Chapter 2 RISK ASSESSMENT

In This Chapter

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

1. **Introduction:** States the purpose of the risk assessment and explains risk.
2. **State Risk Assessment:** Includes the following components:
   - Oregon Hazards: Profiles each of Oregon's hazards by identifying each hazard, its generalized location, and presidentially declared disasters; introduces how the state is impacted by climate change; characterizes each hazard that impacts Oregon; lists historic events; identifies the probability of future events; and introduces how climate change is predicted to impact each hazard statewide.
   - Oregon Vulnerabilities: Includes an overview and analysis of the state's vulnerability to each hazard by identifying which communities are most vulnerable to each hazard based on local and state vulnerability assessments; providing loss estimates for state-owned/leased facilities and critical/essential facilities located in hazard areas; and identifying seismic lifeline vulnerabilities.
   - Future Enhancements: Describes ways in which Oregon is planning to improve future state risk assessments.
3. **Regional Risk Assessment:** Includes the following components for each of the eight Oregon NHMP Natural Hazard Regions:
   - Summary: Summarizes the region's statistical profile and hazard and vulnerability analysis and generally describes projected impacts of climate change on hazards in the region.
   - Profile: Provides an overview of the region's unique characteristics, including a natural environment profile, social/demographic profile, economic profile, infrastructure profile, and built environment profile.
   - Hazards and Vulnerability: Further describes the hazards in each region by characterizing how each hazard presents itself in the region; listing historic hazard events; and identifying probability of future events based on local and state analysis. Also includes an overview and analysis of the region's vulnerability to each hazard; identifies which communities are most vulnerable to each hazard based on local and state analysis; provides loss estimates for state-owned/leased facilities and critical/essential facilities located in hazard areas; and identifies the region's seismic lifeline vulnerabilities.

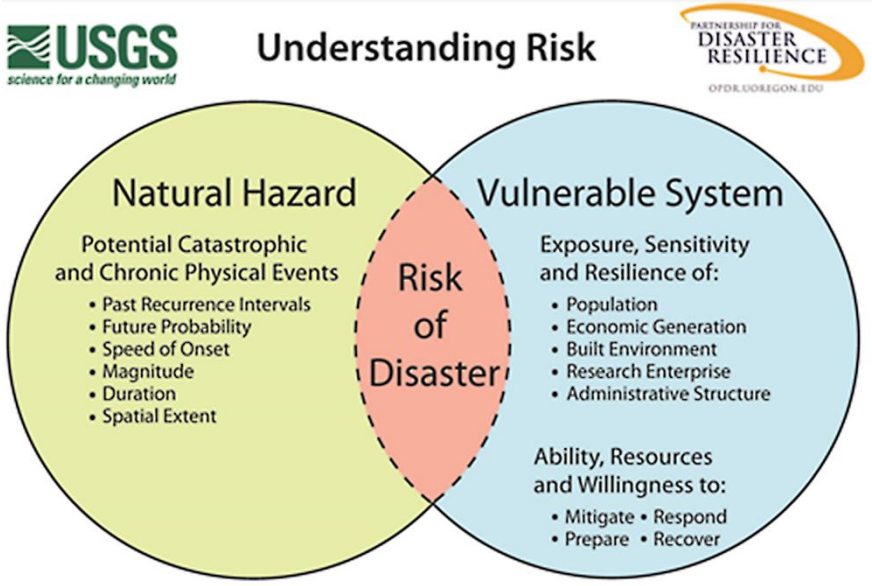
2.1 Introduction

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

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

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

Figure 2-1. Understanding Risk



Source: Wood (2007)

Assessing the state's level of risk involves three components: characterizing natural hazards, assessing vulnerabilities, and analyzing risk. Characterizing natural hazards involves determining hazards' causes and characteristics, documenting historic impacts, and identifying future probabilities of hazards occurring throughout the state. The section in this risk assessment titled "Oregon Hazards" characterizes each of the state's natural hazards.

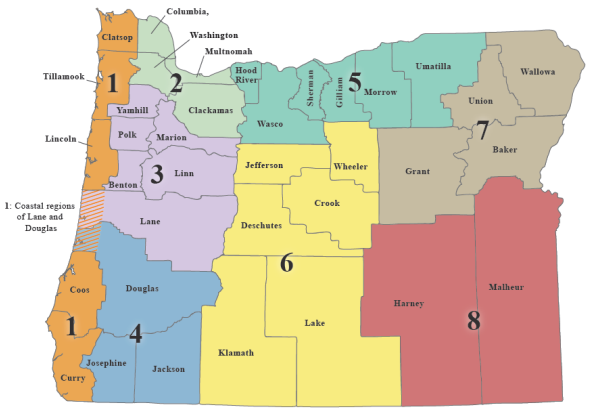
A vulnerability assessment combines information from the hazard characterization with an inventory of the existing (or planned) property and population exposed to a hazard and attempts to predict how different types of property and population groups will be affected by each hazard. Vulnerability is determined by a community's exposure, sensitivity, and resilience to natural hazards as well as by its ability to mitigate, prepare for, respond to, and recover from a disaster. The section Oregon Vulnerabilities identifies and assesses the state's vulnerabilities to each hazard identified in the Oregon Hazards section of this risk assessment.

A risk analysis involves estimating damages, injuries, and costs likely to be incurred in a geographic area over a period of time. Risk has two measurable components: (a) the magnitude of the harm that may result, defined through vulnerability assessments; and (b) the likelihood or probability of the harm occurring, defined in the hazard characterization. Together, the "Oregon Hazards" and "Oregon Vulnerabilities" sections form the risk analysis at the state level.

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

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

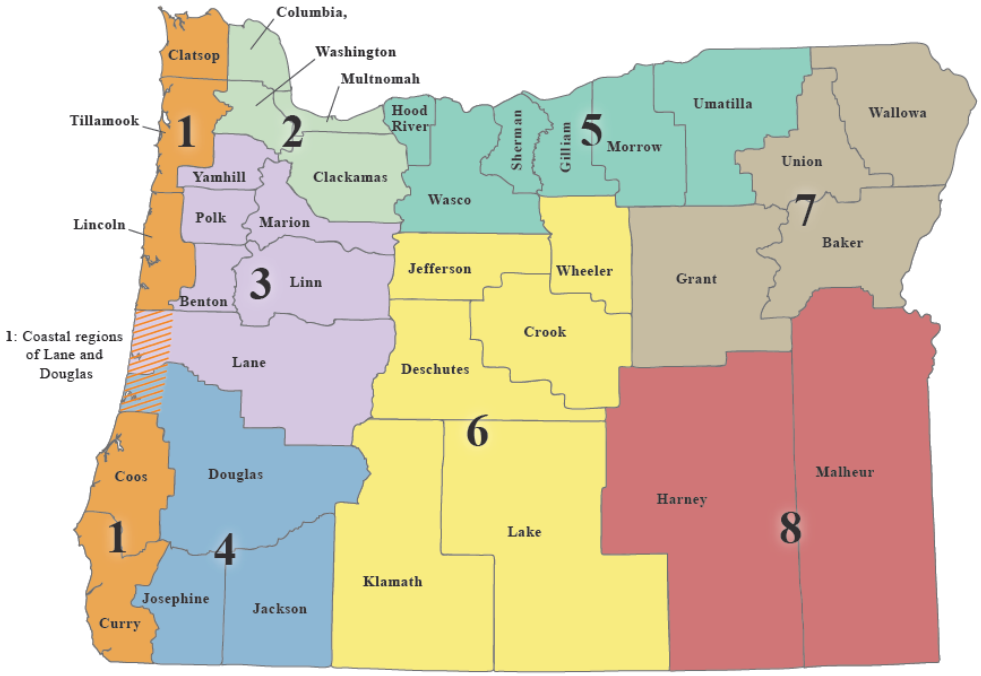
Figure 2-2. Oregon NHMP Natural Hazards Regions



2.3 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 2-81). 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 2-81. 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.

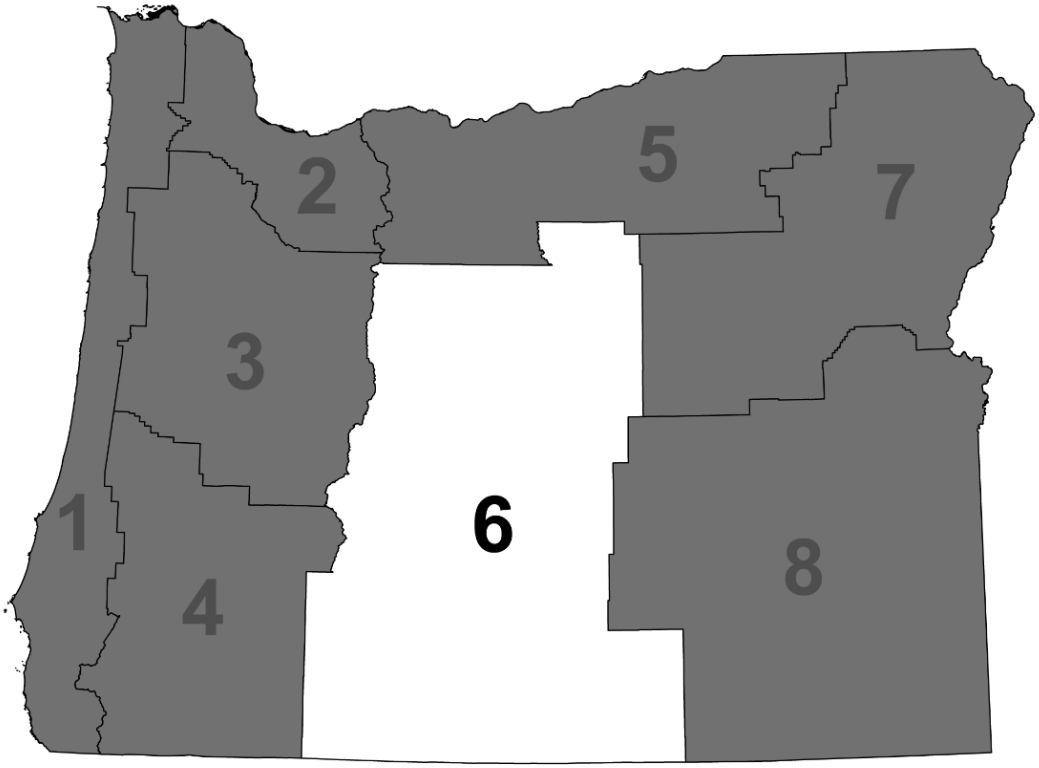
   The research of Susan Cutter, Professor of Geography at the University of South Carolina, Columbia, on vulnerability and environmental hazards provides the framework for discussion of vulnerability in the Regional Profile section. Cutter's framework helps to illustrate the geographic variability of vulnerability and allows policy makers to better understand how to prepare for, mitigate, and reduce vulnerability (Cutter et al., 2003; Cutter, 2006).

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. Average pay in Wheeler County is especially low, only 57% of the state average.

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. Liquid 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. Mobile homes are inherently vulnerable to natural hazard events, and there are a significant number of mobile 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. The U.S. Department of Agriculture

designated both counties "natural disaster areas" due to damages or losses caused by drought – Klamath in 2010 and 2013, and Lake in 2007 and 2013.

Dust Storms: In Central Oregon, dust storms occur when strong winds carry fine silt, sand, and clay particles into the air. These storms can travel hundreds of miles at speeds of at least 25 miles per hour and can reach heights of over 10,000 feet. Dust storms are most common over the areas of dry land that are prevalent within this region. Dust storms affect the region annually during summer months and during periods of drought. In Region 6, Deschutes, Klamath, and Lake Counties have the most dust storms on record.

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. This region has 160 state-owned/leased facilities, valued at over $366 million, in an earthquake hazard zone. Of these, 100 are critical/essential facilities. An additional 721 non-state-owned/leased critical/essential facilities are also located within this hazard zone.

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. There are 66 state-owned/leased facilities, valued at approximately $9 million, located in the region's flood hazard zone. Of these, nine are considered critical/essential facilities. An additional 60 non-state-owned/leased critical/essential facilities are located in this hazard zone.

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. There are 785 state-owned/leased facilities in a landslide hazard zone in this region, valued at over $371 million. Of these, 103 are critical/essential facilities. An additional 744 non-state-owned/leased critical/essential facilities are also located within this hazard zone.

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. There are 32 state-owned/leased facilities located in a volcanic hazard zone within this region, a value of approximately $11.6 million. Of these, none are identified as critical/essential facilities. There are 22 non-state-owned/leased critical/essential facilities located in this hazard zone.

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. There are 504 state-owned/leased facilities located in a wildfire hazard zone with a value of approximately $188 million. Of these, 59 are identified as critical/essential facilities. An additional 350 non-state-owned/leased critical/essential facilities are also located in this hazard zone.

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 mobile 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.

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.

Climate Change

The most reliable information on climate change to date is at the state level. The state information indicates that hazards projected to be impacted by climate change in Region 6 include drought and wildfire. Climate models project warmer drier summers and a decline in mean summer precipitation for Oregon. Coupled with projected decreases in mountain snowpack due to warmer winter temperatures, all eight regions are expected to be affected by an increased incidence of drought and wildfire. An increase in drought could result in the increased incidence of dust storms, though no current research is available on the direct effects of future climate conditions on the incidence of dust storms. Areas that have historically been both hotter and drier than the statewide average — such as Central Oregon counties — are at somewhat higher risk of increased drought and wildfire than the state overall. 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 the section **Introduction to Climate Change**.

2.3.6.2 Profile

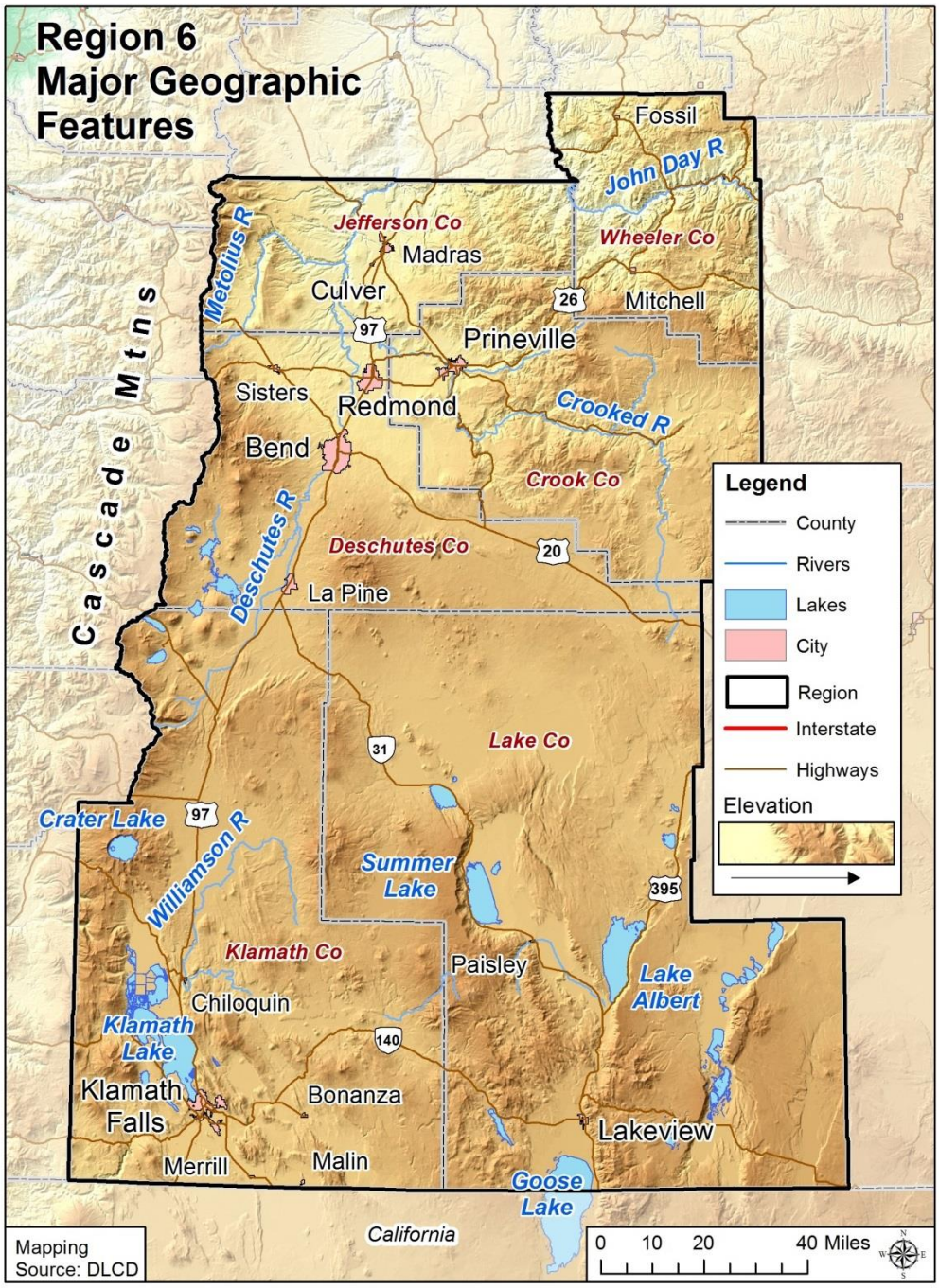
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

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.

