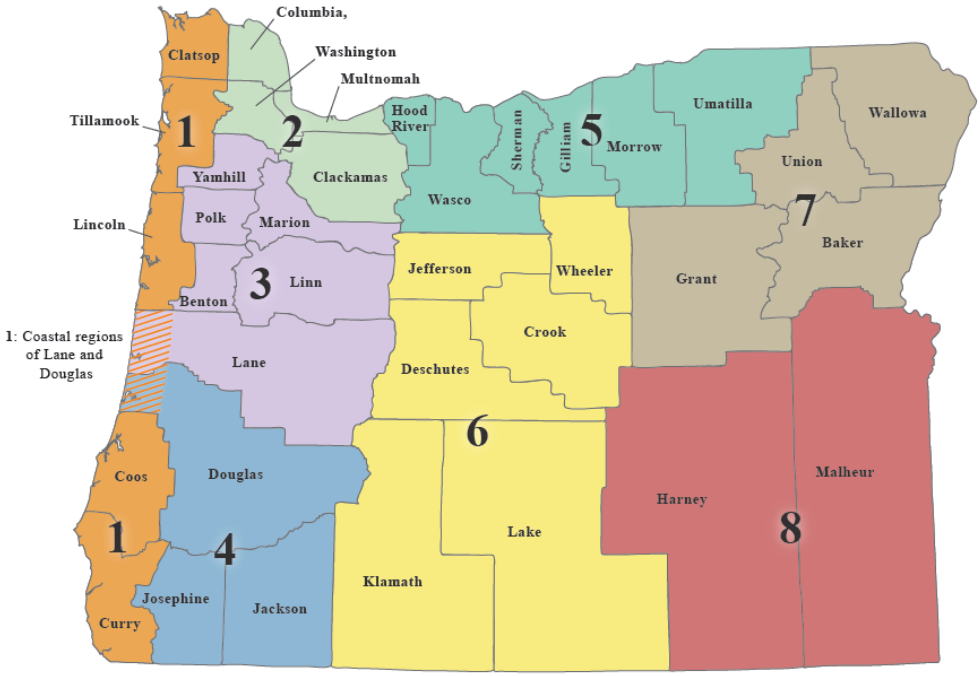
2.3 Regional Risk Assessments

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).

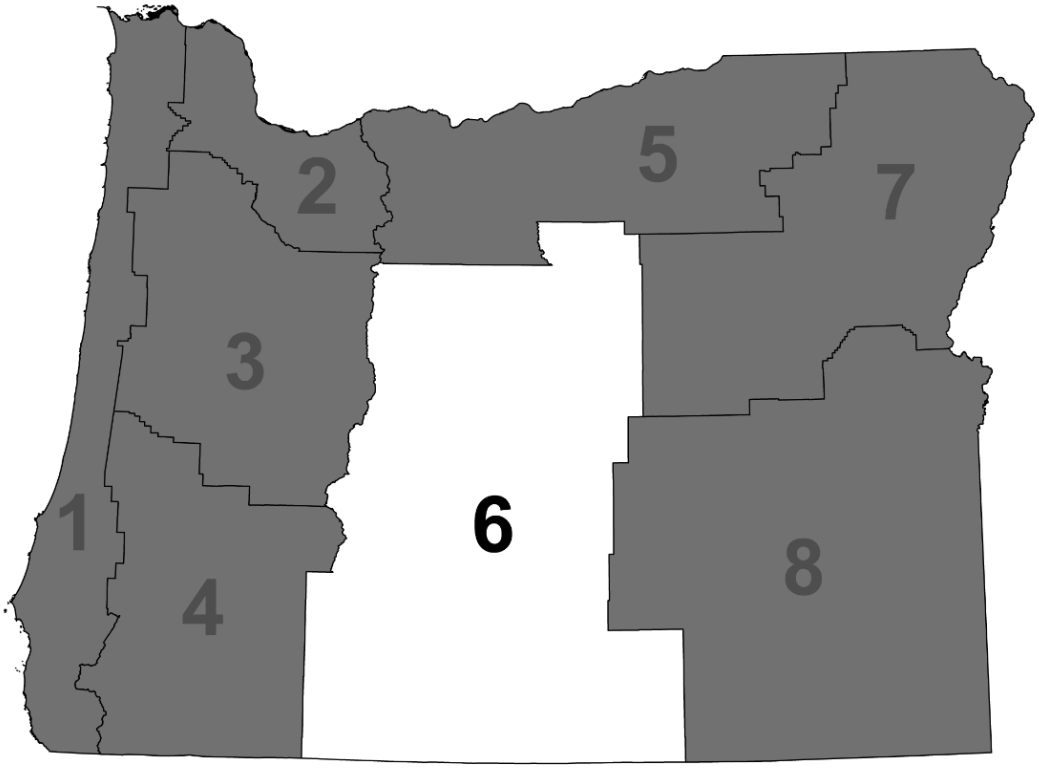
3. The **Hazards and Vulnerability** section first identifies each hazard and its characteristics in the region. Then, the historical events that have impacted the region are listed. Lastly, probabilities and vulnerabilities are discussed as identified by local and state risk assessments. Vulnerabilities

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.

2.3.6 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

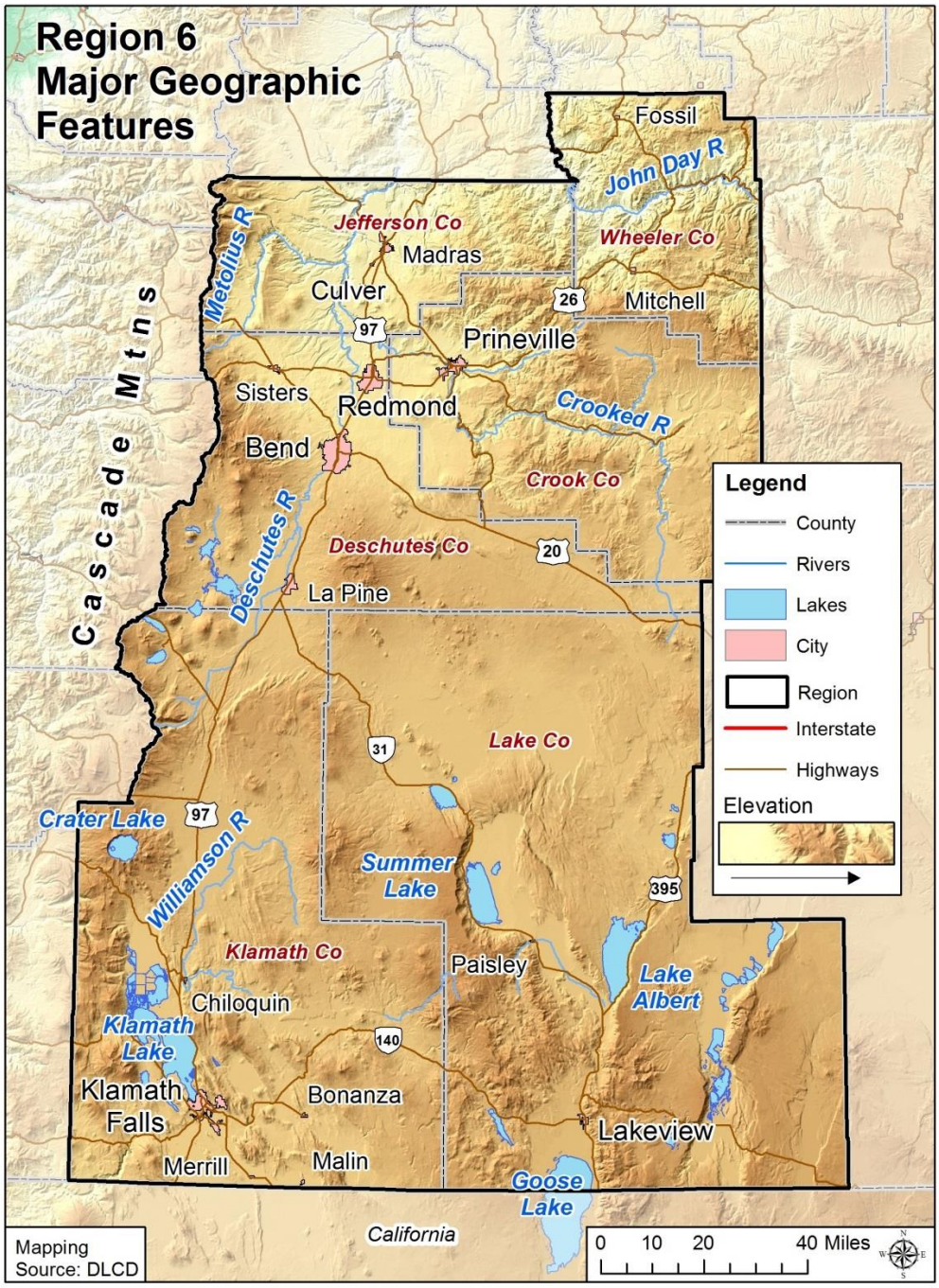
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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.

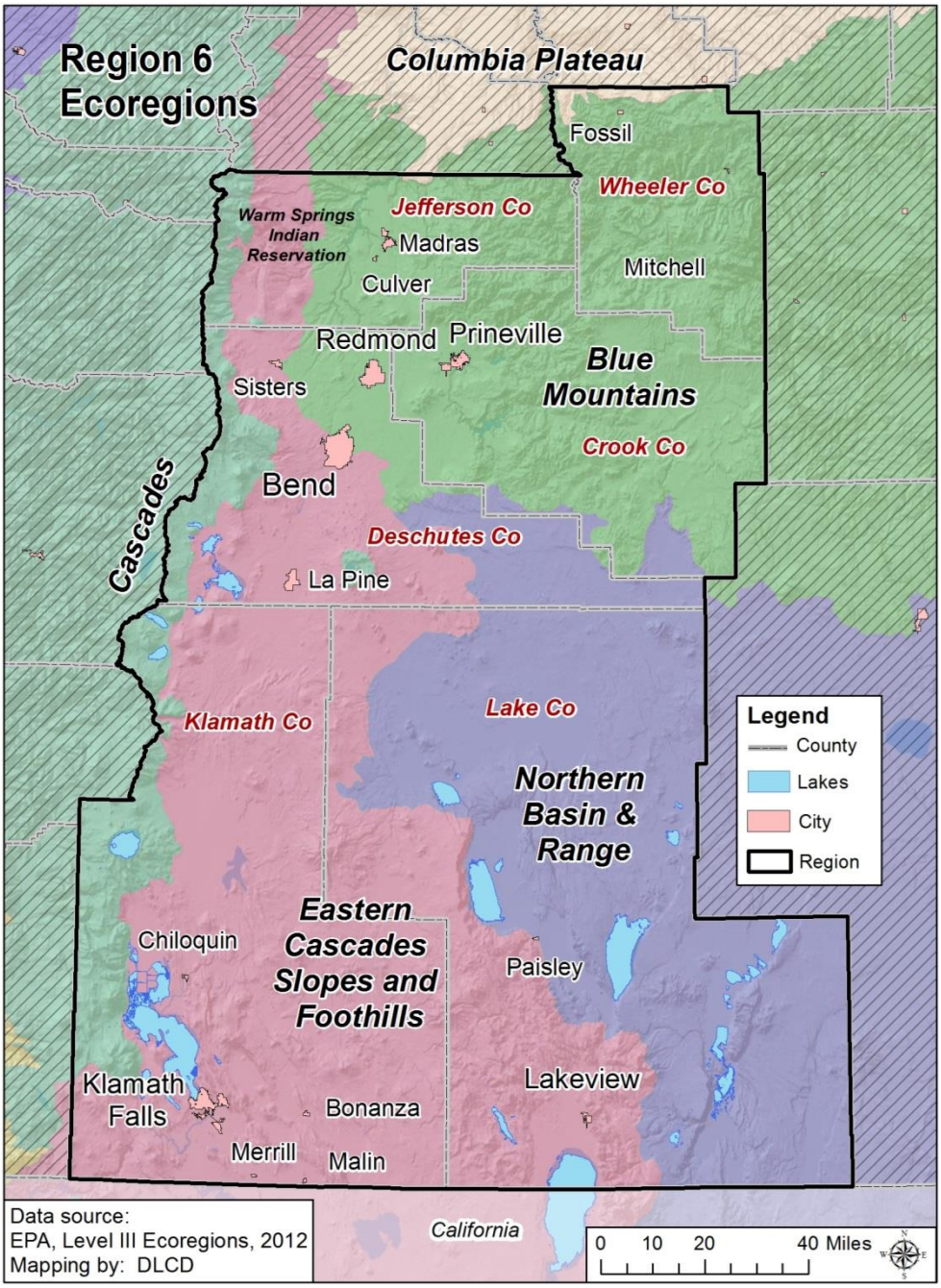
Figure 2-248. Region 6 Major Geographic Features



