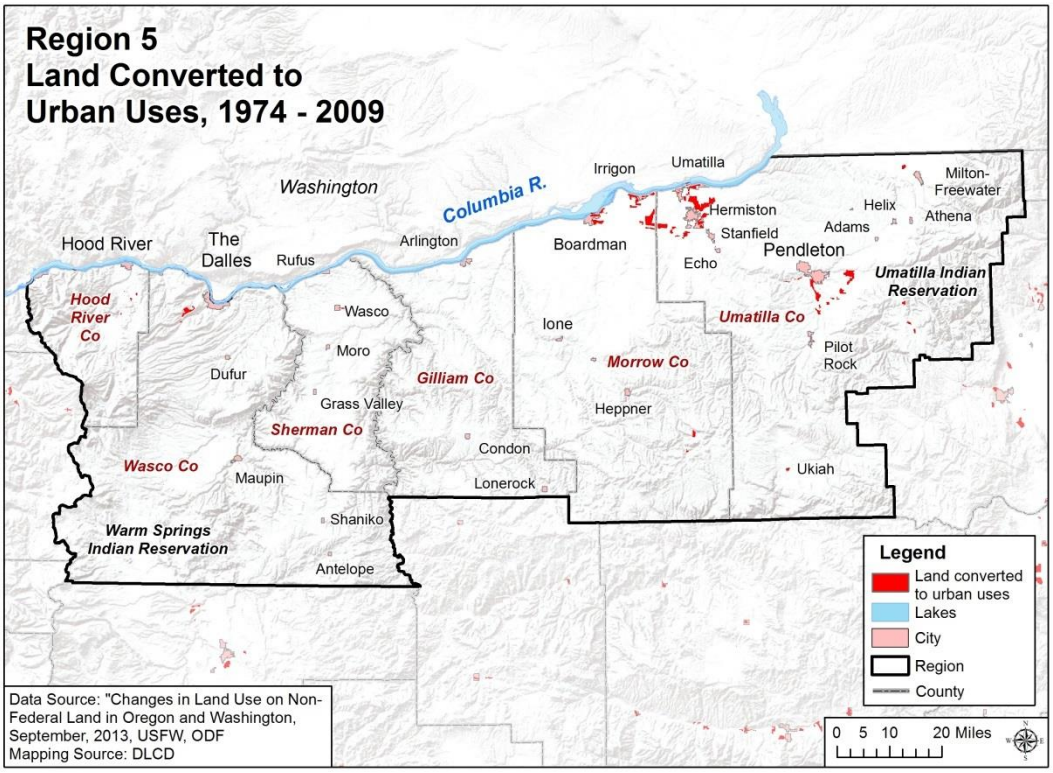
Caithness Shepherds Flat Wind Farm—located in both Morrow and Gilliam Counties—officially opened in 2012 and is one of the largest land-based wind farms in the world. Built entirely on private land, it "deploy[s] 338 wind turbines across 32,100 acres to generate 845 megawatts of clean energy..." (https://caithnessshepherdsflat.com/project-overview-2/, 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

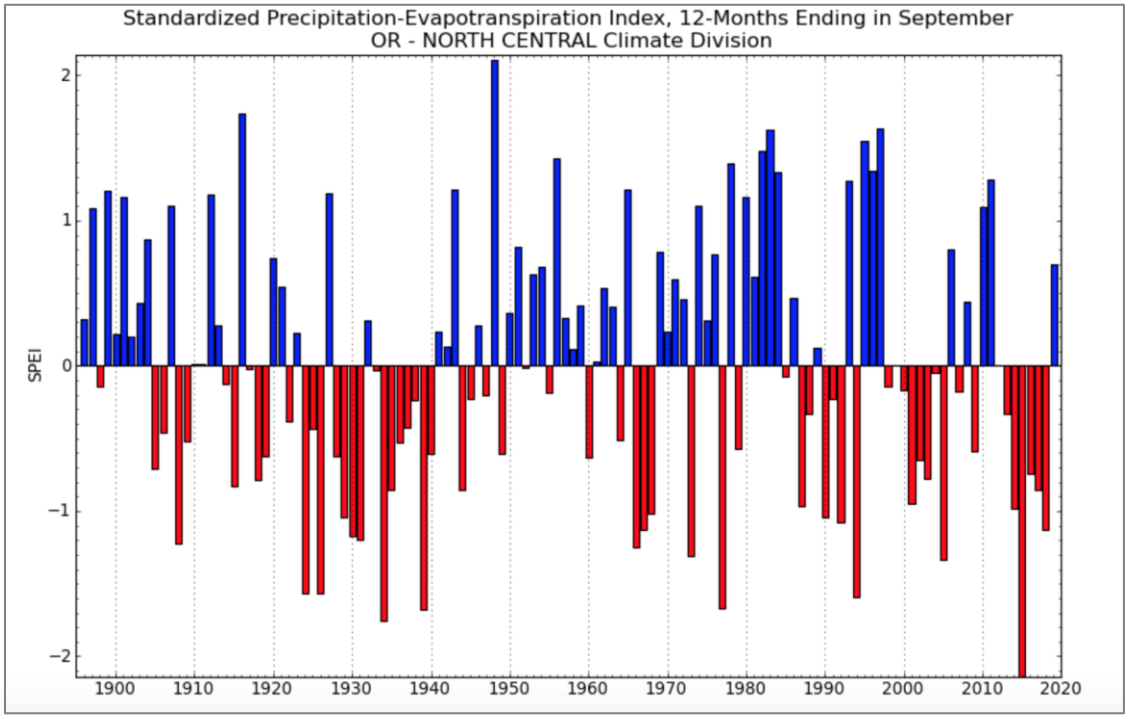
Sources: Taylor Hatton (1999); Oregon Secretary of State's Archives Division; NOAA's Climate at a Glance; Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt; personal communication, Kathie Dello, Oregon Climate Service, Oregon State University



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

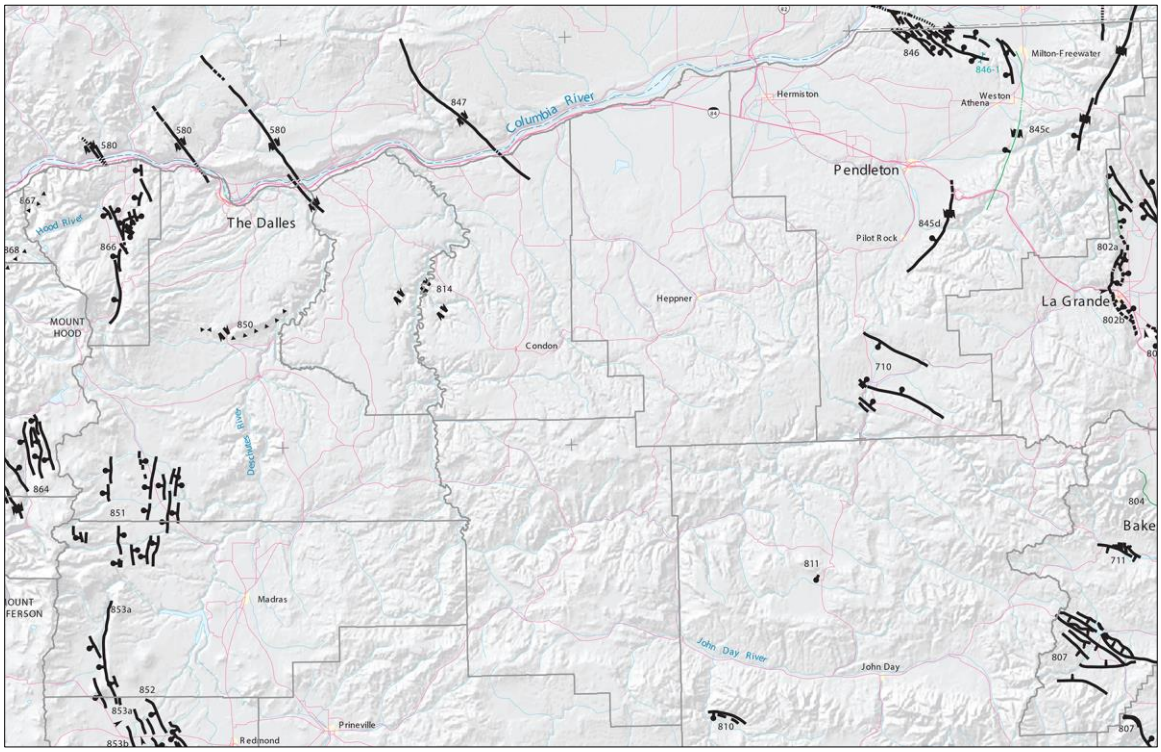
With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based the history of drought declarations, the counties' social vulnerability ratings, and the potential for drought to impact the agricultural 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

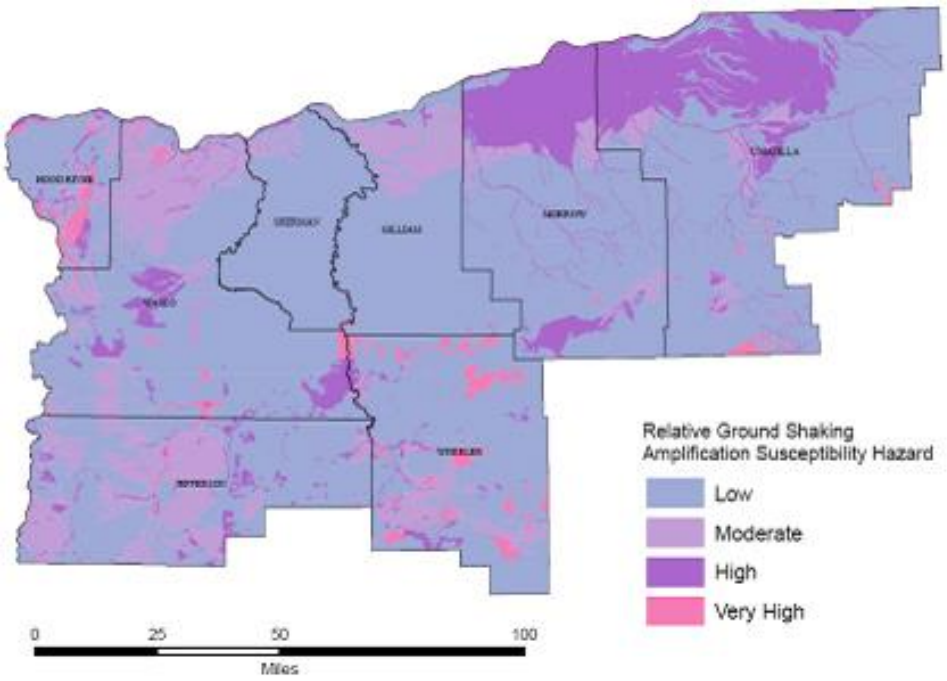


Source: Modified from Personius, et al. (2003)

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.

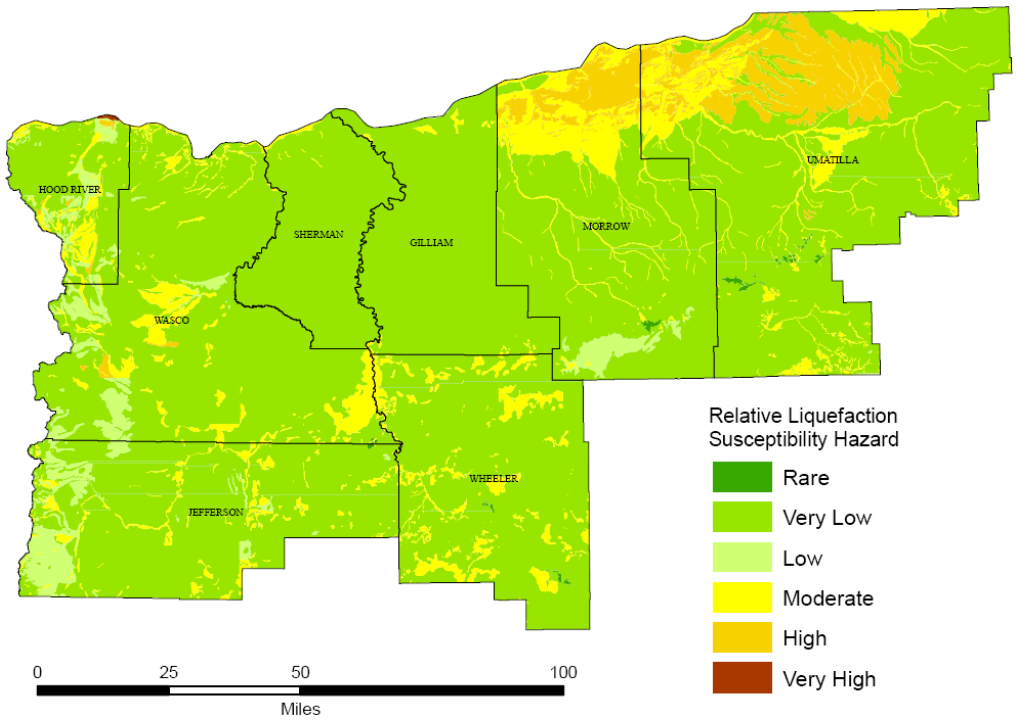
Figure 2-230. Relative Ground Shaking Amplification Hazard in Region 5



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.

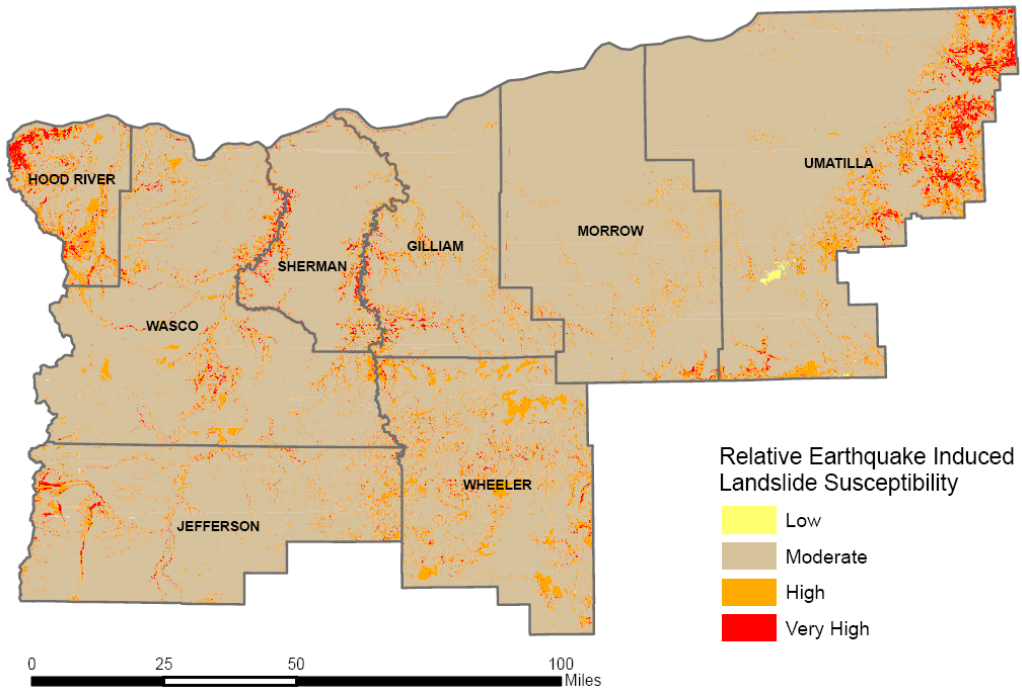
Figure 2-231. Relative Liquefaction Susceptibility Hazard in Region 5



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

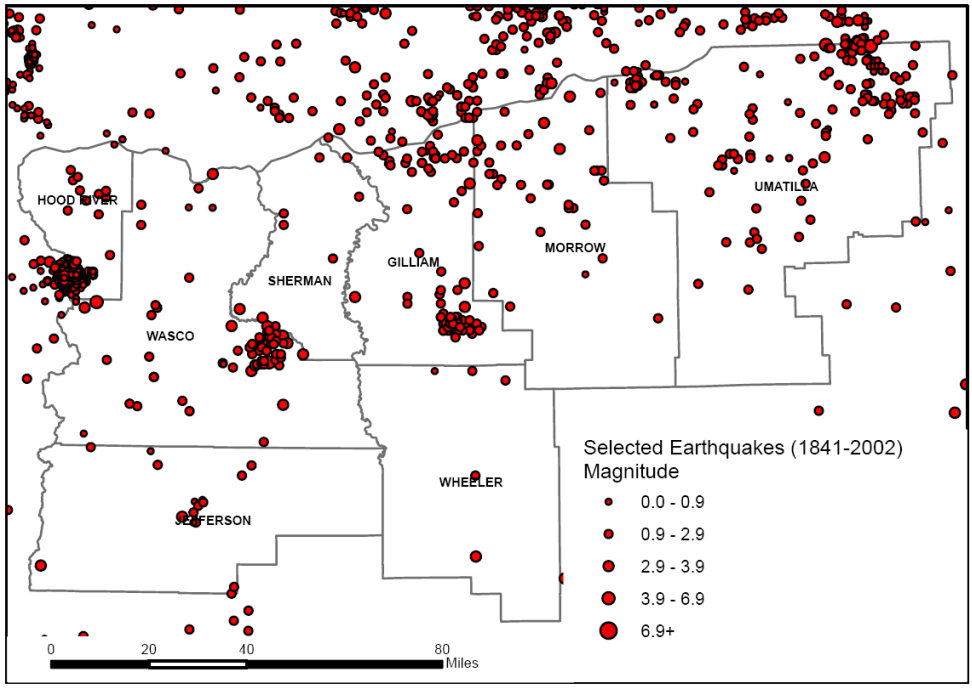


Source: Burns, 2007

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

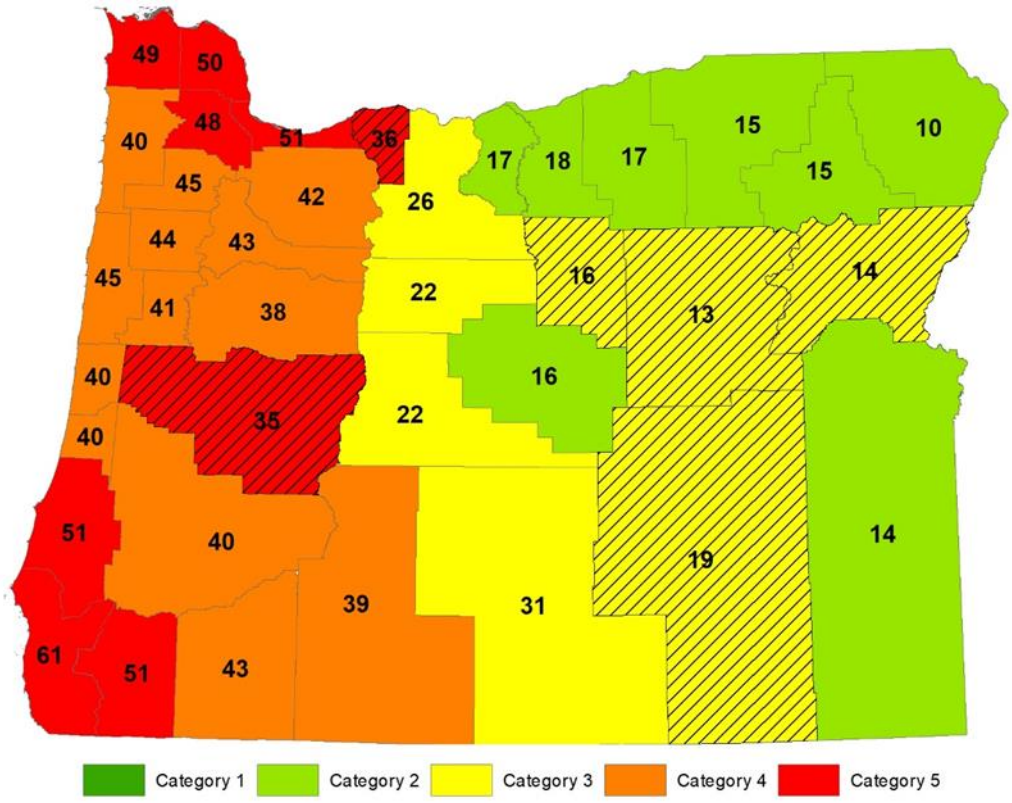
The probability of damaging earthquakes varies widely across the state. In Region 5, the hazard is dominated by local faults and background seismicity.

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

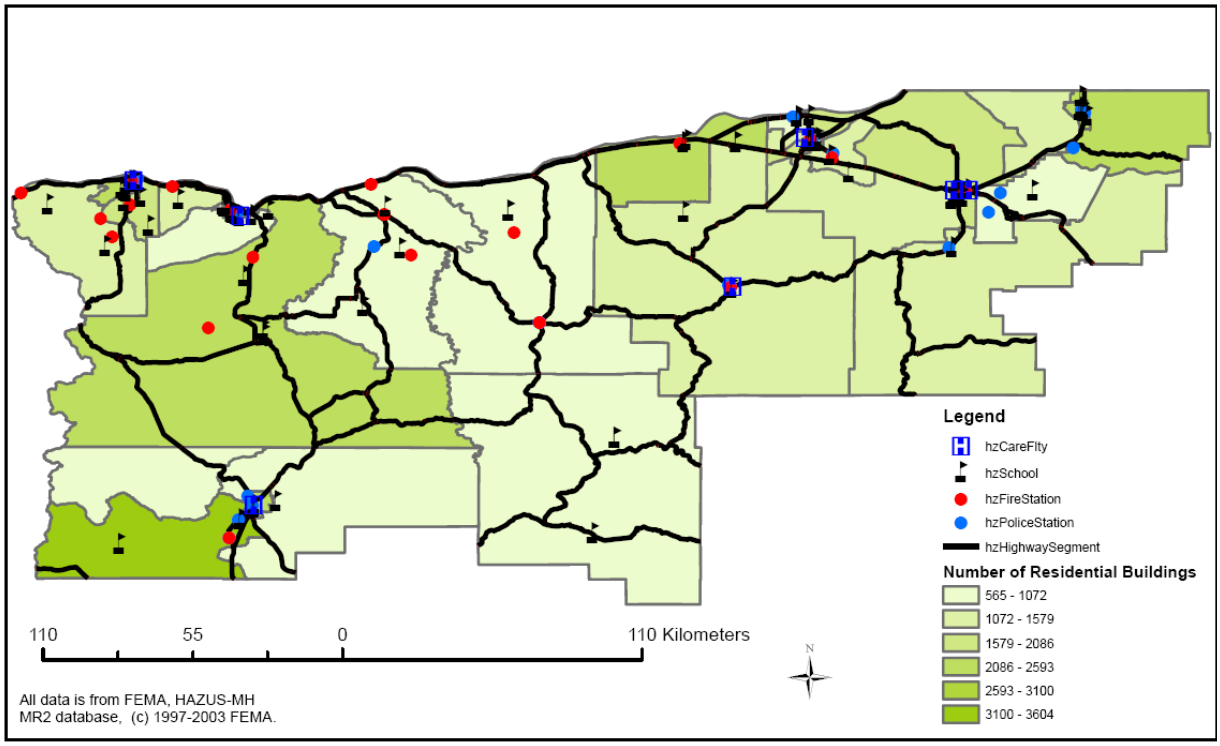
Source: Most recent local hazard vulnerability analyses (Table 2-4)

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	100%	60%	50%	0%	75%	50%
Police stations	100%	0%	100%	0%	79%	0%
Schools	100%	21%	43%	33%	88%	27%
Bridges	100%	100%	100%	88%	99%	98%
Economic losses to infrastructure:						
Highways	$0.1 mil	$37.2 mil	$43.5 mil	$33.1 mil	$77 mil	$35.5 mil
Airports	$3.2 mil	$7.3 mil	$1.7 mil	$2 mil	$16.5 mil	$13.3 mil
Communications	0	$0.08 mil	0	0	$0.05 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

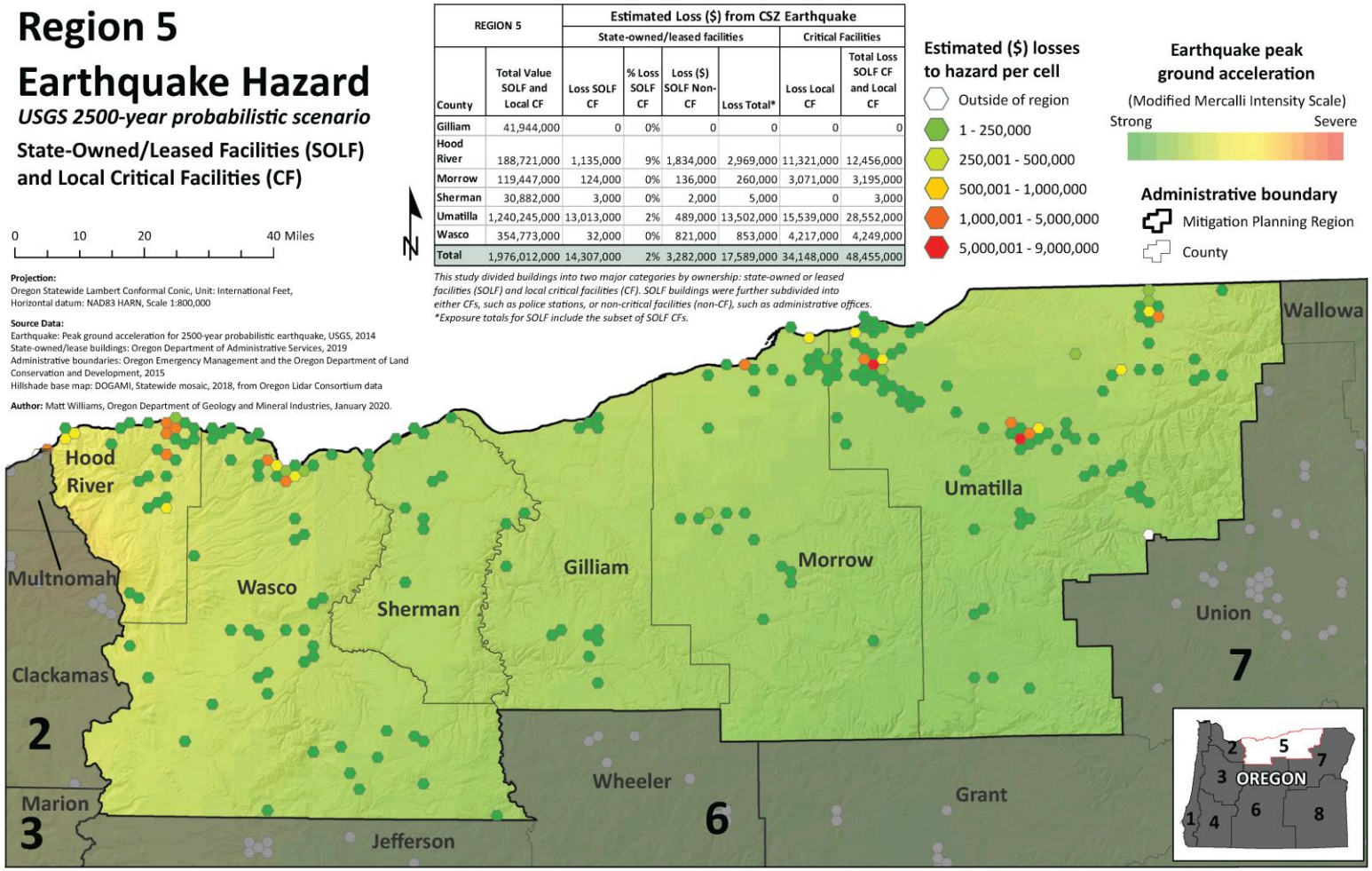
For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a 2500-year probabilistic earthquake scenario in Region 5. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (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

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

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 house-less.

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).

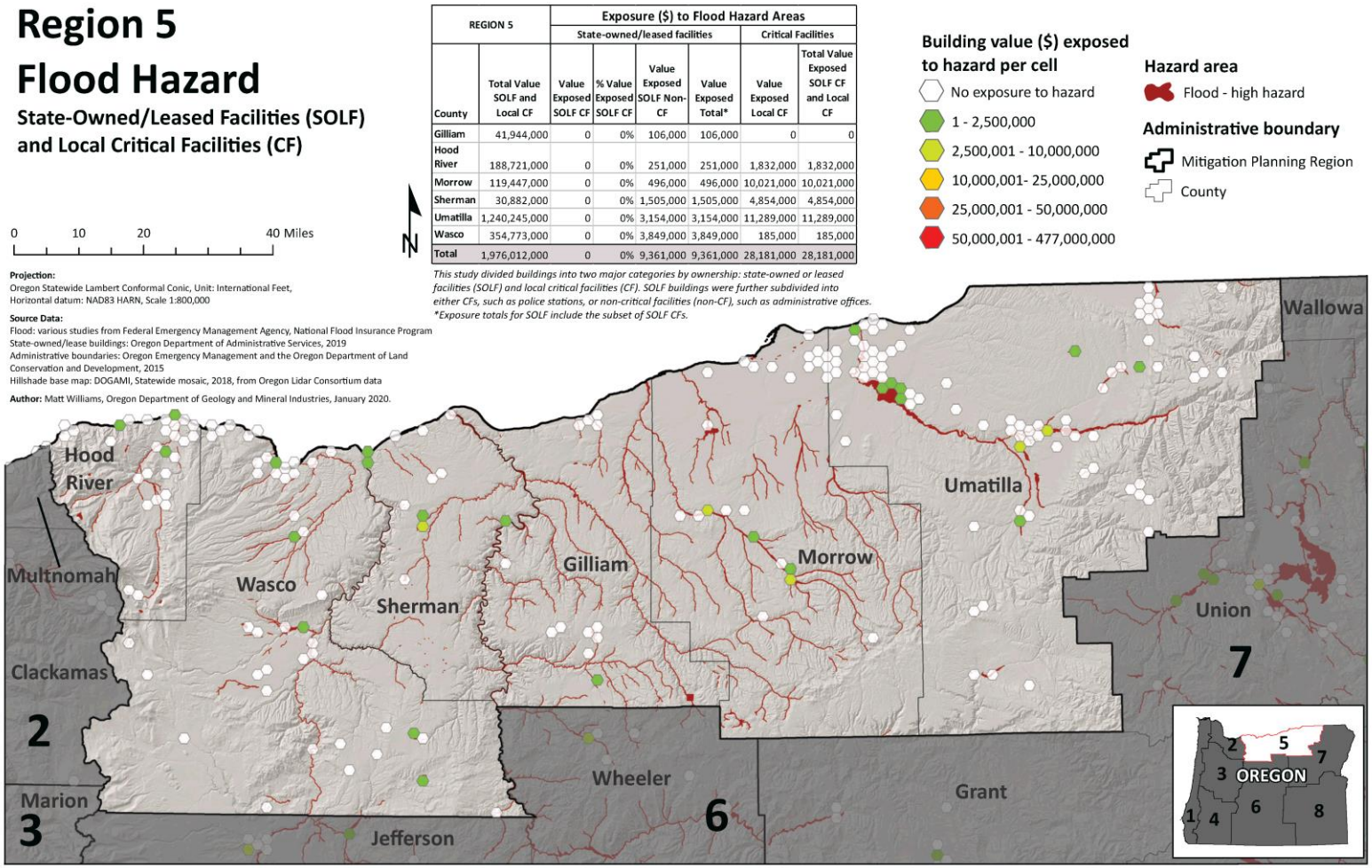
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. The city 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

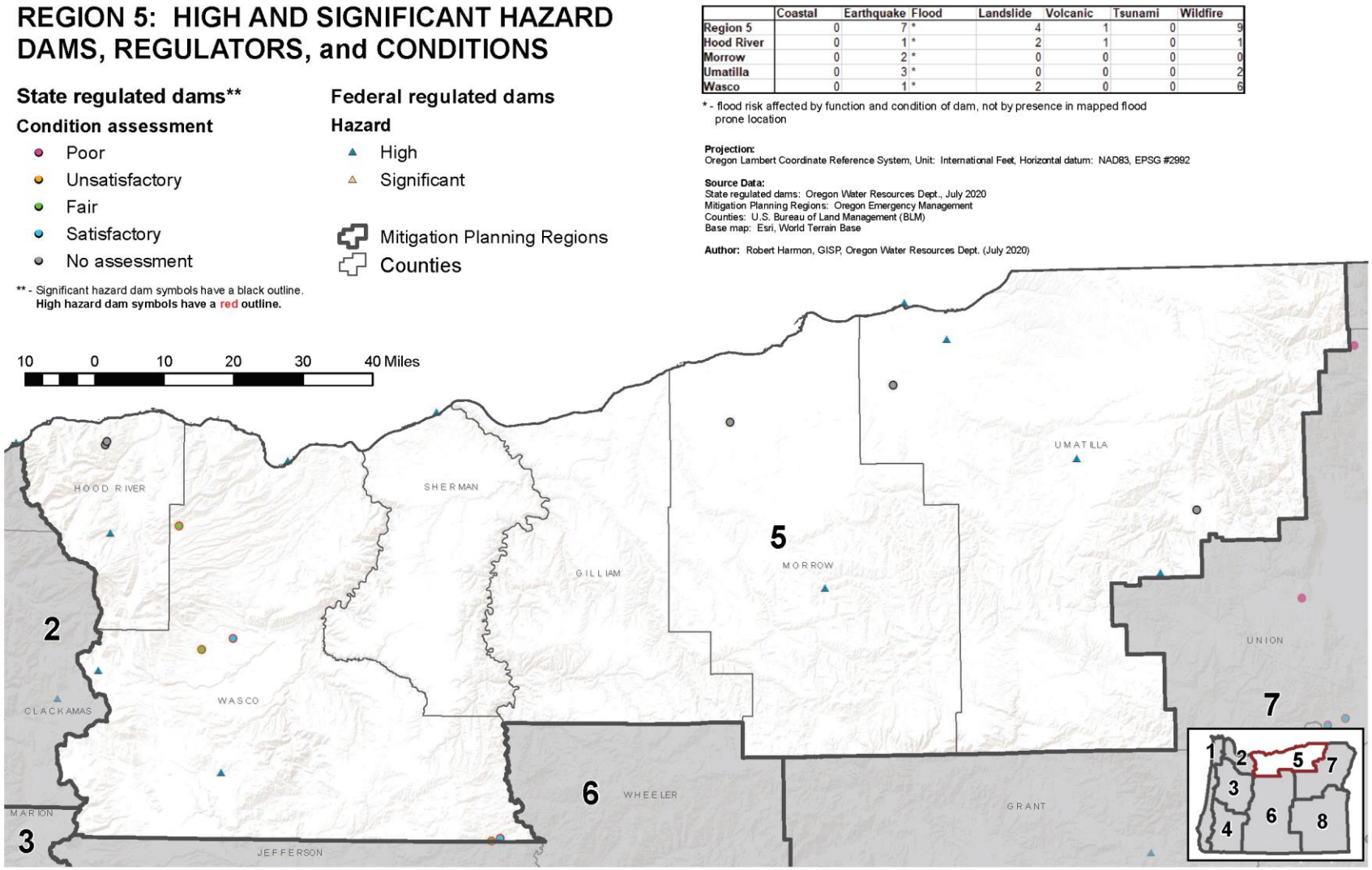
State-Regulated High Hazard Dams not Meeting Safety Standards

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

* - flood risk affected by function and condition of dam, not by presence in mapped flood prone location

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 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

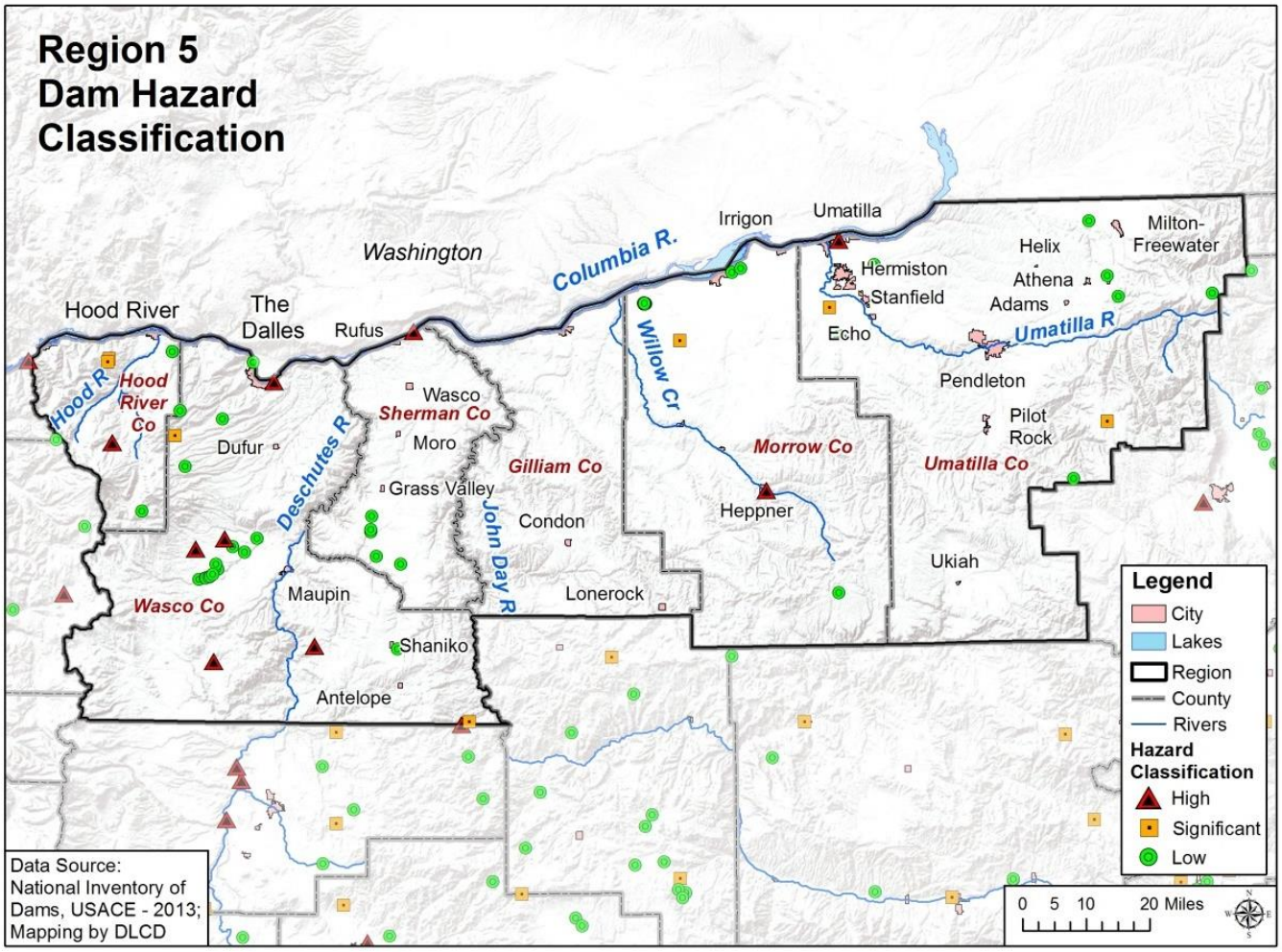
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), no Region 5 counties are considered "most vulnerable 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.