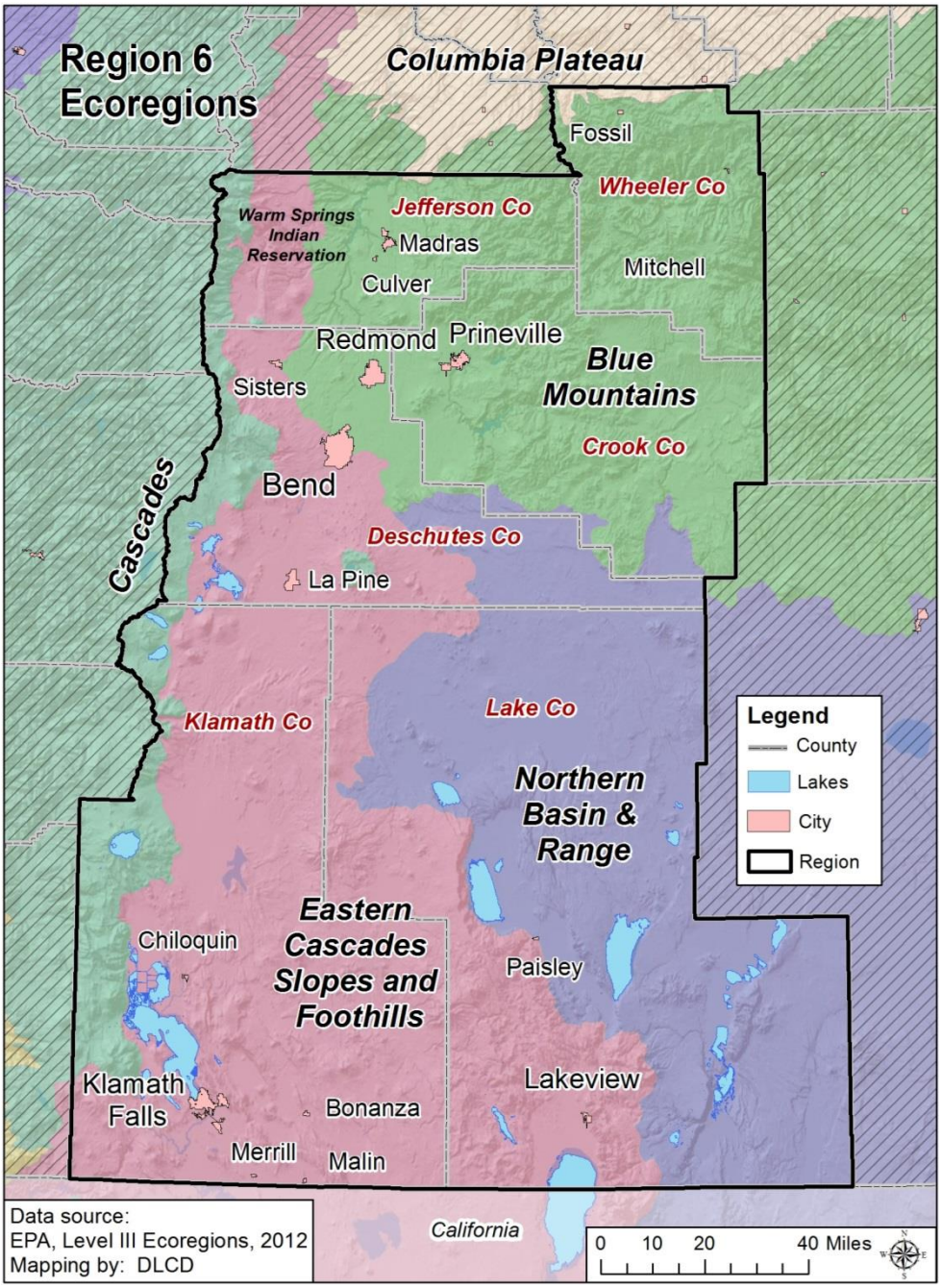
Figure 2-182. Region 6 Major Geographic Features



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 2-183**).

Figure 2-183. 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

Climate refers to the temperatures, weather patterns, and precipitation in the region. This section covers historic climate information. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment** for statewide projections.

Region 6 has diverse ecoregions with varying climatic conditions with the majority of the region's land divided almost equally between the four ecoregions. The region's predominantly

arid climate supports limited agricultural activities, primarily livestock grazing. The region is subject drought, floods, landslides, and wildfires. When considering the climate, snowfall should also be taken into account. Flooding can be a direct result of rain-on-snow events. Likewise, the amount of snowpack in a region can also impact the ability of communities to cope with drought. **Table 2-358** shows mean annual precipitation and temperatures for the three ecoregions in Region 6 (Thorson et al., 2003). Variations in temperature and precipitation vary widely by sub-ecoregion and microclimate. For more detailed and locally relevant climate data refer to the Oregon Climate Service.

Table 2-358. Average Precipitation and Temperature Ranges in Region 6 Ecoregions

Ecoregion	Mean Annual Precipitation Range (inches)	Mean Temperature Range (°F) January min/max	Mean Temperature Range (°F) July min/max
Cascades*	45–140	16/41	38/74
Eastern Cascades slopes and foothills*	10–55	12/40	38/85
Columbia Plateau*	9–25	21/41	52/86
Blue Mountains*	8–60	16/41	43/84
Northern Basin and Range*	6–26	17/42	42/86

*Data have been generalized from all the sub-ecoregions of the ecoregion in Region 6.

Source: Thorson et al. (2003)

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 et al., 2003). If a population is forecast to increase substantially, a community's capacity to provide adequate housing stock, services, or resources for all populations post disaster may be stressed or compromised (Cutter et al., 2003).

Overall, from 2000 to 2013, 85% of the region's growth occurred in Deschutes County, an increase of more than 47,000 people. Wheeler was the only county to decline in population. By 2020, all counties in the region, except Deschutes and Jefferson, are projected to grow at a slower rate than the state overall. Population in Lake and Wheeler Counties is expected to decline.

Table 2-359. Population Estimate and Forecast for Region 6

	2000	2013	Percent Change (2000 to 2013)	2020 Projected	Percent Change (2013 to 2020)
Oregon	3,421,399	3,919,020	14.5%	4,252,100	8.5%
Region 6	226,302	281,435	24.4%	306,608	8.9%
Crook	19,182	20,690	7.9%	21,933	6.0%
Deschutes	115,367	162,525	40.9%	182,455	12.3%
Jefferson	19,009	22,040	15.9%	24,054	9.1%
Klamath	63,775	66,810	4.8%	68,853	3.1%
Lake	7,422	7,940	7.0%	7,936	-0.1%
Wheeler	1,547	1,430	-7.6%	1,378	-3.6%

Source: Population Research Center, Portland State University, 2013; U.S. Census Bureau, 2010 Decennial Census. Table DP-1; Office of Economic Analysis, Long-Term Oregon State's County Population Forecast, 2010-2050, 2013

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. 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 Travel USA, 2011f). 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. Over 13% (3.6 million) of all overnight trips to Oregon included time within Region 6. Three fourths of all trips to the region occur between April and September, and the average travel party contains 3.7 persons. The average trip length is over 4.4 nights (Longwoods Travel USA, 2011f). Visitors to the region are just as likely to lodge in hotels/motels as in private homes and other accommodations.

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 2-360. Annual Visitor Estimates in Person Nights in Region 6

	2011		2012		2013	
	Number	Percent	Number	Percent	Number	Percent
Region 6	9,434	—	9,684	—	9,892	—
Crook	552	100%	602	100%	634	100%
Hotel/Motel	107	19.4%	144	23.9%	176	27.8%
Private Home	206	37.3%	212	35.2%	212	33.4%
Other	239	43.3%	246	40.9%	246	38.8%
Deschutes	5,649	100%	5,895	100%	6,058	100%
Hotel/Motel	1,821	32.2%	1,957	33.2%	2,067	34.1%
Private Home	2,040	36.1%	2,104	35.7%	2,148	35.5%
Other	1,788	31.7%	1,834	31.1%	1,843	30.4%
Jefferson	827	100%	845	100%	869	100%
Hotel/Motel	101	12.2%	114	13.5%	122	14.0%
Private Home	213	25.8%	215	25.4%	222	25.5%
Other	513	62.0%	516	61.1%	525	60.4%
Klamath	2,071	100%	2,020	100%	2,014	100%
Hotel/Motel	685	33.1%	646	32.0%	626	31.1%
Private Home	847	40.9%	831	41.1%	835	41.5%
Other	539	26.0%	543	26.9%	553	27.5%
Lake	262	100%	252	100%	248	100%
Hotel/Motel	65	25%	58	23%	53	21%
Private Home	78	30%	76	30%	76	31%
Other	119	45%	118	47%	119	48%
Wheeler	73	100%	70	100%	69	100%
Hotel/Motel	13	17.8%	10	14.3%	8	11.6%
Private Home	14	19.2%	14	20.0%	14	20.3%
Other	46	63.0%	46	65.7%	47	68.1%

Source: Oregon Travel Impacts: 1991–2013, April 2014. Dean Runyan Associates, 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, while difficult to identify and measure, are disproportionately affected during disasters (Cutter et al., 2003). In Region 6, the proportion of people who identify as having a disability overall is only one percentage point higher than the proportion of people who do so throughout the state. However, the percentages in the individual counties of Region 6 range 3-8% higher, with the exception of Deschutes County where the percentage is lower. Roughly 42% of seniors in each of Jefferson, Lake and Wheeler Counties have a disability. Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events.

Table 2-361. People with a Disability by Age Groups in Region 6, 2012

	Total Population*	With a Disability		Under 18 Years with a Disability		65 Years and Over with a Disability	
	Estimate	Estimate	Percent	Estimate	Percent**	Estimate	Percent**
Oregon	3,796,881	511,297	13.5%	39,439	4.6%	200,374	37.8%
Region 6	274,535	39,778	14.5%	3,558	5.7%	15,570	34.9%
Crook	20,932	3,825	18.3%	214	4.8%	1,628	38.2%
Deschutes	158,076	19,066	12.1%	2,111	5.8%	7,369	31.0%
Jefferson	20,941	3,540	16.9%	351	6.4%	1,345	41.4%
Klamath	65,826	11,574	17.6%	788	5.3%	4,409	38.9%
Lake	7,479	1,501	20.1%	90	6.0%	650	41.7%
Wheeler	1,281	272	21.2%	4	2.1%	169	41.9%

Note: *Total population does not include institutionalized population

Note: **Percent of age group

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP02

Homeless Population

Population estimates of the homeless in Oregon are performed each January. These are rough estimates and can fluctuate with many factors, including the economy or season. The overwhelming majority of homeless are either single adult males or families with children. Communities located along major transportation corridors, such as US-97, tend to have higher concentrations of homeless people (Thomas et al., 2008). This population has held steady in Region 6 from 2009 to 2011 at about 2,800 persons.

Extra attention is needed to care for and serve homeless communities. Some homeless people choose to remain hidden or anonymous, making it especially difficult to mitigate harm to them from natural hazard events. Accessible shelter and social services are key emergency considerations for the homeless community.

Table 2-362. Homeless Population Estimate for Region 6

	2009	2010	2011	3-Year Average
Oregon	17,122	19,208	22,116	19,482
Region 6	2,837	2,811	2,756	2,801
Crook	282	244	229	252
Deschutes	1,867	1,688	1,775	1,777
Jefferson	89	329	271	230
Klamath	599	539	428	522
Lake	0	11	52	21
Wheeler	0	0	1	0

Source: Oregon Point in Time Homeless Count, Oregon Housing and Community Services.
http://www.oregon.gov/ohcs/pages/ra_point_in_time_homeless_count.aspx

Gender

The gender ratio in Region 6 is similar to that of the state, roughly 50:50 (U.S. Census Bureau; n.d.). It is important to recognize that women tend to have more institutionalized obstacles than men during recovery due to sector-specific employment, lower wages, and family care responsibilities (Cutter et al., 2003).

Age

Region 6 has a slightly higher percentage of seniors than the state. Between 20% and 30% of the population in Crook, Lake and Wheeler Counties are seniors. Senior citizens may require 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, the elderly 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 the elderly (Morrow, 1999).

The region's percentage of children is similar to that of the state, except in Wheeler County where its 8% less of its population are children. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. Parents may lose time from work and money when their children's childcare facilities and schools are impacted by disasters (Cutter et al., 2003).

Table 2-363. Population by Vulnerable Age Groups, in Region 6, 2012

	Total Population	Under 18 Years Old		65 Years and Older	
	Estimate	Estimate	Percent	Estimate	Percent
Oregon	3,836,628	864,243	22.5%	540,527	14.1%
Region 6	277,255	62,920	22.7%	45,080	16.3%
Crook	21,102	4,583	21.7%	4,303	20.4%
Deschutes	158,884	36,349	22.9%	23,965	15.1%
Jefferson	21,746	5,467	25.1%	3,333	15.3%
Klamath	66,350	14,821	22.3%	11,480	17.3%
Lake	7,886	1,508	19.1%	1,593	20.2%
Wheeler	1,287	192	14.9%	406	31.5%

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP05

Language

A greater percentage of the population in this region speak English "very well" compared to the state. Deschutes and Klamath Counties have the largest populations who do not speak English "very well." Outreach materials used to communicate with and plan for these communities should take into consideration their language needs.

Table 2-364. English Usage in Region 6, 2012

	Speak English "Very Well"		Speak English Less Than "Very Well"	
	Estimate	**Percent**	**Estimate**	**Percent**
Oregon	3,376,744	93.8%	224,905	6.2%
Region 6	252,787	96.9%	8,096	3.1%
Crook	19,623	98.0%	400	2.0%
Deschutes	145,397	97.3%	3,989	2.7%
Jefferson	18,845	93.4%	1,338	6.6%
Klamath	60,246	96.5%	2,208	3.5%
Lake	7,442	98.0%	152	2.0%
Wheeler	1,234	99.3%	9	0.7%

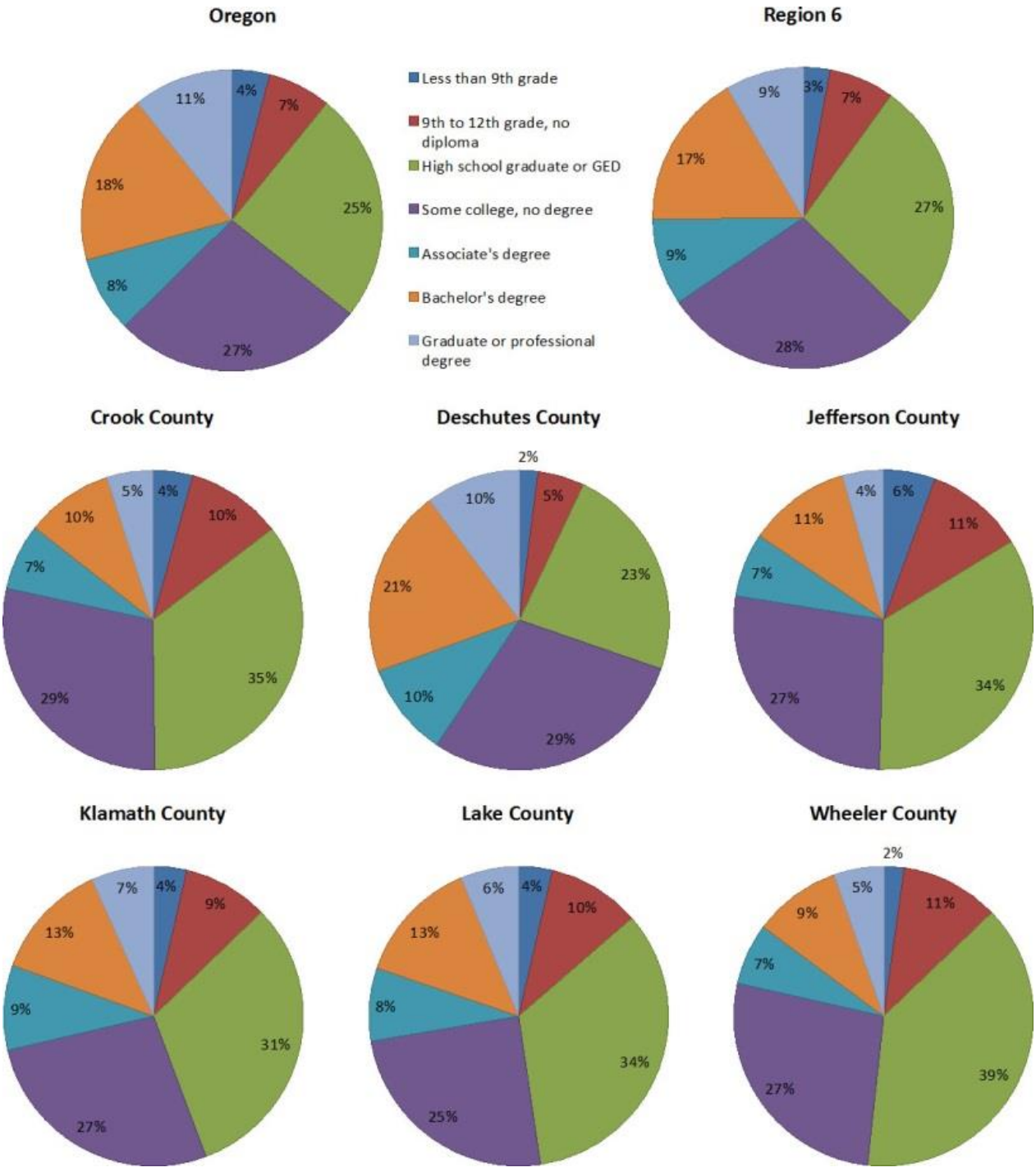
Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP02

Education Level

Studies (Cutter et al., 2003) show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings. The region has a 2% higher percentage of high school graduates (including GEDs) and a 4% lower share of bachelor's degrees compared to state percentages. Deschutes County has the largest percentage of population with a bachelor's degree or higher (41%), while Wheeler County has the lowest percentage (21%).