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.

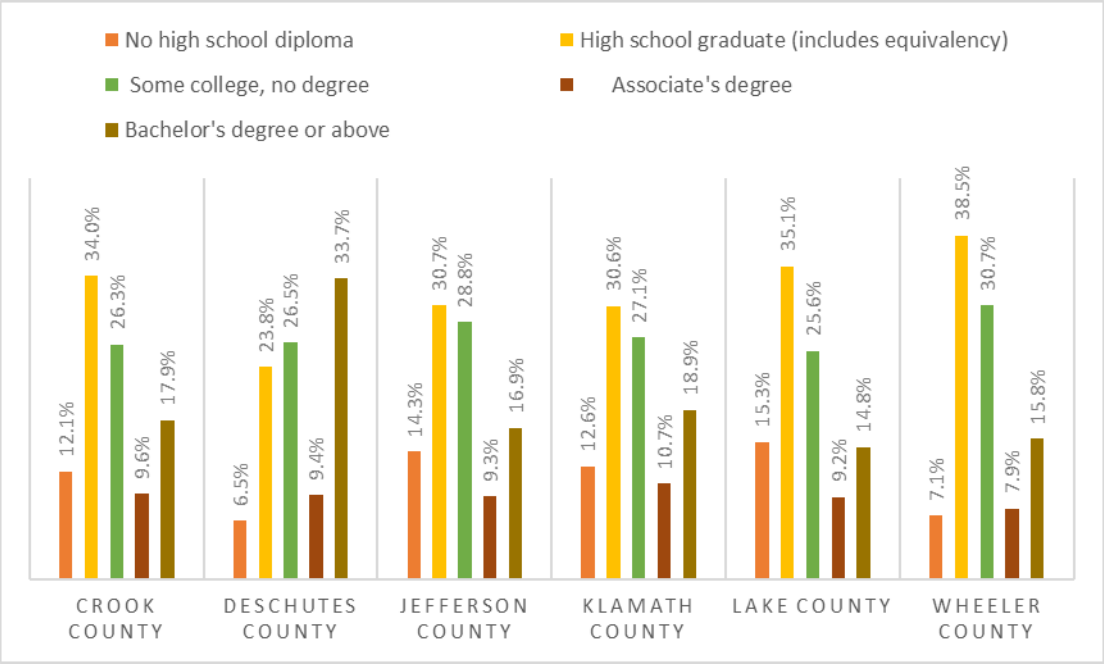
Education Level

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).

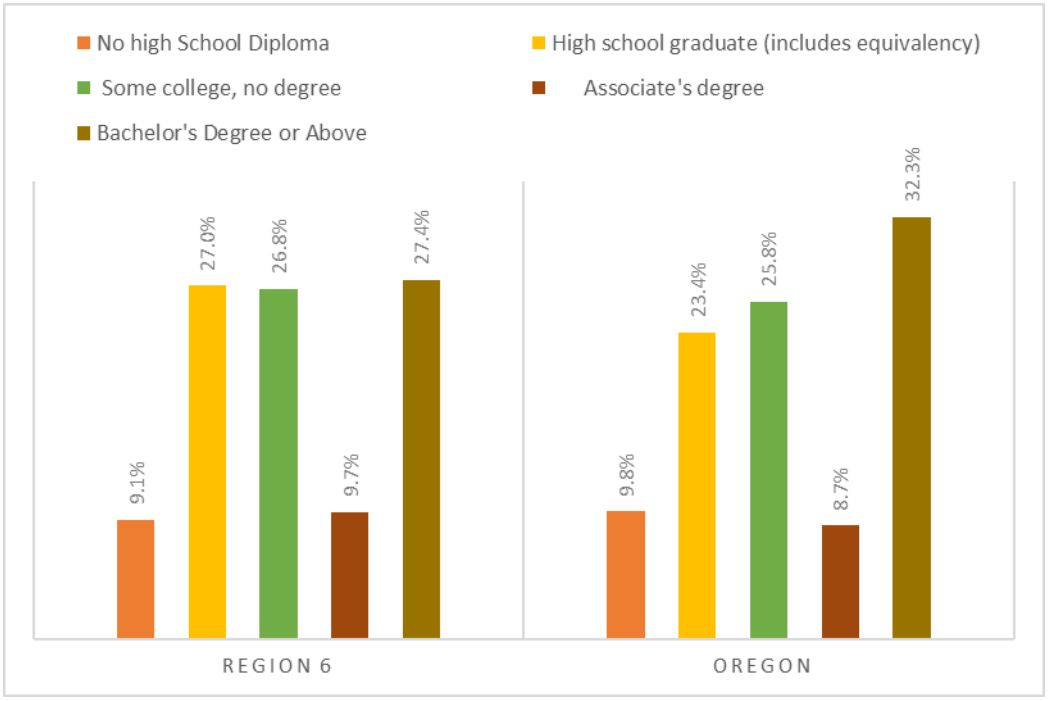
Approximately 27% of residents in Region 6 have a bachelor's degree or higher, which is about five percentage points below the statewide share. The portion of the population with an associate's degree is slightly higher vis-à-vis the state, as is the share of people with some college credit and a high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

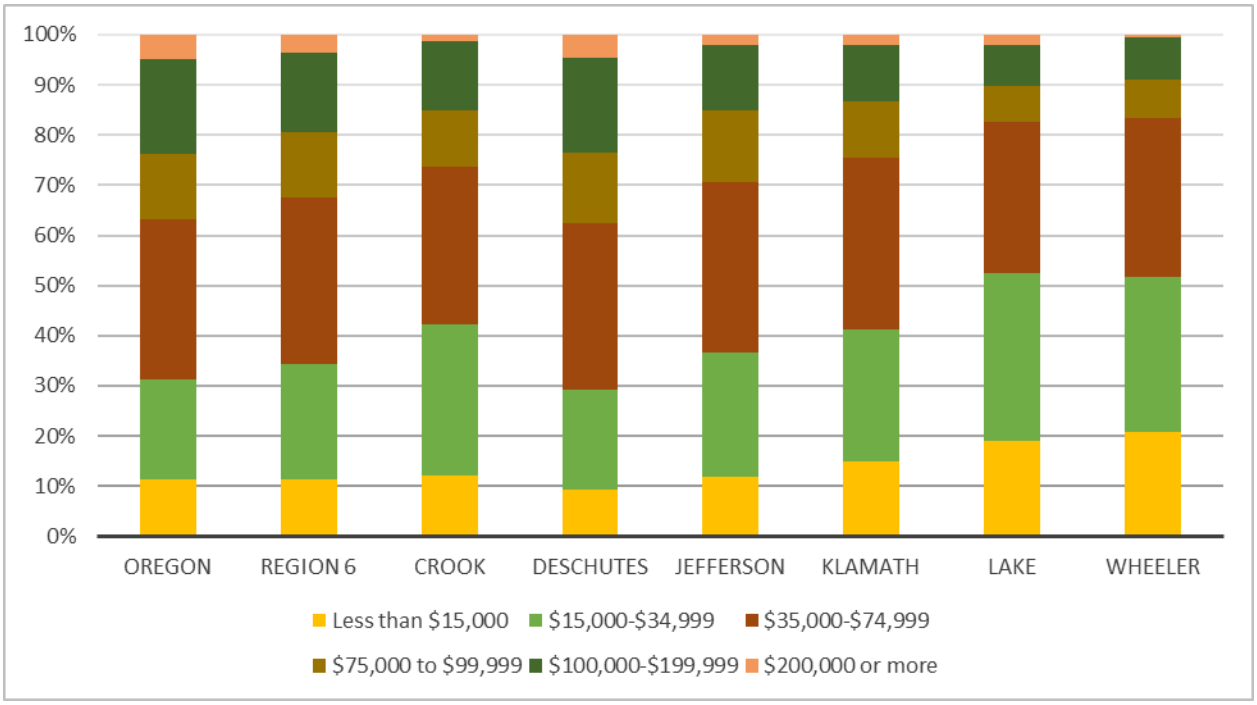
Notes: 2012 dollars are adjusted for 2017 dollars. Data not aggregated at the regional level.

* 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.