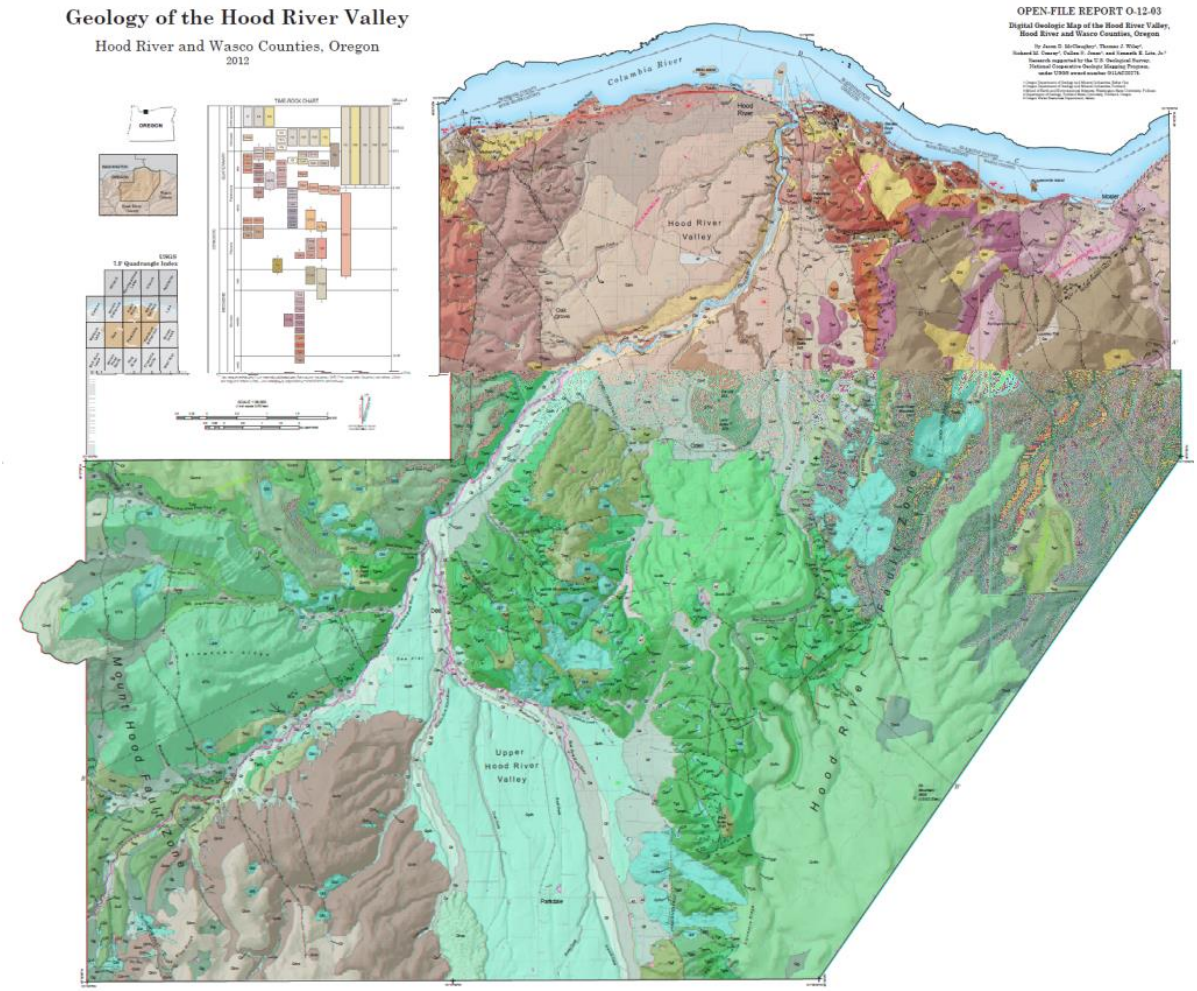
Landslides

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

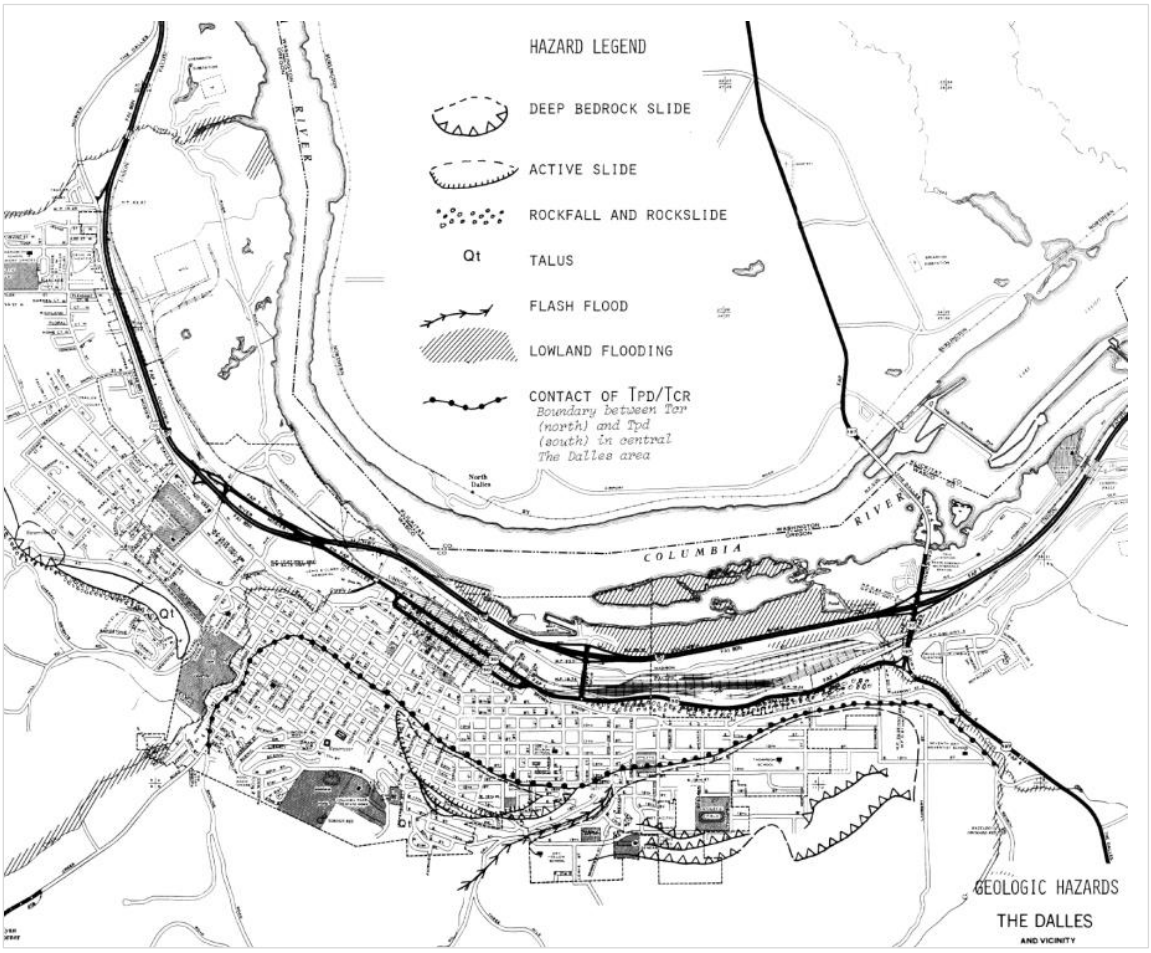
Table 2-527. Historic Landslides in Region 5

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.

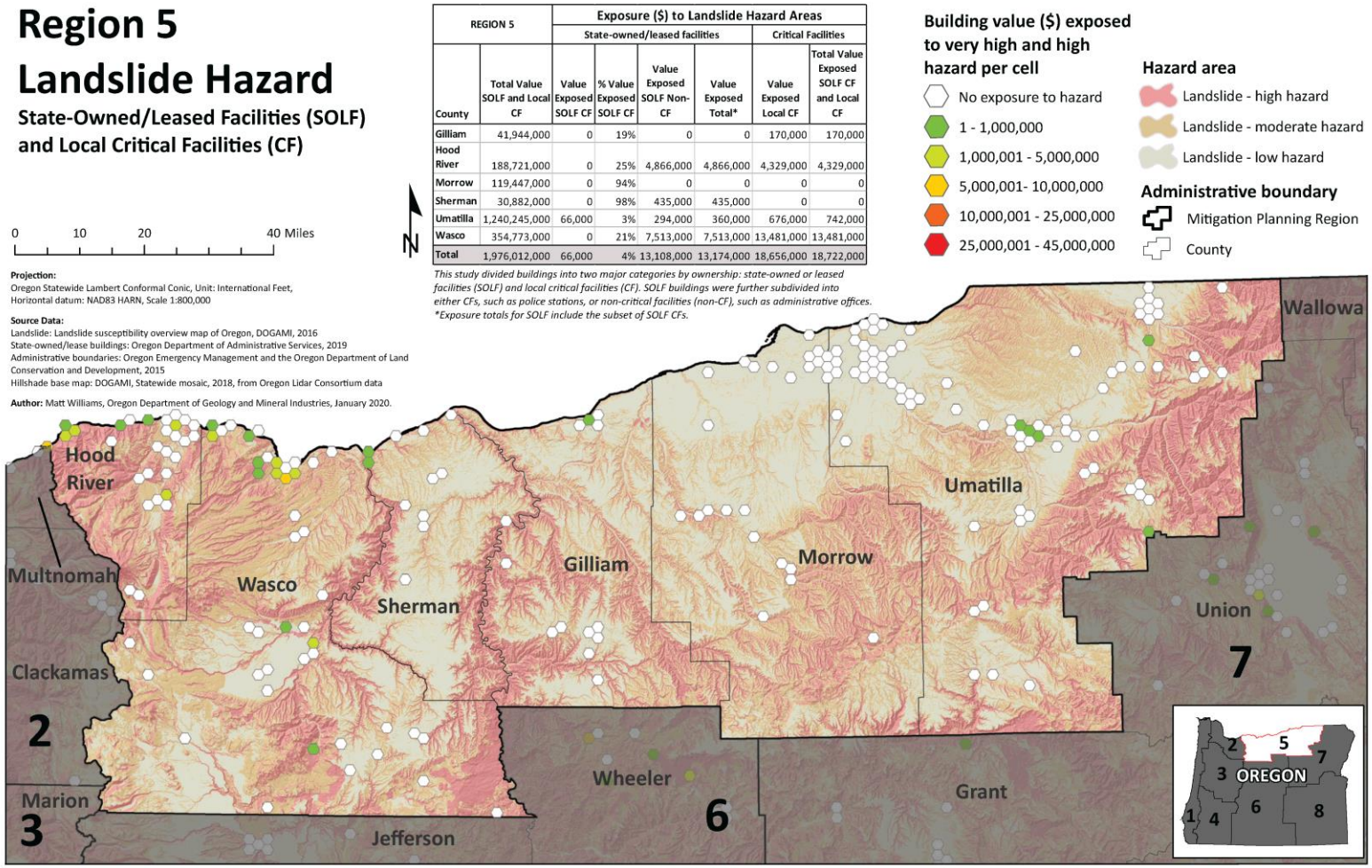
DOGAMI has recently published numerous earthquake and natural hazard reports. **Open-File Report O-11-16, Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon** (Burns W. J., et al., 2011b) provides details about the landslide hazard and risk in 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

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, 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

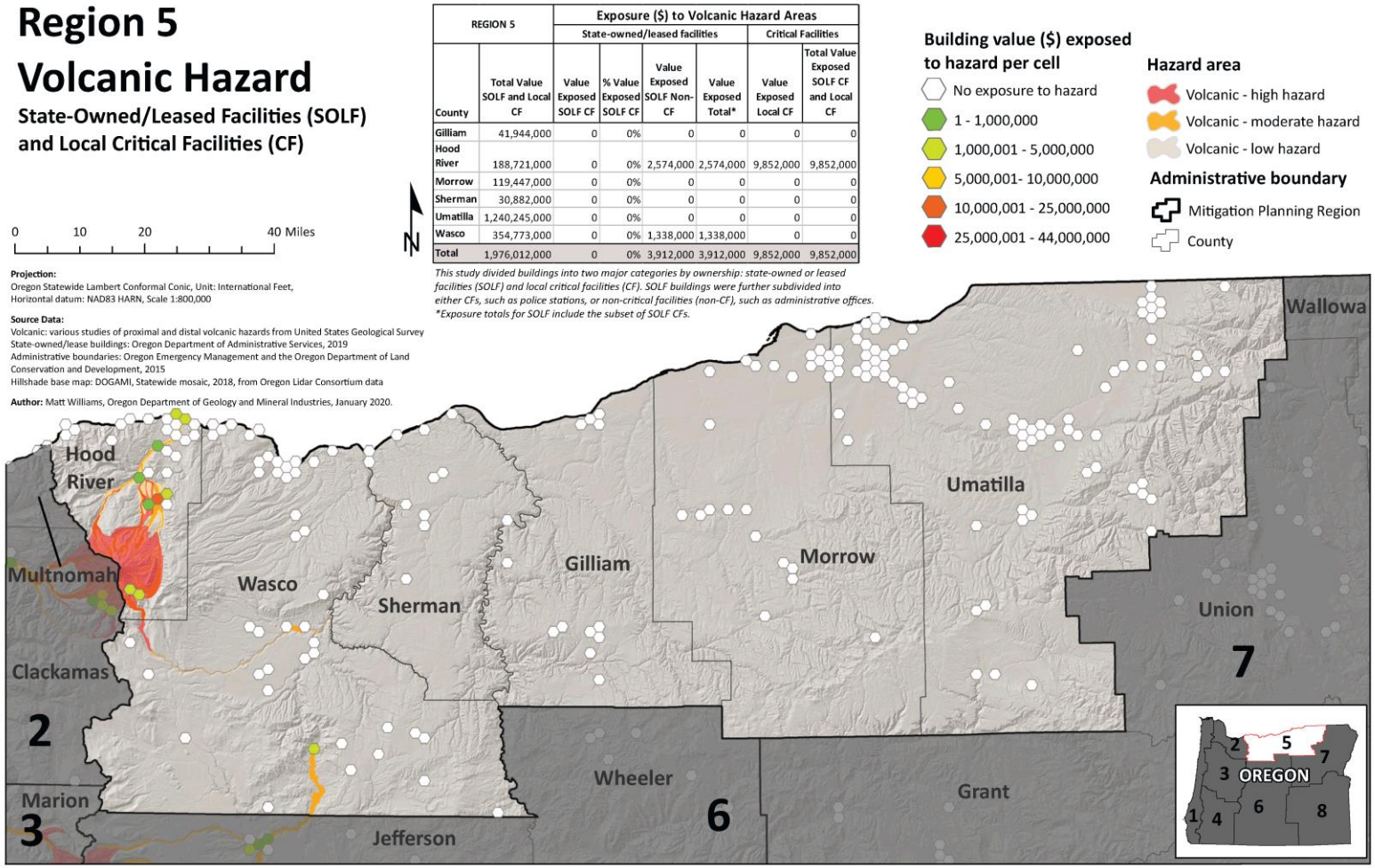
	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	VL	VH	M	VL	M	H

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

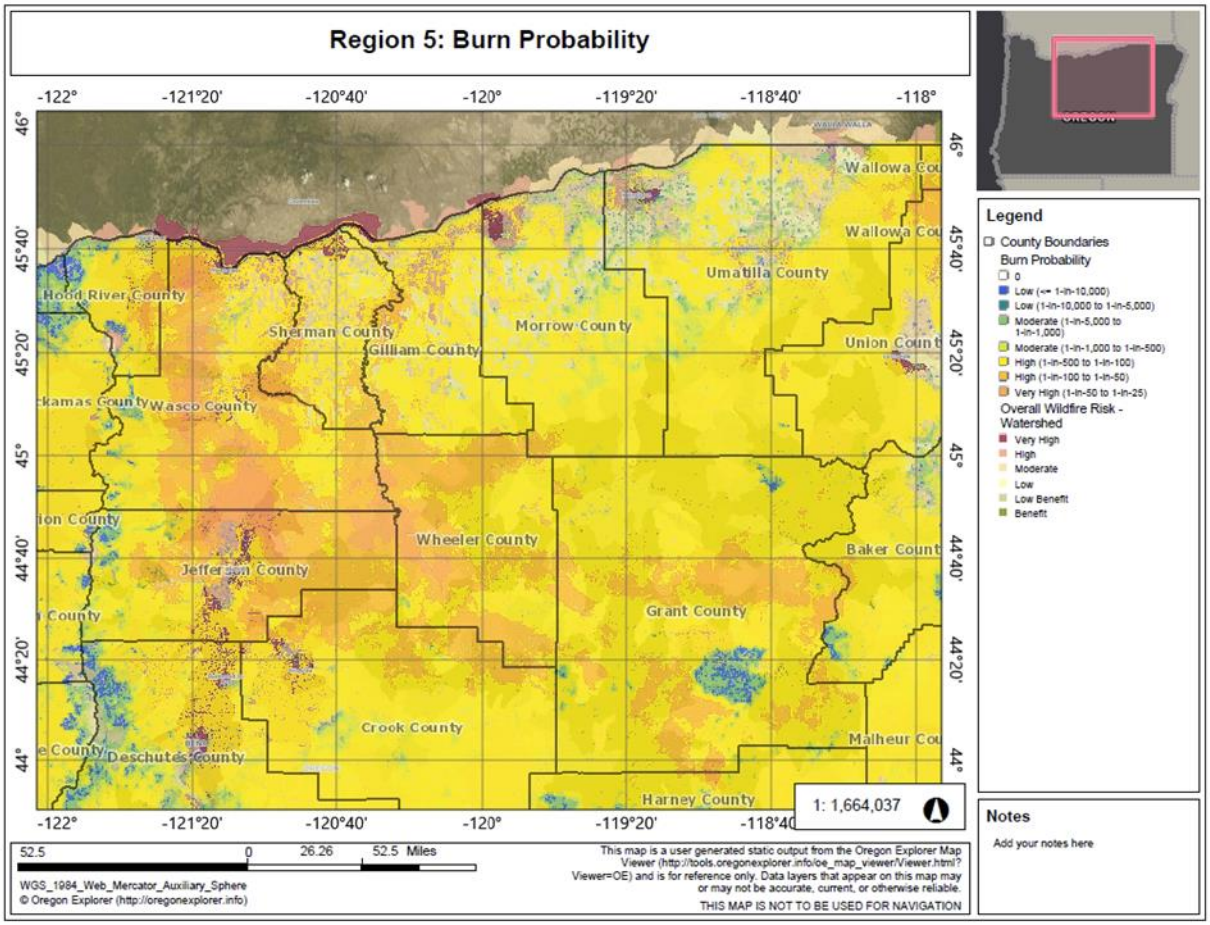
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

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.

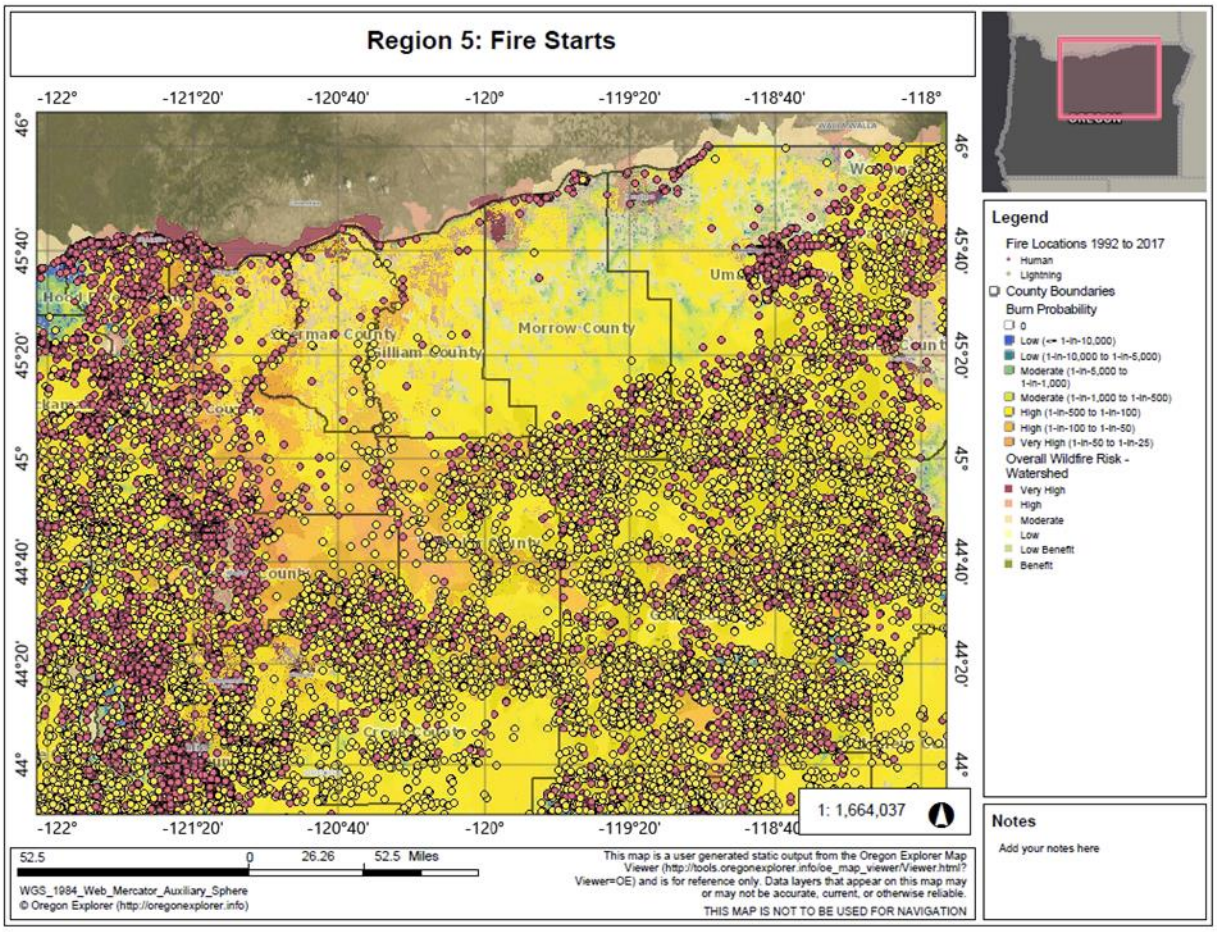
A healthy forest across this region is never free of insects, disease, or other disturbances, and infestations can increase the likelihood of ignition and fire spread. The potential for extreme fire behavior is of concern for any valued property, whether it be a structure or scenic vista at the

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

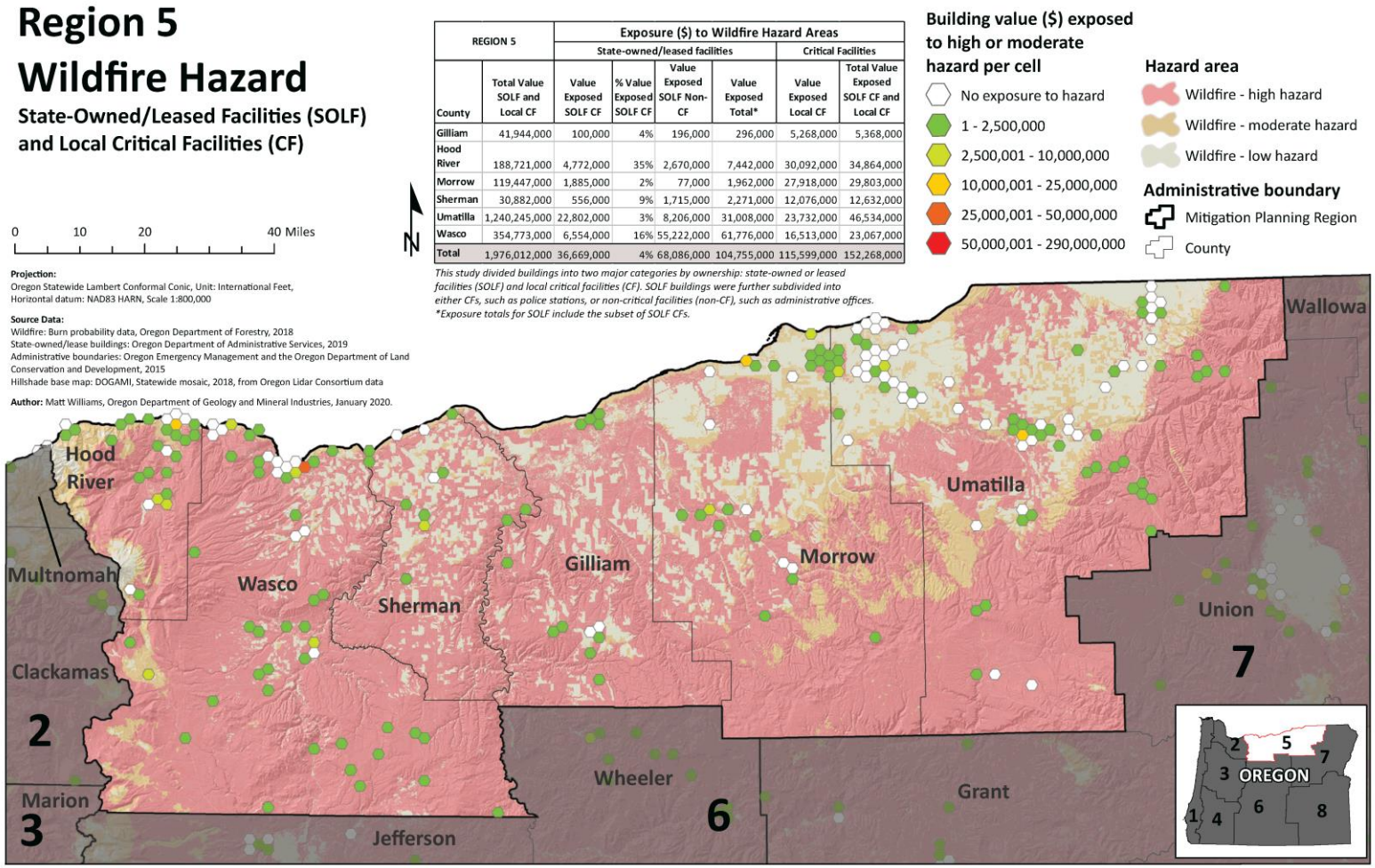
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

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

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

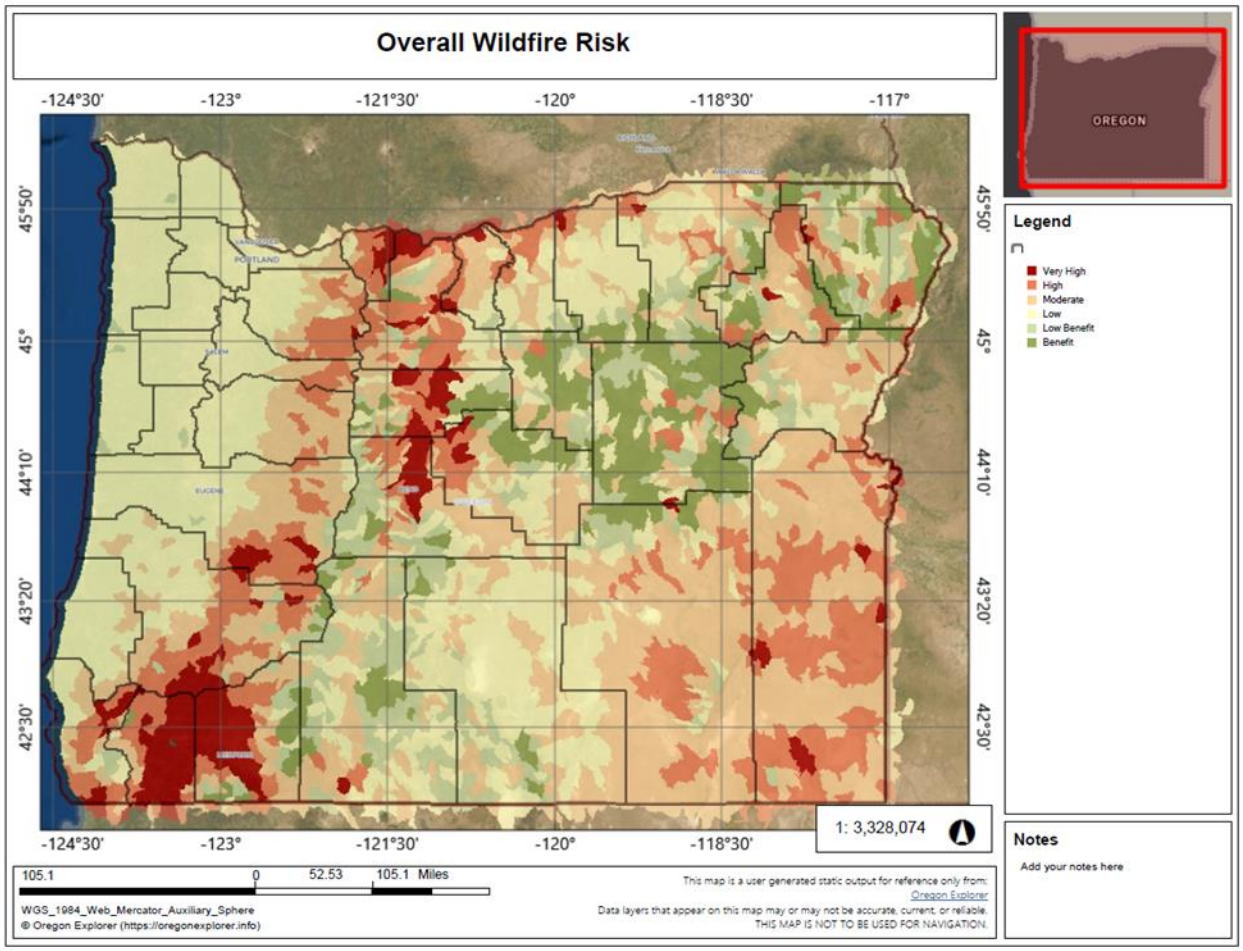
Table 2-544. Risk of Wildfire Hazards in Region 5

	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.

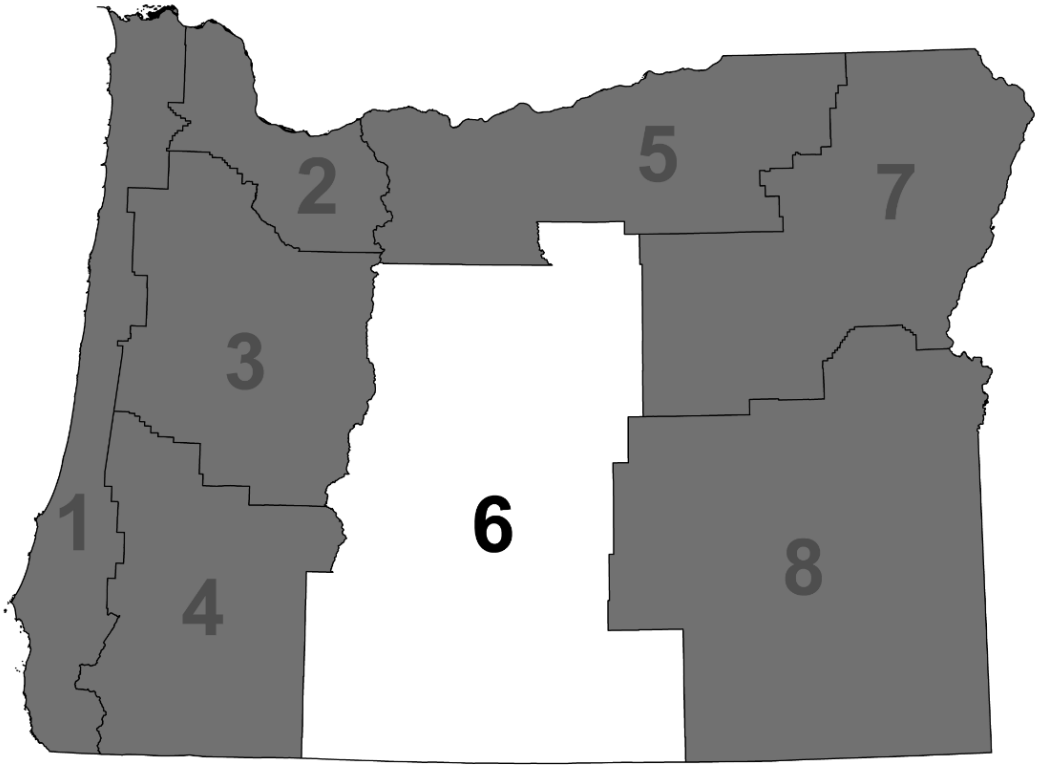
Risk

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

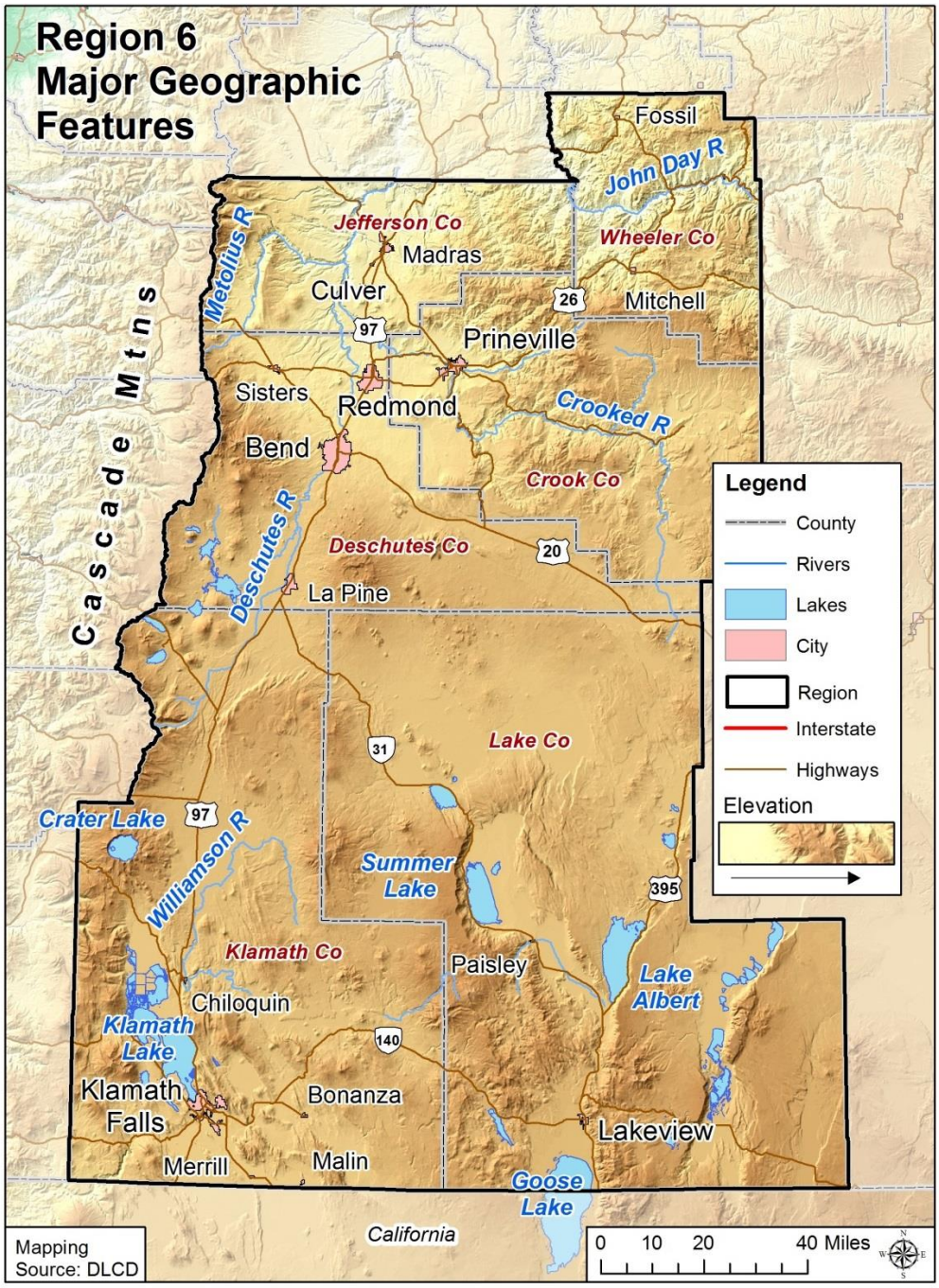
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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.

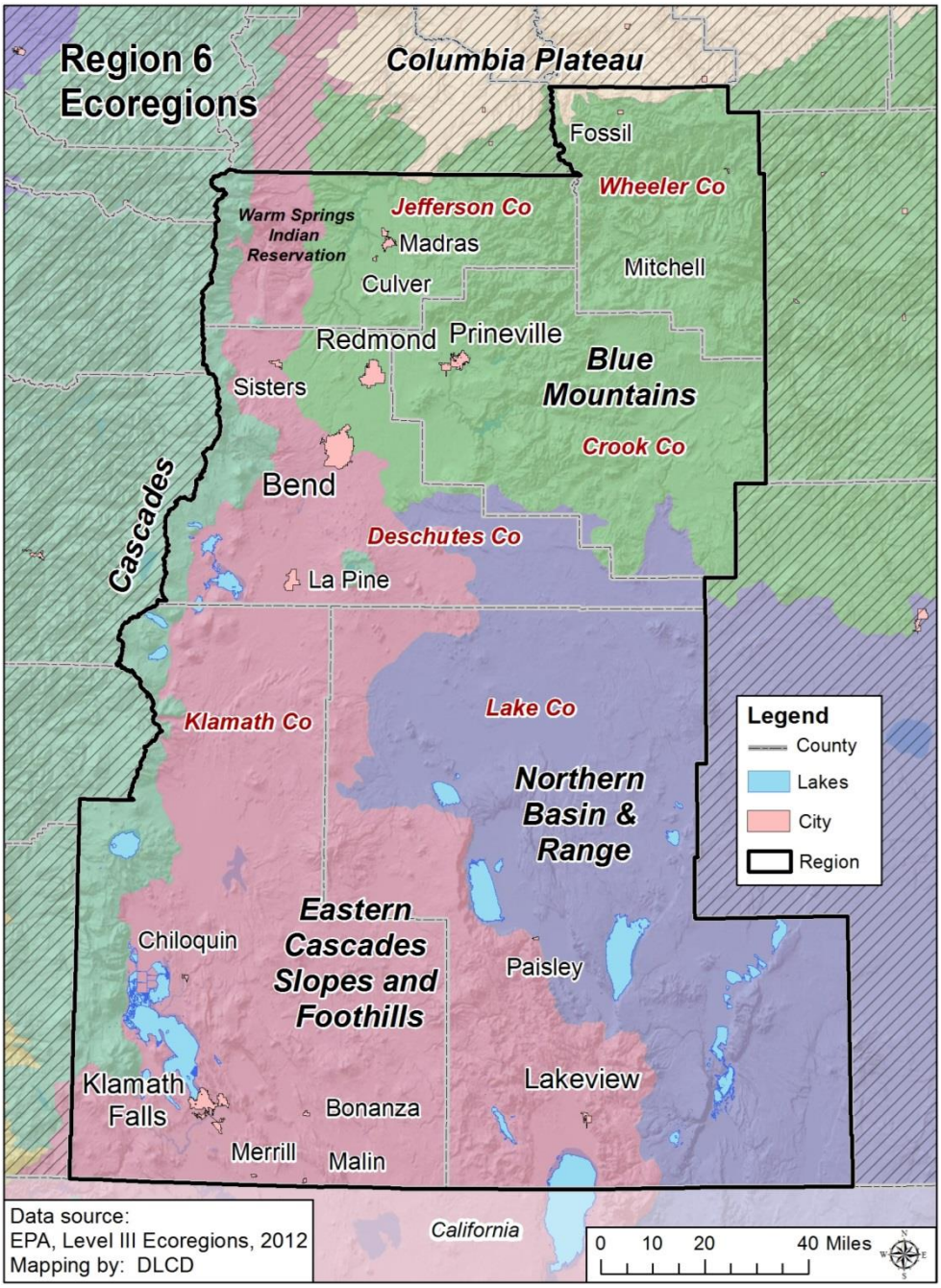
Figure 2-248. Region 6 Major Geographic Features



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.

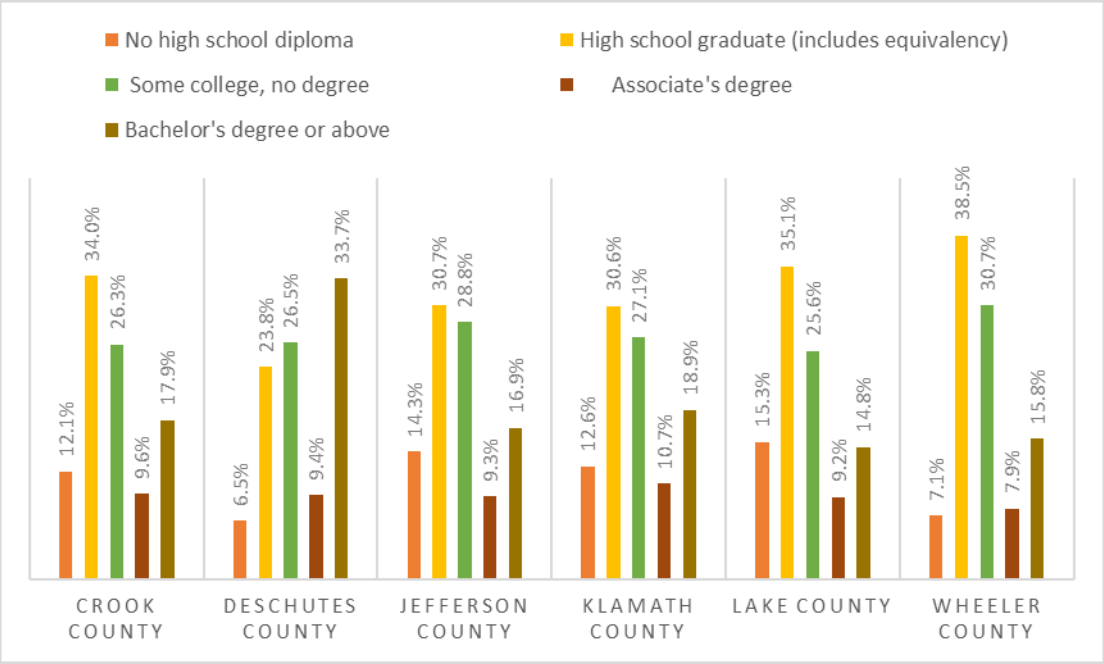
Education Level

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).