Education can influence the ability to access resources, while lack of resources may constrain the ability to understand warning information (Cutter et al., 2003). Therefore, levels of education within the region should be considered when designing hazard outreach materials to local communities.

Figure 2-184. Educational Attainment in Region 6, 2012



Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP02

Income

The impact of a disaster in terms of loss and the ability to recover varies among population groups. According to Susan Cutter's research on vulnerability to environmental hazards, "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, 2006, p. 76). Historically, 80% of the disaster burden falls on the public. Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated in communities, are less likely to have the savings to rebuild after a disaster, and less likely to have access to transportation and medical care.

The financial crisis that began in 2007 affected median household incomes in this region in diverse ways. Crook and Deschutes Counties experienced the greatest losses in median household incomes. Only Jefferson County experienced average household income increases. In 2012, with the exception of Deschutes County, median household incomes were $6,700-$13,700 below statewide numbers. Deschutes County was about $1,400 above the state median income.

Table 2-365. Median Household Income in Region 6

	2009	2012	Percent Change
Oregon	$52,474	$50,036	-4.6%
Region 6	N/A	N/A	N/A
Crook	$49,215	$40,263	-18.2%
Deschutes	$57,697	$51,468	-10.8%
Jefferson	$43,081	$43,330	0.6%
Klamath	$43,920	$41,066	-6.5%
Lake	$40,132	$40,049	-0.2%
Wheeler	$34,609	$36,357	5.1%

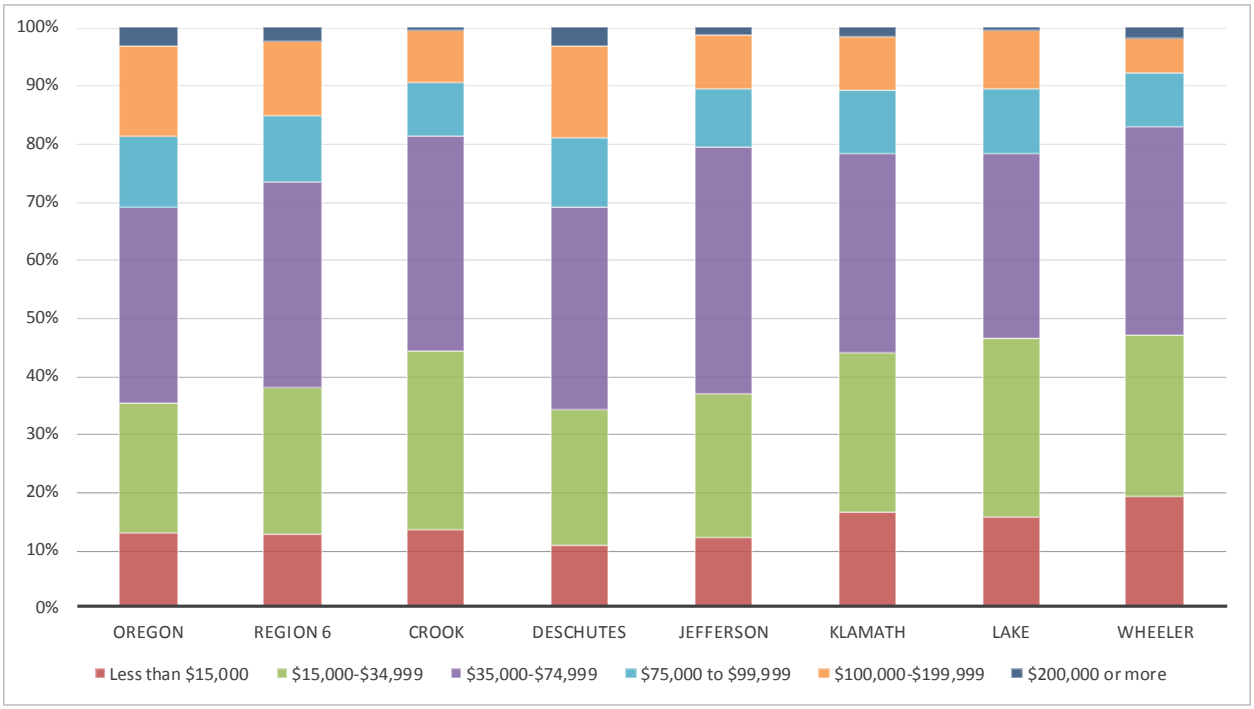
Note: 2009 dollars are adjusted for 2012 using Bureau of Labor Statistics' Consumer Price Index Inflation Calculator.

N/A = data not aggregated at the regional level.

Source: U.S. Census Bureau. 2005–2009 and 2008–2012. American Community Survey – 5-Year Estimates. Table DP03.

Compared to statewide numbers, the region has a smaller percentage of households earning more than $75,000 per year. Just over one third of the region's households earn between $35,000 and $75,000 per year. Crook, Klamath, Lake, and Wheeler Counties have the highest percentage of households earning less than $35,000 per year.

Figure 2-185. Median Household Income Distribution in Region 6, 2012



Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP03

The region has about the same percentage of individuals and children living in poverty as the state overall. By total population, poverty is declining only in Wheeler County. Jefferson and Klamath Counties have the highest total poverty rates, roughly 19%. Almost one third of all children in Jefferson County live in poverty. The largest increase in child poverty is in Deschutes County, with a dramatic increase of almost 61%.

Table 2-366. Poverty Rates in Region 6, 2012

	Total Population in Poverty			Children Under 18 in Poverty		
	Number	Percent	Percent Change*	Number	Percent	Percent Change*
Oregon	584,059	15.5%	17.7%	175,303	20.6%	17.6%
Region 6	41,857	15.3%	28.3%	13,224	21.5%	22.1%
Crook	3,631	17.4%	19.6%	1,171	26.1%	-6.8%
Deschutes	20,633	13.1%	53.9%	6,559	18.3%	60.5%
Jefferson	4,015	19.2%	21.1%	1,624	30.0%	10.1%
Klamath	12,143	18.7%	6.0%	3,493	24.6%	-1.6%
Lake	1,284	17.2%	7.4%	354	23.7%	-15.1%
Wheeler	151	12.0%	-26.0%	23	12.0%	-53.1%

Note: *Percent change since 2009.

Source: U.S. Census Bureau. 2005–2009 and 2008–2012. American Community Survey – 5-Year Estimates, Table S1701

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources (Cutter et al., 2003).

Housing Tenure

Wealth can increase the ability to recover following a natural disaster (Cutter et al., 2003), and homeownership, versus renting, is often linked to having more wealth. Renters often do not have personal financial resources or insurance to help recover post-disaster. On the other hand, renters tend to be more mobile and have fewer assets at risk. In the most extreme cases, renters lack sufficient shelter options when lodging becomes uninhabitable or unaffordable due to natural disaster events.

A smaller percentage of housing units are rented than average; the highest percentage of rental units are in Jefferson County. Lake County has the greatest percentage of vacant units, while Deschutes and Klamath Counties have the greatest total number of vacancies. In addition, the region has about 8% more seasonal or recreational homes than the state, and 70% of these homes are in Deschutes County (U.S. Census Bureau, 2008–2012 American Community Survey, Table DP04 and Table B25004).

Table 2-367. Housing Tenure in Region 6, 2012

	Total Occupied Units	Owner Occupied		Renter Occupied		Vacant^	
		Estimate	Percent	Estimate	Percent	Estimate	Percent
Oregon	1,512,718	945,824	62.5%	566,894	37.5%	105,417	6.3%
Region 6	113,148	75,355	66.6%	37,793	33.4%	11,694	8.5%
Crook	8,745	6,313	72.2%	2,432	27.8%	838	8.2%
Deschutes	64,459	42,620	66.1%	21,839	33.9%	6,466	8.1%
Jefferson	8,005	5,161	64.5%	2,844	35.5%	702	7.2%
Klamath	27,747	18,395	66.3%	9,352	33.7%	3,112	9.5%
Lake	3,566	2,405	67.4%	1,161	32.6%	576	13.1%
Wheeler	626	461	73.6%	165	26.4%	66	7.5%

^ = Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP04 and Table B25004.

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households. Just over one fourth of all households within the region are family households with children. Similar to the state as a whole, this region has about twice as many single-parent households headed by females than by males. Jefferson County has the highest percentage of single-parent households.

Table 2-368. Family vs. Non-family Households in Region 6, 2012

	Total Households	Family Households		Nonfamily Households		Householder Living Alone	
	Estimate	Estimate	Percent	Estimate	Percent	Estimate	Percent
Oregon	1,512,718	964,274	63.7%	548,444	36.3%	421,620	27.9%
Region 6	113,148	76,376	67.5%	36,772	32.5%	28,515	25.2%
Crook	8,745	6,050	69.2%	2,695	30.8%	2,138	24.4%
Deschutes	64,459	43,686	67.8%	20,773	32.2%	15,759	24.4%
Jefferson	8,005	5,604	70.0%	2,401	30.0%	1,858	23.2%
Klamath	27,747	18,411	66.4%	9,336	33.6%	7,451	26.9%
Lake	3,566	2,228	62.5%	1,338	37.5%	1,088	30.5%
Wheeler	626	397	63.4%	229	36.6%	221	35.3%

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP04

Table 2-369 shows household structures for families with children in Region 6.

Table 2-369. Family Households with Children by Head of Household in Region 6, 2012

	Family Households with Children		Single Parent (Male)		Single Parent (Female)		Married Couple with Children	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Estimate	Percent
Oregon	415,538	27.5%	35,855	2.4%	93,575	6.2%	286,108	18.9%
Region 6	31,005	27.4%	3,373	3.0%	6,349	5.6%	21,283	18.8%
Crook	2,266	25.9%	205	2.3%	434	5.0%	1,627	18.6%
Deschutes	18,223	28.3%	1,805	2.8%	3,273	5.1%	13,145	20.4%
Jefferson	2,208	27.6%	370	4.6%	527	6.6%	1,311	16.4%
Klamath	7,395	26.7%	922	3.3%	1,959	7.1%	4,514	16.3%
Lake	825	23.1%	59	1.7%	137	3.8%	629	17.6%
Wheeler	88	14.1%	12	1.9%	19	3.0%	57	9.1%

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP04

Note: The table shows the percent of total households represented by each family household structure category.

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:

- 85% of the region's growth is within Deschutes County.
- Higher percentages of the region's population has a disability than the state as a whole, except in Deschutes County.
- Crook, Lake, and Wheeler Counties have high percentages of seniors.
- All counties except Deschutes have lower than average median household incomes
- Child poverty is increasing in Deschutes and Jefferson Counties.
- Many housing units in Deschutes, Lake, and Klamath Counties are vacant.
- Klamath and Jefferson Counties have high percentages of single-parent households.

Economy

Employment

Employment status and salary level may impact the resilience of individuals and families in the face of disasters as well as their ability to mitigate losses created by natural hazards (Cutter et al., 2003). "The potential loss of employment following a disaster exacerbates the number of unemployed workers in a community, contributing to a slower recovery from the disaster" (Cutter et al., 2003). Though the accelerated growth in Deschutes County has contributed to a broad recovery for the region since the financial crisis that began in 2007, still less than half of the county's 11,000 job losses have been recovered since the recession's peak in 2009 (Tauer, 2014). Deschutes County has the largest labor force and one of the lowest unemployment rates in the region. Wheeler County's labor force has remained relatively stable through the recession due to the county's sparse population and high self-employment rates (Fridley, 2014). Average salaries are lower than state average, ranging from 57% to 89% of that of the state. For example, the average salary in Crook County is $40,118, and in Wheeler County is $25,771.

Table 2-370. Unemployment Rates in Region 1, 2009-2013

	2009	2010	2011	2012	2013	Change (2009-2013)
Oregon	11.1%	10.8%	9.7%	8.8%	7.7%	-3.4%
Region 6	14.7%	14.2%	12.8%	11.8%	10.1%	-4.6%
Crook	17.9%	17.1%	15.3%	14.2%	12.3%	-5.7%
Deschutes	14.7%	14.3%	12.7%	11.4%	9.5%	-5.2%
Jefferson	14.8%	14.4%	13.4%	12.3%	10.7%	-4.1%
Klamath	13.9%	13.3%	12.4%	11.9%	10.7%	-3.2%
Lake	12.4%	13.6%	13.3%	12.8%	11.1%	-1.3%
Wheeler	9.0%	10.6%	9.8%	7.7%	7.1%	-2.0%

Source: Oregon Employment Department, 2014.

Table 2-371. Employment and Unemployment Rates in Region 6, 2013

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	1,924,604	1,775,890	92.3%	148,714	7.7%
Region 6	128,738	115,769	89.9%	12,969	10.1%
Crook	8,707	7,639	87.7%	1,068	12.3%
Deschutes	77,752	70,382	90.5%	7,370	9.5%
Jefferson	9,122	8,143	89.3%	979	10.7%
Klamath	28,905	25,798	89.3%	3,107	10.7%
Lake	3,573	3,176	88.9%	397	11.1%
Wheeler	679	631	92.9%	48	7.1%

Source: Oregon Employment Department, 2014.

Table 2-372. Employment and Payroll in Region 6, 2013

	Employees	Average Pay	Percent State Average
Oregon	1,679,364	$45,010	100%
Region 6	99,445	$36,865	81.9%
Crook	5,833	$40,118	89.1%
Deschutes	63,286	$37,749	83.9%
Jefferson	6,172	$34,196	76.0%
Klamath	21,513	$34,550	76.8%
Lake	2,334	$34,621	76.9%
Wheeler	307	$25,771	57.3%

Source: Oregon Employment Department, 2014

Employment Sectors and Key Industries

In 2013 the five major employment sectors in Region 6 were: (a) Trade, Transportation, and Utilities; (b) Government; (c) Education and Health Services; (d) Leisure and Hospitality; and (e) Professional and Business Services. Between 2012 and 2022, projected growth is expected to create a 18% increase in employment for Central Oregon, including Crook, Deschutes, Jefferson Counties, and a 14% increase in South Central Oregon, including Klamath and Lake Counties. For information on Wheeler County see the Region 5 Risk Assessment (Oregon Employment Department, n.d.b).

Table 2-373. Covered Employment by Sector in Region 6, 2013

Industry	Region 6	Crook County		Deschutes County		Jefferson County	
		Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	99,445	5,833	100%	63,286	100%	6,172	100%
Total Private Coverage	82.0%	4,618	79.2%	54,792	86.6%	3,780	61.2%
Natural Resources & Mining	2.6%	222	3.8%	534	0.8%	457	7.4%
Construction	4.5%	203	3.5%	3,511	5.5%	71	1.2%
Manufacturing	7.9%	731	12.5%	4,209	6.7%	907	14.7%
Trade, Transportation & Utilities	19.3%	1,630	27.9%	12,339	19.5%	793	12.8%
Information	1.7%	70	1.2%	1,407	2.2%	27	0.4%
Financial Activities	4.1%	117	2.0%	3,208	5.1%	111	1.8%
Professional & Business Services	9.7%	297	5.1%	6,879	10.9%	148	2.4%
Education & Health Services	14.8%	556	9.5%	10,330	16.3%	540	8.7%
Leisure & Hospitality	13.6%	553	9.5%	9,901	15.6%	544	8.8%
Other Services	3.7%	236	4.0%	2,457	3.9%	182	2.9%
Private Non-Classified	0.0%	(c)	0.0%	18	0.0%	(c)	0.0%
Total All Government	18.0%	1,216	20.8%	8,494	13.4%	2,392	38.8%
Federal Government	2.4%	304	5.2%	864	1.4%	132	2.1%
State Government	3.0%	203	3.5%	1,245	2.0%	311	5.0%
Local Government	12.5%	709	12.2%	6,385	10.1%	1,949	31.6%

Industry	Region 6	Klamath County		Lake County		Wheeler County	
		Employment	Percent	*Employment*	Percent	Employment	Percent
Total All Ownerships	99,445	21,513	100%	*2,334*	100%	307	100%
Total Private Coverage	82.0%	16,829	78.2%	*1,354*	58.0%	194	63.2%
Natural Resources & Mining	2.6%	999	4.6%	*326*	14.0%	48	15.6%
Construction	4.5%	667	3.1%	*50*	2.1%	(c)	0.0%
Manufacturing	7.9%	1,771	8.2%	*226*	9.7%	(c)	0.0%
Trade, Transportation & Utilities	19.3%	4,077	19.0%	*303*	13.0%	51	16.6%
Information	1.7%	179	0.8%	*18*	0.8%	(c)	0.0%
Financial Activities	4.1%	624	2.9%	*48*	2.1%	(c)	0.0%
Professional & Business Services	9.7%	2,220	10.3%	*61*	2.6%	(c)	0.0%
Education & Health Services	14.8%	3,172	14.7%	*94*	4.0%	55	17.9%
Leisure & Hospitality	13.6%	2,344	10.9%	*164*	7.0%	20	6.5%
Other Services	3.7%	776	3.6%	*60*	2.6%	9	2.9%
Private Non-Classified	0.0%	(c)	0.0%	*(c)*	0.0%	(c)	0.0%
Total All Government	18.0%	4,684	21.8%	*980*	42.0%	113	36.8%
Federal Government	2.4%	883	4.1%	*242*	10.4%	5	1.6%
State Government	3.0%	1,091	5.1%	*176*	7.5%	6	2.0%
Local Government	12.5%	2,710	12.6%	*562*	24.1%	102	33.2%

Source: Oregon Employment Department, 2013

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Each industry faces distinct vulnerabilities to natural hazards. Identifying key industries in the region enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment sectors 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 plans.