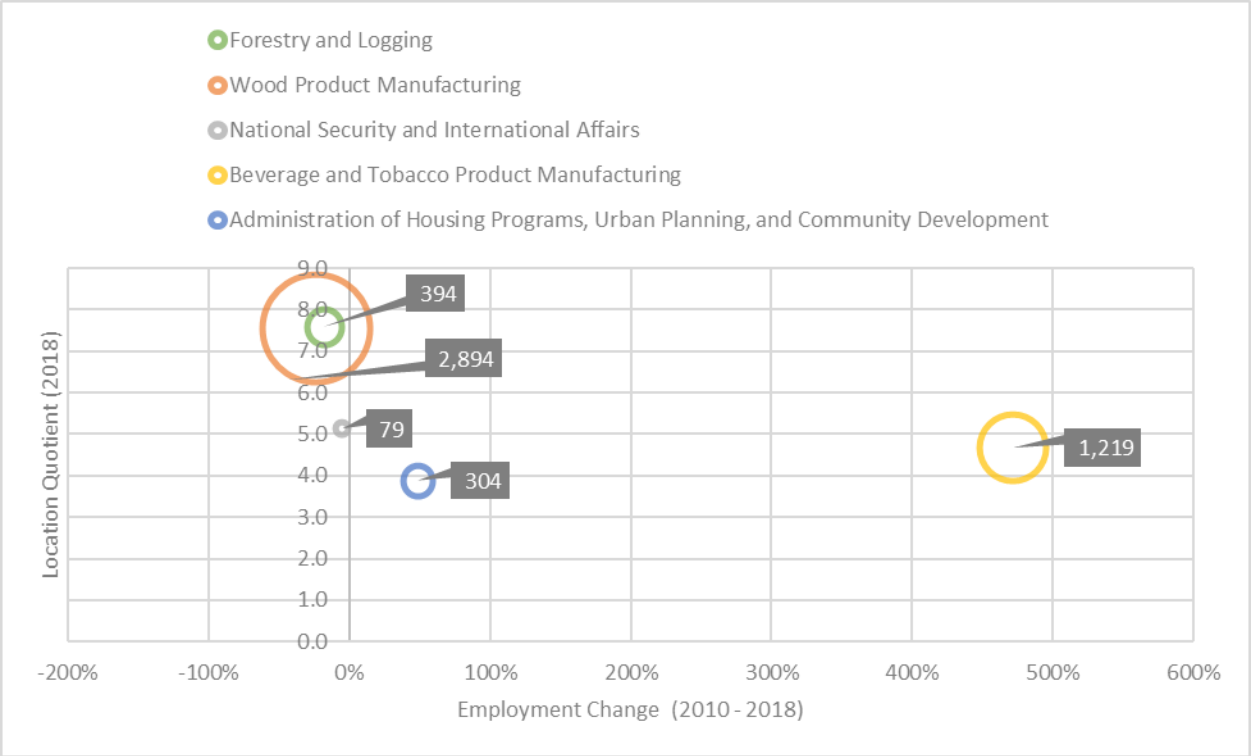
Table 2-571. Most Concentrated Industries and Employment Change in Region 6, 2018

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.

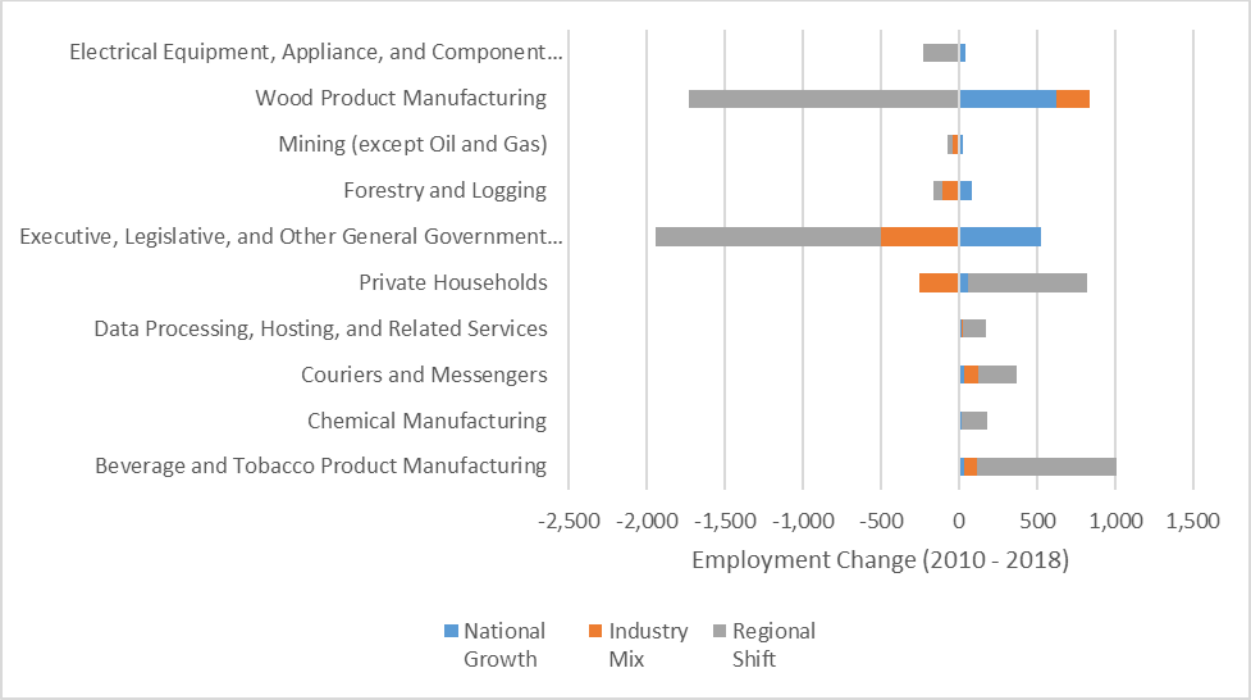
Employment in the Couriers and Messengers subsector is likely a reflection of the global revolution in retail sales. With an increased share of retail shopping occurring online, growth in transportation, storage, and distribution infrastructure and employment has been increasing nationally. Although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

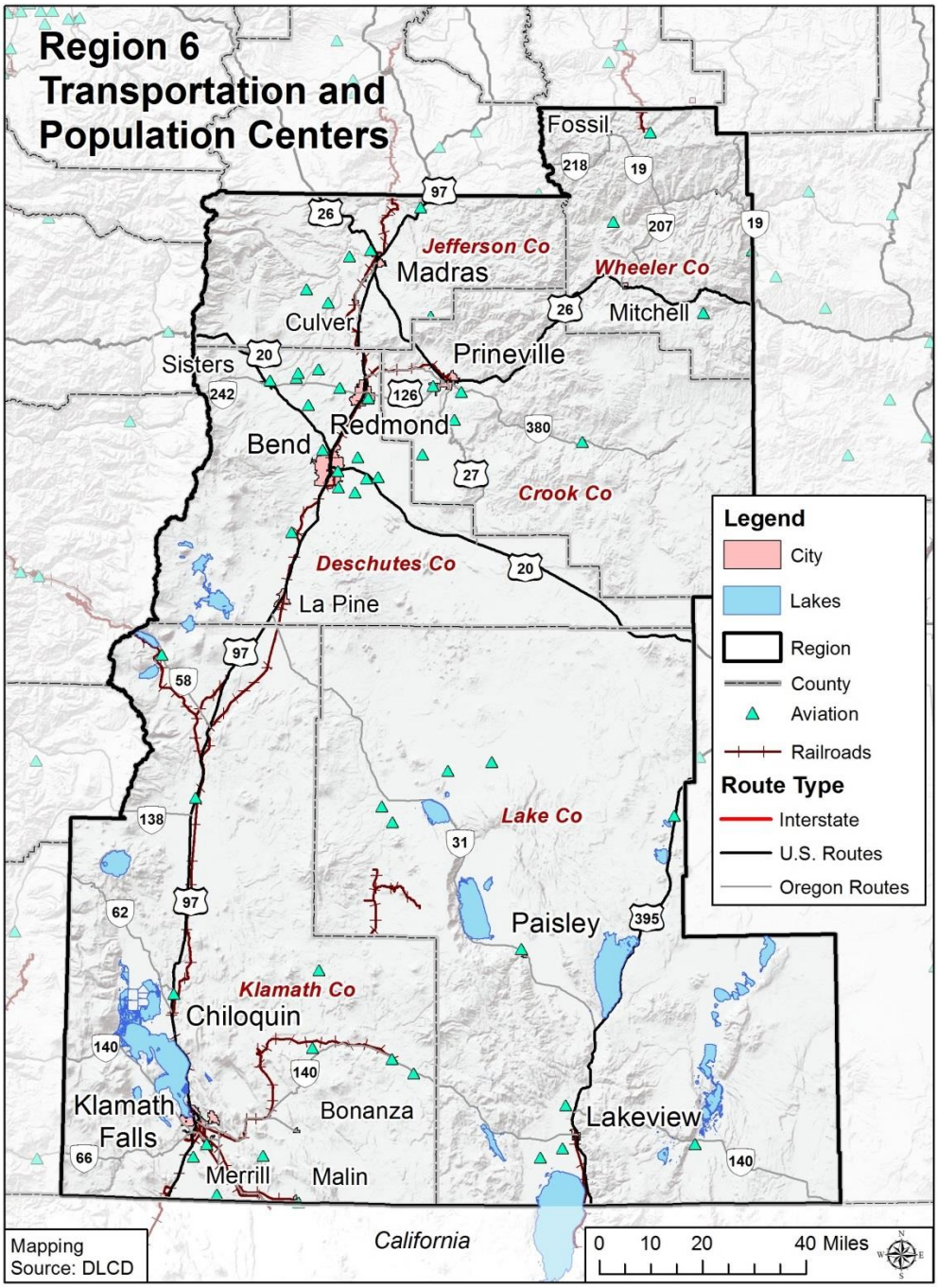
Roads

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.

