# Chapter 2 RISK ASSESSMENT

## *In This Chapter*

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

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

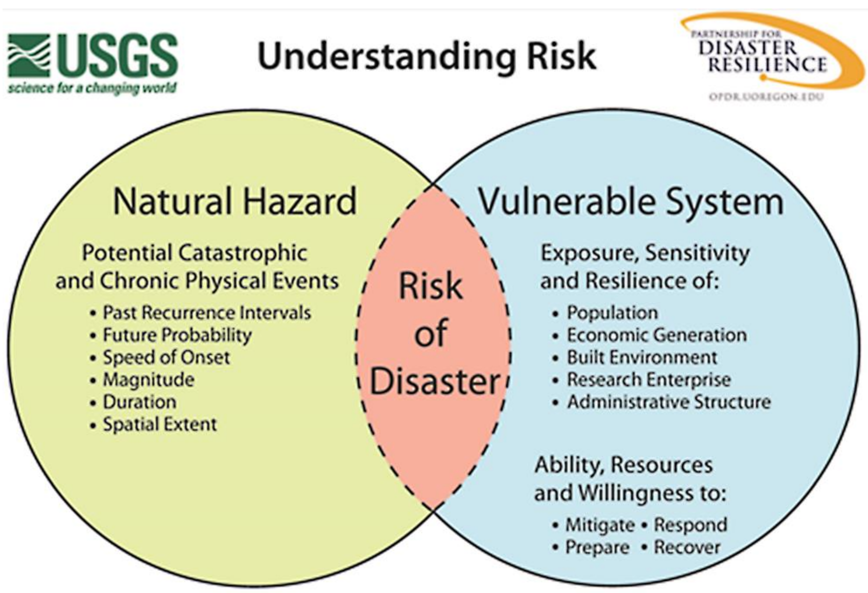
# 2.1 Introduction

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

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

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

**Figure 2-1. Understanding Risk**




Source: Wood (2007)

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

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

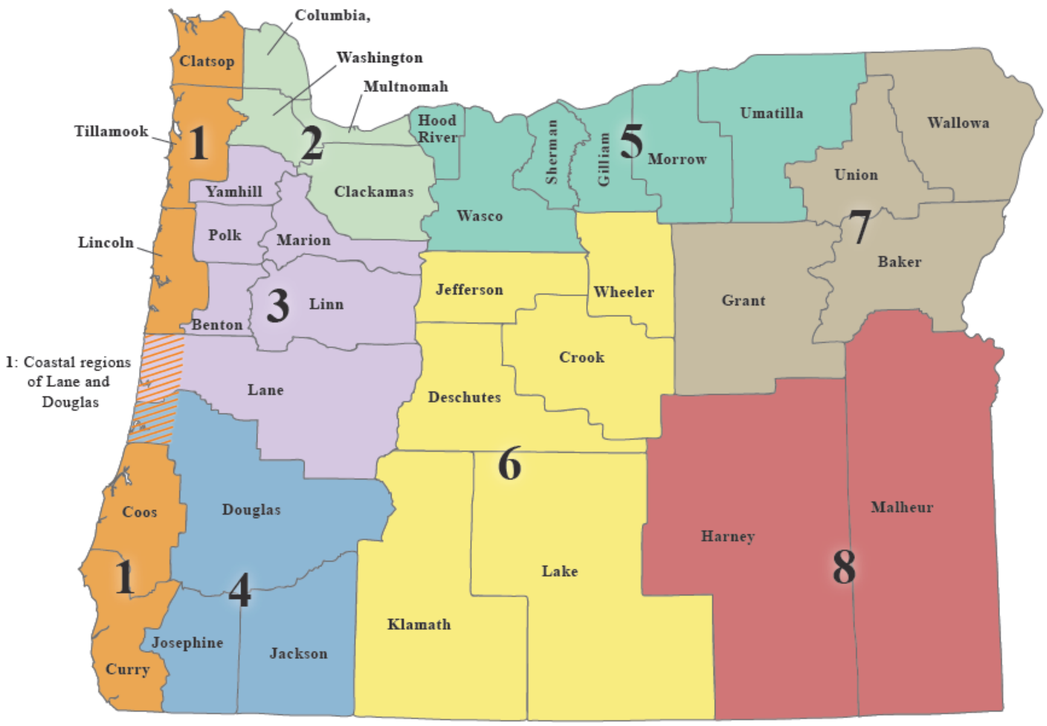
A vulnerability assessment combines information from the hazard characterization with an inventory of the existing (or planned) property and population exposed to a hazard and attempts to predict how different types of property and population groups will be affected by each hazard. Vulnerability is determined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

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

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

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

**Figure 2-2. Oregon NHMP Natural Hazards Regions**



### 2.1.1 Overview

## Hazard Characterization and Analysis

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

### Oregon Hazards

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

**Table 2-1. Oregon Hazard Overview**

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

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

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

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

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

**Table 2-2. Oregon NHMP Hazard Lead Agencies**

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

## Disaster Declarations

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

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

## Table 2-3. Presidential Major Disaster Declarations Since 1955

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

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

*IR = Indian Reservation

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

Source: Oregon Office of Emergency Management (2013)

# Vulnerability Assessments

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

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

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

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

## State Vulnerability Assessment

The exposure analysis and estimate of potential losses to state-owned/leased facilities and critical/essential facilities and local critical facilities located within hazard zones performed by the Department of Geology and Mineral Industries (DOGAMI) for the 2015 Oregon NHMP was updated by DOGAMI in 2019. Loss data are not available in local plans. Therefore, this Plan only includes the most recent estimates provided by DOGAMI.

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

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

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

## Local Vulnerability Assessments

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

The Oregon Military Department's Office of Emergency Management (OEM) periodically collects hazard vulnerability information from each of the 36 counties in the state. The information is generated at the local government level to meet OEM required activities under the State's Emergency Management Grant Program (EMPG) and in many cases to inform Local NHMPs.

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

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

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

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

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

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

Among other things, the hazard analysis can:

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

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

For the purposes of the Oregon NHMP, the State Vulnerability Assessment focuses only on county vulnerability rankings (H, M, L) taken from LNHMP Hazard Analysis scores. These rankings provide the state an understanding of local hazard concerns and priorities. **Table 2-41** presents the local vulnerability rankings for each of Oregon’s 11 hazards by county. Data to update this table was not readily available. In the **Regional Risk Assessments**, county probability and vulnerability rankings are in most cases replaced by the 2020 Risk Assessment rankings. Only where no other data was available or a hazard lead chose to include them were the county rankings identified.

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

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

- **Table 2-4. Local Vulnerability Rankings by County**

| County | Coastal Erosion | Tsunami | Drought | Earthquake | Volcanic | Landslide | Wildfire | Flood | Wind Storm | Winter Storm |
|---|---|---|---|---|---|---|---|---|---|---|
| Baker | | | H | M | L | M | H | M | H | H |
| Benton | | | L | H | L | L | M | M | M | M |
| Clackamas | | | L | H | H | L | M | M | L | M |
| Clatsop | H | H | M | H | M | H | H | H | H | H |
| Columbia | | | L | M | M | M | M | H | H | H |
| Coos | M | H | M | H | M | M | M | H | H | H |
| Crook | | | H | L | H | L | M | H | M | M |
| Curry | | H | | H | H | L | H | H | H | |
| Deschutes | | | L | M | H | | M | L | L | H |
| Douglas - central | | | | M | | M | H | H | M | H |
| Douglas - coastal | L | H | | H | | M | M | M | M | M |
| Gilliam | | | H | M | M | M | M | M | L | H |
| Grant | | | H | M | H | M | H | H | H | H |
| Harney | | | M | L | L | L | H | M | L | M |
| Hood River | | | H | M | L | M | M | M | H | H |
| Jackson | | | M | H | L | L | M | M | H | H |
| Jefferson | | | H | L | H | L | H | M | | H |
| Josephine | | | | H | | | M | M | H | H |
| Klamath | | | M | M | L | | L | M | | M |
| Lake | | | H | H | H | L | M | M | M | H |
| Lane - central | | | M | M | M | L | M | H | M | H |
| Lane - coastal | | H | | H | | M | L | H | H | L |
| Lincoln | | M | L | M | L | | M | L | H | |
| Linn | | | | H | H | | M | H | M | H |
| Malheur | | | H | M | M | M | H | H | M | M |
| Marion | | | | H | M | | M | M | H | H |
| Morrow | | | | H | | M | M | H | M | H |
| Multnomah | | | | H | H | M | M | H | H | H |
| Polk | | | | H | M | | M | H | H | |
| Sherman | | | M | L | L | M | M | M | M | M |
| Tillamook | | H | L | H | M | H | H | H | H | H |
| Umatilla | | | H | M | | | H | M | H | H |
| Union | | | M | H | L | L | H | H | H | H |
| Wallowa | | | H | L | L | L | H | M | M | M |
| Wasco | | | H | M | L | M | M | L | H | H |
| Washington | | | M | H | H | L | M | H | H | H |
| Wheeler | | | H | H | M | H | H | H | M | H |
| Yamhill | | | M | H | | M | L | H | M | H |

Source: OEM, November 2013

## 2.1.2 2020 Risk Assessment Methodology

### 2.1.2.1 Previous Risk Assessments

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

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

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

### 2.1.2.2 2020 Risk Assessment Procedure

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

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

*Probability*

- Probability of a hazard event

*Vulnerability*

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

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

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

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

**Table 2-5. Risk Score Classification: Natural Breaks and Risk Scores**

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

### 2.1.2.3 Risk Assessment Progress and Limitations

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

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

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

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

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

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

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

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

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

#### 2.1.2.4 2020 Risk Assessment Components

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

**Table 2-6. Coastal Hazards, 2020 Risk Assessment**

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

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

Source: DLCD, 2020

**Figure 2-3. Coastal Hazards Risk by Region**

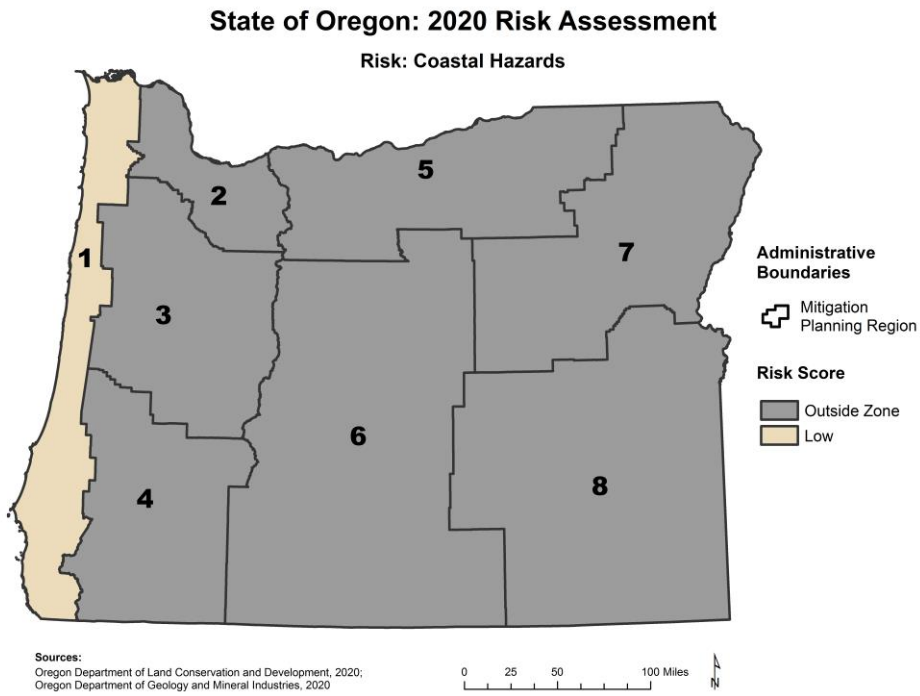



**Figure 2-4. Coastal Hazards Risk by County**

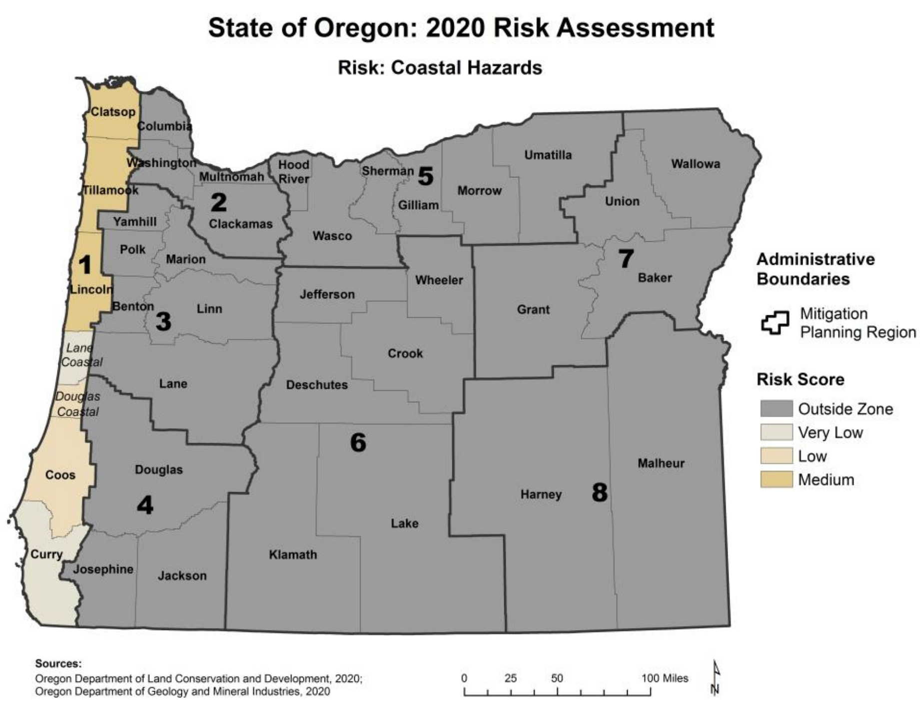


**Table 2-7. Earthquake Hazard, 2020 Risk Assessment**

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

Source: DLCD, 2020

*(Table continued on next page)*

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

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

Source: DLCD, 2020

**Figure 2-5. Earthquake Hazard Risk by Region**

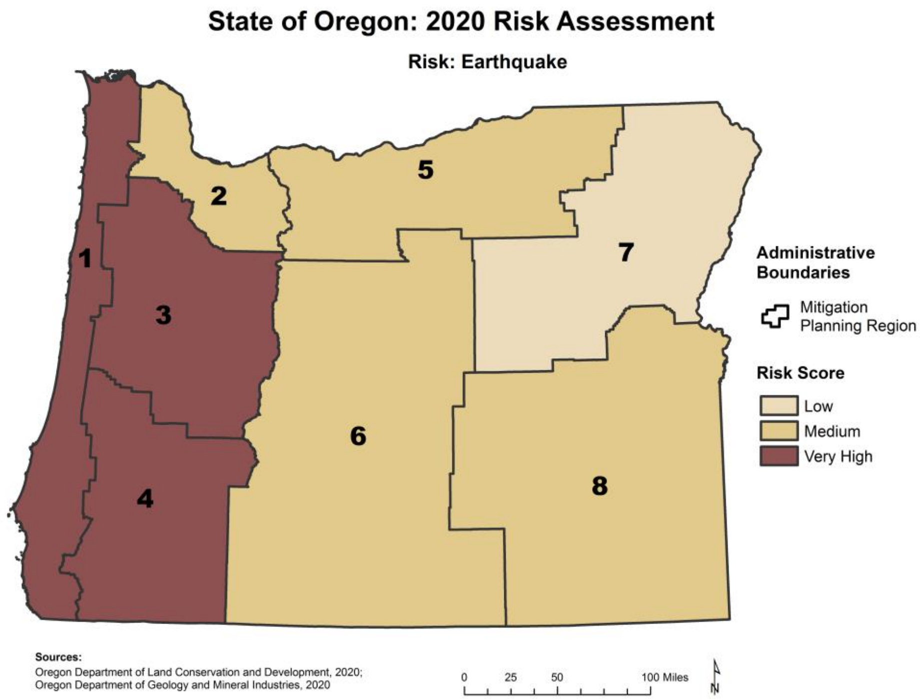



**Figure 2-6. Earthquake Hazard Risk by County**

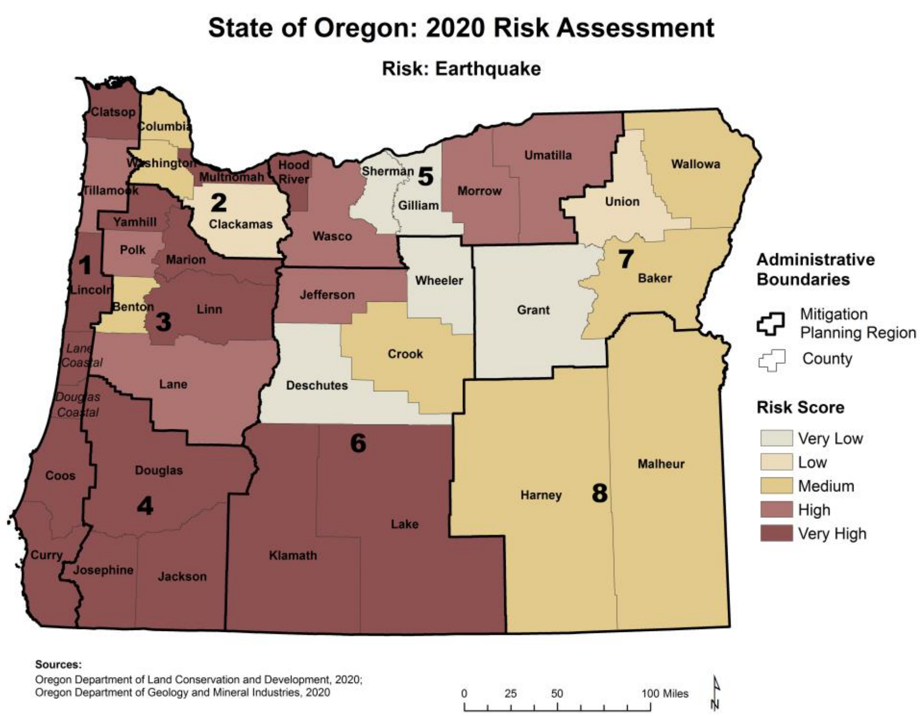


**Table 2-8. Flood Hazard, 2020 Risk Assessment**

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

Source: DLCD, 2020

*(Table continued on next page)*

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

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

Source: DLCD, 2020

**Figure 2-7. Flood Hazard Risk by Region**

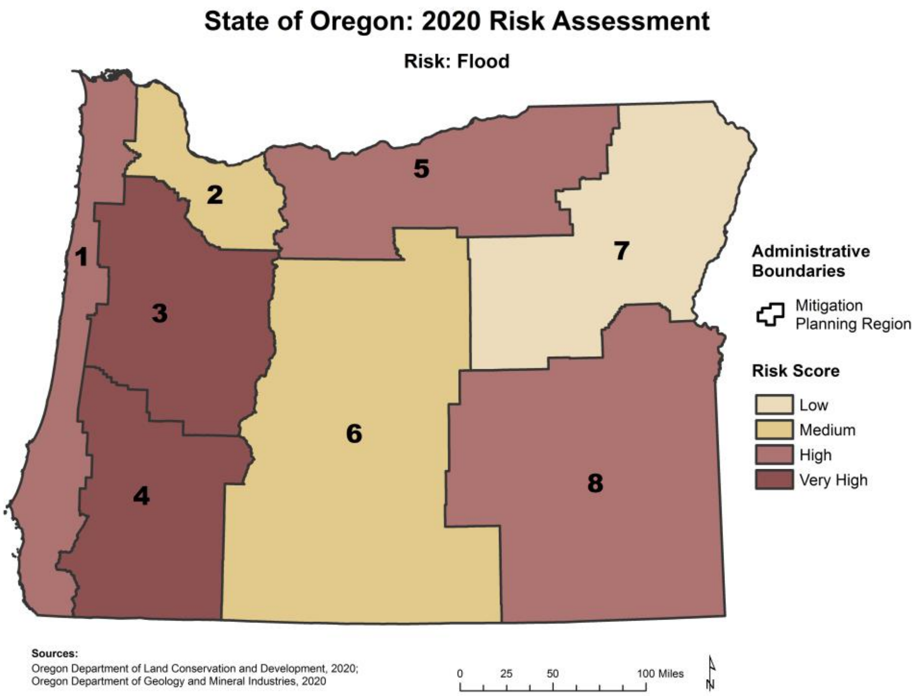



**Figure 2-8. Flood Hazards Risk by County**

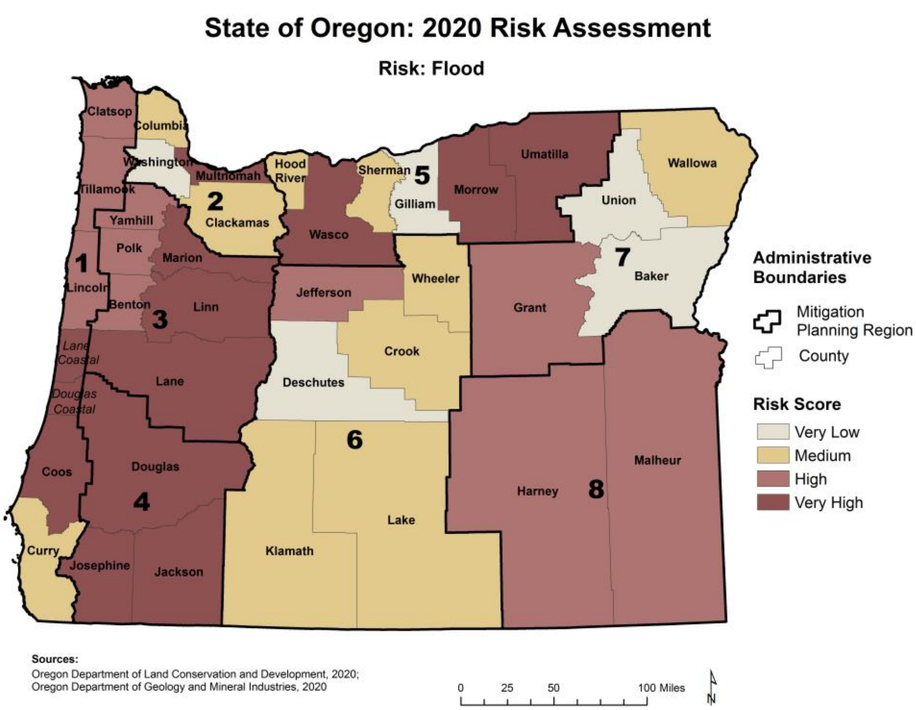


**Table 2-9. Landslide Hazard, 2020 Risk Assessment**

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

Source: DLCD, 2020

*(Table continued on next page)*

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

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

Source: DLCD, 2020

**Figure 2-9. Landslide Hazard Risk by Region**

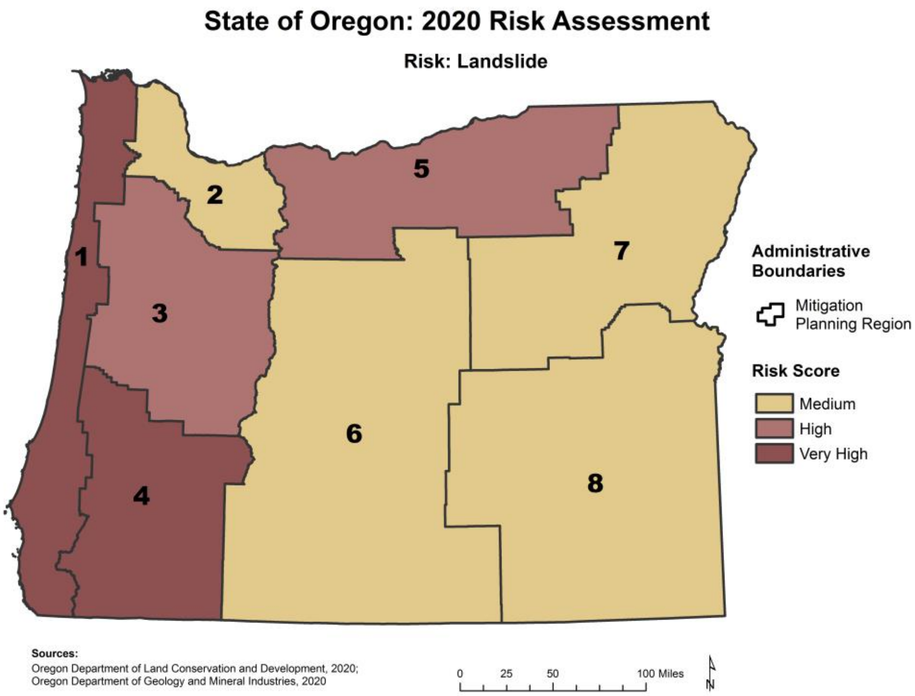



**Figure 2-10. Landslide Hazards Risk by County**

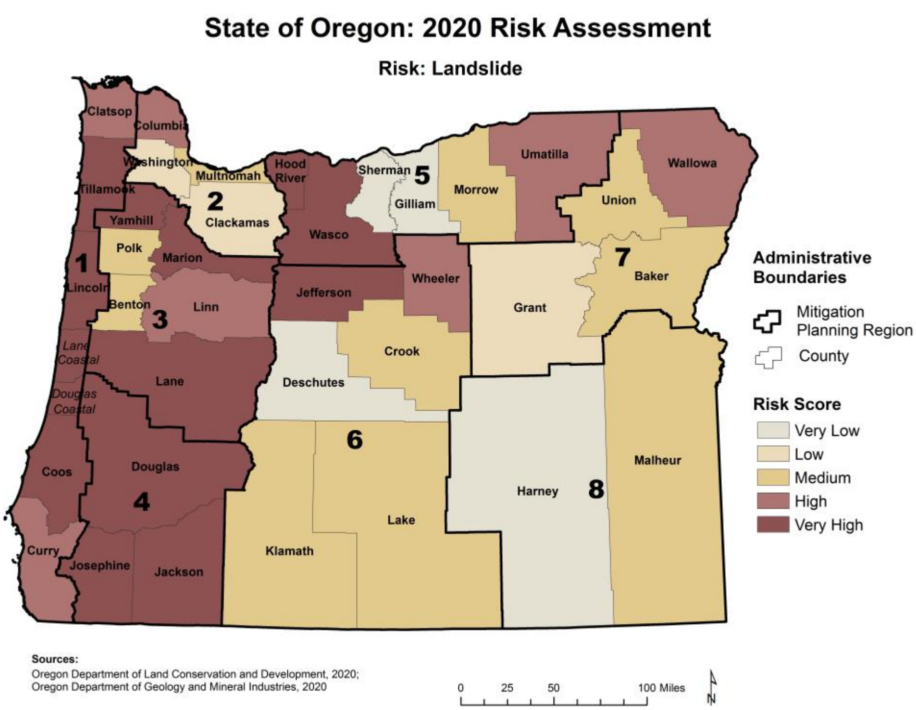


**Table 2-10. Tsunami Hazard, 2020 Risk Assessment**

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

Source: DLCD, 2020

**Figure 2-11. Tsunami Hazard Risk by Region**

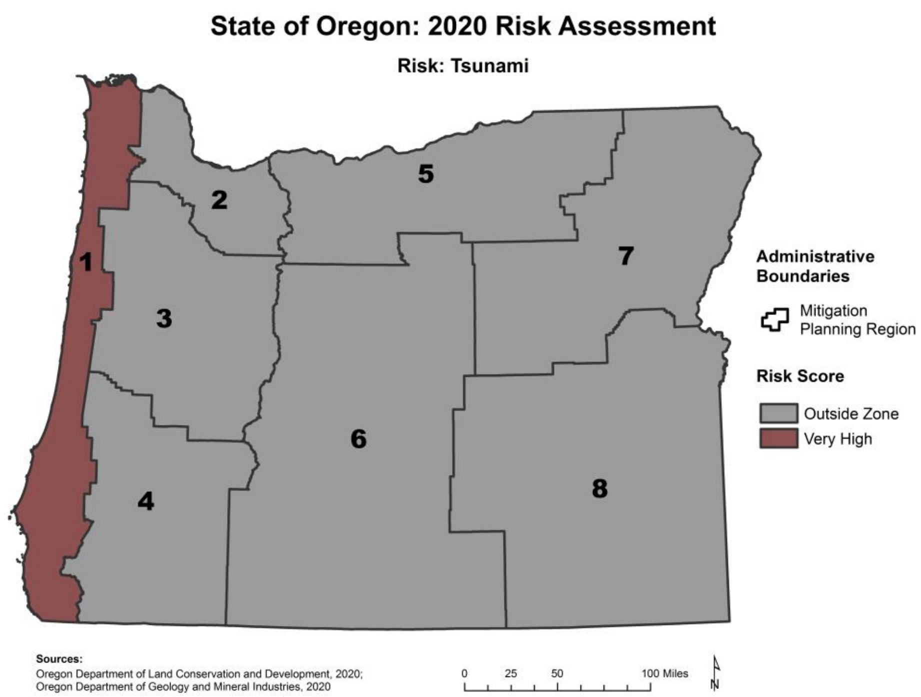



**Figure 2-12. Tsunami Hazards Risk by County**

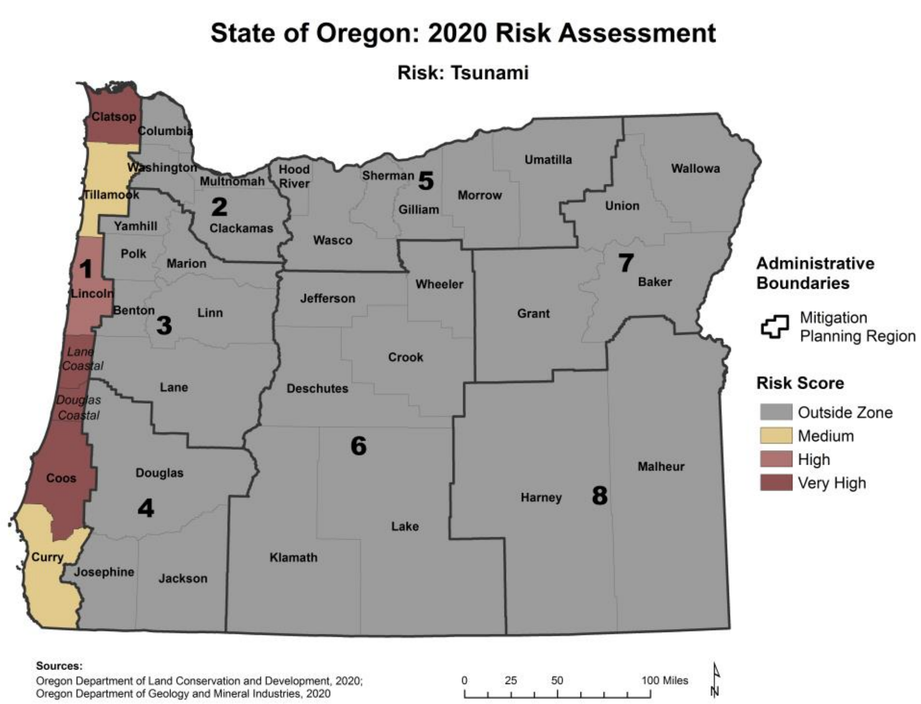


**Table 2-11. Volcanic Hazard, 2020 Risk Assessment**

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

Source: DLCD, 2020

*(Table continued on next page)*

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

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

Source: DLCD, 2020

**Figure 2-13. Volcanic Hazard Risk by Region**

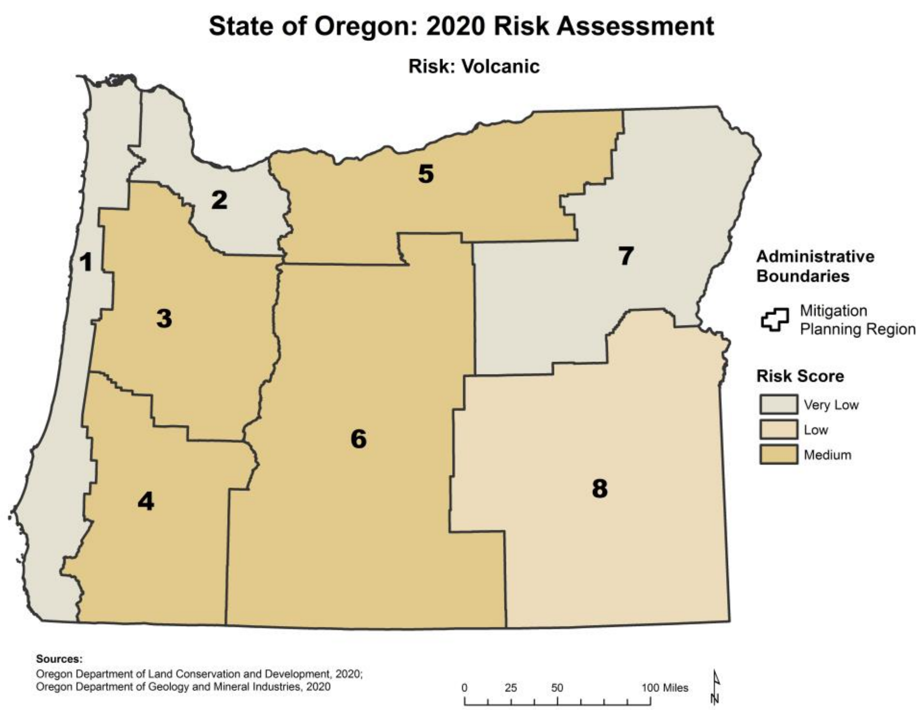



**Figure 2-14. Volcanic Hazard Risk by County**

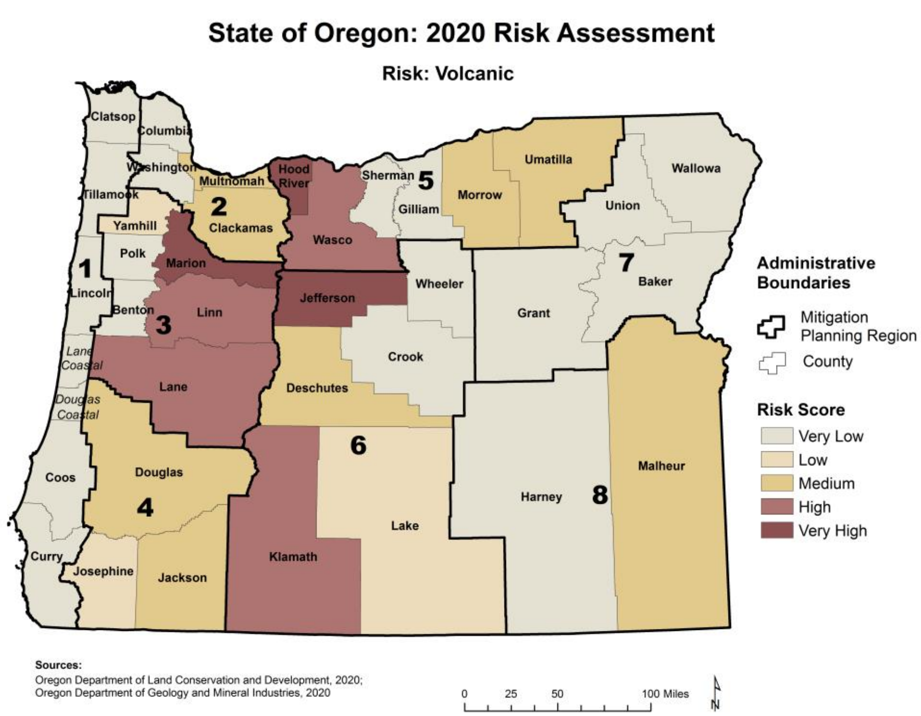


**Table 2-12. Wildfire Hazard, 2020 Risk Assessment**

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

Source: DLCD, 2020

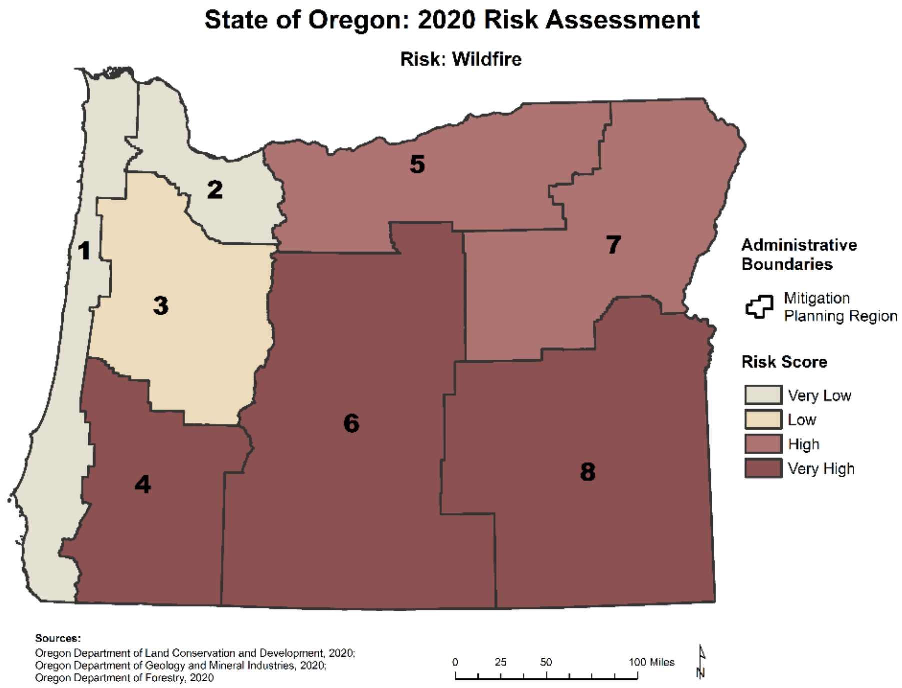
*(Table continued on next page)*

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

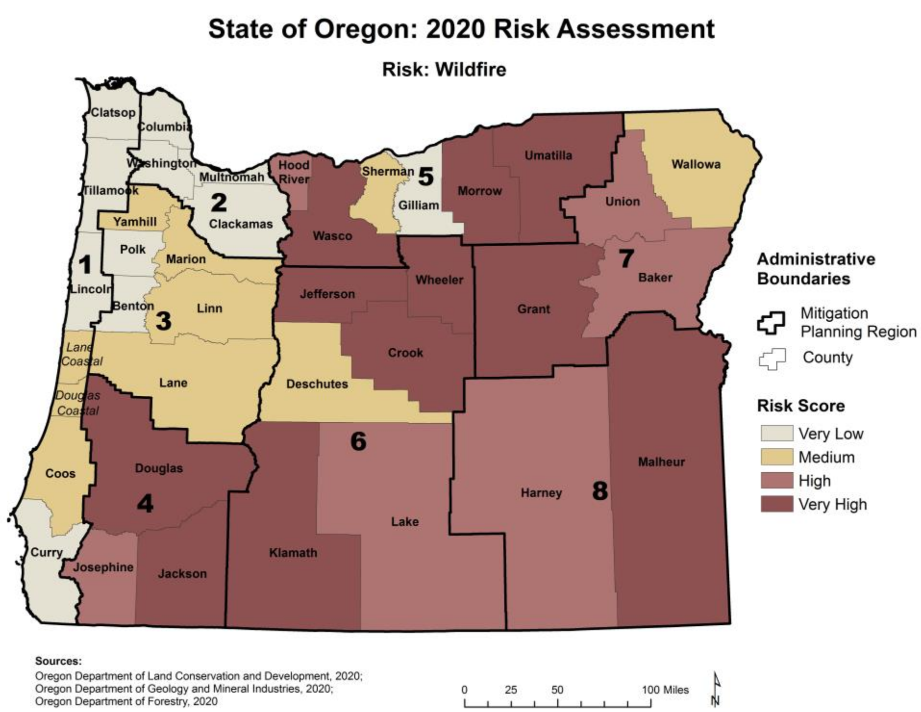
| Wildfire Risk Components | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Probability* | Physical Vulnerability | | | | Social Vulnerability | Vulnerability (Social + Physical) | | Risk (Prob. + Physical + Social) | |
| Region | County | | State Buildings | State Critical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

Source: DLCD, 2020

### Figure 2-15. Wildfire Hazard Risk by Region




### Figure 2-16. Wildfire Hazard Risk by County



### 2.1.2.5 2020 Risk Assessment Findings

While the component tables offer a detailed look at what is driving risk to individual hazards, **Table 2-13**, **Seven Hazards Combined, 2020 Risk Assessment** shows which counties are most at risk when all seven hazards are considered together.