Revenue by Sector

In 2007 Trade (Retail and Wholesale), Manufacturing, and Healthcare and Social Assistance were the highest revenue grossing industries in Region 6. (Revenue data from the 2012 Economic Census will not be released prior to the publication of this Plan.) Combined, these three industries generated over $8.7 billion (92% of total revenue) for the region. Trade (Retail and Wholesale) is the largest grossing sector in all counties.

Note: Due to the small size and few industries in the region the collected data is withheld in several categories, especially for manufacturing, to avoid disclosing data for individual companies. Information is aggregated to the county level.

Table 2-374. Revenue of Top Industries (in Thousands of Dollars) in Region 6, 2007

	Total Revenue (in Thousands)	Trade (Retail and Wholesale)	Manufacturing	Health Care and Social Assistance
Oregon	$277,017,733	44.4%	24.1%	7.3%
Region 6	$10,277,989	53.7%	18.4%	12.9%
Crook	$544,066	44.2%	38.6%	8.7%
Deschutes	$7,069,183	57.0%	12.7%	13.8%
Jefferson	$666,466	53.7%	36.4%	D
Klamath	$1,866,429	42.2%	28.9%	15.3%
Lake	$120,934	76.3%	—	15.2%
Wheeler	$10,911	94.9%	—	D

Source: U.S. Census, Economic Census. 2007, Table ECO700A1

Notes: D = Withheld to avoid disclosing data for individual companies; data are included in higher level totals, and "-" = data not provided.

Sectors that are anticipated to be major employers in the future warrant special attention, especially in the hazard mitigation planning process so workforces and employers can be more prepared to respond and adapt to needs that arise after a natural hazard event. According to the Oregon Employment Department, between 2012 and 2022, the largest job growth in Region 6 is expected to occur in the following sectors: (a) Education and Health Services; (b) Leisure and Hospitality; (c) Trade, Transportation, and Utilities (including retail trade); (d) Professional and Business Services; and (e) Manufacturing (Oregon Employment Department, 2014).

Identifying sectors with a large number of businesses and targeting mitigation strategies to support those sectors can help the region's resiliency. The Trade, Transportation, and Utilities sector includes the most businesses in Region 6, 18.6%. Professional and Business Services has the second most. Other Services, Construction, Education, and Health Services round out the top five sectors in the region (Oregon Employment Department, 2012). While many of these are small businesses, employing fewer than 20 employees, collectively they represent almost two thirds of the businesses in the region. Due to their small size and large collective share of the economy, these businesses are particularly sensitive to temporary decreases in demand, such as may occur following a natural hazard event.

Economic Trends and Issues

Current and anticipated financial conditions of a community are strong determinants of community resilience, since a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly. The Economic analysis shows that Region 6 is particularly vulnerable during a hazard event due to the following characteristics:

- Less than half of the jobs lost at the peak of the financial crisis that began in 2007 have been recovered; and
- Wages in Region 6 are relatively low, particularly in Wheeler County.

Central Oregon has largely rebounded from the financial crisis that began in 2007. This is driven primarily by growth in Deschutes and Crook Counties. The educational and health, professional and business services, leisure and hospitality, and manufacturing sectors, driven by the state's

fastest population growth rate and increasing tourism economy (both summer bicycling and winter skiing), drives the growth in employment within the region (Oregon Employment Department, n.d.c). Klamath, Lake, and Wheeler Counties have slower population growth rates and higher rates of unemployment and have not recovered as fully as the rest of the region. Supporting the growth of dominant industries and employment sectors as well as emerging sectors identified in this analysis can help the region become more resilient to economic downturns that often follow a hazard event (Stahl et al., 2000).

Infrastructure

Transportation

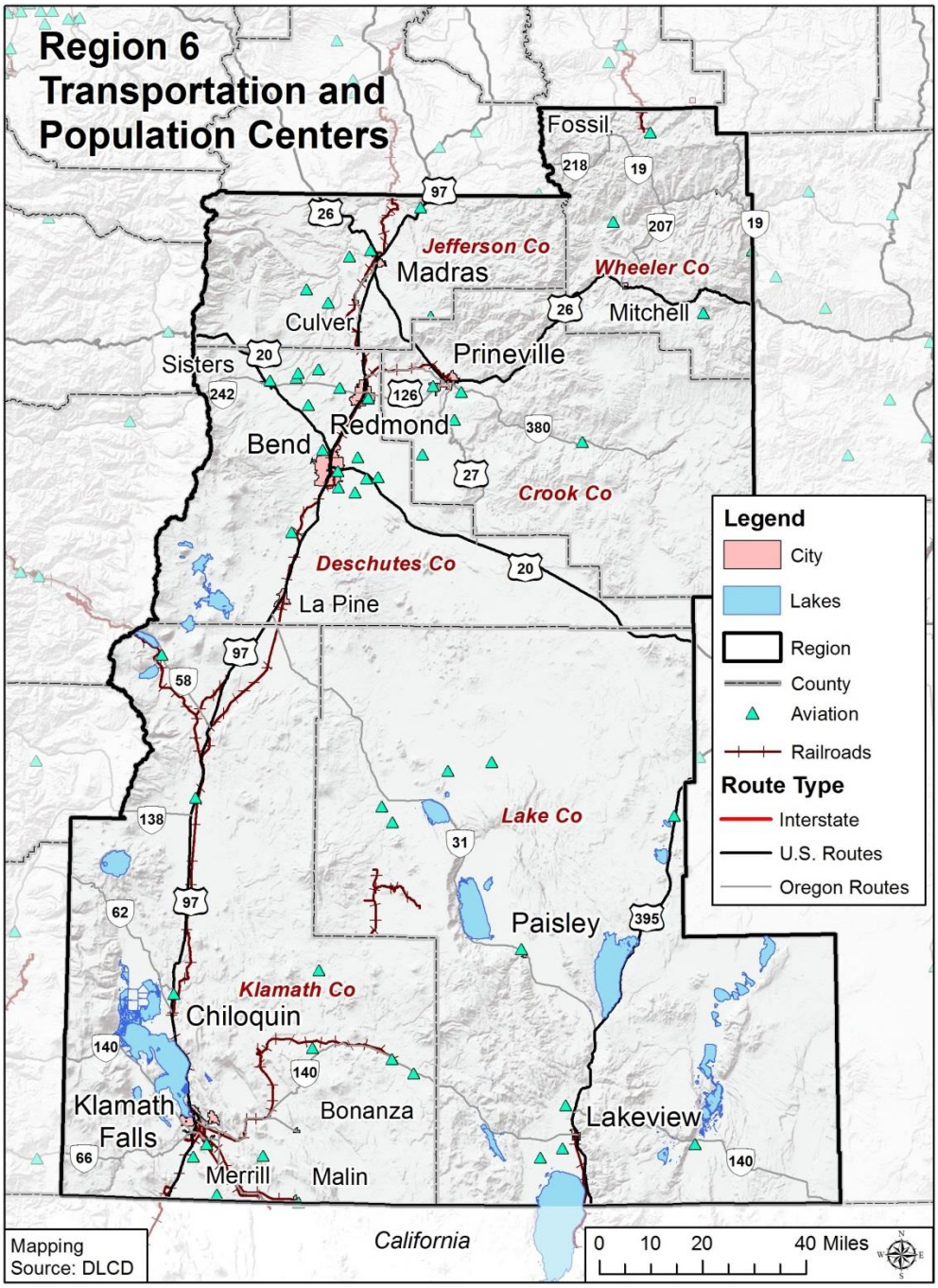
Roads

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 (ODOT's) Seismic Lifeline 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. For information on ODOT's Seismic Lifeline Report findings for Region 6, see **Seismic Lifelines**.

Figure 2-186. Region 6 Transportation and Population Centers



Source: Oregon Department of Transportation, 2014

Bridges

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 2-375 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, 2012, 2013). The table shows that the region has a lower percentage of bridges that are distressed and/or deficient (13%), than does the state (21%). About 15% of the region's ODOT bridges are distressed, compared to 22% for the state.

Table 2-375. Bridge Inventory for Region 6

	State Owned			County Owned			City Owned			Other Owned			Area Total			Historic
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D	Covered
Oregon	610	2,718	22%	633	3,420	19%	160	614	26%	40	115	35%	1,443	6,769	21%	334
Region 6	21	144	15%	27	240	11%	8	57	14%	4	9	44%	60	449	13%	12
Crook	7	28	22%	5	24	21%	1	7	14%	0	0	-	13	63	21%	3
Deschutes	5	48	11%	8	47	17%	5	35	14%	1	4	25%	19	132	14%	2
Jefferson	1	13	7%	9	34	26%	0	4	0%	0	1	0%	10	53	19%	4
Klamath	8	55	16%	5	135	4%	2	11	18%	3	4	75%	18	201	9%	2
Lake	4	25	16%	1	38	3%	0	1	0%	0	0	—	5	64	8%	0
Wheeler	0	23	0%	1	6	17%	0	0	—	0	0	—	1	29	3%	1

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

Source: ODOT (2012, 2013)

Railroads

Railroads that run through Region 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 2-376. 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 2-377 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.).

Table 2-377. 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

Figure 2-187 shows the major dams operated by the Bonneville Power Administration (BPA), which provides hydro-generated electricity to the states consumer owned utilities. The major BPA dams in the region are located on the Deschutes River (Pelton and Round Butte).

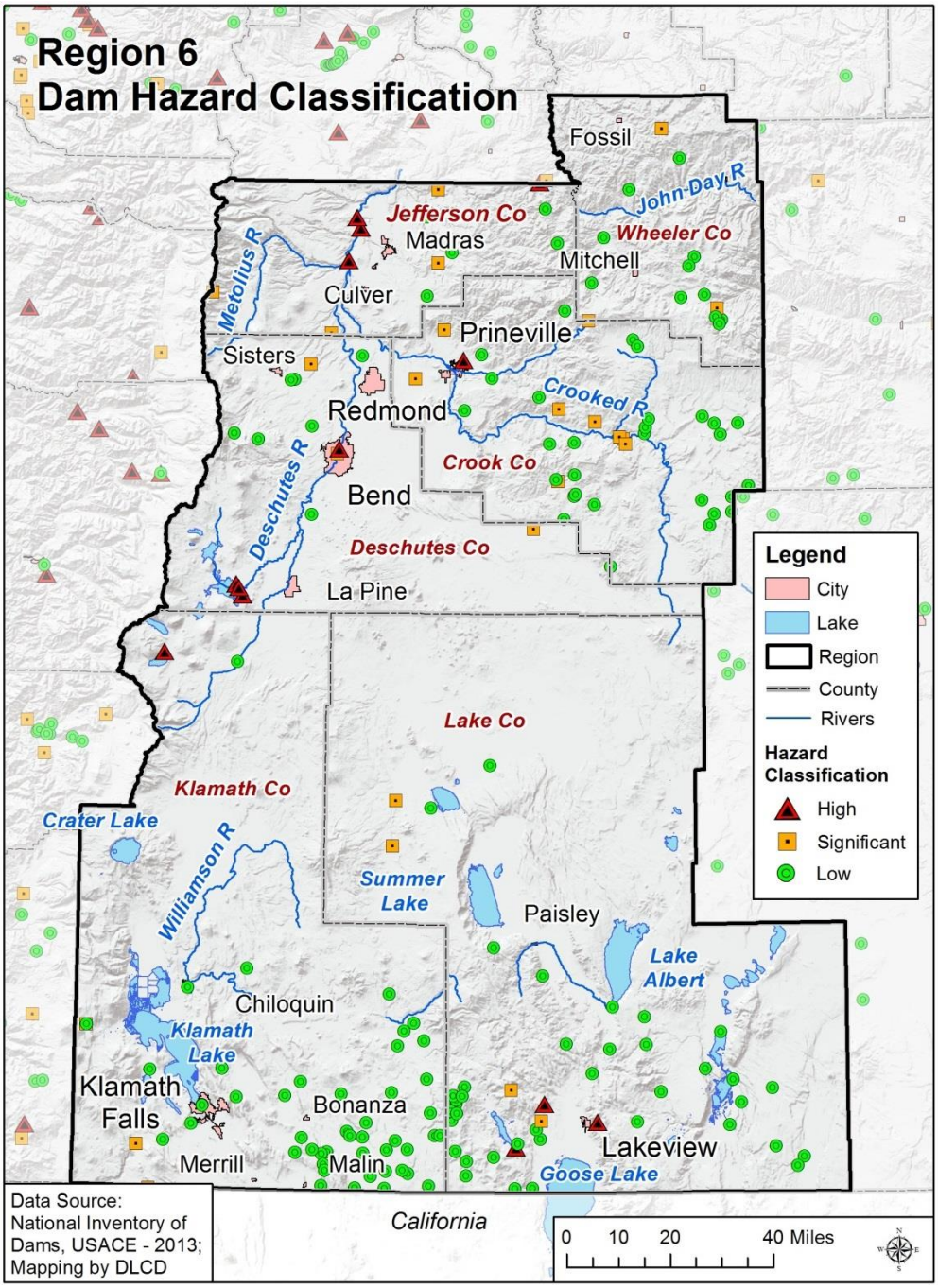
Minor dam failures can occur at any time. Most dam failures result in minor damage to structures and pose little or no risk to life safety. However, the potential for severe damage and fatalities does exist (major dam failures have occurred most recently near Hermiston, 2005, and Klamath Lake, 2006) (Association of Dam Safety Officials, n.d.). The Oregon Water Resources Department maintains an inventory of all large dams located in Oregon (using the National Inventory of Dams (NID) threat potential methodology). Table 2-378 lists the number of dams included in the inventory. The majority of dams in the region are located in Crook (53), Klamath (65), and Lake (79) Counties. There are 19 High Threat Potential dams and 23 Significant Threat Potential dams in the region.

Table 2-378. Threat Potential of Dams in Region 6

	Threat Potential			
	High	Significant	Low	Total Dams
Region 6	19	23	212	254
Crook	5	8	40	53
Deschutes	3	3	12	18
Jefferson	4	4	10	18
Klamath	4	3	58	65
Lake	3	5	71	79
Wheeler	0	0	21	21

Source: Oregon Water Resources Department, Dam Inventory Query, 2014

Figure 2-187. Region 6 Dam Hazard Classification

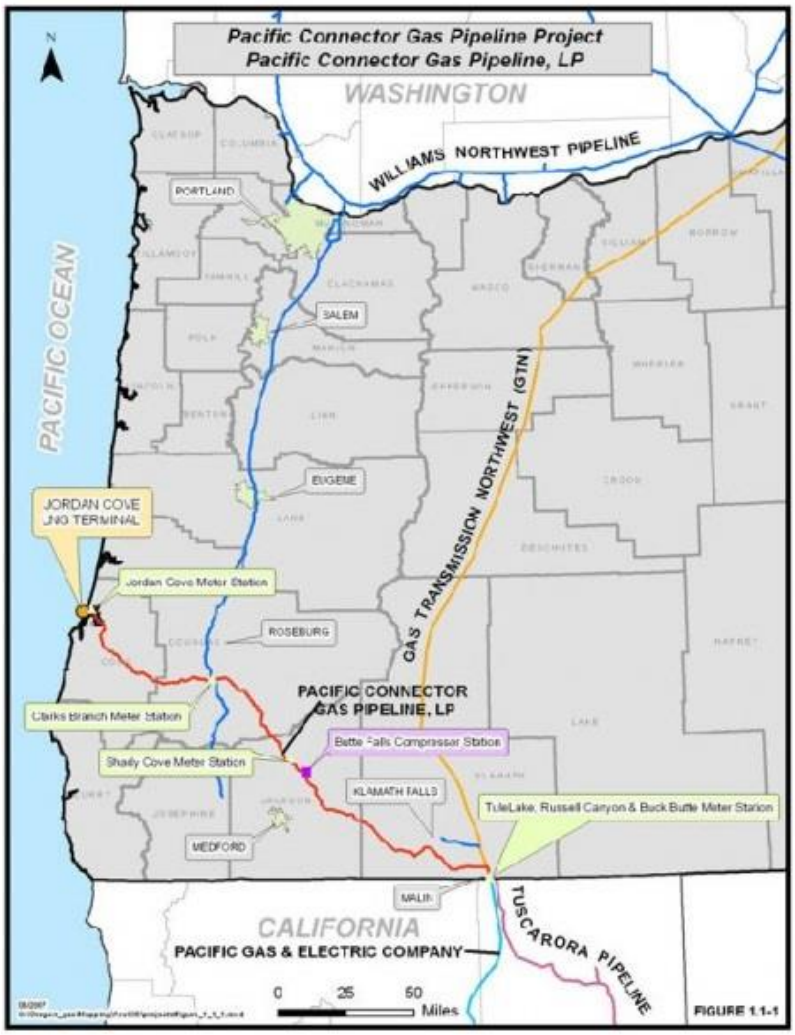


Source: National Inventory of dams, USACE, 2013

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 2-188** 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 2-188. 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 et al., 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 et al., 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. Landslides, flood events, and earthquakes and resulting liquefaction can cause increased erosion and sedimentation in waterways

Underground water supplies and aging or outdated infrastructure — such as reservoirs, treatment facilities, and pump stations — can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems, limiting access to potable water. This can lead to unsanitary conditions that may threaten human health. 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

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 (Department of Land Conservation and Development, website: http://www.oregon.gov/http://www.oregon.gov/).