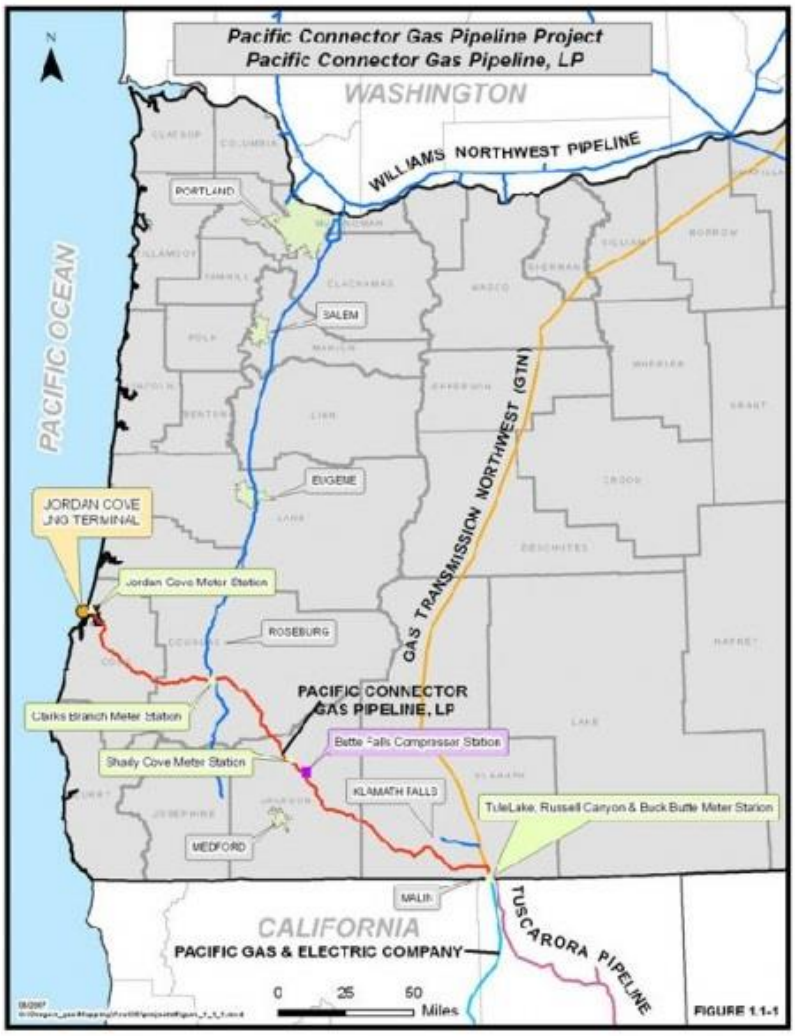
Hydropower

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%

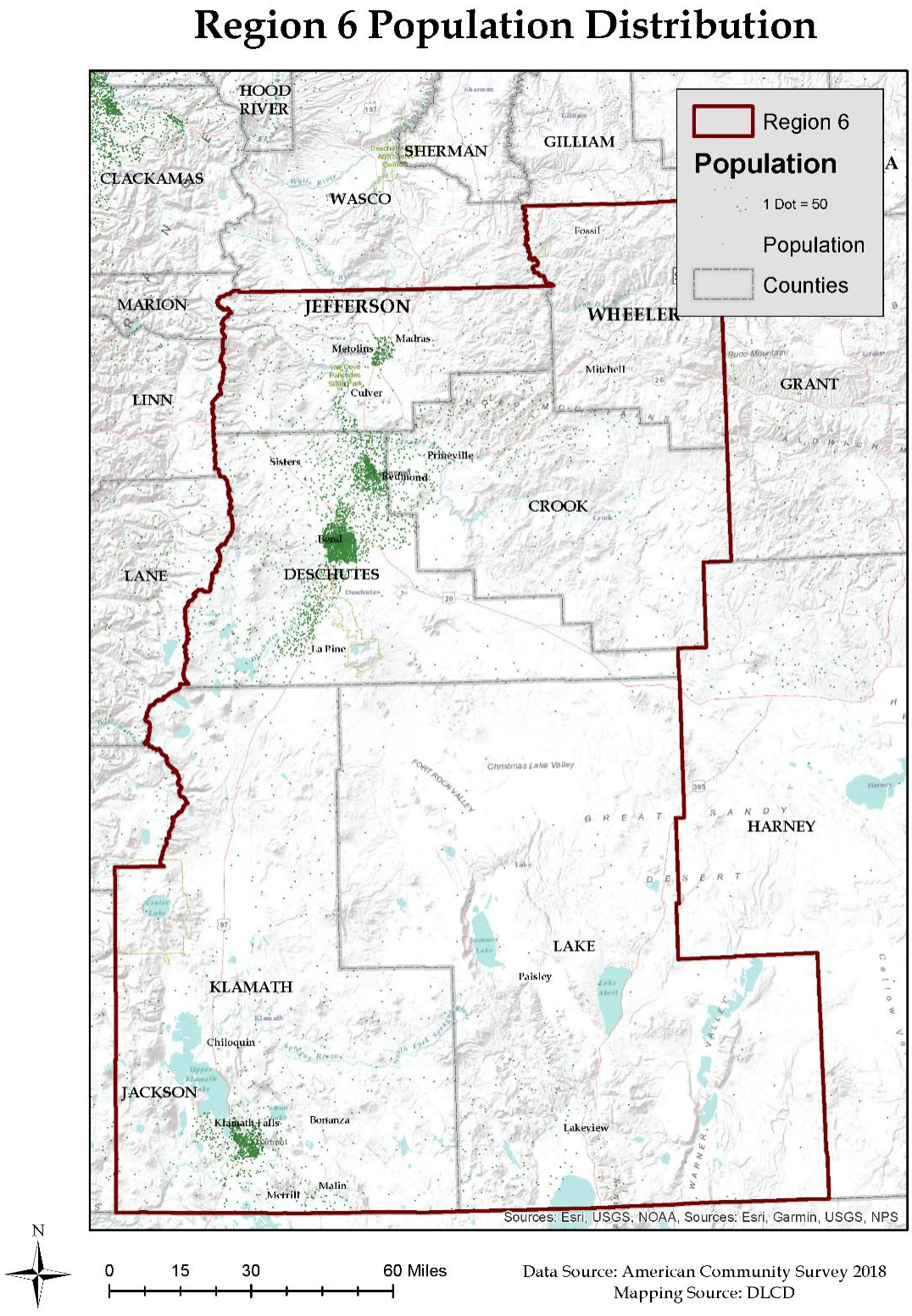
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

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.

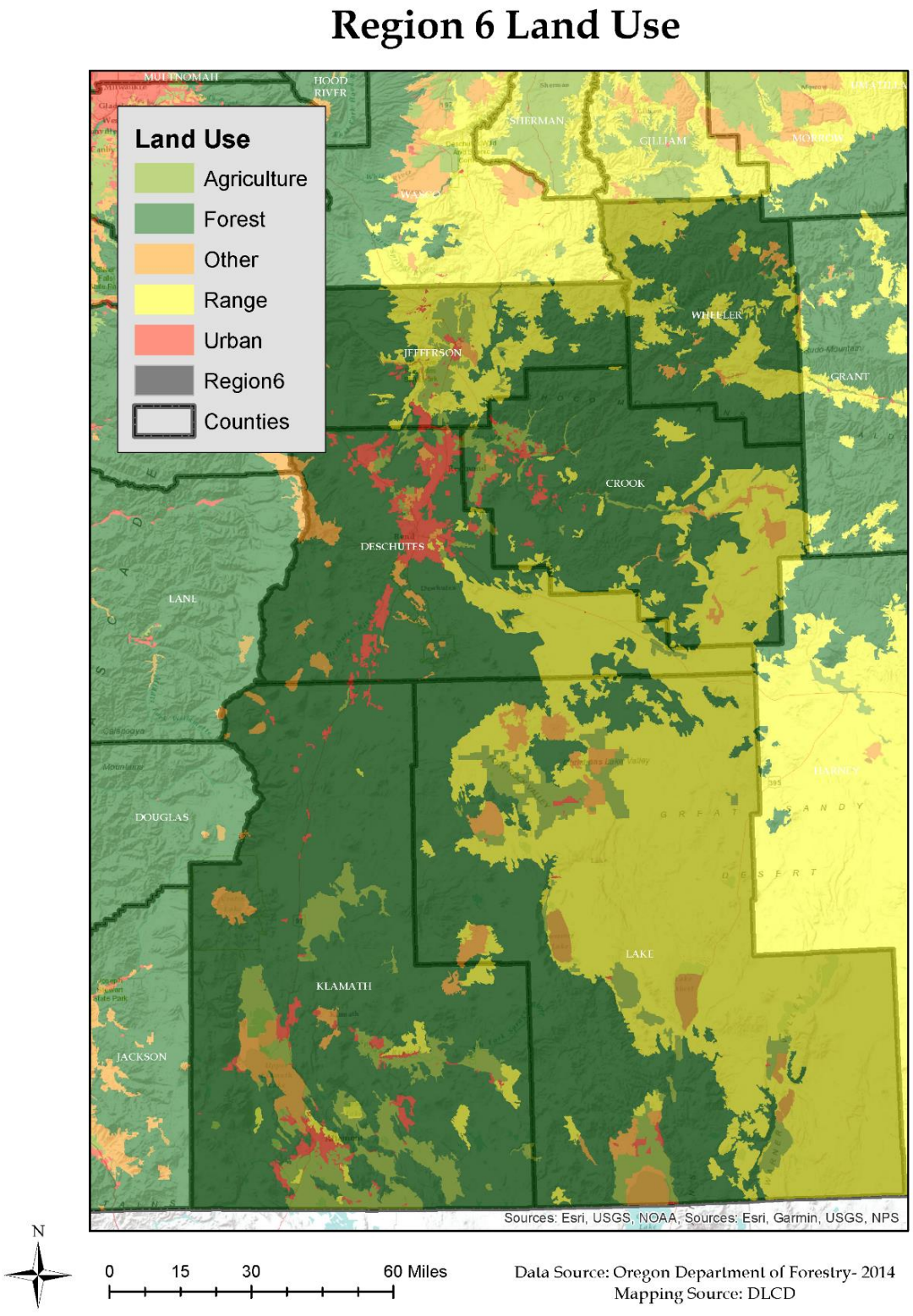
Responding to rapid growth and changing demographics, in 2011 Deschutes County completed a multi-year effort to establish "Plan 2030." This new plan incorporates updated goals and policies, community plans, and new projects like the South County Plan, destination resort remapping, a 2030 Transportation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

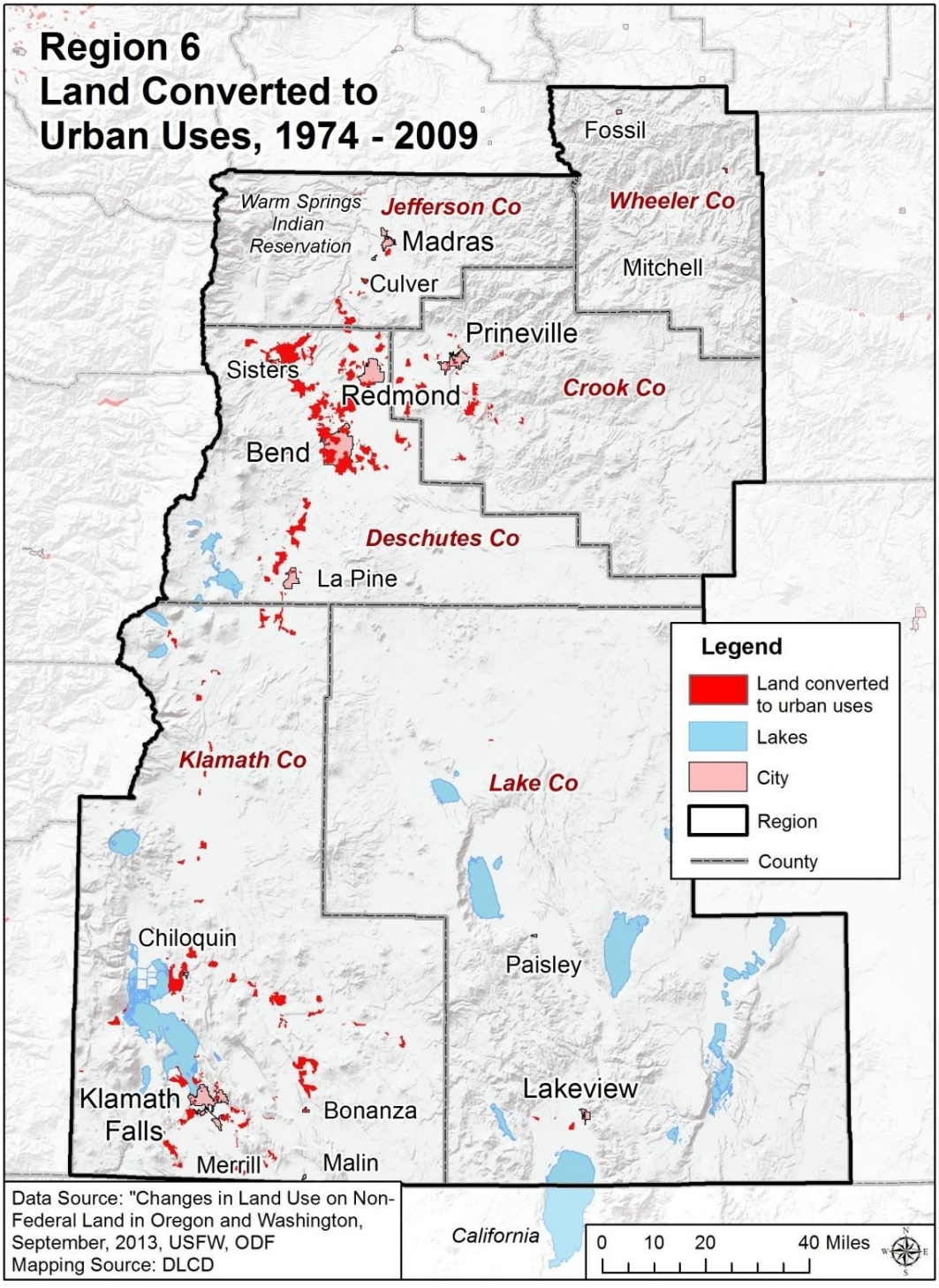
The City of Madras integrated portions of its Natural Hazards Mitigation Plan with its Comprehensive Plan; this serves as a model for other local governments.