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

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

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

**Table 2-13. Seven Hazards Combined, 2020 Risk Assessment**

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

Source: DLCD, 2020

*(Table continued on next page)*

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

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

**Figure 2-17. Seven Hazards Combined Risk by Region**

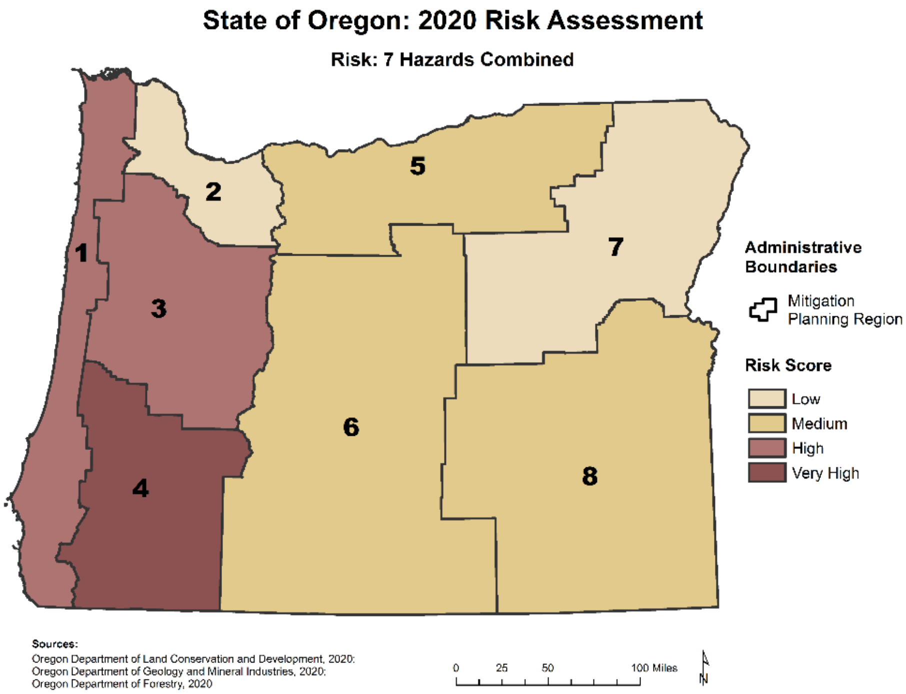
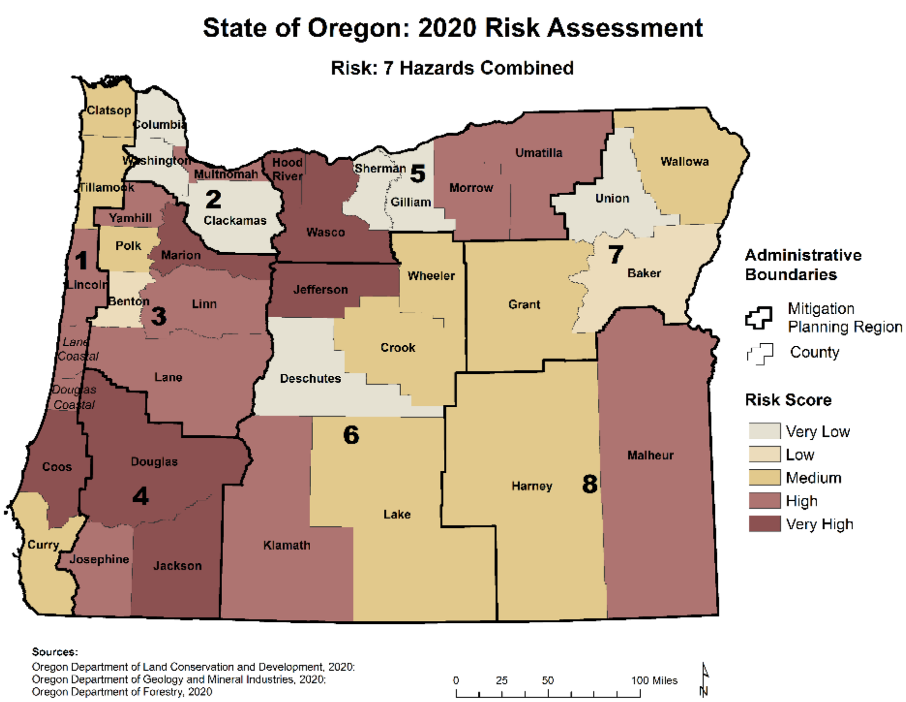



**Figure 2-18. Seven Hazards Combined Risk by County**



### 2.1.2.6 Considering All Eleven Hazards

As mentioned previously, not all of the hazards covered in the Plan are included in the 2020 Risk Assessment. Four hazards - drought, extreme heat, windstorms, and winter storms - are excluded due to insufficient data. Although not included in the official assessment, relying on available data and their expertise, subject-matter experts assigned each hazard a qualitative risk score on the Very Low to Very High (1-5) scale. DLCD used that score to calculate a combined risk score for all eleven hazards using the same methodology employed in the 2020 RA. Based on its combined score, each region and county was assigned a descriptive ranking using the Jenks Natural Breaks Classification method. The results are presented in **Table 2-14**, **Eleven Hazards Combined, 2020 Risk Assessment** in the “Risk Score” and “Risk” columns under the “All Hazards (11)” banner.

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

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

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

**Table 2-14. Eleven Hazards Combined, 2020 Risk Assessment**

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

Source: DLCD, 2020

*(Table continued on next page)*

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

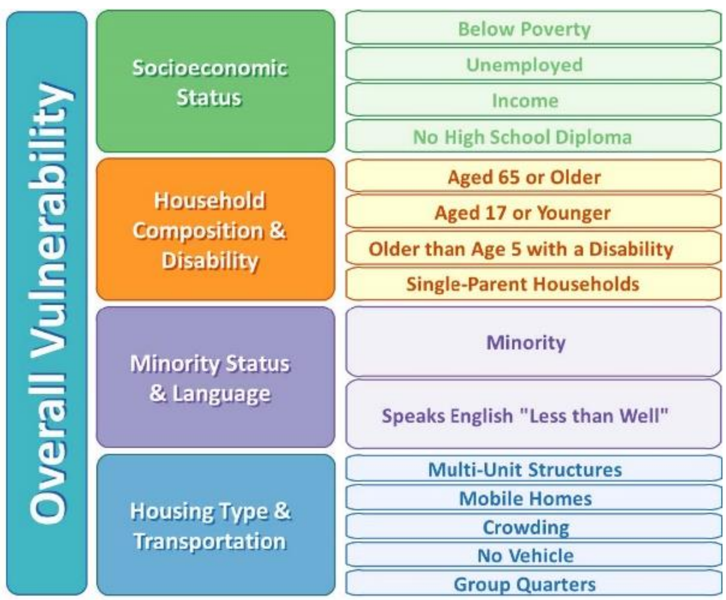
| | Coastal Hazards | | Earthquake | | Flood | | Landslide | | Tsunami | | Volcanic | | Wildfire | | All Hazards (7) | | Drought | Extreme Heat | Wind-storm | Winter Storm | All Hazards (11) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Risk Score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

## 2.1.3 Social Vulnerabilty

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

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

**Figure 2-19. CDC Social Vulnerability Themes and Components**




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

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

While the CDC tool aggregates various socioeconomic characteristics to create a composite measure of vulnerability, each regional community profile examines select risk factors to identify trends and dynamics between and within natural hazard mitigation planning regions. Some of the variables examined in the profiles are the same as or similar to those included in the CDC tool. However, it should be noted that although the CDC index and regional profiles both use estimates from the five-year ACS, the periods are different (2012-2016 versus 2013-2017, respectively). Other characteristics presented in the regional community profiles have been included in previous iterations of this Plan and remain relevant drivers of vulnerability. Table 2-15 illustrates which variables are included in the CDC index that are also presented in the regional community profiles and those that are covered in one but not the other.

**Table 2-15. Comparing Social Vulnerability Variables: CDC Index and Oregon NHMP Regional Community Profiles**

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

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

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

## 2.1.4 Introduction to Climate Change

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

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

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

### 2.1.4.1 Oregon Responses to Climate Change

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

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

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

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

## 2.1.4.2 Past and Future Climate in Oregon

### Historical

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

### Future Climate

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

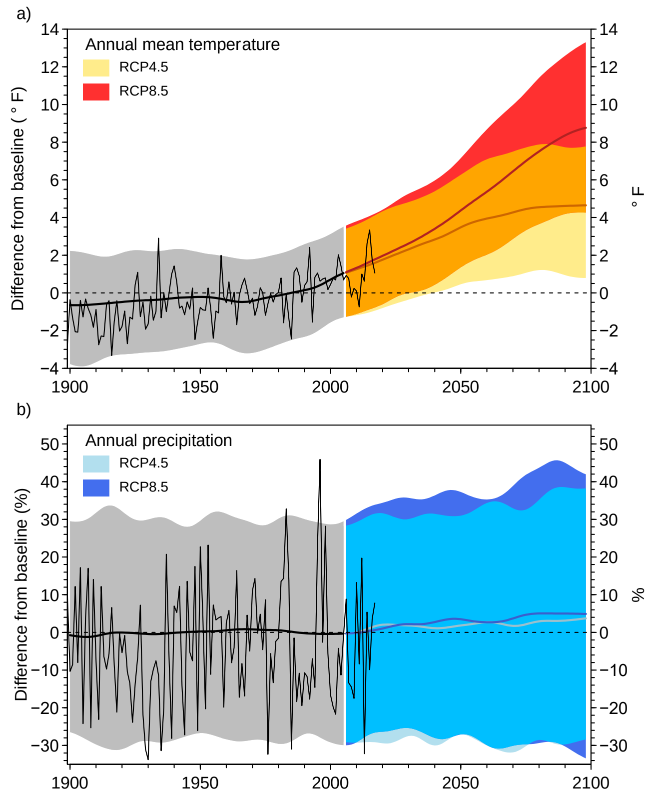
The temperature and precipitation projections summarized for Oregon in this section use data from the grid cells covering Oregon in multiple GCMs driven by two RCPs. The lower emissions scenario, RCP 4.5, represents a moderate effort to reduce global greenhouse gas emissions which peak near mid-21st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

### *Annual*

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

Every climate model shows an increase in temperature for Oregon, with the magnitude of the increase depending on the rate or magnitude of global greenhouse gas emissions. Larger temperature increases are projected under the higher emissions scenario (RCP 8.5) than under the lower emissions scenario (RCP 4.5). There is no plausible scenario in which Oregon cools in the 21st century. CMIP5 global climate models project an increase by mid-21st century (2040–2069) in annual temperatures in Oregon of 1.8°F to 6.9°F over the recent past (1970–1999) (**Table 2-16**). The lower projection is possible only if greenhouse gas emissions are significantly reduced (**Figure 2-20**, RCP 4.5 scenario). Both scenarios show a similar amount of warming through about 2040, meaning that temperatures beyond 2040 depend on global greenhouse emissions occurring now (Dalton et al., 2017). Climate models are split on whether annual precipitation in Oregon will increase or decrease.

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




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

Source: Mote et al. (2019)

### *Seasonal*

Projections of annual temperature and precipitation provide a foundation of general expectations of climate change, but some of the most relevant climate projections for planning purposes, and the most crucial to some of the hazards addressed in this Plan, are projected changes in seasonal temperature and precipitation and projected changes in extreme temperature and precipitation events. **Table 2-16** and **Table 2-17** summarize projections in Oregon's annual and seasonal temperature and precipitation, respectively, based on analyses of CMIP5 data.

**Table 2-16** contains the mean and range of projected changes in Oregon's mean annual temperatures from historical (1970–1999) to mid-21st century (2040–2069), using both RCP 4.5 and RCP 8.5 scenarios. Projected changes are shown annually and for each season. Of particular note in **Table 2-16** is that both scenarios (for RCP 4.5 and RCP 8.5) show projected increases in average temperature for the year and for every season. All models are in agreement that each season will be warmer in the future, and that the largest amount of warming will occur in the summer. Increased summer temperatures will increase the risk of wildfires, drought, and heat waves as well as increase health-threats from poor air quality conditions. Increased average winter temperatures will result in less snowpack in Oregon, which also contributes to increase risk of “snow droughts”—years with normal precipitation, but lack of sufficient accumulated snowpack due to warm temperatures.

**Table 2-16. Projected Future Changes in Oregon’s Mean Annual and Seasonal Temperatures from Late 20th Century (1970–1999) to Mid-21st Century (2040–2069) under RCP 4.5 and RCP 8.5 Scenarios**

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

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

Source: Dalton et al. (2017)

Table 2-17 contains a summary of projected mean percent change and range of changes for total precipitation in Oregon from historical (1970–1999) to mid-21st century (2040–2069), under both RCP 4.5 and RCP 8.5 scenarios. Projected changes are shown annually and for each season. Note in the “Annual” column in Table 2-4 that precipitation amounts are projected to remain within the range of current natural variability. However, Table 2-4 also shows that there is some indication from climate models that summers will be drier in the future. Such warmer and drier summers projected for Oregon would increase the risk of wildfire and drought hazards.

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

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

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

Source: Dalton et al. (2017)

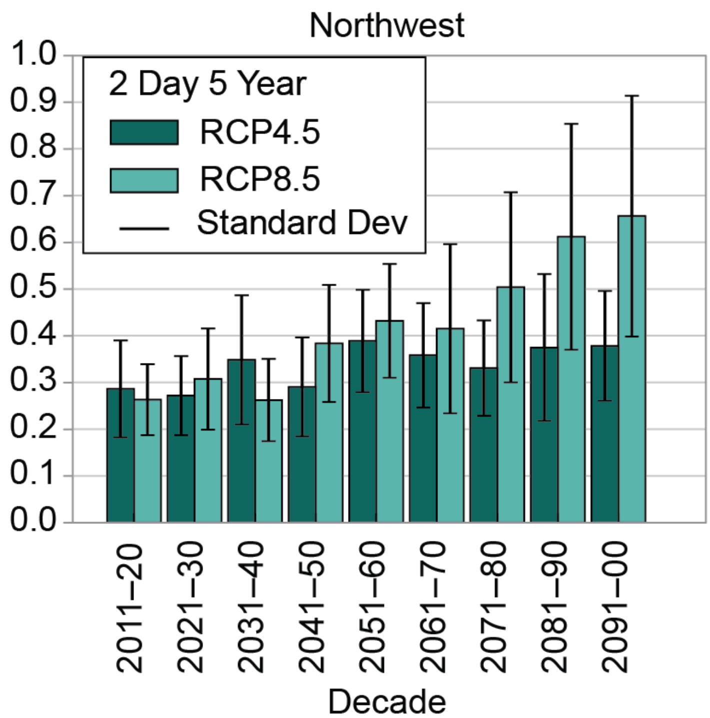
### *Extremes*

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

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

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

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



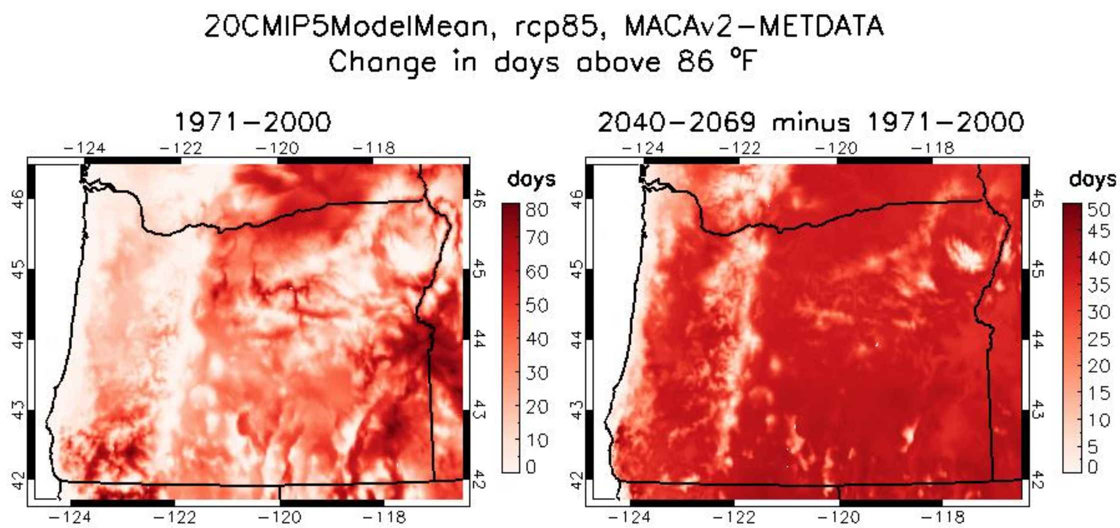

Calculated for 2006–2100 but decadal anomalies begin in 2011. Error bars are ±1 standard deviation; standard deviation is calculated from the 14 or 16 model values that represent the aggregated average over the regions, over the decades, and over the ensemble members of each model. The average frequency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

Source: Easterling et al. (2017)

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

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

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




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

Source: Mote et al. (2019)

## Effect of Oregon's Future Climate Conditions on Natural Hazards

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

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

The Framework is concurrently being updated (2020) along with the 2020 Oregon NHMP. Development of Oregon's 2010 Climate Change Adaptation Framework was significant in that the state began to address the need to plan for the effects of future climate conditions.

Furthermore, Oregon's 2010 Framework was the first state-level adaptation strategy based on climate risks as opposed to affected sectors. Oregon's 2010 Framework lays out 11 climate risks that are of concern to the state. The risks provide a consistent basis for agencies and communities to review plans and decisions to identify measures to reduce those risks. Many of the risks in the 2010 Oregon Framework are natural hazards.

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

## Relationship Between Adaptation Framework Risks and Hazards in the Oregon NHMP

**Table 2-18. Relationship Between Adaptation Framework Risks and Hazards in the Oregon NHMP**

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

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

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

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

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

### *Coastal Erosion and Coastal Flooding*

**Regions affected: 1**

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

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

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

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

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

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

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

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

### *Extreme Heat*

**Regions affected: 1-8**

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

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

Extreme heat events will to continue to increase in frequency and severity under continued climate warming. The number of days with temperatures greater than 86°F (30°C)—"hot days"—are expected to increase across Oregon (**Figure 2-22**). In the baseline period (1970–1999), the hottest parts of the state—lower elevation portions of eastern Oregon, as well as the Rogue River valley—experience at least 30 hot days per year. By mid-21st century under the higher scenario (RCP 8.5), most locations in Oregon except the mountains and the coast will experience at least an additional 30 hot days per year, in many places doubling the frequency of such days (Mote et al., 2019). Closer to home for some Oregonians, a three-fold increase in heat-related illness has been documented in Oregon with each 10 °F rise in daily maximum temperature.

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

### *Droughts and Wildfires*

**Regions affected: 1-8**

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

Virtually all climate models project warmer, drier summers for Oregon, with mean projected increases in summer temperatures of 4.5 to 6.3°F and a decline in mean summer precipitation amounts of 6.3 to 8.7% by mid-21st century relative to late-20th century depending on emissions scenario (**Table 2-16**, **Table 2-17**). These summer conditions will be coupled with projected decreases in mountain snowpack due to warmer winter temperatures. Models project a mean increase in winter temperatures of 3.3 to 4.5°F by mid-21st century relative to late-20th century depending on emissions scenario (**Table 2-16**). This combination of factors exacerbates the likelihood of drought, which in turn can dry out vegetation often leading to an increase in the incidence and likelihood of wildfires. Vegetation dryness is expected to increase across most of Oregon—with the most pronounced increases in southern Oregon, the eastern Cascade Range, and parts of the Blue Mountains—resulting in increased wildfire frequency and area burned across the state, even in areas west of the Cascade Range where wildfire has historically been infrequent (Dalton et al., 2017).

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

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

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

#### *Wildfire*

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

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

#### *Droughts*

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

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

### *Winter Storms, Floods, and Landslides*

**Regions affected: 1–4**

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

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

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

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

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

#### *Floods*

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

#### *Landslides*

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

### *Windstorms*

Regions affected: Unknown

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

### 2.1.4.3 Evolving Climate Science and the Oregon NHMP

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### 2.1.5.1 Assessment Methods

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

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

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

For the 2020 Risk Assessment, DOGAMI used the percentage of building value exposed or a loss ratio to a given hazard to calculate a vulnerability score for each county in each category of potential loss for each hazard faced by a county. Scores for coastal hazards and tsunamis were only calculated for counties in Region 1. The percentage of exposure or loss for each county for each hazard was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High) using the Jenks Natural Breaks method. DOGAMI applied this method to the results for all state facilities, state critical facilities, and local critical facilities. The vulnerability scores derived from this method were used along with other parameters (e.g. social vulnerability index) to calculate an overall vulnerability score for each county for each hazard and an overall risk score for each county for all hazards combined.

### 2.1.5.2 Hazard Data Limitations

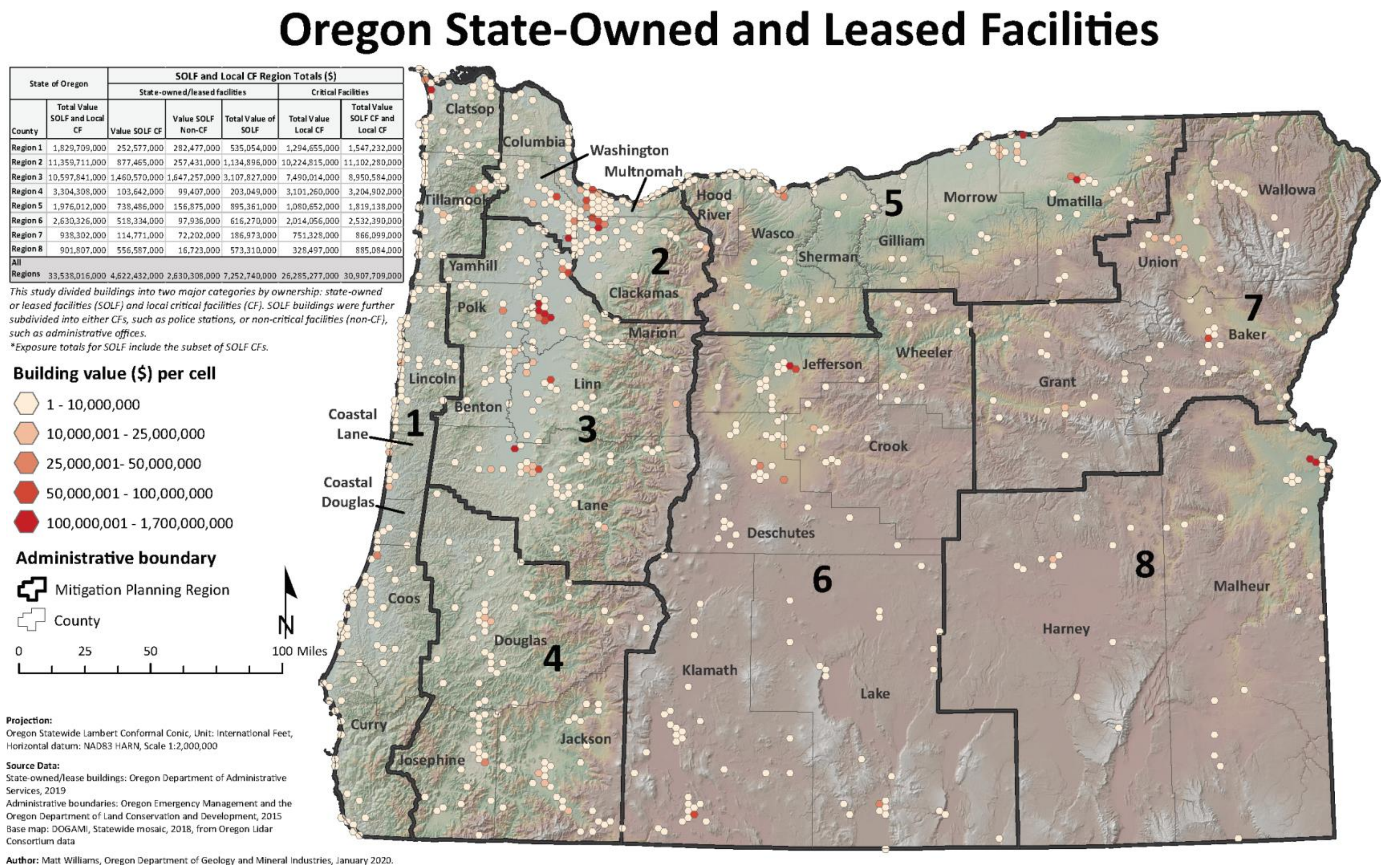
This assessment evaluates each hazard individually; there are no comprehensive or multi-hazard assessments. In order to prioritize facilities most vulnerable facilities to natural hazards, DOGAMI categorized most hazards with simple classification schemes (most commonly "High," "Moderate," "Low," or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

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

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

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

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

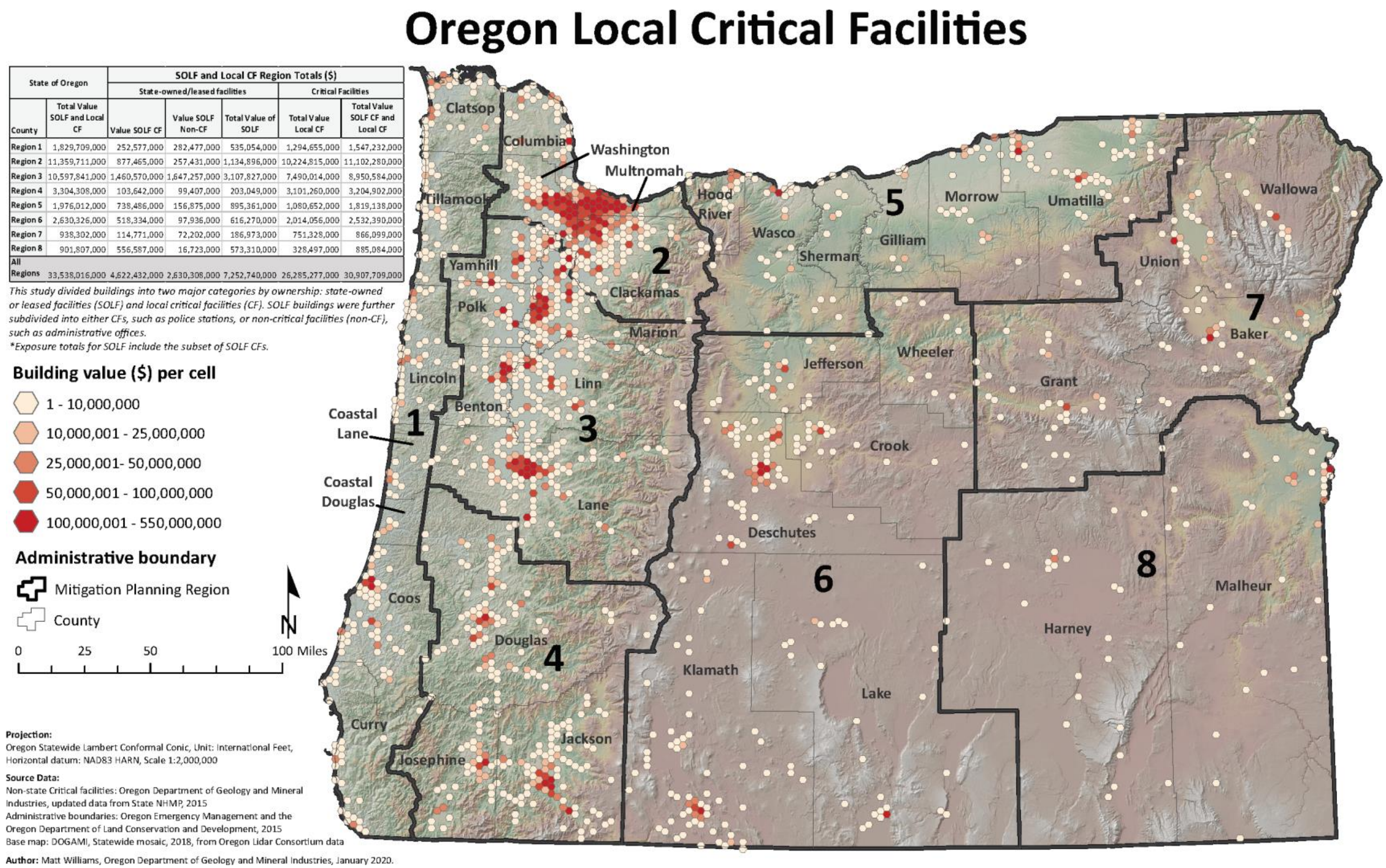


| State of Oregon | | SOLF and Local CF Region Totals ($) | | | | |
|---|---|---|---|---|---|---|
| | | State-owned/leased facilities | | | Critical Facilities | |
| County | Total Value SOLF and Local CF | Value SOLF CF | Value SOLF Non-CF | Total Value of SOLF | Total Value Local CF | Total Value SOLF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



Source: DOGAMI

**Figure 2-24. Statewide Distribution of Local Critical Facilities**




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

Source: DOGAMI

## 2.1.5.3 Facilities within Hazard Areas

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

### Coastal Erosion

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

#### *Coastal Erosion Hazard Facility Summary*

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

### Earthquake

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

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

### *Earthquake Hazard Facility Summary*

Of 5,350 state facilities evaluated, 838 building were flagged as completely or extensively damaged following a CSZ event (Regions 1-4) or a 2500-year probabilistic scenario (Regions 5-8) totaling over $1.3 billion of damages to property. Among the 1,647 critical state facilities, 360 were flagged as completely or extensively damaged. DOGAMI determined that out of the 8,757 local critical facilities, 1,880 buildings were flagged as completely or extensively damaged following a CSZ event (Regions 1-4) or a 2500-year probabilistic scenario (Regions 5-8) totaling over $4.3 billion of damages to property.

## Flood

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

### *Flood Hazard Facility Summary*

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

## Landslides and Debris Flow

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

### *Landslide Hazard Facility Summary*

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

## Tsunami

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

The recurrence interval associated with each local source tsunami scenario is as follows (Priest and others, 2013):

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

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

### *Tsunami Hazard Facility Summary*

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

## Volcanic Hazards

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

### *Volcanic Hazard Facility Summary*

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

## Wildfire

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

### *Wildfire Hazard Facility Summary*

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

### 2.1.6 Seismic Transportation Lifeline Vulnerabilities

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

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

The Governor's Task Force on Resilience Plan Implementation (ORTF) recommendations on implementation of the Oregon Resilience Plan (ORP) issued in September 2014 brought forward the most critical recommendations of the ORP to be implemented in the 2015-17 biennium. With respect to transportation infrastructure resilience, the ORTF recommended that additional revenue be identified to complete the most critical backbone routes identified in ODOT's Seismic Options Report within a decade, and the complete program by 2060. The funding source should be ongoing and "pay-as-you-go," rather than financed through bonding, to provide resources for all phases over the course of several decades.[1]

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

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

[1] Report to the 77th Legislative Assembly dated October 1, 2014 from the Governor's Task Force on Resilience Plan Implementation, October 1, 2014

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

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

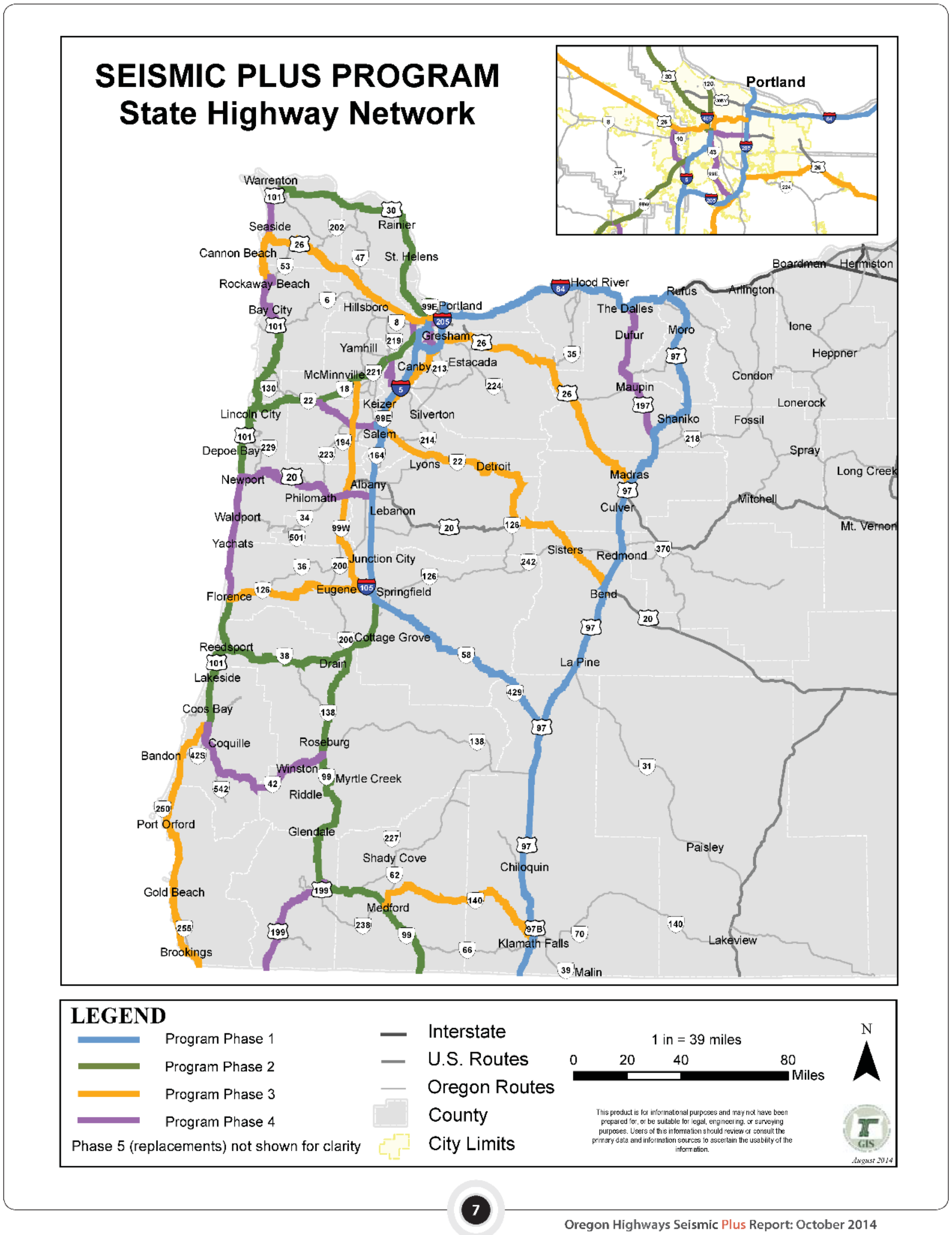
The 2021-2024 STIP funding includes $31M to address ODOT bridge seismic needs.

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

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

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

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



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

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

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

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

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

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

This project was conducted by the ODOT Transportation Development Division (TDD) from September 2011 through April 2012, in coordination and consultation with Bridge, Maintenance, Geotechnical, and other impacted divisions within the agency, as well as with other state agencies including the Oregon Department of Geological and Mineral Industries (DOGAMI) and the Public Utility Commission (PUC) through a Project Management Team (PMT) and Steering Committee (SC). The full report (https://www.oregon.gov/ODOT/Planning/Documents/Seismic-Lifelines-Evaluation-Vulnerability-Synthese-Identification.pdf) is located in **9.1.14**, Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification.