Settlement Patterns

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.

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.

Table 2-379. Urban and Rural Populations in Region 6

	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	0%	1,547	1,441	-6.9%

Source: U.S. Census Bureau. 2000 Decennial Census, Table P002 and 2010 Decennial Census, Table P2

Table 2-380. Urban and Rural Housing Units in Region 6

	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	0%	842	895	6.3%

Source: U.S. Census Bureau. 2000 Decennial Census, Table H002 and 2010 Decennial Census, Table H2

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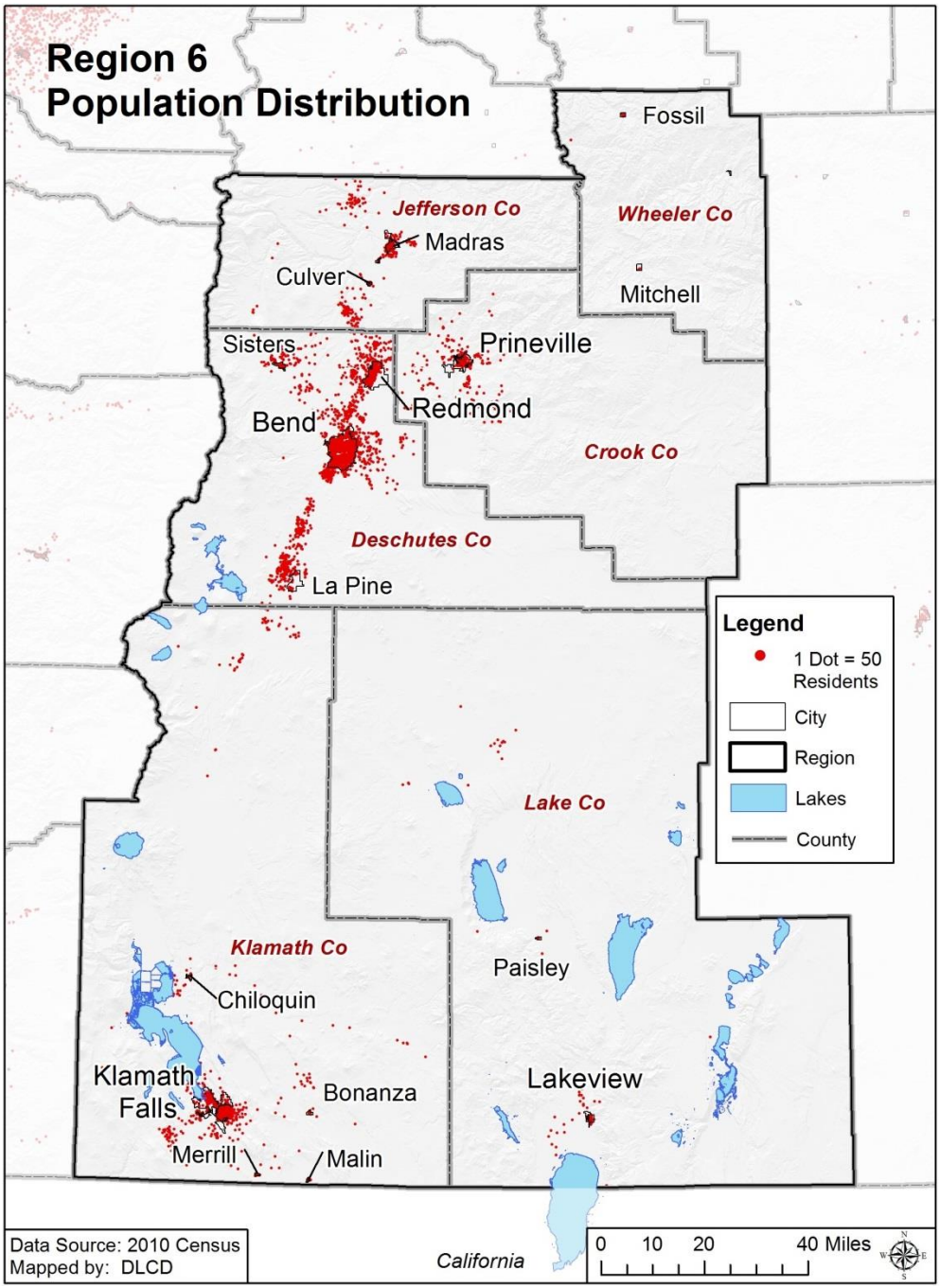
Figure 2-189. Region 6 Population Distribution



Source: U.S. Census, 2012

Land Use and Development 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 (36%) 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, 2011).

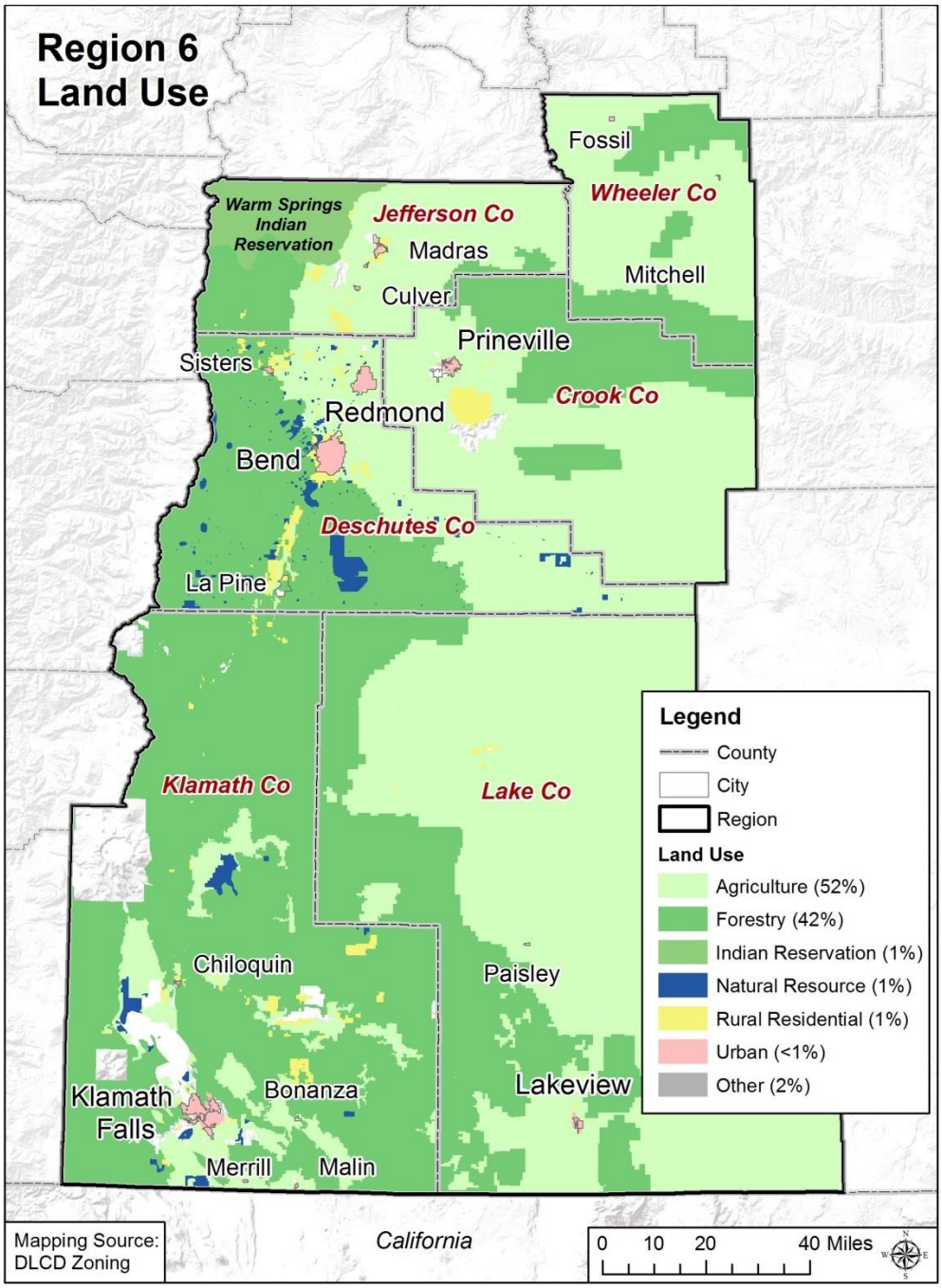
Responding to rapid growth and changing demographics, in 2011 Deschutes County completed a multi-year effort to establish "Plan 2030." This new plan incorporates updated goals and policies, community plans, and new projects like the South County Plan, destination resort remapping, a 2030 Transportation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

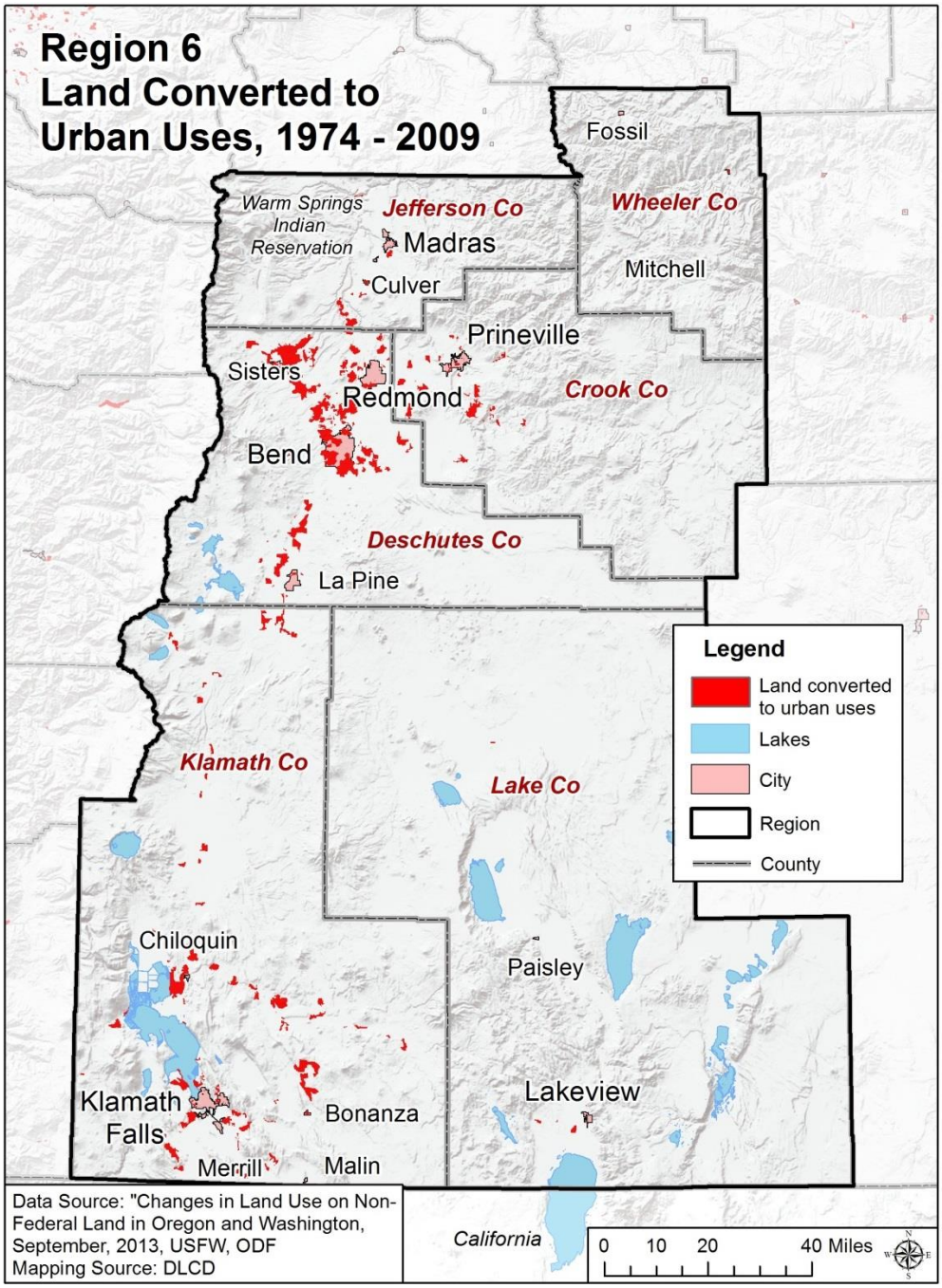
The City of Madras in 2014 began working on integrating portions of its Comprehensive Plan with its Local Natural Hazards Mitigation Plan; this may prove to be a model for others.

Figure 2-190. Region 6 Land Use



Source: Department of Land Conservation and Development, 2014

Figure 2-191. 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

Housing

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. Almost two thirds of the region's housing stock is single-family homes. Mobile homes account for 13% of Region 6's housing, and roughly 70% of all mobile homes are located in Deschutes and Klamath Counties. In natural hazard events such as earthquakes and floods, mobile homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of OES, 1997).

Table 2-381. Housing Profile for Region 6, 2012

	Total Housing Units	Single Family		Multi-Family		Mobile Homes	
		Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Oregon	1,673,593	1,140,319	68.1%	460,852	27.5%	139,768	8.4%
Region 6	138,082	102,288	74.1%	17,474	12.7%	18,017	13.0%
Crook	10,204	7,763	76.1%	663	6.5%	1,669	16.4%
Deschutes	80,039	61,145	76.4%	11,557	14.4%	7,308	9.1%
Jefferson	9,807	6,409	65.4%	1,009	10.3%	2,337	23.8%
Klamath	32,737	23,393	71.5%	4,033	12.3%	5,250	16.0%
Lake	4,413	2,914	66.0%	204	4.6%	1,243	28.2%
Wheeler	882	664	75.3%	8	0.9%	210	23.8%

Note: The percentages listed above do not reflect the number of structures that are built within special flood hazard areas or that are at risk of seismic damage.

Source: U.S. Census Bureau. 2008–2012, American Community Survey 5-Year Estimates, Table B25024

Aside from location and type of housing, the year structures were built (**Table 2-382**) 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.

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 quarter 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. Regionally, just under 54% of the housing stock was built before 1990 and the codification of seismic building standards.

Table 2-382. Age of Housing Stock in Region 6, 2012

	Total Housing Units	Pre 1970		1970 to 1989		1990 or later	
		Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Oregon	1,673,593	609,062	36.4%	518,569	31.0%	545,962	32.6%
Region 6	138,082	32,008	23.2%	42,128	30.5%	63,946	46.3%
Crook	10,204	2,840	27.8%	2,624	25.7%	4,740	46.5%
Deschutes	80,039	10,166	12.7%	24,414	30.5%	45,459	56.8%
Jefferson	9,807	2,325	23.7%	2,952	30.1%	4,530	46.2%
Klamath	32,737	14,015	42.8%	10,623	32.4%	8,099	24.7%
Lake	4,413	2,183	49.5%	1,286	29.1%	944	21.4%
Wheeler	882	479	54.3%	229	26.0%	174	19.7%

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 2-383** 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 2-383. 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	Sep. 28, 2007
Bend	Sep. 4, 1987	Sep. 28, 2007
La Pine	Sep. 28, 2007	Sep. 28, 2007
Sisters	Sep. 29, 1986	Sep. 28, 2007
Jefferson County	July 17, 1989	July 17, 1989
Culver	Sep. 4, 1987	Sep. 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	Sep. 5, 1990
Paisley	Sep. 15, 1989	Sep. 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, Community Status Book Report

State-Owned/Leased and Critical/Essential Facilities

In 2014 the Department of Geology and Mineral Industries updated the 2012 Oregon NHMP inventory and analysis of state-owned/leased facilities and critical/essential facilities. Results from this report relative to Region 6 can be found in **Table 2-384**. The region contains 5.1% of the total value of state-owned/leased critical/essential facilities.

Table 2-384. Value of State-Owned/Leased Critical and Essential Facilities in Region 6

	Total Property Value (State Facilities)	Percent State Total
Oregon	$7,339,087,023	100%
Region 6	$371,339,811	5.1%
Crook	$17,310,982	0.2%
Deschutes	$105,581,675	1.4%
Jefferson	$164,051,549	2.2%
Klamath	$41,694,108	0.6%
Lake	$38,521,237	0.5%
Wheeler	$4,180,262	0.1%

Source: DOGAMI

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 is declining in population. The region's housing stock is largely single-family homes, though Jefferson, Lake, and Wheeler Counties have approximately triple the state's percentage of mobile homes. Roughly half the homes in Klamath, Lake, and Wheeler were built before 1970. 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.