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

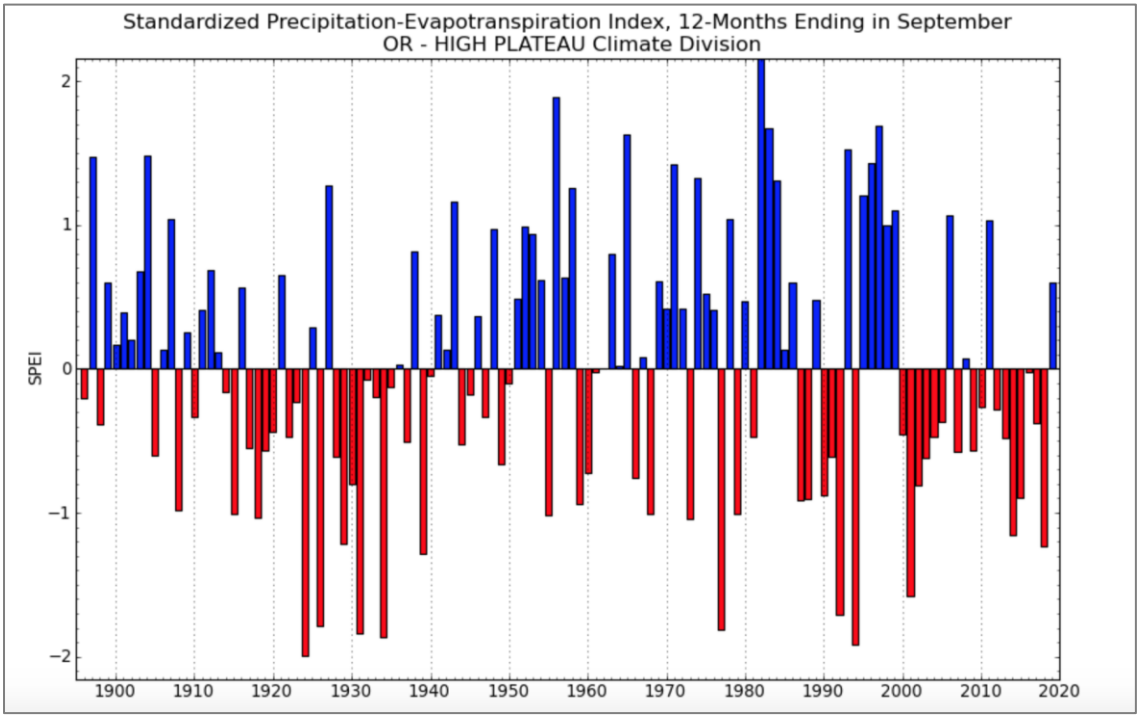
Date	Location	Description
1929–1931	Region 1–3, 5–7 (1929-1930); Region 6 and 7 (1930-1931) (extreme drought)	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country; moderate to severe drought affected 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.

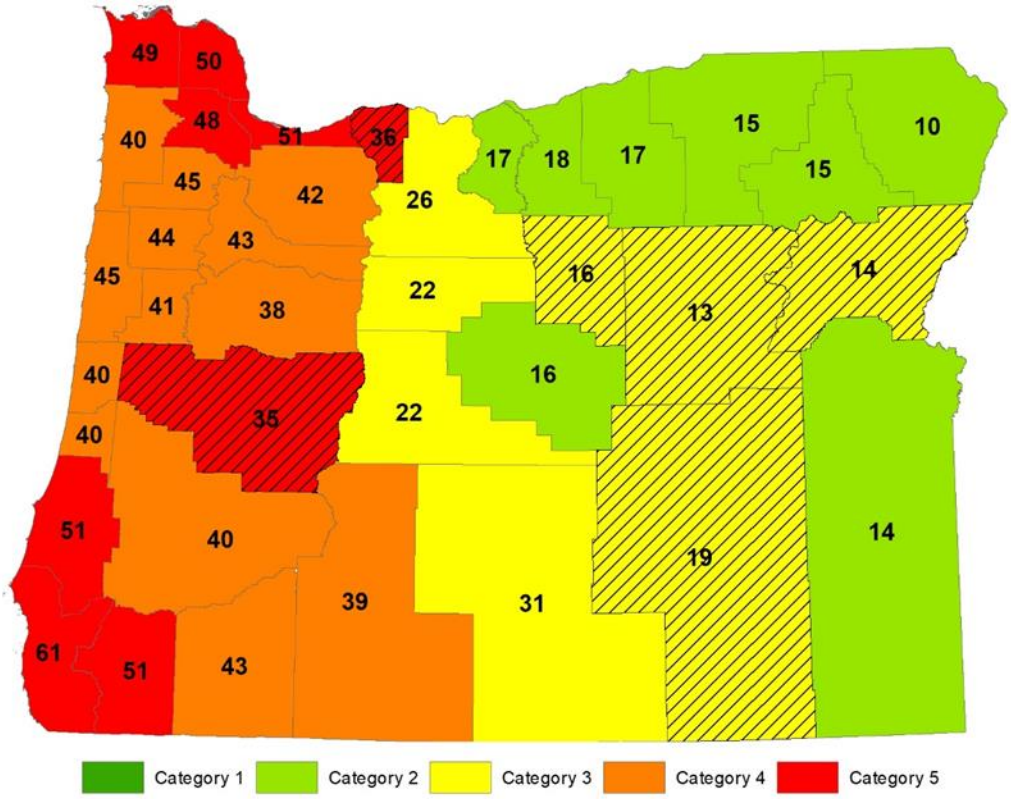
DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered faults. If a county had newly discovered faults

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)

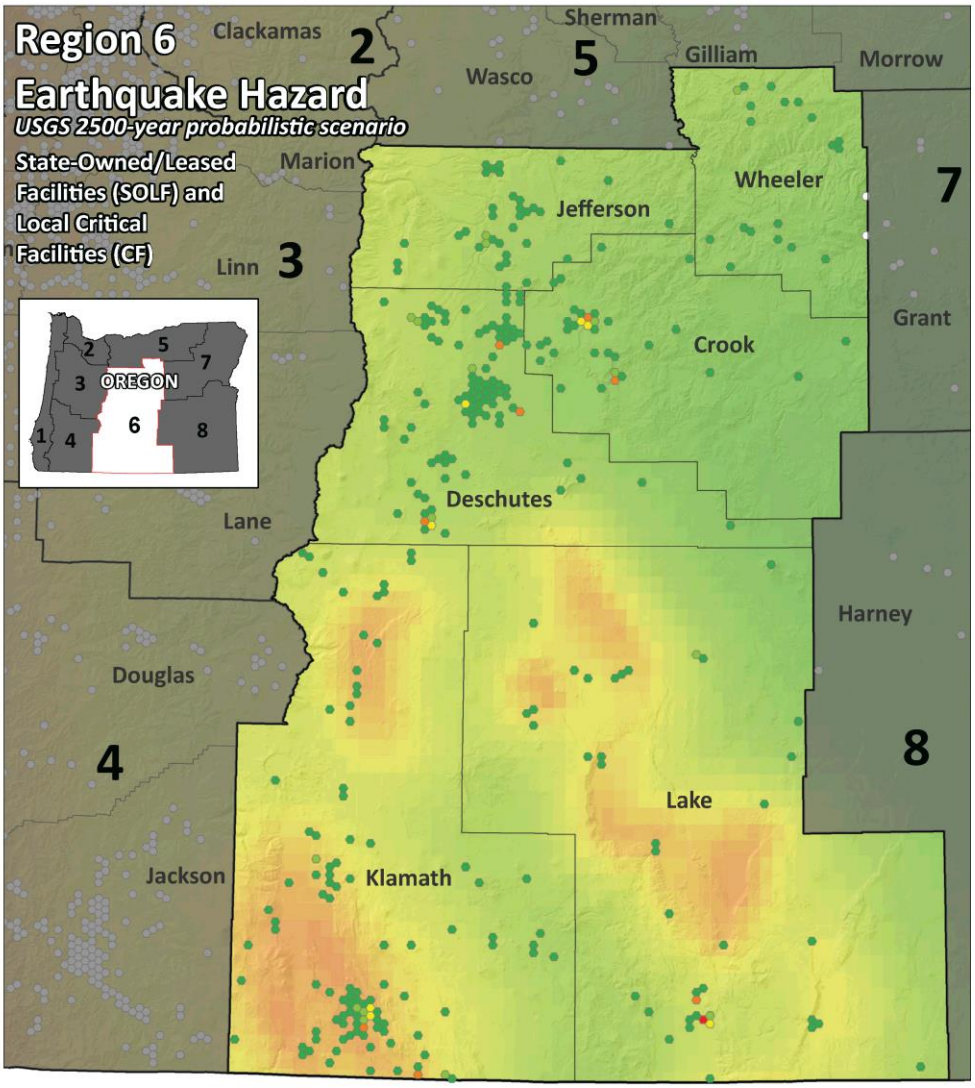
State-Owned/Leased Buildings And Critical Facilities And Local Critical Facilities

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).