#### 2.1.6.1 Methodology

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

**Step 1: Identify Study Corridors**

State highways west of US-97 were selected as study corridors that met one or more of the following characteristics (**Table 2-19**):

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

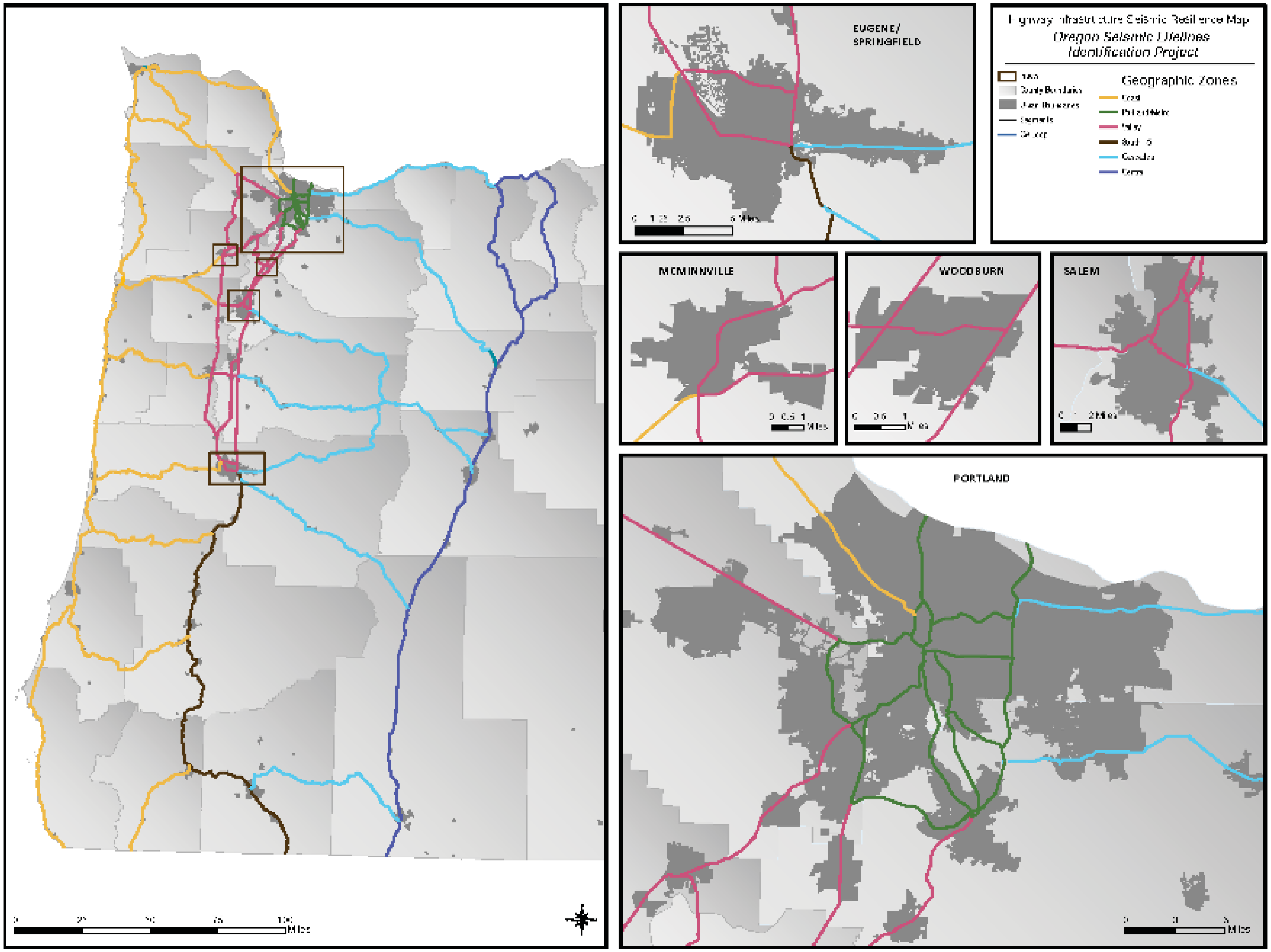
The study corridors were grouped geographically into the following six distinct zones within the western half of the state (**Figure 2-26**):

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

**Step 2: Develop Evaluation Framework**

The PMT established an evaluation framework that consists of the following four main elements: goals, objectives, criteria, and parameters (**Table 2-19**).

**Figure 2-26. OSLR Geographic Zones**




Source: ODOT

**Table 2-19. OSLR Evaluation Framework**

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

Source: ODOT

The criteria in the evaluation framework fell into three categories:

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

Criteria within each category are listed in **Table 2-20**.

**Table 2-20. OSLR Criteria by Group**

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

Source: ODOT

**Step 3: Analyze Selected Highways**

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

**Step 4: Solicit Feedback from Steering Committee**

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

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

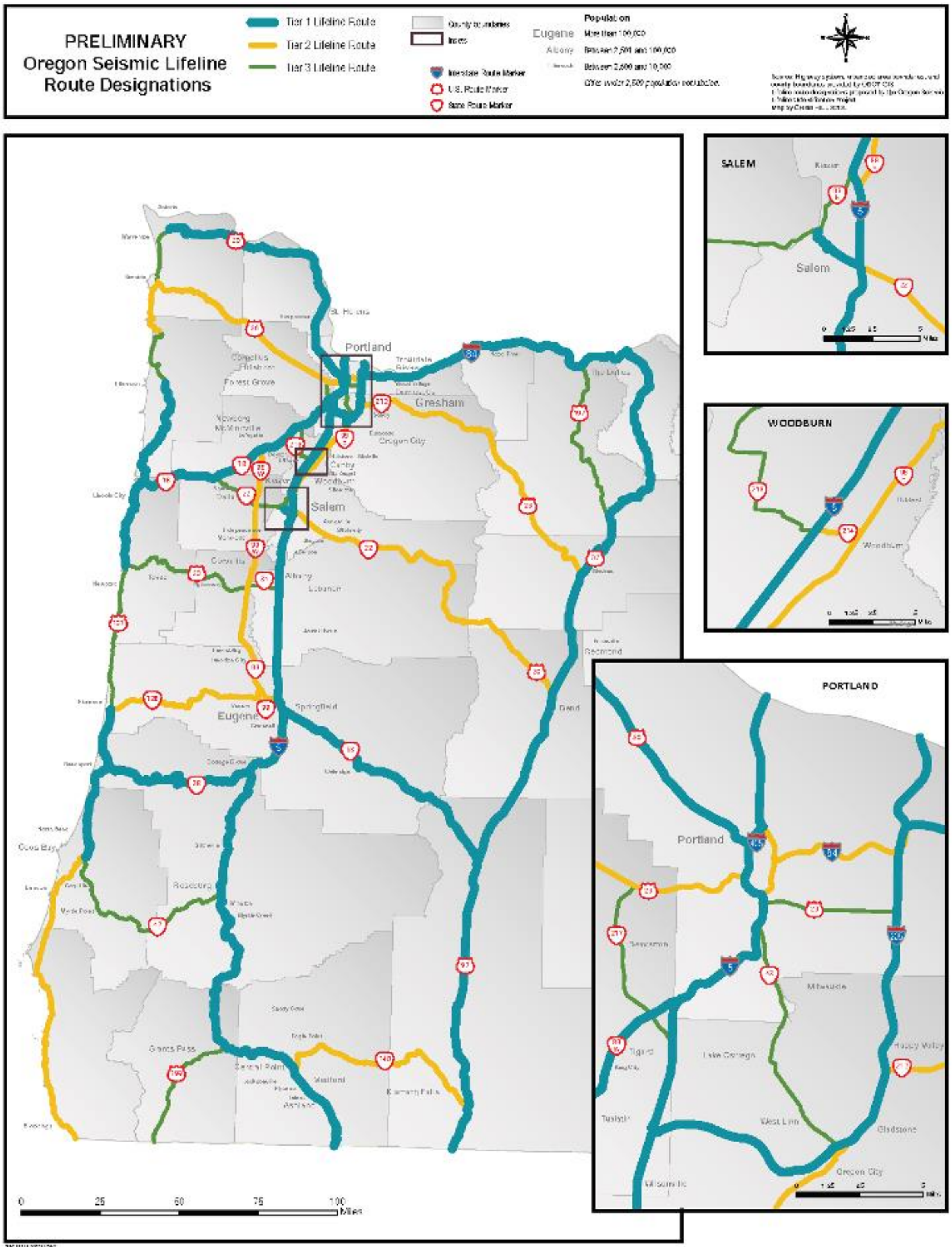
**Step 5: Propose a System of Lifeline Routes**

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

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

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

**Figure 2-27. Preliminary Oregon Seismic Lifeline Routes, by Tier**




Source: ODOT

### 2.1.6.2 Seismic Hazards Affecting Lifeline Routes

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

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

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

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

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

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

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

### 2.1.6.3 State Vulnerability

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

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

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

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

### 2.1.6.4 Statewide Loss Estimates

The OSLR project included consideration of the costs of retrofitting bridges and other highway facilities to support the tiering decisions and a preliminary work for revenue requests for implementation. Cost estimates were made for construction projects to mitigate or correct vulnerabilities on the recommended Seismic Lifelines system. Details can be found in Appendix A of the Seismic Plus Report (**Appendix 9.1.12**).

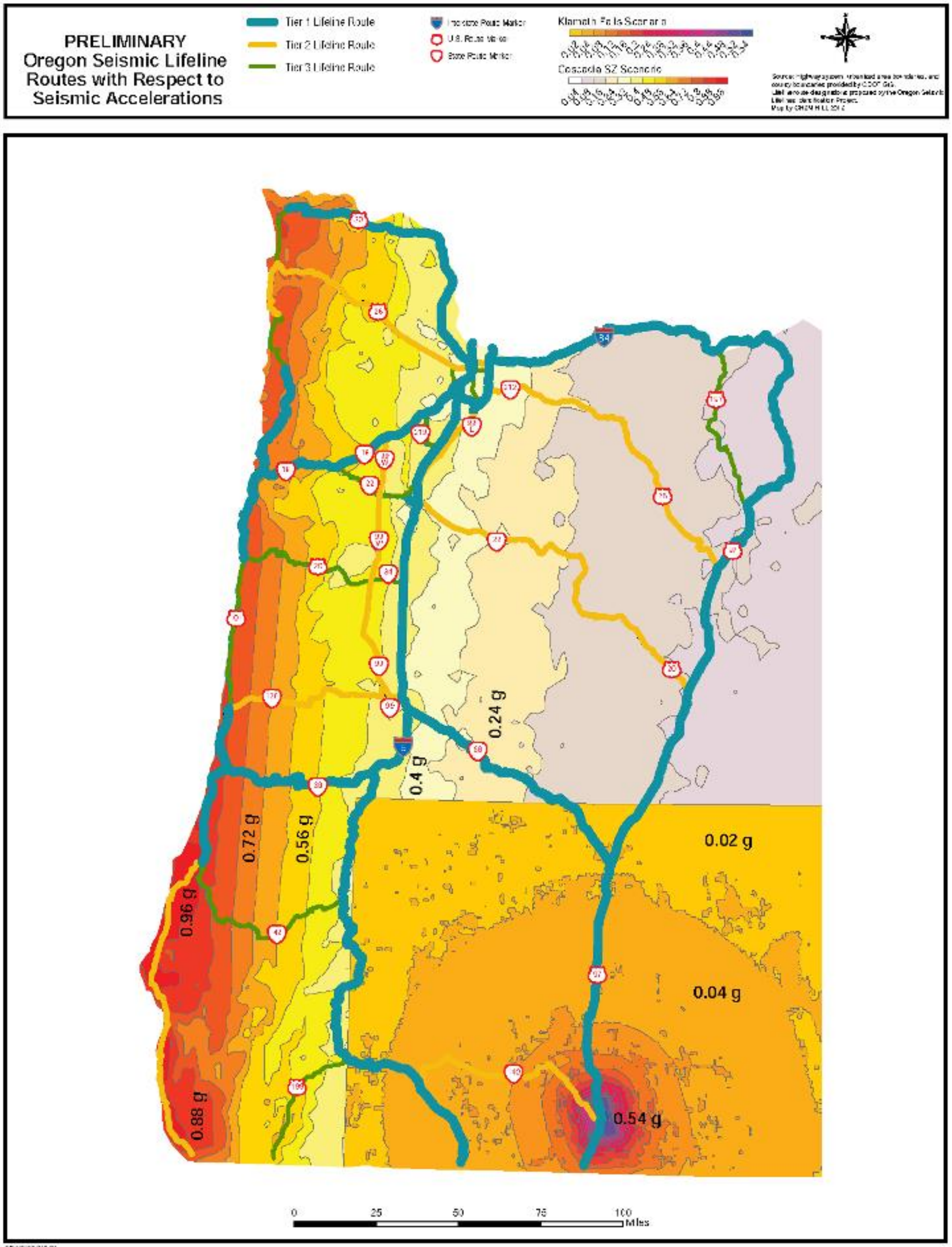
Appendices G and H of that report (**Appendix 9.1.12**) address both a scenario wherein a major earthquake occurs and a scenario wherein a major earthquake does not occur**.** This analysis was done to answer a slightly different question: what is the value of making the recommended improvements to the identified lifeline routes?

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

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

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

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




Source: OSLR, ODOT

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

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

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

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

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

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

### 2.1.6.5 Data

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

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

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

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

### 2.1.6.6 Anticipated Next Steps [move footnotes to references section]

Funds provided by the HB 2017 are mainly allocated for the seismic work on Phase 1 highway segments. With the current budget for bridge seismic retrofitting, it may take even more than the originally planned (20-30 years) to strengthening all the roadway in Phase 1. The 2014 Seismic Plus Report shows similar mitigation costs for other phases, but those figures will look much different 20-30 years from now. It is not clear how long the HB 2017 will authorize funds to support ODOT's seismic program, but even if it were to be indefinite, inflation 20-30 years from now will diminish the buying power of these funds.[2]

[2] Albert Nako, Elizabeth Hunt and Bret Hartman, Personal communications, May 2020

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

- More detailed level estimates that capture site specific costs associated with staging and foundation work; and
- A recent trend of increasing construction costs noted for all work types across the Agency. [3]

Based on the estimated costs, it would take decades to complete Phase 1 of the Seismic Plus Program at which time many of the bridges that were initially retrofitted would be reaching the end of their service life. Without additional funds it is unlikely that all five phases could be completed as planned. Most of the bridges would be replaced because of their age and conditions before they would be considered for seismic retrofit. Also, to address seismic resiliency bridges still in relatively good condition would need to be replaced.[4]

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

The second priority will be around evaluating alternate lifeline routes by addressing the portion of I-5 north of Eugene similar to the Southern Oregon Triage project. The process of identifying a route south of Eugene, involved a triage strategy that included the use of local roads and bridges to provide a lifeline following a Cascadia seismic event.[6]

HB 2017 seismic funding available after the Southbound Santiam River Bridge retrofit is funded will be used to address bridges identified for work as part of an updated strategy.[7]

During the 2021-2024 STIP scoping process, ODOT realized this need to re-evaluate the current approach. Since publication of the 2019 Bridge Condition Report, ODOT has developed a Seismic Implementation Plan that currently is in draft form and anticipated for Oregon Transportation Commission approval sometime in the later part of 2020. The Implementation Plan will provide guidance for maximizing seismic resiliency with the current budget by considering detour routes

[3] 2019 Bridge Condition Report

[4] Ibid

[5] Ibid

[6] Ibid

[7] Ibid

for the most expensive state bridges and/or adopting triage approaches for certain highway segments. [8]

HB 2017 provided funding for an additional seismic project entitled the Southern Oregon Triage strategy. The strategy focuses on mitigating seismic impacts along Interstate 5 south of Eugene, and OR 140, which are key lifeline routes to and from the Rogue Valley. Most of the seismic impacts on the routes are expected to be addressed through quick repairs or temporary detours. The funding will be used to address those bridges and potentially unstable slopes that are more problematic or where a feasible detour does not exist.[9]

Right of way funding is available for Coastal Maintenance Stations at central coast and Coos Bay; an additional facility at Astoria is being considered but is not currently funded. Each station will be supplied with seismic response kits. The purpose of the kits is to stockpile key materials and supplies that can be used to assist local communities in the early days following a seismic event. The kits will include culvert pipes of various sizes; construction materials; solar power generators and trailer mounted solar light panels; diesel and unleaded fuel storage tanks; survival supplies (water, field rations, first aid supplies); power tools; batteries; portable boats; flat railroad cars; and satellite phones and Ham radios.[10]

The Bridge Seismic Standards Engineer and other ODOT leadership, is working collaboratively with Oregon counties to develop planning reports documenting county routes and priorities for seismic resiliency. ODOT provides bridge data and technical support and the counties provide information about their network. While the information is useful for county planning, a comparison can be made to the state seismic bridge priorities to determine possible state highway detour routes that may be more cost effective to seismically retrofit or replace. Eventually the planning reports may provide an opportunity for seismic resiliency funding from either state or federal funds. [11]

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[8] Nako, Hunt and Hartman, personal communications, May 2020

[9] 2019 Bridge Condition Report

[10] Ibid and personal communications with ODOT staff, May 2020

[11] Ibid

## 2.1.7 Cultural Resources

### 2.1.7.1 Overview

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

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

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

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

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

### 2.1.7.2 Existing Efforts

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

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

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

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

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

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

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

### 2.1.7.3 Future Strategic Opportunities

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

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

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

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

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

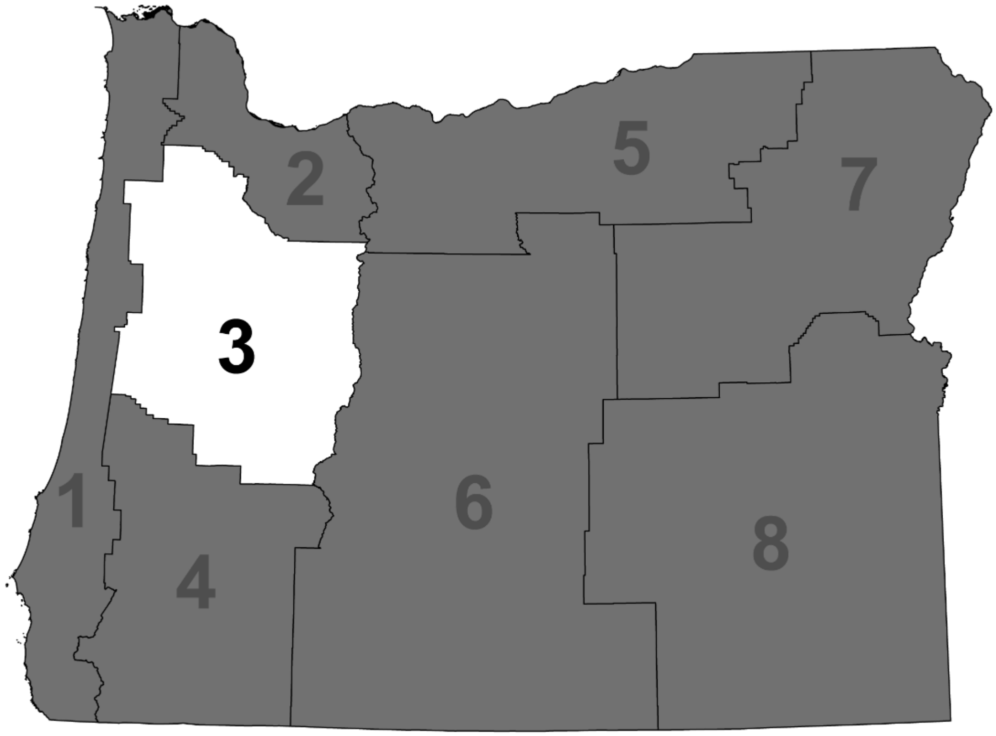
- Identify opportunities to include volunteers and collection curators in the mitigation, notification, response, and recovery phases of disaster management to ensure resource protection.
- Continue to assist local representatives in resource identification and recordation.
- Compile “Connecting to Collections”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

#### 2.1.7.4 Summary

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

### 2.3.3 Region 3: Mid/Southern Willamette Valley

Benton, *Lane (non-coastal), Linn, Marion, Polk, and Yamhill Counties




Note: The coastal portion of Lane County is within Region 1. Where data are available for the coastal areas of Lane County, the data are provided within the Region 1 profile; otherwise, countywide datasets are reported in this profile.

## 2.3.3.1 Summary

### Regional Profile

The region's demographic, economic, infrastructure, and development patterns indicate that some populations, structures, and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

The region's social vulnerability is particularly challenged in Lane, Marion, Benton, and Linn Counties. The following vulnerability indicators have been identified for one or more of those counties: high numbers of tourists, persons with disabilities, renters, people living in poverty, people who do not speak English very well, children, and seniors. Median household incomes have fallen in Marion and Lane Counties. Homeless populations have dramatically increased in Lane and Yamhill Counties.

The region has a number of key industries and employment sectors providing economic stability for the region. The exceptions are Linn and Yamhill Counties, which rely heavily on fewer key industries. Except for in Benton County, wages are lower in Region 3 than statewide.

Transportation networks across the region are vulnerable to natural hazard events, especially seismic events. Following a Cascadia earthquake event, access across the Willamette River and along I-5 may be limited due to bridge collapse. Lane County has a particularly high number of state-owned bridges that are distressed or deficient. The Eugene Airport, the state's second largest airport, could become a staging ground after a natural disaster, but is also vulnerable to a catastrophic seismic event.

Energy facilities and conveyance system infrastructure in the region support the regional economy and are vulnerable to natural hazard events. The region is a key provider of hydroelectricity for the state. Roughly 14% (53) of all dams in the region have either Significant or High Threat Potential. The majority of dams in the region are in Marion and Yamhill Counties. Liquid Natural Gas is transmitted via pipelines that run through Marion, Linn, and Lane Counties.

Water systems in the region are particularly vulnerable to hazard events because they tend to be older, centralized, lacking in system redundancies and sourced from surface water. Combined sewer overflow (CSO) during high-water events is one such threat. Low impact development (LID) stormwater systems, such as those employed by the City of Eugene, can help communities better manage high-precipitation events.

Urban growth in Region 3 is 4 times rural growth. The majority of growth is occurring in urban areas along I-5, in the region's major cities: Eugene, Albany, Corvallis, Salem, and the Portland Metro Area. Linn County has the highest percentage of mobile homes, which are inherently more vulnerable to natural hazards events. Almost two thirds of all homes in the region were built before 1990 and seismic building standards. Over one third of all homes in Polk and Yamhill Counties were built before floodplain management standards.

## Hazards and Vulnerability

Region 3 is affected by nine of the 11 natural hazards that affect Oregon communities. Coastal hazards and tsunamis do not directly impact this region.

**Droughts:** The region is affected by droughts to a lesser extent than other areas in the state. Though not common in Region 3, a dry winter or spring could reduce community water supplies, impacting recreation, agriculture and the regional economy.

**Earthquakes:** Four types of earthquakes affect Region 3: (a) shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) the offshore Cascadia Subduction Zone (CSZ) Fault, and (d) earthquakes associated with renewed volcanic activity. The CSZ is the chief earthquake hazard for the Mid/Southern Willamette Valley. This area is particularly vulnerable due to the large area susceptible to earthquake-induced landslide, liquefaction, and ground shaking. In a 500-year model for a CSZ event or combined crustal events, five of the 15 counties with highest expected damages and losses are in this region: Lane, Marion, Benton, Linn, and Yamhill. Seismic lifelines will be affected by prolonged ground shaking with several roadways susceptible to landslide, rockfall, or liquefaction. There are 2,134 state-owned/leased facilities in this region's earthquake hazard zone, valued at over $4.2 billion. Of these, 455 are critical/essential facilities. An additional 2,413 non-state-owned/leased critical/essential facilities are also located within this hazard zone.

**Floods:** The most common types of flooding events affecting the Mid/Southern Willamette Valley are riverine and sheet flooding. The most damaging floods are rain-on-snow events and the backing up of tributaries that takes place in December and January in association with La Niña events. While all of the region's counties are considered moderately vulnerable to flooding, the coastal portion of Lane County and the cities of Eugene-Springfield, Salem, Scio, and Sheridan are considered the most vulnerable. This region has the third most repetitive flood loss properties (46) of which four are Severe Repetitive Loss (SRL) properties. There are 28 state-owned/leased facilities, valued at approximately $13 million, located in the region's flood hazard zone. Of these, one is considered a critical/essential facility. An additional 90 non-state-owned/leased critical/essential facilities are also located in this hazard zone.

**Landslides:** Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Rain-induced landslides can occur during winter months. Earthquakes can also trigger landslides. Vulnerability is increased in highly populated areas, such as in the Cities of Corvallis, Eugene, and Salem, and in the Coast and Cascade Mountains. There are 2,134 state-owned/leased facilities, valued at over $4.2 billion, within this hazard zone in Region 3. Of these, 455 are critical/essential facilities. An additional 2,413 non-state-owned/leased critical/essential facilities are also located within this hazard zone.

**Volcanoes:** Volcanic activity may occur within the eastern areas of Lane, Linn, and Marion Counties that coincide with the crest of the Cascade mountain range. Most volcanic activity is considered local; however, lahars and ashfall can travel many miles. As such, small mountain communities, dams, reservoirs, energy-generating facilities, and highways in the region may be vulnerable to volcanic activity. There are 28 state-owned/leased facilities located in the volcanic hazard zone in this region, with an approximate value of $13 million. Of these, one is identified as a critical/essential facility. An additional 90 non-state-owned/leased critical/essential facilities are also located in this hazard zone.

**Wildfires:** Wildfire risk is low to moderate in the Mid/Southern Willamette Valley. Wildfires that do occur usually happen in the late summer. The areas of greatest vulnerability are wildland-urban interface communities. There are 610 state-owned/leased facilities located in a wildfire hazard zone with a value of approximately $315 million. Of these, 70 are identified as critical/essential facilities. An additional 587 non-state-owned/leased critical/essential facilities are also located in this hazard zone.

**Windstorms:** Windstorms can occur when winds generated in the Pacific Ocean travel inland in a northeasterly direction. Strong winds from the south are also possible in this region and often cause the most damage. Windstorms affect the region annually. These storms generally impact the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland.

**Winter Storms:** Colder weather and higher precipitation and can occur in the region annually. More severe winter storms occur about every 4 years. Due to the infrequent nature of severe storms in Region3, winter storm preparedness is not a priority of most communities.

## Climate Change

The hazards faced by Region 3 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon. Coupled with projected decreases in mountain snowpack due to warmer winter temperatures, Region 3 is expected to be affected by an increased incidence of drought and wildfire. In Region 3, climate change would result in increased frequency of drought due to low spring snowpack (*very likely*, >90%), low summer runoff (*likely*, >66%), and low summer precipitation and low summer soil moisture (*more likely than not*, >50%). It is *very likely* (>90%) that Region 3 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*).

Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (*high confidence*) that is *more likely than not* (>50%) to lead to an increase in the incidence and magnitude of damaging floods (*low confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

While winter storms and windstorms affect Region 3, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section 2.2.1.2, **Introduction to Climate Change**.

## 2.3.3.2 Profile

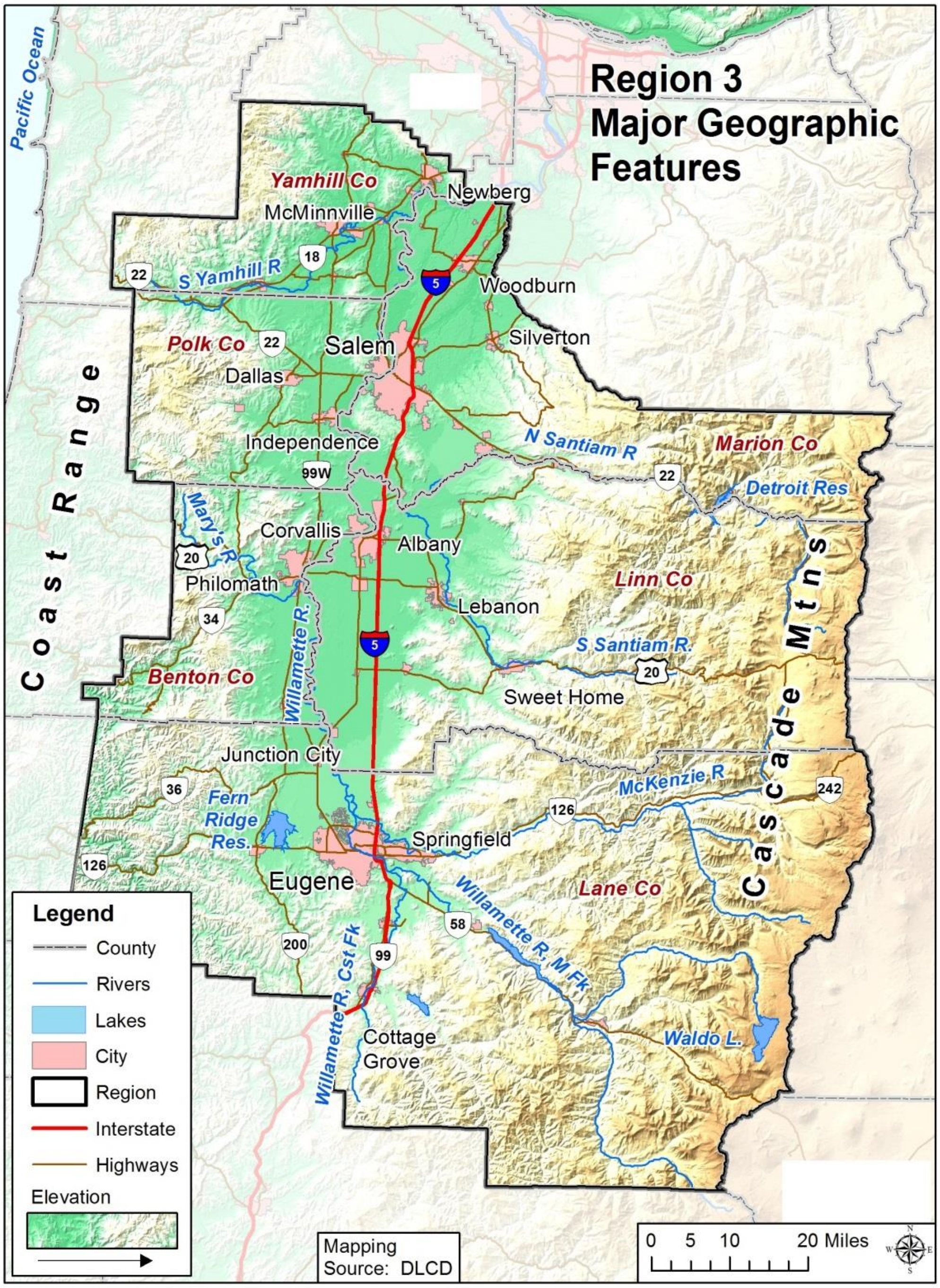
**Requirement: 44 CFR §201.4(d):** The Plan must be reviewed and revised to reflect changes in development…

### Natural Environment

#### *Geography*

The Mid/Southern Willamette Valley is approximately 10,163 square miles in size, and includes Benton, Lane (non-coastal), Linn, Marion, Polk, and Yamhill Counties. Mountain ranges and watersheds shape the region's topography. Region 3 begins at the Cascades crest in the east, and extends to the Coast Range in the west. It extends from the base of the Calapooya Mountains in the south to the Portland suburbs in the north. The major watershed is the Willamette River with smaller water bodies feeding it as it flows north into the Columbia River. The original Oregon Trail settlers sought out the fertile soil and ample rainfall of the Willamette Valley for their homesteads. The region is still an agriculturally vital area.

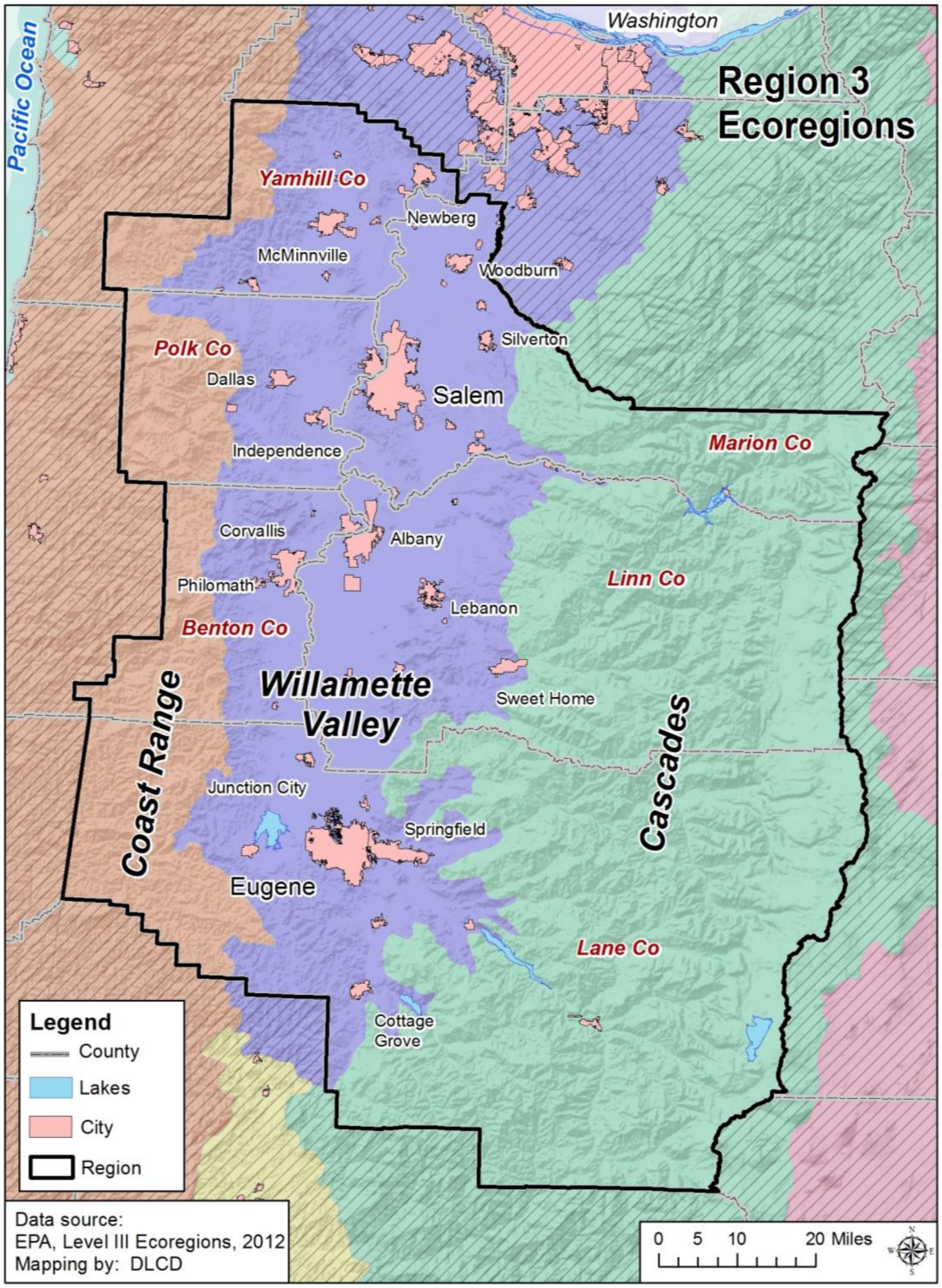
**Figure 2-164. Region 3 Major Geographic Features**




Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 3 is composed of three ecoregions: the Cascades, the Willamette Valley, and the Coast Range.

**Figure 2-165. Region 3 Ecoregions**




**Cascades:** This ecoregion is underlain by volcanic soils. Naturally occurring mixed conifer forests have given way to predominantly Douglas fir forests that are managed for commercial logging. Logging activities have put a strain on the ecological health of streams in the area (Thorson et al., 2003). Waterways in the steeper valleys support threatened cold-water salmonids including Chinook salmon, steelhead, and bull trout. Streams, lakes, reservoirs, rivers, and glacial lakes at higher elevations are key sources of water. Large volcanic peaks, glaciers, and year-round snowfields punctuate the alpine and subalpine areas of the ecoregion (Thorson et al., 2003).

**Coast Range:** The eastern slope of the Coast Range is located within Region 3. Soils in this ecoregion are a mixture of sedimentary and volcanic composition. Volcanic soils are underlain by basaltic rocks resulting in more consistent summer streamflows and supporting runs of spring Chinook salmon and summer steelhead. Sedimentary soils in this ecoregion are prone to failure following clearcuts, which may be of concern as the commercial Douglas fir forests located here are highly productive commercial logging areas. Landslides can impact the safety of nearby infrastructure and health of the region's waterways. The ecoregion's sedimentary soils can create more concerns for stream sedimentation than areas with volcanic soils (Thorson et al., 2003).

**Willamette Valley:** Terraces and floodplains dominate the nearly flat central Willamette Valley. The valley floor is dotted with scattered hills and buttes and is bordered by the adjacent foothills. Historically, valley waterways meandered throughout floodplains on the nearly flat valley floor, contributing to the valley's highly fertile soil and supporting the dominance of oak savannah and prairie ecosystems. Today the Willamette River and its tributaries are highly channelized, helping to protect property, but also restricting the flow of these waterways and threatening stream health. Productive soils and temperate climate make this ecoregion one of the most important agricultural areas in Oregon. The valley's flat terraces have made urban and suburban development possible (Thorson et al., 2003).

### *Climate*

This section covers historic climate information only. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment**.

The Willamette Valley's mild climate, long growing season, and abundant moisture supports the most diversified agriculture in the state. Precipitation generally occurs in the winter months, falling mostly as rain in the valley, but building snowpack in the mid-elevations of the Cascade foothills. The region's wet winters can lead to flood, landslide, and winter storm risks while dry summers can lead to drought and wildfire risks. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-253** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 3 based on data from the NOAA National Centers for Environmental Information.

**Table 2-253. Average Precipitation and Temperature in Region 3 Counties and Climate Divisions**

| Sub-Region | Annual Precipitation Mean & Range (1981–2010) | January & July Mean Precipitation (1981–2010) | Annual Mean Temperature (1981–2010) | January & July Average Min/Max Temperature (1981–2010) |
|---|---|---|---|---|
| Benton County | 58.91” (38.67”–94.51”) | Jan: 9.17” Jul: 0.53” | 52.1°F | Jan: 34.9°F /46.8°F Jul: 51.6°F /80.2°F |
| Lane County | 64.72” (46.07”–101.5”) | Jan: 9.09” Jul: 0.77” | 49.9°F | Jan: 33.3°F /44.8°F Jul: 50.8°F /77.0°F |
| Linn County | 70.78” (51.06”–112.43”) | Jan: 9.95” Jul: 0.87” | 49.2°F | Jan: 32.1°F /43.7°F Jul: 50.1°F /77.4°F |
| Marion County | 64.66” (44.46”–102.94”) | Jan: 9.25” Jul: 0.84” | 49.8°F | Jan: 32.6°F /44.1°F Jul: 51.1°F /77.3°F |
| Polk County | 66.62” (42.46”–108.27”) | Jan: 10.55” Jul: 0.59” | 51.6°F | Jan: 34.9°F /46.1°F Jul: 51.7°F /78.9°F |
| Yamhill County | 59.91” (38.41”–97.23”) | Jan: 9.39” Jul: 0.59” | 51.7°F | Jan: 35.1°F /45.8°F Jul: 52.2°F /78.6°F |
| Climate Division 2 “Willamette Valley” | 58.11” (39.98”–92.22”) | Jan: 8.35” Jul: 0.69” | 51.5°F | Jan: 34.6°F /45.9°F Jul: 52.2°F /78.6°F |
| Climate Division 4 “Northern Cascades” | 80.7” (59.67”–127.71”) | Jan: 11.41” Jul: 1.05” | 45.7°F | Jan: 28.5°F/39.8°F Jul: 48.2°F/74.2°F |

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 15, 2019 from https://www.ncdc.noaa.gov/cag/.