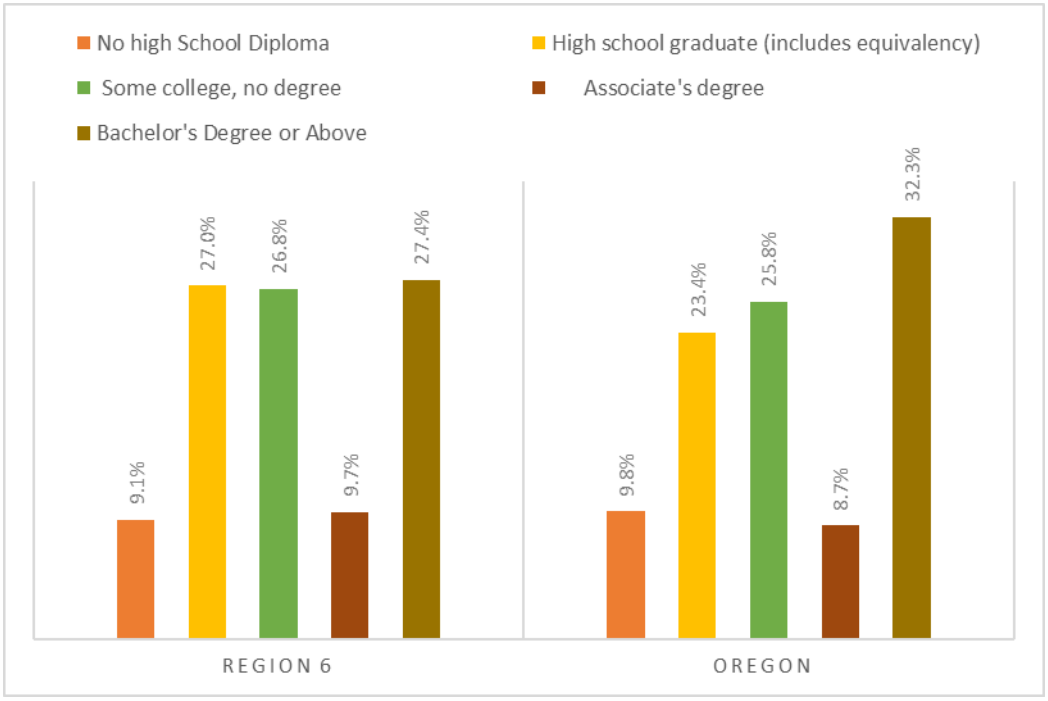
Approximately 27% of residents in Region 6 have a bachelor's degree or higher, which is about five percentage points below the statewide share. The portion of the population with an associate's degree is slightly higher vis-à-vis the state, as is the share of people with some college credit and a high 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

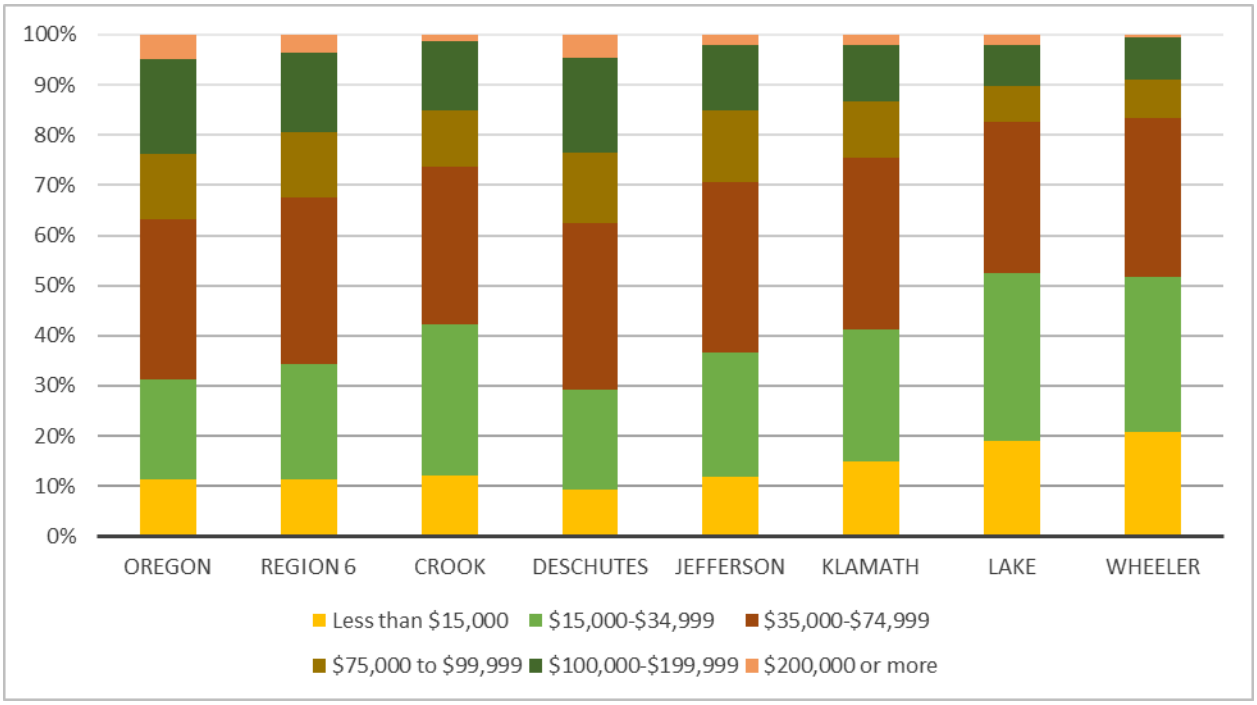
Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

* 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.

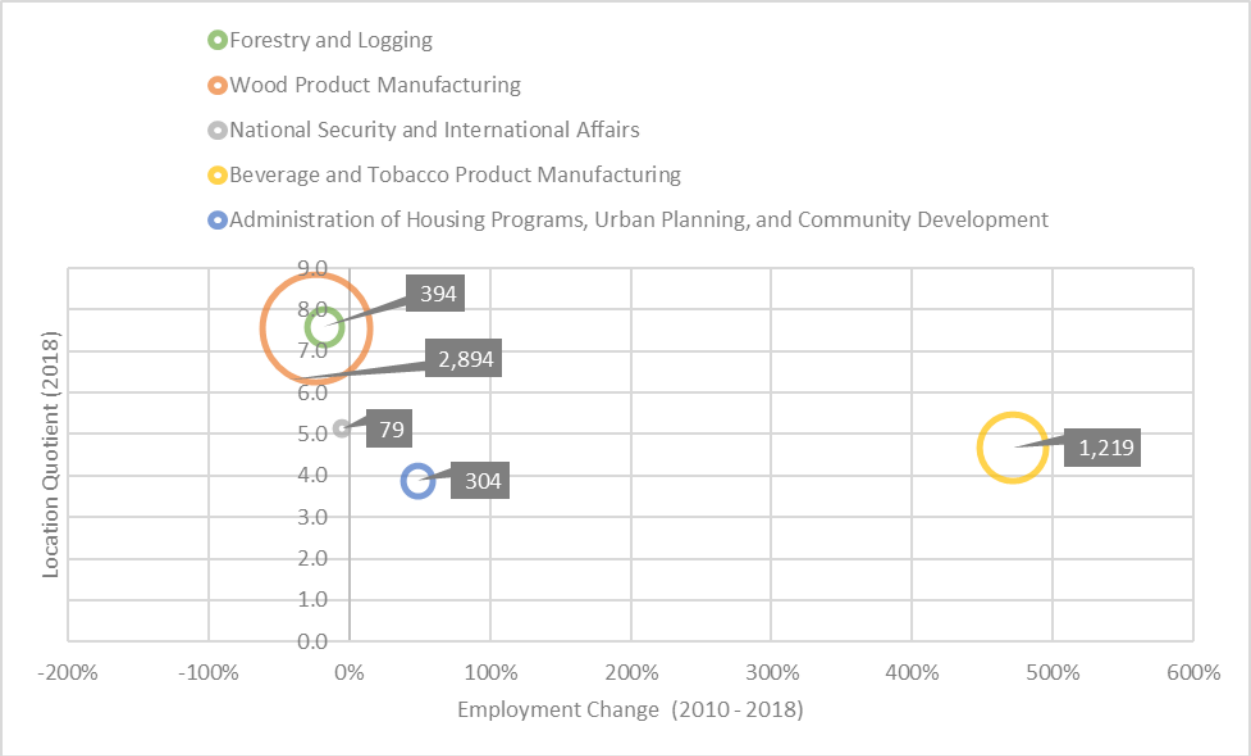
Table 2-571. Most Concentrated Industries and Employment Change in Region 6, 2018

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.

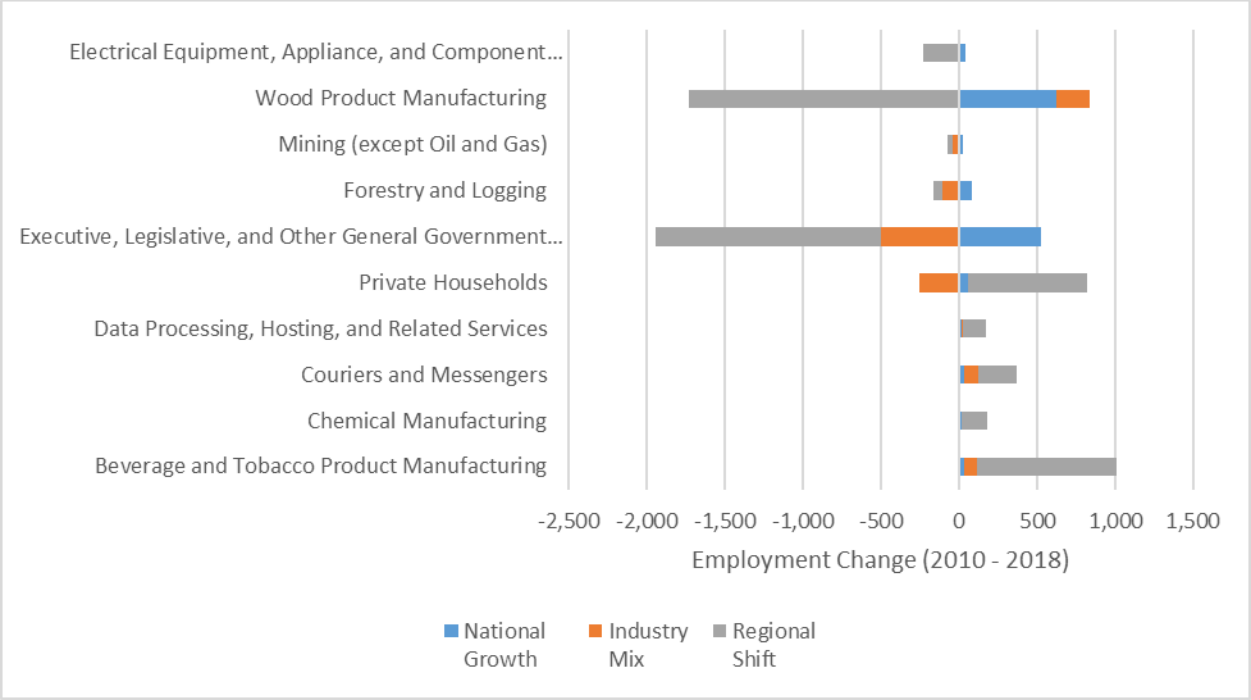
Employment in the Couriers and Messengers subsector is likely a reflection of the global revolution in retail sales. With an increased share of retail shopping occurring online, growth in transportation, storage, and distribution infrastructure and employment has been increasing nationally. Although 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

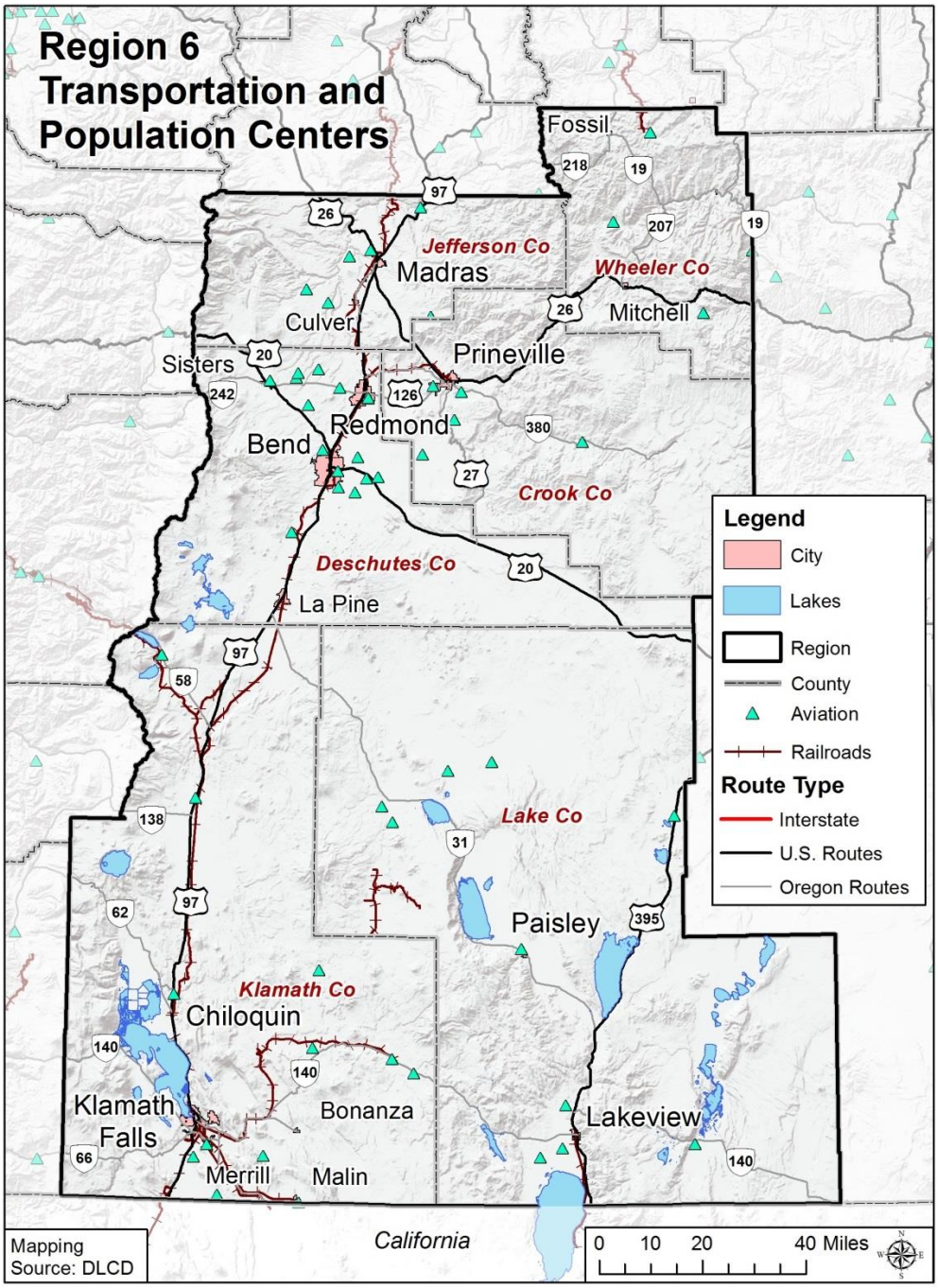
Roads

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.

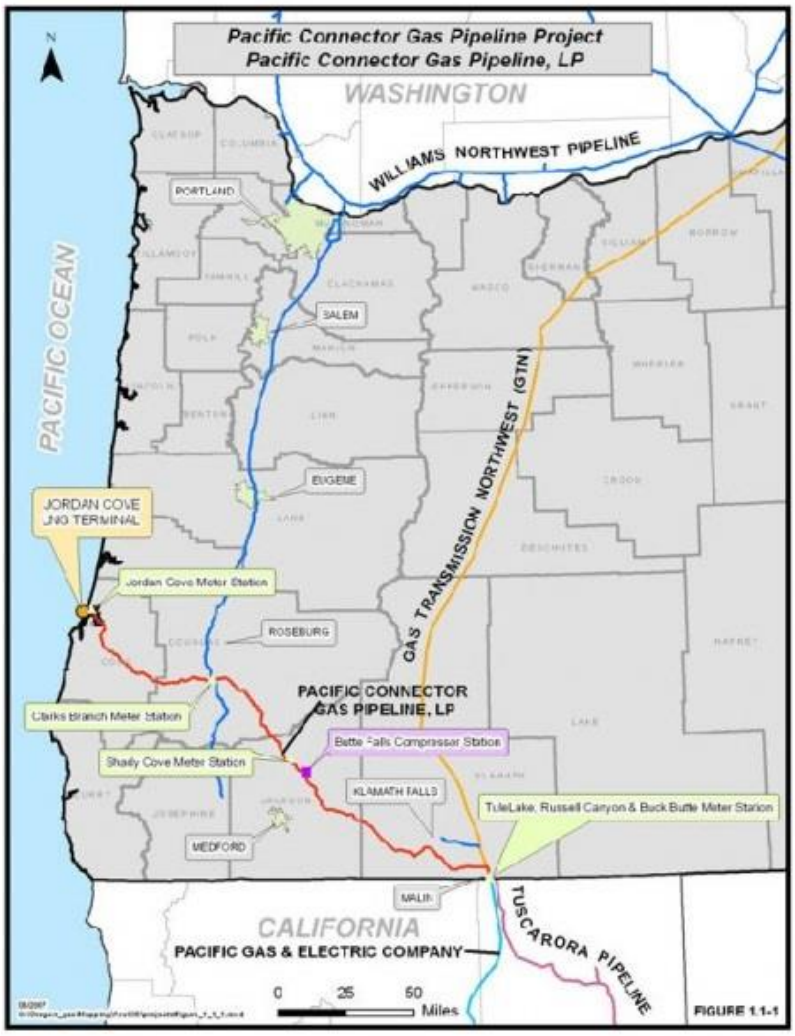
Hydropower

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%

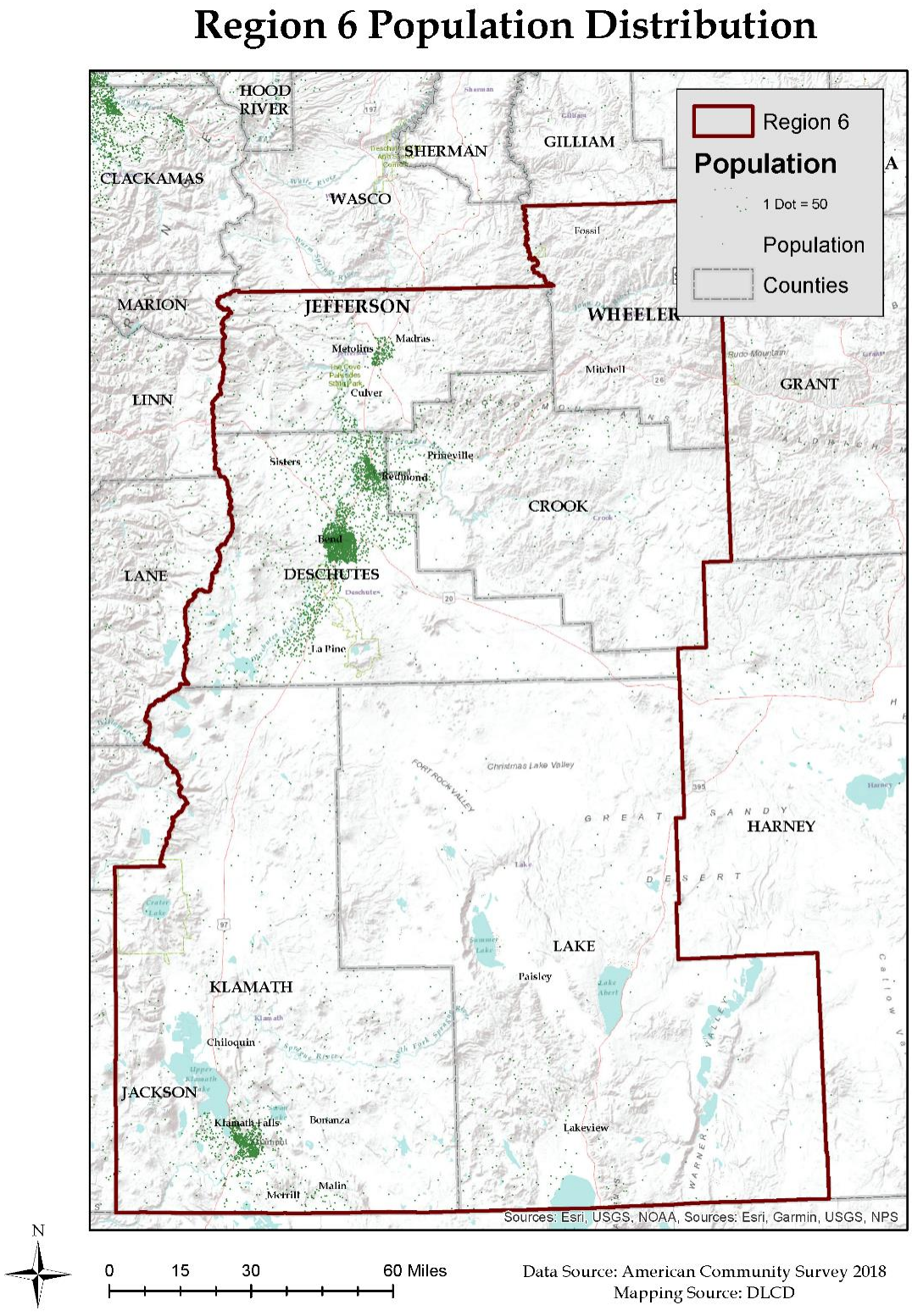
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

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.

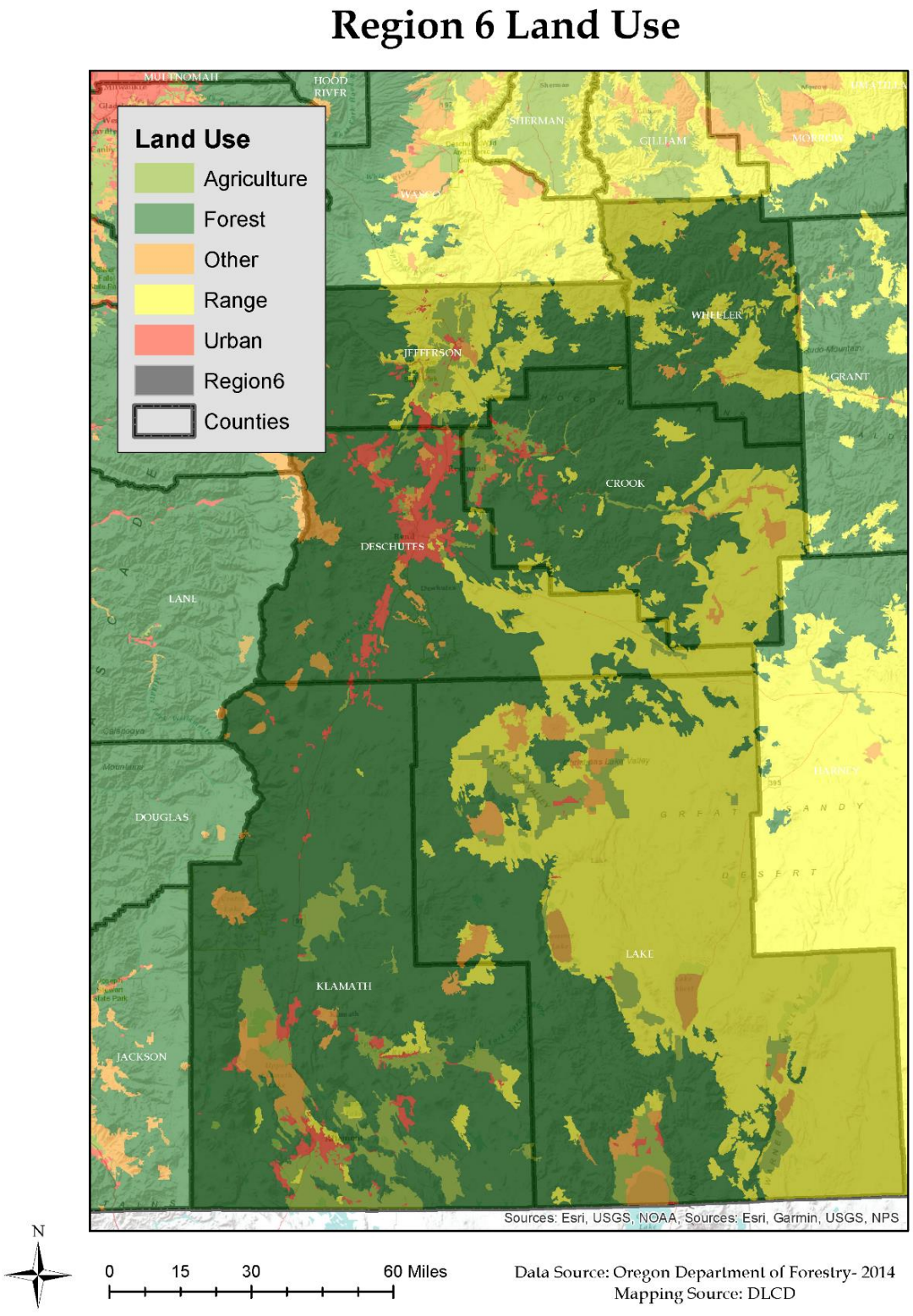
Responding to rapid growth and changing demographics, in 2011 Deschutes County completed a multi-year effort to establish "Plan 2030." This new plan incorporates updated goals and policies, community plans, and new projects like the South County Plan, destination resort remapping, a 2030 Transportation 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.

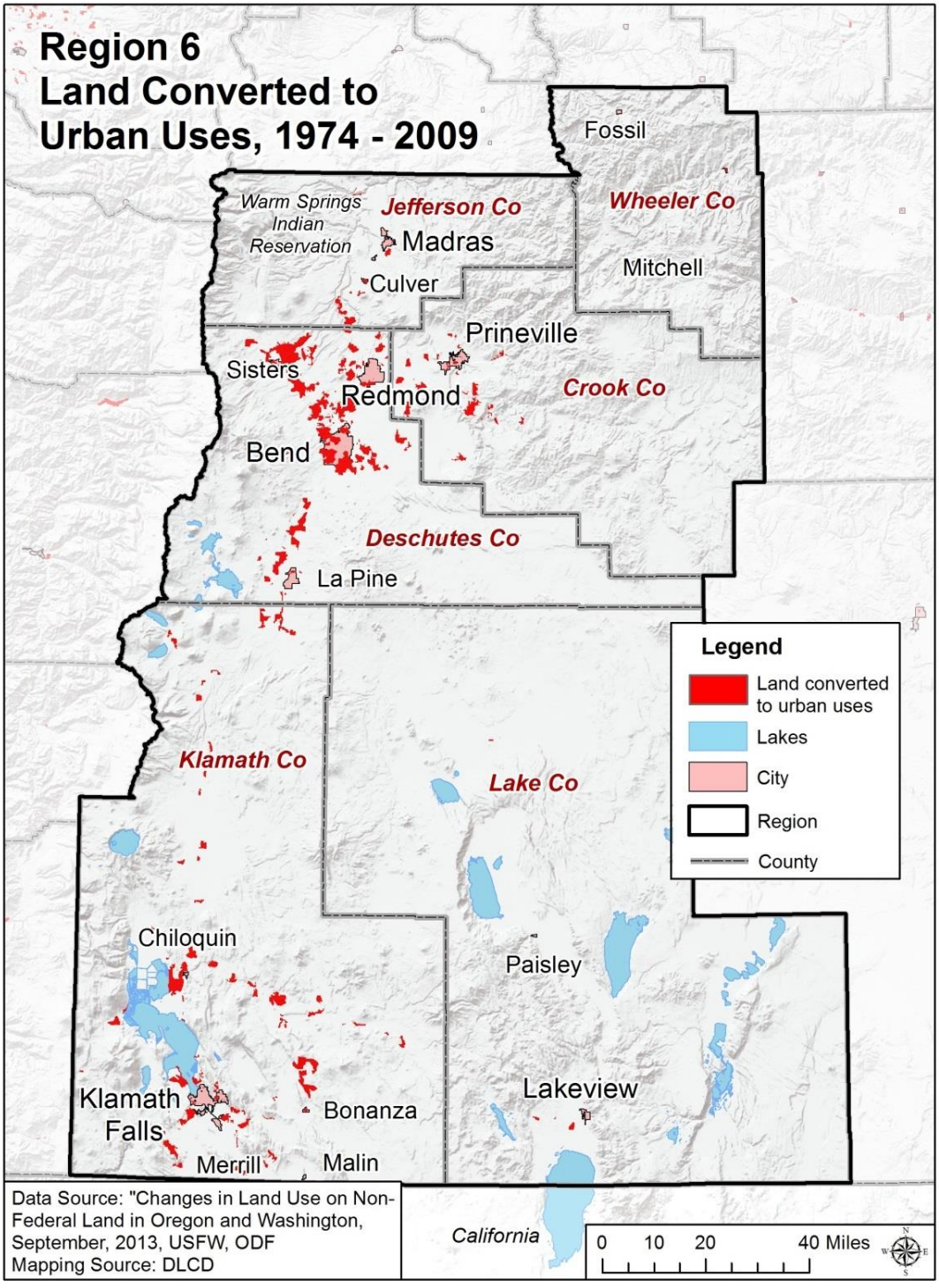
The City of Madras integrated portions of its Natural Hazards Mitigation Plan with its Comprehensive Plan; this serves as a model for other local governments.

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

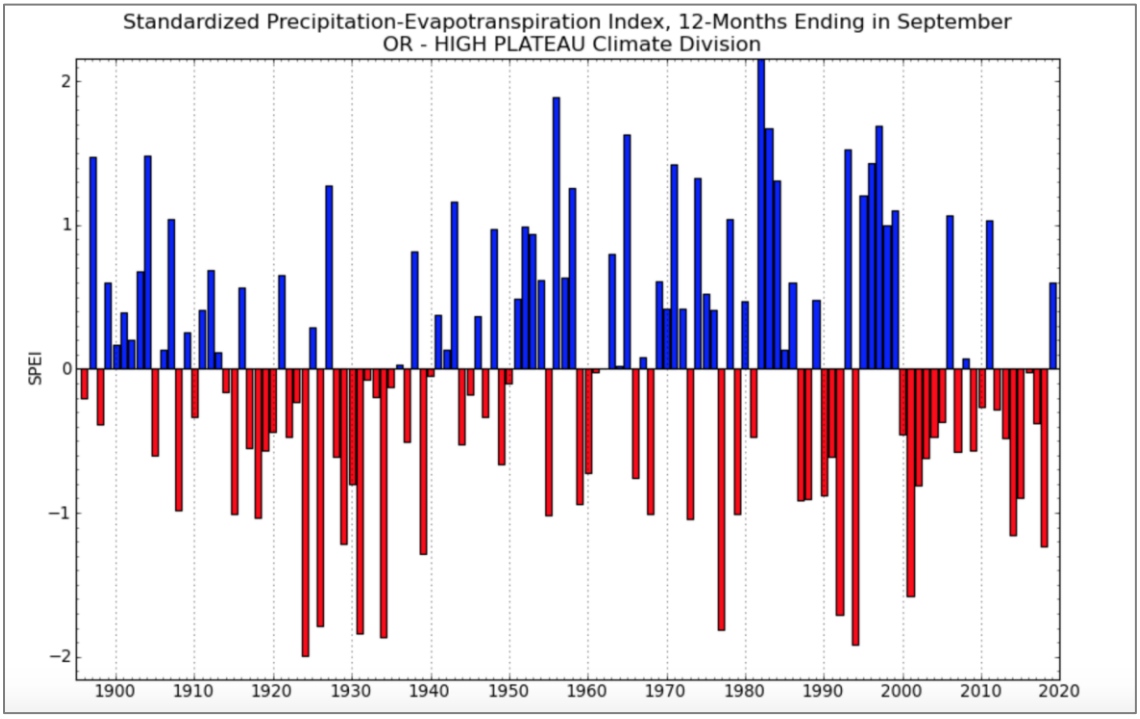
Sources: Taylor and Hatton (1999); Oregon Secretary of State's Archives Division (Governor's Executive Orders); NOAA's Climate at a Glance; Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt; personal communication, Kathie Dello, Oregon Climate Service, Oregon State 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.

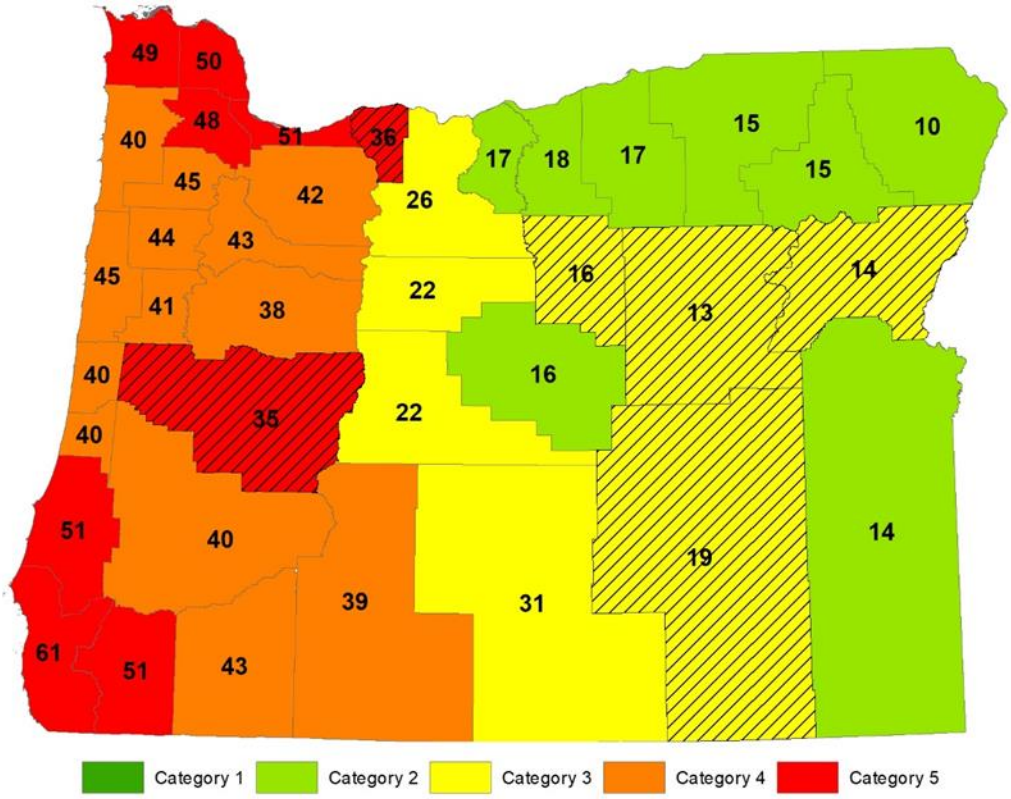
DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults

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)

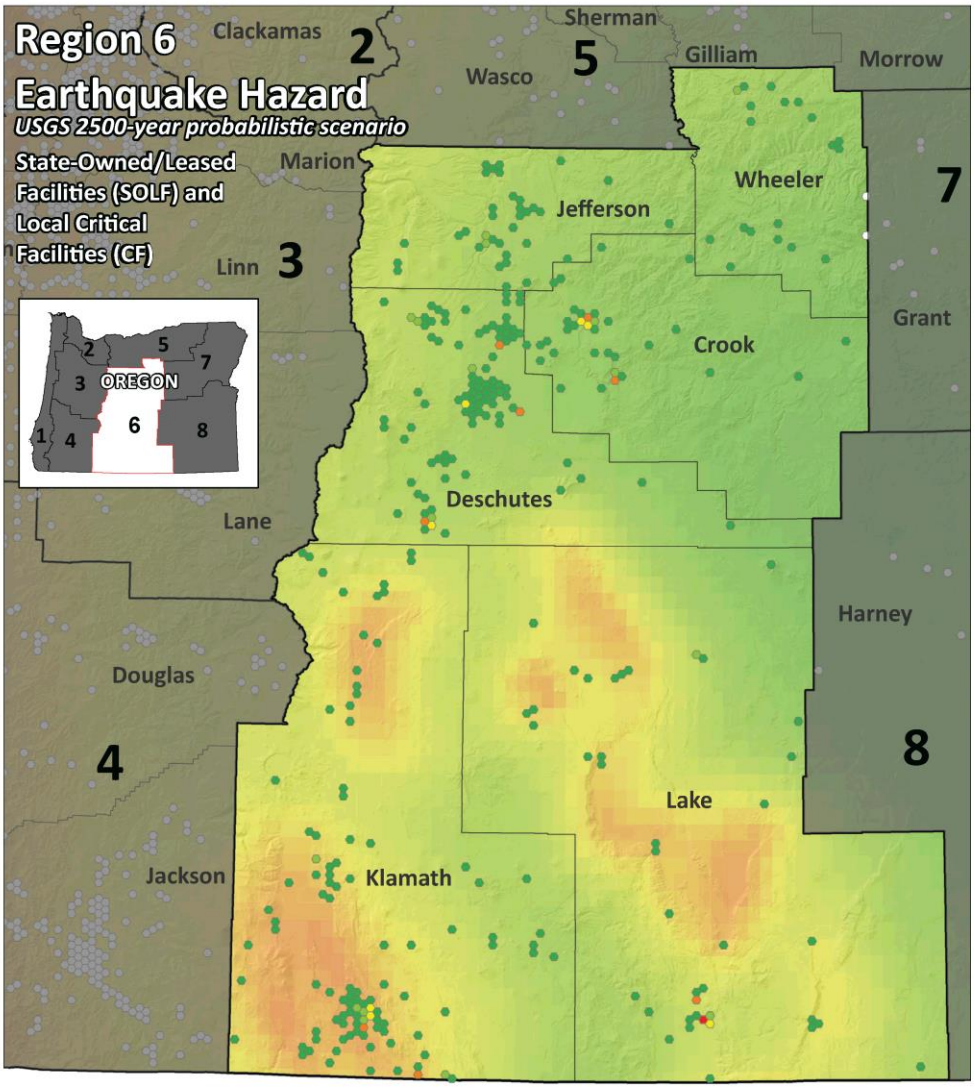
State-Owned/Leased Buildings And Critical Facilities And Local Critical Facilities

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.



Estimated ($) losses to hazard per cell

- Outside of region
- 1 - 250,000
- 250,001 - 500,000
- 500,001- 1,000,000
- 1,000,001 - 2,500,000
- 2,500,001 - 5,500,000

Earthquake peak ground acceleration
(Modified Mercalli Intensity Scale)
Moderate — Severe

Administrative boundary
- Mitigation Planning Region
- County

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).

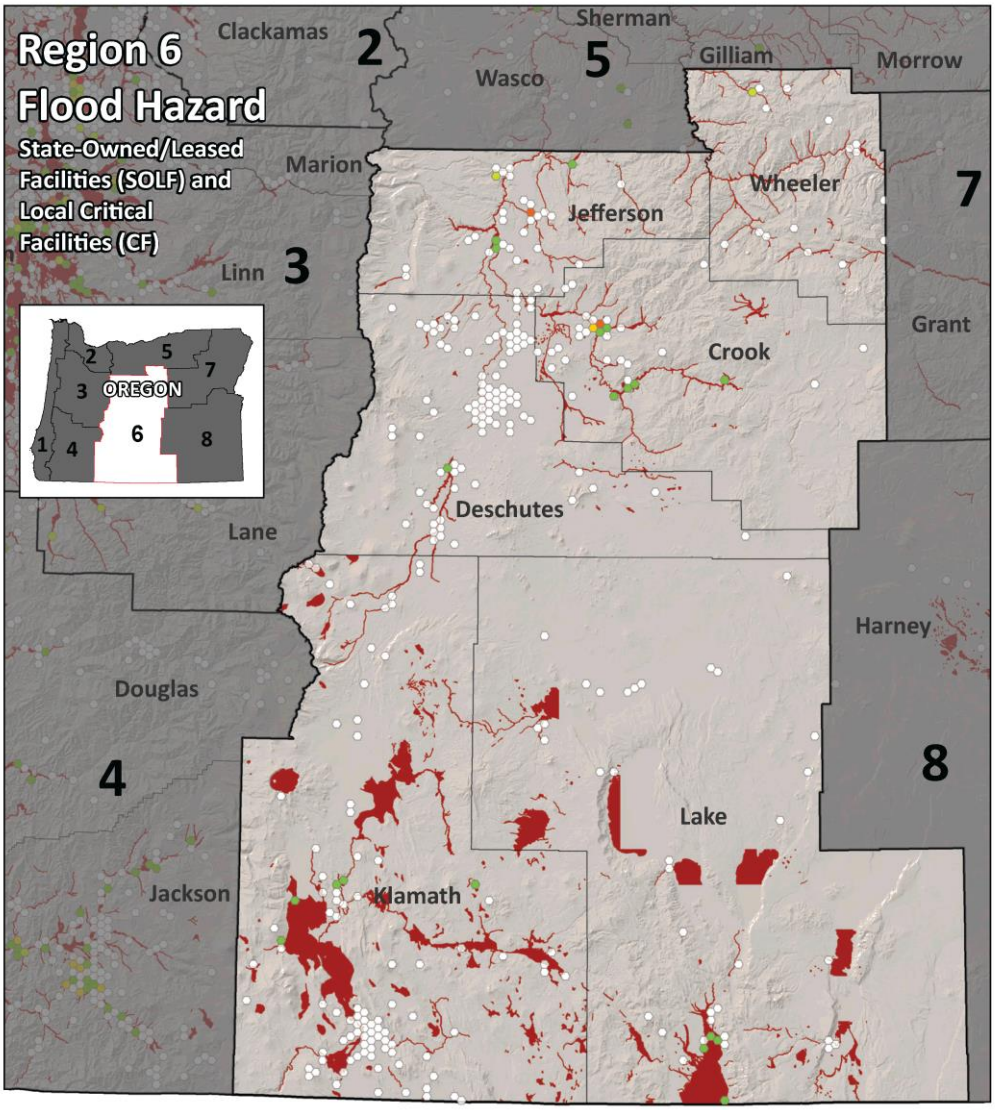
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS) Program, which results in reduced flood insurance costs. 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.