2.3.6.3 Hazards and Vulnerability

Droughts

Characteristics

Every county in Central Oregon has experienced drought conditions at some point during the past 10 years, with Klamath County receiving the most Governor-declared declarations. A summary of Governor-declared droughts since 1995 is given in **Table 2-385**. 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 August 2013, Klamath and Lake Counties were declared natural disaster areas.

Historic Drought Events

Table 2-385. Historic Droughts in Region 6

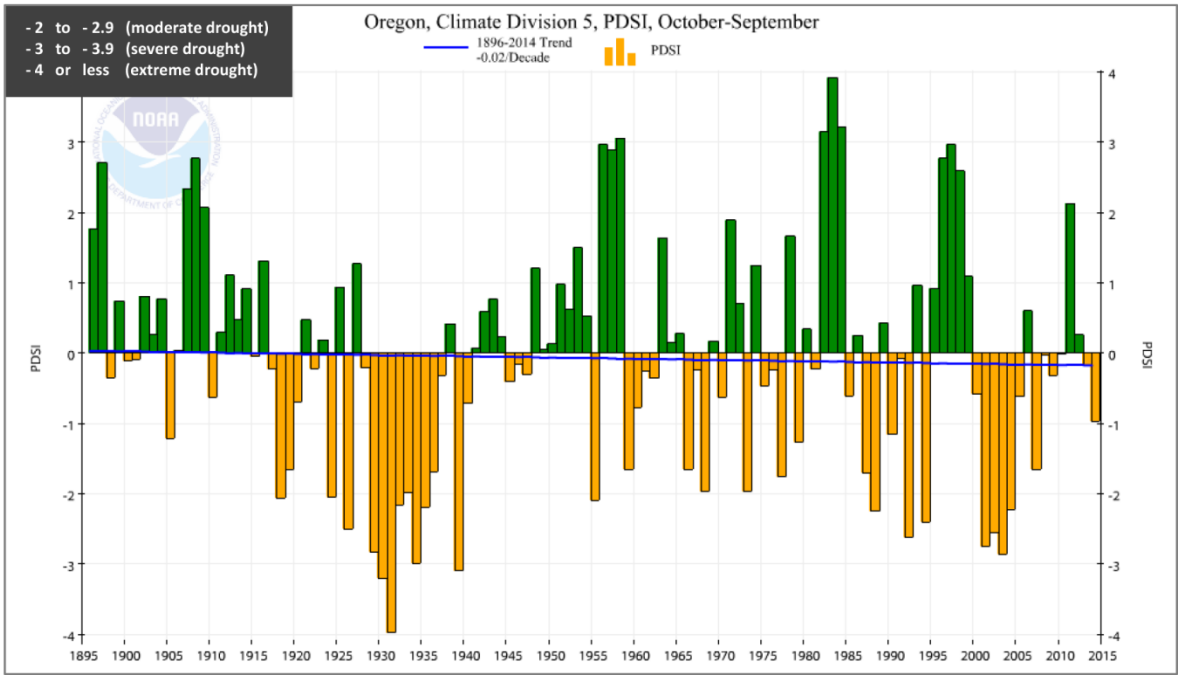
Date	Location	Description
1929–1931	Region 1–3, 5–7 (1929-1930); Region 6 and 7 (1930-1931) (extreme drought)	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country; moderate to severe drought affected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

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 National Climatic Data Center, which provides historical climate data showing wet and dry conditions, using the Palmer Drought Severity Index (PDSI), that dates back to 1895. The Palmer Index is not the best indicator of water availability for Oregon as it does not account for snow or ice (delayed runoff), but it has the advantage of providing the most complete, long-term record. **Figure 2-192** 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, 1931 was the driest year in this record with an index value of -3.98. The late 1920s were moderately dry, followed with many severe droughts in the 1930s. 1992 and 1994 were moderate years, followed by many moderate, nearly severe drought years in the early 2000s.

Figure 2-192. Palmer Drought Severity Index for Region 6



Source: National Climatic Data Center, http://www.ncdc.noaa.gov/cag/

The PDSI 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, but in terms of severity, these years were higher in PDSI values. Water Year 1934, for example, had a PDSI value of −5.58, compared to the high plateau region value of −2.99. Also the south central

region had more occurrences of "severe droughts" than the high plateau region. Water Year 1977 was the fourth driest year for the south central Oregon (PDSI value −3.89), whereas in the high plateau region, 1977 had a PDSI value of −1.76 (normal or mid-range condition).

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers the probability that Region 6 will experience drought is shown in **Table 2-386**. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (—). See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-386. Local Probability Assessment of Drought 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

State Assessment

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.

Vulnerability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the region's vulnerability to drought is shown in **Table 2-387**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-387. Local Vulnerability Assessment of Drought in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	H	L	H	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

Oregon has not undertaken a comprehensive statewide analysis to identify which communities are most vulnerable to drought. However, based on a review of drought declarations issued by the Governor, Klamath County could be considered one of the communities most vulnerable to drought and its related impacts. Since 1992, Klamath County has been under a drought declaration during 11 of the past 22 years, more than any other county in the state.

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.

Lake County could also be considered one of the communities most vulnerable to drought and its related impacts, based on Governor-declared drought declarations. Declarations have been issued in 1992, 2001 (which continued through June 2003), 2005, 2007, 2012, and most recently in February 2014.

Dust Storms

Characteristics

The characteristics of dust storms in Region 6 are well described in the State Risk Assessment, **Drought** section. There is little about the dust storms in this region that differs from the general description, except to note that agricultural practices generally don't play as big a role as they do in Region 5. That written, Central Oregon farmers, ranchers, homeowners, resort properties, and wildlife sometimes find themselves vying for limited water. This competition for scarce water can affect the locations and amounts of dust lifted into the atmosphere, and blown on the wind.

Examples of dust storms in this region are listed in **Table 2-388**. One of the most recent significant storms occurred in April 2001. High winds blowing dust from a recently plowed field severely limited visibility.

Historic Dust Storms

Table 2-388. Historic Dust Storms Affecting Region 6

Date	Location	Description
Apr. 1931[1]	central Oregon	a heavy bank of clouds filled with dust reportedly worked their way over mountain passes into the Santiam Canyon
Mar. 1935	central Oregon	"A dust storm which reduced visibility to a few hundred yards spread over several Central Oregon counties… slowing traffic on the Dallas (sic) – California highway and spreading a fine coating of dry dust over all adjacent wheat lands." [2]
Apr. 2001	near Klamath Falls	US-97 about 5 miles north of Klamath Falls was closed for approximately 6 hours following three separate crashes; 11 cars were involved, sending nine people to the hospital; the accidents were due to severely limited visibility caused by high winds blowing dust from a recently plowed field across the highway. [3]
June 2004[4]	Lake County	blowing dust from a dry lake bed filled the sky in and near Summer Lake
Mar. 2005	Deschutes and Jefferson Counties	visibilities of a half mile or less due to blowing dust were reported from this event; "Motorists on Highway 97 north of Madras reported visibilities down to near zero at times" [5]
Nov. 2009[6]	Lake County	an alkaline dust storm blew into Lakeview

Sources:

(1) Oregon Statesman, "Dust, Wind, and Fire Cause Great Damage," April 23, 1931, and "Dust Storm Precedent on Record 88 Years Ago," April 26, 1931; information on this event, as well as the 1906 event, may also be found in the Pacific Northwest Quarterly, "The Pacific Northwest Dust Storm of 1931," Paul C. Pitzer, April 1988, pp. 50-55, as informed by the following sources used by Mr. Pitzer:

Albany Democrat-Herald, April 22, 1931
Astoria Evening Budget, April 24, 1931
Coos Bay Times, April 22, 23, 1931
Corvallis Gazette-Times, April 22, 24, 1931
Pendleton East Oregonian, April 22, 1931
Portland Oregonian, April 22, 25, 26 and May 1, 1931
Portland Oregonian, Lancaster Pollard, August 21, 1955 and November 25, 1962
Roseburg News-Review, April 22, 23, 1931
Salem Oregon Journal, April 22, 23, 24, 1931
San Francisco Chronicle, April 25, 1931
The Dalles Optimist, April 24, 1931
Wenatchee Daily World, April 22, 1931
Beef Cattle Industry in Oregon: 1890-1938, Dexter K. Strong, 1940
Wind Erosion and Dust Storms in Oregon, Arthur King, 1938

(2) New York Times, March 25, 1935, p. 17; "the Dallas" clearly should be "The Dalles." It may be that someone in New York believed that they were correcting a typographical error.

(3) One of the sources for this is the Herald and News, April 17, 2001, though there are other sources.

(4) The Oregonian (and Associated Press), June 21, 2004

(5) https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=5439654

(6) https://en.wikipedia.org/wiki/Goose_Lake_%28Oregon%E2%80%93California%29

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers the probability that Region 6 will experience dust storms is depicted **Table 2-389**. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (—). See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-389. Local Probability Assessment of Dust Storms in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	L	—	—	—	—	—

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

Five significant storms in 75 years indicates the history and probability of dust storms in Region 6 are both high.

Vulnerability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the region's vulnerability to dust storms is shown in **Table 2-390**. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (—). See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-390. Local Vulnerability Assessment of Dust Storms in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	L	—	—	—	—	—

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

It is difficult to specifically identify the communities most vulnerable to dust storms in Region 6, but Deschutes, Klamath, and Lake Counties are the places with an identified history. Poor visibility leading to motor vehicle crashes is the worst potential impact of these storms; often these crashes result in fatalities and major injuries. Other impacts include poor air quality, including dust infiltration of equipment and engines, loss of productive soil, and an increase in fine sediment loading of creeks and rivers.

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 2-193**.

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 2-391. 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

*BCE: Before Common Era.

Sources: Wong and Bolt (1995); Pacific Northwest Seismic Network

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the probability that Region 6 will experience earthquakes is shown in **Table 2-392**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-392. Local Probability Assessment of Earthquakes in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	L	M	L	M	M	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

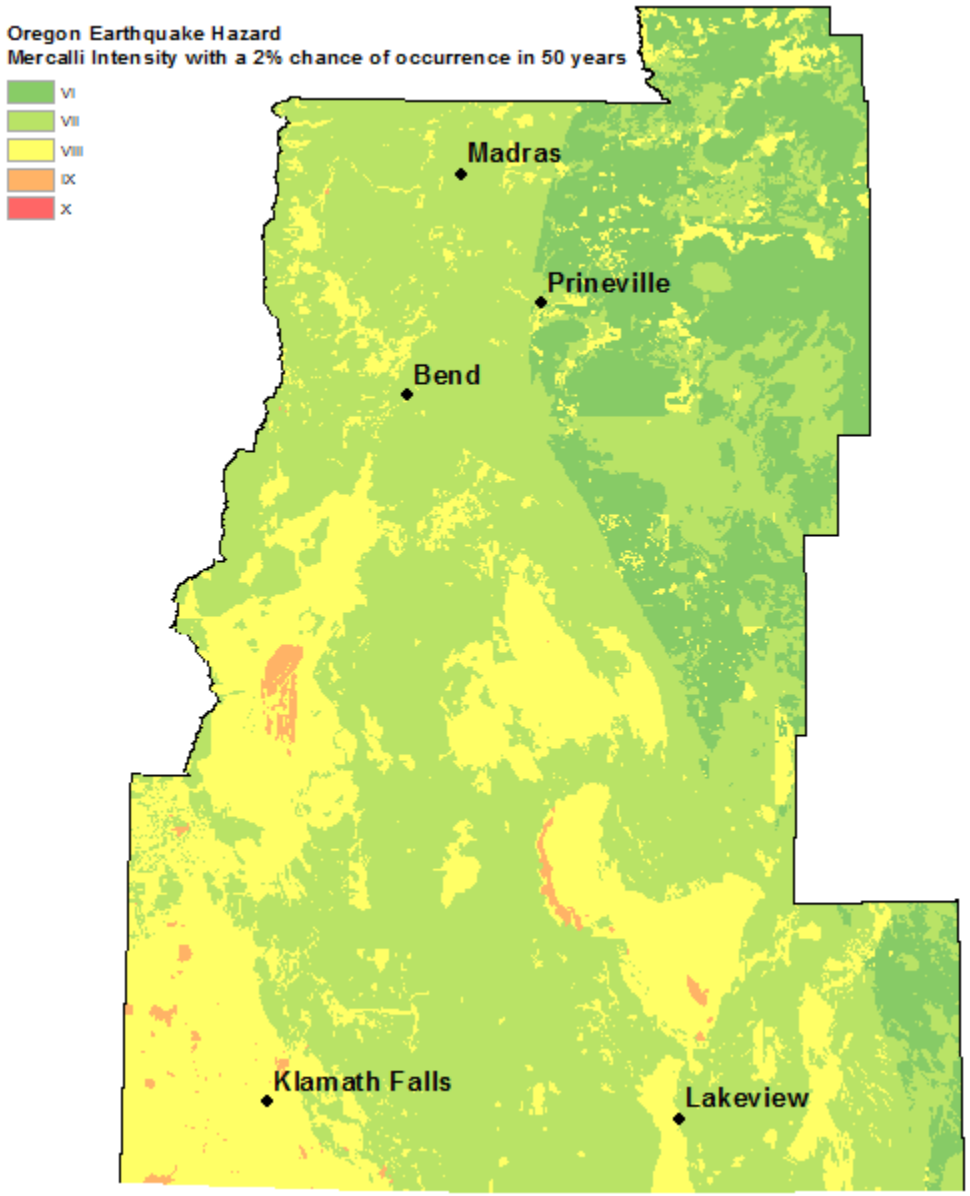
State Assessment

The probability of damaging earthquakes varies widely across the state. In Region 6, the hazard is dominated by local faults and background seismicity.

The probabilistic earthquake hazard for Region 6 is depicted in **Figure 2-193**. This map shows the expected level of earthquake damage that has a 2% chance of occurring in the next 50 years. The map is based on the 2008 USGS National Seismic Hazard Map and has been adjusted to account for the effects of soils following the methods of Madin and Burns (2013). In this case, the strength of shaking calculated as peak ground acceleration and peak ground velocity is expressed as Mercalli intensity, which describes the effects of shaking on people and structures. This map incorporates all that is known about the probabilities of earthquake on all Oregon faults, including the Cascadia Subduction Zone.

The Cascadia subduction zone is responsible for most of the hazard shown in **Figure 2-193**. The paleoseismic record includes 18 magnitude 8.8–9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7 to 12%. An additional 10–20 smaller, magnitude 8.3–8.5, earthquakes affected only the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37–43%.

Figure 2-193. Probabilistic Earthquake Hazard in Region 6



Color zones show the maximum level of earthquake shaking and damage (Mercalli Intensity Scale) expected with a 2% chance of occurrence in the next 50 years. A simplified explanation of the Mercalli levels is:

VI	Felt by all, weak buildings cracked;
VII	Chimneys break, weak buildings damaged, better buildings cracked;
VIII	Partial collapse of weak buildings, unsecured wood frame houses move;
IX	Collapse and severe damage to weak buildings, damage to wood-frame structures; and
X	Poorly built structures destroyed, heavy damage in well-built structures.

Source: Madin and Burns (2013)

Vulnerability

Based on the OEM hazard analysis conducted by county emergency program managers, the region's vulnerability to earthquakes is shown in **Table 2-393**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-393. Local Vulnerability Assessment of Earthquakes in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	L	M	L	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

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 2-394** and **Table 2-395**.