## Demography

### *Population*

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter, Boruff, & Shirley, 2003). Population change includes two major components: natural increase (births minus deaths) and net migration (in-migrants minus out-migrants) (USDA, 2020). If a population is forecast to increase substantially, a community’s capacity to provide adequate housing stock, services, or resources for all populations after a disaster may be stressed or compromised.

Between 2010 and 2018, the region grew less quickly than the state as a whole. Benton County saw the largest percentage increase and Lane County saw the smallest. Over the next decade, all counties in the region are expected to increase in population. Polk and Yamhill Counties are projected to grow most quickly. Net in-migration is expected to increase and be the main driver of population growth in Yamhill County, with the cities of Newberg and McMinnville leading the way (Population Research Center, Portland State University, 2020). Lane County is projected to continue growing, albeit more slowly than its regional peers. Like many places in Oregon, Lane County has an aging population and the majority of growth is projected to occur from in-migration (Population Research Center, Portland State University, 2019).

**Table 2-254. Population Estimate and Forecast for Region 3**

| | 2010 | 2018 | Percent Change (2010 to 2018) | 2030 Projected | Percent Change (2018 to 2030) |
|---|---|---|---|---|---|
| **Oregon** | 3,831,074 | 4,195,300 | 9.5% | 4,694,000 | 11.9% |
| **Region 3** | 1,043,897 | 1,127,835 | 8.0% | 1,257,889 | 11.5% |
| Benton | 85,579 | 93,590 | 9.4% | 106,498 | 13.8% |
| Lane | 351,715 | 375,120 | 6.7% | 396,195 | 5.6% |
| Linn | 116,672 | 125,575 | 7.6% | 140,871 | 12.2% |
| Marion | 315,335 | 344,035 | 9.1% | 388,420 | 12.9% |
| Polk | 75,403 | 82,100 | 8.9% | 98,501 | 20.0% |
| Yamhill | 99,193 | 107,415 | 8.3% | 127,404 | 18.6% |

Source: Population Research Center, Portland State University (2018), Certified Population Estimates; Population Research Center, Portland State University (2019), Current Forecast Summaries for All Areas & Oregon Final Forecast Table by Age (2019); U.S. Census Bureau, 2010 Decennial Census. Table DP-1Tourists

### *Tourists*

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 3 are largely centered on touring (traveling to experience scenic beauty, history, and culture), special events, and outdoor activities (Longwoods International, 2017). The average travel party contains 2.8 persons, and 81% of their trips originate from California, Oregon, or Washington. In this region, the average trip length is 2.3 nights (Longwoods International, 2017). Within the region, Lane County has the greatest number of tourist from 2016 to 2018. The presence of the University of Oregon in Eugene is likely a key driver of tourism in Lane County; however, conventions, outdoor recreation and touring has also been cited as important (Omundson, 2019).

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

**Table 2-255. Annual Visitor Estimates in Person Nights in Region 3**

| | 2016 | | 2017 | | 2018 | |
|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent |
| **Region 3** | 19,743 | | 19,706 | | 20,130 | |
| **Benton** | 1,427 | 100% | 1,432 | 100% | 1,523 | 100% |
| Hotel/Motel | 451 | 31.6% | 442 | 31% | 495 | 33% |
| Private Home | 889 | 62.3% | 903 | 63% | 941 | 62% |
| Other | 87 | 6.1% | 86 | 6% | 87 | 6% |
| **Lane** | 8,173 | 100% | 8,042 | 100% | 8,286 | 100% |
| Hotel/Motel | 2,042 | 25.0% | 1,974 | 25% | 2,057 | 25% |
| Private Home | 4,766 | 58.3% | 4,713 | 59% | 4,857 | 59% |
| Other | 1,365 | 16.7% | 1,354 | 17% | 1,372 | 17% |
| **Linn** | 1,972 | 100% | 1,965 | 100% | 1,992 | 100% |
| Hotel/Motel | 393 | 20% | 389 | 20% | 391 | 20% |
| Private Home | 1,243 | 63% | 1,244 | 63% | 1,264 | 63% |

| | 2016 | | 2017 | | 2018 | |
|---|---|---|---|---|---|---|
| Other | 336 | 17% | 332 | 17% | 337 | 17% |
| **Marion** | 5,387 | 100% | 5,436 | 100% | 5,408 | 100% |
| Hotel/Motel | 1,137 | 21% | 1,158 | 21% | 1,124 | 21% |
| Private Home | 3,701 | 69% | 3,735 | 69% | 3,733 | 69% |
| Other | 549 | 10% | 544 | 10% | 551 | 10% |
| **Polk** | 1,101 | 100% | 1,125 | 100% | 1,148 | 100% |
| Hotel/Motel | 199 | 18.1% | 196 | 17.4% | 201 | 17.5% |
| Private Home | 793 | 72.0% | 820 | 72.9% | 837 | 72.9% |
| Other | 110 | 10.0% | 109 | 9.7% | 110 | 9.6% |
| **Yamhill** | 1,683 | 100% | 1,706 | 100% | 1,773 | 100% |
| Hotel/Motel | 539 | 32% | 551 | 32% | 592 | 33% |
| Private Home | 1,050 | 62% | 1,061 | 62% | 1,087 | 61% |
| Other | 95 | 6% | 94 | 6% | 95 | 5% |

Source: Dean Runyan Associates (2019, March). Oregon Travel Impacts Statewide Estimates: 1992-2018p. Retrieved from http://www.deanrunyan.com/doc_library/ORImp.pdf

### *Persons with Disabilities*

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003). A similar percentage of the people in Region 3 identify as having a disability as do people throughout the state.

The region also has a similar share of younger people (< 18) and older people (≥ 65) with a disability. Within the region, Linn and Lane Counties have the highest percentages of people with a disability. Benton County has the smallest percentage among its overall population and among its younger and older populations.

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all. .

**Table 2-256. People with a Disability by Age Group in Region 3**

| | With a Disability (Total Population) | | | Under 18 Years with a Disability | | | 65 Years and Over with a Disability | | |
|---|---|---|---|---|---|---|---|---|---|
| | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) |
| **Oregon** | 14.6% | ☑ | 0.1% | 4.6% | ☑ | 0.2% | 37.1% | ☑ | 0.4% |
| **Region 3** | 15.5% | ☑ | 0.3% | 5.3% | ☑ | 0.4% | 37.9% | ☑ | 0.7% |
| Benton | 10.5% | ☑ | 0.6% | 4.8% | ☑ | 1.1% | 30.6% | ☑ | 2.5% |
| Lane | 16.8% | ☑ | 0.5% | 5.4% | ☑ | 0.7% | 37.7% | ☑ | 1.1% |
| Linn | 17.4% | ☑ | 0.9% | 5.4% | ☑ | 1.2% | 41.4% | ☑ | 1.9% |
| Marion | 14.8% | ☑ | 0.5% | 5.4% | ☑ | 0.7% | 37.9% | ☑ | 1.5% |
| Polk | 14.4% | ☑ | 0.9% | 4.9% | ⊙ | 1.4% | 36.7% | ☑ | 2.7% |
| Yamhill | 15.7% | ☑ | 0.9% | 5.7% | ☑ | 1.3% | 40.4% | ☑ | 2.6% |

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark . However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

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

### *Homeless Population*

The U.S Department of Housing and Urban Development requires Continuums of Care to conduct the Point-in-Time Count (PIT), a biennial count of both sheltered and unsheltered people experiencing homelessness. These are rough estimates and can fluctuate with many factors. They should be understood as the absolute minimum number of people experiencing homelessness in the area (Oregon Housing and Community Services, 2019). Moreover, the PIT does not fully depict the extent of housing insecurity, as it excludes families or individuals that might be staying with friends or family due to economic hardship. The count also obscures the demographic composition of the houseless population, frequently undercounting people of color, for example (Oregon Housing and Community Services, 2019).

With the exception of Marion County, all counties in the region reported an increase in the overall number of homeless persons between 2017 and 2019. Linn County reported the largest percentage increase during this period (54%), while Lane County reported the greatest increase in the total number of people experiencing homelessness. Lane County also reported an increase in its unsheltered homeless population during this period and has one of the largest homeless populations in the state (Oregon Housing and Community Services , 2019).

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate their vulnerability. Disasters that result in damage to the built environment can place additional stress on temporary shelters, a vital service for many people experiencing homelessness (Peacock , Dash, Zhang, & Van Zandt, 2017). Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

**Table 2-257. Homeless Population Estimate for Region 3**

| | 2015 | 2017 | 2019 | Period Average |
|---|---|---|---|---|
| **Oregon** | 13,077 | 13,953 | 15,800 | 14,277 |
| **Region 3** | 3,091 | 3,640 | 4,575 | 3,769 |
| Benton | 127 | 287 | 331 | 248 |
| Lane | 1,473 | 1,529 | 2,165 | 1,722 |
| Linn | 222 | 180 | 277 | 226 |
| Marion | 732 | 1,049 | 974 | 918 |
| Polk | 42 | 102 | 121 | 88 |
| Yamhill | 495 | 493 | 707 | 565 |

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

## *Biological Sex and Gender*

The concepts of sex and gender are often used interchangeably but are distinct; sex is based on biological attributes (chromosomes, anatomy, hormones) and gender is a social construction that may differ across time, cultures, and among people within a culture (U.S. Census Bureau, 2019). Moreover, the two may or may not correspond (U.S. Census Bureau, 2019).

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019). According to the survey, there are slightly more women than men (98.3 men for every 100 women) (U.S. Census Bureau, 2019). The same is true for all counties in the region, except Benton County, which has slightly more men (101.9 men for every 100 women) (U.S. Census Bureau, 2019). Within the region, Polk County has the greatest male to female disparity (94.5 men for every 100 women) (U.S. Census Bureau, 2019).

Primarily empirical research has begun to emerge about the ways in which gender influences resilience to disasters. It indicates that gender influence is much more pervasive and expressed differently among men, women, LGBTQ+, and non-binary populations than has generally been recognize (Enarson, 2017). This is an area deserving of more attention as the field develops

## *Age*

Region 3 has the same proportion of older adults, persons aged 65 and older, as the state as a whole. Within the region, Benton and Marion Counties have the smallest share of older adults (14.6%) and Lane and Linn Counties have the greatest (17%). Older adults require special consideration in the planning process. They are more likely to have a disability and require assistance from others to complete routine tasks. Family or neighbors who might ordinarily assist them might be unable to help during a disaster event (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Moreover, an older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

Children, persons under the age of 18, also represent a vulnerable segment of the population. Within the region, Benton County has the smallest share (16.7%) of children and Marian County has the greatest (25.3%). Special consideration should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. Parents may lose time from work and money when their children's childcare facilities and schools are impacted by disasters (Cutter, Boruff, & Shirley, 2003).

**Table 2-258. Population by Vulnerable Age Group, in Region 3**

| | Total Population | Under 18 Years Old | | | 65 Years and Older | | |
|---|---|---|---|---|---|---|---|
| | Estimate | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) |
| **Oregon** | 4,025,127 | 21.5% | ☑ | 0.1% | 16.3% | ☑ | 0.1% |
| **Region 3** | 1,085,279 | 21.9% | ☑ | 0.0% | 16.3% | ☑ | 0.0% |
| Benton | 88,249 | 16.7% | ☑ | 0.1% | 14.6% | ☑ | 0.1% |
| Lane | 363,471 | 19.0% | ☑ | * | 17.7% | ☑ | 0.1% |
| Linn | 121,074 | 23.1% | ☑ | * | 17.6% | ☑ | 0.1% |
| Marion | 330,453 | 25.3% | ☑ | * | 14.6% | ☑ | 0.1% |
| Polk | 79,666 | 23.3% | ☑ | * | 16.9% | ☑ | 0.1% |
| Yamhill | 102,366 | 23.1% | ☑ | 0.1% | 15.9% | ☑ | 0.1% |

*Indicates that the estimate has been controlled to be equal to a fixed value and so it has no sampling error.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark . However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau (2018). Table DP05: ACS Demographics and Housing Estimates, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from http://factfinder2.census.gov/

## *Language*

Special consideration should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to language and culturally appropriate outreach materials. Similar to the state, almost 94% of the region's population speaks English "very well". Notably, approximately 11% of the people in Marion County speak English less than "very well". Outreach materials used to communicate with and plan for this community should take into consideration their language needs.

**Table 2-259. English Usage in Region 3**

| | Speak English Less Than "Very Well" | | | | |
|---|---|---|---|---|---|
| | Estimate | CV** | MOE (+/−) | Percent | % MOE (+/−) |
| **Oregon** | 222,428 | ☑ | 4,116 | 5.9% | 0.1% |
| **Region 3** | 57,156 | ☑ | 2,058 | 5.6% | 0.2% |
| Benton | 3,550 | ☑ | 466 | 4.2% | 0.6% |
| Lane | 9,080 | ☑ | 861 | 2.6% | 0.2% |
| Linn | 2,352 | ☑ | 404 | 2.1% | 0.4% |
| Marion | 33,206 | ☑ | 1,578 | 10.8% | 0.5% |
| Polk | 3,797 | ☑ | 587 | 5.1% | 0.8% |
| Yamhill | 5,171 | ☑ | 529 | 5.4% | 0.5% |

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark . However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

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

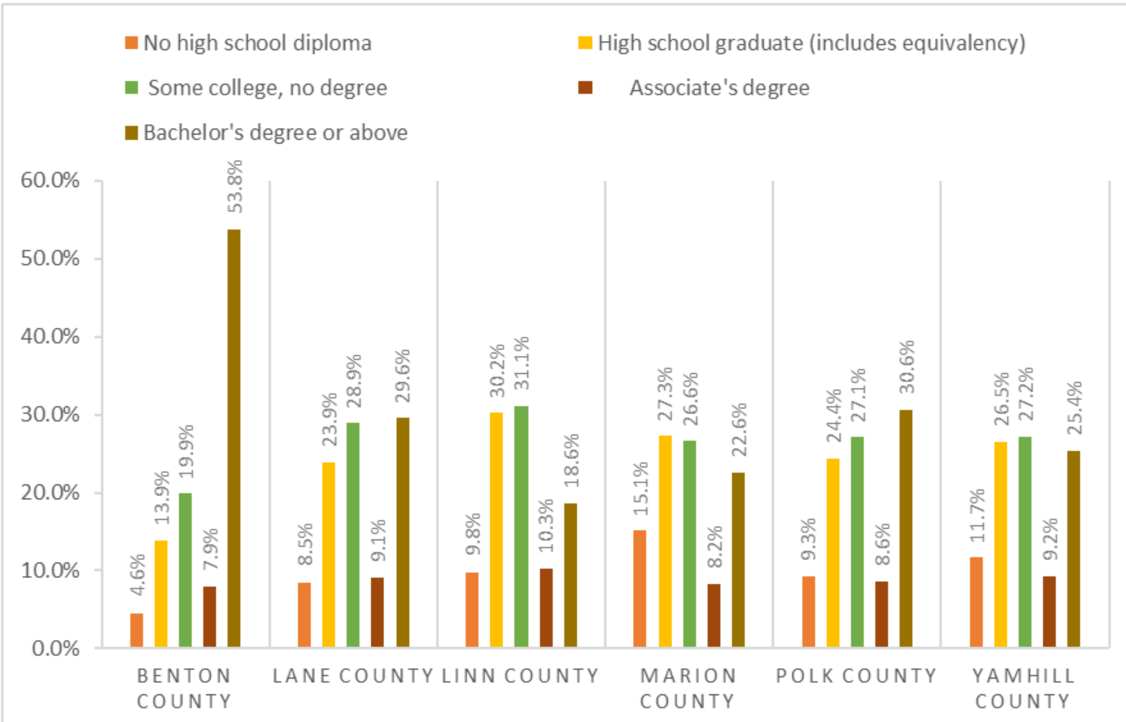
## *Education Level*

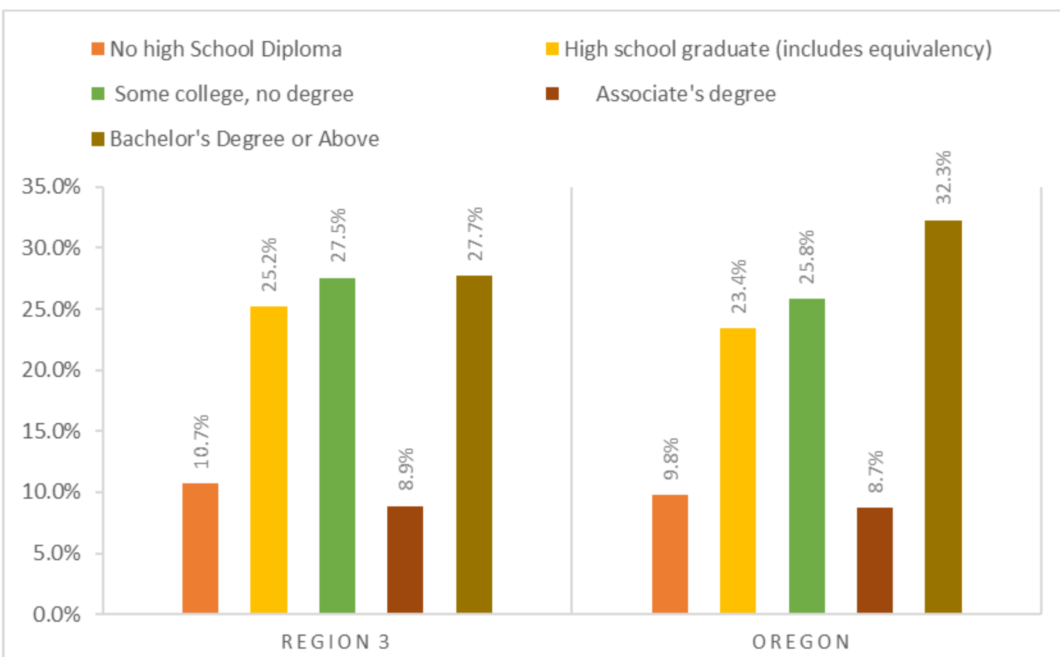
Studies show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings (Cutter, Boruff, & Shirley, 2003). Furthermore, education can influence an individual's ability to understand and act on warning information, navigate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

Approximately 28% of residents in Region 3 have a bachelor's degree or higher, which is approximately five percentage points lower than the statewide estimate. One tenth of residents in the region do not have a high school diploma, which is similar to the statewide share. Approximately one-quarter of the population has received some college credit. Similar to the statewide share, roughly 9% of Region 3 residents, or between 5%-10% in each county, has an associate's degree.

Benton County is a notable outlier in the region and state, with nearly 54% of residents holding a four-year degree or more. This is likely a result of a relatively small population and the presence of Oregon State University in Corvallis. Within the region, Linn County has the smallest share of residents with at a bachelor's degree or more (18.6%) and Marion County has the highest share of residents without a high school diploma (15.1%).

**Figure 2-166. Educational Attainment in Region 3: (top) by County, (bottom) Regional vs. Statewide**




Source: U.S. Census Bureau (2018). Table DP02: Selected Social Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from http://factfinder2.census.gov/

### *Income and Poverty*

The impact of a disaster in terms of loss and the ability to recover varies among population groups. "The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event" (Cutter S. L., 2006). Historically, 80% of the disaster burden falls on the public (Stahl, 2000). Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, are less likely to have the savings to rebuild after a disaster, and are less likely to have access to transportation and medical care.

Across the region, median household income generally declines with distance from the Portland Metropolitan Area. Yamhill County has the highest median household income, approximately $2,000 above the statewide median. Lane County has the lowest and is approximately $8,000 below the statewide estimate. From 2012 to 2017, only Lane County and Marion County experienced a statistically significant change in median household income—both increased.

**Table 2-260. Median Household Income in Region 3**

| | 2008–2012 | | | 2013–2017 | | | Statistically Different* |
|---|---|---|---|---|---|---|---|
| | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) | |
| **Oregon** | $53,427 | ☑ | $338 | $56,119 | ☑ | $370 | Yes |
| **Region 3** | — | — | — | — | — | — | — |
| Benton | $51,963 | ☑ | $2,574 | $54,682 | ☑ | $2,361 | No |
| Lane | $45,680 | ☑ | $858 | $47,710 | ☑ | $857 | Yes |
| Linn | $50,518 | ☑ | $1,304 | $49,515 | ☑ | $1,904 | No |
| Marion | $49,750 | ☑ | $848 | $53,828 | ☑ | $1,048 | Yes |
| Polk | $56,343 | ☑ | $2,001 | $56,032 | ☑ | $2,412 | No |
| Yamhill | $57,650 | ☑ | $2,043 | $58,392 | ☑ | $2,118 | No |

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

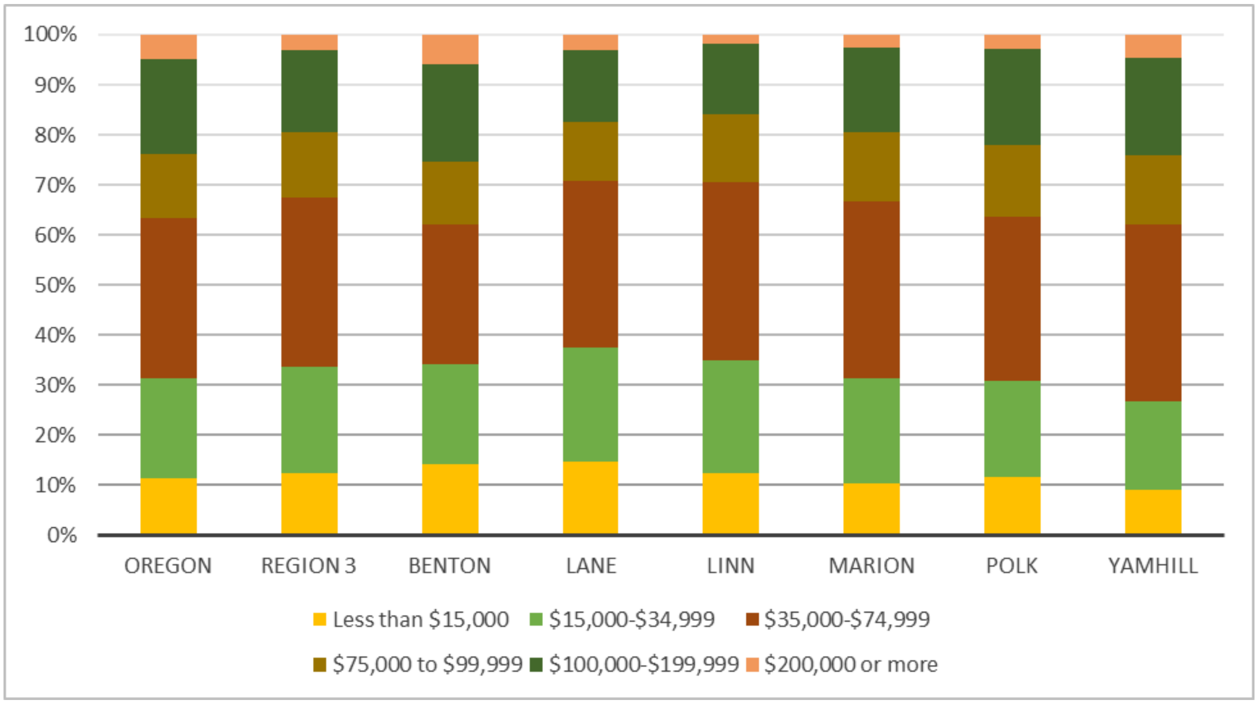
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates the two estimates are not statistically different.

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% – use with extreme caution) is shown with a red x-mark . However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2002 and 2013-2017. American Community Survey – 5-Year Estimates. Table CP03

The region has a larger share of its households earning less than $35,000 per year than the state as a whole. Within the region, Lane County has the highest percentage of people in the lowest income bracket, less than $15,000 per year, and Yamhill has the smallest share. Benton and Yamhill Counties have a higher percentage of households earning more than $75,000 per year than the state.

**Figure 2-167. Median Household Income Distribution in Region 3**




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

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018).

A greater share of the regional population overall is living in poverty compared to the state as a whole. Marion County was the only county in the region to experience a statistically significant change—a decrease—in the share of people experiencing poverty from 2012 to 2017. All counties in the region, with the exception of Yamhill County, have a higher percentage of people living in poverty than the state as a whole. Benton County has the largest share of people living in poverty, approximately six percentage points more than the statewide estimate and 3.7 above the regional share. However, it should be noted that poverty rates can be influenced by college students living off-campus. Past U.S. Census Bureau research found that Benton, Lane, and Polk Counties saw statistically significant decreases in poverty rates after the exclusion of off-campus college students (Benson & Bishaw, 2017). The majority of counties in their research saw decreases of five percentage points or less in their poverty rates when college students living off campus were excluded from the sample (Benson & Bishaw, 2017).

A higher percentage of children in Region 3 are living in poverty compared to the statewide share. Although Marion County continues to have the highest percentage of child poverty in the region, it was the only county that experienced a statistically significant decrease from 2012 to 2017. Benton County has the lowest estimate in the region, approximately six percentage points below the regional share.

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

**Table 2-261. Poverty Rates in Region 3**

| | Total Population in Poverty | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2008-2012 | | | 2013-2017 | | | Statistical Difference?* |
| | Estimate | CV** | MOE (+/−) | Estimate | CV** | MOE (+/−) | |
| **Oregon** | 15.5% | ☑ | 0.3% | 14.9% | ☑ | 0.3% | No |
| **Region 3** | 17.8% | ☑ | 0.5% | 17.0% | ☑ | 0.4% | No |
| Benton | 21.6% | ☑ | 1.3% | 20.7% | ☑ | 1.1% | No |
| Lane | 18.8% | ☑ | 0.7% | 18.8% | ☑ | 0.7% | No |
| Linn | 16.7% | ☑ | 1.3% | 16.1% | ☑ | 1.5% | No |
| Marion | 18.0% | ☑ | 1.0% | 15.9% | ☑ | 0.9% | Yes |
| Polk | 14.6% | ☑ | 1.5% | 15.4% | ☑ | 1.5% | No |
| Yamhill | 13.9% | ☑ | 1.4% | 13.7% | ☑ | 1.3% | No |

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

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark . However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2012 and 2013-2017. American Community Survey – 5-Year Estimates, Table S1701

**Table 2-262. Child Poverty in Region 3**

| | Children Under 18 in Poverty | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2008-2012 | | | 2013-2017 | | | Statistical Difference?* |
| | Estimate | CV** | MOE (+/−) | Estimate | CV** | MOE (+/−) | |
| **Oregon** | 20.6% | ✓ | 0.5% | 19.0% | ✓ | 0.6% | Yes |
| **Region 3** | 22.7% | ✓ | 1.0% | 20.7% | ✓ | 1.0% | Yes |
| Benton | 16.4% | ✓ | 3.4% | 12.8% | ✓ | 2.9% | No |
| Lane | 20.3% | ✓ | 1.7% | 20.3% | ✓ | 1.8% | No |
| Linn | 25.2% | ✓ | 2.7% | 21.6% | ✓ | 3.0% | No |
| Marion | 27.1% | ✓ | 1.8% | 23.2% | ✓ | 2.0% | Yes |
| Polk | 18.9% | ✓ | 3.4% | 17.5% | ✓ | 3.7% | No |
| Yamhill | 18.8% | ✓ | 2.7% | 19.5% | ✓ | 2.9% | No |

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

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark . However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2008-2012 and 2013-2017. American Community Survey – 5-Year Estimates, Table S1701

## *Housing Tenure*

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability (Cutter, Boruff, & Shirley, 2003). Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships (Lee & Van Zandt, 2019).

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster (Cutter, Boruff, & Shirley, 2003). Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions (Lee & Van Zandt, 2019).

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter (Lee & Van Zandt, 2019).

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster (Lee & Van Zandt, 2019). Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety (Lee & Van Zandt, 2019). Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all (Lee & Van Zandt, 2019).

The percentage of homeownership exceeds that of the state in Linn, Polk, and Yamhill Counties. Benton County has a higher rate of renter occupied units than other counties in the region. This number is likely driven by rental demand for off campus housing for students attending Oregon State University in Corvallis.

**Table 2-263. Housing Tenure in Region 3**

| | Total Occupied Units | Owner Occupied | | | Renter Occupied | | |
|---|---|---|---|---|---|---|---|
| | | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) |
| **Oregon** | 1,571,631 | 61.7% | ☑ | 0.3% | 38.3% | ☑ | 0.3% |
| **Region 3** | 410,949 | 60.7% | ☑ | 0.4% | 39.3% | ☑ | 0.5% |
| Benton | 34,775 | 56.9% | ☑ | 1.5% | 43.1% | ☑ | 1.5% |
| Lane | 148,752 | 58.8% | ☑ | 0.7% | 41.2% | ☑ | 0.7% |
| Linn | 46,265 | 64.1% | ☑ | 1.5% | 35.9% | ☑ | 1.5% |
| Marion | 116,077 | 59.8% | ☑ | 0.8% | 40.2% | ☑ | 0.8% |
| Polk | 29,128 | 64.6% | ☑ | 1.9% | 35.4% | ☑ | 1.9% |
| Yamhill | 35,952 | 67.9% | ☑ | 1.4% | 32.1% | ☑ | 1.4% |

Source: U.S. Census Bureau, 2013–2017 American Community Survey 5-Year Estimates, Table DP04; http://factfinder2.census.gov/

### *Families and Living Arrangements*

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households (Cutter, Boruff, & Shirley, 2003). Living alone can also be a risk factor—especially in poorer communities that lack adequate social infrastructure (Klinenberg, 2016). The American Community Survey defines a family household as one that contains a householder and one or more other people living in the same unit who are related by birth, marriage, or adoption. Conversely, a nonfamily household is one where someone is either living alone, or with nonrelatives only.

Region 3 is predominantly composed of family households. Benton and Lane Counties have higher percentages of non-family households and single-person households, estimates which are likely influenced by the presence of large universities. The region as a whole has approximately the same percentage of households with children as the state, but a greater share of single-parent households. Marion County has the highest percentage of single-parent households, followed closely by Linn and Yamhill Counties.

### Table 2-264. Family vs. Non-family Households in Region 3

| | Total Households | Family Households | | | Nonfamily Households | | | Householder Living Alone | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Estimate | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) |
| **Oregon** | 1,571,631 | 63.3% | ☑ | 0.2% | 36.7% | ☑ | 0.2% | 27.7% | ☑ | 0.2% |
| **Region 3** | 410,949 | 64.0% | ☑ | 0.5% | 36.0% | ☑ | 0.5% | 26.8% | ☑ | 0.4% |
| Benton | 34,775 | 55.9% | ☑ | 1.5% | 44.1% | ☑ | 1.5% | 27.9% | ☑ | 1.4% |
| Lane | 148,752 | 59.1% | ☑ | 0.7% | 40.9% | ☑ | 0.7% | 29.6% | ☑ | 0.7% |
| Linn | 46,265 | 68.1% | ☑ | 1.4% | 31.9% | ☑ | 1.4% | 24.7% | ☑ | 1.2% |
| Marion | 116,077 | 68.2% | ☑ | 0.8% | 31.8% | ☑ | 0.8% | 25.5% | ☑ | 0.8% |
| Polk | 29,128 | 67.9% | ☑ | 1.5% | 32.1% | ☑ | 1.5% | 24.0% | ☑ | 1.5% |
| Yamhill | 35,952 | 70.5% | ☑ | 1.6% | 29.5% | ☑ | 1.6% | 23.2% | ☑ | 1.5% |

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark . However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. http://factfinder2.census.gov/. Table DP02: Selected Social Characteristics

### Table 2-265. Family Households with Children by Head of Household in Region 3

| | Family Households with Children | | | Single Parent (Male or Female) | | |
|---|---|---|---|---|---|---|
| | Estimate | CV** | MOE (+/−) | Estimate | CV** | MOE (+/−) |
| **Oregon** | 26.2% | ☑ | 0.2% | 8.1% | ☑ | 0.2% |
| **Region 3** | 26.3% | ☑ | 0.4% | 8.5% | ☑ | 0.3% |
| Benton | 21.8% | ☑ | 1.0% | 4.6% | ☑ | 0.8% |
| Lane | 22.6% | ☑ | 0.5% | 7.8% | ☑ | 0.5% |
| Linn | 27.7% | ☑ | 1.0% | 9.6% | ☑ | 1.0% |
| Marion | 30.4% | ☑ | 0.8% | 10.2% | ☑ | 0.8% |
| Polk | 27.9% | ☑ | 1.4% | 7.4% | ☑ | 1.3% |
| Yamhill | 29.1% | ☑ | 1.2% | 9.1% | ☑ | 1.1% |

**The circle with a checkmark, circle within a circle, and circle with an x-mark indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with a green checkmark, medium reliability (CV between 15-30% – be careful) is shown as a yellow circle within a circle, and low reliability (CV >30% - use with extreme caution) is shown with a red x-mark . However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error and the need for precision.

Source: U.S. Census Bureau. 2013-2017 American Community Survey. http://factfinder2.census.gov/ . Table DP02: Selected Social Characteristics

### *Social and Demographic Trends*

The social and demographic analysis shows that Region 3 is particularly vulnerable during a hazard event in the following categories:

- Except for Marion County, all counties in the region experienced an increase in the overall number of homeless persons between 2015 and 2019.
- Lane County has one of the largest homeless populations in the state and experienced an increase in its unsheltered population during the same period.
- Approximately 11% of the population in Marion County does not speak English "very well".
- A greater share of the regional population is living in poverty compared to the statewide percentage. Moreover, a higher percentage of children are living in poverty in the region compared to the state as a whole. Marion County has the highest child poverty rate.
- Marion, Linn, and Yamhill have a higher share of single-parent households compared to the statewide estimate.

## Economy

The impact of natural hazards on economic conditions depends on many variables. For example the vulnerability of businesses' labor, capital, suppliers, and customers are all relevant factors (Zhang , Lindell, & Prater, 2009). Some industries rebound quickly and even thrive following a disaster, manufacturing and construction, for example. Others, like wholesale and retail, rebound more slowly or never recover (Zhang , Lindell, & Prater, 2009). Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how employment sectors, workforce participants, financial and natural resources, and critical infrastructure are interconnected and interdependent.

### *Employment and Unemployment*

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 3 have been steadily declining since they peaked in 2009 during the Great Recession. Within the region, rates are similar to the statewide average and consistently lowest in Benton County and highest in Linn County. Reflecting largest populations, the majority of employment is in Marion and Lane Counties.

**Table 2-266. Civilian Labor Force in Region 3, 2018**

| | Civilian Labor Force | Employed Workers | | Unemployed | |
|---|---|---|---|---|---|
| | Total | Total | Percent | Total | Percent |
| **Oregon** | 2,104,516 | 2,017,155 | 95.8% | 87,361 | 4.2% |
| **Region 3** | 544,552 | 521,334 | 95.7% | 23,218 | 4.3% |
| Benton | 48,345 | 46,810 | 96.8% | 1,535 | 3.2% |
| Lane | 181,761 | 173,596 | 95.5% | 8,165 | 4.5% |
| Linn | 58,551 | 55,780 | 95.3% | 2,771 | 4.7% |
| Marion | 161,676 | 154,716 | 95.7% | 6,960 | 4.3% |
| Polk | 39,695 | 37,959 | 95.6% | 1,736 | 4.4% |
| Yamhill | 54,524 | 52,473 | 96.2% | 2,051 | 3.8% |

Source: Oregon Employment Department, 2019

**Table 2-267. Civilian Unemployment Rates in Region 3, 2014-2018**

| | 2014 | 2015 | 2016 | 2017 | 2018 | Change (2014-2018) |
|---|---|---|---|---|---|---|
| **Oregon** | 6.8% | 5.6% | 4.8% | 4.1% | 4.2% | −2.6% |
| **Region 3** | 6.9% | 5.8% | 5.0% | 4.3% | 4.3% | −2.7% |
| Benton | 5.1% | 4.2% | 3.9% | 3.2% | 3.2% | −1.9% |
| Lane | 6.9% | 5.8% | 5.1% | 4.4% | 4.5% | −2.4% |
| Linn | 8.1% | 6.7% | 5.7% | 4.7% | 4.7% | −3.4% |
| Marion | 7.4% | 6.0% | 5.1% | 4.3% | 4.3% | −3.1% |
| Polk | 6.8% | 5.6% | 5.0% | 4.3% | 4.4% | −2.4% |
| Yamhill | 6.4% | 5.3% | 4.6% | 3.8% | 3.8% | −2.6% |

Source: Oregon Employment Department, 2019

### *Supersectors and Subsectors*

The North American Industry Classification System (NAICS) is a framework used by the United States, Canada, and Mexico to collect, analyze, and publish data about the North American economy. The classification system groups “economic units that have similar production processes” according to a six-digit hierarchical structure (Office of Management and Budget , 2020). “The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry” (Office of Management and Budget , 2020). The U.S. Bureau of Labor Statistics through its Quarterly Census of Employment and Wages program adds to the NAICS hierarchy by grouping NAICS sectors into supersectors (U.S. Bureau of Labor Statistics, 2019). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 1 were:

1. Trade, Transportation and Utilities
2. Education and Health Services
4. Local Government
5. Manufacturing
6. Leisure and Hospitality

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region’s resiliency. A business establishment is an “economic unit… that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity” (U.S. Bureau of Labor Statistics, 2019). In Region 3, the following supersectors comprise a significant share of all business establishments.