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 1:1,200,000

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 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.*

0 15 30 60 Miles

N

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

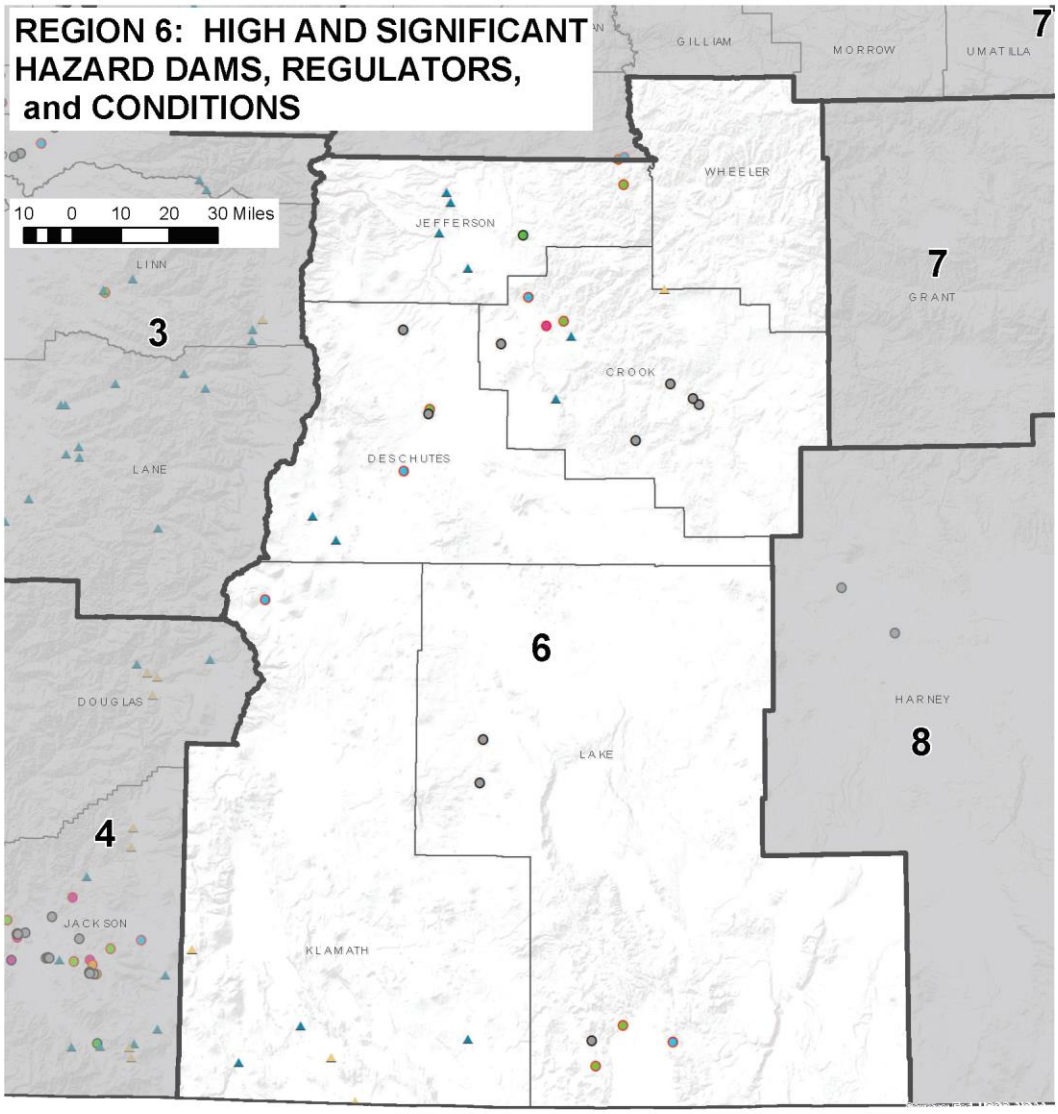
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Barnes Butte Reservoir	OR00284	POOR	1,787	1,648	Crook

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

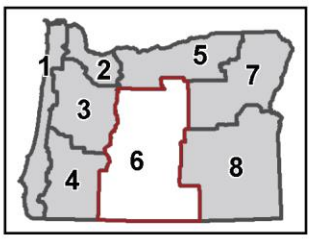
Mitigation Planning Regions
Counties

** - 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

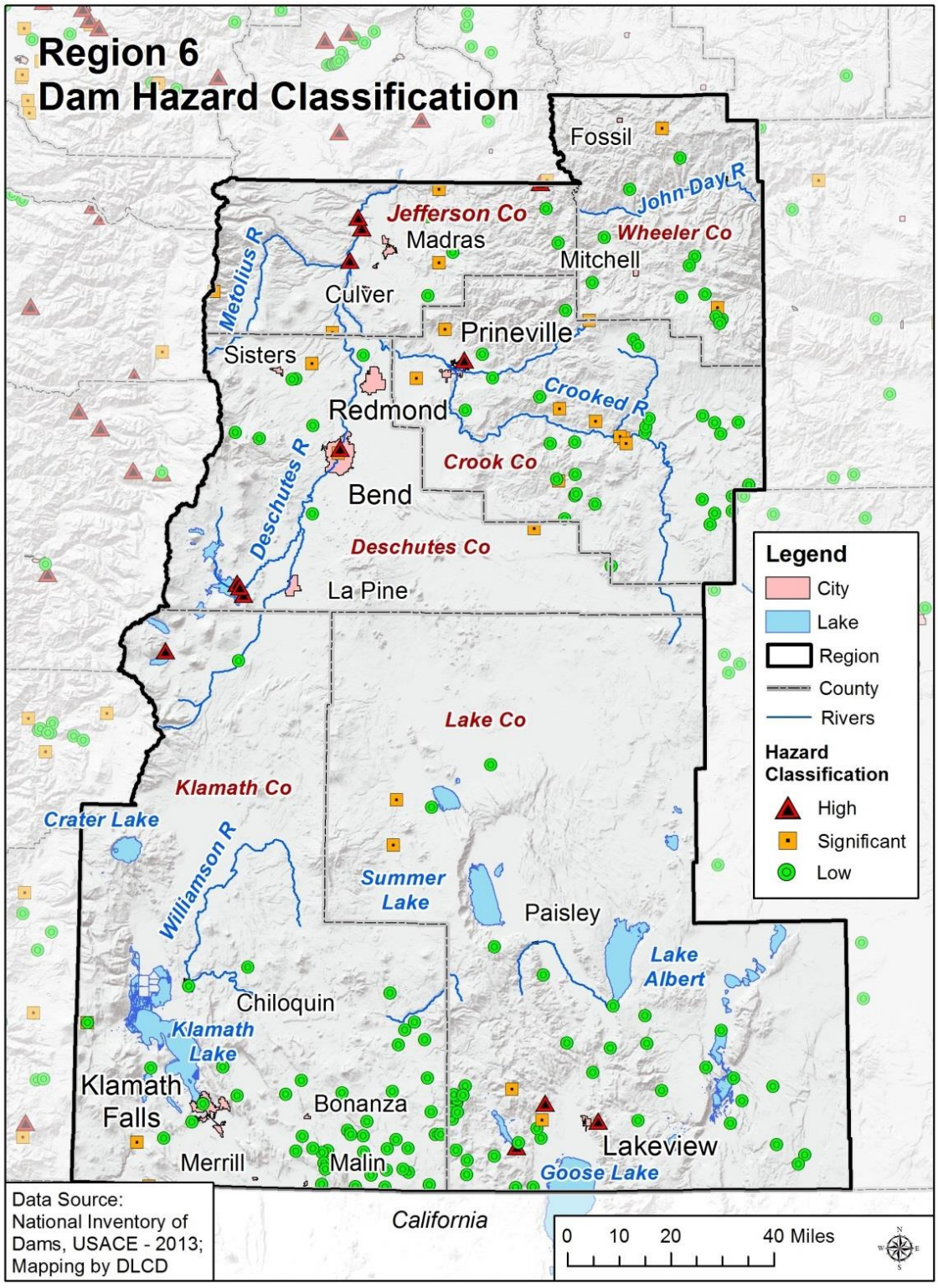
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), only Crook County in Region 6 has a high hazard dam 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

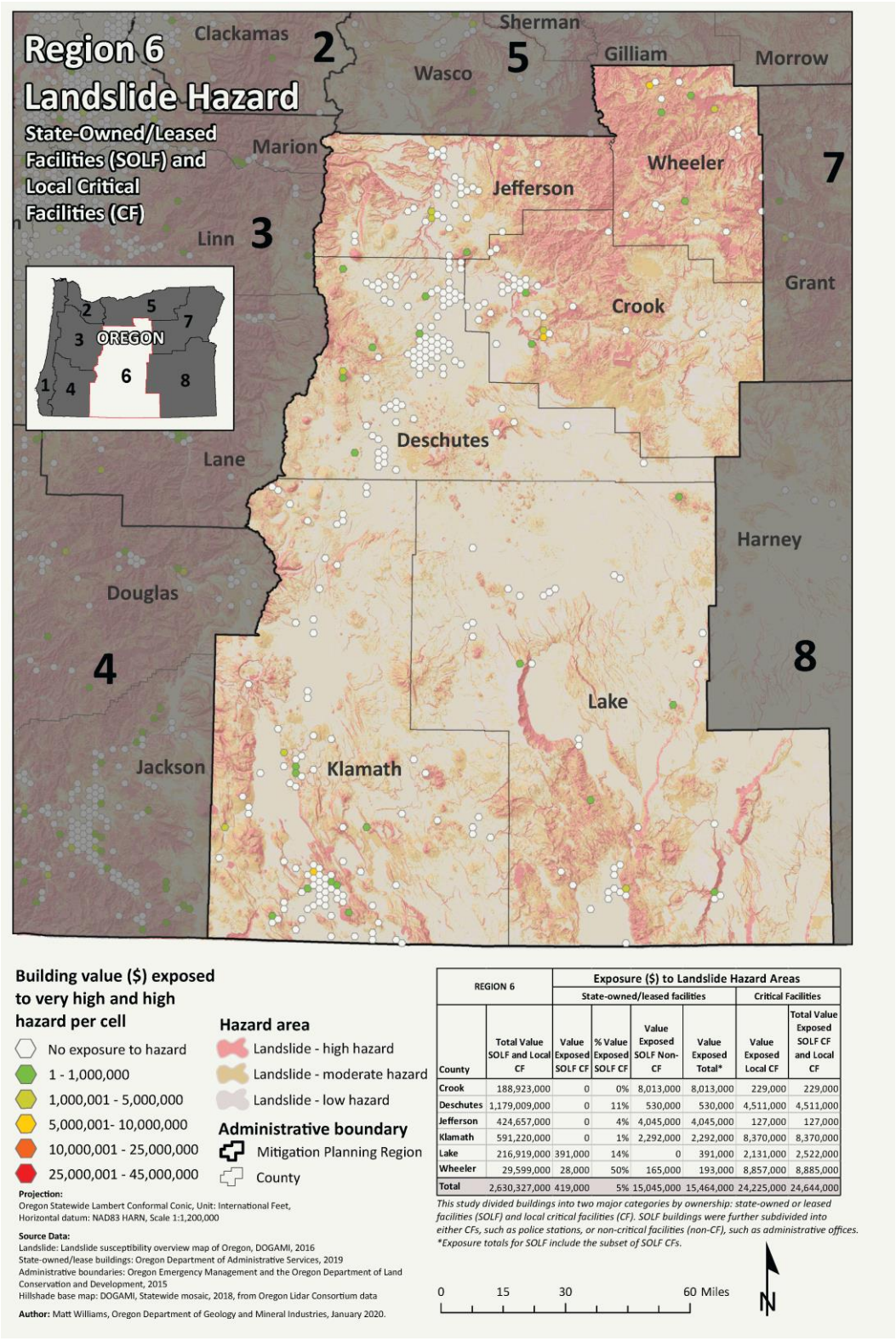
Source: DOGAMI and DLCD, 2020

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

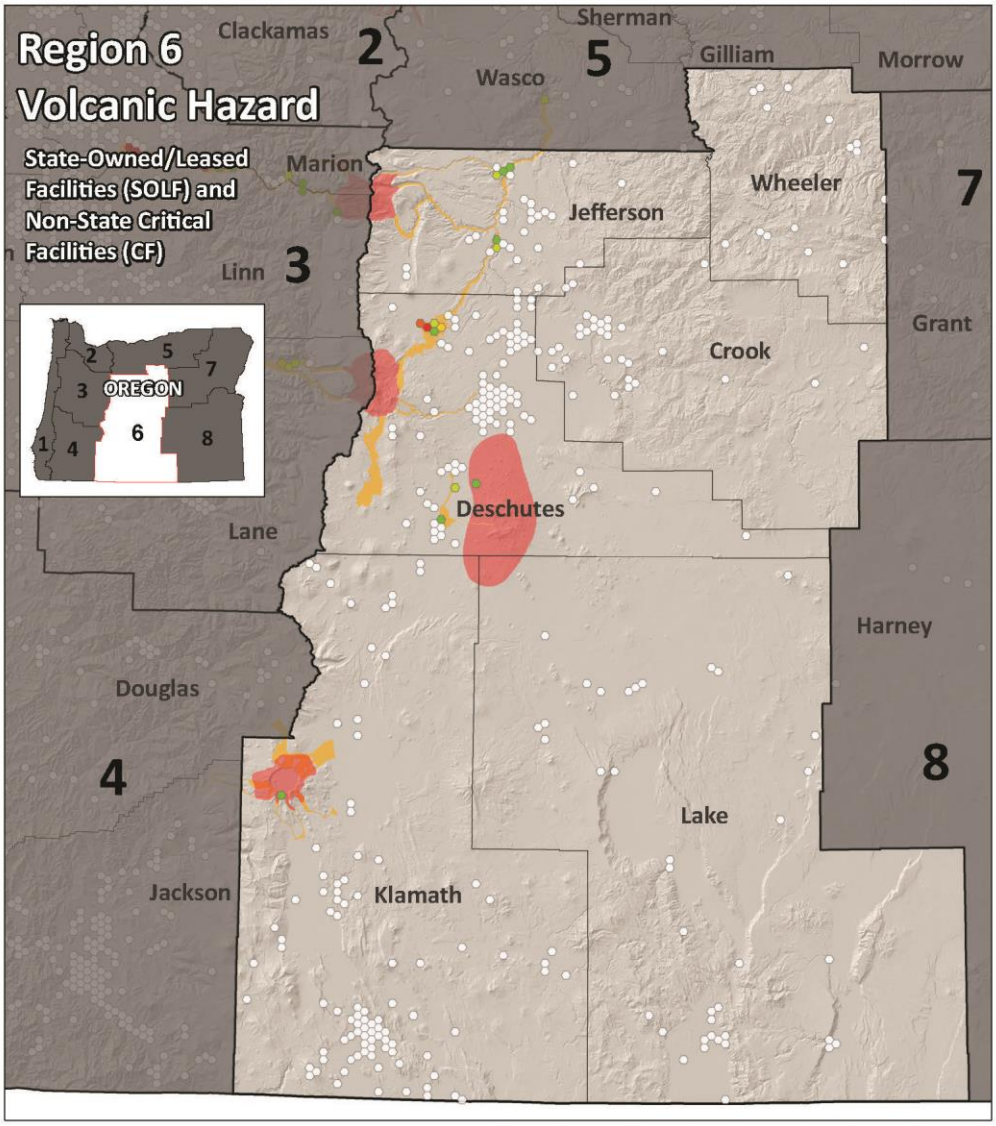
	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Risk	VL	M	VH	H	L	VL

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

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

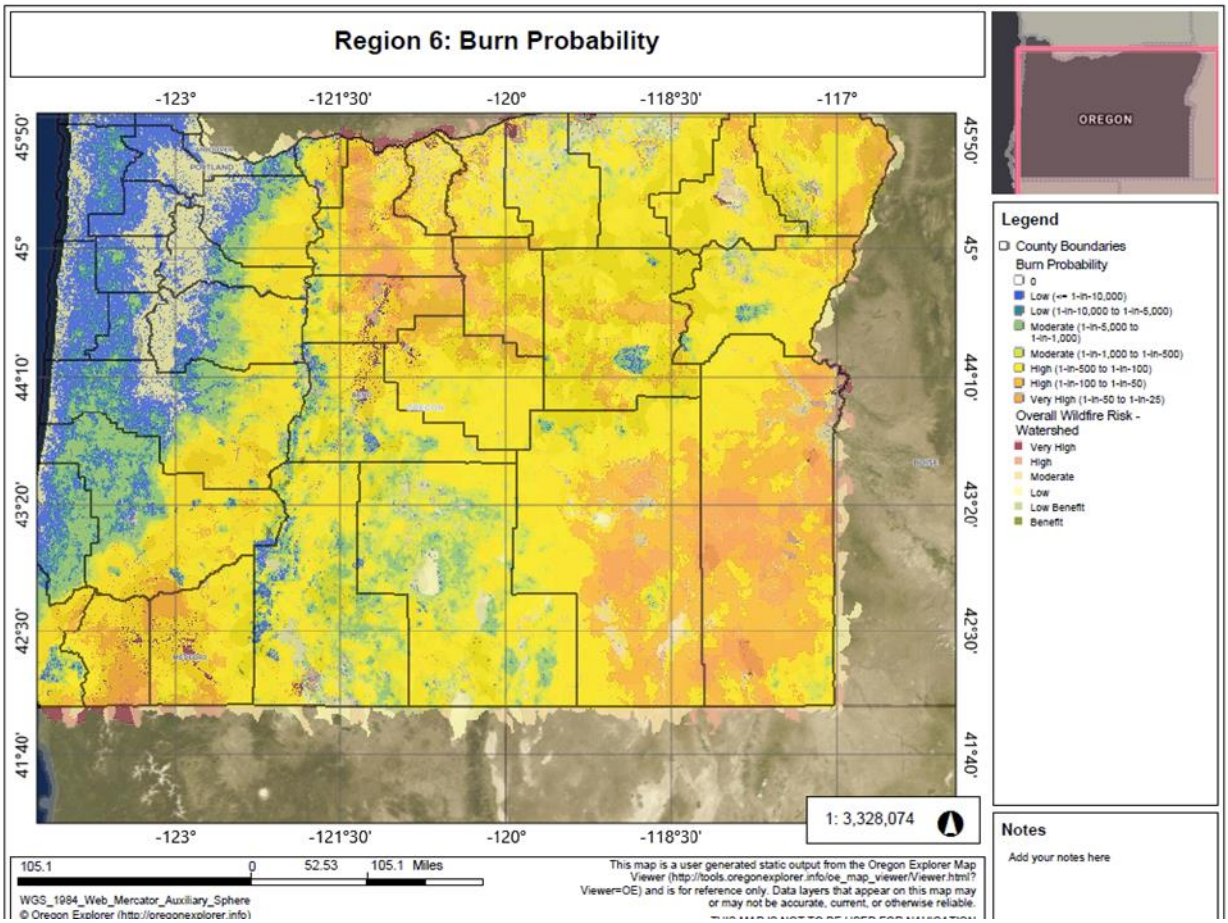
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

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.

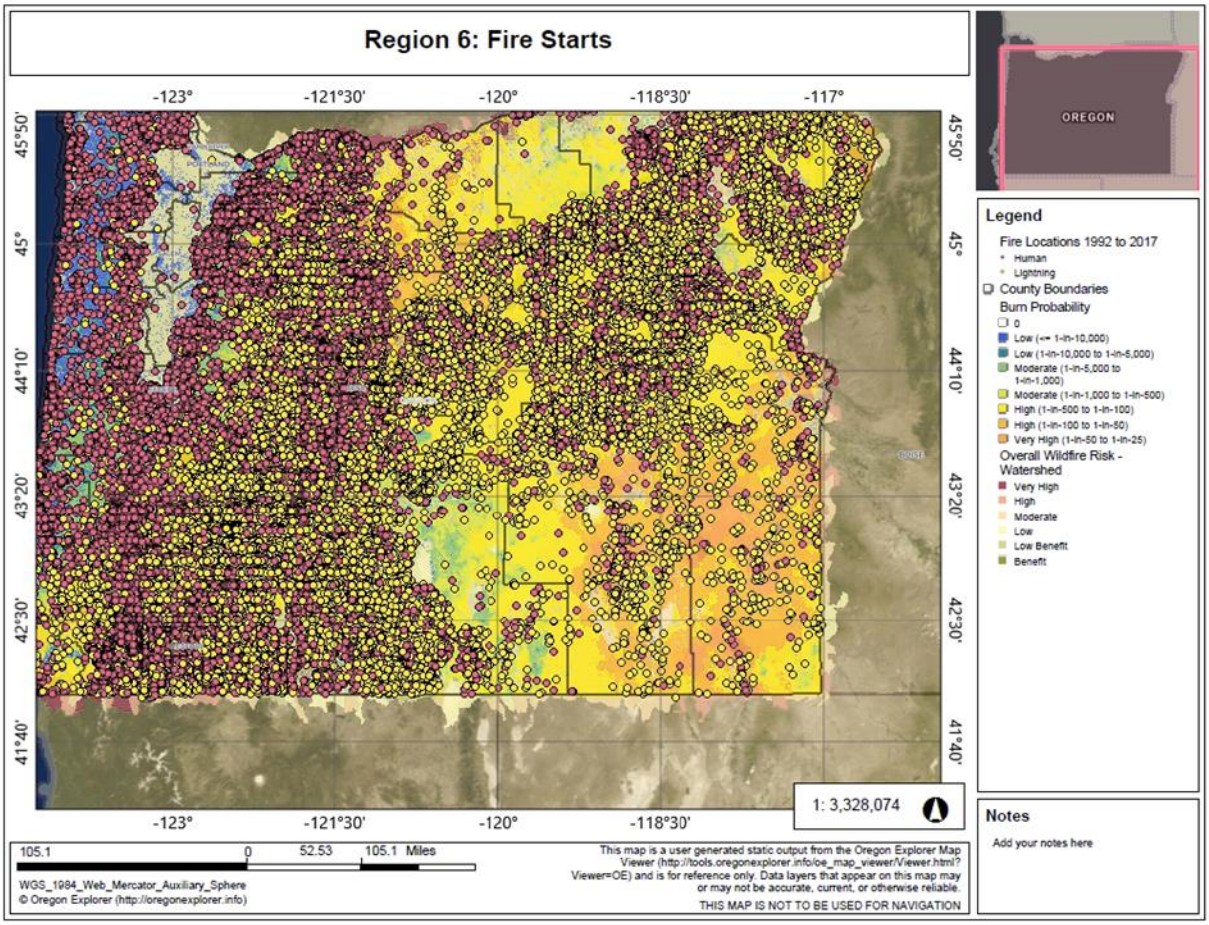
Fire protection districts are created and staffed to deal with the fire emergency needs of the property within the district. Wildland fires that threaten multiple homes simultaneously can

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

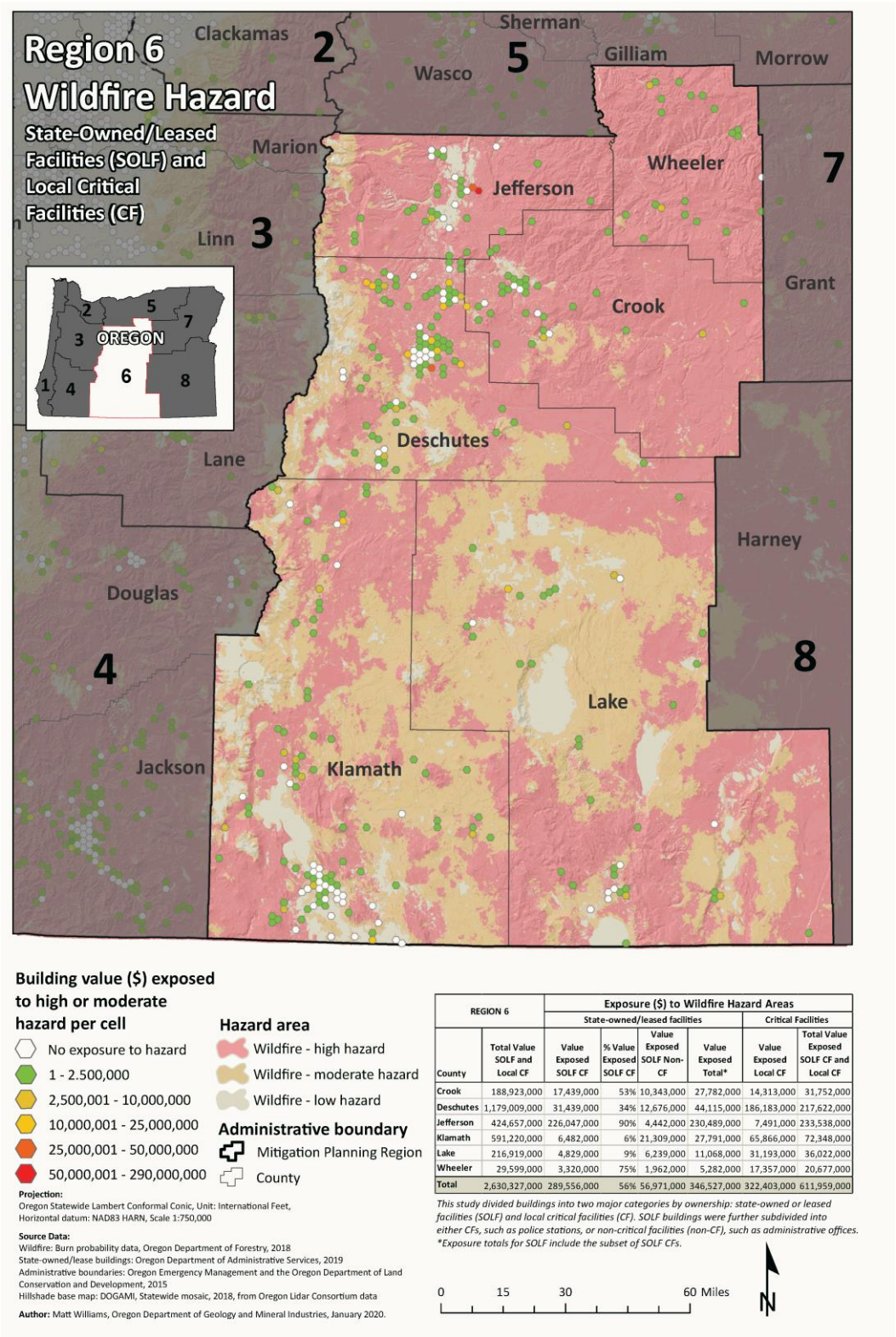
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

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

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

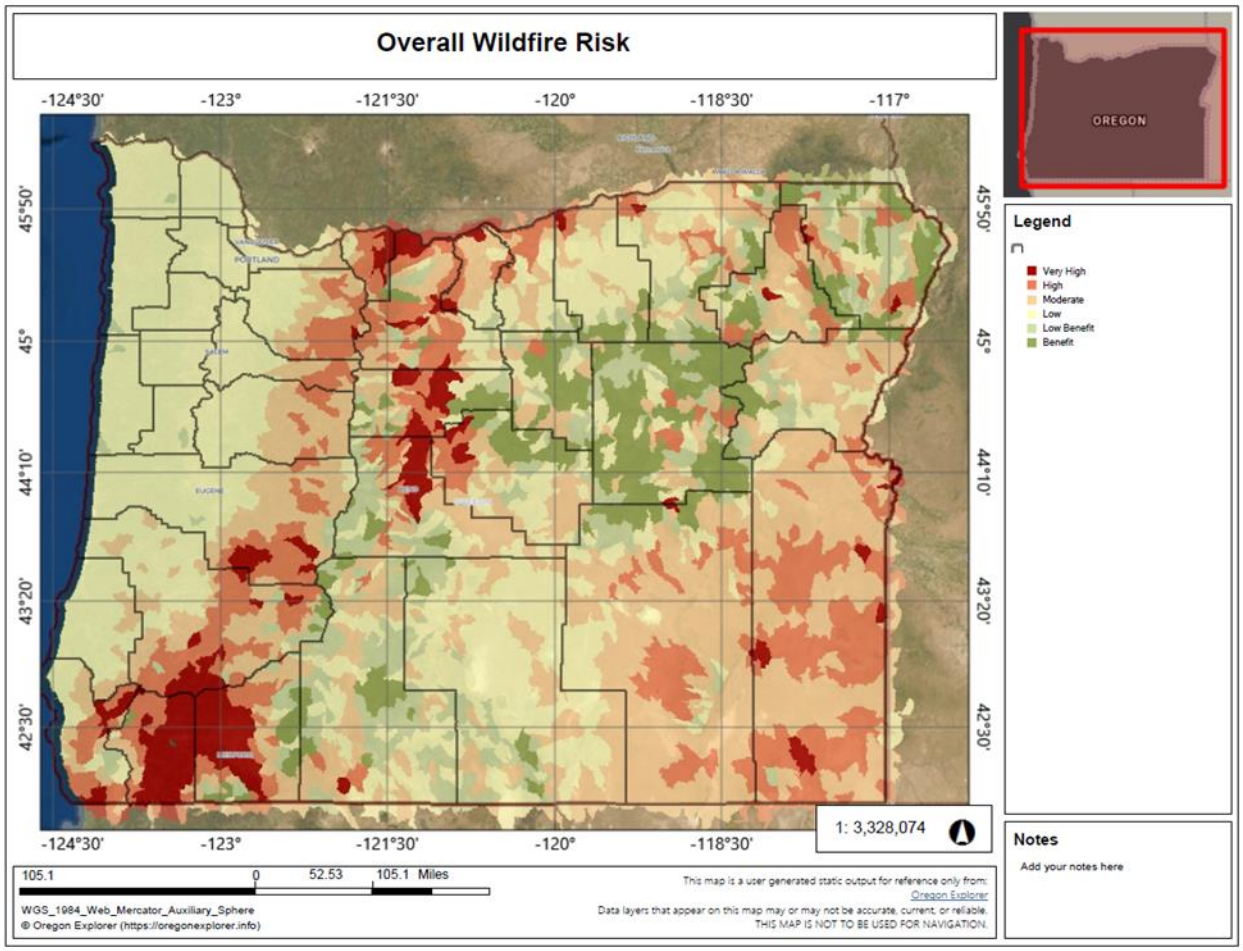
Table 2-639. Risk of Wildfire Hazards in Region 6

	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.

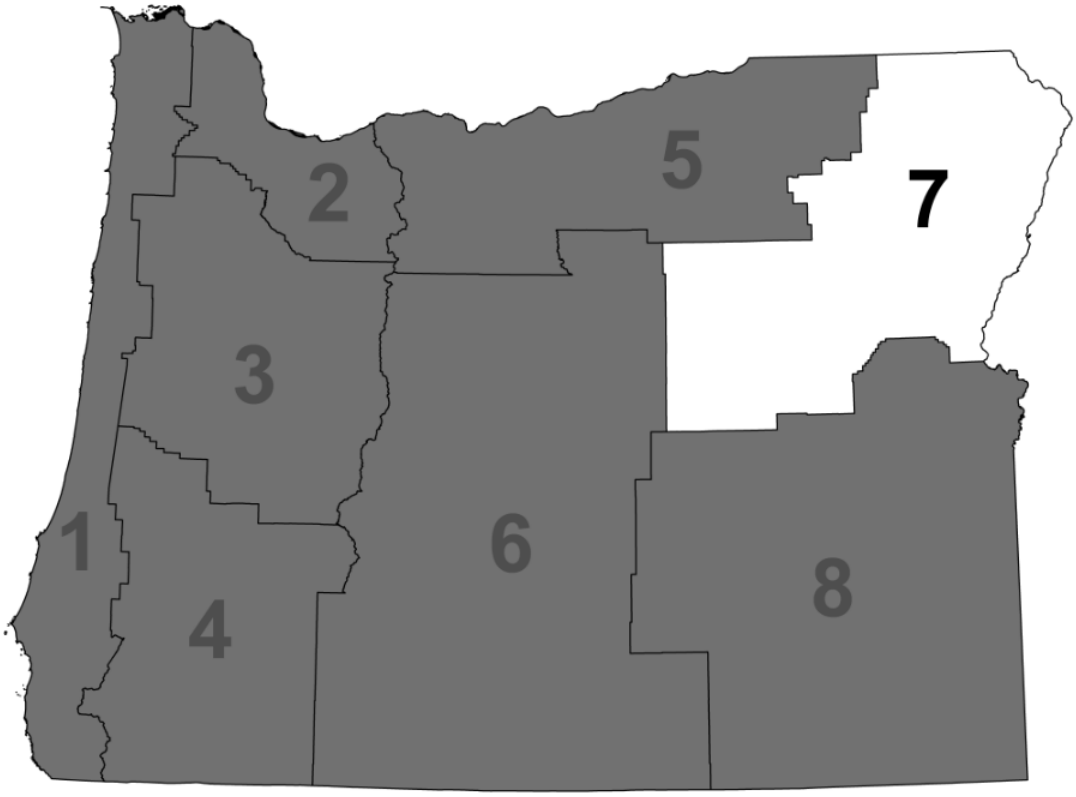
Risk

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

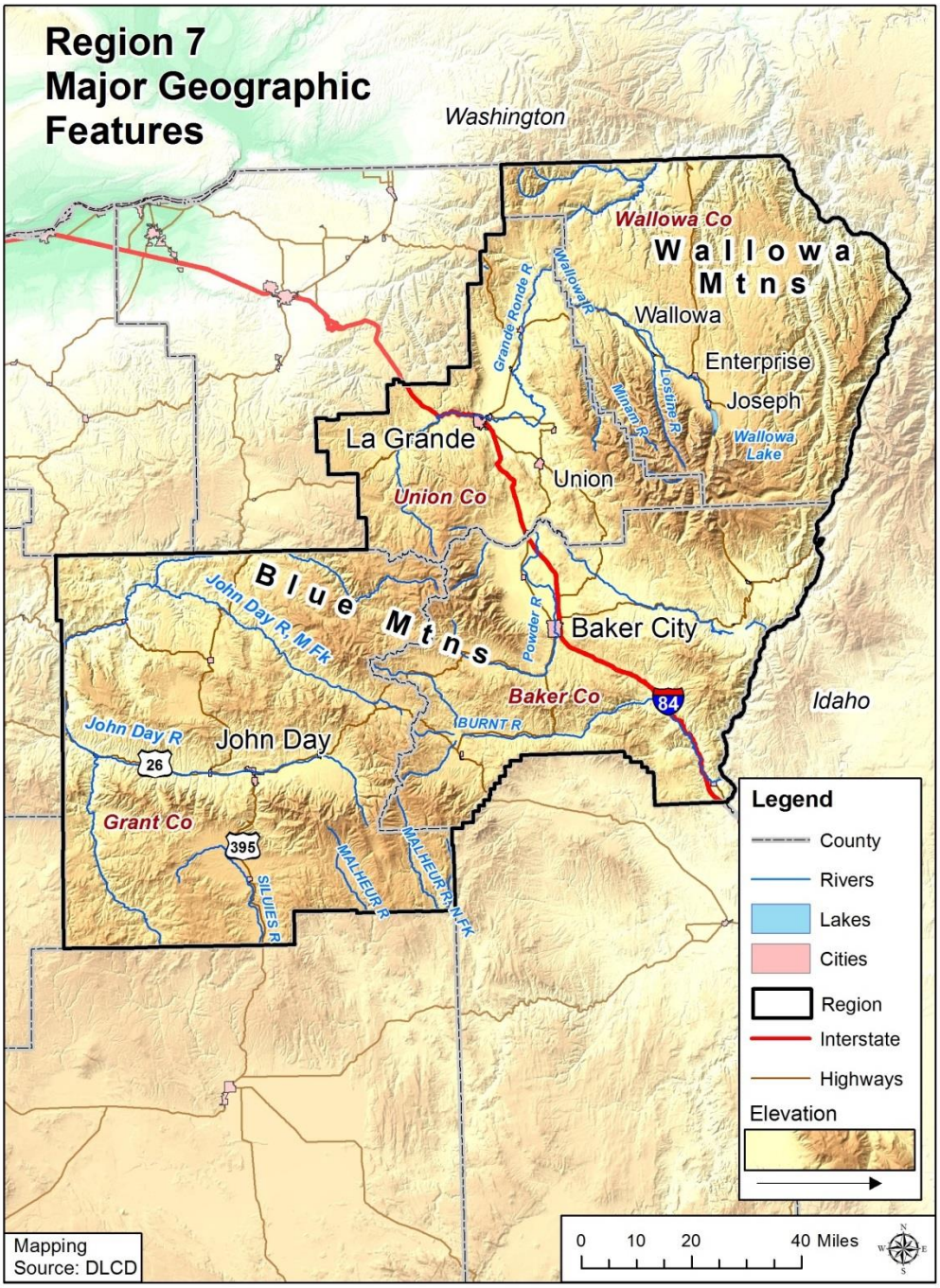
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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.

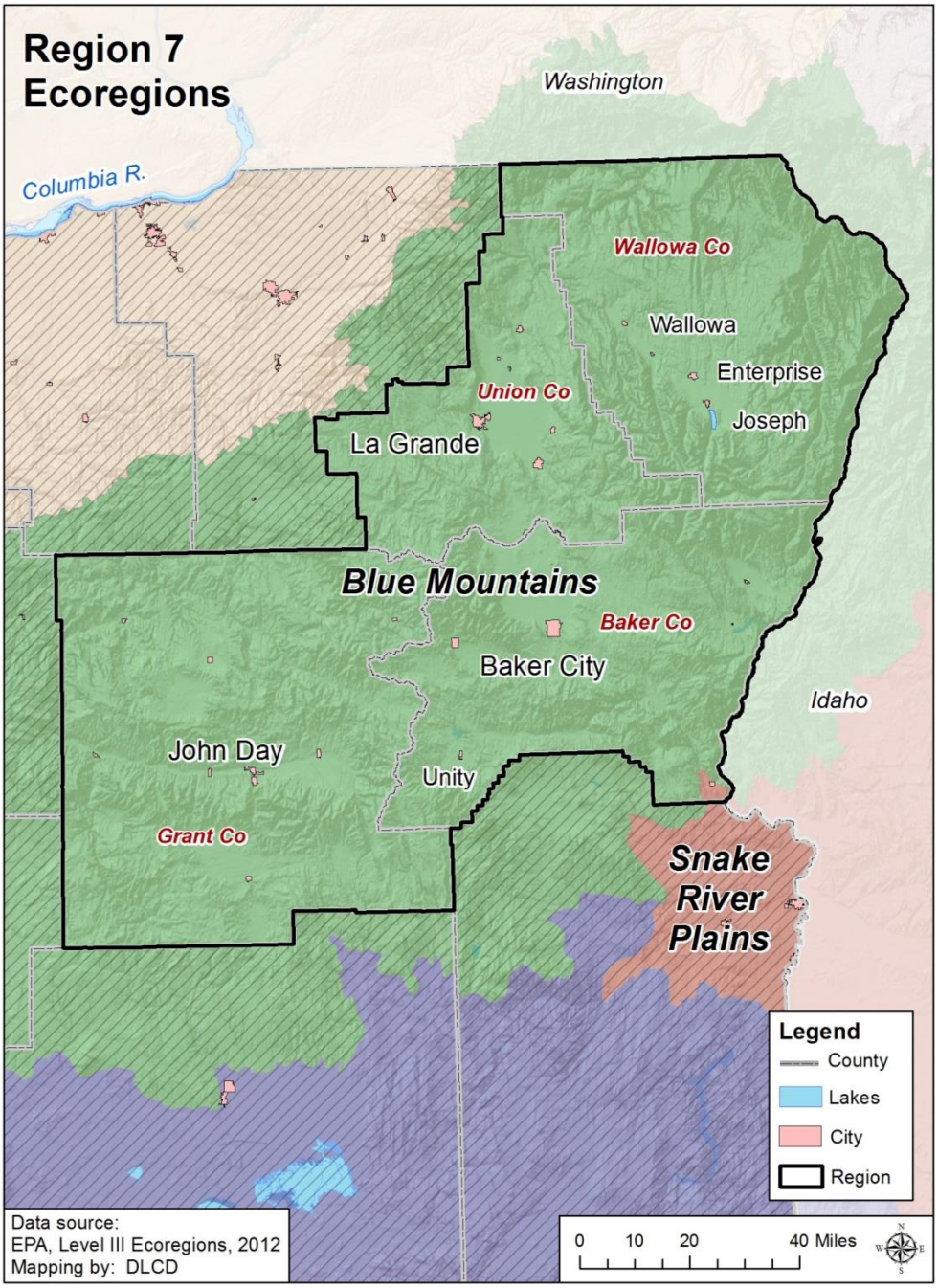
Figure 2-271. Region 7 Major Geographic Features



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.