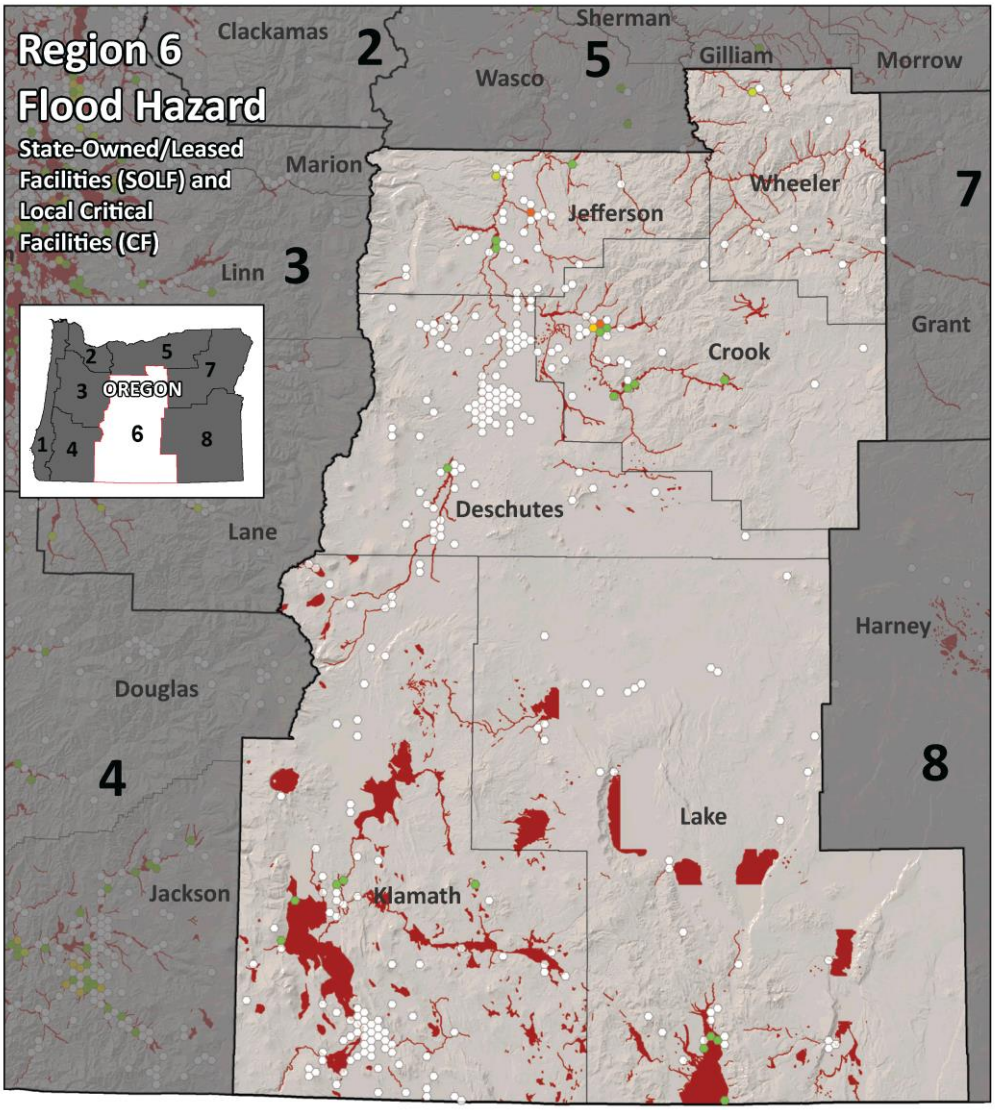
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS) Program, which results in reduced flood insurance costs.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

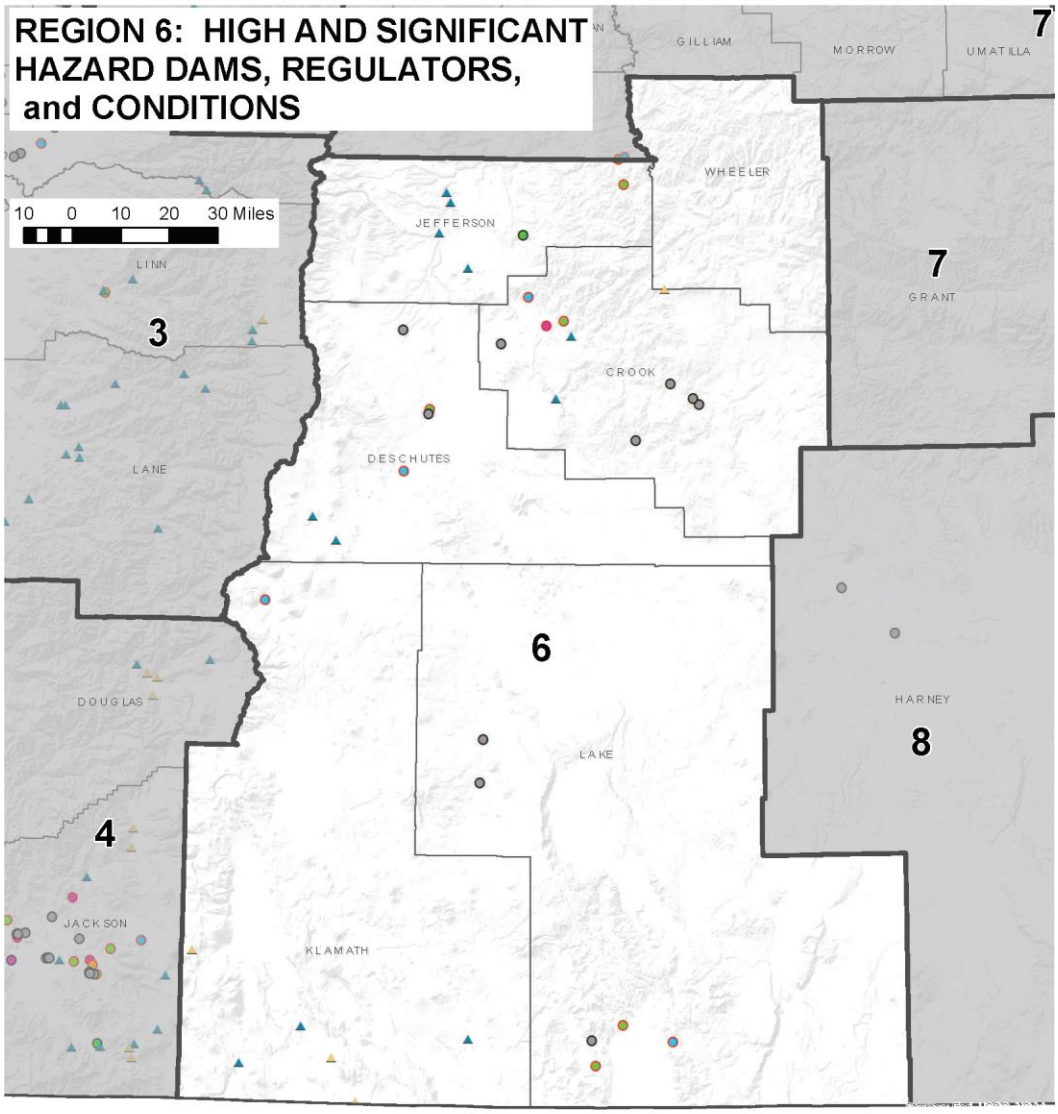
Dam	NID#	Condition Rating	Daytime PAR (number of people)	Nighttime PAR (number of people)	County
Barnes Butte Reservoir	OR00284	POOR	1,787	1,648	Crook

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

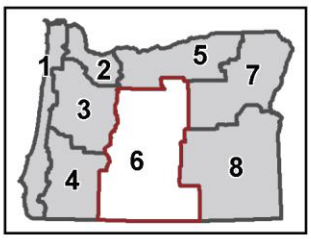
Mitigation Planning Regions
Counties

** - 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

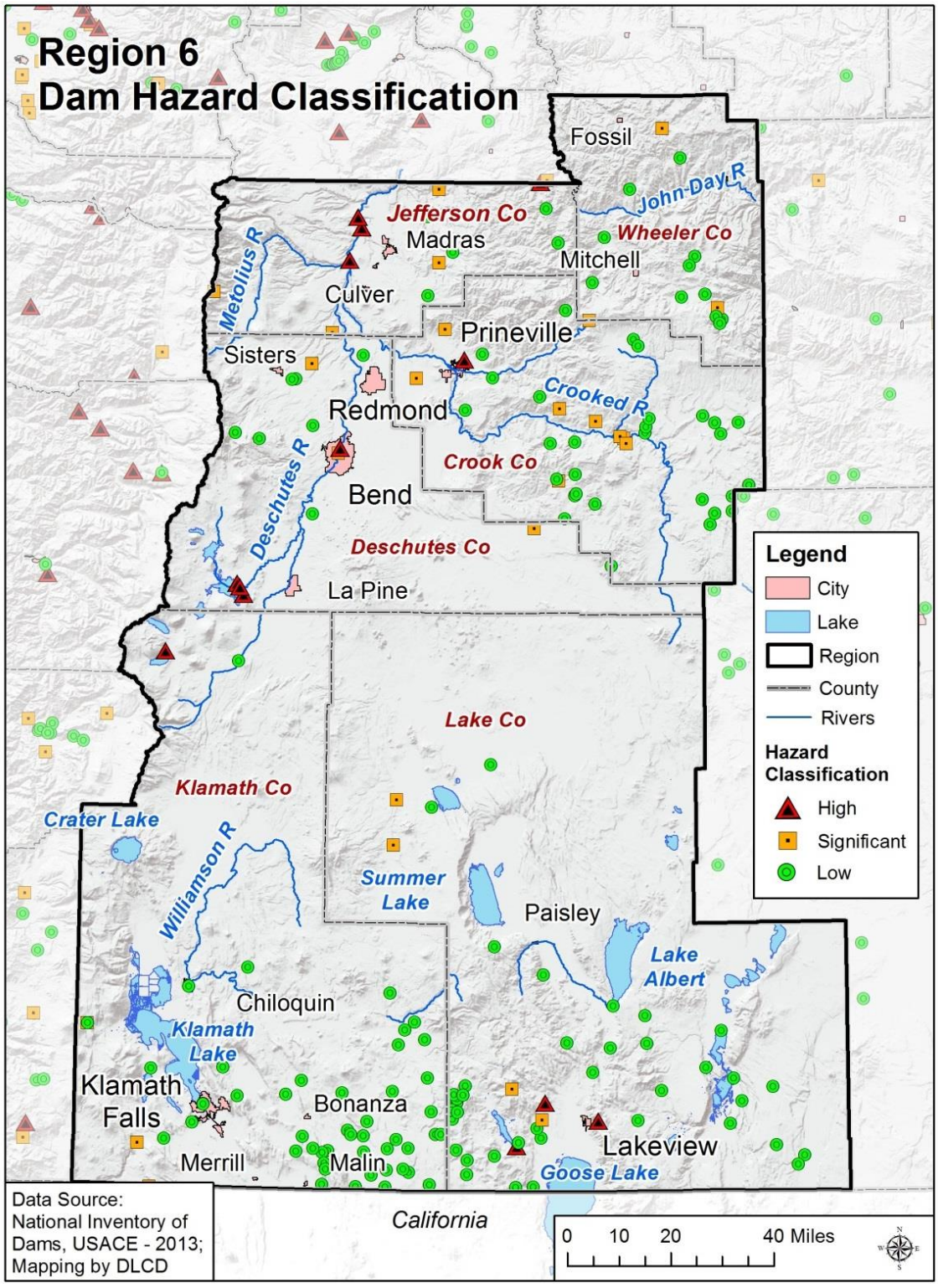
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), only Crook County in Region 6 has a high hazard dam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