- The Other Services supersector includes the highest number of establishments in Region 3, 17.7% of the share (QCEW, 2018).
- Trade Transportation and Utilities is second largest, with 15.8% of all establishments (QCEW, 2018).

- Professional and Business Services is third with 13.5% of the regional share (QCEW, 2018).
- Professional and Business comprises is fourth, comprising 10.7% of all establishments (QCEW, 2018).
- The Construction supersector is fifth largest, making up 9.9% of all businesses (QCEW, 2018).

While supersectors are useful abstractions, it's important to remember that within are many small businesses employing fewer than 20 employees (Valdovinos, 2020). Due to their small size, these businesses are particularly sensitive to disruptions that may occur following a natural hazard event.

**Table 2-268. Covered Employment by Sector in Region 3**

| Industry | Region 3 | Benton County | | Lane County | | Linn County | |
|---|---|---|---|---|---|---|---|
| | % | Employment | % | Employment | % | Employment | % |
| **Total All Ownerships** | 100.0% | 38,058 | 100.0% | 156,759 | 100.0% | 47,341 | 100.0% |
| **Total Private Coverage** | 81.4% | 28,542 | 75.0% | 132,431 | 84.5% | 40,649 | 85.9% |
| Natural Resources & Mining | 4.6% | 1,083 | 2.8% | 2,360 | 1.5% | 2,447 | 5.2% |
| Construction | 5.4% | 1,198 | 3.1% | 7,204 | 4.6% | 3,030 | 6.4% |
| Manufacturing | 10.0% | 3,013 | 7.9% | 14,195 | 9.1% | 8,263 | 17.5% |
| Trade, Transportation & Utilities | 17.0% | 4,589 | 12.1% | 29,873 | 19.1% | 9,948 | 21.0% |
| Information | 1.1% | 600 | 1.6% | 2,411 | 1.5% | 393 | 0.8% |
| Financial Activities | 3.5% | 1,123 | 3.0% | 6,200 | 4.0% | 1,387 | 2.9% |
| Professional & Business Services | 9.3% | 4,284 | 11.3% | 18,188 | 11.6% | 2,959 | 6.3% |
| Education & Health Services | 16.6% | 6,760 | 17.8% | 27,763 | 17.7% | 6,438 | 13.6% |
| Leisure & Hospitality | 9.9% | 4,260 | 11.2% | 17,558 | 11.2% | 3,893 | 8.2% |
| Other Services | 4.0% | 1,622 | 4.3% | 6,630 | 4.2% | 1,872 | 4.0% |
| Unclassified | 0.0% | 11 | 0.0% | 48 | 0.0% | 19 | 0.0% |
| **Total All Government** | 18.6% | 9,516 | 25.0% | 24,328 | 15.5% | 6,692 | 14.1% |
| Total Federal Government | 1.0% | 476 | 1.3% | 1,802 | 1.1% | 306 | 0.6% |
| Total State Government | 4.9% | 216 | 0.6% | 1,680 | 1.1% | 599 | 1.3% |
| Total Local Government | 12.7% | 8,824 | 23.2% | 20,846 | 13.3% | 5,787 | 12.2% |

| Industry | Region 3 | Marion County | | Polk County | | Yamhill County | |
|---|---|---|---|---|---|---|---|
| | % | Employment | % | Employment | % | Employment | % |
| **Total All Ownerships** | 100.0% | 155,949 | 100.0% | 20,442 | 100.0% | 36,339 | 100.0% |
| **Total Private Coverage** | 81.4% | 121,028 | 77.6% | 15536 | 76.0% | 32155 | 88.5% |
| Natural Resources & Mining | 4.6% | 9,565 | 6.1% | 1750 | 8.6% | 3,669 | 10.1% |
| Construction | 5.4% | 9,993 | 6.4% | 1031 | 5.0% | 1,977 | 5.4% |
| Manufacturing | 10.0% | 10,862 | 7.0% | 2272 | 11.1% | 6896 | 19.0% |
| Trade, Transportation & Utilities | 17.0% | 25,739 | 16.5% | 2467 | 12.1% | 4844 | 13.3% |
| Information | 1.1% | 1,288 | 0.8% | 65 | 0.3% | 242 | 0.7% |
| Financial Activities | 3.5% | 5,714 | 3.7% | 463 | 2.3% | 1007 | 2.8% |
| Professional & Business Services | 9.3% | 13,555 | 8.7% | 1232 | 6.0% | 1940 | 5.3% |
| Education & Health Services | 16.6% | 24,704 | 15.8% | 3325 | 16.3% | 6392 | 17.6% |
| Leisure & Hospitality | 9.9% | 13,642 | 8.7% | 1995 | 9.8% | 3792 | 10.4% |
| Other Services | 4.0% | 5,916 | 3.8% | 924 | 4.5% | 1386 | 3.8% |
| Unclassified | 0.0% | 51 | 0.0% | 11 | 0.1% | 9 | 0.0% |
| **Total All Government** | 18.6% | 34,921 | 22.4% | 4,905 | 24.0% | 4,184 | 11.5% |
| Total Federal Government | 1.0% | 1,294 | 0.8% | 112 | 0.5% | 440 | 1.2% |
| Total State Government | 4.9% | 19,350 | 12.4% | 343 | 1.7% | 211 | 0.6% |
| Total Local Government | 12.7% | 14,277 | 9.2% | 4,450 | 21.8% | 3,532 | 9.7% |

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

Source: Oregon Employment Department. (2019). Quarterly Census of Employment and Wages. Retrieved from Qualityinfo.org

Each supersector faces distinct vulnerabilities to natural hazards. Identifying a region's dominant supersectors and the underlying industries enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment supersectors has sensitivity to natural hazards, as follows.

**Trade, Transportation, and Utilities:** Retail Trade is the largest employment sector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region.

**Education and Health Services:** The Health and Social Assistance industries play important roles in emergency response in the event of a disaster. Health care is a relatively stable revenue sector regionally with an abundant distribution of businesses primarily serving a local population.

**Manufacturing:** This supersector is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons the manufacturing sector may be susceptible to disruptions in transportation infrastructure. However, manufacturers are often less dependent on local markets for sales, which may contribute to the economic resilience of this sector. The timber manufacturing industry is particularly vulnerable to droughts, landslides, and wildfires.

**Leisure and Hospitality:** This supersector primarily serves regional residents with disposable income and tourists. The behavior of both of these social groups would be disrupted by a natural disaster. Regional residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Looking at industrial subsectors (three-digit NAICS) provides greater detail about the regional economy while maintaining a level of aggregation useful for analysis. The table below shows the top ten industries by share of employment within the region. Notably, in Region 2, three of the largest subsectors by share of employment are healthcare related, Ambulatory—also known as outpatient services—Health Care Services, Nursing and Residential Care Facilities, and Hospitals. Many of the top employment subsectors are similar across regions. For example, Food Services and Drinking Places and Educational Services are the two largest employment subsectors in Region 6. These subsectors also rank highly in other regions. Conversely, other subsectors, such as Crop Production, are more unique to the region.

**Table 2-269. Industries with Greatest Share of Employment in Region 3, 2018**

| Industry | Employment Share | Employment (2018) |
|---|---|---|
| Educational Services | 9% | 49,375 |
| Food Services and Drinking Places | 8% | 45,386 |
| Administrative and Support Services | 6% | 30,211 |
| Ambulatory Health Care Services | 5% | 24,936 |
| Nursing and Residential Care Facilities | 4% | 19,834 |
| Hospitals | 4% | 18,981 |
| Specialty Trade Contractors | 3% | 18,456 |
| Social Assistance | 3% | 18,306 |
| Professional, Scientific, and Technical Services | 3% | 18,050 |
| Crop Production | 3% | 16,292 |

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

### *Industry Concentration and Employment Change*

A location quotient (LQ) is a metric used to identify a region's area of industrial specialization. It is calculated by comparing an industry's share of regional employment with its share of employment in a reference economy (Quinterno, 2014). If a LQ is higher than 1.0, employment in that industry is more concentrated in that region than in the reference economy. In this case, the reference economy is the United States as a whole. Industries with a high LQ indicate the region might have a competitive advantage and that the industry is potentially—but not always—exporting goods and services. Understanding regional competitiveness and targeting mitigation strategies that make exporting industries less vulnerable can help the region's resiliency. Location quotients, however, require careful interpretation; analysis of employment data should be paired with local knowledge of regional business dynamics.

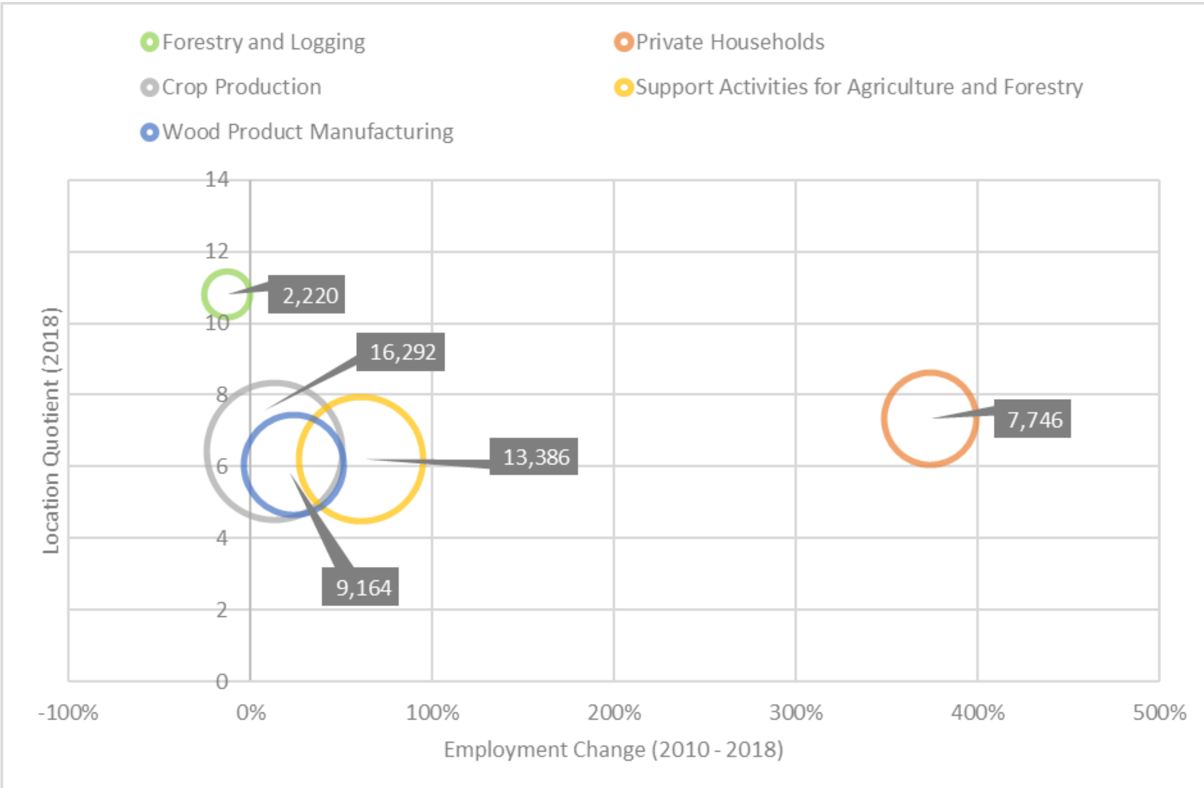
**Table 2-270. Most Concentrated Industries and Employment Change in Region 3, 2018**

| Industry | Location Quotient | Employment (2018) | Employment Change (2010–2018) |
|---|---|---|---|
| Forestry and Logging | 10.8 | 2,220 | −13% |
| Private Households | 7.3 | 7,746 | 374% |
| Crop Production | 6.4 | 16,292 | 13% |
| Support Activities for Agriculture and Forestry | 6.2 | 13,386 | 61% |
| Wood Product Manufacturing | 6.1 | 9,164 | 24% |

Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 3 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

**Figure 2-168. Location Quotients, Employment Change, and Total Employment in Region 3, 2018**




Source: U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018), Retrieved from: https://ledextract.ces.census.gov/static/data.html; Calculations for location quotient, average employment, and employment change by DLCD

Four of the region's five most concentrated industries are natural resource based—three have ties to timber. The Forestry and Logging subsector has the highest location quotient, but constitutes a small share of overall employment and shed jobs from 2010 to 2018. The Wood Product Manufacturing subsector has a location quotient over six—a value five-hundred percent higher than would be expected vis-à-vis the nation; the sector increased employment by nearly a quarter during the eight-year period. Employment concentrations in Crop Production and Support Activities of Agriculture and Forestry reflects the rich agricultural economy of the Mid-Willamette Valley and together comprise a significant number of jobs.

### *Fastest Growing and Declining Industries*

Empirical analysis suggests that natural disasters can accelerate preexisting economic trends (Zhang , Lindell, & Prater, 2009). Therefore, it is important for local planners to understand their region's existing economic context, which industries are growing and which are declining.

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 3's fastest growing and declining industries.

**Table 2-271. Fastest Growing and Declining Industries in Region 3, 2010-2018**

| Industry | Employment Change | Employment (2010) | Employment (2018) |
|---|---|---|---|
| **Fastest Growing** | | | |
| Private Households | 374% | 1,636 | 7,746 |
| Motion Picture and Sound Recording Industries | 265% | 771 | 2,811 |
| Other Information Services | 208% | 224 | 692 |
| Air Transportation | 144% | 446 | 1,086 |
| Construction of Buildings | 101% | 4,474 | 9,009 |
| **Fastest Declining** | | | |
| Apparel Manufacturing | −67% | 472 | 155 |
| Paper Manufacturing | −41% | 1,344 | 797 |
| Executive, Legislative, and Other General Government Support | −37% | 13,019 | 8,210 |
| Wholesale Electronic Markets and Agents and Brokers | −31% | 1,772 | 1,227 |
| Publishing Industries (except Internet) | −23% | 3,614 | 2,776 |

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

Mirroring a statewide trend, employment in the Private Households subsector grew quickly in Oregon from 2010 to 2018 (Wallis, 2019). The Private Households industry employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019).

While most employment in the Motion Picture and Sound Recording Industries subsector is concentrated in the Portland metro area, Region 3 experienced strong growth in the subsector during the eight-year period. This regional specialty is indicated in the shift-share analysis, which shows the regional-shift as the largest driver of growth. Part of the increase is likely driven by the state's reputation as a hub for multimedia artists and animators (Starbuck, 2016).

Growth in the Construction of Buildings subsector was strong and mostly driven by regional factors. One reason for strong growth through the period, however, is that the subsector was severely impacted by the housing-bubble that led to the Great Recession. The decline in employment began around 2007 and was at its lowest point in 2010 (Cooke, 2019).

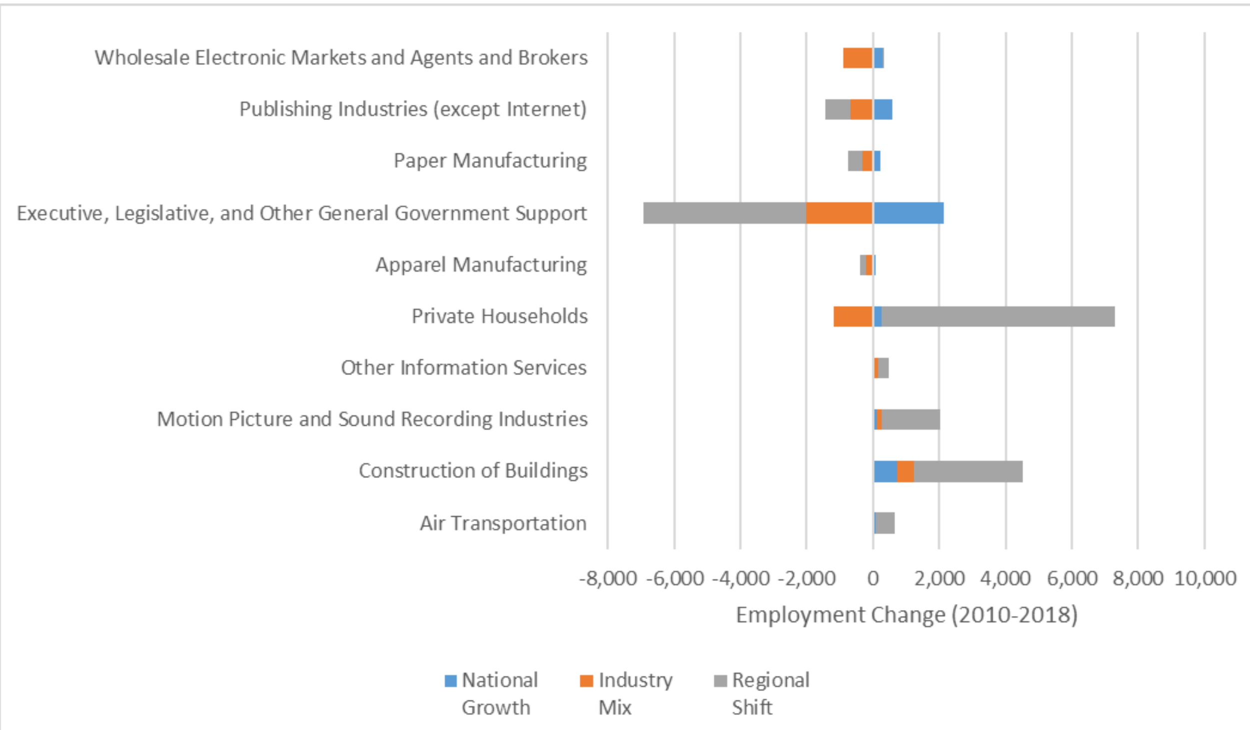
The Air Transportation and Other Information Services subsectors also experienced strong growth during the period. Growth in the Air Transportation subsector was likely drive in part by increased service and passenger travel in Eugene. According to the shift-share analysis, most of the growth in both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

The Wholesale Electronic Markets and Agents and Brokers subsector—which coordinates the sale of goods owned by others, typically for a commission or fee—lost jobs during the 2010 to 2018 period. According to the shift-share analysis, the job loss was not driven by regional factors but forces impacting the industry nationwide. The subsector is part of the larger Wholesale

Trade Sector, which generally saw an increase in employment in the state since the end of the Great Recession (Tauer, 2019).

The largest decline occurred in the Executive, Legislative, and Other General Government support. While some of the loss can be explained by trends in the subsector nationally, the regional shift suggests something unique happened in the region during the period. The same is true for trends in the Paper Manufacturing, Publishing Industries (Except Internet), and Apparel Manufacturing subsectors. Losses in the Paper Manufacturing subsector represent the continuation of a decade’s long statewide trend (Knoder, Paper Cuts: Oregon's Declining Paper Industry, 2018). Increased competition from abroad is a key driver of employment loss statewide (Knoder, Paper Cuts: Oregon's Declining Paper Industry, 2018). Job loss in Publishing Industries (Except Internet), a subsector comprised of newspaper and periodical businesses, is likely driven by shifts in the media landscape, away from print materials to online platforms.

**Figure 2-169. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 3, 2010-2018**




U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

**Table 2-272. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 2, 2010-2018**

| Industry | Employment Change | National Growth | Industry Mix | Regional Shift |
|---|---|---|---|---|
| **Fastest Growing** | | | | |
| Air Transportation | 640 | 740 | −24 | 591 |
| Construction of Buildings | 4,535 | 732 | 505 | 3,298 |
| Motion Picture and Sound Recording Industries | 2,040 | 126 | 116 | 1,798 |
| Other Information Services | 467 | 37 | 114 | 316 |
| Private Households | 6,110 | 268 | −1,200 | 7,043 |
| **Fastest Declining** | | | | |
| Apparel Manufacturing | −317 | 77 | −209 | −185 |
| Executive, Legislative, and Other General Government Support | −4,808 | 2,130 | −2,028 | −4,910 |
| Paper Manufacturing | −547 | 220 | −304 | −464 |
| Publishing Industries (except Internet) | −838 | 591 | −683 | −746 |
| Wholesale Electronic Markets and Agents and Brokers | −545 | 290 | −882 | 48 |

U.S. Census Bureau (2019), LEHD, Quarterly Workforce Indicators (2010 & 2018); Calculations for shift share by DLCD

## *Economic Trends and Issues*

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. The economic analysis of the region shows the following situations increase Region 3's level of vulnerability to natural hazard events:

- Unemployment in Linn County is consistently higher than its regional counterparts and higher than the statewide average;
- Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- The Forestry and Logging subsector, an area of competitive advantage for the region, shed jobs from 2010-2018.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event (Stahl et al., 2000).

## Infrastructure

### *Transportation*

#### *Roads*

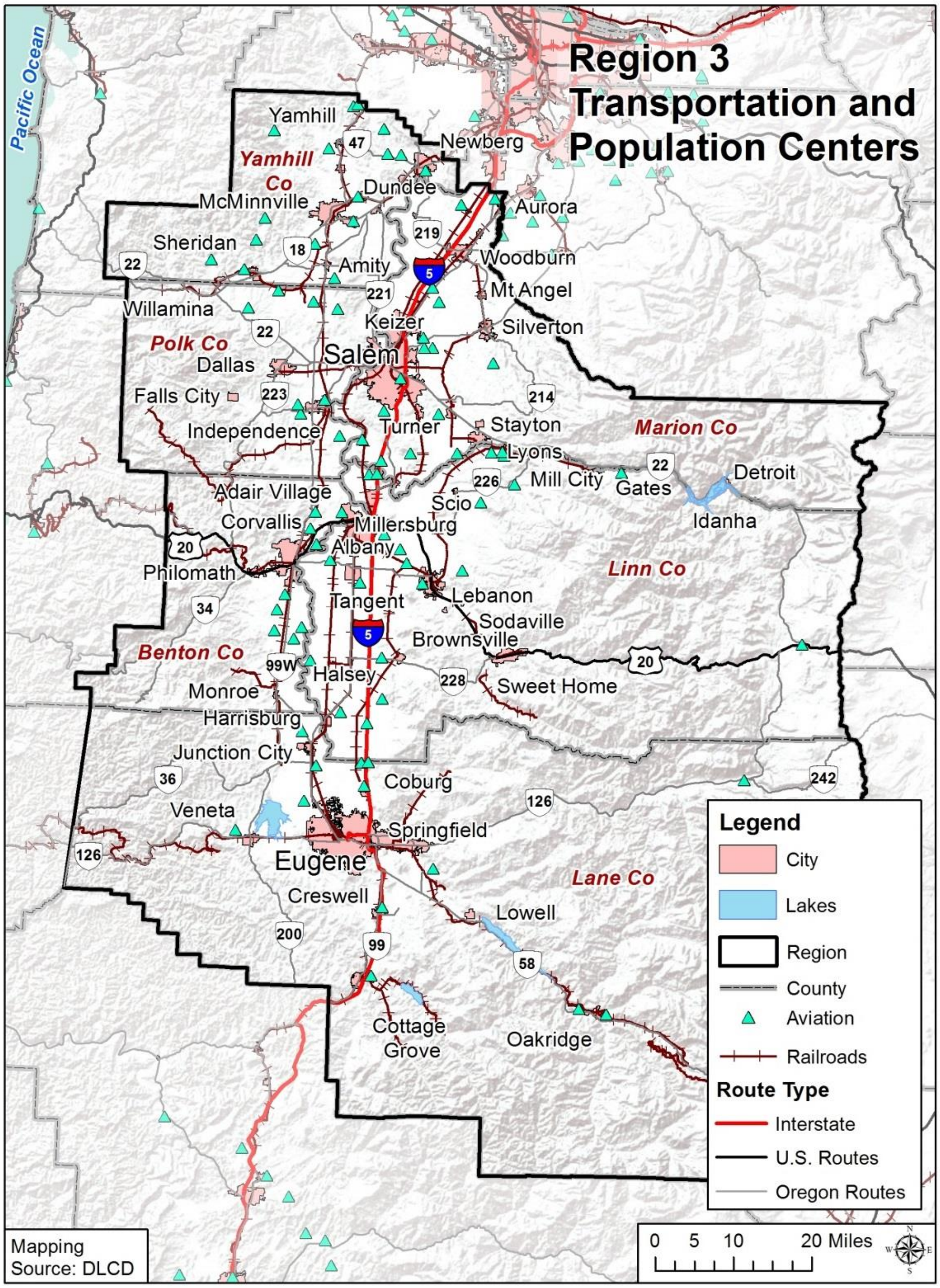
The highway system in the Region 3 centers on I-5 and the major east-west highways that intersect it. Recent population growth in the region has increased the number of vehicles on the roads. Many trips through the region originate outside the region in the Portland Metropolitan Area. Portland drivers commonly enter the region to reach Salem, The Spirit Mountain Casino, and coastal destinations. Many new residents of Yamhill County commute to Portland for work. **Figure 2-170** shows Region 3's highways and population centers.

Region 3's growing population centers bring more workers, automobiles and trucks onto roads. A high percentage of workers driving alone to work coupled with interstate and international freight movement on the I-5 corridor create additional stresses on transportation systems. Some of these include added maintenance, congestion, oversized loads, and traffic accidents.

Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuations and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

According to the Oregon Department of Transportation's (ODOT's) 2014 Seismic Plus Report (**Appendix 9.1.12**), the region has high exposure to earthquakes, especially a Cascadia Subduction Zone event. Therefore, the seismic vulnerability of the region's lifelines, including roadways and bridges, is an important issue. For information on ODOT's 2012 Seismic Lifelines Report findings for Region 3, see **Seismic Lifelines**.

**Figure 2-170. Region 3 Transportation and Population Centers**




Source: Oregon Department of Transportation, 2014

## *Bridges*

ODOT lists 2,096 bridges in the counties that comprise Region 3.

Because of earthquake risk in Region 3, the seismic vulnerability of the region's bridges is an important issue. Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or that are part of regional and local systems that are maintained by the region's counties and cities.

Table 2-273 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. These ratings do not imply that a bridge is unsafe (ODOT, 2020). A significant improvement in the condition of the region's bridges reduced to 7% (from 29% in 2012 and 2013) the percentage of the region's bridges that are distressed or deficient. About 2% (from 22% in 2012 and 2013) of the region's ODOT bridges are distressed. Seventeen percent of all bridges in Linn County are categorized as such, the highest percentage for any county in Oregon. Thirteen percent of city owned bridges in Linn County and 25% of Linn County owned bridges are categorized by ODOT as distressed or deficient.

**Table 2-273. Bridge Inventory for Region 3**

| | State Owned | | | County Owned | | | City Owned | | | Other Owned | | | Area Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Di | ST | %D* | De | ST | %D | De | ST | %D | De | ST | %D | D | T | %D |
| **Oregon** | 42 | 2,760 | 2% | 258 | 3,442 | 7% | 30 | 643 | 5% | 16 | 121 | 13% | 346 | 6,966 | 5% |
| **Region 3** | 12 | 717 | 2% | 119 | 1126 | 11% | 11 | 227 | 5% | 4 | 26 | 15% | 146 | 2096 | 7% |
| Benton | 0 | 44 | 0% | 11 | 93 | 12% | 2 | 29 | 7% | 0 | 2 | 0% | 13 | 168 | 8% |
| Lane | 7 | 290 | 2% | 7 | 410 | 2% | 2 | 74 | 3% | 2 | 11 | 18% | 18 | 785 | 2% |
| Linn | 2 | 142 | 1% | 77 | 306 | 25% | 5 | 40 | 13% | 0 | 4 | 0% | 84 | 492 | 17% |
| Marion | 0 | 138 | 0% | 10 | 139 | 7% | 1 | 71 | 1% | 0 | 6 | 0% | 11 | 354 | 3% |
| Polk | 0 | 52 | 0% | 5 | 89 | 6% | 1 | 13 | 8% | 2 | 2 | 100% | 8 | 156 | 5% |
| Yamhill | 3 | 51 | 6% | 9 | 89 | 10% | 0 | 0 | N/A | 0 | 1 | 0% | 12 | 141 | 9% |

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

Source: ODOT (2020)

### *Railroads*

Railroads are major providers of regional and national cargo and trade flows. Railroads that run through the Mid/Southern Willamette region primarily run in a north-south direction. The Union Pacific Railroad (UP) is the major freight railroad. An Amtrak passenger train also runs on the UP line. It runs north to Spokane and south to Southern California where the tracks turn east and continue to Texas. Other freight railroads in the region include the Central Oregon and Pacific, the Albany and Eastern, the Portland and Western, the Hampton Railway, the Willamette and Pacific, and the Willamette Valley Railway.

Oregon's rail system is critical to the state's economy, energy, and food systems. Rail systems export lumber and wood products, pulp and paper, and other goods produced in Oregon and products from other states that are shipped to and through Oregon by rail (Cambridge Systematics, 2014).

Rails are sensitive to icing from winter storms that can occur in the Mid/Southern Willamette Valley. Disruptions to the rail system can result in economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

#### *Airports*

Fifteen public airports, 73 private airports, two public helipads, and 16 private helipads serve Region 3. The Eugene Airport is the largest public airport in the region and the second busiest in Oregon (Federal Aviation Administration, 2012). The airport is owned, operated, and administered by the City of Eugene. It serves 10 hubs and six air carriers with approximately 56 arriving and departing flights daily (Eugene, Oregon website, Visitors page, https://www.eugene-or.gov/index.aspx?NID=1715).

**Table 2-274. Public and Private Airports in Region 3**

| | Number of Airports by FAA Designation | | | | |
|---|---|---|---|---|---|
| | Public Airport | Private Airport | Public Helipad | Private Helipad | Total |
| **Region 3** | 15 | 73 | 2 | 16 | 106 |
| Benton | 1 | 9 | 0 | 1 | 11 |
| Lane | 7 | 9 | 1 | 5 | 22 |
| Linn | 3 | 20 | 0 | 2 | 25 |
| Marion | 2 | 13 | 1 | 6 | 22 |
| Polk | 1 | 7 | 0 | 0 | 8 |
| Yamhill | 1 | 15 | 0 | 2 | 18 |

Source: FAA Airport Master Record (Form 5010), 2014

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on air freight may also be impacted by airport closures.

### *Energy*

#### *Electricity*

The region is served by several investor-owned, public, cooperative, and municipal utilities. The Bonneville Power Administration is the area's wholesale electricity distributor. Pacific Power and Light (Pacific Power) is the largest investor-owned utility company serving primarily Linn, Polk, and Marion Counties. Portland General Electric is another investor-owned utility and serves Marion and Yamhill Counties. The Blachly-Lane Electric Cooperative, Lane County Electric Cooperative, and Western Oregon Electric Cooperative each serve a portion of Region 3. Four municipal utility districts serve the region: Eugene Water and Electric Board, Monmouth, McMinnville, and Springfield Utility Board. In addition, the Central Lincoln People's Utility District, Consumer's Power, Inc., Emerald People's Utility District, and Salem serve portions of the region.

The Mid/Southern Willamette Valley has a total of 16 power-generating facilities: 11 hydroelectric power facilities, one natural gas power facility, and four “other” facilities (primarily biomass and solar photovoltaic). In total, the power-generating facilities have the ability to produce up to 668 megawatts (MW) of electricity.

**Table 2-275. Power Plants in Region 3**

| | Hydro-electric | Natural Gas | Wind | Coal | Other* | Total |
|---|---|---|---|---|---|---|
| **Region 3** | 11 | 1 | 0 | 0 | 4 | 16 |
| Benton | 0 | 0 | 0 | 0 | 0 | 0 |
| Lane | 7 | 1 | 0 | 0 | 1 | 9 |
| Linn | 4 | 0 | 0 | 0 | 1 | 5 |
| Marion | 0 | 0 | 0 | 0 | 0 | 0 |
| Polk | 0 | 0 | 0 | 0 | 0 | 0 |
| Yamhill | 0 | 0 | 0 | 0 | 2 | 2 |
| **Energy Production (MW)** | 585 | 51 | 0 | 0 | 32 | 668 |

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

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

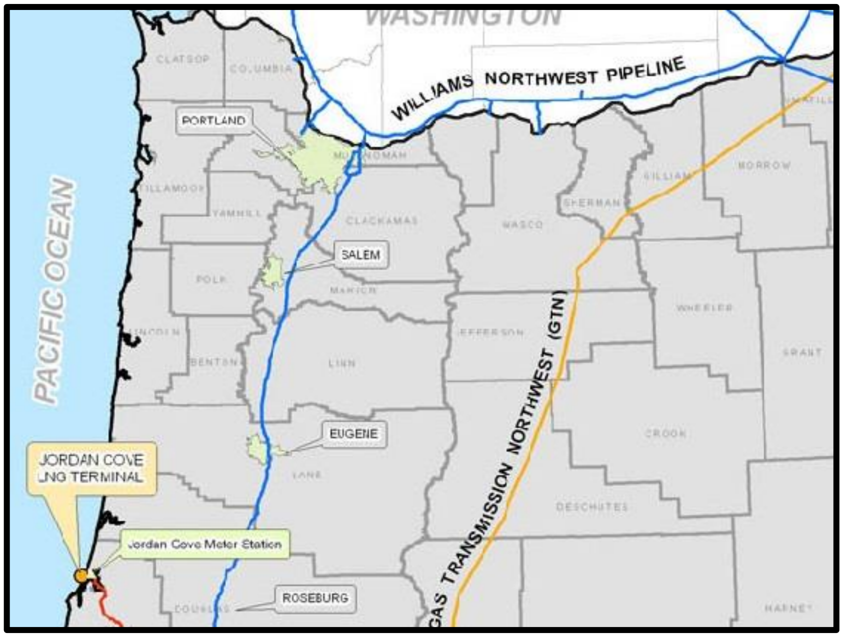
### *Hydropower*

The majority of electrical power in Region 3 is generated hydroelectrically. The Detroit, Carmen-Smith, and Lookout Point dams generate the most power for the region. They are each capable of generating over 100 MW. There are also several power plants that use biomass as their energy source (Loy, 2001). Bonneville Power Administration (BPA) provides hydro-generated electricity to the state’s consumer-owned utilities. BPA’s major dams in Region 3 are located on the following rivers: North Santiam River (Big Cliff and Detroit), South Santiam River (Foster and Green Peter), McKenzie River (Cougar), and Middle Fork of the Willamette River (Dexter, Lookout Point and Hills Creek).

### *Natural Gas*

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to Pacific Power’s portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-171** shows the Williams Northwest Pipeline, which runs through Marion, Linn, and Lane Counties (in blue) (Pipelines International, 2009). LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

**Figure 2-171. Liquefied Natural Gas Pipelines in Region 3**




Source: Retrieved from [http://gs-press.com.au/images/news_articles/cache/Pacific_Connector_Gas_Pipeline_Route-0x600.jpg](http://gs-press.com.au/images/news_articles/cache/Pacific_Connector_Gas_Pipeline_Route-0x600.jpg)

### *Utility Lifelines*

The Mid/Southern Willamette Valley is an important thoroughfare for oil and gas pipelines and electrical transmission lines, connecting Oregon to California and Canada. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe but infrequent natural hazards such as earthquakes. If these lines fail or are disrupted, the essential functions of the community can become severely impaired.

The electric, oil, and gas lines that run through the Mid/Southern Willamette region are both municipally and privately owned. A network of electrical transmission lines running through the region allows Oregon utility companies to exchange electricity with other states and Canada. Most of the natural gas Oregon uses originates in Alberta, Canada. Northwest Natural Gas owns one main natural gas transmission pipeline. An oil pipeline originating in the Puget Sound runs through the region and terminates in Eugene.

## *Telecommunications*

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio) under the Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013). Marion, Yamhill, and Polk Counties are part of the Capitol Operational Area. Lane, Benton, Linn, and coastal Douglas Counties are part of the South Valley Operational Area. Counties in this area can launch emergency messages by contacting the Oregon Emergency Response System (OERS) which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communication capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation's status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

#### *Television*

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The local primary station identified as the emergency messengers by the Oregon State Emergency Alert System Plan in Region 3 is KWVT-TV Channel 17 in Salem.

#### *Telephone and Broadband*

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 3. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is becoming more readily available in the region with a greater number of providers and service types available within major communities and along major transportation corridors (I-5, OR-99, etc.). The majority of areas that lack access to broadband service are in Coast Range and the Cascades mountains (NTIA, n.d.). Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

#### *Radio*

Radio is readily available to those who live within Region 3 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for the Capitol Operational Area are:

- KOPB-FM, 91.5 MHZ, Salem; and
- WXL-96.475 MHZ, Salem.

Radio transmitters for the South Valley Operational Area are (Oregon Office of Emergency Management, 2013):

- KWAX-FM, 91.1 MHZ, Eugene; 91.6 MHZ, Florence; 101.9 MHZ, Cottage Grove;
- KKNU-FM, 93.3 MHZ Eugene; 100.9 MHZ, Florence; 101.9 MHZ, Cottage Grove; and
- KOAC-AM, 550 KHZ, Albany, 103.1 MHZ, Corvallis.

#### *Ham Radio*

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). Region 3 is served by ARES District 4. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency

Management, n.d.). The official ham emergency station calls for Region 3 include (American Relay Radio League Oregon Chapter, www.arrloregon.org) include:

- Benton County: W7DMR;
- Lane County: K7BHB, N7NFS;
- Linn County: W7ACW;
- Marion County: KE70LU, KD7MGF, KC7BRZ, WA7ABU, KE7EXX, W7SDP;
- Polk County: KG7G; and
- Yamhill County: W7IG.

### *Water*

Water infrastructure includes drinking water, stormwater, and wastewater systems. All of these systems possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

#### *Drinking Water*

In Region 3 the majority of the municipal drinking water supply is obtained primarily from surface water sources. Surface water is drawn from rivers and smaller tributaries. These surface water sources are often backed up by groundwater that is drawn from an aquifer when surface water levels get low, especially in summer months

Rural residents draw water from surface water, groundwater wells, or springs. Areas with sedimentary and volcanic soils may be subject to high levels of arsenic, hydrogen sulfide, and fecal coliform bacteria, which can impact the safety of groundwater sources. In Polk County, saltwater naturally occurs in some aquifers, which presents a challenge during water shortages when aquifers are relied upon for backup water supply. In areas where no new live-flow water rights are available, farmers and ranchers are turning to above-ground storage to help supply water for crop irrigation during dry seasons.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. Non-point source pollution is a major threat to surface water quality, and may include stormwater runoff from roadways, agricultural operations, timber harvest, erosion and sedimentation. Landslides, flood events, and liquefaction from earthquakes can cause increased erosion and sedimentation in waterways.