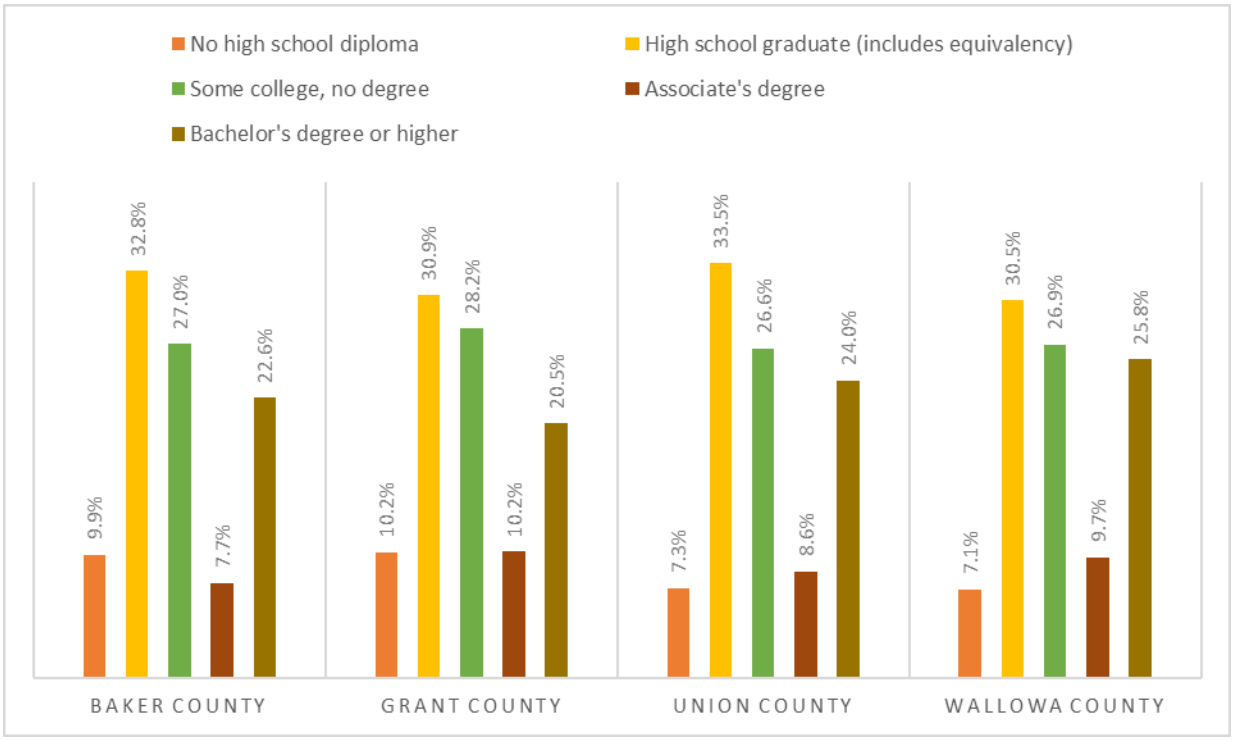
Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

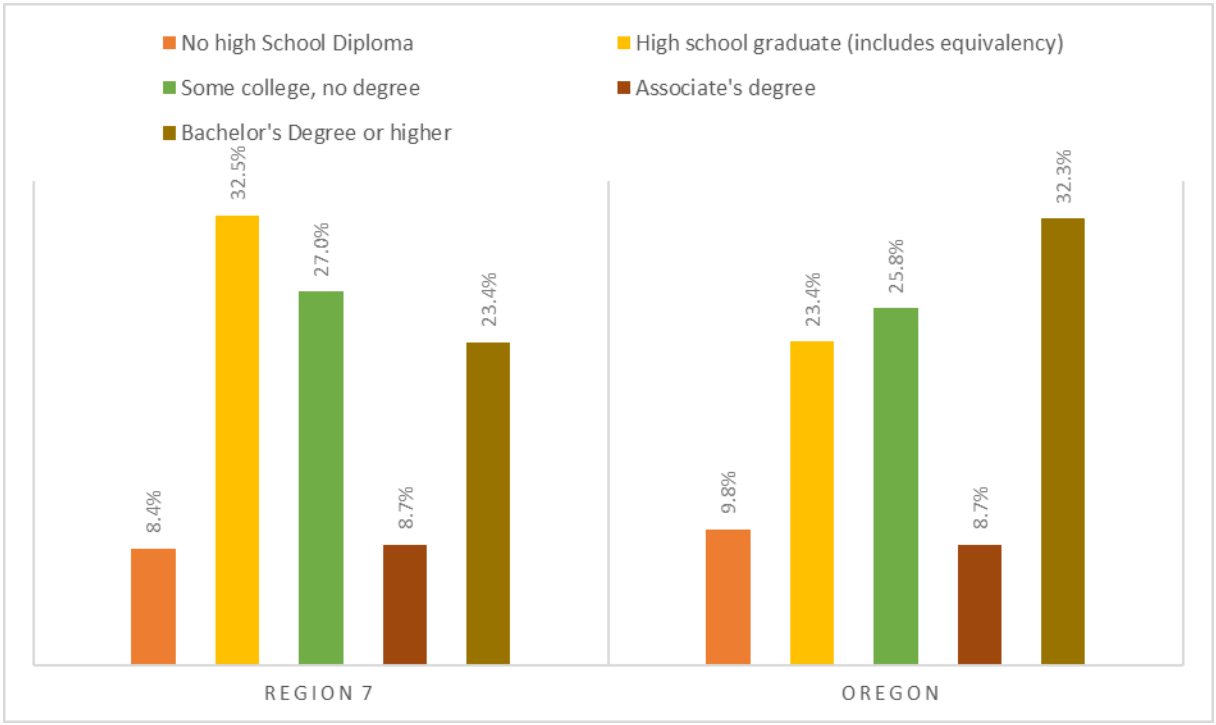
Education Level

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.

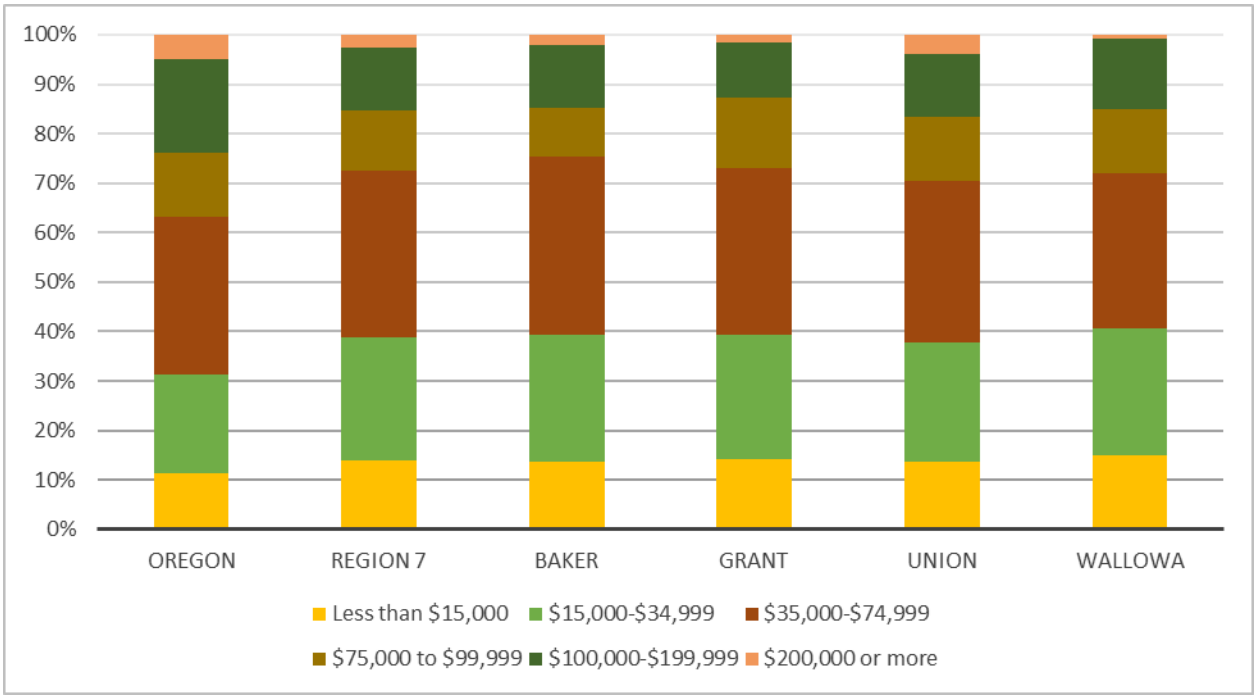
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**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.

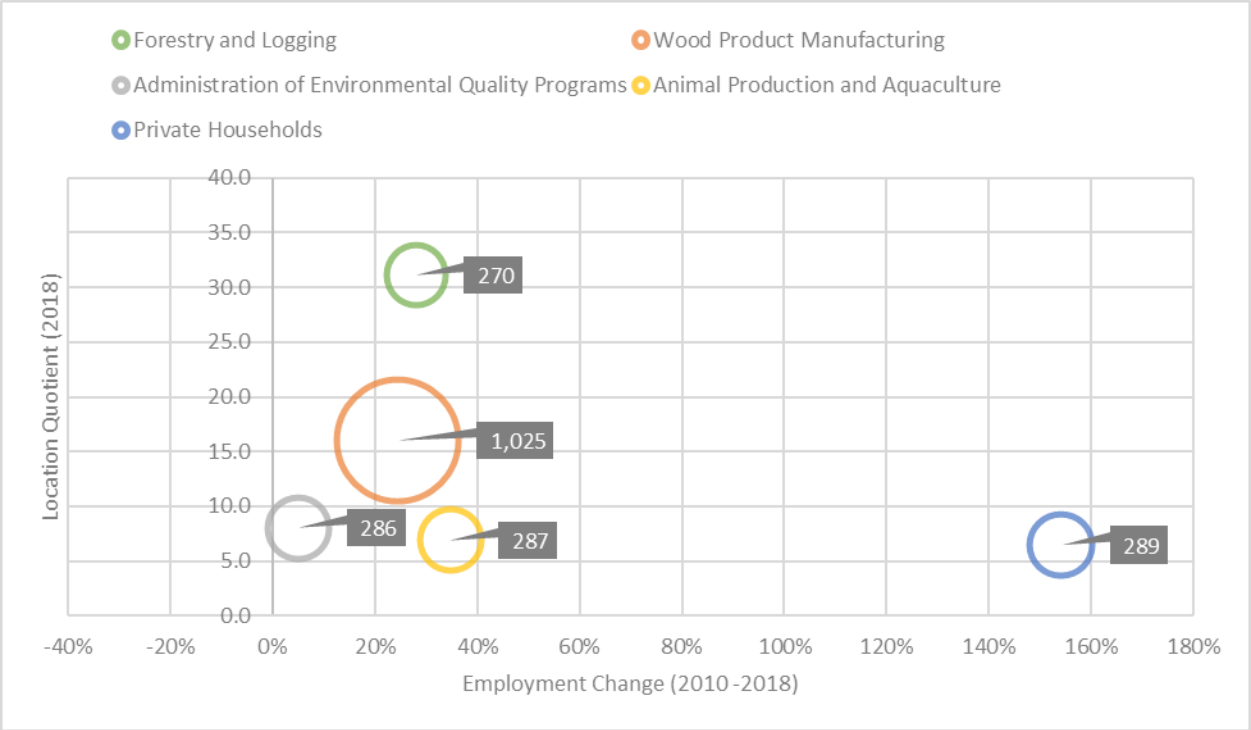
Table 2-666. Most Concentrated Industries and Employment Change in Region 7, 2018

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

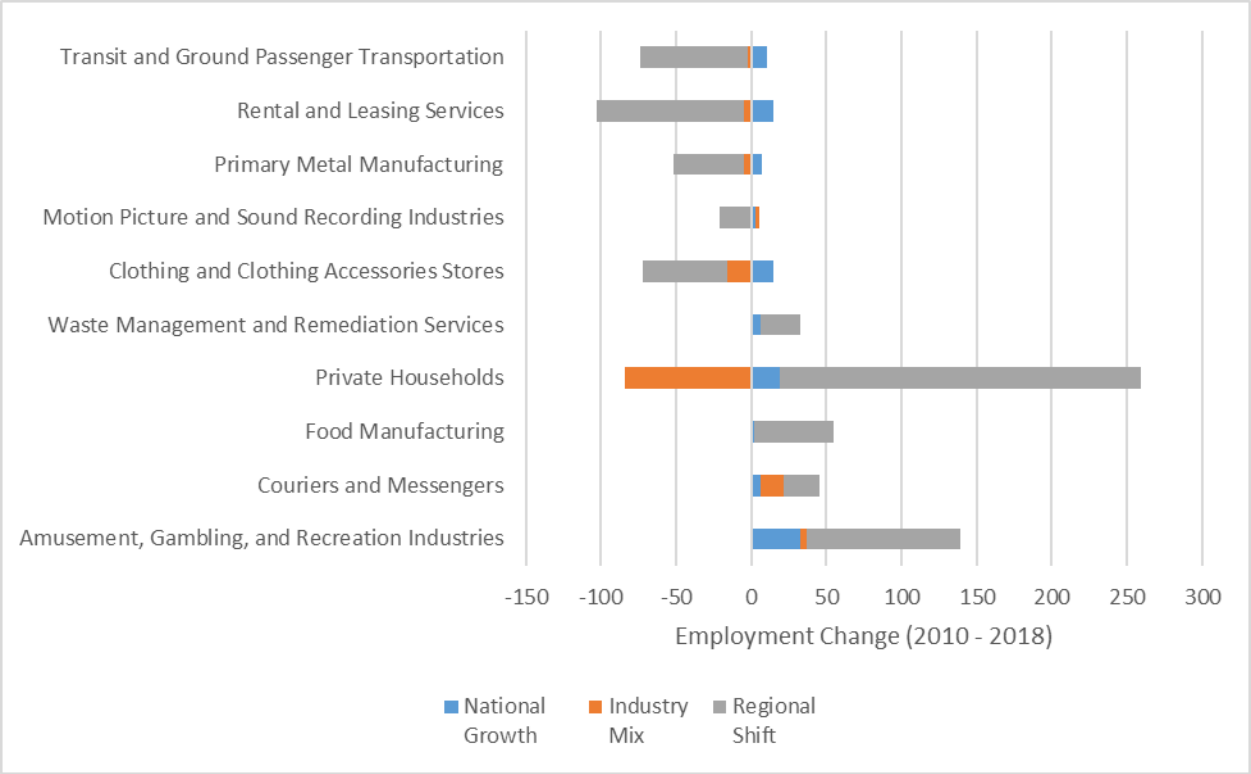
Due to a smaller population, the fastest growing industries started with meager employment in 2010—each under two-hundred. Consequently, small changes in absolute terms equate to significant percent increases. According to the shift share analysis, growth in all five subsectors was driven by largely 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

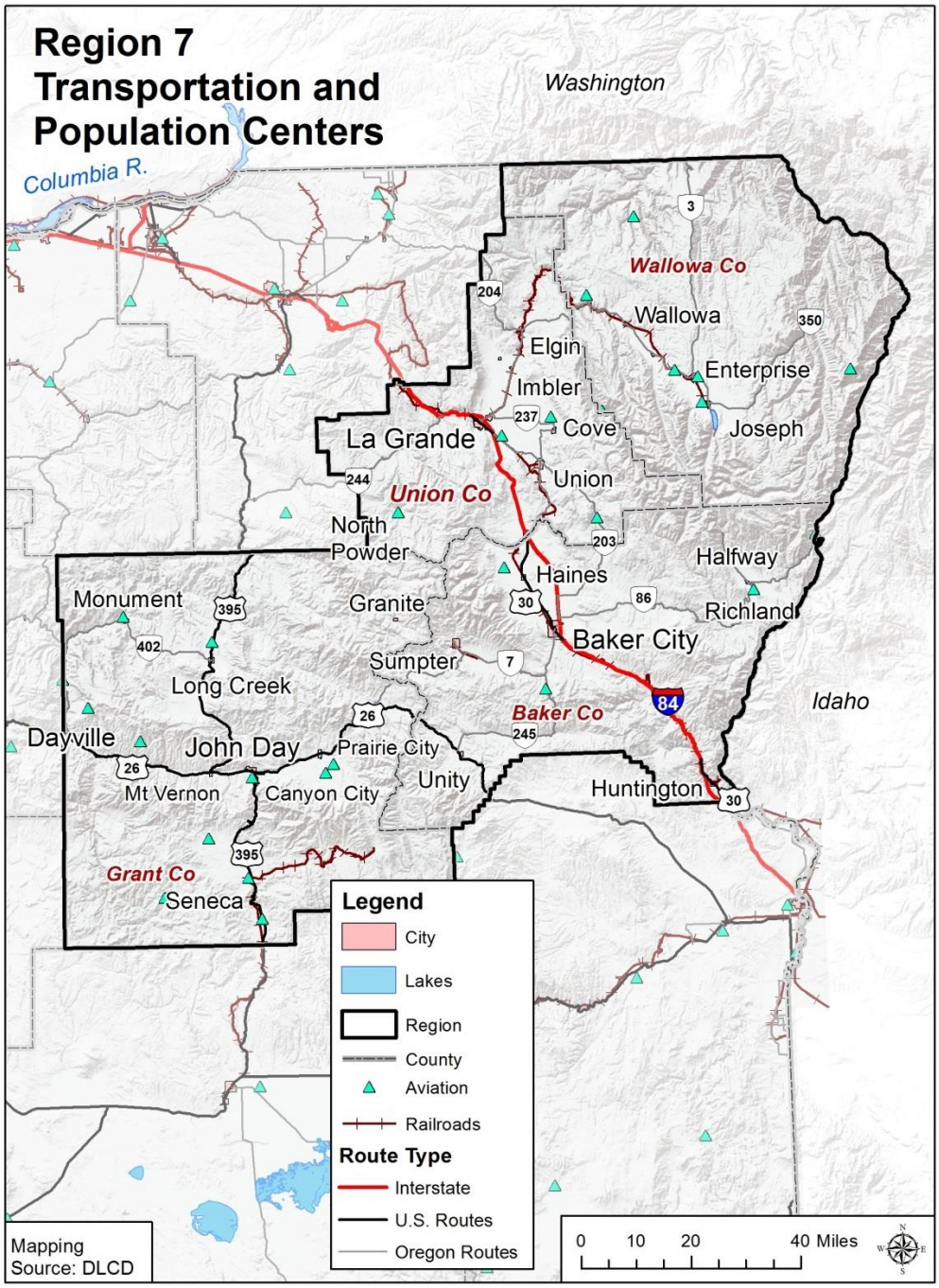
The largest population bases in Region 7 are located along the region's major freeways. I-84 runs north-south and is the main passage for automobiles and trucks traveling east of the Cascade Range between Portland and Idaho. US-26, US-244, OR-245, and US-395 provide access west into Grant County. OR-82 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

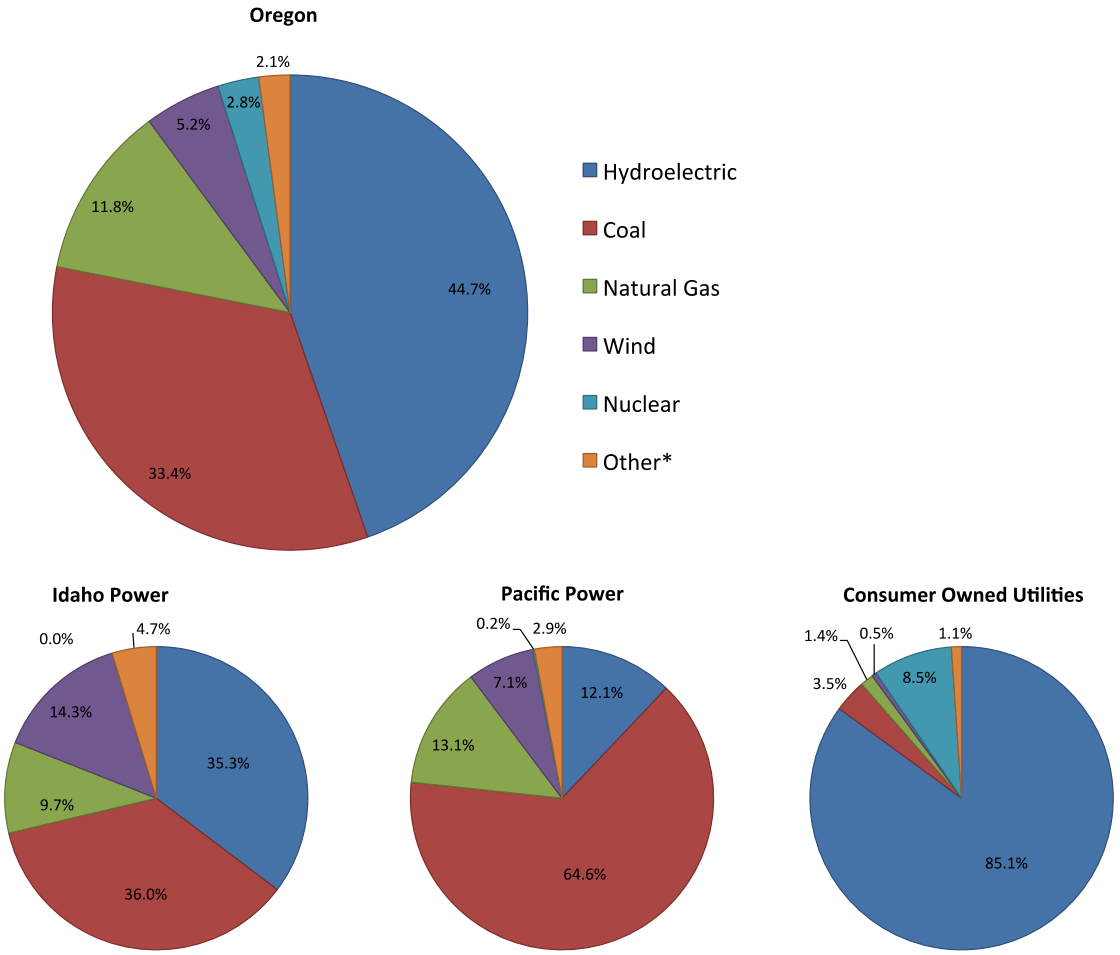
*"Other" includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

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=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 2-279. 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%

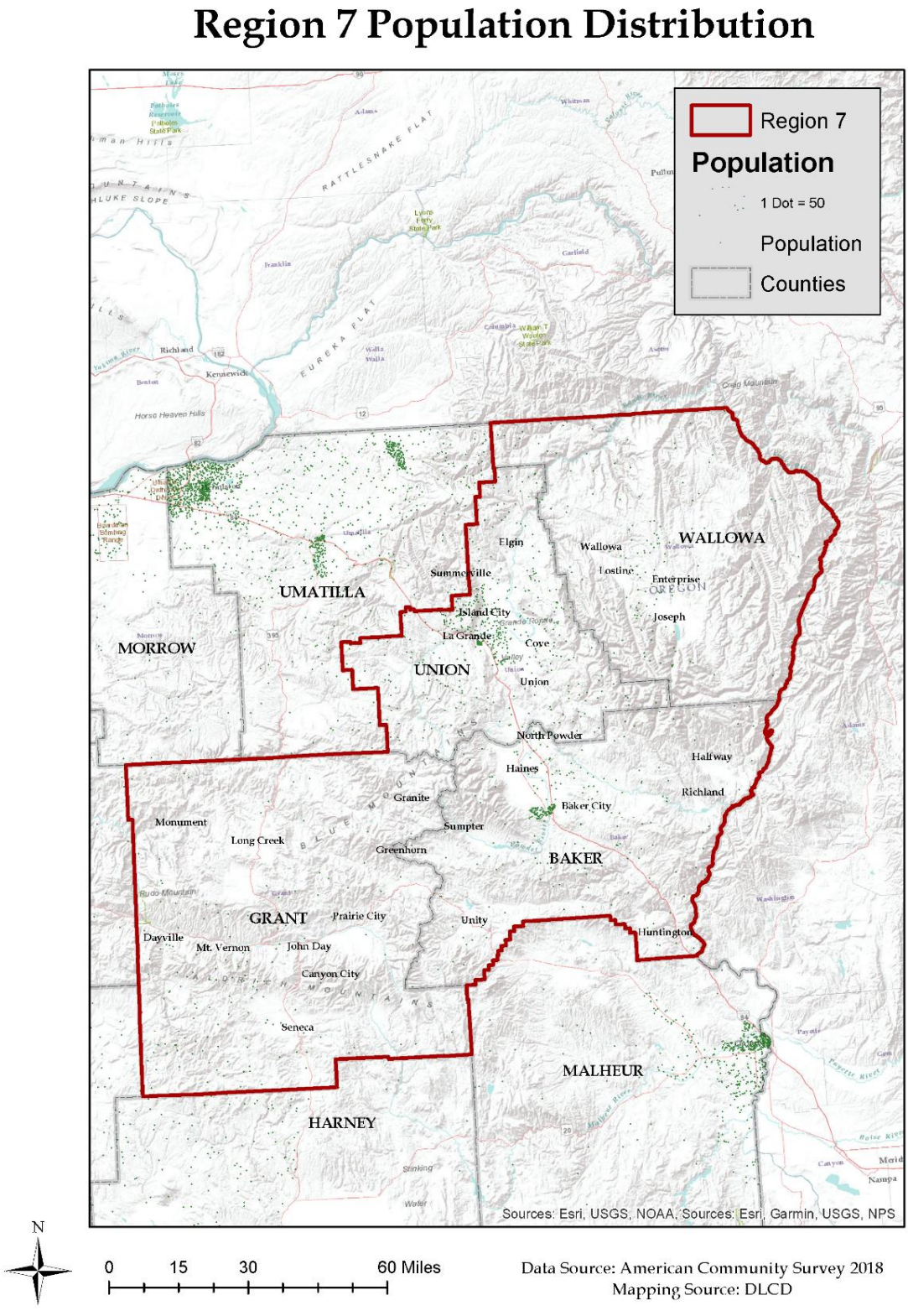
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

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

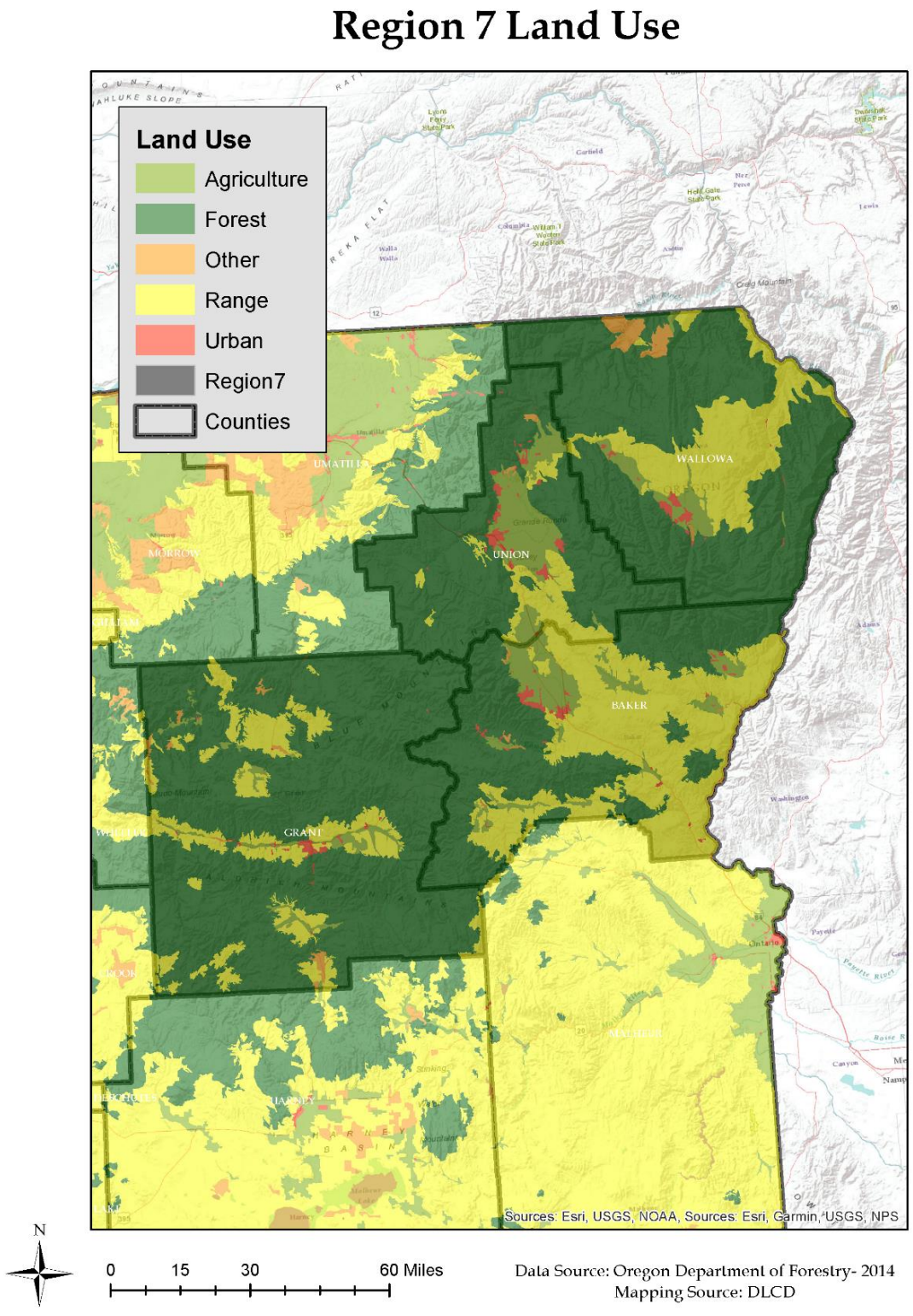
Land Use Patterns

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.

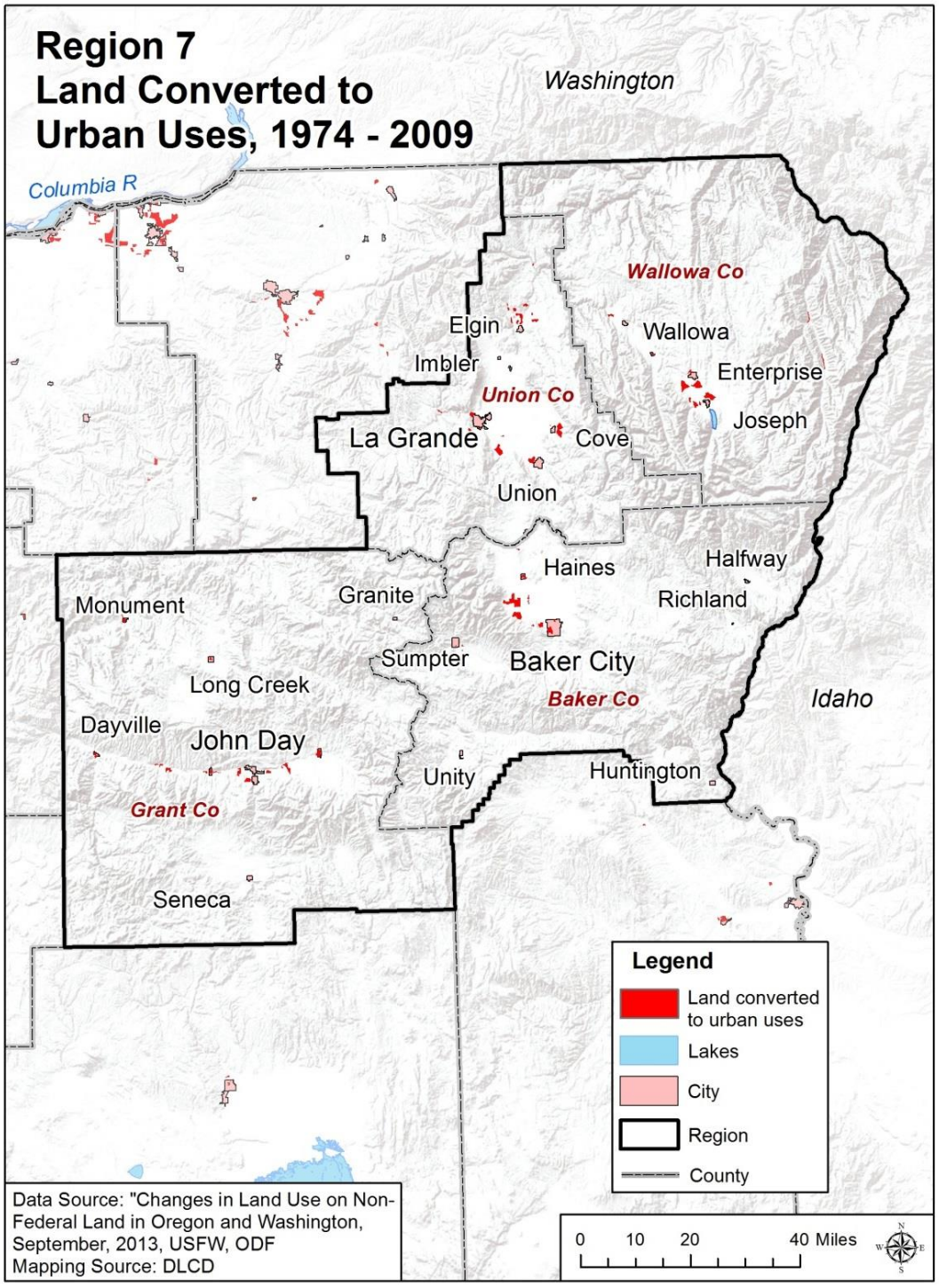
To the extent it has occurred, development has generally been located along existing transportation corridors. Nearly half of the people in Region 7 reside in the cities of Baker City, John Day, La Grande, and Enterprise, and most unincorporated development in this region is located along the I-84 corridor.

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

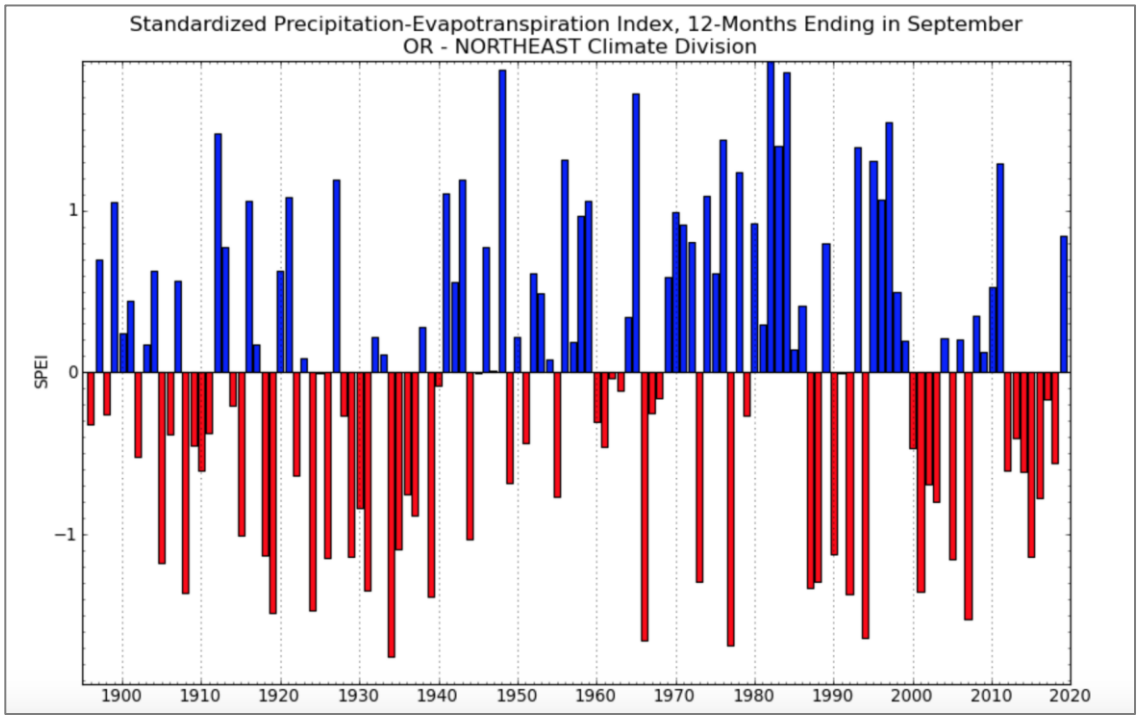
Sources: Taylor and Hatton (1999). The Oregon Weather Book: State of Extremes, and the Oregon Secretary of State's Archives Division. NOAA's Climate at a Glance. Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt. Personal Communication, Kathie Dello, Oregon Climate 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.



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

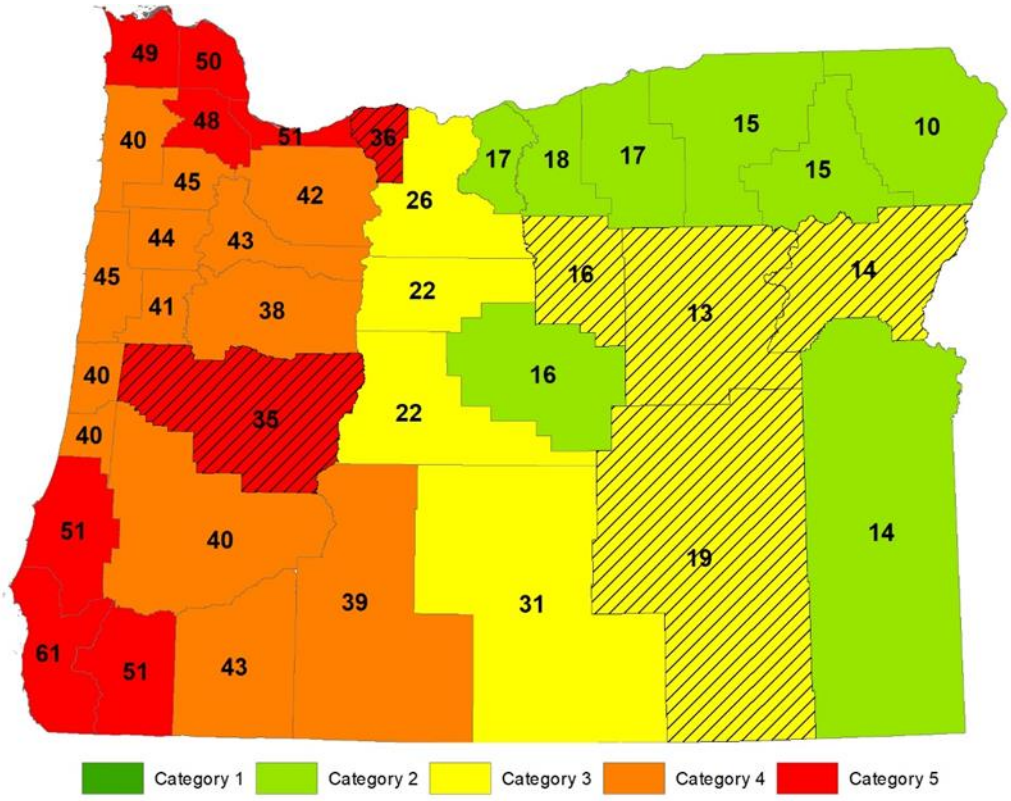
The probability of damaging earthquakes varies widely across the state. In Region 7, the hazard is dominated by local faults and background seismicity.

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)

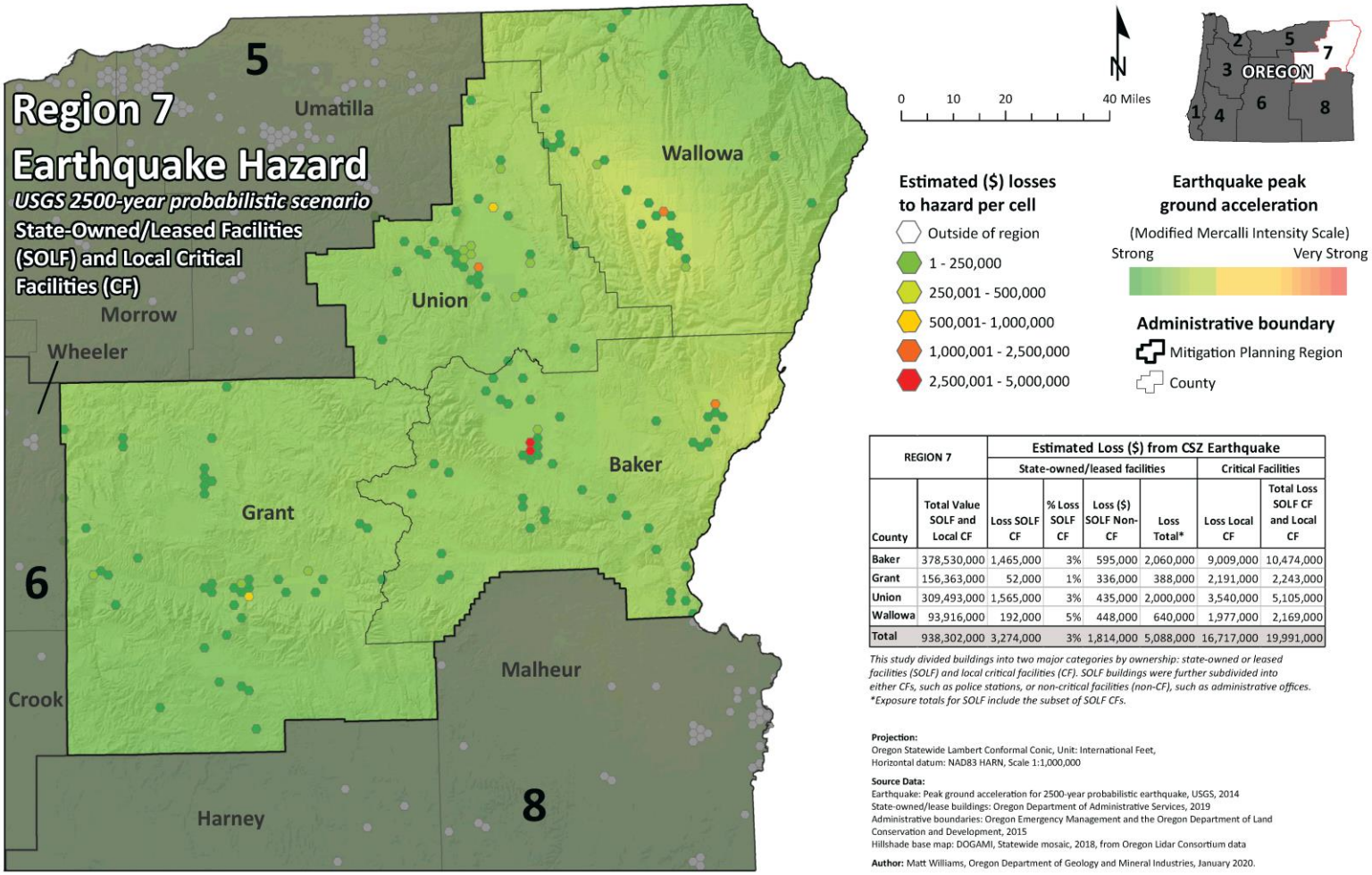
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

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).