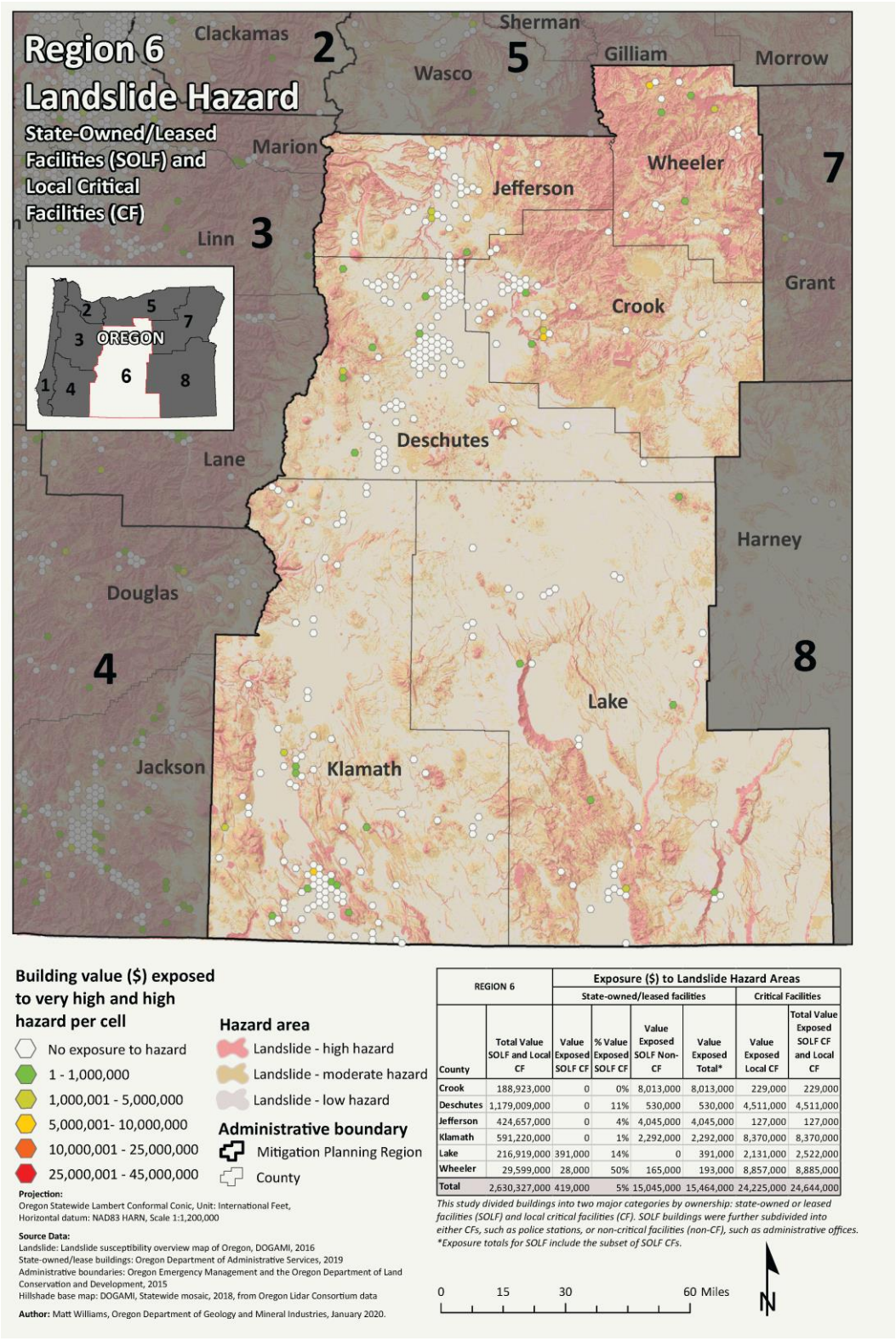
Source: DOGAMI and DLCD, 2020

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

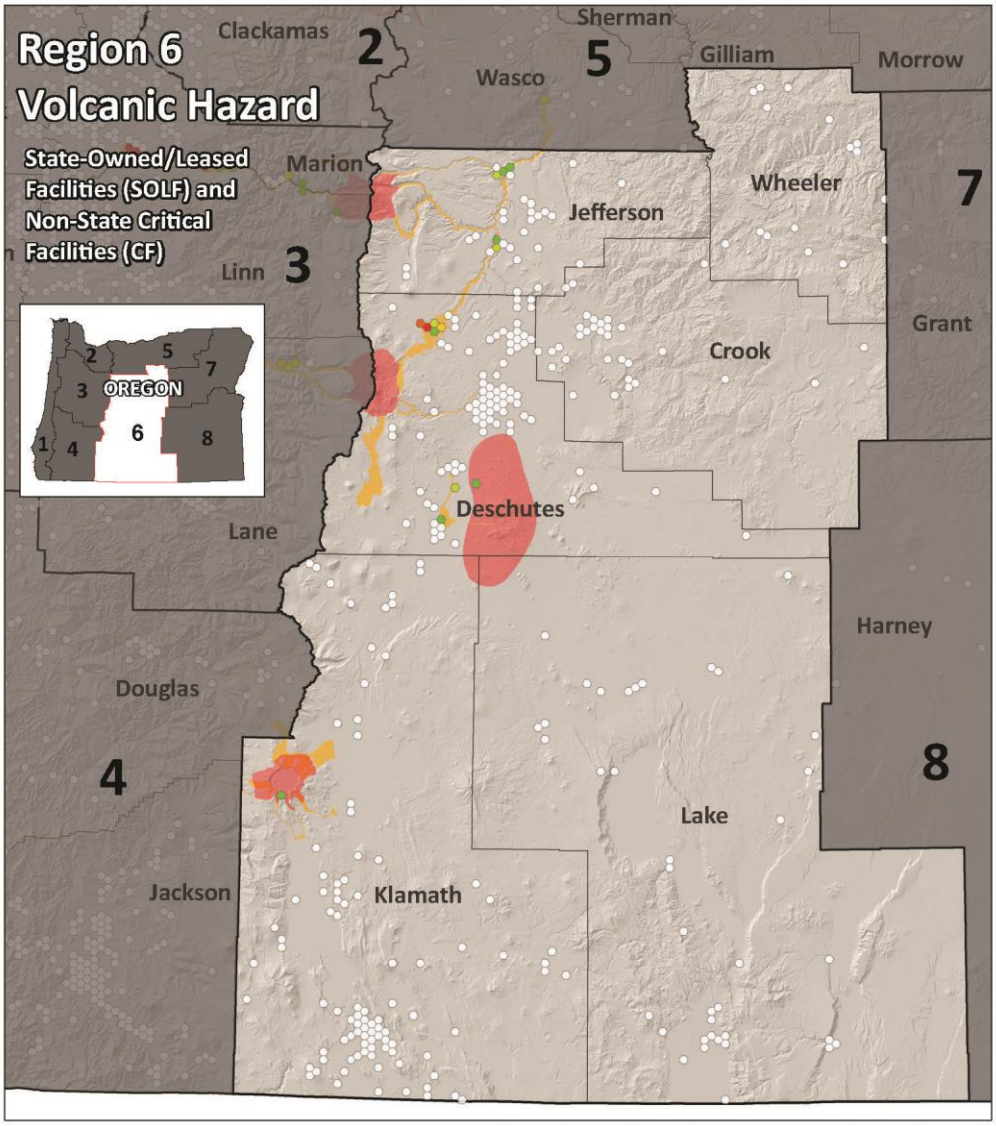
	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Risk	VL	M	VH	H	L	VL

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

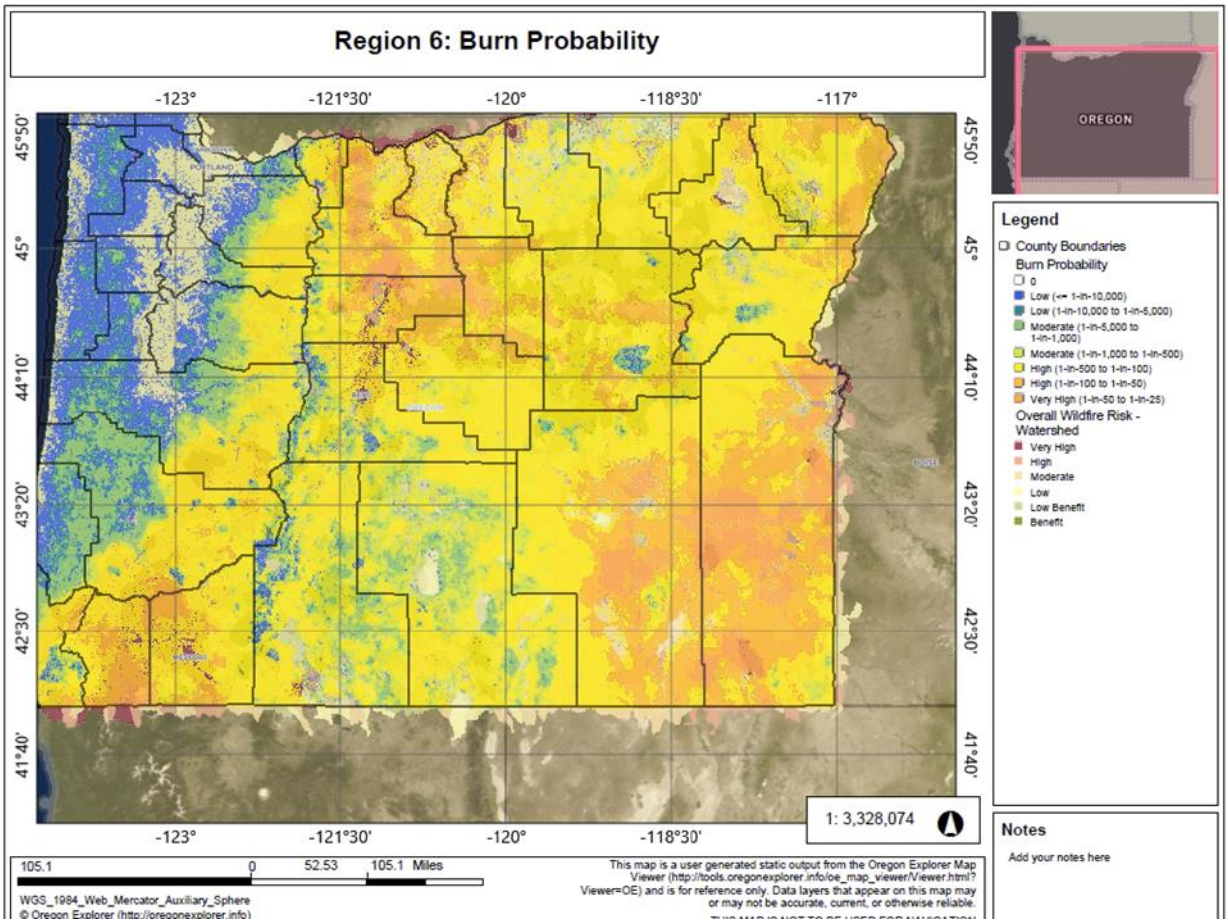
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

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.