Table 2-394. Building Collapse Potential in Region 6

	Level of Collapse Potential			
County	**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 2-395. 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 and Clark (1999)

Table 2-396. 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 mil	$764,000	$41 mil
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

Source: Wang and Clark (1999)

Table 2-397. 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

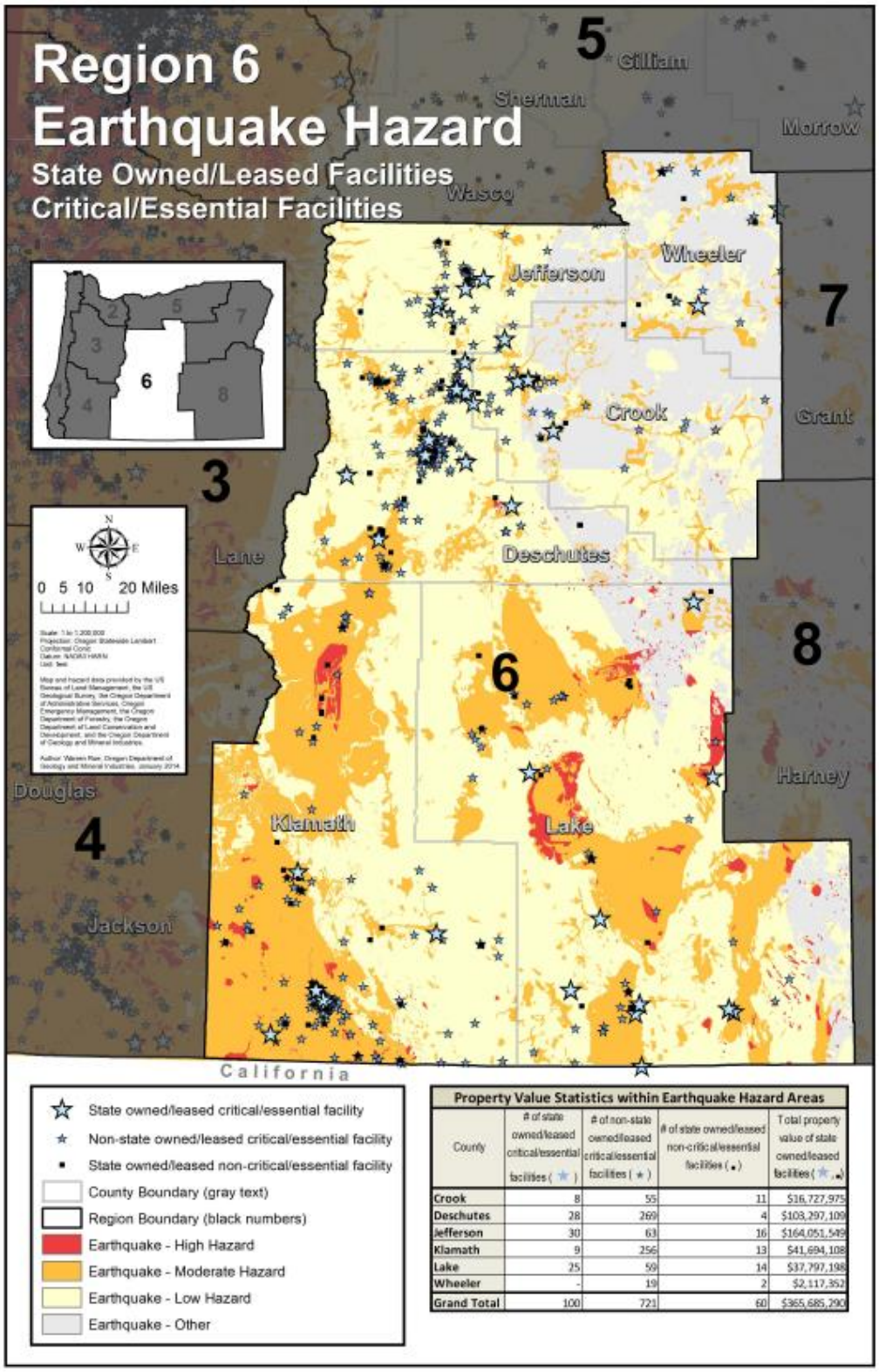
Source: Wang and Clark (1999)

STATE-OWNED/LEASED FACILITIES AND CRITICAL AND ESSENTIAL FACILITIES

The following information is based on a state facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. See the State Risk Assessment, **Oregon Vulnerabilities** section for more information.

Of 5,693 state facilities evaluated, 160 totaling roughly $366 million worth of property are located in an earthquake hazard zone in Region 6 (**Figure 2-194**). Among the 1,141 critical/essential state facilities, 100 are in an earthquake hazard zone in Region 6. Additionally, 721 non-state critical/essential facilities in Region 6 are located in an earthquake hazard zone.

Figure 2-194. State-Owned/Leased Facilities and Critical/Essential Facilities in an Earthquake Zone in Region 6



Property Value Statistics within Earthquake Hazard Areas

County	# of state owned/leased critical/essential facilities (★)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (★ , ▪)
Crook	8	55	11	$16,727,975
Deschutes	28	269	4	$103,297,109
Jefferson	30	63	16	$164,051,549
Klamath	9	256	13	$41,694,108
Lake	25	59	14	$37,797,198
Wheeler	-	19	2	$2,117,362
Grand Total	100	721	60	$365,685,290

Source: DOGAMI

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 2.2.2.6, Seismic Transportation Lifeline Vulnerabilities**, and the full report can be accessed at **Appendix 9.1.13**, *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.

Floods

Characteristics

Central Oregon is subject to a variety of flood conditions, including: (a) spring runoff from melting snow, (b) intense warm rain during the winter months, (c) ice-jam flooding, (d) local flash flooding, (e) lake flooding associated with high winds (e.g., Klamath Lake), and (f) 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.

Historic Flood Events

Table 2-398. 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
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

Source: Taylor and Hatton (1999)

Source: Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org

Source: U.S. Department of Commerce. National Climatic Data Center. Available from http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Table 2-399. 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 and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the probability that Region 6 will experience flooding is shown in **Table 2-400**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-400. Local Probability Assessment of Floods in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	H	H	H	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

The Federal Emergency Management Agency (FEMA) has mapped the 10, 50, 100, and 500-year floodplains corresponding to a 10%, 2%, 1%, and 0.2% chance of a certain magnitude flood in any given year in Region 6 counties. In addition, FEMA has mapped the 100-year floodplain (i.e., 1% flood) in the incorporated cities. The 100-year flood is the benchmark upon which the National Flood Insurance Program (NFIP) is based.

All of the Region 6 counties have Flood Insurance Rate Maps (FIRM); 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.

Significant flooding occurs at least once every 5–7 years.

Vulnerability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers the region's vulnerability to flooding is shown in **Table 2-401**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-401. Local Vulnerability Assessment of Floods in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	H	L	M	M	M	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

The Oregon Department of Land Conservation and Development (DLCD) created a countywide flood vulnerability index by compiling data from NOAA's Storm Events Database and from FEMA's National Flood Insurance Program. Data were calculated statewide for the period 1978 through 2013 for five input datasets: number of events, structure and crop damage estimates in dollars and NFIP claims number and dollar amounts. The mean and standard deviation were calculated for each input. Then, each county was assigned a score ranging from 0 to 3 for each of these inputs according to **Table 2-402**.

Table 2-402. Scoring for Vulnerability Index

Score	Description
3	county data point is greater than 2.5 times standard deviation for the input data set
2	county data point is greater than 1.5 times standard deviation for the input data set
1	county data point is within standard deviation
0	no data reported

Source: DLCD

DLCD summed the scores for each of the five inputs to create a county-by-county vulnerability index. The maximum possible score is 15. A score over 6 indicates that at least one variable significantly exceeds average values.

Each county in this region received a flood vulnerability score of 5, except for Klamath County which received a score of 6.

FEMA has identified no Repetitive Loss properties in Region 6 (FEMA NFIP BureauNet, http://bsa.nfipstat.fema.gov/, accessed 12/1/2014).

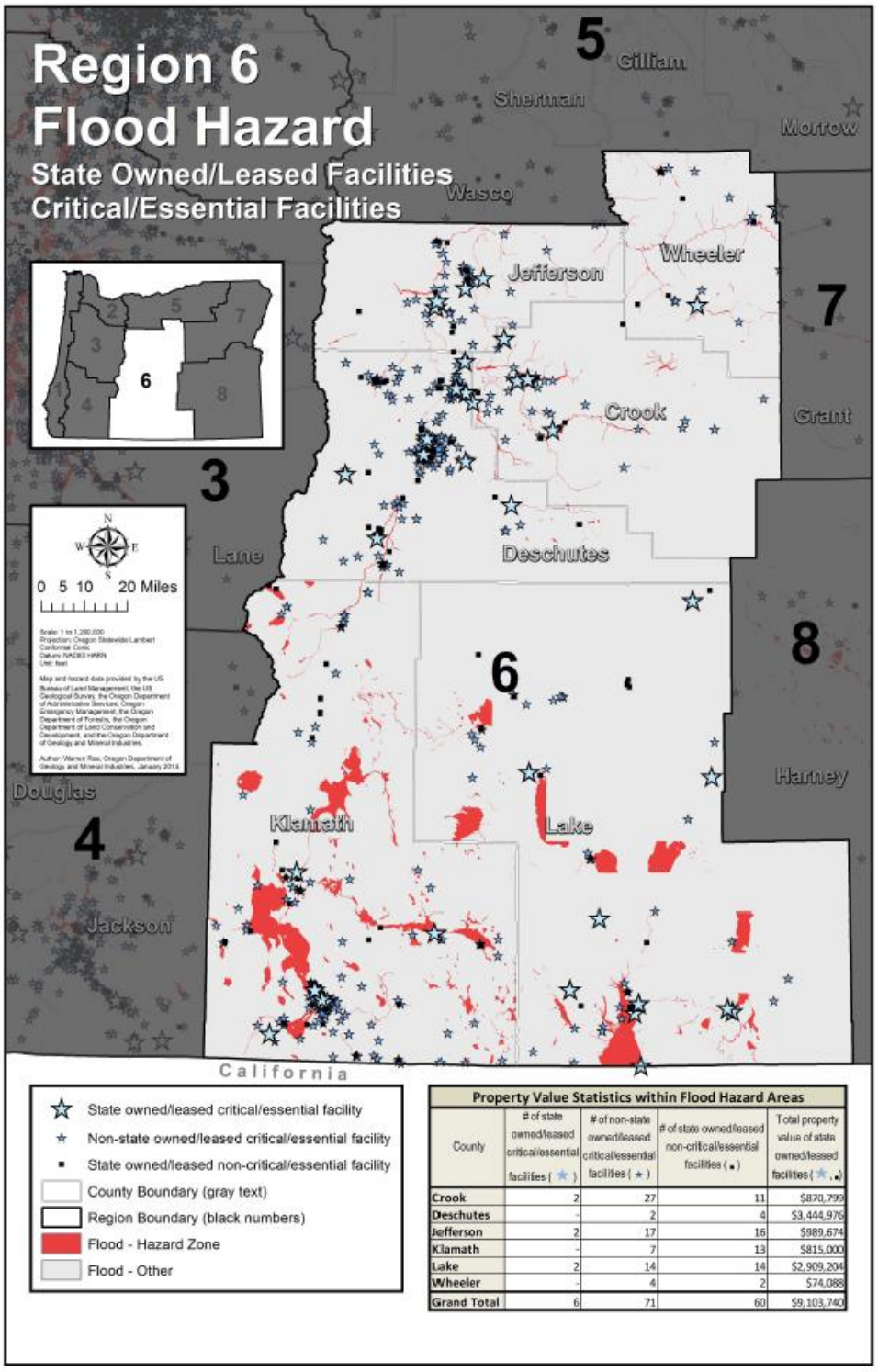
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS) Program, which results in reduced flood insurance costs. No Region 6 communities participate in the CRS Program.

STATE-OWNED/LEASED FACILITIES AND CRITICAL AND ESSENTIAL FACILITIES

The following information is based on a state facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. See the State Risk Assessment, **Oregon Vulnerabilities** section for more information.

Of the 5,693 state facilities evaluated, 66 are currently located within a flood hazard zone in Region 6 and have an estimated total value over $9 million (**Figure 2-195**). Of these, six are identified as a critical or essential facility. An additional 60 non-state-owned/leased critical/essential facilities are located in a flood hazard zone in Region 6.

Figure 2-195. State-Owned/Leased Facilities and Critical/Essential Facilities in a Flood Hazard Zone in Region 6



Property Value Statistics within Flood Hazard Areas

County	# of state owned/leased critical/essential facilities (★)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (★ , ▪)
Crook	2	27	11	$870,799
Deschutes	-	2	4	$3,444,976
Jefferson	2	17	16	$989,674
Klamath	-	7	13	$815,000
Lake	2	14	14	$2,909,204
Wheeler	-	4	2	$74,088
Grand Total	6	71	60	$9,103,740

Source: DOGAMI

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 2-403. Significant Landslides in Region 6

Date	Location	Description
Dec. 2005	Jefferson County	damage: $11,666.67 * (includes Sherman and Wasco Counties)

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

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the probability that Region 6 will experience landslides is shown in **Table 2-404**. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (—). See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-404. Local Probability Assessment of Landslides in Region 5

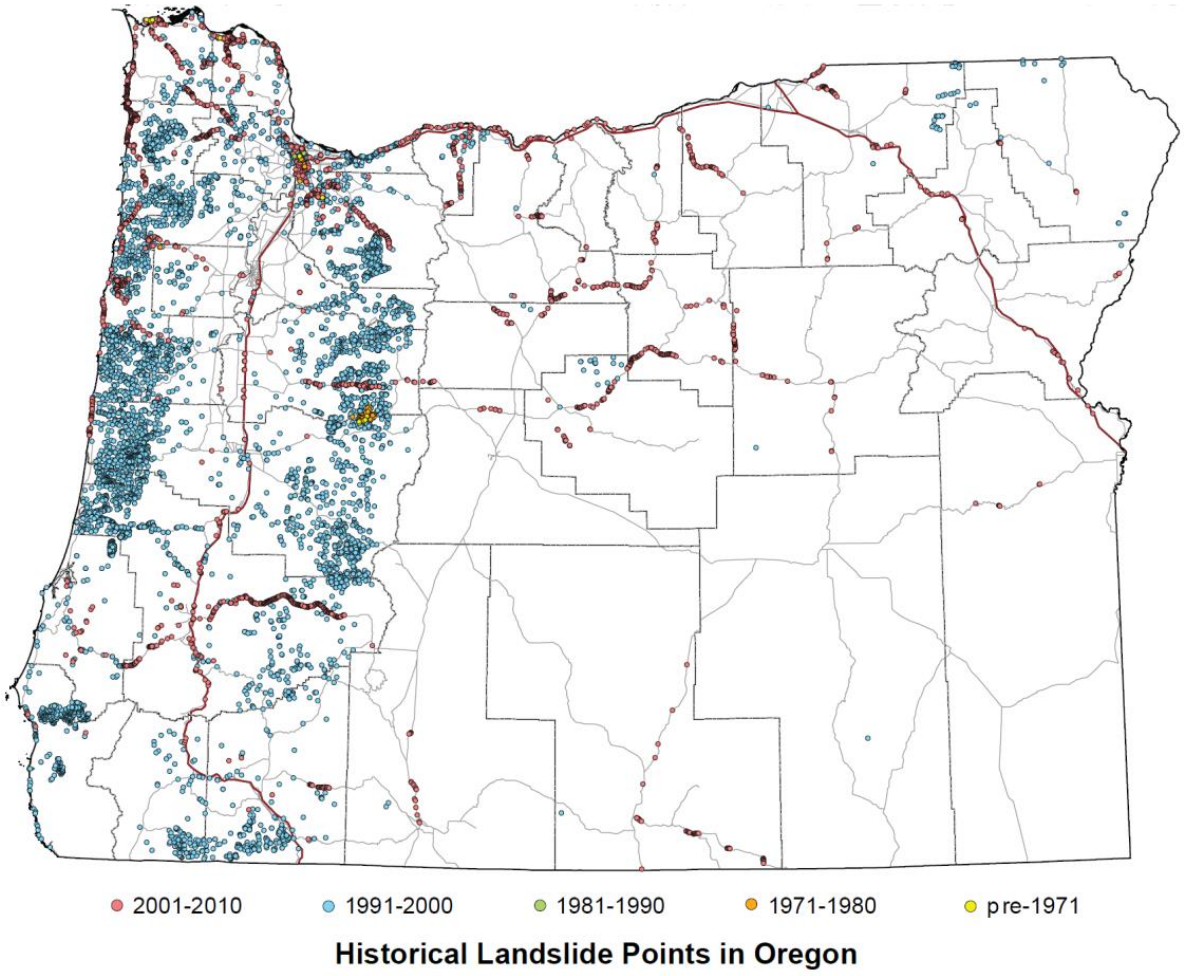
	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	M	—	M	—	M	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

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.