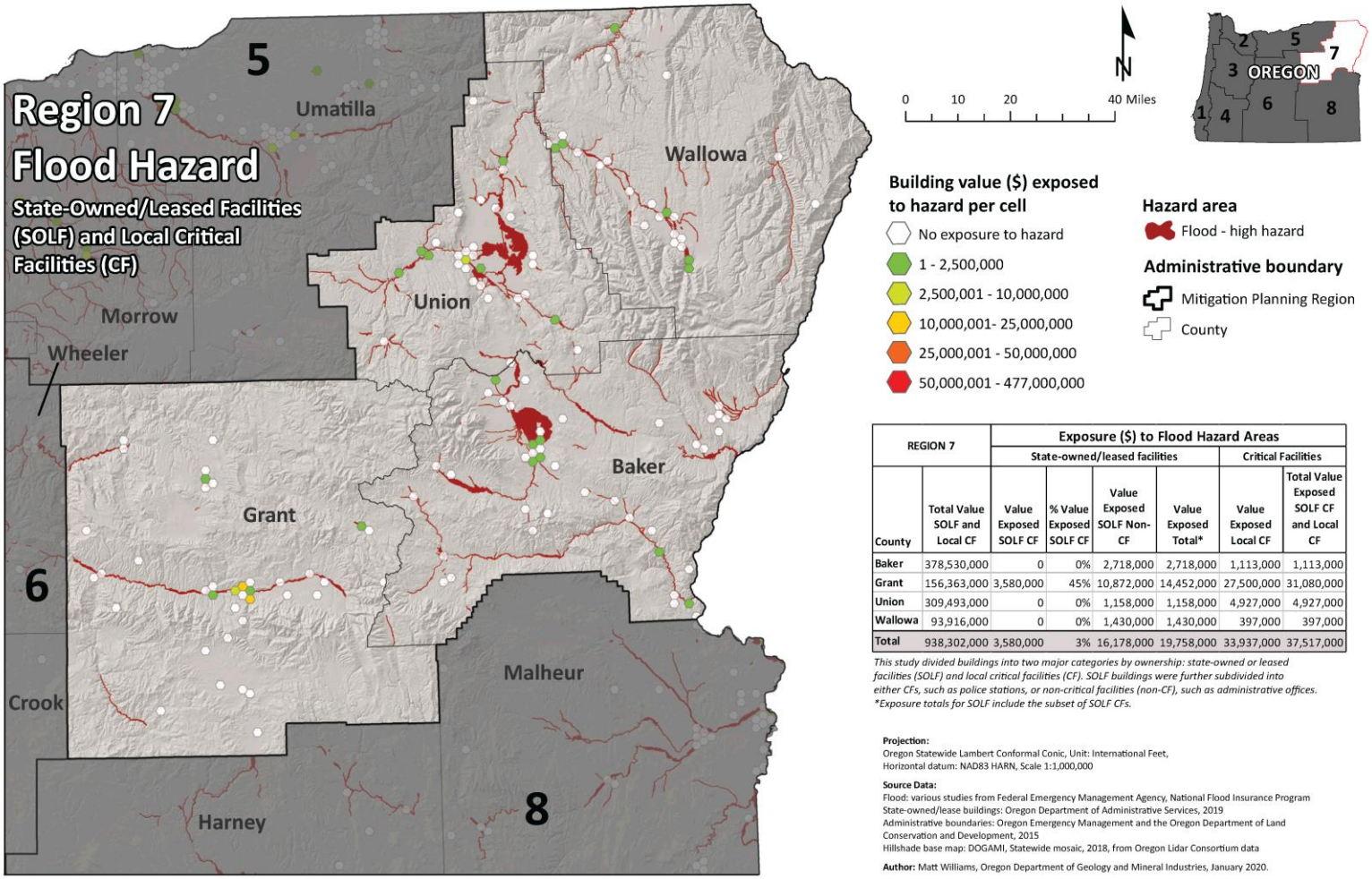
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS) Program, which results in reduced flood insurance costs. 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

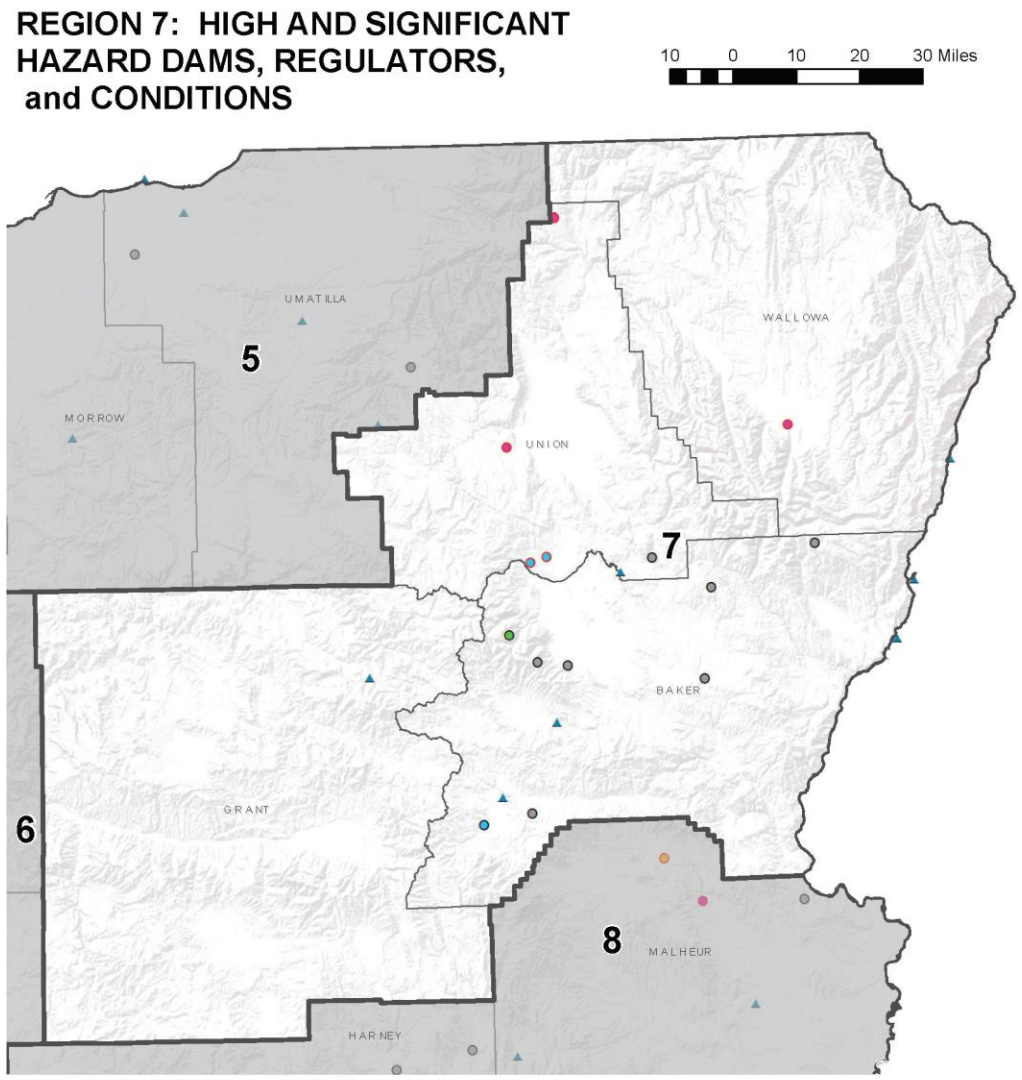
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Jubilee Lake		POOR	Small	Small	Union
Morgan Lake Dam	OR00653	POOR	11,128	6,362	Union
Wallowa Lake (Top of Dam)	OR00465	POOR	1,131	1,334	Wallowa

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	Earthqual	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

Federal regulated dams
Hazard
- High
- Significant

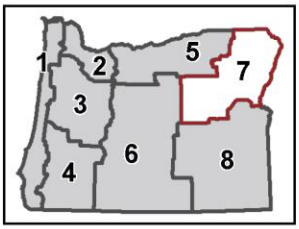
Mitigation Planning Regions
Counties

** - 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 2-713, 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.

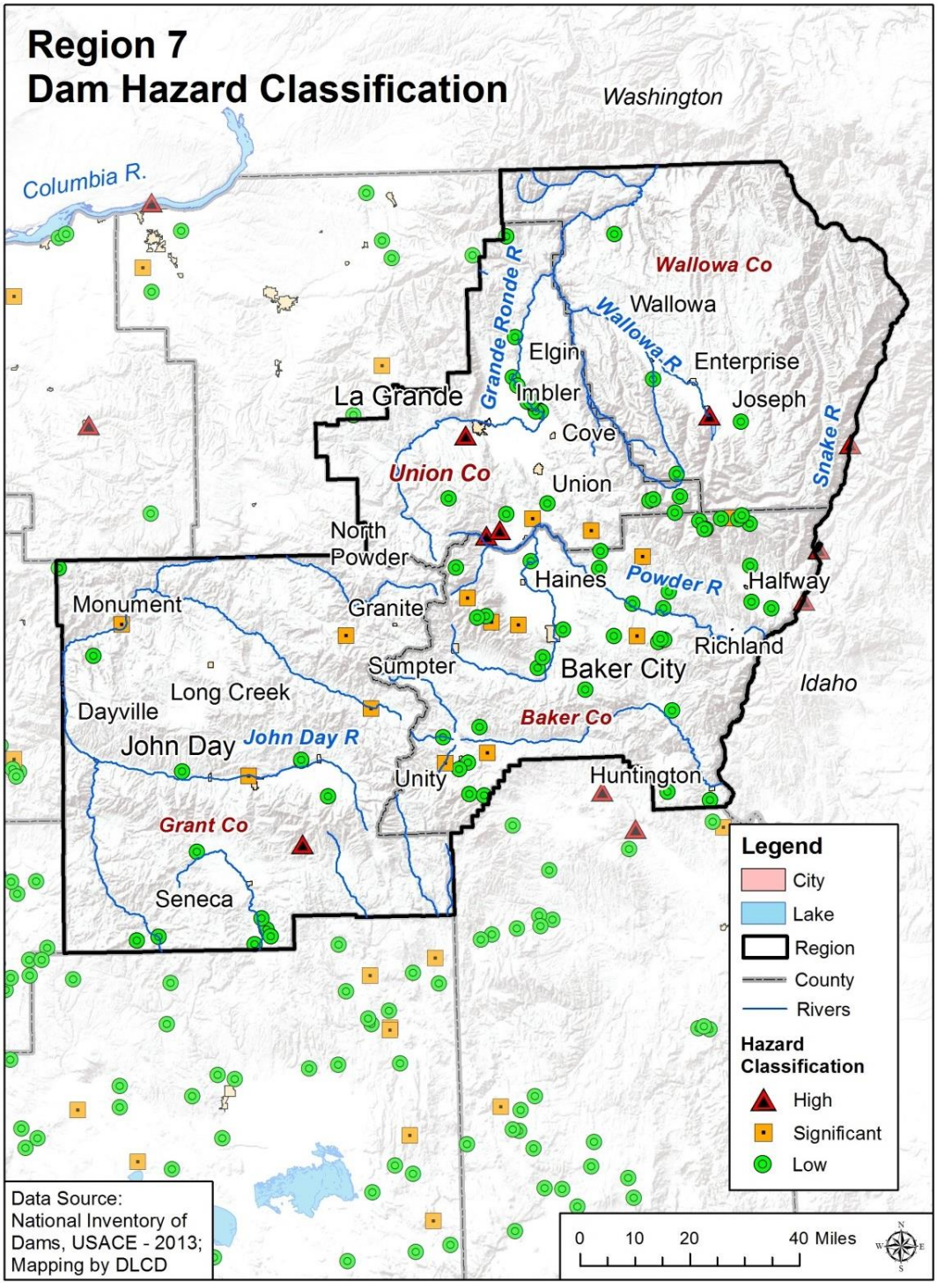
As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable jurisdictions” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The 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

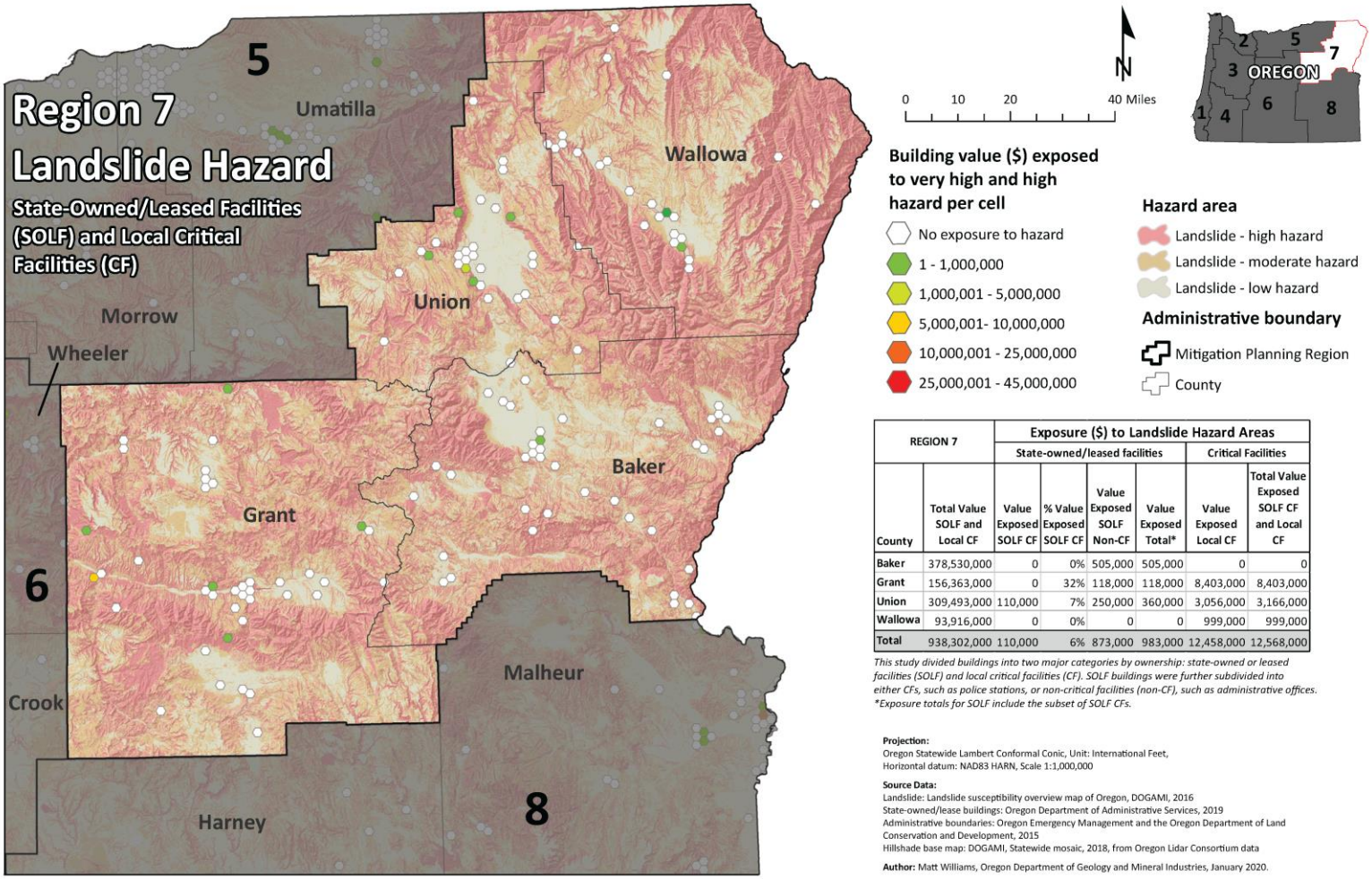
Source: DOGAMI and DLCD, 2020

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

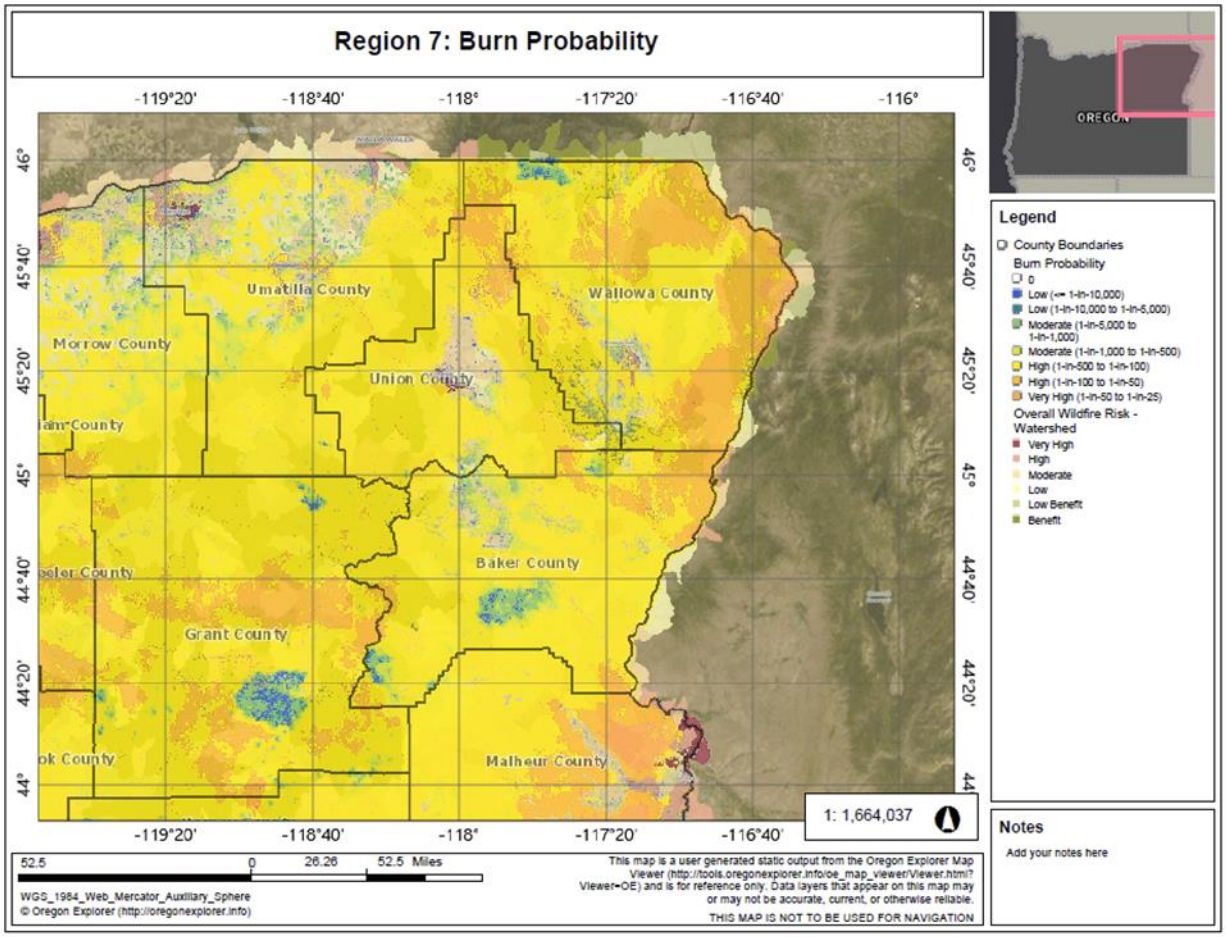
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

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



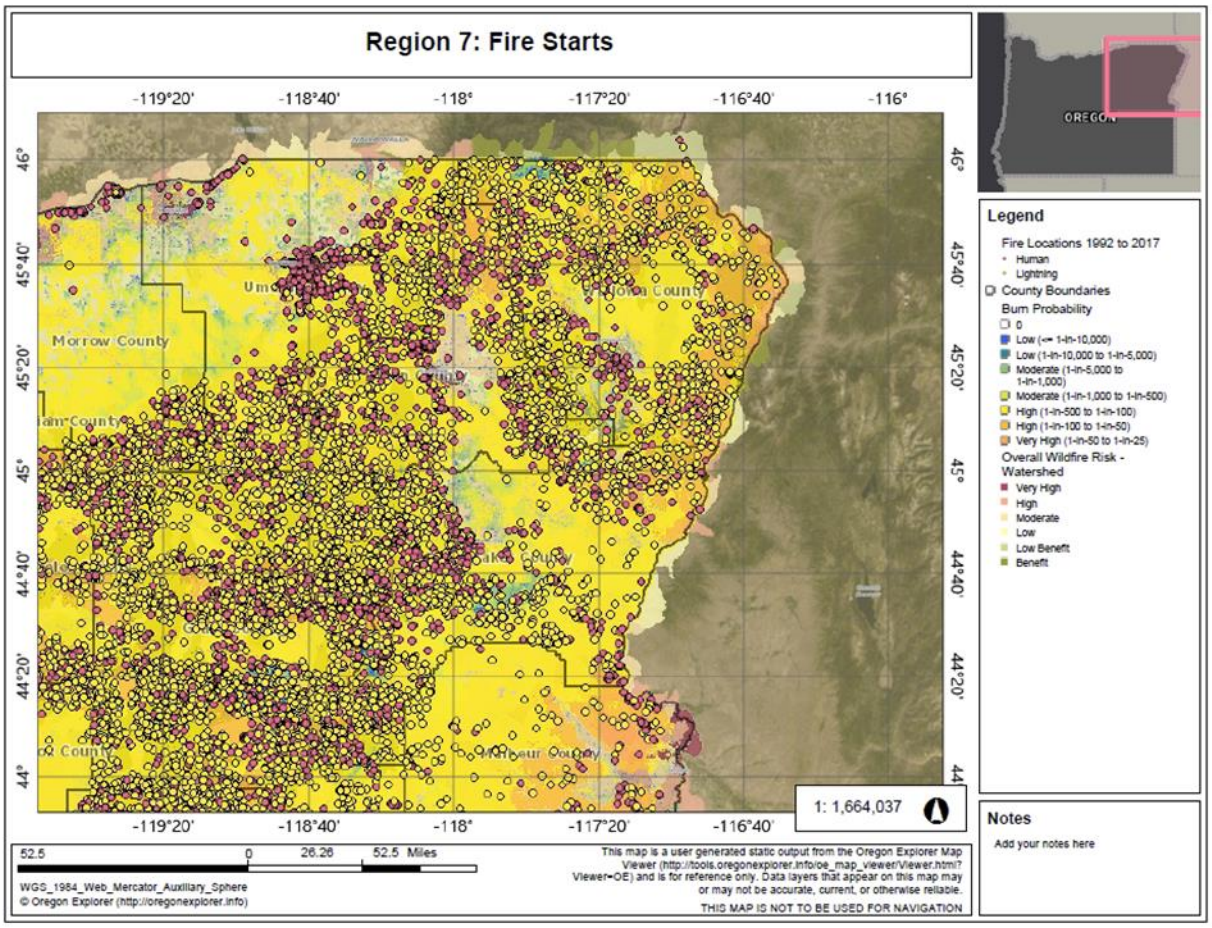
Source: Oregon Wildfire Risk Explorer, March 2020

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			

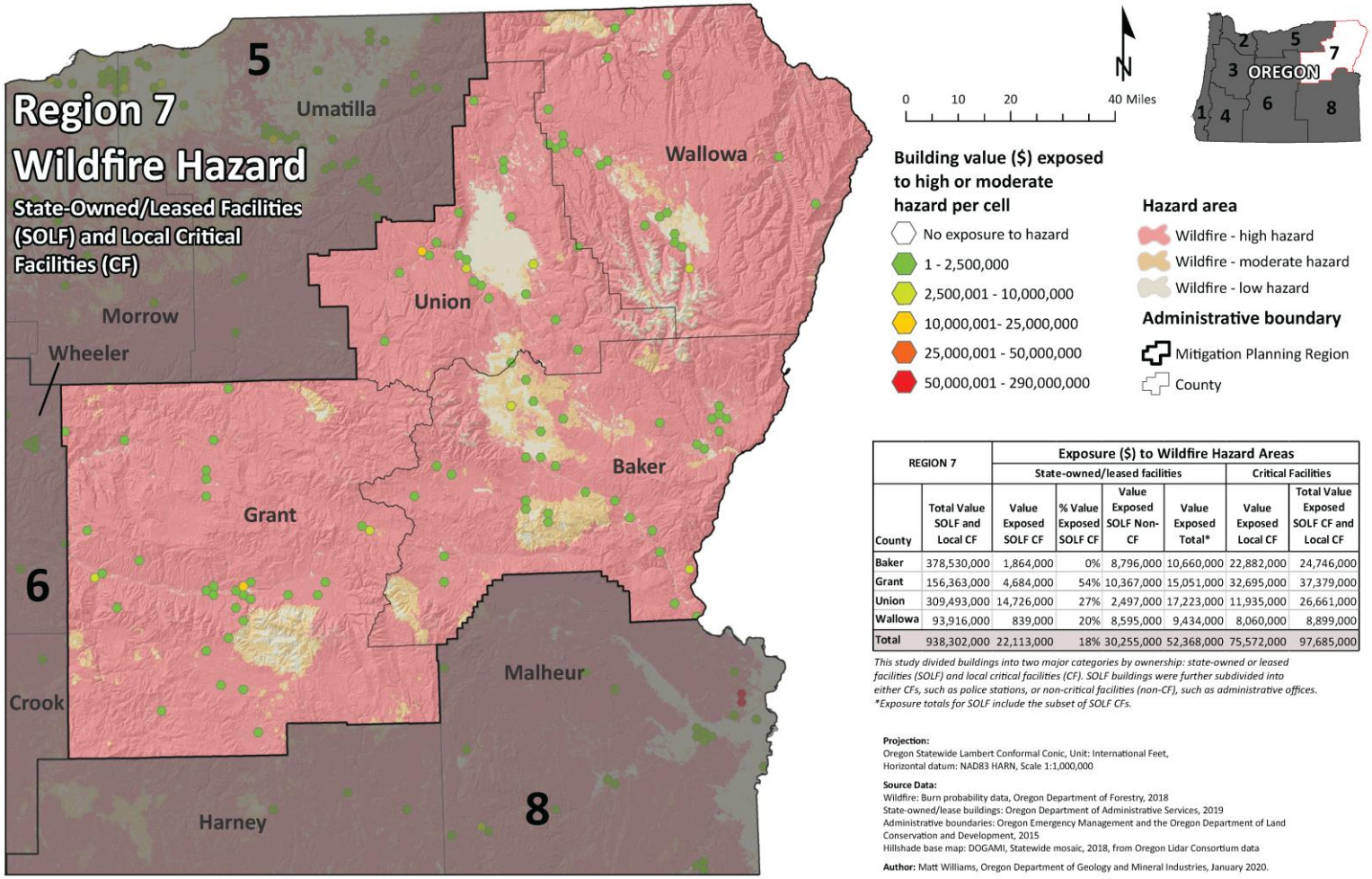
Source: Oregon Department of Forestry 2020 Communities at Risk Report

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

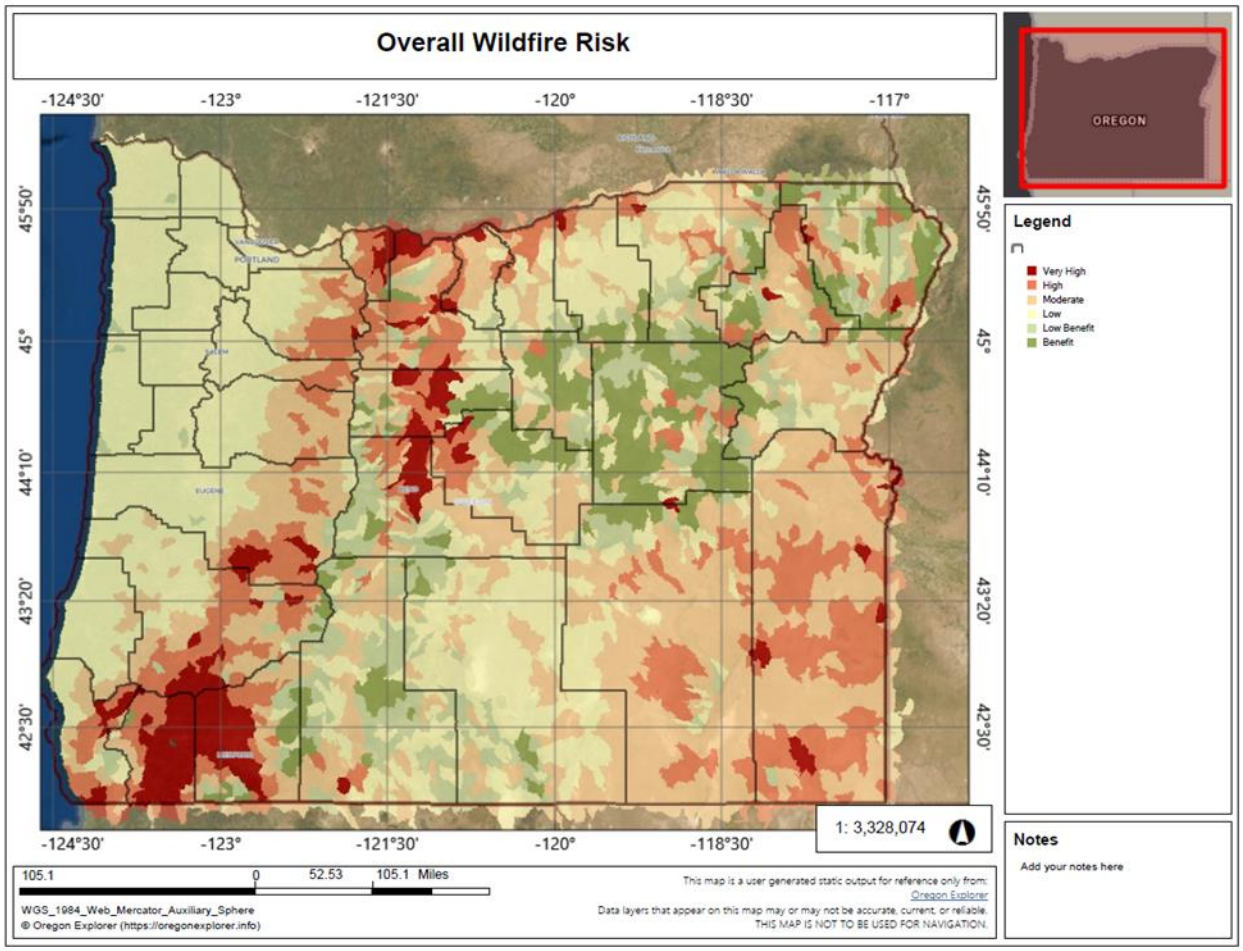
Table 2-731. Risk of Wildfire Hazards in Region 7

	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.

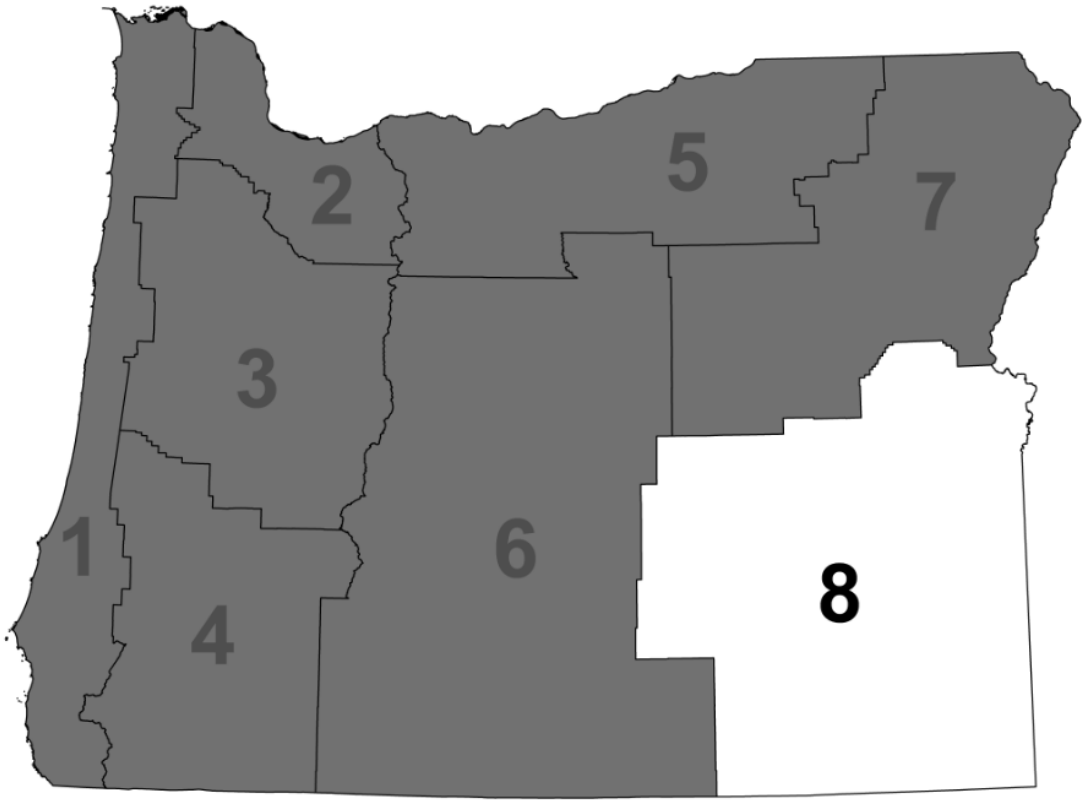
Risk

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

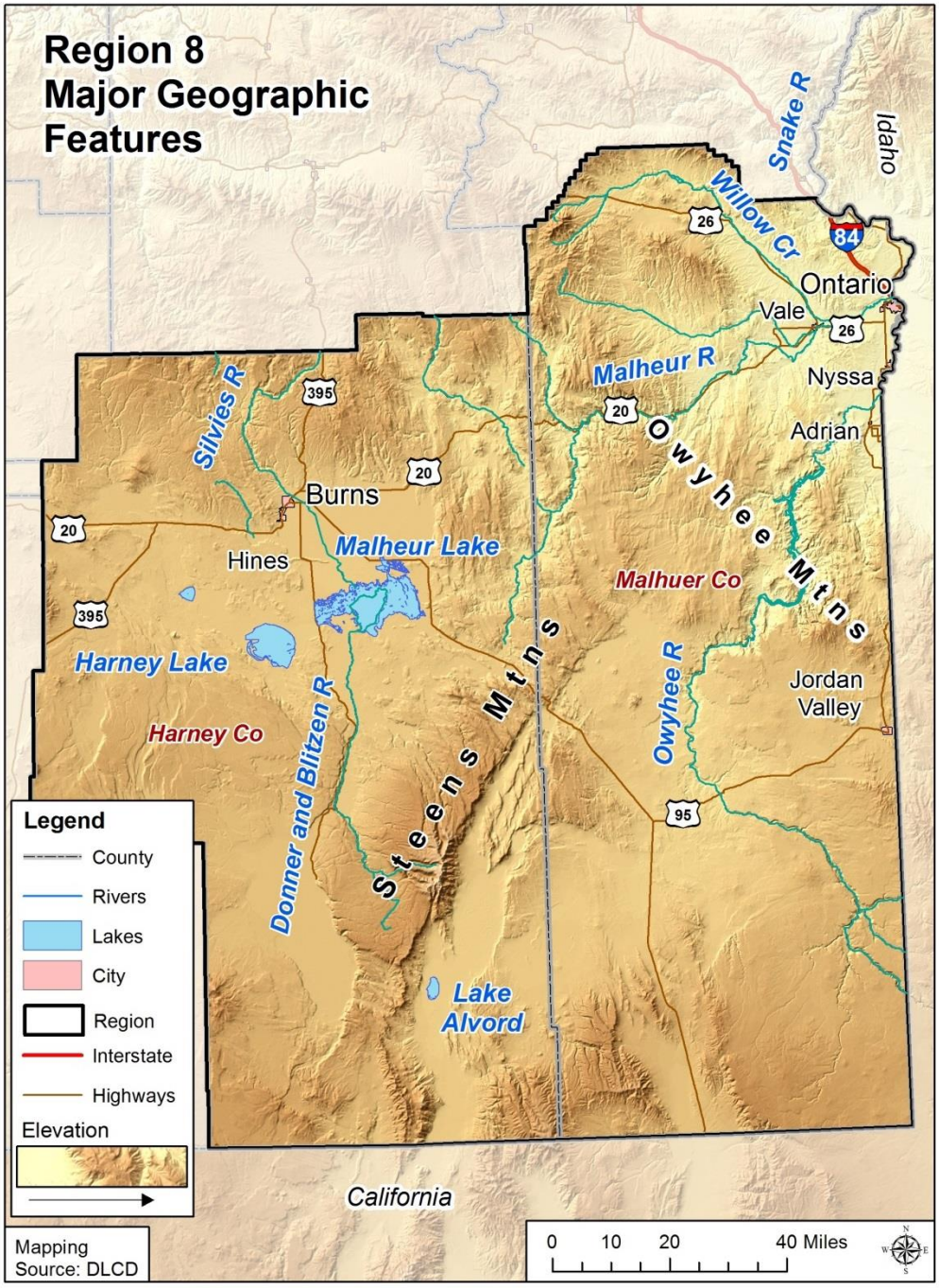
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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.

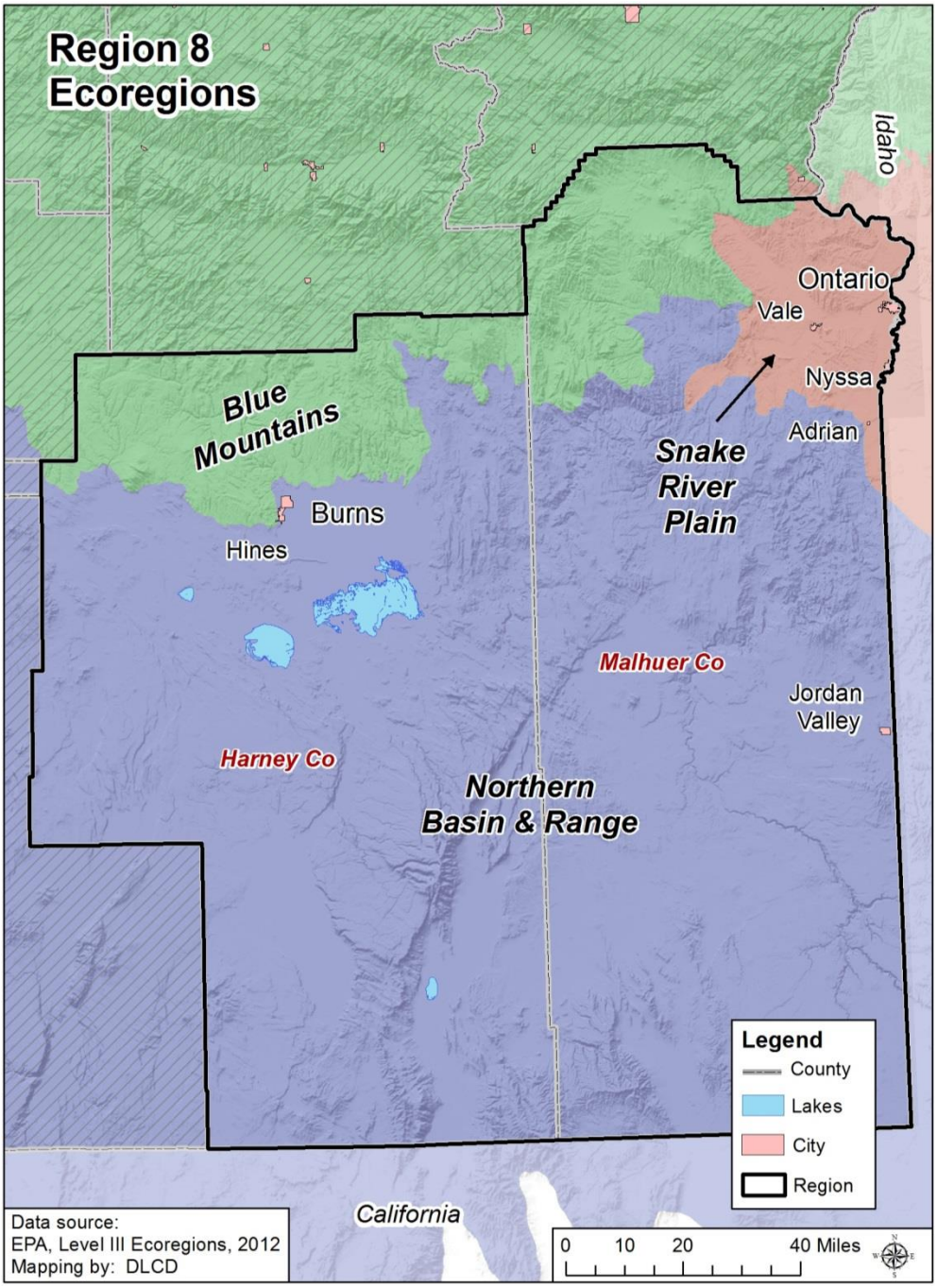
Figure 2-294. Region 8 Major Geographic Features



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.