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

#### *Stormwater and Wastewater*

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enter surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 3, most local building codes and stormwater management plans emphasize use of centralized storm sewer systems to manage stormwater. Requirements for stormwater mitigation vary in Region 3. Low impact development (LID) mitigation strategies can alleviate or lighten the burden to a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, at lower speed, and at lower temperatures. Most cities in Region 3 use the State of Oregon Residential Specialty Code, which does not address the issue of stormwater mitigation on new or existing construction. However, some cities, such as Eugene, require LID stormwater mitigation strategies in their building code. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems, and increase a community's resilience to many types of hazard events.

### *Infrastructure Trends and Issues*

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

Roads, bridges, railroads, and airports are vulnerable to natural hazards. Failures of this infrastructure can be devastating to the economy and health of the region's residents. Bridges are particularly vulnerable to seismic events. Forty-four percent of all state-owned bridges in the region that have been identified as distressed or deficient are within Lane County. Railroads are sensitive to icing from winter storms. The second largest airport in the Oregon is in Region 3, along with several smaller airports and helipads.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. The majority of power in the region is generated hydroelectrically and there are 16 power-generating facilities in the Mid/Southern Willamette Valley. The majority of dams are in Marion and Yamhill Counties. The three major dams are Detroit, Carmen-Smith, and Lookout Point. Roughly 14% (53) of all dams in the region are either Significant or High Threat Potential. Liquid Natural Gas is transported through the region via the Williams Northwest Pipeline that runs through Marion, Linn, and Lane Counties.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services do not cover many rural areas of the region that are distant from major transportation corridors. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Water systems in the region are particularly vulnerable to hazard events because they tend to be centralized and lacking in system redundancies. Furthermore, because most drinking water is sourced from surface water, the region is at risk of high levels of pollutants entering waterways such as through combined sewers that overflow during high-water events. Older, centralized infrastructure in storm and wastewater infrastructure creates vulnerability in the system during flood events. The City of Eugene employs decentralized, low-impact development (LID) stormwater systems to better manage high-precipitation events.

## Built Environment

### *Development Patterns*

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program is 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards (DLCD website, 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.

Regionally, between 2000 and 2010, urban areas in the Mid/Southern Willamette Valley have grown comparably to other urban areas statewide, with the greatest increases in population occurring in Linn, Polk, and Yamhill Counties. Benton is the only county in the region to experience a more even distribution of population growth in both urban and rural areas, roughly 9%. The most extreme shifts between urban and rural areas occurred in Yamhill County — 28% increase in urban populations and a 10.8% decrease in rural populations.

The percent growth of housing units in urban areas between 2000 and 2010 is almost 4 times that in rural areas. Linn, Polk, and Yamhill Counties have had the greatest increases in urban housing. Rural housing has increased by almost 16% in Benton County.

Unsurprisingly, populations tend to cluster around major road corridors and waterways. This holds true for the major cities of Eugene, Albany, Corvallis, and Salem and for the cities of Portland Metro area.

### Table 2-276. Urban and Rural Populations in Region 3, 2010

| | Urban | | | Rural | | |
|---|---|---|---|---|---|---|
| | 2000 | 2010 | % Change | 2000 | 2010 | % Change |
| **Oregon** | 2,694,144 | 3,104,382 | 15.2% | 727,255 | 726,692 | -0.1% |
| **Region 3** | 738,040 | 850,560 | 15.2% | 198,347 | 193,337 | -2.5% |
| Benton | 63,378 | 69,521 | 9.7% | 14,775 | 16,058 | 8.7% |
| Lane | 260,514 | 290,084 | 11.4% | 62,445 | 61,631 | -1.3% |
| Linn | 65,349 | 79,759 | 22.1% | 37,720 | 36,913 | -2.1% |
| Marion | 241,260 | 274,046 | 13.6% | 43,574 | 41,289 | -5.2% |
| Polk | 47,672 | 60,378 | 26.7% | 14,708 | 15,025 | 2.2% |
| Yamhill | 59,867 | 76,772 | 28.2% | 25,125 | 22,421 | -10.8% |

Source: U.S. Census Bureau, 2010 Census.

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

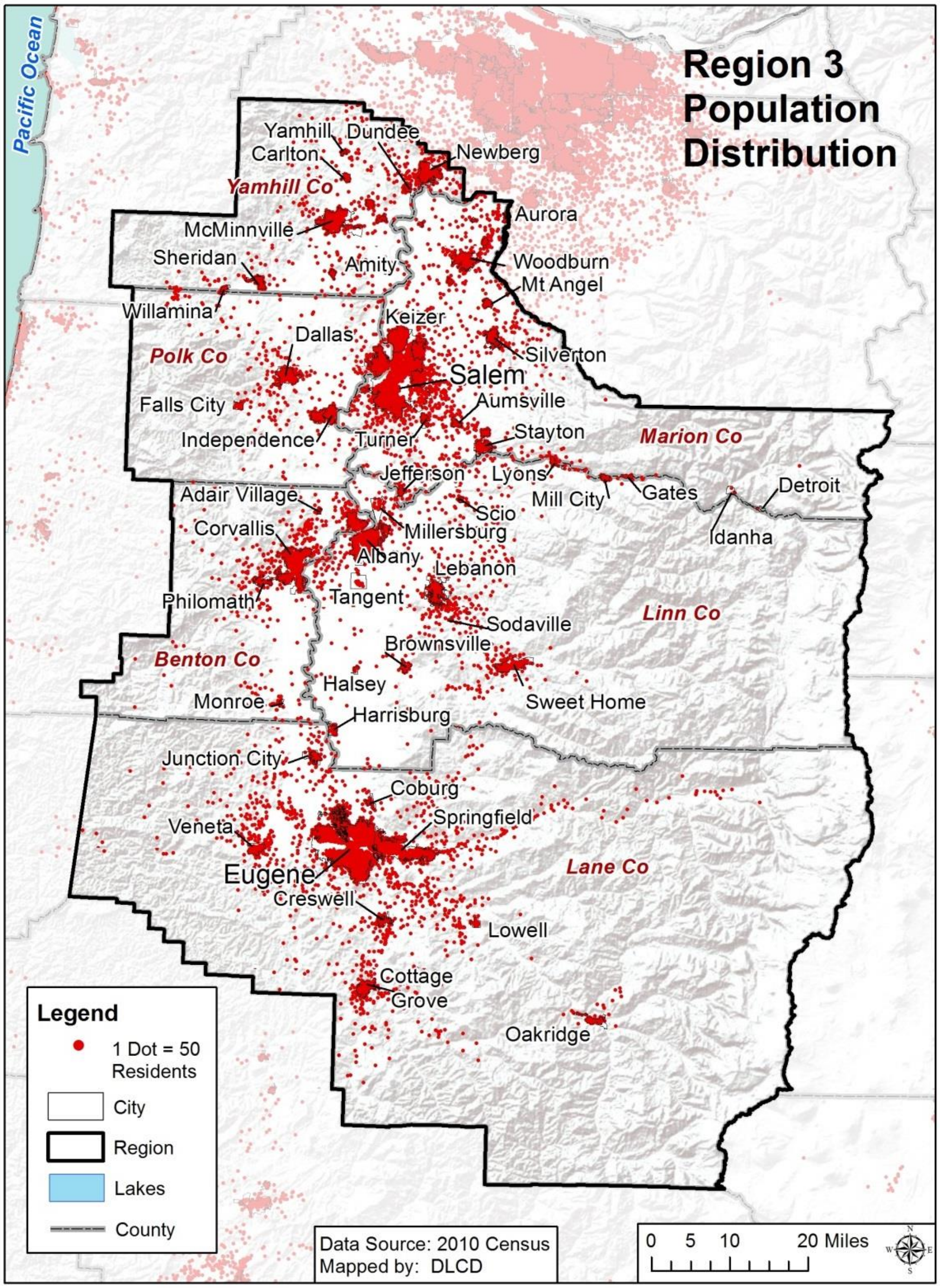
### Table 2-277. Urban and Rural Housing Units in Region 3, 2010

| | Urban | | | Rural | | |
|---|---|---|---|---|---|---|
| | 2000 | 2010 | % Change | 2000 | 2010 | % Change |
| **Oregon** | 1,131,574 | 1,328,268 | 17.4% | 321,135 | 347,294 | 8.1% |
| **Region 3** | 298,306 | 348,148 | 16.7% | 78,046 | 81,390 | 4.3% |
| Benton | 26,115 | 29,459 | 12.8% | 5,865 | 6,786 | 15.7% |
| Lane | 112,750 | 128,267 | 13.8% | 26,196 | 27,845 | 6.3% |
| Linn | 27,712 | 33,467 | 20.8% | 14,809 | 15,354 | 3.7% |
| Marion | 91,846 | 104,590 | 13.9% | 16,328 | 16,358 | 0.2% |
| Polk | 18,851 | 24,204 | 28.4% | 5,610 | 6,098 | 8.7% |
| Yamhill | 21,032 | 28,161 | 33.9% | 9,238 | 8,949 | -3.1% |

Source: Source: U.S. Census Bureau, 2010 Census.

APA Citation: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table H2
U.S. Census Bureau (n.d.). 2000 Decennial Census, Table H002

**Figure 2-172. Region 3 Population Distribution**




Source: U.S. Census, 2012

### *Land Use and Development Patterns (Lettman, 2011)*

Similar to Region 2, Region 3 overall has a larger percentage of private land (58%) than federal land (40%), with most of the federal holdings ranging up the slopes of the Cascades. However, the northern portion is dominated by agricultural activities, while the southern end has a much larger share of BLM and Forest Service timberland. As a result, Polk County, for example, is mostly privately owned, while just 42% of Lane County (minus the coastal portion) is in private hands.

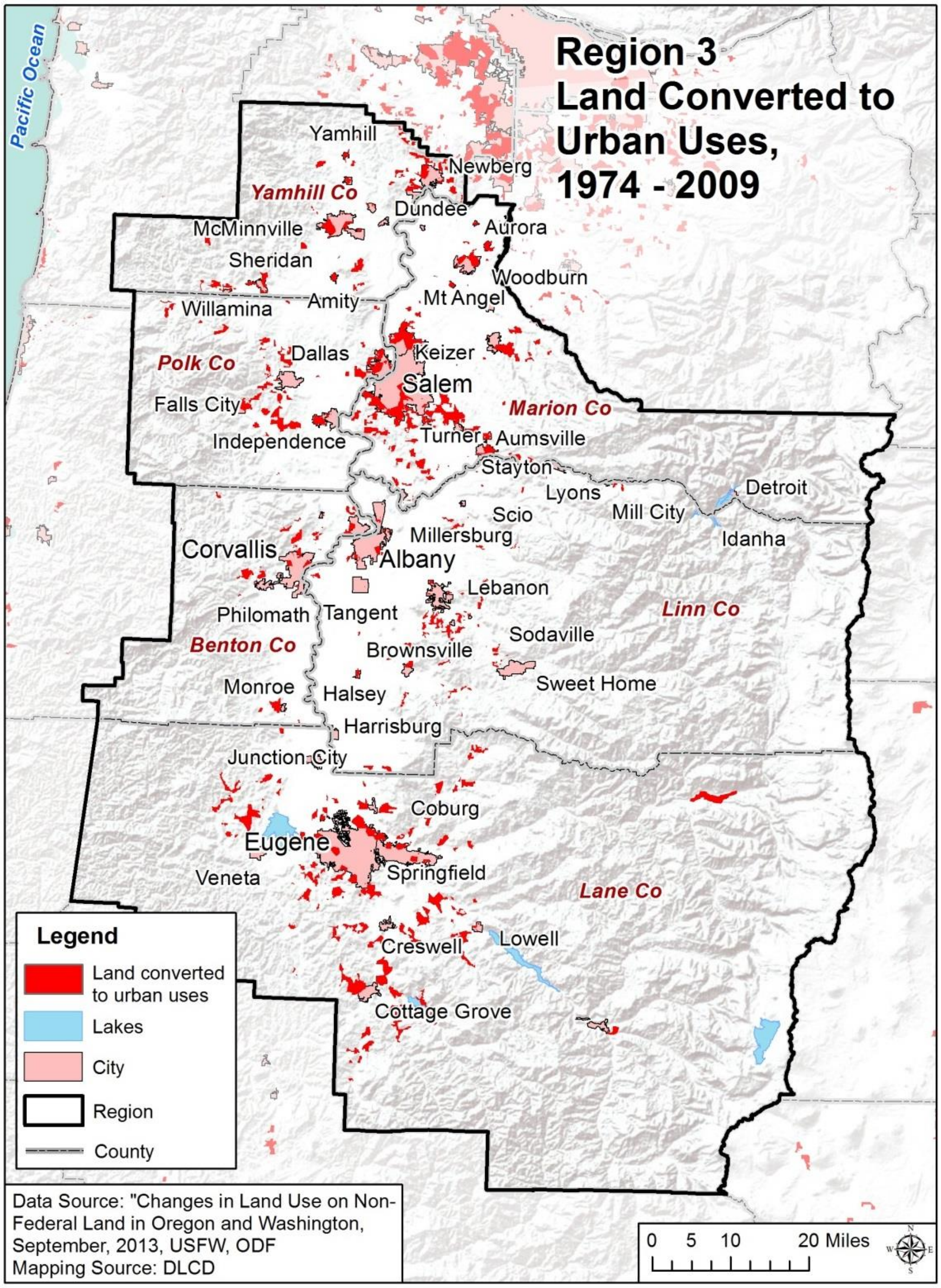
The South Willamette Region is a land of contrasts, with urban areas nestled within productive farmland, bordered by the Cascade and Coast Range timberlands. I-5 runs the length of the region, and this area's economy is shaped by the transportation system. With 61 incorporated communities in the region, there is continued pressure on area ecosystems from population growth, land use conversion, and altered habitat, fire regimes, and floodplain development.

Oregon Department of Forestry data shows that in the 25-year period between 1984 and 2009, approximately 147,000 acres of farm and range land in the state transitioned from land use classes more conducive to commercial farm or forest practices into more developed land classes. Almost half of all farm land conversion occurred in central Oregon, while nearly one quarter took place in the Metro area and one quarter in the general area of Region 3 (Lettman, 2011).

This region of the state is often subject to major flooding events, and communities have experienced major floods in 1861, 1890, 1945, 1956, 1964, 1996, and 2011. Generally, they have responded by keeping their flood ordinances current as well as going beyond minimum standards. For example, Corvallis, Albany, and Benton County integrate natural hazard information into their Comprehensive Plan, assuring that proper planning, such as determining if enough buildable land is available for future growth, and policies that regulate and prohibit development in natural hazard areas, will help minimize the extent of damage from future hazard events.

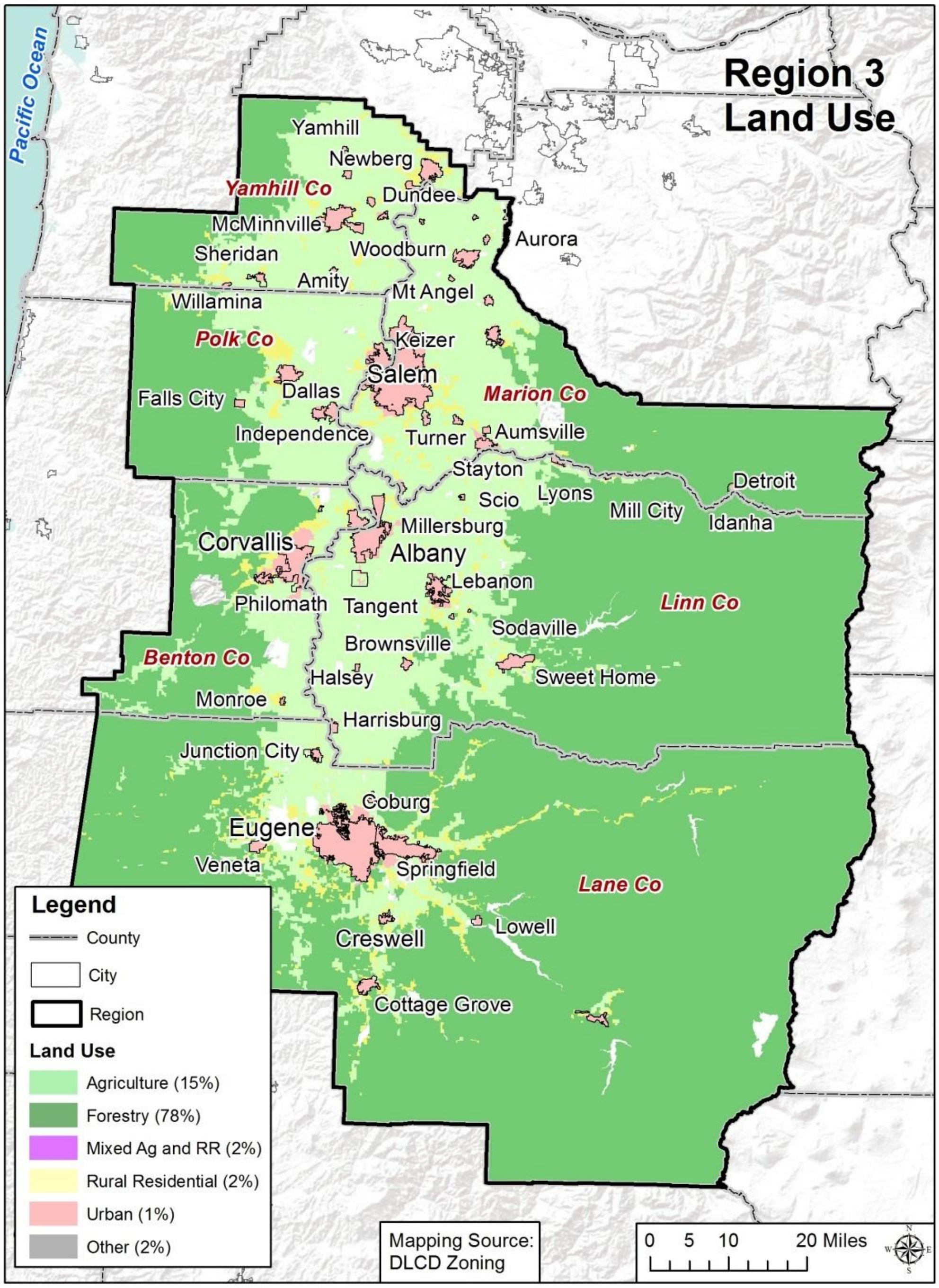
The Eugene-Springfield area is the second largest metropolitan area in Oregon, but expansion options are restricted by potential landslide and flood hazard areas. These communities are doing what they can to accommodate growth inside existing UGBs while minimizing encroachment into known hazard areas. One strategy they are using is to allow increased intensity of development outside of hazard areas, reducing the need to develop within them. For example, Eugene minimizes residential development on steep slopes by requiring larger lot sizes, and using floodplain areas as parks and open spaces. Overall, Eugene's average density has increased, and the mix of housing types is shifting toward more multi-family (DLCD, internal communication, 2014).

**Figure 2-173. Region 3 Land Converted to Urban Uses, 1974–2009**




Source: Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

**Figure 2-174. Region 3 Land Use**




Source: DLCD, Statewide Zoning

### *Housing*

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. The majority of the region's housing stock is single-family homes. Mobile residences make up 9.0% of Region 3's housing overall, but Linn and Yamhill Counties have a higher share of mobile homes. 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 2-278. Housing Profile for Region 3**

| | Total Housing Units | Single Familiy | | | Multi Family | | | Mobile Homes | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) |
| **Oregon** | 1,733,041 | 68.1% | ☑ | 0.3% | 23.5% | ☑ | 0.3% | 8.2% | ☑ | 0.1% |
| **Region 3** | 441,923 | 68.3% | ☑ | 0.5% | 22.4% | ☑ | 0.5% | 9.0% | ☑ | 0.3% |
| Benton | 37,789 | 64.7% | ☑ | 1.5% | 29.0% | ☑ | 1.9% | 6.0% | ☑ | 6.0% |
| Lane | 160,440 | 67.5% | ☑ | 0.7% | 23.2% | ☑ | 0.9% | 8.8% | ☑ | 0.4% |
| Linn | 49,688 | 71.9% | ☑ | 1.3% | 16.4% | ☑ | 1.3% | 11.5% | ☑ | 0.9% |
| Marion | 124,317 | 66.4% | ☑ | 1.0% | 24.5% | ☑ | 1.0% | 8.9% | ☑ | 0.5% |
| Polk | 31,403 | 72.6% | ☑ | 2.0% | 19.7% | ☑ | 1.9% | 7.6% | ☑ | 1.0% |
| Yamhill | 38,286 | 73.6% | ☑ | 1.8% | 15.3% | ☑ | 1.5% | 10.6% | ☑ | 1.0% |

Notes: *Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red "x" icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau. 2013-2017. American Community Survey 5-Year Estimates

APA Citation: U.S. Census Bureau (2018).Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from http://factfinder2.census.gov/

**Table 2-279. Housing Vacancy in Region 3**

| | Total Housing Units | Vacant^ | | |
|---|---|---|---|---|
| | | Estimate | CV ** | MOE (+/−) |
| **Oregon** | 1,733,041 | 5.6% | ☑ | 0.2% |
| **Region 3** | 441,923 | 5.6% | ☑ | 0.3% |
| Benton | 37,789 | 7.0% | ☑ | 1.1% |
| Lane | 160,440 | 5.1% | ☑ | 0.5% |
| Linn | 49,688 | 5.7% | ☑ | 0.9% |
| Marion | 124,317 | 5.7% | ☑ | 0.6% |
| Polk | 31,403 | 6.4% | ☑ | 1.4% |
| Yamhill | 38,286 | 5.3% | ☑ | 1.1% |

Notes: ^ Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.
**Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red “x” icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. http://factfinder2.census.gov/. Table B25004: Vacancy Status

Aside from location and type of housing, the year structures were built (**Table 2-280**) has implications for level of vulnerability to natural hazards. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events.

Also in the 1970s, FEMA began assisting communities with floodplain mapping as part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally 35.6% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances. Just under one third of the region’s housing stock was built after 1990 and the codification of seismic building standards. Only 10% of homes in Polk and Yamhill Counties were built after 1990 and current seismic building standards.

**Table 2-280. Age of Housing Stock in Region 3**

| | Total Housing Units | Pre 1970 | | | 1970 to 1989 | | | 1990 or Later | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) | Estimate | CV ** | MOE (+/−) |
| **Oregon** | 1,733,041 | 34.6% | ☑ | 0.3% | 30.5% | ☑ | 0.3% | 34.9% | ☑ | 0.3% |
| **Region 3** | 441,923 | 34.2% | ☑ | 0.5% | 32.6% | ☑ | 0.5% | 33.3% | ☑ | 0.5% |
| Benton | 37,789 | 34.5% | ☑ | 2.0% | 31.2% | ☑ | 1.9% | 34.3% | ☑ | 1.8% |
| Lane | 160,440 | 37.5% | ☑ | 0.9% | 32.3% | ☑ | 0.9% | 30.2% | ☑ | 0.8% |
| Linn | 49,688 | 38.7% | ☑ | 1.8% | 30.0% | ☑ | 1.6% | 31.3% | ☑ | 1.4% |
| Marion | 124,317 | 31.5% | ☑ | 1.0% | 36.4% | ☑ | 1.1% | 32.0% | ☑ | 1.0% |
| Polk | 31,403 | 28.5% | ☑ | 2.0% | 26.6% | ☑ | 1.9% | 44.9% | ☑ | 2.1% |
| Yamhill | 38,286 | 27.3% | ☑ | 1.7% | 30.4% | ☑ | 1.7% | 42.3% | ☑ | 1.9% |

Notes: *Green, orange, and red icons indicate the reliability of each estimate using the coefficient of variation (CV). This table may not contain all these symbols. The lower the CV, the more reliable the data. High reliability (CV <15%) is shown with green checkmark icon, medium reliability (CV 15–30% — be careful) is shown with orange dot icon, and low reliability (CV >30% — use with extreme caution) is shown with red “x” icon. However, there are no absolute rules for acceptable thresholds of reliability. Users should consider the margin of error (MOE) and the need for precision.

Source: U.S. Census Bureau. 2013-2017. American Community Survey 5-Year Estimates. Table B25034

Table 2-281 shows the initial and current FIRM effective dates for Region 3 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, Flood section.

**Table 2-281. Community Flood Map History in Region 3**

| | Initial FIRM | Current FIRM |
|---|---|---|
| **Benton County** | August 5, 1986 | June 2, 2011 |
| Albany | *see Linn County* | *see Linn County* |
| Corvallis | Jan. 3, 1985 | June 2, 2011 |
| Monroe | Sep. 26, 1975 | June 2, 2011 |
| Philomath | June 15, 1982 | June 2, 2011 |
| **Lane County** | Dec. 18, 1985 | June 2, 1999 |
| Coburg | Jan. 6, 1985 | June 2, 1999 (M) |
| Cottage Grove | Nov. 15, 1985 | June 2, 1999 |
| Creswell | Sep. 18, 1985 | June 2, 1999 |
| Dunes City | Mar. 24, 1981 | June 2, 1999 (M) |
| Eugene | Sep. 29, 1986 | June 2, 1999 |
| Florence | May 17, 1982 | June 2, 1999 |
| Junction City | June 15, 1982 | June 2, 1999 |
| Lowell | June 2, 1999 | June 2, 1999 (M) |
| Oakridge | June 3, 1986 | June 2, 1999 |
| Springfield | Sep. 27, 1985 | June 2, 1999 |
| Veneta | Feb. 1, 1984 | June 2, 1999 |
| Westfir | Aug. 19, 1985 | June 2, 1999 |
| **Linn County** | Sep. 29, 1986 | Sep. 29, 2010 |
| Albany | April 3, 1985 | Sep. 29, 2010 |
| Brownsville | Aug. 17, 1981 | Sep. 29, 2010 |
| Halsey | Sep. 29, 2010 | Sep. 29, 2010 |
| Harrisburg | Feb. 3, 1982 | Sep. 29, 2010 |
| Idanha | Mar. 1, 1979 | Sep. 29, 2010 |
| Lebanon | July 2, 1981 | Sep. 29, 2010 |
| Lyons | Dec. 15, 1981 | Sep. 29, 2010 |
| Mill City | Mar. 1, 1979 | Sep. 29, 2010 |
| Millersburg | June 15, 1982 | Sep. 29, 2010 |
| Scio | Aug. 1, 1984 | Sep. 29, 2010 |
| Sweet Home | Mar. 1, 1982 | Sep. 29, 2010 |
| Tangent | May 17, 1982 | Sep. 29, 2010 |
| Waterloo | Sep. 29, 2010 | Sep. 29, 2010 |
| **Marion County** | Aug. 15, 1979 | Jan. 2, 2003 |
| Aumsville | Mar. 1, 1979 | Jan. 19, 2000 |
| Aurora | June 5, 1979 | **Jan.** 19, 2000 |
| Detroit | June 30, 1976 | Jan. 19, 2000 |
| Gates | Dec. 4, 1979 | Jan. 19, 2000 |
| Gervais | June 30, 1976 | June 30, 1976 |
| Hubbard | Feb. 5, 1986 | Jan. 19, 2000 |
| Jefferson | Mar. 1, 1979 | Jan. 19, 2000 |
| Keizer | May 1, 1985 | Jan. 19, 2000 |
| Mt. Angel | Jan.19, 2000 | Jan. 19, 2000 |
| Salem | June 15, 1979 | Jan. 2, 2003 |
| Scotts Mills | Mar. 1, 1979 | Jan. 19, 2000 |
| Silverton | Mar. 1, 1979 | Jan. 19, 2000 |
| St. Paul | Jan. 19, 2000 | Jan. 19, 2000 |
| Stayton | Mar. 1, 1979 | Jan. 19, 2000 |
| Turner | Apr. 2, 1979 | Jan. 19, 2000 |
| Woodburn | Mar. 1, 1979 | Jan. 19, 2000 |
| **Polk County** | Feb. 15, 1978 | Dec. 19, 2006 |
| Dallas | Apr. 5, 1988 | Dec. 19, 2006 |
| Falls City | July 7, 1981 | Dec. 19, 2006 |
| Independence | Apr. 5, 1988 | Dec. 19, 2006 |
| Monmouth | Apr. 5, 1988 | Dec. 19, 2006 |
| Salem | *see Marion County* | *see Marion County* |
| **Yamhill County** | Sep. 30, 1983 | Mar. 2, 2010 |
| Amity | Dec. 1, 1981 | Mar. 2, 2010 |
| Carlton | June 30, 1976 | Mar. 2, 2010 |
| Dayton | June 1, 1982 | Mar. 2, 2010 |
| Dundee | Mar. 1, 1982 | Mar. 2, 2010 |
| Lafayette | June 15, 1982 | Mar. 2, 2010 |
| McMinnville | Dec. 1, 1982 | Mar. 2, 2010 |
| Newberg | Mar. 1, 1982 | Mar. 2, 2010 |
| Sheridan | Aug. 1, 1990 | Mar. 2, 2010 |
| Willamina | Mar. 15, 1982 | Mar. 2, 2010 |
| Yamhill, City | Mar. 1, 1982 | Mar. 2, 2010 |

(M) = no elevation determined; all Zone A, C, and X.

Source: Federal Emergency Management Agency, 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 3 can be found in **Table 2-282**. The region contains 58.3% of the total value of state-owned/leased critical/essential facilities. Many of the facilities are associated with the universities in Eugene and Corvallis and with state offices in Salem.

**Table 2-282. Value of State-Owned/Leased Critical and Essential Facilities in Region 3**

| | Total Property Value (State Facilities) | Percent State Total |
|---|---|---|
| **Oregon** | $7,339,087,023 | 100% |
| **Region 3** | $4,277,900,069 | 58.3% |
| Benton | $1,093,373,557 | 14.9% |
| Lane | $283,280,825 | 3.9% |
| Linn | $75,555,783 | 1.0% |
| Marion | $2,771,586,104 | 37.8% |
| Polk | $37,996,619 | 0.5% |
| Yamhill | $16,107,182 | 0.2% |

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 3 is largely an urban county with urban development focused around the major cities along I-5. Urban areas in Linn, Polk, and Yamhill are growing at a higher rate than the state, while Benton County's rural population is growing at a higher rate. The region has a slightly higher percentage of mobile homes than the state — the highest percentage being in Linn County 12.7%. Over one third of all homes in Polk and Yamhill Counties were built before 1970 and floodplain management standards. Furthermore, almost two thirds of the region's homes were built before 1990 and seismic building standards. All of the region's FIRMs have been modernized or updated.

## 2.3.3.3 Hazards and Vulnerability

### Droughts

#### *Characteristics*

Droughts are not common in Region 3. In 1992, the Governor declared a drought for all 36 counties in Oregon. However, since 1992, no Governor-declared droughts have occurred in Region 3 until 2015 when the Governor declared drought in Marion, Linn, and Lane counties. Federal drought declarations were given to all 36 Oregon counties in 2015. Nonetheless, a dry winter or spring can have an effect on water supplies within the Mid/Southern Willamette Valley.

#### *Historic Drought Events*

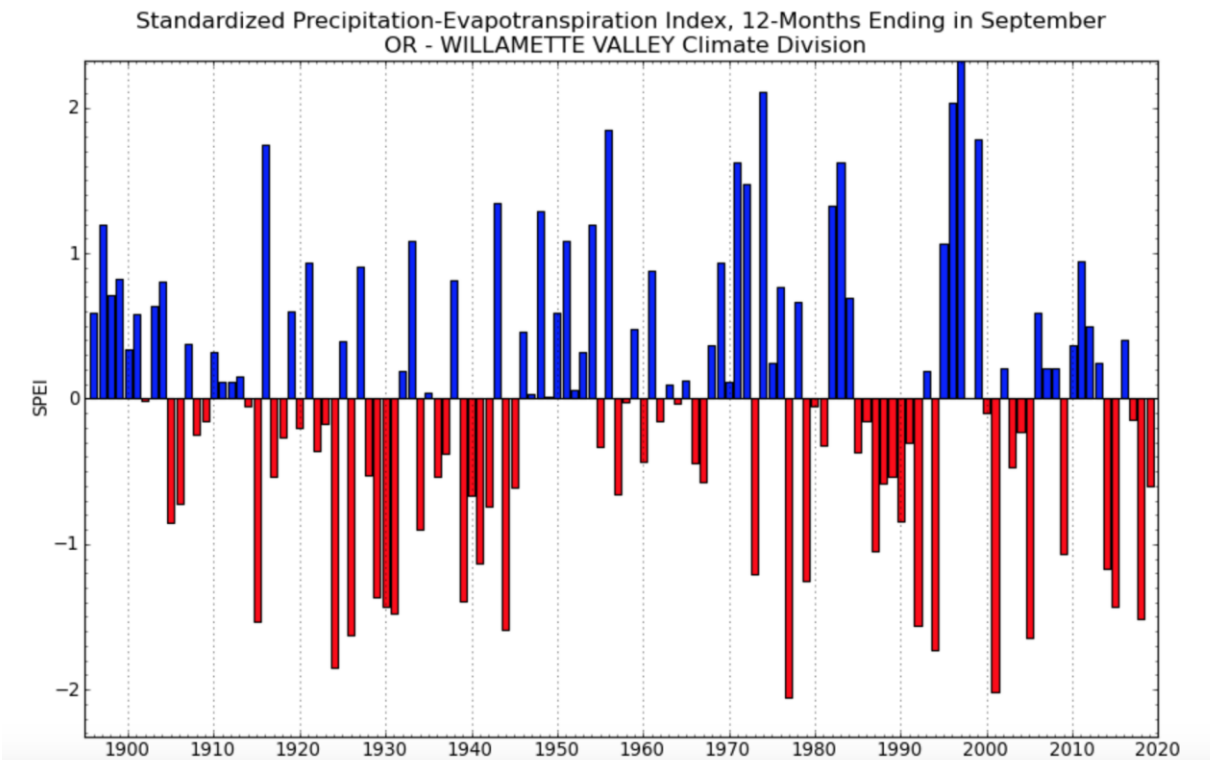
**Table 2-283. Historic Droughts in Region 3**

| Date | Location | Description |
|---|---|---|
| 1923-1924 | statewide | prolonged statewide drought that caused major problems for agriculture |
| 1928-1930 | Regions 1–3, 5–7 | moderate to severe drought affected much of the state; the worst years in Region 2 were 1928–1930, which initiated an era of many drier than normal years |
| 1938-1939 | statewide | the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country; Water Year 1939 was one of the more significant drought years in during that period |
| 1991-1992 | statewide, especially Regions 1–4, 8 | 1992 fell toward the end of a generally dry period, which caused problems throughout the state; the 1992 drought was most intense in eastern Oregon, with severe drought occurring in Region 1 |
| 2000-2001 | Regions 2–4, 6, 7 | the driest water year on record in the Willamette Valley (NOAA Climate Division 2); warmer than normal temperatures combined with dry conditions |
| 2015 | statewide | Governor-declared drought in 25 counties, including Marion, Linn, and Lane, with federal declarations in all counties. |

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

Historical drought information can also be obtained from the West Wide Drought Tracker, which provides climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. **Figure 2-175** shows years where drought or dry conditions affected the Willamette Valley (Climate Division 2). Based on this index, Water Years 1977 and 2001 were extreme drought years for the Willamette Valley. Years with at least moderate drought have occurred 21 times during 1895–2019 (**Table 2-284**).


**Figure 2-175. Standard Precipitation-Evapotranspiration Index for Region 3**




Drought Severity Scale: -1 to -1.49 = moderate drought; -1.5 to -1.99 = severe drought; -2.0 or less = extreme drought.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

**Table 2-284. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 2 according to Standard Precipitation-Evapotranspiration Index**

| Moderate Drought (SPEI < -1.0) | Severe Drought (SPEI < -1.5) | Extreme Drought (SPEI < -2.0) |
|---|---|---|
| 1931 | 1924 | 1977 |
| 1930 | 1994 | 2001 |
| 2015 | 2005 | |
| 1939 | 1926 | |
| 1929 | 1944 | |
| 1979 | 1992 | |
| 1973 | 1915 | |
| 2014 | 2018 | |
| 1941 | | |
| 2009 | | |
| 1987 | | |

Note: Within columns, rankings are from more severe to less severe.

Source: West Wide Drought Tracker, https://wrcc.dri.edu/wwdt/time/

Although not shown here, drought data from Climate Division 4, "the High Cascades," could also be analyzed to show a broader picture of drought impacts in Hazard Regions 2 and 3.

### *Probability*

**Table 2-285. Probability of Drought in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | VL | L | L | L | VL | VL |

Source: OWRD, DLCD

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases.

A comprehensive risk analysis is needed to fully assess the probability and impact of drought to Oregon communities. Such an analysis could be completed statewide to analyze and compare the risk of drought across the state.

Benton, Polk, and Yamhill Counties have received drought declarations in only 3% of the years since 1992, Marion and Linn in 7%, and Lane in 10%. This accounts for their very low and low probability, respectively, of experiencing drought.

#### *Climate Change*

Even though drought is infrequent in the mid-southern Willamette Valley, climate models project warmer, drier summers for Oregon, including Region 3. These summer conditions coupled with projected decreases in mid-to-low elevation mountain snowpack due to warmer winter temperatures increases the likelihood that Region 3 would experience increased frequency of one or more types of drought under future climate change. In Region 3, climate change would result in increased frequency of drought due to low spring snowpack (very likely, >90%), low summer runoff (likely, >66%), and low summer precipitation and low summer soil moisture (more likely than not, >50%). In addition, Region 3, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton et al., 2017).

### *Vulnerability*

**Table 2-286. Vulnerability to Drought in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | L | M | H | VH | M | H |

Source: OWRD, DLCD

Oregon has yet to undertake a comprehensive, statewide analysis to identify which communities are most vulnerable to drought.

Although long-term drought conditions are uncommon in the mid-Willamette Valley, a dry winter or spring could affect many communities and water users throughout the Basin. Recreation, particularly at the reservoirs owned and operated by the U.S. Army Corps of Engineers, contributes greatly to the valley's economy. Communities, such as Detroit in Marion County, can be economically impacted by low reservoir levels. The Willamette Valley is also home to one of the most productive and diverse agricultural regions in the United States. Drought, especially a long drought, could significantly impact agricultural production.