Figure 2-196. Historic Landslides in Oregon



Source: Burns et al. (2011a)

Vulnerability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the region's vulnerability to landslides is depicted **Table 2-405**. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (—). See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-405. Local Vulnerability Assessment of Landslides in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	L	—	L	—	L	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

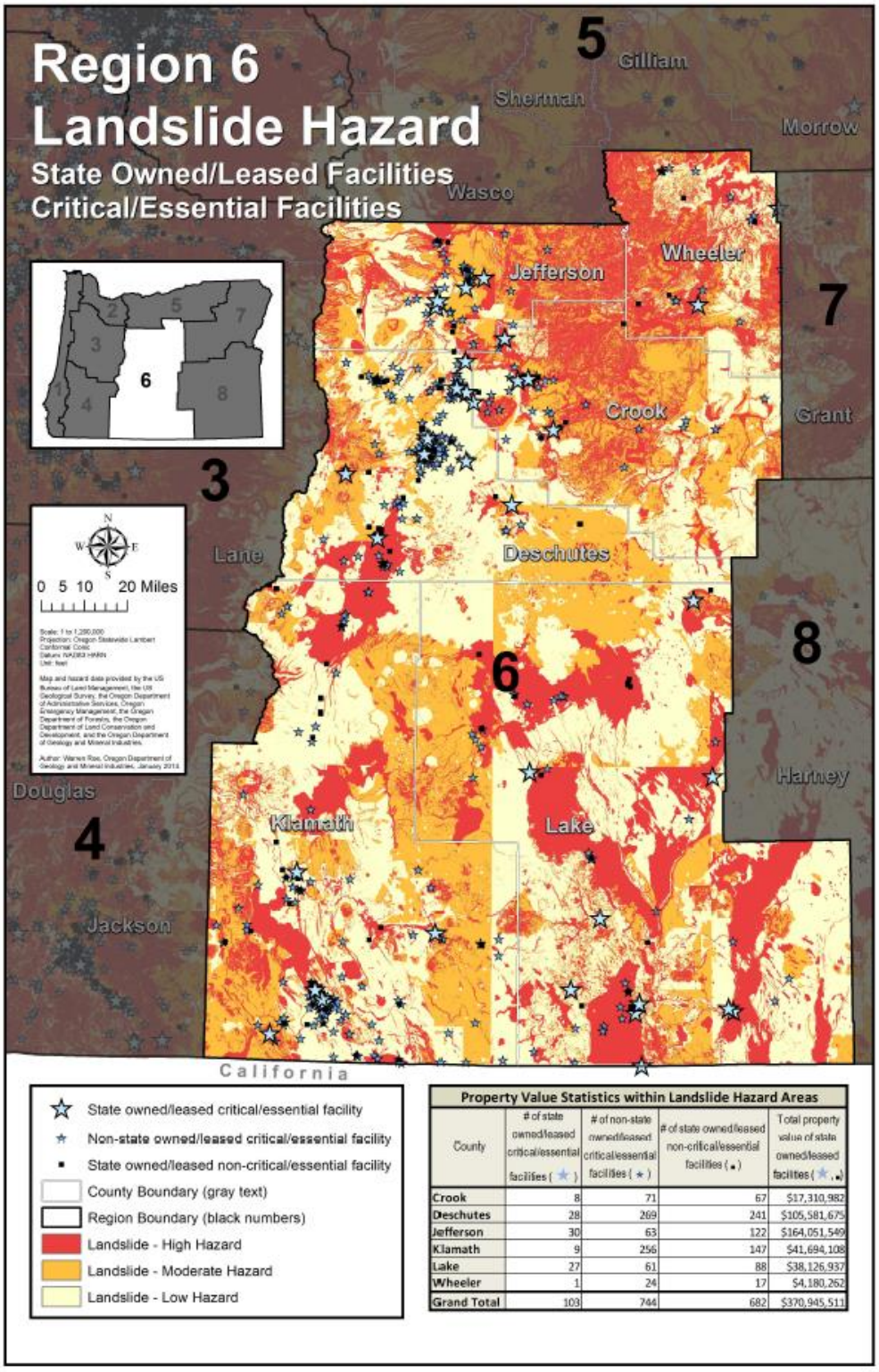
Many of the historic landslides occur along the highways in this region and the areas along the Cascade Mountains (Burns et al., 2012).

STATE-OWNED/LEASED FACILITIES AND CRITICAL AND ESSENTIAL FACILITIES

The following information is based on a state facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. See the State Risk Assessment, **Oregon Vulnerabilities** for more information.

Of the 5,693 state facilities evaluated, 785 are located within landslide hazard areas in Region 6, totaling roughly $371 million (**Figure 2-197**). This includes 103 critical or essential facilities. An additional 744 critical/essential facilities not owned/leased by the State are located within a landslide hazard zone in Region 6.

Figure 2-197. State-Owned/Leased Facilities and Critical/Essential Facilities in a Landslide Hazard Zone in Region 6



Property Value Statistics within Landslide Hazard Areas

County	# of state owned/leased critical/essential facilities (★)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (★, ▪)
Crook	8	71	67	$17,310,982
Deschutes	28	269	241	$105,581,675
Jefferson	30	63	122	$164,051,549
Klamath	9	256	147	$41,694,108
Lake	27	61	88	$38,126,937
Wheeler	1	24	17	$4,180,262
Grand Total	103	744	682	$370,945,511

Source: DOGAMI

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 2-406. 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 and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the probability that Region 6 will experience volcanic hazards is shown in **Table 2-407**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-407. Local Probability Assessment of Volcanic Activity in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	L	L	L	L	L	L

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

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 et al., 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 2-408** describes the probability of volcano-related hazards in Region 6.

Table 2-408. 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

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the region's vulnerability to volcanic hazards is shown in **Table 2-409**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-409. Local Vulnerability Assessment of Volcanic Activity in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	H	H	H	L	H	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

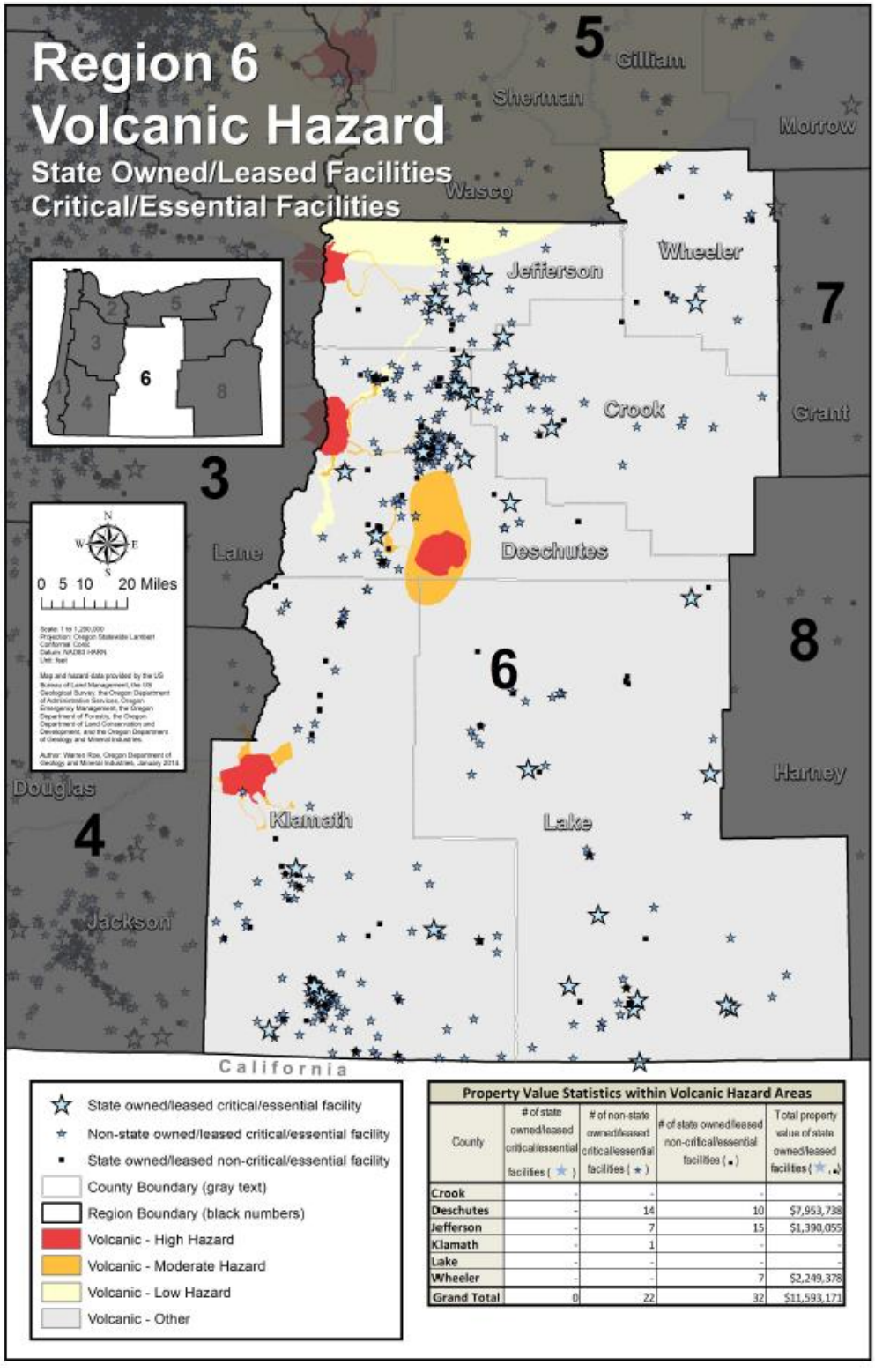
The U.S. Geological Survey has addressed volcanic hazards at Mount Jefferson (Walder et al., 1999), the Three Sisters (Scott et al., 2001), Newberry Volcano (Sherrod et al., 1997), and Crater Lake (Bacon et al., 1997). These reports include maps depicting the areas at greatest risk. Communities which 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.

STATE-OWNED/LEASED FACILITIES AND CRITICAL AND ESSENTIAL FACILITIES

The following information is based on a state facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. See the State Risk Assessment, **Oregon Vulnerabilities** for more information.

Of the 5,693 state facilities evaluated, 32 are within a volcanic hazard zone in Region 6 and total about $11.6 million in property value (**Figure 2-198**). None of these state facilities are critical or essential facilities. 22 non-state critical/essential facilities are located in volcanic hazard zones in Region 6.

Figure 2-198. State-Owned/Leased Facilities and Critical/Essential Facilities in a Volcanic Hazard Zone in Region 6



Property Value Statistics within Volcanic Hazard Areas

County	# of state owned/leased critical/essential facilities (★)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (★, ▪)
Crook	-	-	-	-
Deschutes	-	14	10	$7,953,738
Jefferson	-	7	15	$1,390,055
Klamath	-	1	-	-
Lake	-	-	-	-
Wheeler	-	-	7	$2,249,378
Grand Total	0	22	32	$11,593,171

Source: DOGAMI

Wildfires

Characteristics

Oregon Senate Bill 360 Forestland-Urban Interface Protection Act has been implemented in all counties in Region 6. The growth of the wildland-urban interface occurs 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 2-410. 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	

Source: Oregon Department of Forestry, 2013

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the probability that Region 6 will experience wildfire is shown in **Table 2-411**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-411. Local Probability Assessment of Wildfire in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Probability	H	H	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

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 a 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.

Vulnerability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the region's vulnerability to wildfire is shown in **Table 2-412**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-412. Local Vulnerability Assessment of Wildfire in Region 6

	Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Vulnerability	M	M	M	L	M	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

Based on data from the 2013 West Wide Wildfire Risk Assessment, in Region 6, Deschutes, Jefferson and Klamath Counties have high percentages of wildland acres subject to Fire Risk, Wildland Development Areas, Fire Effects, or Fire Threat, making them especially vulnerable.

In addition, each year a significant number of people build homes within or on the edge of the forest (urban-wildland interface area), thereby increasing vulnerability. These communities have been designated "Wildland-Urban Interface Communities" and are shown in **Table 2-413**.

The checkerboard pattern of land ownership 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 2-413. Wildland-Urban Interface Communities by County in Region 6

Crook	Deschutes	Jefferson	Klamath	Lake	Wheeler
Jasper Point Resort	Bend	Ashwood	Beaty	Adel	Fossil
Paulina	Black Butte	Camp Sherman	Beaver Marsh	Christmas Valley	Mitchell
Post	Brothers	Crooked River Ranch	Bly	Drew's Gap	Richmond
Prineville	Elk Lake	Culver	Bly Mountain	Lakeview Basin	Spray
	Hampton	Gateway	Bonanza	New Pine Creek	Twickenham
	La Pine	Madras	Chemult	Paisley	Winlock
	Redmond	Metolius	Chiloquin	Plush	
	Sisters-Cloverdale	Warm Springs	Crater Lake	Silver Lake	
	Sunriver		Crescent	South Drews	
	Terrebonne		Crescent Lake	Summer Lake	
	Tumalo		Dairy	Valley Falls / Chandler	
			Diamond Lake Junction		
			Gilchrist		
			Harriman		
			Keno		
			Klamath Falls		
			Little River		
			Malin		
			Merrill		
			Odell Lake		
			Rocky Point		
			Rosedale		
			Running Y		
			Sand Creek		
			Klamath		
			Sprague River Valley		
			Sycan Estates		

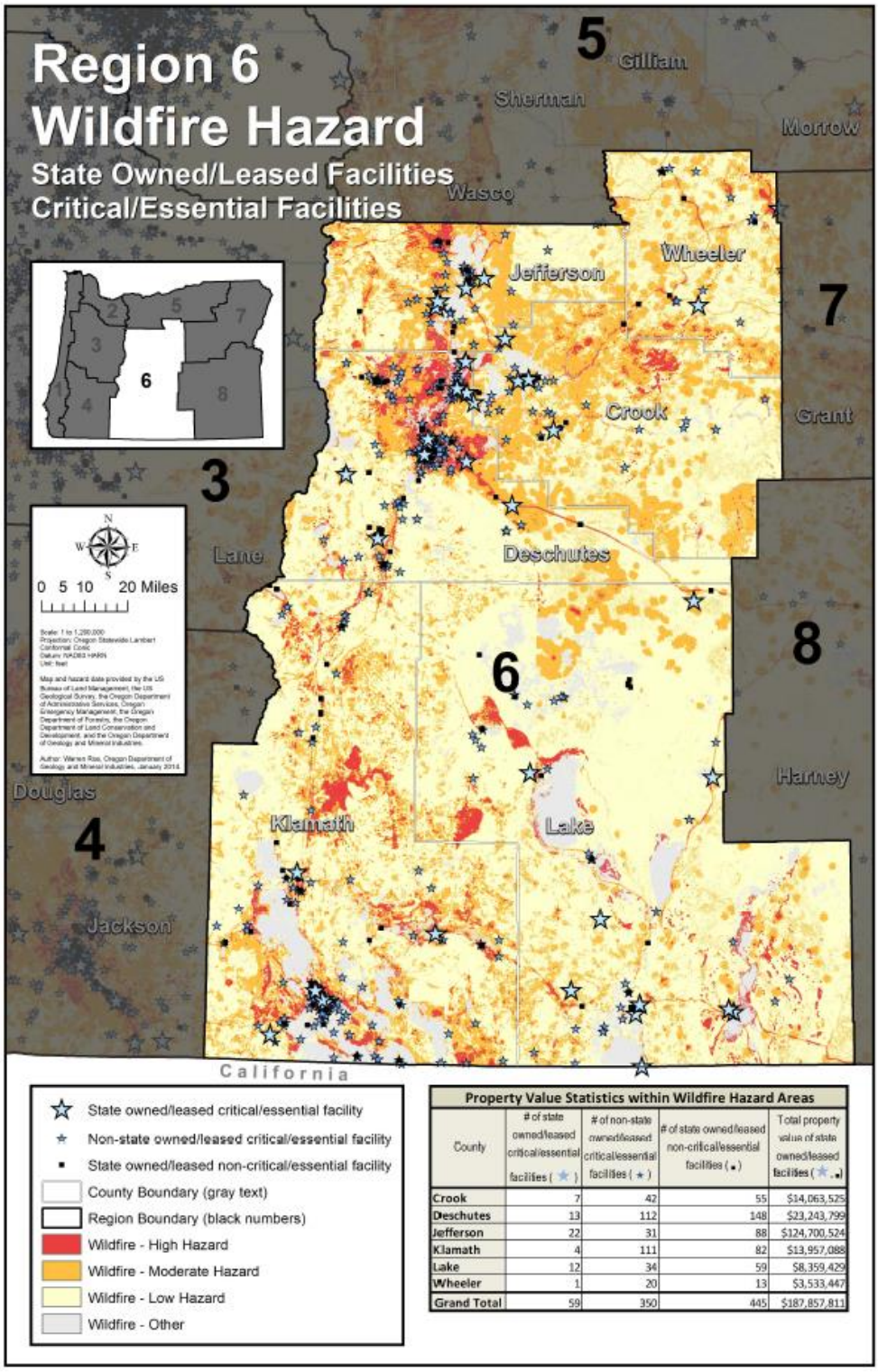
Source: Oregon Dept. of Forestry Statewide Forest Assessment September, 2006

STATE-OWNED/LEASED FACILITIES AND CRITICAL AND ESSENTIAL FACILITIES

The following information is based on a state facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. See the State Risk Assessment, **Oregon Vulnerabilities** for more information.

Of the 5,693 state facilities evaluated, 504 are within a wildfire hazard zone in Region 6 and total roughly $188 million in value (**Figure 2-199**). Among those, 59 are state critical/essential facilities. An additional 350 non-state critical/essential facilities are also located in Region 6.

Figure 2-199. State-Owned/Leased Facilities and Critical/Essential Facilities in a Wildfire Hazard Zone in Region 6



Property Value Statistics within Wildfire Hazard Areas

County	# of state owned/leased critical/essential facilities (★)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (★, ▪)
Crook	7	42	55	$14,063,525
Deschutes	13	112	148	$23,243,799
Jefferson	22	31	88	$124,700,524
Klamath	4	111	82	$13,957,088
Lake	12	34	59	$8,359,429
Wheeler	1	20	13	$3,533,447
Grand Total	59	350	445	$187,857,811

Source: DOGAMI

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 2-414. 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

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

Table 2-415. 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

Source: Taylor and Hatton (1999)

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the probability that Region 6 will experience windstorms is shown in **Table 2-416**. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (—). See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-416. Local Probability Assessment of Windstorms 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

State Assessment

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.

Vulnerability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the region's vulnerability to windstorm is shown in **Table 2-417**. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (—). See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-417. Local Vulnerability Assessment of 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

State Assessment

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.

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 2-418. 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

Source: Taylor and Hatton (1999); and unknown sources.

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. 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. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the probability that Region 6 will experience winter storms is shown in **Table 2-419**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-419. Local Probability Assessment of Winter Storms 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

State Assessment

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.

Vulnerability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers, the region's vulnerability to winter storms is shown in **Table 2-420**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-420. Local Vulnerability Assessment of 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

State Assessment

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.