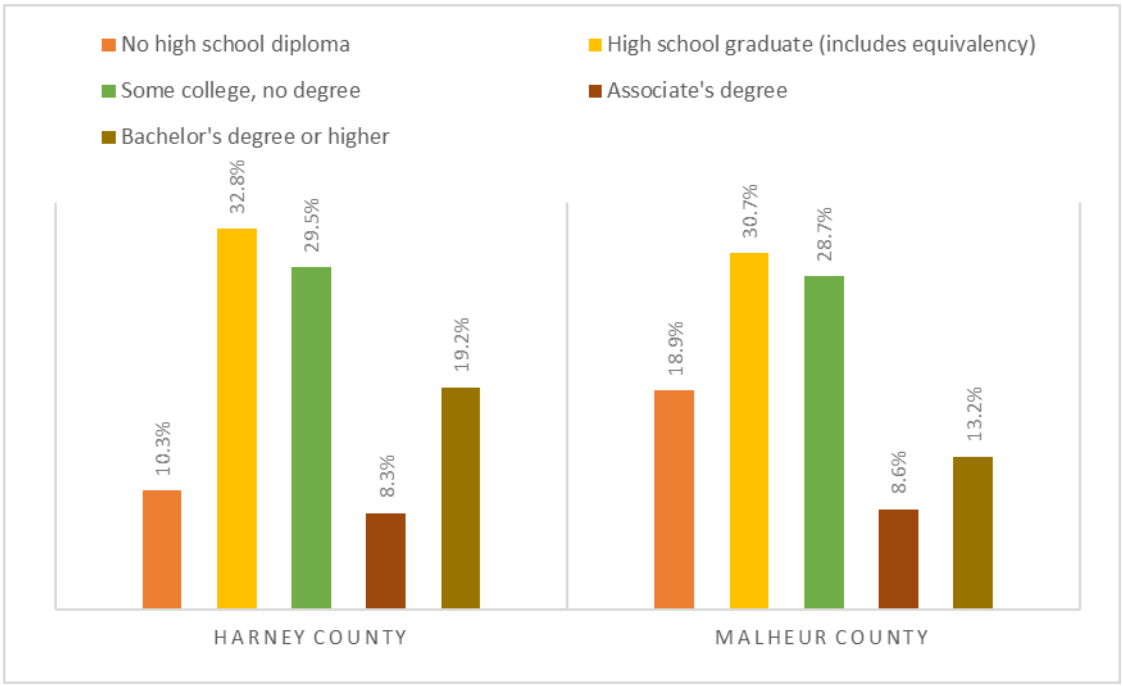
Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

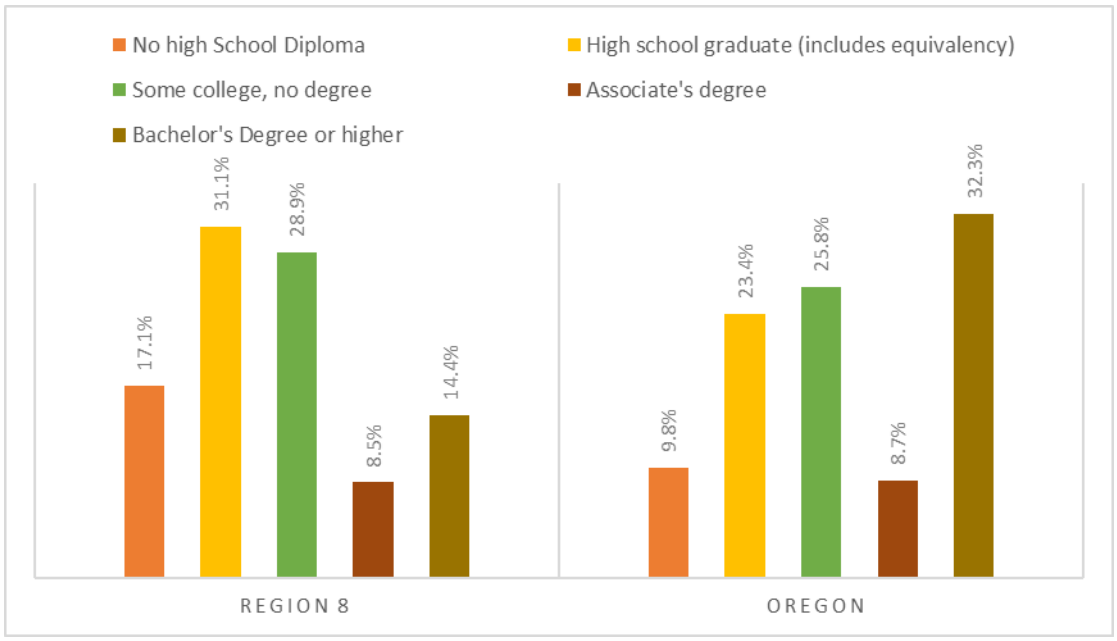
Education Level

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.

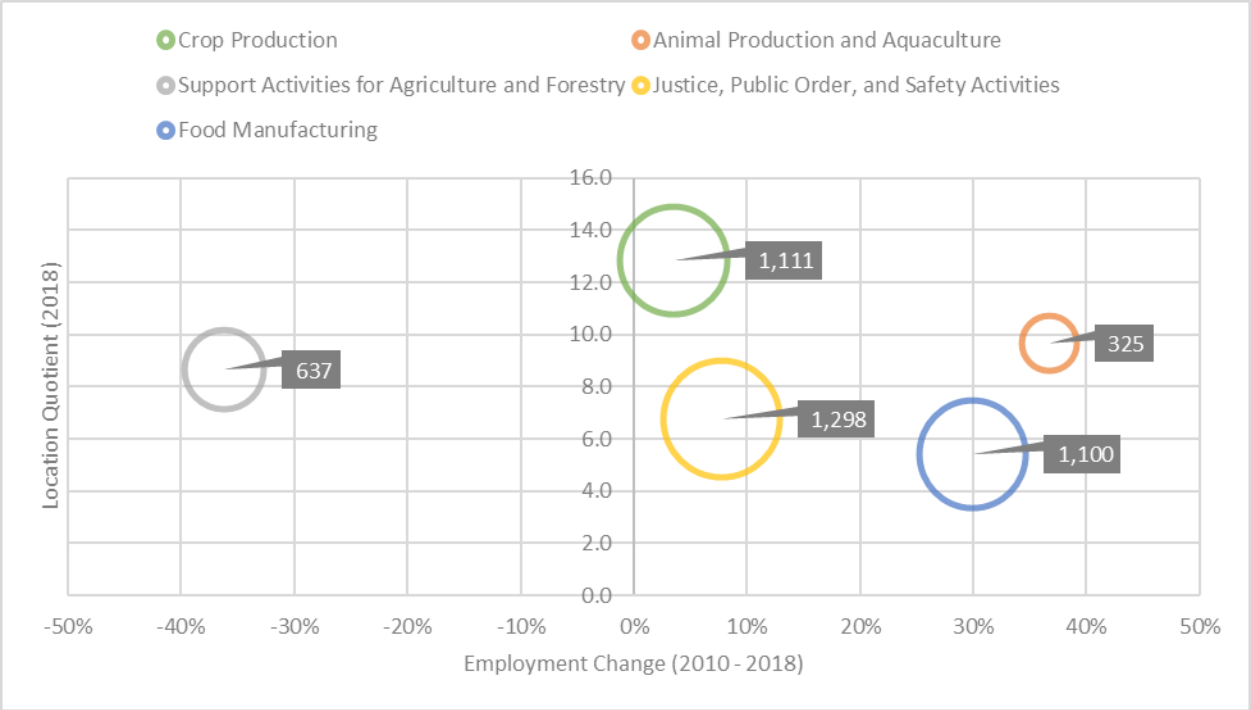
Table 2-757. Most Concentrated Industries and Employment Change in Region 8, 2018

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

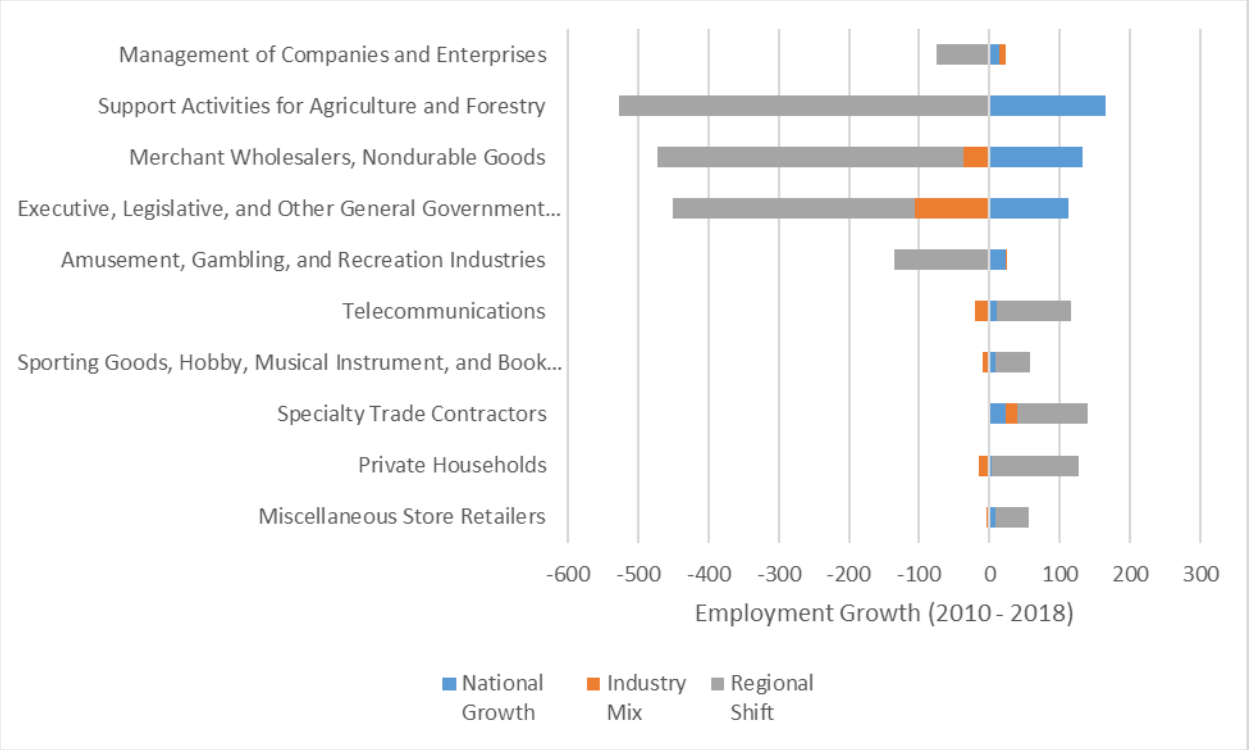
Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Private Households	546%	21	133
Telecommunications	149%	63	158
Miscellaneous Store Retailers	104%	50	103
Sporting Goods, Hobby, Musical Instrument, and Book Stores	104%	47	97
Specialty Trade Contractors	102%	136	275
Fastest 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

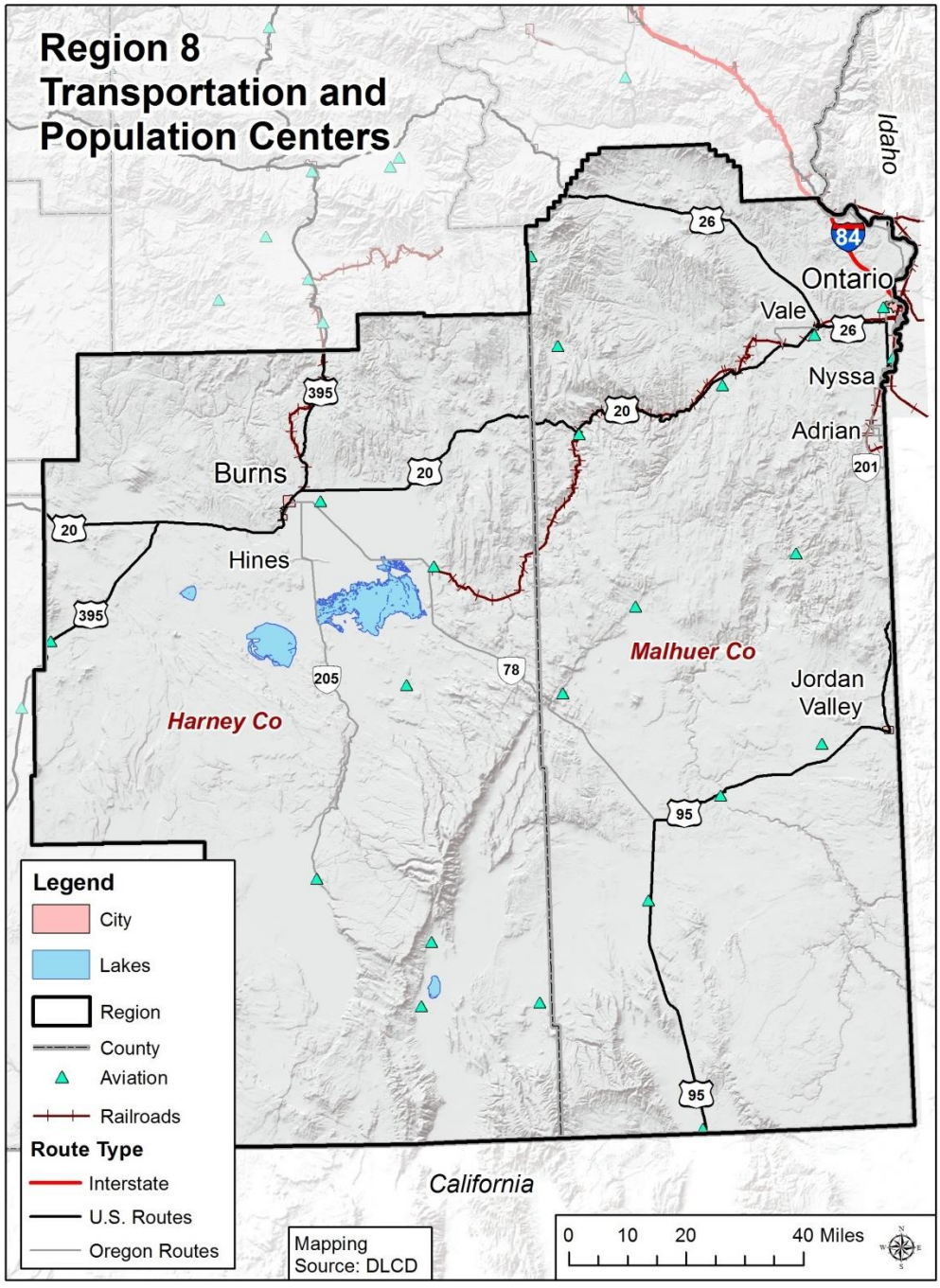
The largest population bases in Region 8 are located along the region's major highways: I-84, US-20, US-26, and US-95. I-84 runs north-south and is the main passage for automobiles and trucks traveling east of the Cascade Range between Portland and Idaho **Figure 2-300** shows Region 8's highways and 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.

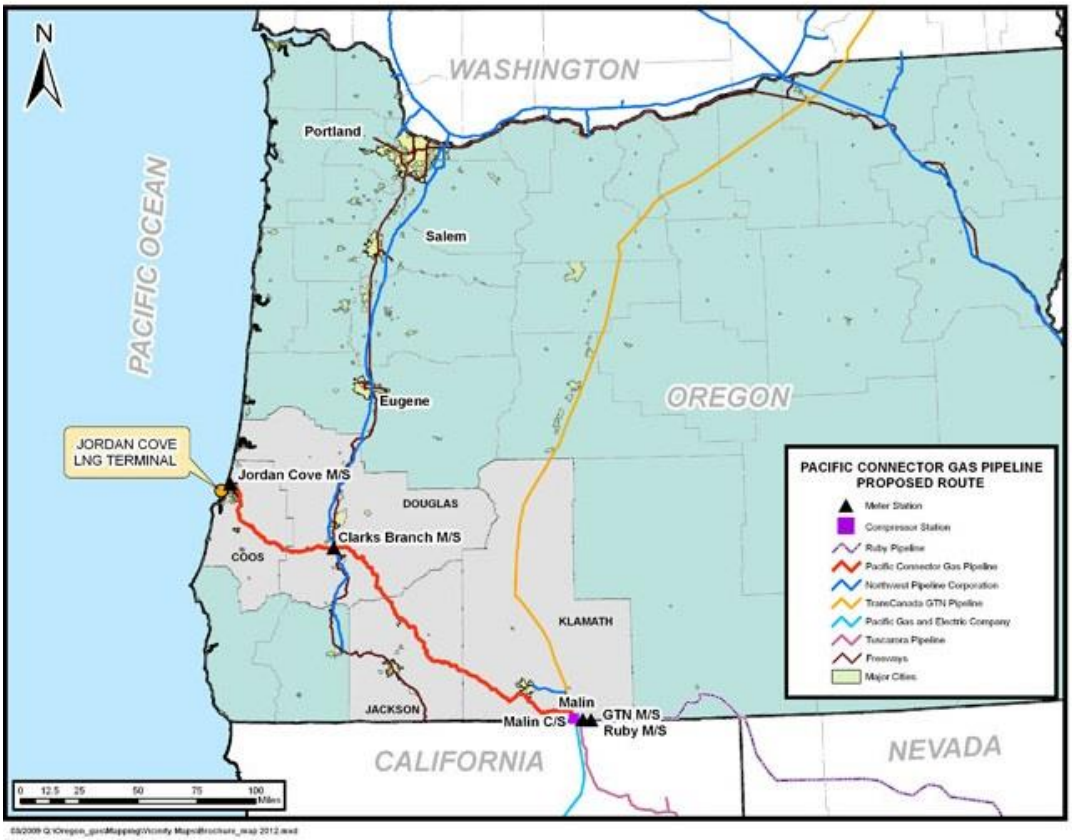
Hydropower

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

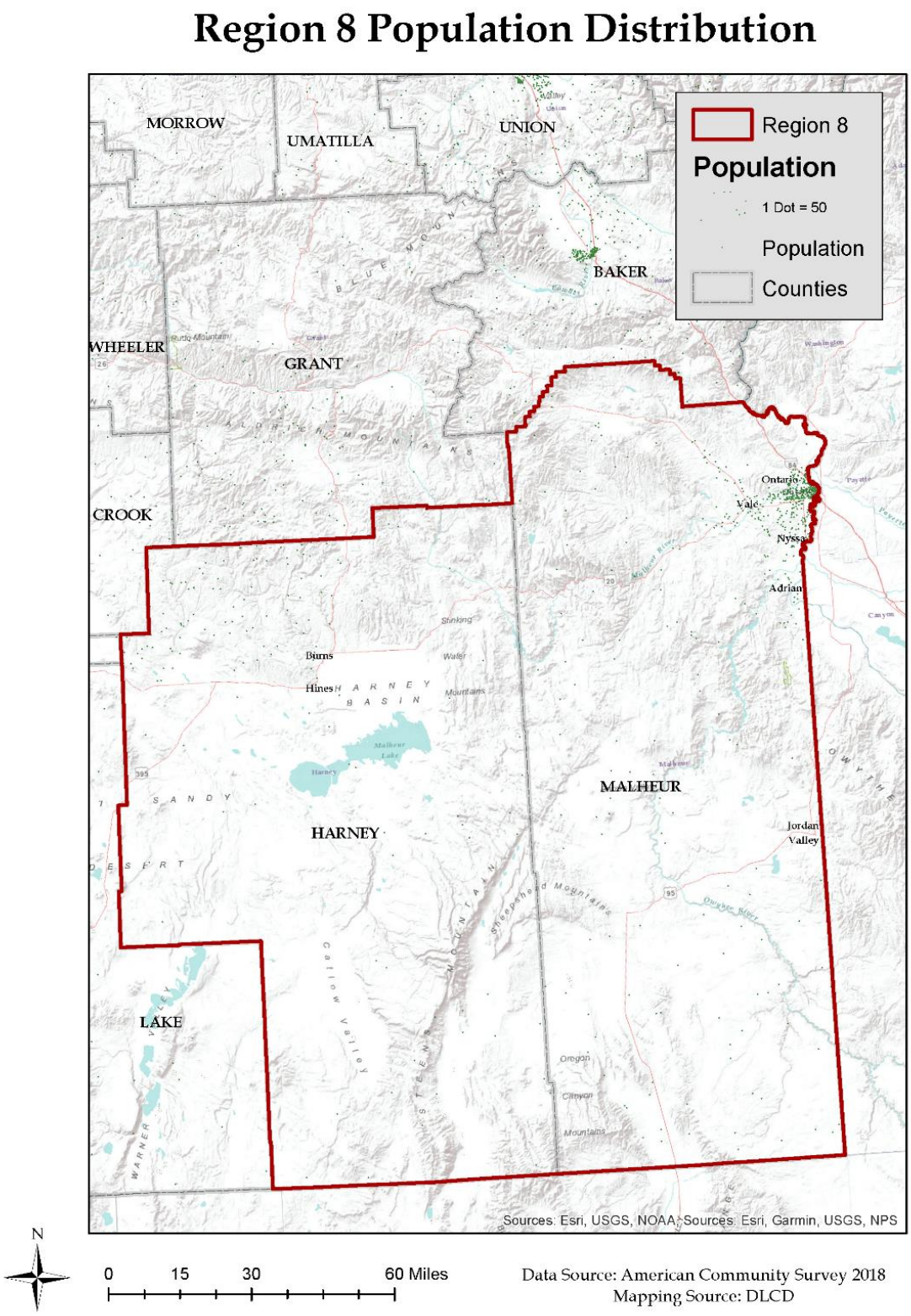


Table 2-764. Urban and Rural Housing Units in Region 8, 2010

	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 2-768Table 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.

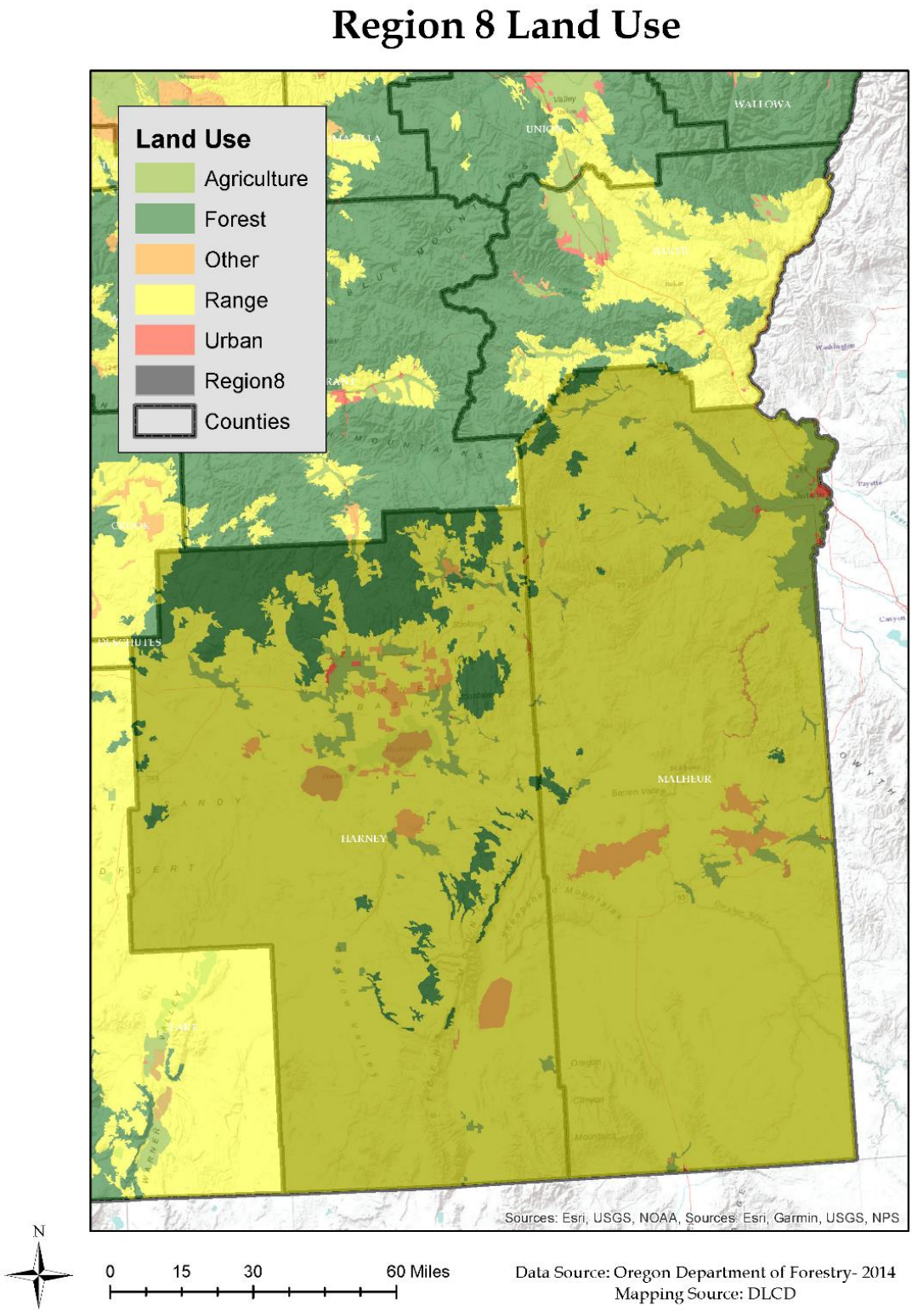
Overall, Region 8 is overwhelmingly rangeland, with the Bureau of Land Management (BLM) controlling much of the land. The land cover is largely grasslands and shrubs. Irrigated fields in the county's northeast corner, known as Western Treasure Valley, are the center of intensive and diversified farming.

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.



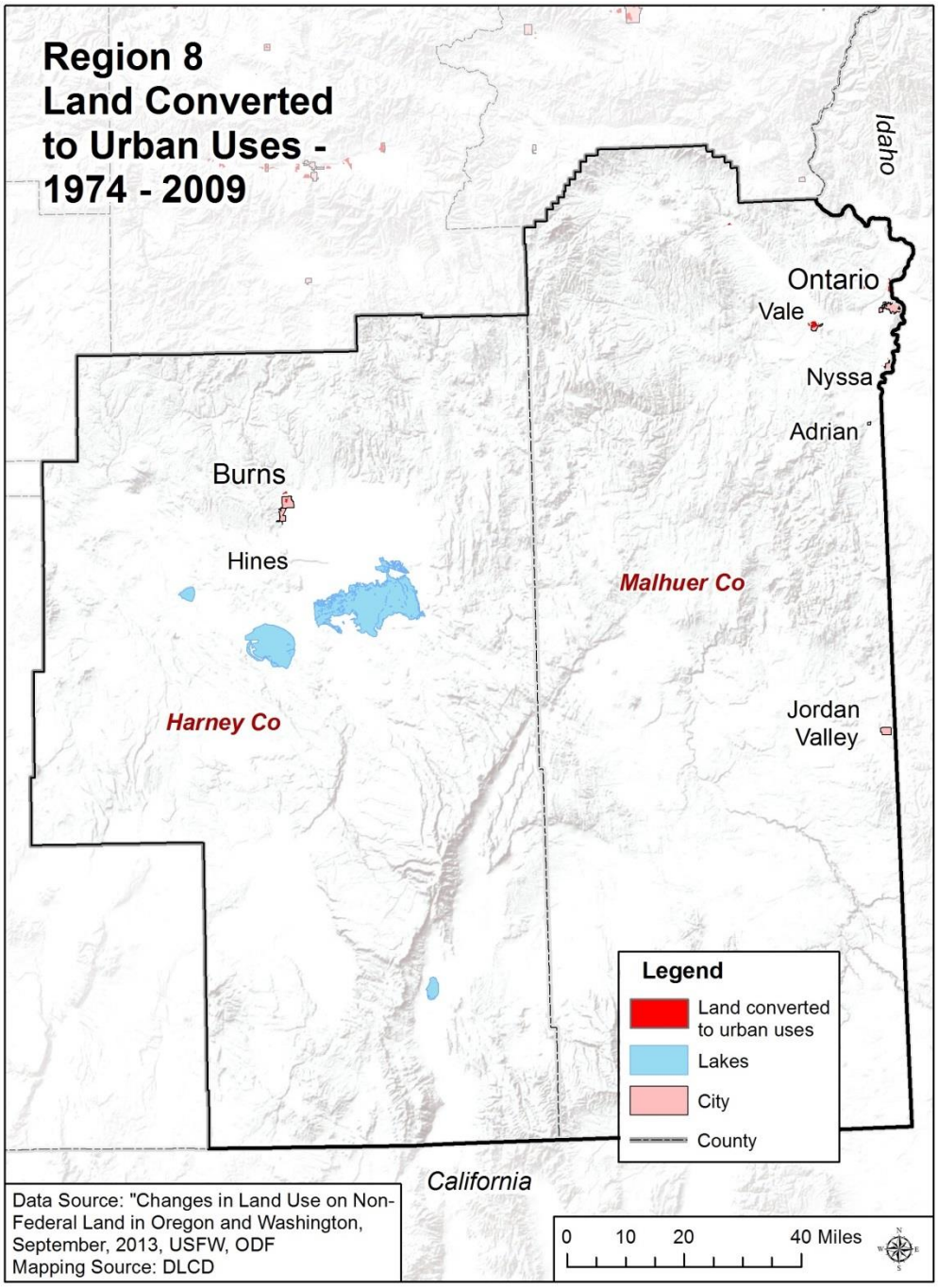
In July 2015, the Land Conservation and Development Commission adopted the "Sage Grouse Rule" to prevent listing of sage-grouse as under the Endangered Species Act. The rule protects sage-grouse habitat and limits the loss of core habitat from development. Counties review development applications for 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

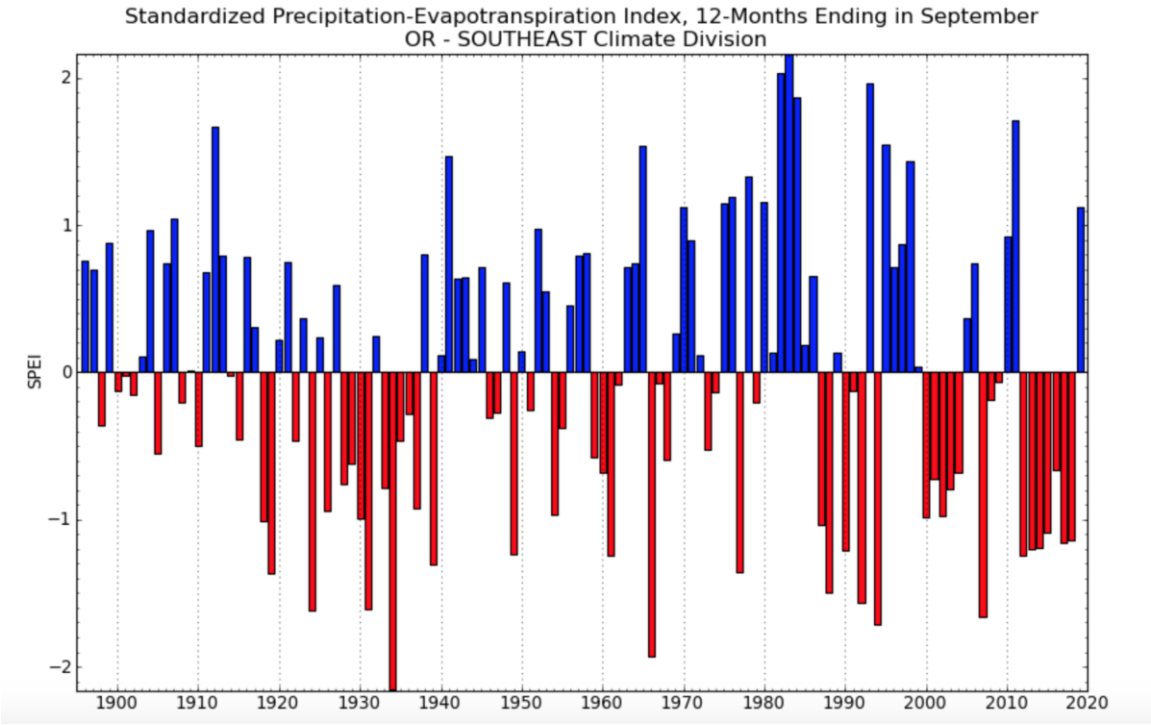
Historical drought information can also be obtained from the West Wide Drought Tracker, which provides historical climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895.



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

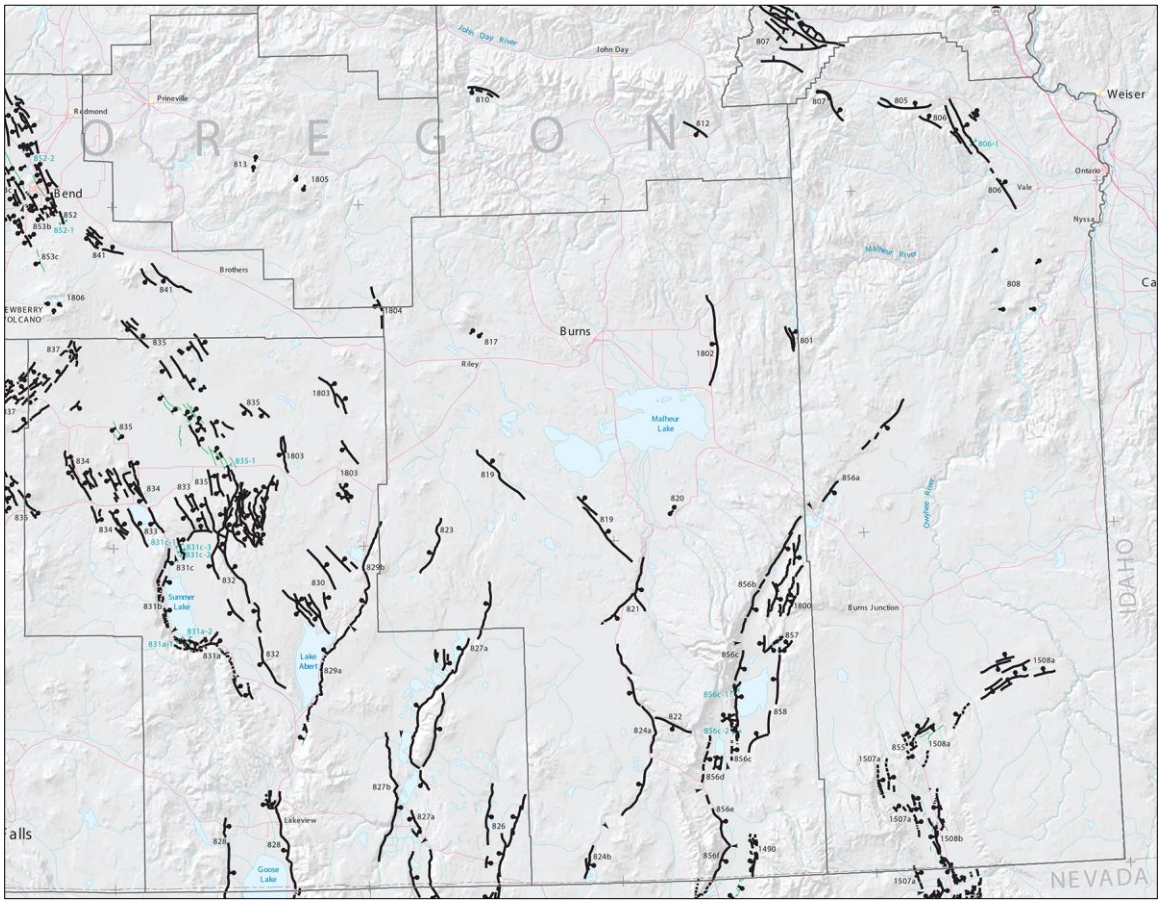
With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based on the very high probability of drought and vulnerability to it, risk of drought in Region 8 is considered very high.

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

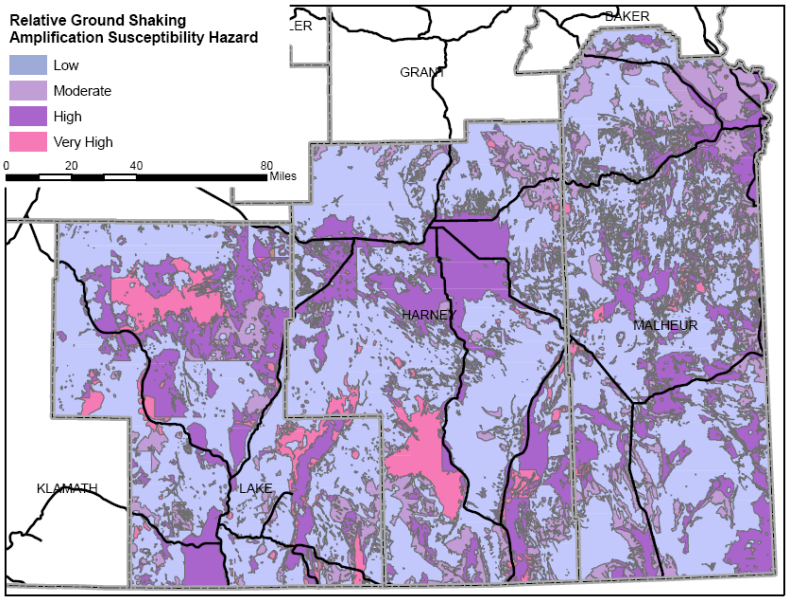


Source: Modified from Personius, et al. (2003)

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.

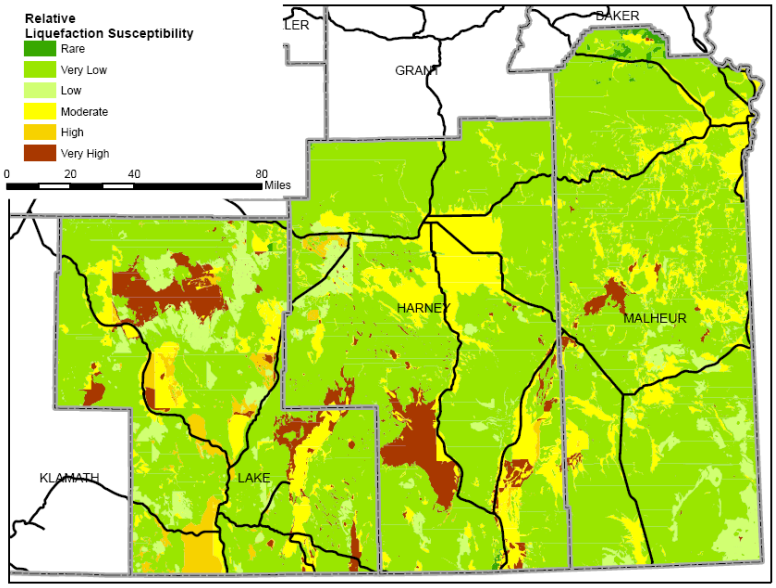
Figure 2-307. Relative Ground Shaking Amplification Hazard in Region 8



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.

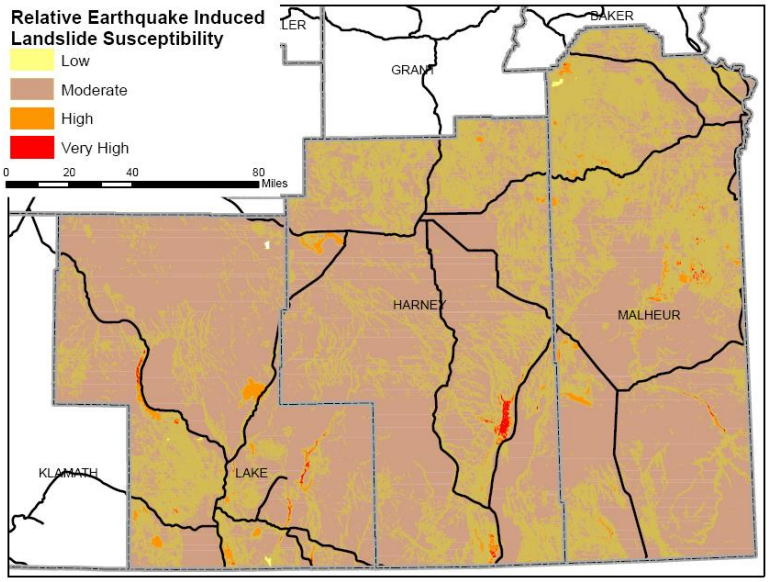
Figure 2-308. Relative Liquefaction Susceptibility Hazard in Region 8



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



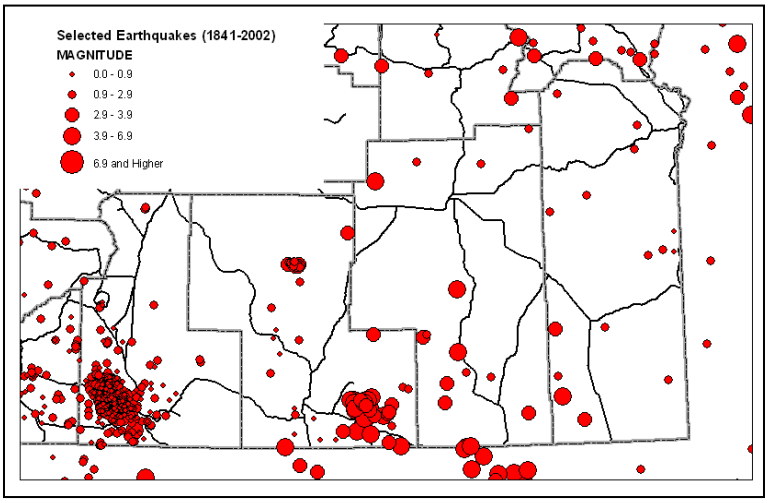
Source: Burns (2007)

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

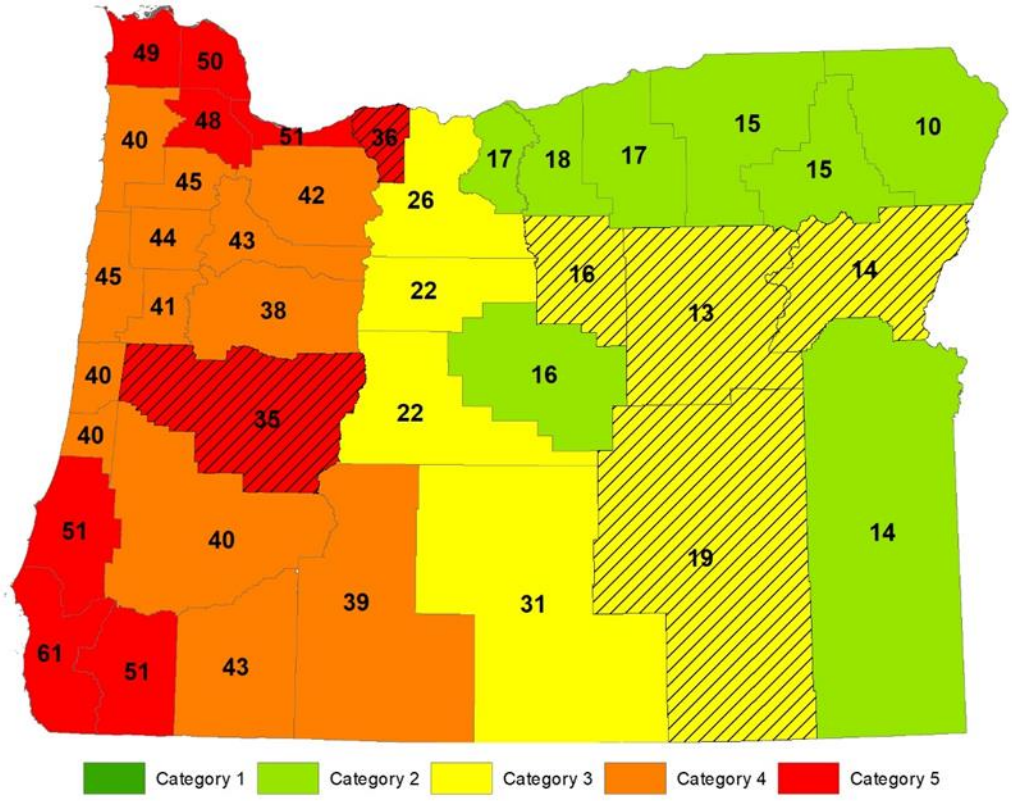
The probability of damaging earthquakes varies widely across the state. In Region 8, the hazard is dominated by local faults and background seismicity.