#### *Social Vulnerability*

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1-5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

Marion County's social vulnerability score is very high, Linn and Yamhill Counties' high. Lane and Polk Counties' social vulnerability score is moderate, Benton County's low. The social vulnerability score indicates the extent of impact of any natural hazard, including drought, on a county's population. Marion, Linn, and Yamhill are the communities most vulnerable to drought in Region 3.

### *Risk*

**Table 2-287. Risk of Drought in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Risk | L | M | H | H | M | M |

Source: OWRD, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based on social vulnerability, a review of Governor-declared drought declarations since 1992, and the potential for drought to impact Region 3's agricultural productivity and other economic drivers, Region 3 is considered to generally be at moderate to high risk from drought.

## Earthquakes

### *Characteristics*

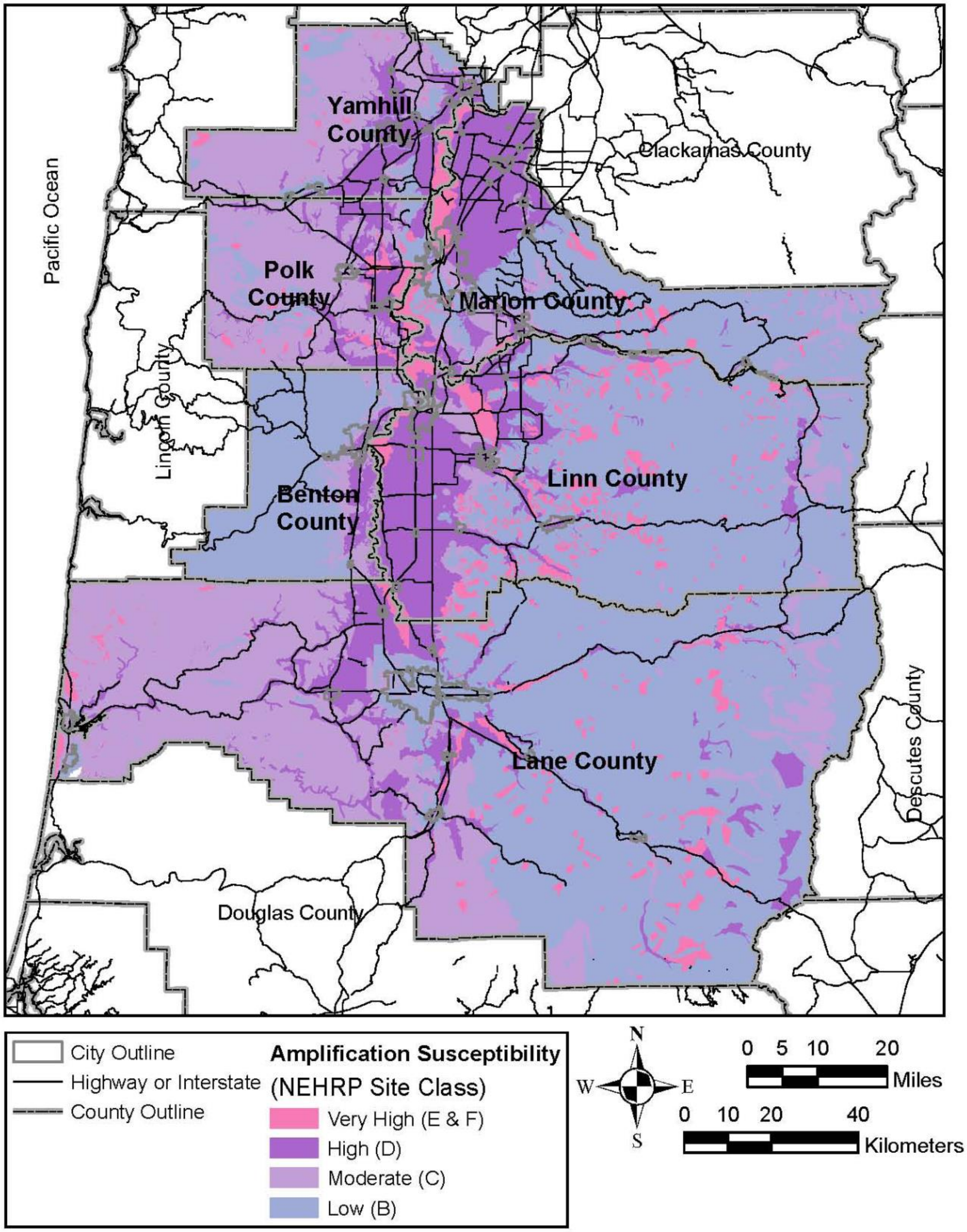
The geographic position of Region 3 makes it susceptible to earthquakes from four sources: (a) the off-shore Cascadia Fault Zone, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) shallow crustal events within the North America Plate, and (d) earthquakes associated with renewed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

Region 3 has experienced a few historic earthquakes centered in the region. In addition, the region has been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. All considered, there is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region and along the Cascadia Fault Zone. Deep-seated intra-plate events have been discovered by scientists in the region’s historic and pre-historic record, as occurred near Olympia, Washington in 1949 and 2001, could generate magnitudes as large as M7.5.

Earthquakes produced through volcanic activity could possibly reach magnitudes of 5.5. The 1980 Mount St. Helens eruption was preceded by a magnitude 5.1 earthquake. Despite the fact that Cascade volcanoes are some distance away from the major population centers in Region 3, earthquake shaking and secondary earthquake-related hazards such as lahars could cause major damage to these centers.

Earthquake-associated hazards include severe ground shaking, liquefaction of fine-grained soils, and landsliding. The severity of these effects depend on several factors, including the distance from the earthquake source, the ability of soil and rock to conduct seismic energy, and the degree and composition of slope materials. As seismic waves travel through bedrock, some energy propagates through surface soils to the ground surface. Soil deposits can either deamplify or amplify the shaking based on the characteristics of the deposit. This phenomenon is generally referred to as ground shaking amplification (GSA). **Figure 2-176** displays the areas in Region 3 with greater and lesser ground shaking amplification hazard.

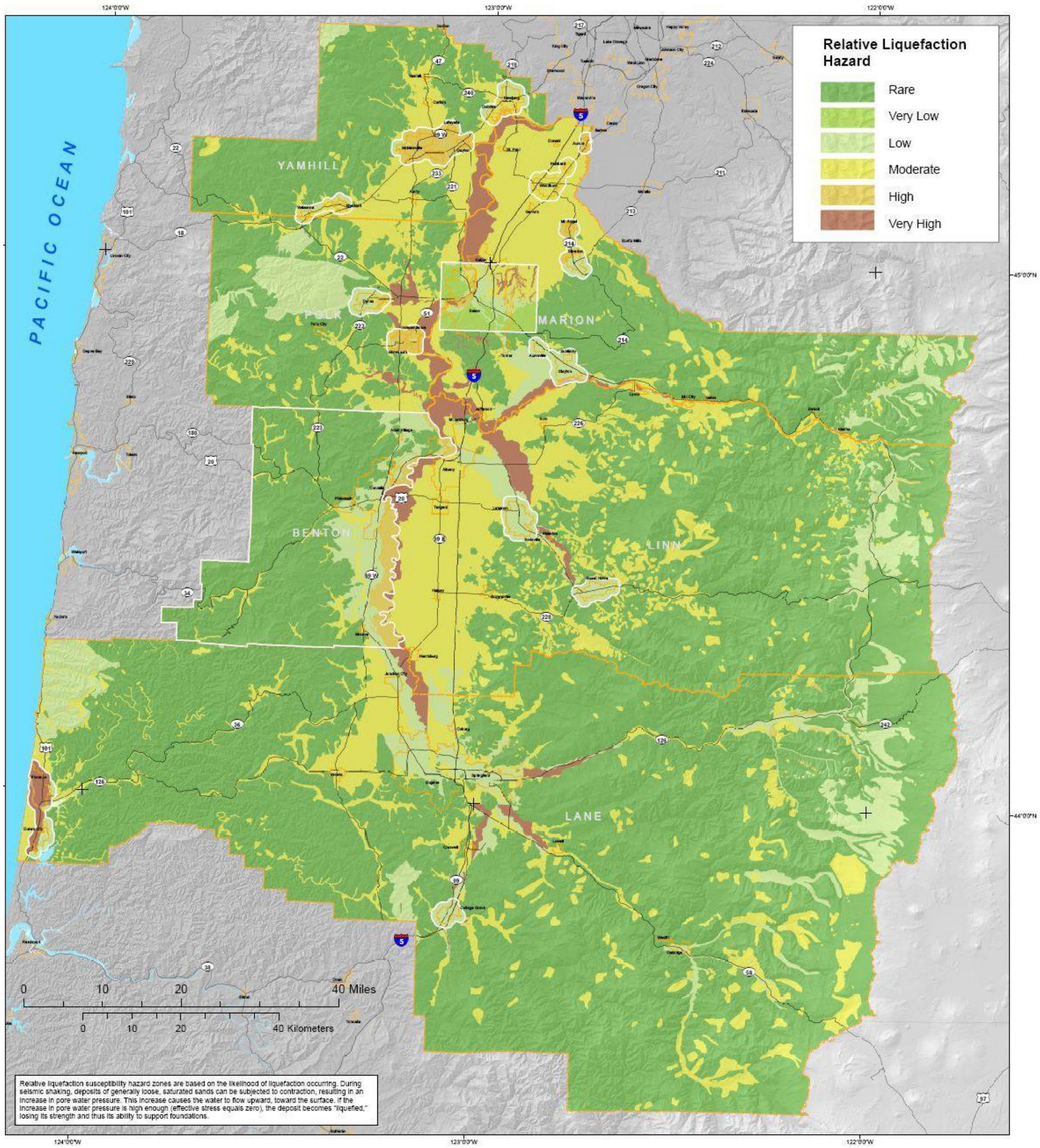
**Figure 2-176. Amplification Susceptibility for Region 3**




Source: Burns et al. (2008)

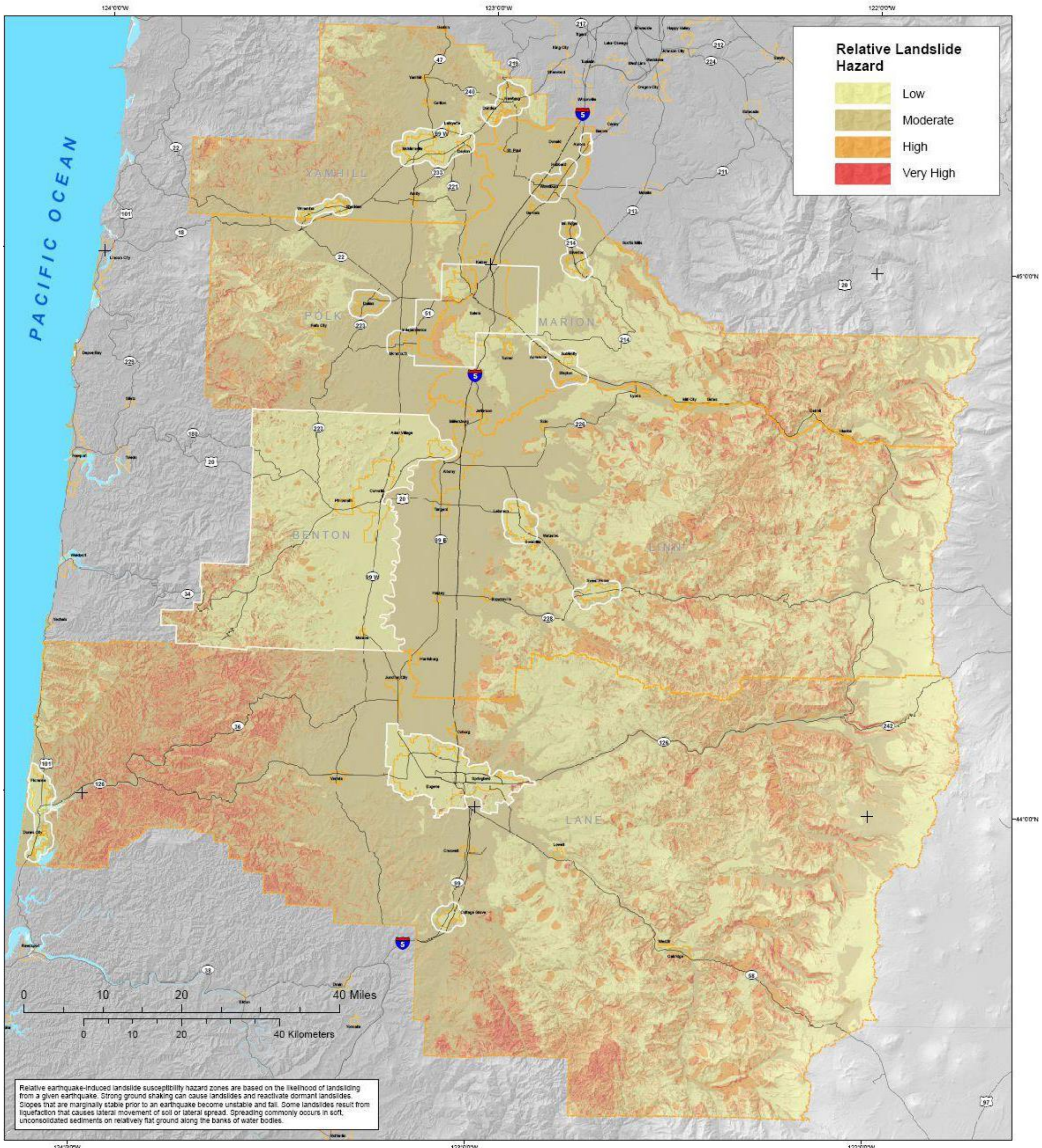
During seismic shaking, deposits of loose saturated sands can be subjected to contraction resulting in an increase in pore water pressure. If the increase in pore water pressure is high enough, the deposit becomes “liquefied,” losing its strength and thus its ability to hold and support loads. Figure 2-177 displays the areas in the region with greater and lesser liquefaction hazard.

**Figure 2-177. Relative Liquefaction Hazard for Region 3**




Source: Burns et al. (2008)

**Figure 2-178. Earthquake Induced Landslide Hazards for Region 3**




Source: Burns et al. (2008)

### *Historic Earthquake Events*

**Table 2-288. Significant Earthquakes Affecting Region 3**

| Date | Location | Magnitude (M) | Comments |
|---|---|---|---|
| Approximate Years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900 | offshore, Cascadia Subduction Zone | probably 8-9 | mid-points of the age ranges for these six events |
| Jan. 1700 | offshore, Cascadia Subduction Zone | about 9.0 | generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast |
| Apr. 1896 | McMinnville, Oregon | 4 | also felt in Portland |
| July 1930 | Perrydale, Oregon | 4 | cracked plaster |
| Apr. 1949 | Olympia, Washington | 7.1 | Intraplate event. Damage: significant (Washington); minor (NW Oregon) |
| Aug. 1961 | Albany, Oregon | 4.5 | damage: minor (Albany) |
| Nov. 1962 | Portland area, Oregon | 5.5 | shaking up to 30 seconds; chimneys cracked; windows broken; furniture moved |
| Mar. 1963 | Salem, Oregon | 4.6 | damage: minor (Salem) |
| Mar. 1993 | Scotts Mills, Oregon | 5.6 | FEMA-985-DR-Oregon; center: Mt. Angel-Gales Creek fault; damage: $30 million (including Oregon State Capitol in Salem) |
| Feb. 2001 | Nisqually, Washington | 6.8 | felt in the region; damage: none reported |
| Jul. 4, 2015 | East of Springfield, OR | 4.0 | |

*BCE: Before Common Era.

Sources: Wong and Bott (1995); Pacific Northwest Seismic Network, https://pnsn.org/

### *Probability*

**Table 2-289. Assessment of Earthquake Probability in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | H | VH | H | H | H | H |

Source: DOGAMI, 2020

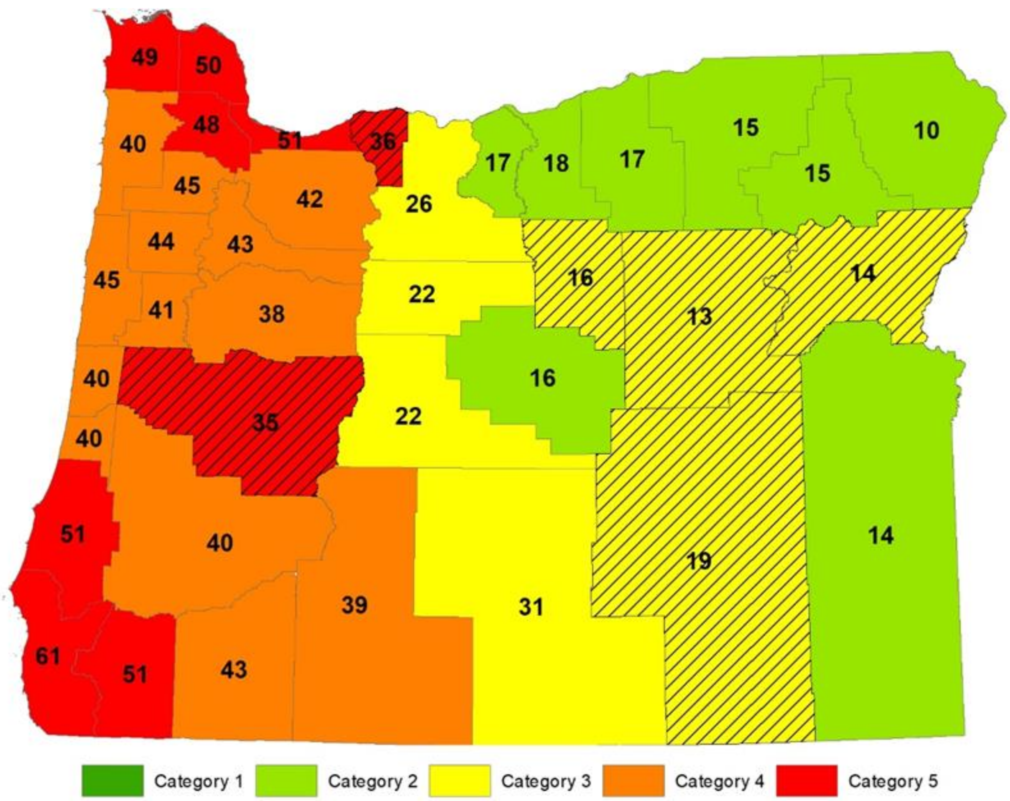
The probability of damaging earthquakes varies widely across the state. In Region 3 the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well-understood recurrence history.

DOGAMI has developed a new probability ranking for Oregon counties that is based on the average probability of experiencing damaging shaking during the next 100 years, modified in some cases by the presence of newly discovered lidar faults. If a county had newly discovered faults that were within 10-12 miles of a community, the category defined by the average probability of damaging shaking was increased one step.

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

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-179**.

**Figure 2-179. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults**




Source: DOGAMI, 2020)

The Cascadia subduction zone is responsible for most of the hazard shown in **Figure 2-179**. The paleoseismic record includes 18 magnitude 8.8–9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7 to 12%. An additional 10 to 20 smaller, magnitude 8.3–8.5, earthquakes affected only the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37–43%.

### *Vulnerability*

**Table 2-290. Assessment of Vulnerability to Earthquakes in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | L | L | VH | VH | M | VH |

Source: DOGAMI and DLCD, 2020

#### *State Assessment*

Region 3 is especially vulnerable to earthquake hazards because much of the area is susceptible to earthquake-induced landslides, liquefaction, and strong ground shaking.

Of the 15 counties in the state with the highest expected damages and losses based on the 500 year model, the following counties are located in Region 3:

- Lane,
- Marion,
- Benton,
- Linn, and
- Yamhill.

The Oregon Department of Geology and Mineral Industries (DOGAMI) developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) the Cascadia Subduction Zone (CSZ), and (b) combined crustal events (500-year model). Both models use Hazus, a software program developed by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event is based on a potential M8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from such an event. The 500-year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults. Neither model takes unreinforced masonry buildings into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning and policy making purposes. Despite their limitations, the models do provide some approximate estimates of damage and are useful to understand the relative relationships between the counties.

Table 2-291, Table 2-292, Table 2-293, and Table 2-294 show estimated losses in each county, including building collapse potential and damages based on three model scenarios.

### Table 2-291. Building Collapse Potential in Region 3

| County | Level of Collapse Potential | | | |
|---|---|---|---|---|
| | Low (< 1%) | Moderate (>1%) | High (>10%) | Very High (100%) |
| Benton | 13 | 5 | 22 | 3 |
| Lane* | 126 | 69 | 68 | 8 |
| Linn | 74 | 15 | 30 | 23 |
| Marion | 94 | 34 | 88 | 30 |
| Polk | 13 | 11 | 17 | 4 |
| Yamhill | 30 | 20 | 22 | 5 |

*Does not include the Lane County coastal communities of Deadwood, Florence, Mapleton, and Swisshome, which are addressed in the Region 1 Profile.

Source: Lewis (2007)

### Table 2-292. Estimated Losses in Region 3 from a M9 CSZ and Local Crustal Event

| County | Building Value (Billions) | Total Building Related Losses from an M9.0 CSZ Event (Billions) | Total Building Related Losses from a Crustal Earthquake (Billions) |
|---|---|---|---|
| Benton | $4.85 | $1.1 | $0.8 |
| Lane | $21.055 | $5.0 | $3.4 |
| Linn | $5.669 | $1.2 | $1.3 |
| Marion | $15.86 | $2.6 | $3.9 |
| Polk | $3.467 | $0.6 | $0.4 |
| Yamhill | $4.597 | $1.2 | $1.5 |

Source: Burns et al. (2008)

### Table 2-293. Estimated Losses in Region 3 Associated with an M8.5-9.0 Subduction Event

| Category | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Injuries (5 pm time period) | 1,356 | 3,945 | 1,049 | 2,492 | 678 | 1,190 |
| Deaths (5 pm time period) | 96 | 264 | 67 | 157 | 43 | 74 |
| Displaced Households | 2,375 | 7,633 | 2,563 | 5,787 | 1,822 | 3,082 |
| Economic losses for buildings | $1,049.51 m | $4,652 m | $1,150.68 m | $2,604.95m | $624.43 m | $1198.48 m |
| Operational after Day 1 | | | | | | |
| Fire station | 100% | 100% | 100% | 100% | 100% | 100% |
| Police Station | 100% | 100% | 100% | 100% | 100% | 100% |
| Schools | 91% | 100% | 100% | 99% | 100% | 98% |
| Bridges | 91% | 84% | 100% | 89% | 82% | 85% |
| Economic loss to infrastructure | | | | | | |
| Highways | $ 33.5 m | $211 m | $4.4 m | $127.7 m | $59.4 m | $60.2 m |
| Airports | $0 m | $13.3 m | $23.10 m | $13 m | $14 m | $21.4 m |
| Communications | $0 m | $0.33 m | $0.07 m | $0.03 m | $0.05 m | $0.03 m |
| Debris generated (thousands of tons) | 0 | 2,000 | 0 | 1,000 | 0 | 0 |

Source: Burns et al. (2008)

**Table 2-294. Estimated Losses in Region 3 Associated with an Arbitrary M6.5-6.9 Crustal Event**

| Mitigation Factors | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Injuries (5 pm time period) | 557 | 1,821 | 993 | 3,249 | 321 | 1,178 |
| Deaths (5 pm time period) | 33 | 96 | 59 | 189 | 18 | 67 |
| Displaced households | 1,755 | 7,716 | 3,683 | 10,701 | 1,412 | 4,256 |
| Economic losses from buildings | $762.25 m | $3,351.03 m | $1,315.72 m | $3979.57 m | $409.43 m | $1,525.35 m |
| Operational the day after the event: | | | | | | |
| Fire station | 75% | 100% | 77% | 61% | 100% | |
| Police Station | 75% | 91% | 40% | 65% | 100% | |
| Schools | 91% | 99% | 70% | 74% | 100% | |
| Bridges | 100% | 97% | 91% | 86% | 93% | |
| Economic losses to infrastructure: | | | | | | |
| Highways | $18.7 m | $106 m | $129.70 m | $271.5 m | $35.7 m | $71.3 m |
| Airports | $19.3 m | $16 m | $38.3 m | $38 m | $11 m | $43.9 m |
| Communications | $ 0.24 m | $0.63 m | $0.11 m | $0.18 m | $0.05 m | $0.10 m |
| Debris generated (in thousands of tons) | 0 | 1,000 | 0 | 1,000 | 0 | 0 |

Source: Burns et al. (2008)

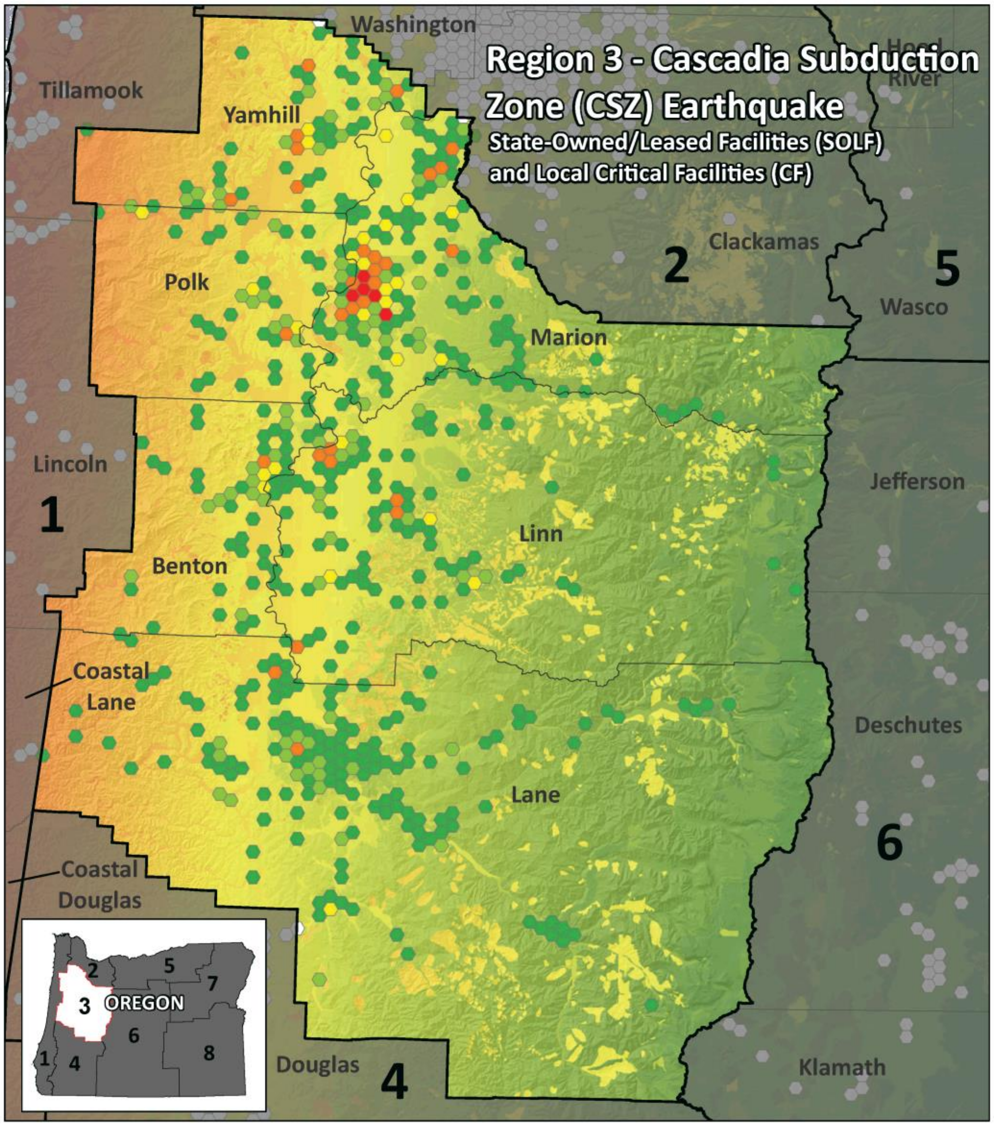
### *State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities*

For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a Magnitude 9 Cascadia Subduction Zone (CSZ) event in Region 3. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

DOGAMI used the loss ratio to formulate a separate relative vulnerability score for the state buildings, state critical facilities, and local critical facilities data sets. The percentage of loss for each county was statistically distributed into 5 categories (Very Low, Low, Moderate, High, or Very High).

In Region 3, a CSZ event could cause a potential loss of almost $843M in state building and critical facility assets, 93% of it in Marion County alone. The potential loss in local critical facilities is somewhat greater at almost $1.2B. Again, Marion County's potential loss is greatest at 48%. Potential losses in Lane Line, Polk, and Yamhill Counties are similar, ranging 9-14%. Benton County's potential loss is significantly less. **Figure 2-180** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

**Figure 2-180. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Cascadia Subduction Zone Earthquake Hazard Zone in Region 3.High-resolution, full-size image linked from Appendix 9.1.22.**




Estimated ($) losses to hazard per cell
- Outside of region
- 1 - 1,000,000
- 1,000,001 - 5,000,000
- 5,000,001 - 10,000,000
- 10,000,001 - 50,000,000
- 50,000,001 - 477,000,000

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

Administrative boundary
- Mitigation Planning Region
- County

**Projection:**
Oregon Statewide Lambert Conformal Conic, Unit: International Feet, Horizontal datum: NAD83 HARN, Scale 1:750,000

**Source Data:**
CSZ Earthquake: Peak ground acceleration from the Oregon Resilience Plan, DOGAMI, 2013
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

**Author:** Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

| REGION 3 | | Estimated Loss ($) from CSZ Earthquake | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | State-owned/leased facilities | | | | | Critical Facilities | |
| County | Total Value SOLF and Local CF | Loss SOLF CF | % Loss SOLF CF | Loss ($) SOLF Non-CF | Loss Total* | Loss Local CF | Total Loss SOLF CF and Local CF | |
| Benton | 642,420,000 | 2,268,000 | 11% | 4,976,000 | 7,244,000 | 76,996,000 | 79,264,000 | |
| Lane | 2,960,570,000 | 1,133,000 | 0% | 18,348,000 | 19,481,000 | 104,898,000 | 106,031,000 | |
| Linn | 934,323,000 | 11,744,000 | 21% | 5,250,000 | 16,994,000 | 165,778,000 | 177,522,000 | |
| Marion | 4,700,844,000 | 341,971,000 | 28% | 449,154,000 | 791,125,000 | 570,657,000 | 912,628,000 | |
| Polk | 508,293,000 | 1,827,000 | 1% | 1,366,000 | 3,193,000 | 115,000,000 | 116,827,000 | |
| Yamhill | 851,391,000 | 3,951,000 | 29% | 801,000 | 4,752,000 | 148,163,000 | 152,114,000 | |
| Total | 10,597,841,000 | 362,894,000 | 25% | 479,895,000 | 842,789,000 | 1,181,492,000 | 1,544,386,000 | |

*This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.*
**Exposure totals for SOLF include the subset of SOLF CFs.*

0 10 20 40 Miles
N

Source: DOGAMI

### *Historic Resources*

Of the 19,731 historic resources in Region 3, only 10% are in an area of high or very high liquefaction potential. Almost three quarters of those, 74%, are located in Linn County. Another 20% are located in Marion and Polk Counties. Many more (44%) of Region 3's historic resources are located in areas of high or very high potential for ground shaking amplification. Of those, 27% are located in Marion County. Benton, Linn, and Yamhill Counties have sizable shares of historic resources at risk of ground shaking amplification as well, ranging from 14 to 24%.

### *Archaeological Resources*

Three thousand five hundred thirty-four archaeological resources are located in earthquake hazard areas in Region 3. Only three archaeological resources listed on the National Register of Historic Places and six eligible for listing are located in areas of high earthquake hazards. Eleven have been determined not eligible, and 200 have not been evaluated. All of the listed and eligible resources in areas of high earthquake hazards are located in Lane, Linn, and Marion Counties. Overall, the majority archaeological resources in earthquake hazard areas in Region 3 are in Lane County (55%) followed by Linn County (24%).

### *Social Vulnerability*

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1-5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in Region 3 is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well". Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Linn, Marion, and Yamhill Counties are most vulnerable, each with a very high rating. Polk County has a moderate rating and Benton and Lane Counties both have a low rating.

### *Seismic Lifelines*

"Seismic lifelines" are the state highways ODOT has identified as most able to serve response and rescue operations, reaching the most people and best supporting economic recovery. The process, methodology, and criteria used to identify them are described in Section **2.1.6, Seismic**

**Transportation Lifeline Vulnerabilities**, and the full report can be accessed at **Appendix 9.1.14**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification* (OSLR). According to that report, seismic lifelines in Region 3 have the following vulnerabilities.

Regional delineations for this Plan and for the OSLR are slightly different. Regions in the OSLR that correspond to Region 3 include sections of the Valley and Cascades Geographic Zones.

*Valley Geographic Zone (OLSR).* The Valley Geographic Zone generally consists of two or three north-south routes through the Willamette Valley and a variety of east-west connectors between those routes. The entire area is likely to experience sustained ground shaking, with many roadways in areas subject to landslide and rockfall or liquefaction. Seismic lifeline routes that provide redundant north-south movement were designated.

The Tier 1 system in the Valley Geographic Zone consists of the following corridors:

- I-5,
- OR-99W from I-5 to OR-18 near Dayton,
- OR-18 from OR-99W near Dayton to McMinnville, and
- OR-22 from I-5 to OR-99E in Salem.

The Tier 2 system in the Valley Geographic Zone consists of the following corridors:

- US-26 from OR-47 to OR-217,
- OR-99W from McMinnville to Junction City,
- OR-99 from Junction City to I-5 in Eugene,
- OR-99E from Oregon City to I-5 in Salem, and
- OR-214 in Woodburn from I-5 to OR-99E.

The Tier 3 system in the Valley Geographic Zone consists of the following corridors:

- OR-219 from Newberg to Woodburn,
- OR-99E in Salem from I-5 to OR-22,
- OR-22 from OR-99W to Salem, and
- OR-34 from Corvallis to I-5.

Region 3 includes the central area of the Cascades Geographic Zone. These routes connect the highly seismically impacted western portion of the state to the less seismically impacted central portion of the state. The Tier 1 system in this region consists of OR-58. The Tier 2 system in the Cascades Geographic Zone in Region 3 consists of OR-22 from Salem to Santiam Junction and US-20 from Santiam Junction to Bend. There are no corridors designated as Tier 3 in the Region 3 Cascades Geographic Zone.

*Regional Impact.*

- Ground shaking: In Region 3, ground shaking will be of a magnitude and duration to cause property damage, possibly severe. Unreinforced structures, roadbeds, and bridges will be damaged to varying extents, and there will be damaged areas on lifelines that will be impassable without at least temporary repairs.
- Landslides and rockfall: Many rural and some developed area roadways in Region 3 are cut into or along landslide-prone features. A major seismic event will increase

landslide and rockfall activities and may reactivate ancient slides that are currently inactive.

- Liquefaction: Structures in wetland, alluvial and other saturated areas may be subject to liquefaction damage; the total area of such impacts will vary with the extent of saturated soils at the time of the event.

*Regional Loss Estimates.* Highway-related losses include disconnection from supplies and replacement inventory, and the loss of tourists and other customers who must travel to do business with affected businesses.

*Most Vulnerable Jurisdictions.* Benton, Lane, Linn, Marion, Polk, and Yamhill Counties are generally equally vulnerable to ground shaking from a CSZ event. Each county has some steep roads in rural and developed areas that may experience landslides. All three have some transportation facilities along river beds or crossing rivers that may be vulnerable to liquefaction.

### *Risk*

**Table 2-295. Risk of Earthquake Hazards in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Risk | M | H | VH | VH | H | VH |

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Linn, Marion, and Yamhill Counties are at very high risk from earthquakes; Lane and Polk are at high risk. Only Benton County has a moderate risk. Its very high probability and high vulnerability of local critical facilities are moderated by the very low vulnerability of state buildings and critical facilities as well as its low social vulnerability

## Extreme Heat

### *Characteristics*

Extreme temperatures aren't as common in western Oregon compared to other parts of the state, however, Region 3 does experience days above 90°F nearly every year. Eugene has an average of about 13 days per year above 90°F.

### *Historic Extreme Heat Events*

**Table 2-296. Historic Extreme Heat Events in Region 3**

| Date | Location | Notes |
|---|---|---|
| June 24–26, 2006 | Region 1–3, 5 | A broad upper ridge of unusually high height coupled with a thermally-induced surface trough of low pressure lingered over the Pacific Northwest for several days. This pattern resulted in persistent offshore flow, and therefore many days of record-smashing high temperatures. Portland International Airport had 101 degrees on June 26 breaking the old record at 94 degrees in 1987. |
| July 20-24, 2006 | Region 1–3, 5, 7 | An unusually strong ridge of high pressure brought several days of record breaking hot and humid weather to NW Oregon. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row. On July 21, Portland reported 104°F. |
| June 28–30, 2008 | Region 2, 3, 5, 7 | An upper level ridge and thermal trough across the Pacific Northwest produced temperatures above 100 degrees for two consecutive days breaking records in many locations. Two people died of heat-related illness. |
| July 1, 2014 | Region 3 | An upper level ridge combined with a surface thermal trough and low level offshore winds resulted in a hot day across Northwest Oregon where inland temperatures peaked in the upper 90s. |
| Summer 2015 | Region 2, 3 | A series of heat waves struck western Oregon in the summer of 2015, Oregon's hottest year on record, driven by a strong, persistent upper level ridge over the region. Heat waves occurred June 7–9, June 26–28, July 1–5, July 28–30, and August 18–19. Heat-related illnesses and deaths were markedly greater during these heat wave periods and cooling shelters were opened. High temperatures were 10–20°F above normal and overnight low temperatures were also unseasonably warm. Many locations broke both daytime high temperature records as well as warm overnight low temperature records. |
| June 2–5, 2016 | Region 3 | Excessive Heat Event: Unseasonably strong ridge of high pressure resulted in a period of early-season hot temperatures across Northwest Oregon. Temperatures of 95 to 100 in early June lead to people seeking relief at local rivers. Three drownings were reported. |
| August 1–4, 2017 | Region 2–4, 6 | Excessive Heat Event: Strong high pressure brought record breaking heat to many parts of southwest, south central, and northwest Oregon.<br>Region 2–3: The record-breaking heat led people to seek relief at local rivers. Two people drowned while swimming. |
| July 12–17, 2018 | Region 2, 3, 4 | Region 2–3: High pressure over the region led to a stretch of hot day July 12 through July 17th. Hot temperatures led people to cool off in local rivers. There were two drownings recorded on July 16 and July 18. Temperatures on July 16th near the Sandy River in Troutdale got up to 98 degrees |

Source: https://www.ncdc.noaa.gov/stormevents

### *Probability*

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning "very low." Region 3 relative probability rankings are shown in **Table 2-297**. Most of the region is in the center quintile of extreme heat frequency meaning relative probability is moderate compared to the rest of the state. The coastal portion of Lane County is included in Region 3 for this assessment.