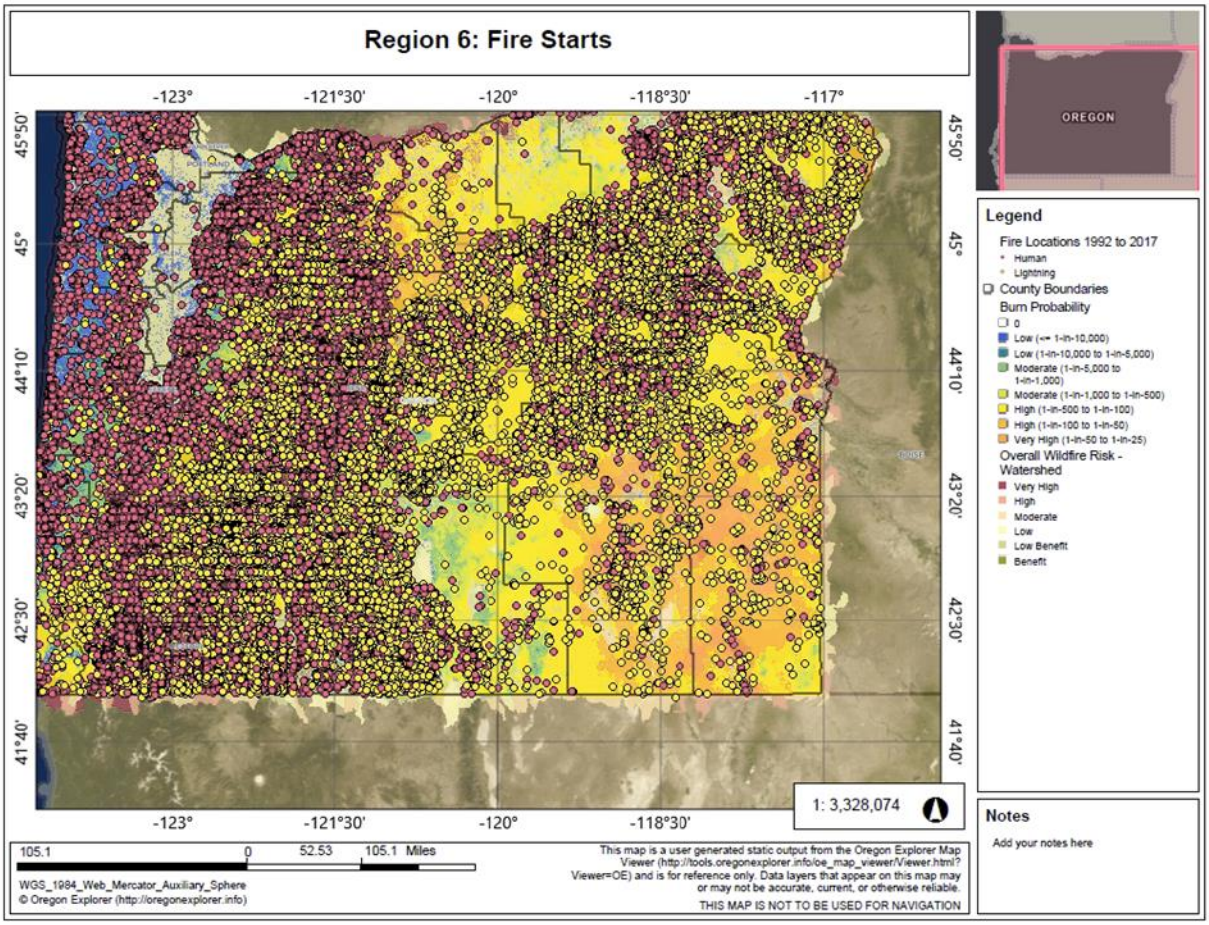
Fire protection districts are created and staffed to deal with the fire emergency needs of the property within the district. Wildland fires that threaten multiple homes simultaneously can

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

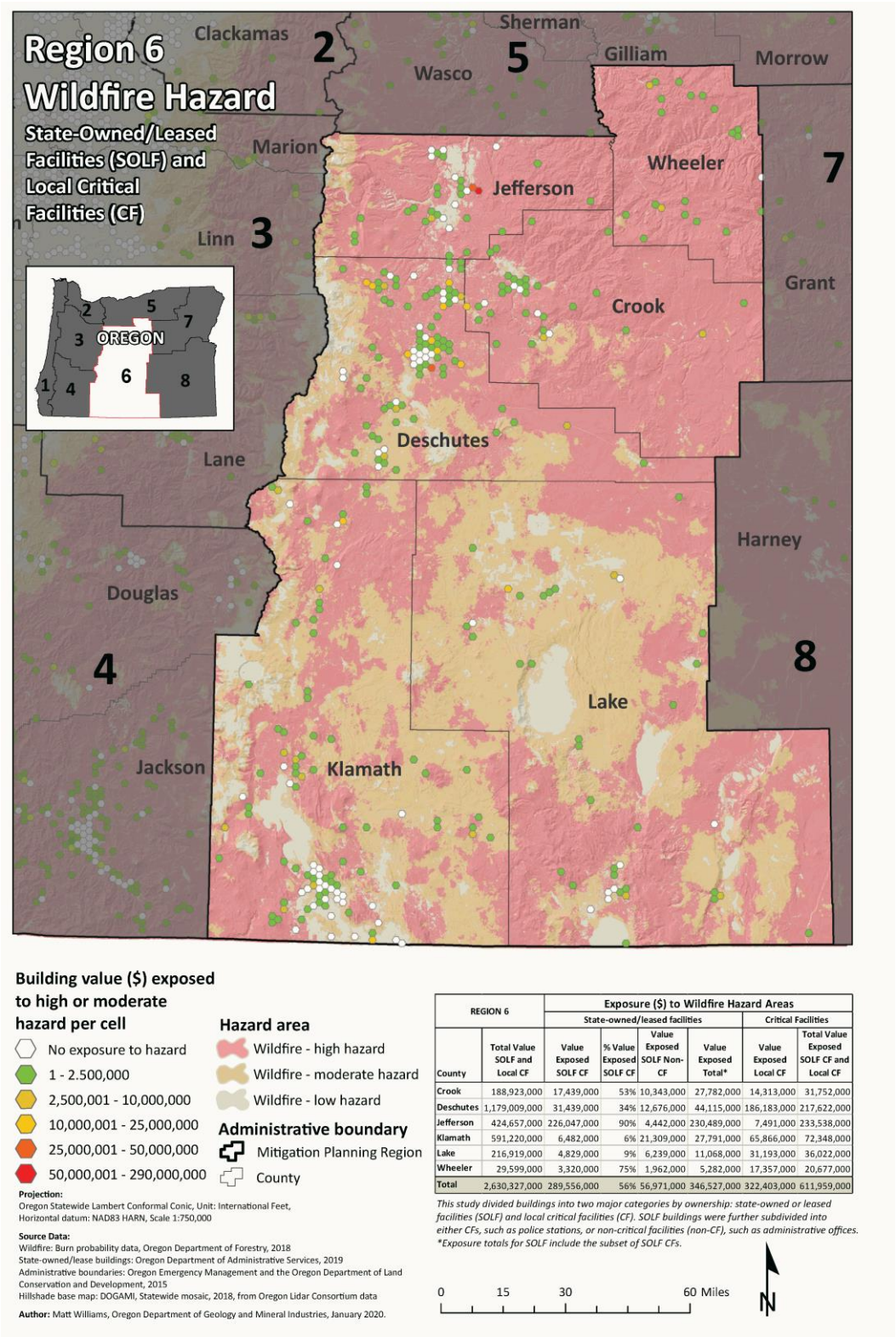
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

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

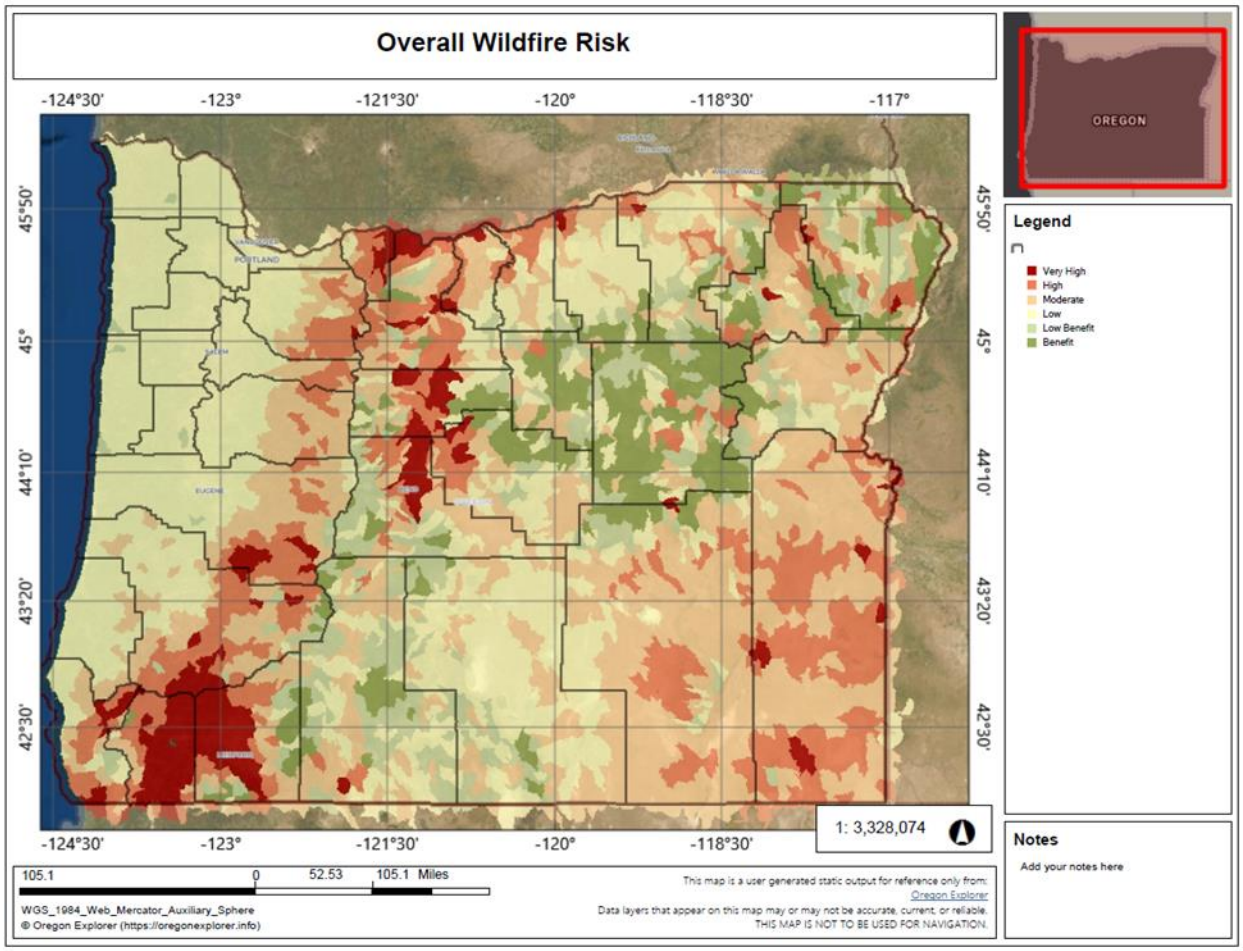
Table 2-639. Risk of Wildfire Hazards in Region 6

	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.