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)

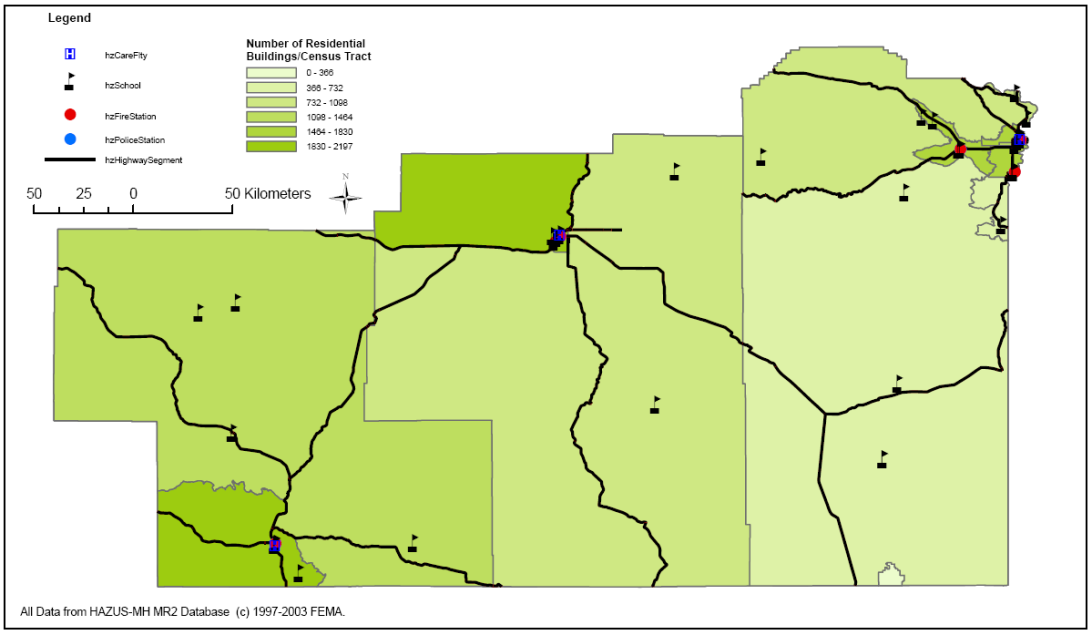
Table 2-780. Assessment of Vulnerability to Earthquakes in Region 8

	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

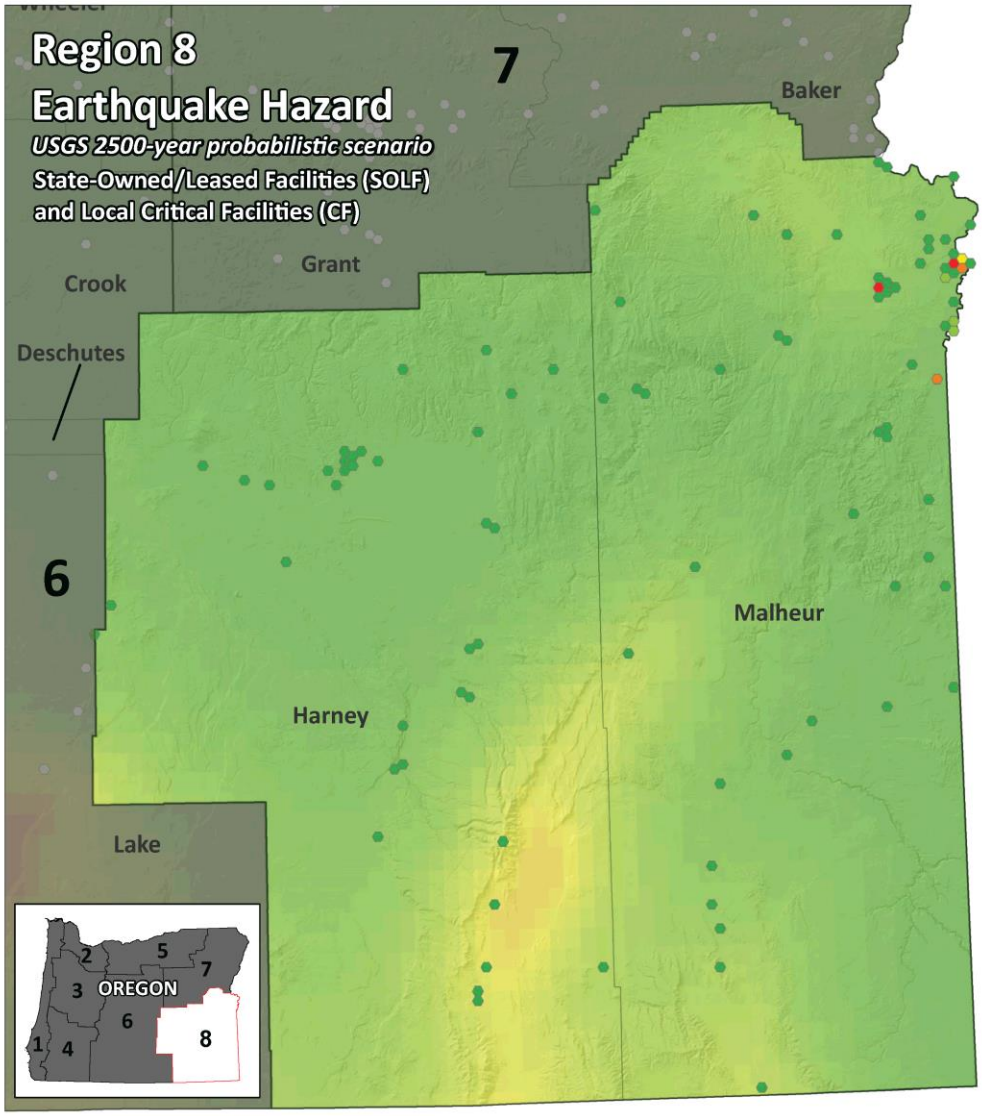
State-Owned/Leased Buildings And Critical Facilities And Local Critical Facilities

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).

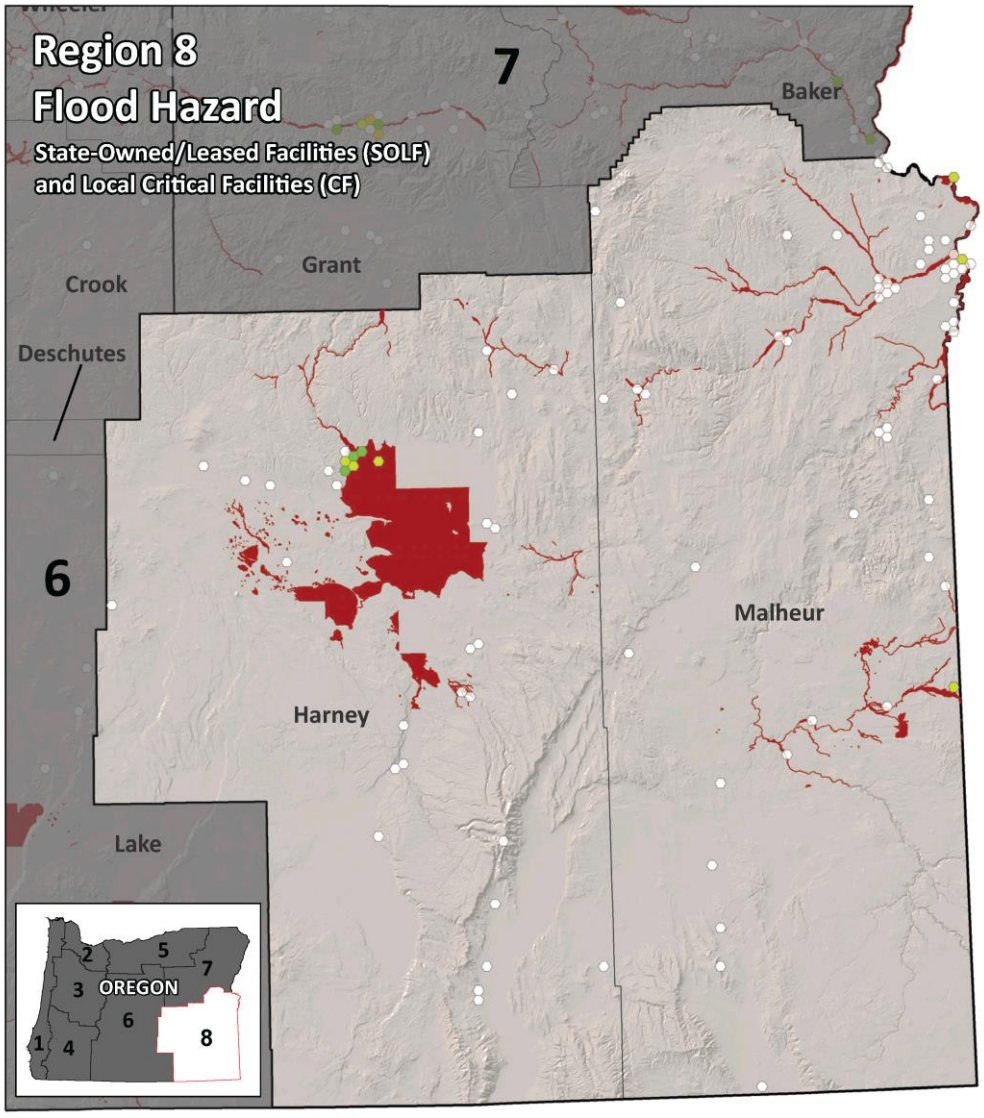
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS) Program, which results in reduced flood insurance costs. 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

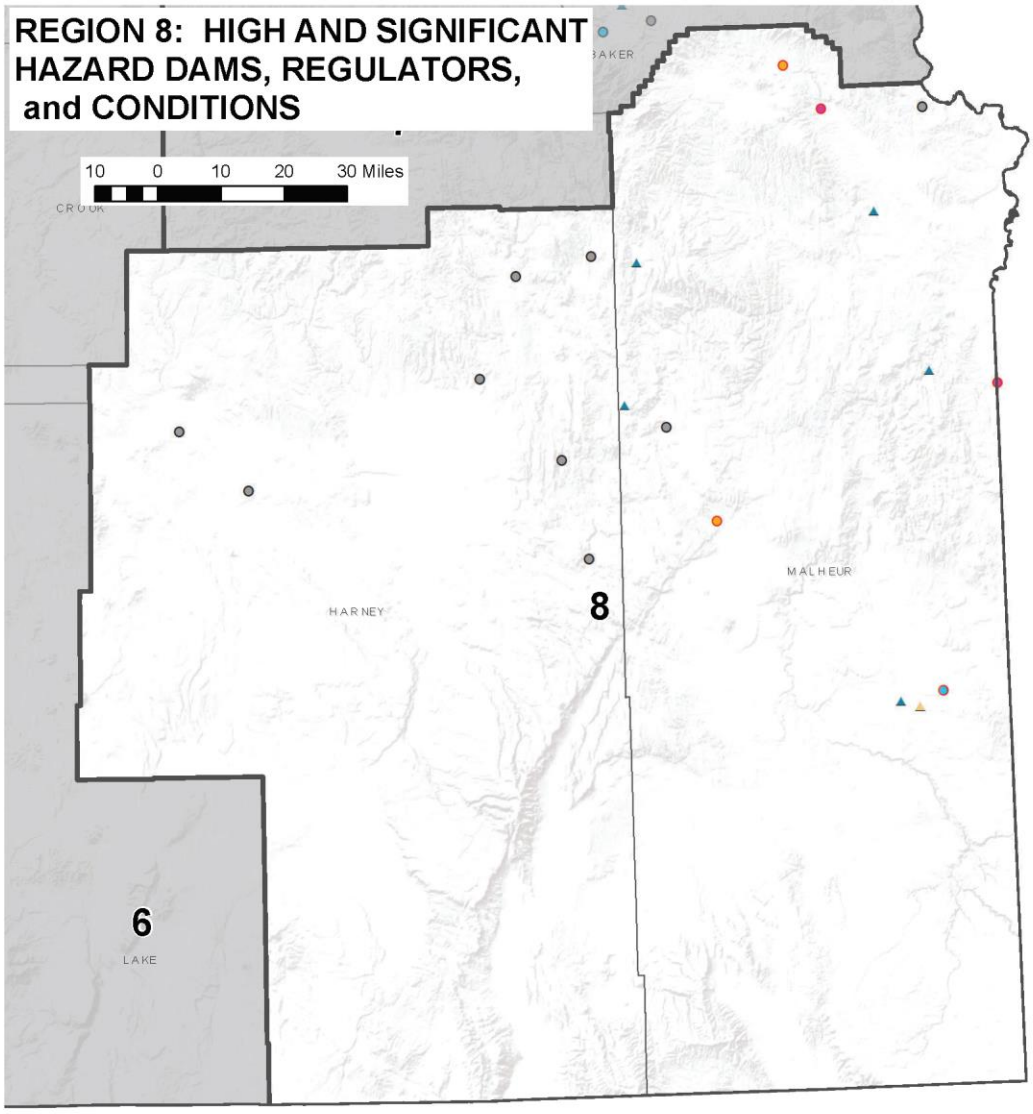
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Crowley Reservoir	OR00132	UNSAT	3	3	Malheur
Lonesome Lake		POOR	Small	Small	Malheur
Pole Creek	OR00239	POOR	37	103	Malheur
Willow Creek 3 (Malheur)	OR00390	UNSAT	3,426	3,518	Malheur

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

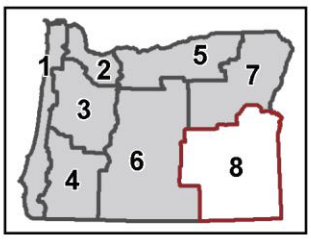
- High
- Significant

- 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

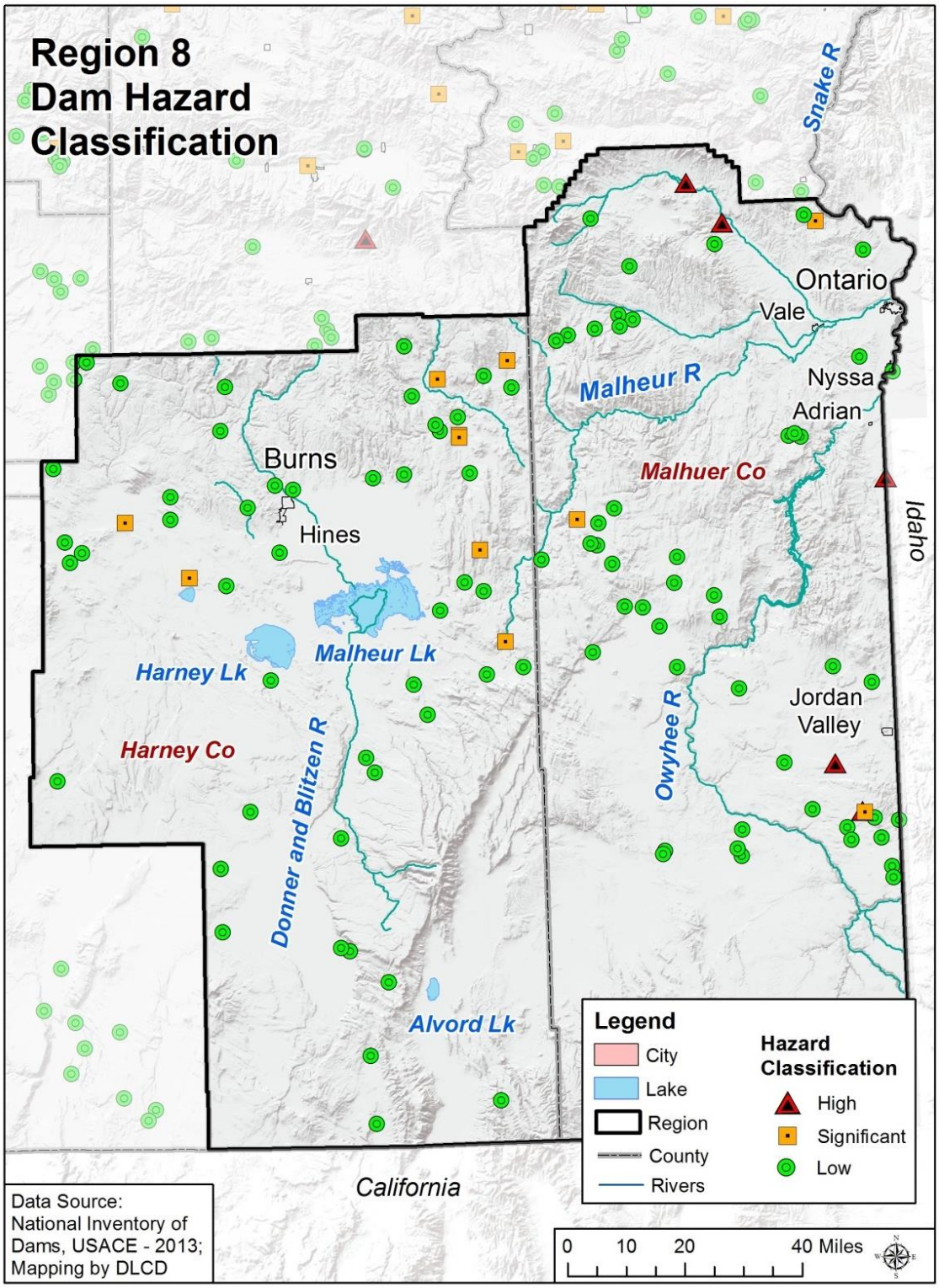
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), only Malheur County in Region 8 has high hazard dams 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

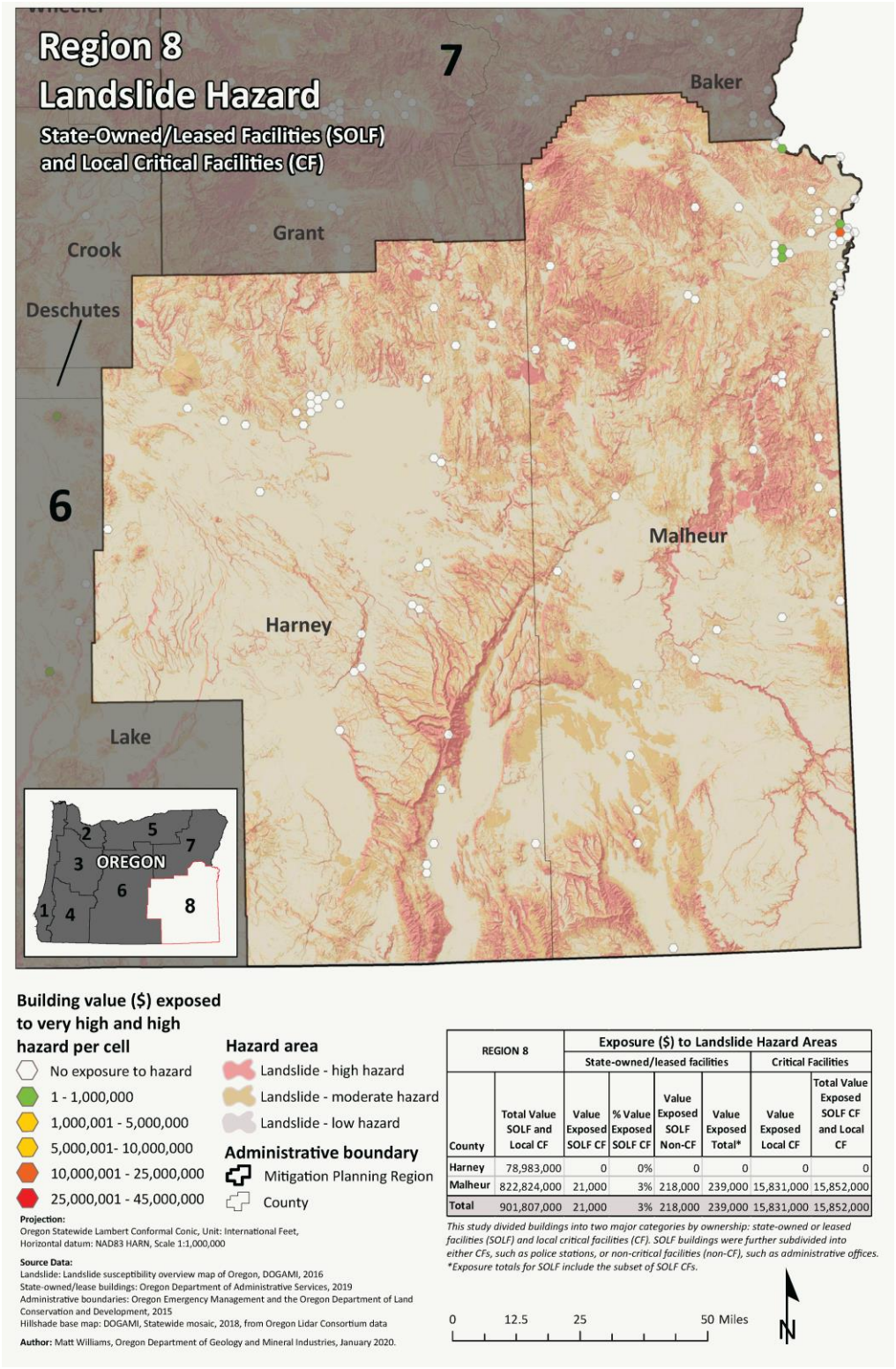
Landslides pose significant threats to people and infrastructure. Landslides have caused damage and loss in Region 8, and it is very likely that they will again. Most of the people and infrastructure in Region 8 are located in one of the major cities in the region which are located along highways. The 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

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.

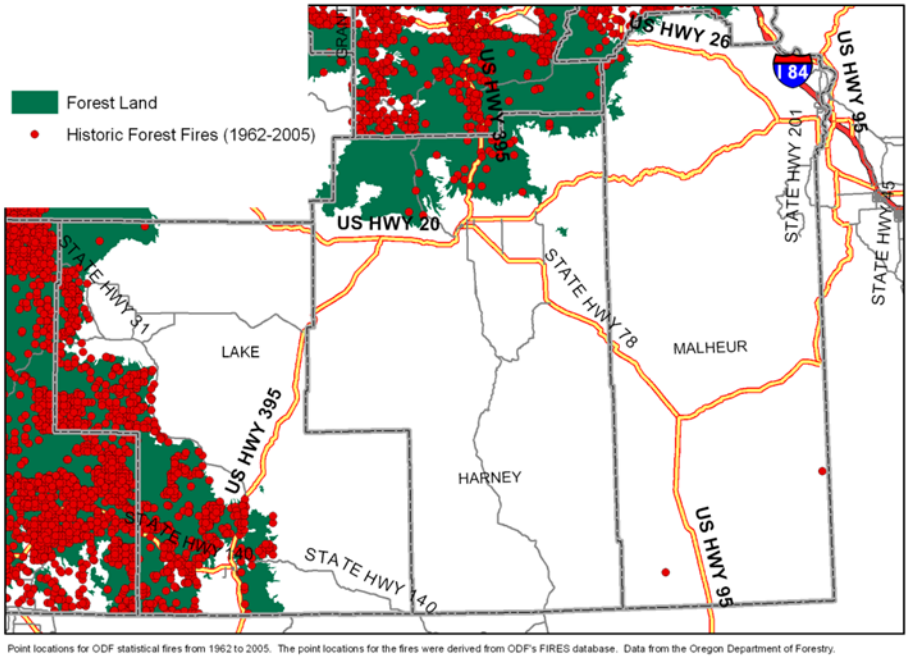
Historic Wildfire Events

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

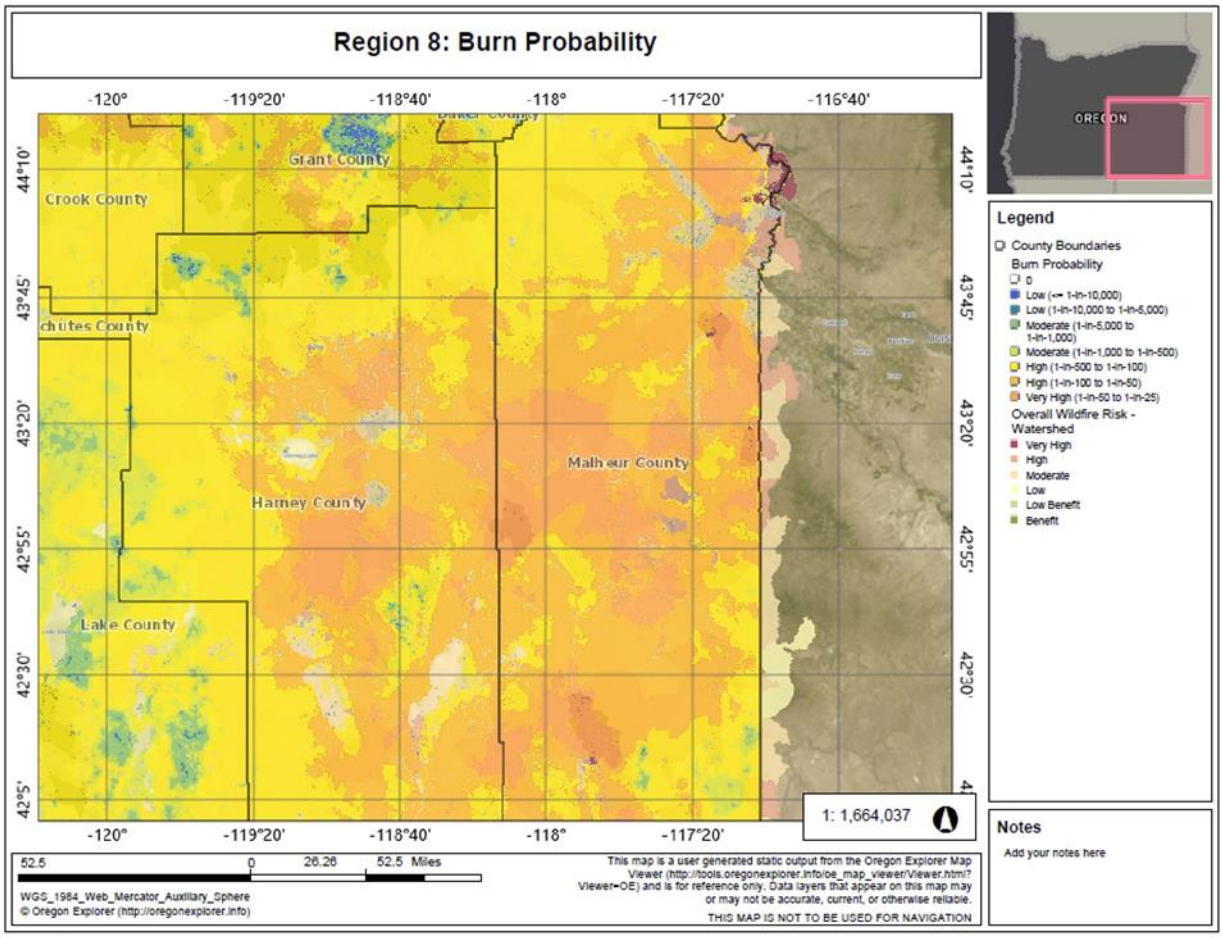
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

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

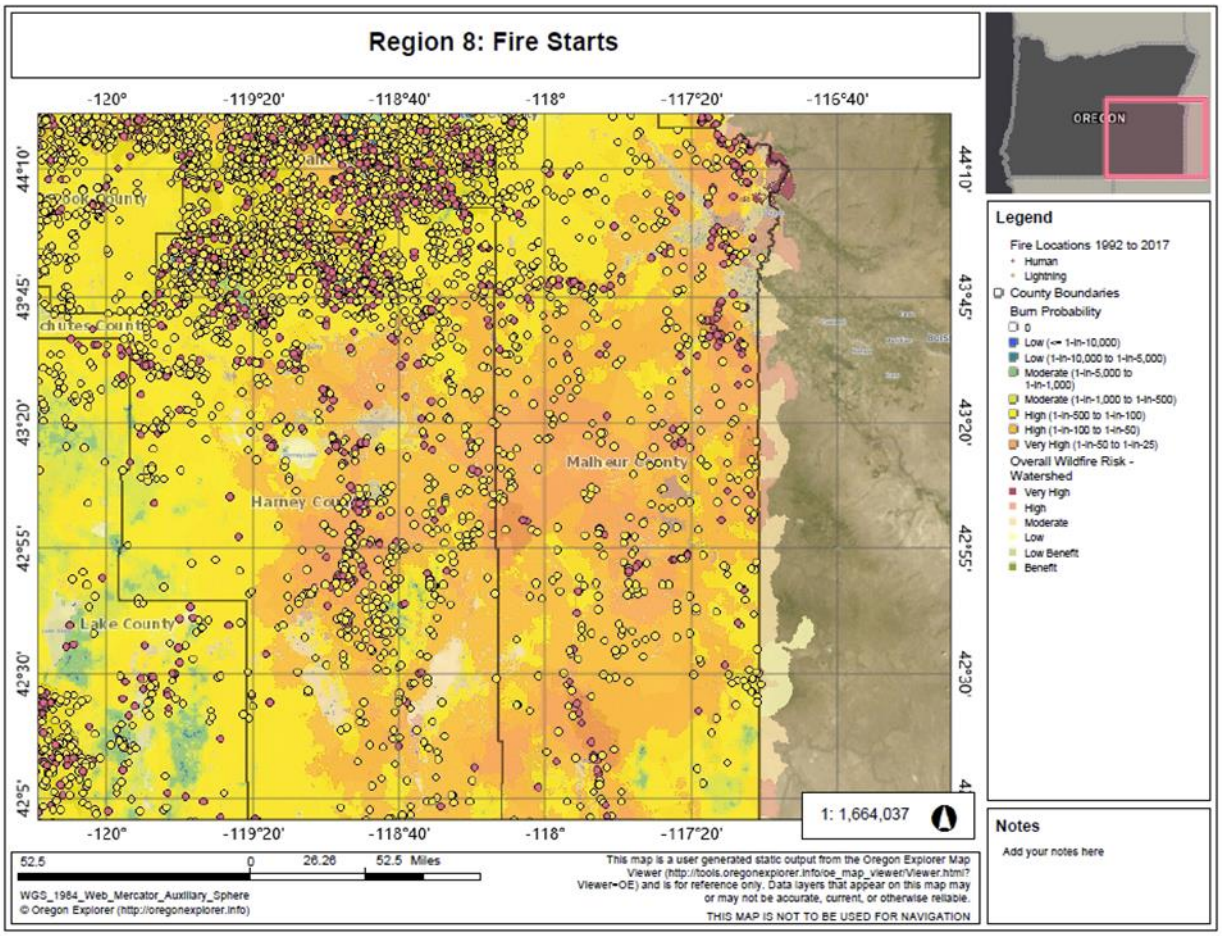
The forests and grasslands of Region 8 are highly susceptible to wildfire and many of the cities and unincorporated communities, in addition to rangelands and agricultural lands, are vulnerable to its effects. Wildfires are an annual occurrence and have varied in size from under 10 acres to over 100,000 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

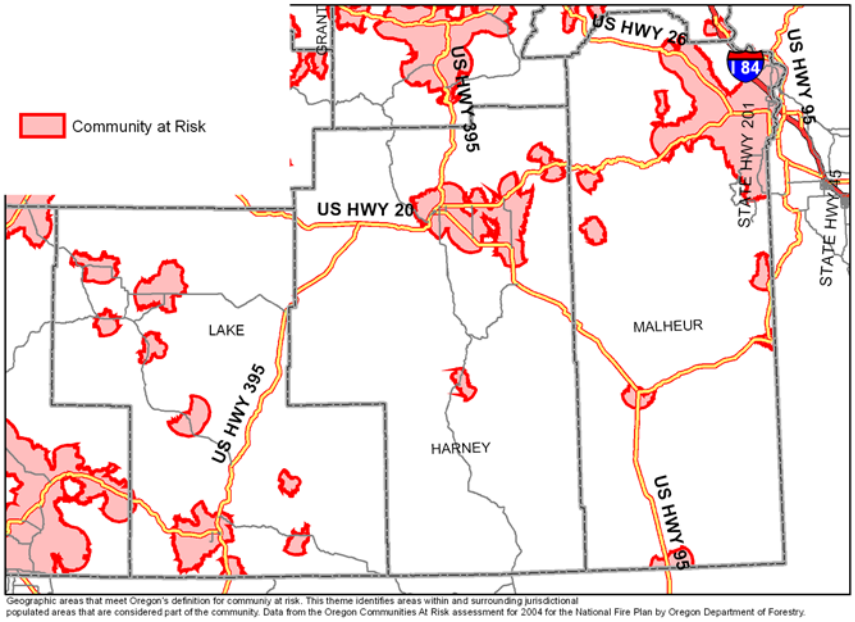
Table 2-821. Assessment of Vulnerability to Wildfire in Region 8 – 2020 Vulnerability Assessment

	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

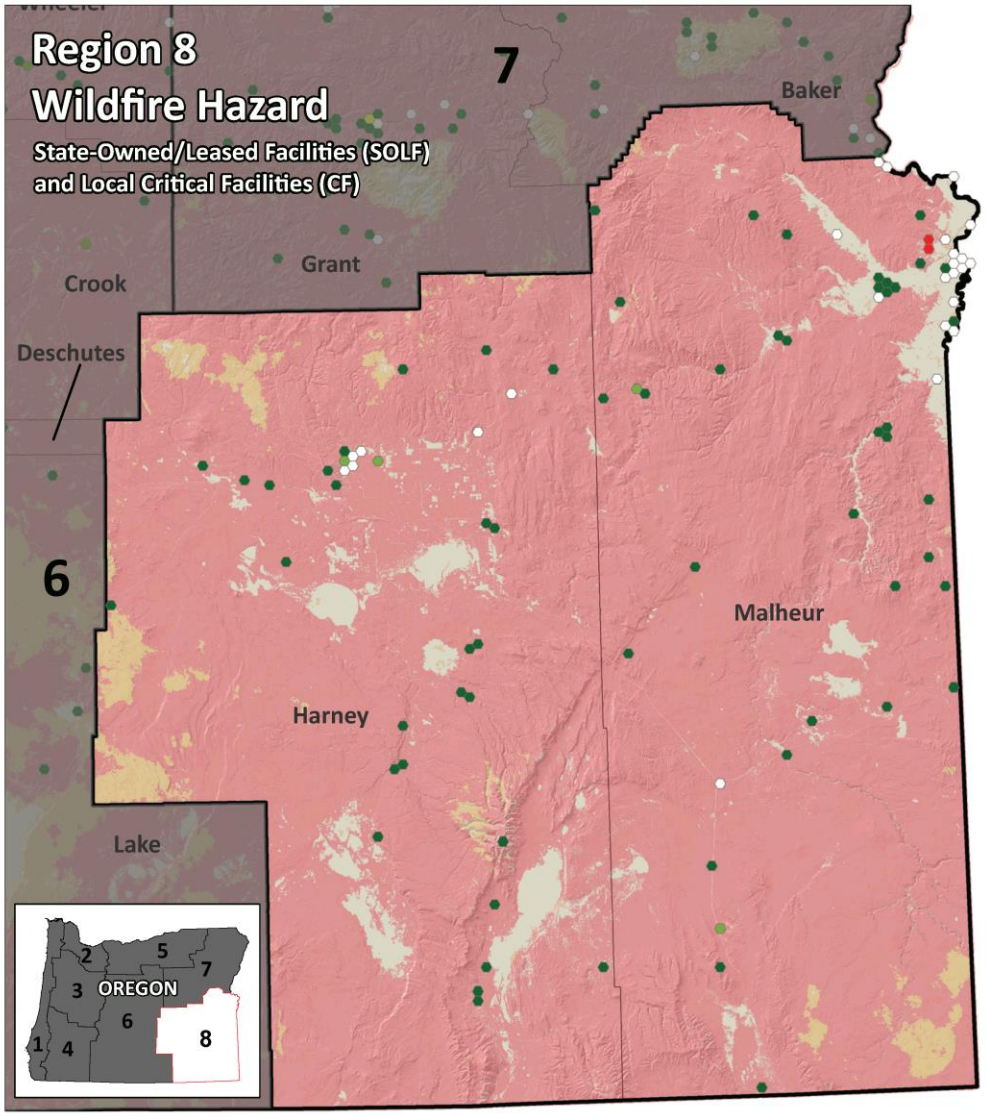
Source: Oregon Department of Forestry 2020 Communities at Risk Report

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.



Building value ($) exposed to high or moderate 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 - 290,000,000

Hazard area

- Wildfire - high hazard
- Wildfire - moderate hazard
- Wildfire - low 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:
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 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.*

0 12.5 25 50 Miles

N

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

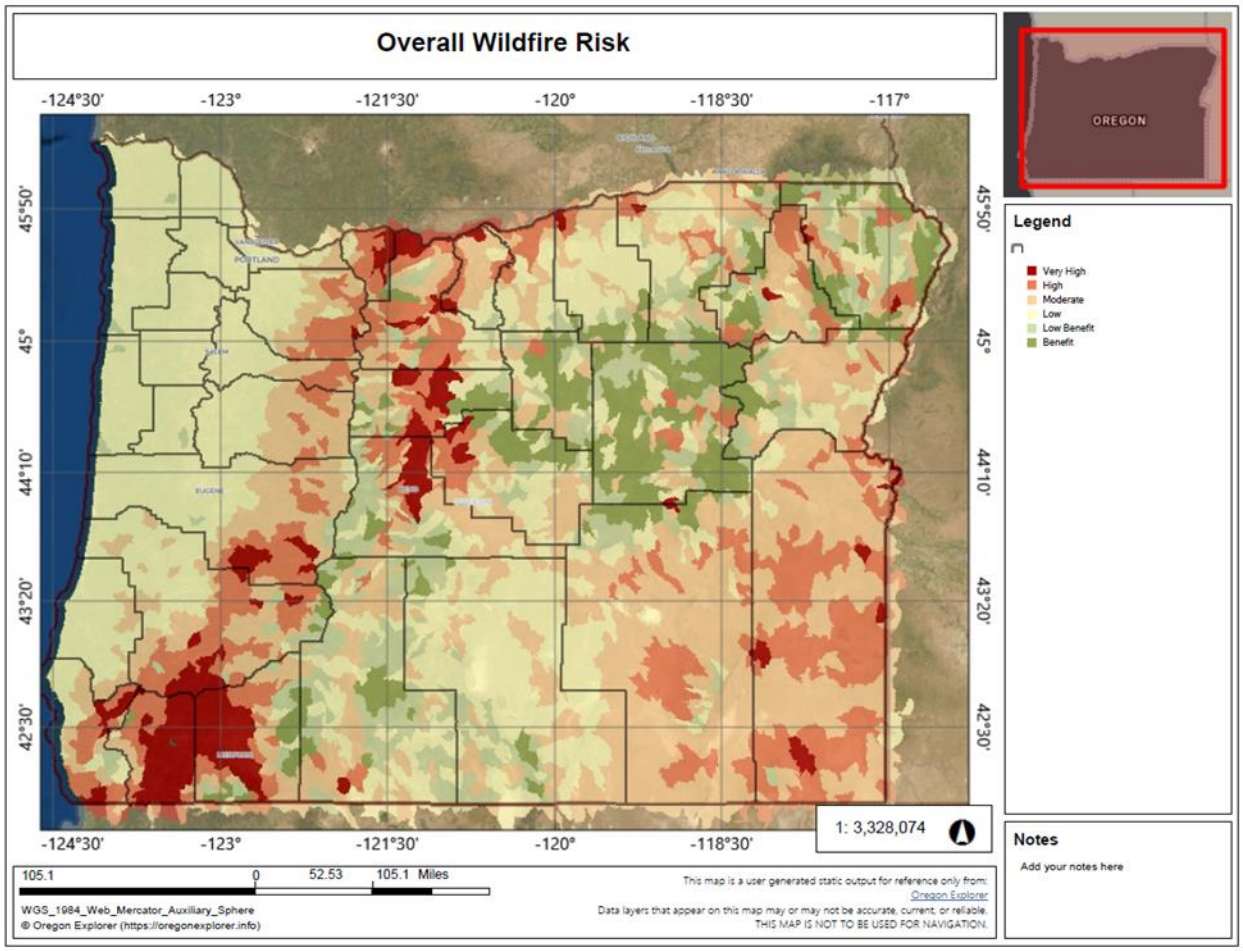
Table 2-823. Risk of Wildfire Hazards in Region 8

	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.