**Table 2-297. Probability of Extreme Heat in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | M | M | M | L | M | M |

Source: Oregon Climate Change Research Institute, https://climatetoolbox.org/

### *Climate Change*

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Extreme temperatures are relatively rare in Region 3, but are projected to increase under future climate change. **Table 2-298** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 3.

**Table 2-298. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 3 Counties**

| County | Historic Baseline | 2050s Future |
|---|---|---|
| Benton | 4 | 25 |
| Lane | 4 | 24 |
| Linn | 3 | 22 |
| Marion | 3 | 20 |
| Polk | 4 | 23 |
| Yamhill | 5 | 24 |

Note: Numbers represent the multi-model mean from 18 CMIP5 climate models

Source: Oregon Climate Change Research Institute using data from the Northwest Climate Toolbox, https://climatetoolbox.org/.

## *Vulnerability*

Vulnerability of Oregon counties to extreme heat is discussed in Section 2.2.1.3, **Extreme Heat**. Vulnerability is defined as the combination of sensitivity to extreme heat and level of adaptive capacity in response to extreme heat.

For this assessment, sensitivity to extreme heat events was defined using the Center for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index, https://svi.cdc.gov/data-and-tools-download.html.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

Adaptive capacity to extreme heat is defined here as percent of homes with air conditioning, however the authors note that this measure has its flaws. First, it assumes that people who have access to cooling systems are able to afford to use them. Second, the data only includes single-family homes, which omits populations living in multi-family housing or who are house-less.

Because extreme heat isn't as common in western Oregon ("moderate" probability) compared to other parts of the state, many people may not be accustomed or prepared when an extreme heat event occurs ("moderate" adaptive capacity). In Cooling Zone 1, which includes Region 3, 58% of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

The relative vulnerability of Oregon counties to extreme heat was determined by adding the rankings for sensitivity (social vulnerability) and adaptive capacity (air conditioning). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total vulnerability scores of 1–2 earned a ranking of 1 (very low); scores of 3–4 earned a ranking of 2 (low); scores of 5–6 earned a ranking of 3 (moderate); scores of 7–8 earned a ranking of 4 (high); and scores of 9–10 earned a ranking of 5 (very high). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-299 displays the total vulnerability rankings as well as ranking for sensitivity and adaptive capacity for each county in NHMP Region 3. Table 2-300 provides the summary descriptors of Region 3's vulnerability.

Combining sensitivity and adaptive capacity, Region 3's relative vulnerability to extreme heat is "High." With their high vulnerability ratings, Linn, Marion, and Yamhill Counties are the most vulnerable to extreme heat in Region 3.

**Table 2-299. Relative Vulnerability Rankings for Region 3 Counties**

| County | Sensitivity | Adaptive Capacity | Vulnerability |
|---|---|---|---|
| **Region 3** | **4** | **3** | **4** |
| Benton | 2 | 3 | 3 |
| Lane | 3 | 3 | 3 |
| Linn | 4 | 3 | 4 |
| Marion | 5 | 3 | 4 |
| Polk | 3 | 3 | 3 |
| Yamhill | 4 | 3 | 4 |

Source: Oregon Climate Change Research Institute

**Table 2-300. Vulnerability to Extreme Heat in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | M | H | H | H | H | H |

Source: Oregon Climate Change Research Institute

### *Risk*

With respect to extreme heat, risk is defined as the combination of the probability of extreme heat events, sensitivity to extreme heat, and level of adaptive capacity in response to extreme heat.

The total relative risk of Oregon counties to extreme heat was determined by adding the rankings for probability and vulnerability (sensitivity and adaptive capacity). The sum of the two components ranged from 1 to 10. Rankings were determined as follows: total risk scores of 1–2 earned a ranking of 1 (“very low”); scores of 3–4 earned a ranking of 2 (“low”); scores of 5–6 earned a ranking of 3 (“moderate”); scores of 7–8 earned a ranking of 4 (“high”); and scores of 9–10 earned a ranking of 5 (“very high”). Rankings for NHMP regions are averages of the counties within a region and rounded to the nearest whole number.

Table 2-301 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 3. Table 2-302 provides the summary descriptors of Region 3’s risk to extreme heat.

Combining probability and vulnerability, Region 3’s relative risk to extreme heat is “Moderate.” Linn and Yamhill Counties are at high risk.

**Table 2-301. Risk Rankings for Region 3 Counties**

| County | Probability | Vulnerability | Risk |
|---|---|---|---|
| **Region 3** | **3** | **4** | **3** |
| Benton | 3 | 3 | 3 |
| Lane | 3 | 3 | 3 |
| Linn | 3 | 4 | 4 |
| Marion | 2 | 4 | 3 |
| Polk | 3 | 3 | 3 |
| Yamhill | 3 | 4 | 4 |

Source: Oregon Climate Change Research Institute

**Table 2-302. Risk of Extreme Heat in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Risk | M | M | H | M | M | H |

Source: Oregon Climate Change Research Institute

## Floods

### *Characteristics*

Region 3 has a lengthy flood history. Notable floods affecting Region 3 are shown in **Table 2-303**. **Table 2-304** describes flood sources for each of the counties in the region. Additionally, sheet flooding occurs on agricultural land. Because this occurs far from a source river or stream, however, such flood areas are not depicted on federal Flood Insurance Rate Maps.

Most of the serious flooding experienced in Region 3 occurs in December and January. These events are usually associated with La Niña conditions, which result in prolonged rain and rapid snowmelt on saturated or frozen ground. This sudden influx of water causes rivers to swell, forcing tributary streams to back up and flood communities.

Region 3 is protected by several flood control dams.

A very large 1964 flood was a result of unusually intense precipitation on frozen topsoil, augmented by snowmelt in the mountains and valley. Without upstream flood control structures, the 1964 flood would have been the largest flood of the 20th century, with a peak discharge of 320,000 cubic feet per second (cfs) at the Albany gage. However, upstream dams reduced the peak discharge to 186,000 cfs.

The unincorporated areas of Region 3 are nearly all agricultural lands or timberlands. Flood damage in those areas would be limited to farm crops, farm buildings and residences, and erosion of croplands.

The Federal Emergency Management Agency (FEMA) has mapped most flood-prone streams in Oregon. The maps depict the 1% flood (100 year) upon which the National Flood Insurance Program is based. All of the Region 2 counties have Flood Insurance Rate Maps (FIRM). The FIRMs were issued at the following times:

- Benton, June 6, 2011 with some panels issued on December 8, 2016;
- Lane, June 2, 1999;
- Linn, September 29, 2010 with some panels issued on December 8, 2016;
- Marion, January 19, 2000 with some panels issued October 18, 2019;
- Polk, December 19, 2006with some panels issued October 18, 2019; and
- Yamhill, March 2, 2010.

FEMA is working through the Risk MAP process in Lane County to update the FIRMs. Preliminary FIRMs are anticipated in February 2020 to be followed with CCO meetings with local officials and eventual public review of the updated FIRMs.

The Risk MAP project for the Upper Willamette anticipates draft maps to be issued in summer 2020.

### *Historic Flood Events*

**Table 2-303. Significant Historic Floods Affecting Region 3**

| Date | Location | Characteristics | Type of Flood |
|---|---|---|---|
| Dec. 1861 | Willamette Basin and coastal rivers | preceded by two weeks of heavy rain; every town on the Willamette was flooded or washed away; 635,000 cfs at Portland | rain on snow; snow melt |
| Jan. 1881 | Willamette Basin | Lane, Linn, Benton, Marion, Polk, Yamhill, Clackamas, Multnomah Counties | |
| Feb. 1890 | Willamette Basin and coastal rivers | second largest known flood in the Willamette Basin; almost every large bridge washed downstream | rain on snow |
| Dec. 1937 | western Oregon | flooding followed heavy rains; considerable highway flooding; landslides | rain on snow |
| Jan. 1953 | western Oregon | widespread flooding in western Oregon accompanied by windstorm | rain on snow |
| Dec. 1964-Jan. 1965 | Willamette Basin | record flooding throughout Willamette Basin; two intense storms; near-record early season snow depths; largest flood in Oregon since dam construction on upper Willamette (1940s–50s; $34 million in damages | rain on snow |
| Jan. 1974 | western Oregon | flooding followed heavy wet snow and freezing rain; nine counties received Disaster Declaration | rain on snow |
| Dec. 1978 | western Oregon | intense heavy rain, snowmelt, saturated ground; one fatality in Region 3 (Benton County) | rain on snow |
| Feb. 1986 | entire state | severe statewide flooding; rain and melting snow; numerous homes flooded and highways closed | snow melt |
| Feb. 1987 | western Oregon | Willamette River and tributaries; mudslides; damaged highways and homes | rain on snow |
| Feb. 1996 | entire state | deep snow pack, warm temperatures, record-breaking rains; flooding, landslides, power-outages (FEMA-1099-DR-Oregon) | rain on snow |
| Nov. 1996 | entire state | record-breaking precipitation; local flooding/landslides (FEMA-1149-DR-Oregon) | rain on snow |
| Dec. 2005 | Polk, Marion, Linn, Lane and Benton Counties | heavy rains causing rivers to crest above flood stage in Polk, Marion, Linn, Lane, and Benton Counties, as well as other counties in the Willamette Valley | riverine |
| Jan. 2006 | Willamette Valley | heavy rains caused many rivers to crest above flood stage in the Willamette Valley, causing road closures and damage to agricultural lands | riverine |
| Dec. 2007 | Yamhill | South Yamhill River flooded near McMinnville, causing damage to roads and bridges, 120 homes in Sheridan along with a few businesses and churches, and causing minor damage in Willamina; total county-wide damage estimates at $9.6 million | riverine |
| Dec. 2007 | Polk | major flooding in Suver and other areas in Polk County; total losses equal $1 million for entire county | riverine |
| Jan. 2012 | Polk, Marion, Yamhill, Lincoln, Benton, Linn and Lane Counties | heavy rain and wind; ice (DR-4055); flooding in the Willamette Valley; 130 homes and seven businesses were damaged in the City of Turner; 29 streets were closed in the City of Salem; the state motor pool lost 150 vehicles and thousands of gallons of fuel; Thomas Creek in the City of Scio overtopped, damaging several buildings | riverine |

| Date | Location | Characteristics | Type of Flood |
|---|---|---|---|
| Nov. 2012 | Curry, Josephine, and Lane Counties | heavy precipitation; the Curry Coastal Pilot reported over 2 million dollars in infrastructure damage in Brookings and another 2 million in Curry County due to recent heavy rains; sinkholes and overflowing sewage facilities were also reported; according to KVAL news, Eugene Public Works has opened its emergency command center to deal with numerous flooding incidents, including two flooded intersections | riverine |
| Feb. 2014 | Lane, Coos, Marion and Tillamook and Counties | A series of fronts resulted in a prolonged period of rain for Northwest Oregon, and minor flooding of several of the area's rivers from February 12th through February 17th. Heavy rains caused the Coquille River at Coquille to flood. The flood was categorized as a moderate flood. The Nehalem River near Foss in Tillamook County exceeded flood stage on February 18th, 2014. | riverine |
| Dec. 2014 | Tillamook, Lincoln, Lane, Polk Clackamas, Benton Coos and Douglas Counties | A slow moving front produced heavy rain over Northwest Oregon which resulted in the flooding of eight rivers. Another impact from the rain were a couple of land/rock slides that both blocked two highways. Heavy rain brought flooding to several rivers in southwest Oregon. | riverine |
| Dec. 2015 | Tillamook, Lincoln, Washington, Clackamas, Multnomah, Lane, Columbia, Hood River, Polk, Coos, Douglas, Jackson and Curry Counties | A moist pacific front produced heavy rainfall across Northwest Oregon which resulted in river flooding, urban flooding, small stream flooding, landslides, and a few sink holes. After a wet week (December 5 through Dec 11), several rivers were near bank full ahead of another front on December 12th. Flooding from the Nehalem River and Rock Creek in Vernonia resulted in evacuation of homes and the implementation of the Vernonia Emergency Command Center. Heavy rain resulted in a land slide that closed OR47 at mile marker 8. More than $15 million dollars in property damage reported in these counties combined. | |
| Nov. 2016 | Columbia, Tillamook, Lincoln, Benton, Washington, Polk, and Yamhill Counties | A moist Pacific front moving slowly across the area produced heavy rainfall, resulting in flooding of several rivers across Northwest Oregon and at least two landslides. | riverine |
| Feb. 2017 | Marion, Polk, Yamhill, Washington, Columbia, Benton, Tillamook, Lane, Coos, Curry, Klamath, Wheeler and Malheur Counties | High river flows combined with high tide to flood some areas near the southern Oregon coast. Heavy rain combined with snow melt caused flooding along the Coquille River and the Rogue River twice this month in southwest Oregon. Heavy rain combined with snow melt caused flooding along the Sprague River in south central Oregon. Flows on the John Day river reached flood levels downstream of Monument due to the breaking up of an ice jam. | riverine and coastal flooding |
| Oct. 2017 | Tillamook, Benton, and Clackamas Counties | A very potent atmospheric river brought strong winds to the north Oregon Coast and Coast Range on October 21st. What followed was a tremendous amount of rain for some locations along the north Oregon Coast and in the Coast Range, with Lees Camp receiving upwards of 9 inches of rain. All this heavy rain brought the earliest significant Wilson River Flood on record, as well as flooding on several other rivers around the area. | riverine |
| June 2018 | Lane County | In Lane County an upper-level trough moved across the area from the southwest, generating strong thunderstorms which produced locally heavy rainfall, lightning, hail, and gusty winds. | |
| April 2019 | Lane, Benton, Marion, Clackamas and Linn Counties | | |

Sources: Taylor and Hatton (1999); National Climatic Data Center Storm Events, located at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

**Table 2-304. Principal Riverine Flood Sources by County in Region 3**

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

Sources: FEMA, Benton County Flood Insurance Study (FIS), Aug. 15, 1996; FEMA, Lane County FIS, June 2, 1999; FEMA, Linn County FIS, Sept. 29, 1986; FEMA, Marion County FIS, July 13, 2001; FEMA, Polk County FIS, Dec. 19, 1995; FEMA, Yamhill County FIS, Sept. 30, 1983

### *Probability, Vulnerability, and Risk*

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the "OEM Hazard Analysis Methodology" used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.17**.

The purpose of the probability and vulnerability scores is to identify high-priority areas to which local and state governments can target mitigation actions.

## Probability

### *Local Assessment*

Participants in each county's Natural Hazard Mitigation Plan update process used the OEM hazard analysis methodology to analyze the probability that Region 3 will experience flooding. The resulting estimates of probability are shown in **Table 2-305**.

**Table 2-305. Local Assessment of Flood Probability in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | H | H | H | H | H | H |

Source: Benton County MJNHMP (2016), Lane County MJNHMP (2018), Linn County MJNHMP (2017); Marion County MJNHMP (2017), Polk County MJNHMP (2017), Yamhill County Multi-Jurisdictional Hazard Mitigation Plan Update (2014)

### *State Assessment*

Using the methodology described in the Section 2.2.7.1, Floods/Probability, the state assessed the probability of flooding in the counties that comprise Region 3. The results are shown in **Table 2-306**.

**Table 2-306. State Assessment of Flood Probability in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | VH | VH | VH | H | H | H |

Source: DOGAMI

### *Climate Change*

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Along the Willamette River and its tributaries (Regions 2, 3, and 4), the largest increases in extreme river flows are more likely to be upstream (towards Cascades headwaters), and less likely as one travels downstream. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

## Vulnerability

### *Local Assessment*

Based on the OEM hazard analysis conducted by participants in the NHMP update process, the region's vulnerability to flooding is shown in **Table 2-307**.

**Table 2-307. Local Assessment of Vulnerability to Flood in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | M | H | M | H | M | H |

Source: Benton County MJNHMP (2016), Lane County MJNHMP (2018), Linn County MJNHMP (2017); Marion County MJNHMP (2017), Polk County MJNHMP (2017), Yamhill County Multi-Jurisdictional Hazard Mitigation Plan Update (2014)

*State Assessment*

**Table 2-308. State Assessment of Vulnerability to Flood in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | L | M | H | VH | M | M |

Source: DOGAMI, DLCD

Participants in the county NHMPs were consulted to evaluate critical facilities and infrastructure vulnerabilities. Most counties in Region 3 have not yet catalogued critical facilities and infrastructure and therefore have not yet analyzed the hazards to which these facilities are subject. These counties have begun to consider that analysis by establishing mitigation actions such as developing a list of hazard types to be mapped and then identifying, locating and obtaining the necessary data to plot critical facilities and infrastructure to show their location within the hazard areas. Benton County did catalogue those critical facilities located in the floodplain, but was not able to analyze whether these facilities might be damaged by flooding. Among these facilities were the wastewater/sewage treatment plants in Alsea, Corvallis, Monroe and Philomath, and Corvallis High School.

### *Repetitive Losses*

FEMA has identified 46 Repetitive Loss buildings in Region 3, four of which are Severe Repetitive Loss properties. This region has the third most repetitive flood losses of the Oregon NHMP Natural Hazard Regions, reflecting its downstream location in or near the Willamette Valley, often flat topography, and population density.

**Table 2-309. Flood Severe/Repetitive Losses and Community Rating System Communities by County in Region 3**

| County | RL/SRL | Number of CRS Communities per County |
|---|---|---|
| Benton | 3 | 2 |
| *Lane | 30 | 3 |
| ** Linn | 7 | 1 |
| ***Marion | 15 | 2 |
| Polk | 1 | 1 |
| Yamhill | 5 | 1 |
| **Totals** | **61** | **10** |

*Includes non-coastal sections of Lane County.

**Albany is a CRS community located in both Benton and Linn Counties. For the purposes of this table, Albany is counted as being in Linn County.

***Salem is located in both Marion and Polk Counties. For the purposes of this table, Salem is counted as being in Marion County due to the way FEMA categorizes the City of Salem.

Source: FEMA NFIP Community Information System, https://isource.fema.gov/cis/ accessed February 2020

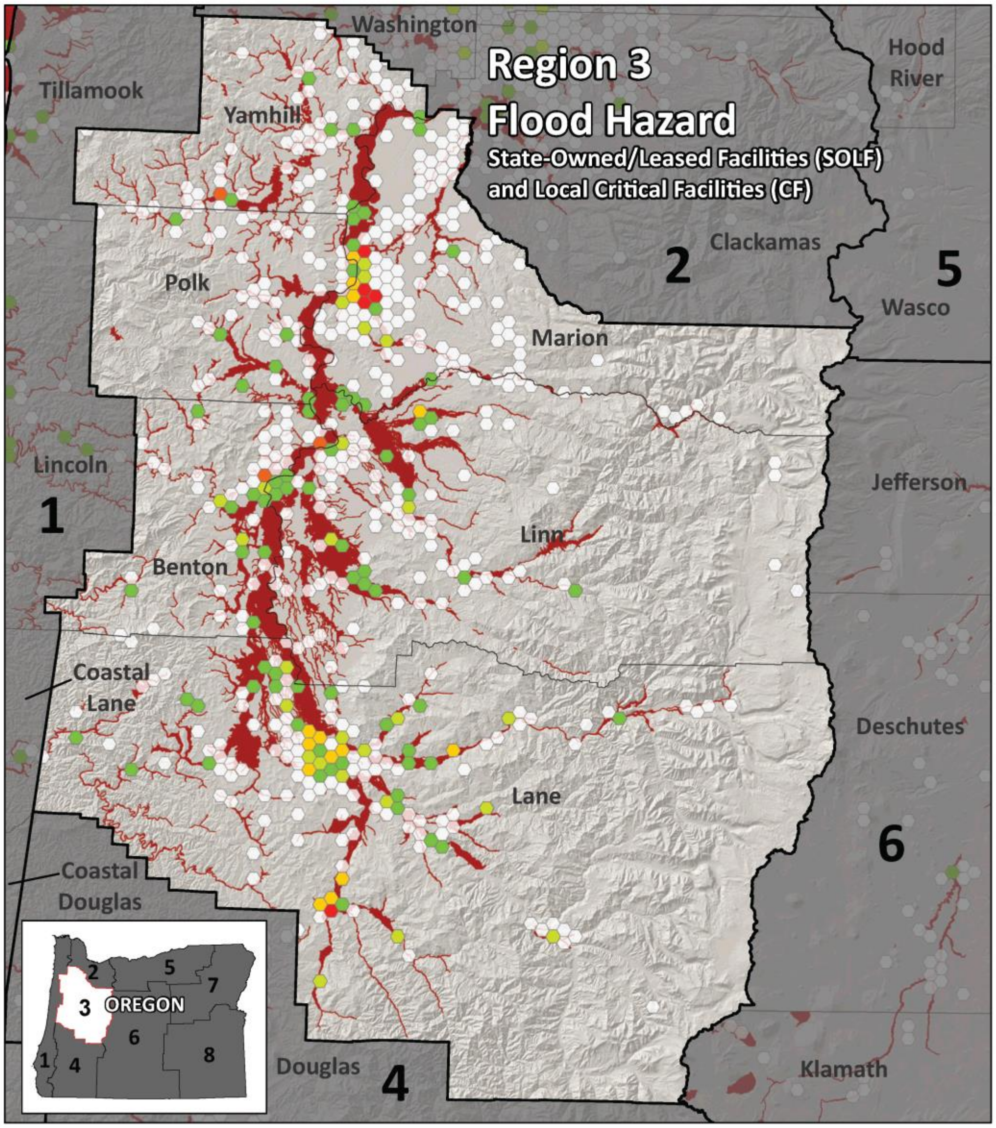
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. Benton, Lane, Marion, and Polk Counties participate in CRS, as do the cities of Albany, Corvallis, Eugene, Salem, and Sheridan.

*State-Owned/Leased Facilities and Critical/Essential Facilities*

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 3, there is a potential loss from flooding of over $676M in state building and critical facility assets, 93% of it in Marion County alone. The next greatest share is about $37M, only one-half percent, in Lane County. There is a similar potential loss due to flood in local critical facilities: close to $677.6M, forty percent and 32% in Lane and Marion Counties, respectively. The next greatest share, 14% is in Benton County. **Figure 2-181** illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding.

**Figure 2-181. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in Region 3.High-resolution, full-size image linked from Appendix 9.1.22.**




**Building value ($) exposed to hazard per cell**

- No exposure to hazard
- 1 - 2,500,000
- 2,500,001 - 10,000,000
- 10,000,001- 25,000,000
- 25,000,001 - 50,000,000
- 50,000,001 - 477,000,000

**Hazard area**

- Flood - high hazard

**Administrative boundary**

- Mitigation Planning Region
- County

**Projection:**
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:750,000

**Source Data:**
Flood: various studies from Federal Emergency Management Agency, National Flood Insurance Program
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

**Author:** Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

| REGION 3 | | Exposure ($) to Flood Hazard Areas | | | | | |
|---|---|---|---|---|---|---|---|
| | | State-owned/leased facilities | | | | Critical Facilities | |
| County | Total Value SOLF and Local CF | Value Exposed SOLF CF | % Value Exposed SOLF CF | Value Exposed SOLF Non-CF | Value Exposed Total* | Value Exposed Local CF | Total Value Exposed SOLF CF and Local CF |
| Benton | 642,420,000 | 347,000 | 2% | 692,000 | 1,039,000 | 92,350,000 | 92,697,000 |
| Lane | 2,960,570,000 | 6,321,000 | 5% | 30,669,000 | 36,990,000 | 274,029,000 | 280,350,000 |
| Linn | 934,323,000 | 0 | 0% | 7,582,000 | 7,582,000 | 41,873,000 | 41,873,000 |
| Marion | 4,700,844,000 | 305,263,000 | 24% | 323,025,000 | 628,288,000 | 216,685,000 | 521,948,000 |
| Polk | 508,293,000 | 0 | 0% | 2,126,000 | 2,126,000 | 24,735,000 | 24,735,000 |
| Yamhill | 851,391,000 | 0 | 0% | 59,000 | 59,000 | 27,886,000 | 27,886,000 |
| Total | 10,597,841,000 | 311,931,000 | 22% | 364,153,000 | 676,084,000 | 677,558,000 | 989,489,000 |

*This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.*
**Exposure totals for SOLF include the subset of SOLF CFs.*

0 10 20 40 Miles

N

Source: DOGAMI, 2020

*Historic Resources*

Of the 19,731 historic resources in Region 3, two thousand three hundred seventy-seven (12%) are located in an area of high flood hazard. Of those, 1,480 (62%) are located in Lane County. The next greatest share, 17%, is in Marion County.

*Archaeological Resources*

Of the 854 archaeological resources located in high flood hazard areas in Region 3, fifty-two percent are located in Lane County. The next greatest share, 24% is in Linn County. Twenty-two are listed on the National Register of Historic Places and 37 are eligible for listing. Twenty have been determined not eligible and 775 have not been evaluated as to their eligibility. The listed resources are located in Lane (15), Marion (6), and Yamhill (1) Counties. Thirteen and 14 of the eligible resources are located in Lane and Marion Counties, respectively; the rest are spread throughout Region 3.

*Social Vulnerability*

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1-5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Marion County is very highly vulnerable and Linn County is highly vulnerable to the impacts of flood. Marion County's very high vulnerability score is driven by the high value of state buildings, state critical facilities, and local critical facilities in the county as well as its very high social vulnerability. Linn County's high score is driven primarily by its high social vulnerability. While Lane County has twice as many repetitive or severe repetitive loss properties, Marion County still has a significant number. Lane County has significantly more historic and archaeological resources than Marion or Linn Counties.

*Most Vulnerable Communities*

Marion, Lane, and Linn Counties are the most vulnerable to flood hazards in Region 3.

*Risk*

**Table 2-310. Risk of Flood Hazards in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Risk | H | VH | VH | VH | H | H |

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, all Region 3 counties are at great risk from floods; Lane, Linn, and Marion Counties face the greatest risk

# Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

## *Analysis and Characterization*

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owners property to community destruction with mass fatalities. The 1889 Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost. Oregon's first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

**Table 2-311. Historic Significant Dam Failures in Region 3**

| Year | Location | Description |
|---|---|---|
| 1982 | Mann creek dam near Sweet Home in Linn Co. | Washed out multiple forest roads |
| 2016 | Heater Reservoir near Sublimity in Marion Co. | Flooded area occupied by Christmas tree packers, flooded paved road |

Source: Oregon Water Resources Department Dam Safety Program records

### *Dam Hazard Ratings*

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 28 High Hazard dams and 38 Significant Hazard dams in Region 3.

**Table 2-312. Summary: High Hazard and Significant Hazard Dams in Region 3**

| | Hazard Rating | | |
|---|---|---|---|
| | State | | Federal |
| | High | Significant | High |
| Region 3 | 9 | 38 | 19 |
| Benton | 1 | 1 | 0 |
| Lane | 1 | 5 | 13 |
| Linn | 1 | 0 | 6 |
| Marion | 2 | 13 | 0 |
| Polk | 2 | 8 | 0 |
| Yamhill | 2 | 11 | 0 |

Source: Oregon Water Resources Department, 2019

**Table 2-313. High Hazard and Significant Hazard Dams in Region 3**

| County | Name | Rating | Regulator |
|---|---|---|---|
| Benton | North Fork | High | State |
| Benton | Thompson (Benton) | Significant | State |
| Lane | Blue River Dam | High | Federal |
| Lane | Cottage Grove | High | Federal |
| Lane | Cougar Reservoir | High | Federal |
| Lane | Dexter | High | Federal |
| Lane | Dorena | High | Federal |
| Lane | Fall Creek Reservoir | High | Federal |
| Lane | Fern Ridge | High | Federal |
| Lane | Hills Creek Reservoir | High | Federal |
| Lane | Hult Log Storage Pond | High | Federal |
| Lane | Leaburg Dam | High | Federal |
| Lane | Lookout | High | Federal |
| Lane | Walterville Power Intake | High | Federal |
| Lane | Walterville Pumped S. Pond | High | Federal |
| Lane | Santa Clara | High | State |
| Lane | Farnam Creek Reservoir | Significant | State |
| Lane | Forcia And Larsen Log Pond | Significant | State |
| Lane | Ford Farms Reservoir | Significant | State |
| Lane | Schwartz Reservoir | Significant | State |
| Lane | Vaughn Log Pond | Significant | State |
| Linn | Big Cliff Dam | High | Federal |
| Linn | Detroit Reservoir | High | Federal |
| Linn | Foster Reservoir | High | Federal |
| Linn | Green Peter Reservoir | High | Federal |
| Linn | Smith River | High | Federal |
| Linn | Trail Bridge Reg. Reservoir | High | Federal |
| Linn | Foster Log Pond | High | State |
| Marion | Franzen | High | State |
| Marion | Silver Creek | High | State |
| Marion | Barnes Bros. Reservoir | Significant | State |
| Marion | Berger Lake | Significant | State |
| Marion | Fredericks Pond | Significant | State |
| Marion | Funrue | Significant | State |
| Marion | Heater Dam | Significant | State |
| Marion | Heater Reservoir #2 | Significant | State |
| Marion | Koinenia Lake Dam | Significant | State |
| Marion | Lorence Lake | Significant | State |
| Marion | Neil Creek Reservoir | Significant | State |
| Marion | Peterson, Floyd | Significant | State |
| Marion | Pettit Reservoir | Significant | State |
| Marion | Spring Lake Estates | Significant | State |
| Marion | Waldo Lake | Significant | State |
| Polk | Croft | High | State |
| Polk | Mercer | High | State |
| Polk | Deraeve Reservoir #1 (Lower) | Significant | State |

| County | Name | Rating | Regulator |
|---|---|---|---|
| Polk | Eola Hills Reservoir | Significant | State |
| Polk | Fern Creek | Significant | State |
| Polk | Kennel Reservoir | Significant | State |
| Polk | Koning "E" Reservoir | Significant | State |
| Polk | Mt. Springs Ranch Dam | Significant | State |
| Polk | Olson Reservoir (Mark) | Significant | State |
| Polk | Shaffer Reservoir | Significant | State |
| Yamhill | Baker, Er | High | State |
| Yamhill | Mcguire | High | State |
| Yamhill | Amity Hills Dam | Significant | State |
| Yamhill | Haskins Creek Dam | Significant | State |
| Yamhill | Hickory Hill Farm | Significant | State |
| Yamhill | Jensen (Yamhill Farm) | Significant | State |
| Yamhill | Katz Farm | Significant | State |
| Yamhill | Kuehne Dam | Significant | State |
| Yamhill | Muhs Quarry Dam | Significant | State |
| Yamhill | Olson Flashboard Dam | Significant | State |
| Yamhill | Panther Creek Reservoir | Significant | State |
| Yamhill | Walker (Bryan Creek) | Significant | State |
| Yamhill | Yamhill Vista Dam #5 | Significant | State |

Source: Oregon Water Resources Department, 2019

### *Probability*

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally-regulated. A dam's condition is considered public information for state-regulated dams, but the conditions of federally-regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.

- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Five of the nine state-regulated high hazard dams are in satisfactory condition and four are in fair condition.

**Table 2-314. Summary: Condition of High Hazard State-Regulated Dams in Region 3**

| | Condition of State-Regulated High Hazard Dams | | | | |
|---|---|---|---|---|---|
| | **Satisfactory** | **Fair** | **Poor** | **Unsatisfactory** | **Not Rated** |
| Region 3 | 5 | 4 | 0 | 0 | 0 |
| Benton | 1 | 0 | 0 | 0 | 0 |
| Lane | 1 | 0 | 0 | 0 | 0 |
| Linn | 0 | 1 | 0 | 0 | 0 |
| Marion | 1 | 1 | 0 | 0 | 0 |
| Polk | 1 | 1 | 0 | 0 | 0 |
| Yamhill | 1 | 1 | 0 | 0 | 0 |

Source: Oregon Water Resources Department, 2019

**Table 2-315. Condition of High Hazard State-Regulated Dams in Region 3**

| County | Dam Name | Condition |
|---|---|---|
| Benton | North Fork | Satisfactory |
| Lane | Santa Clara | Satisfactory |
| Linn | Foster Log Pond | Fair |
| Marion | Silver Creek | Fair |
| Marion | Franzen | Satisfactory |
| Polk | Mercer | Fair |
| Polk | Croft | Satisfactory |
| Yamhill | Baker, Er | Fair |
| Yamhill | Mcguire | Satisfactory |

Source: Oregon Water Resources Department, 2019

### *State-Regulated High Hazard Dams not Meeting Safety Standards*

There are no state-regulated high hazard dams in Region 3 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

### *Climate Change*

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

### *Vulnerability*

#### *Most Vulnerable Communities*

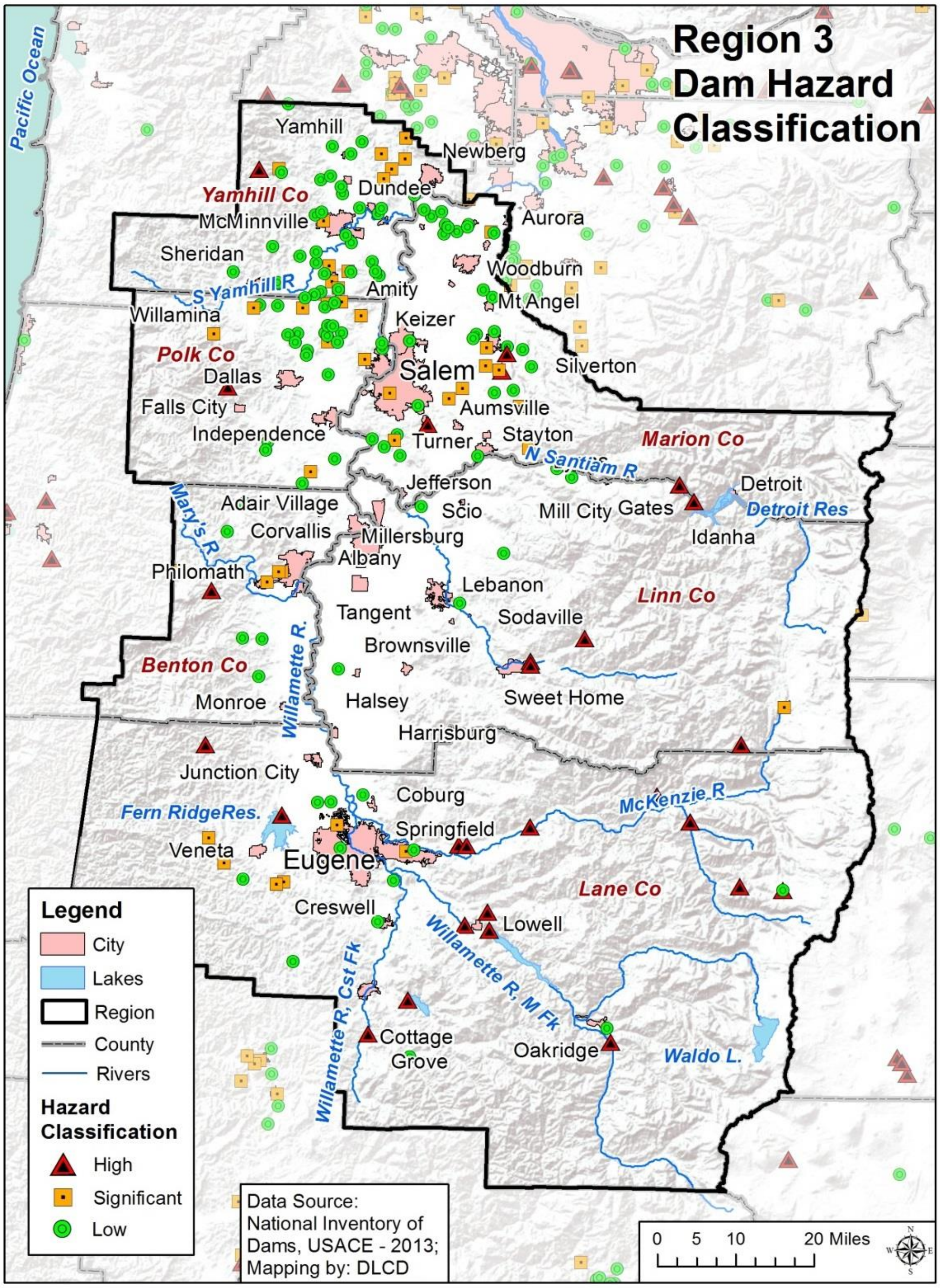
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), no Region 3 counties are considered “most vulnerable communities” because none have high hazard dams in poor or unsatisfactory condition.

As with high hazard dams, whether counties with significant hazard dams are actually “most vulnerable communities” depends on the conditions of those dams. Since the dams’ conditions have not yet been rated, we cannot determine the counties’ vulnerability with respect to significant hazard dams. The counties with the most state-regulated significant hazard dams are Marion (13) and Yamhill (11).

### *Risk*

The potential for damage to a dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

**Figure 2-182. Region 3 Dam Hazard Classification**




Source: National Inventory of Dams, USACE, 2013

# Landslides

## *Characteristics*

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the Coast Range and Cascade Mountains have a very high incidence of landslides. For example, the Vineyard Mountain area near Corvallis, which is in the Coast Range foothills, experienced at least half a dozen landslides during the January 2009 storm. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage.

## *Historic Landslide Events*

**Table 2-316. Historic Landslides in Region 3**

| Date | Location | Incident |
|---|---|---|
| Aug. 1957 | near Westfir, Oregon | rock slide; fatalities: two workers |
| Feb. 1996 | | FEMA-1099-DR-Oregon; heavy rains and rapidly melting snow contributed to thousands of landslides/debris flows across the state; many on clear cuts that damaged logging roads |
| Nov. 1996 | Benton, Lane, Lincoln, and Yamhill Counties | DR-1107; hundreds of landslides |
| Nov. 1996 | Lane and Douglas Counties | FEMA-1149-DR-Oregon; heavy rain triggered mudslides (Lane and Douglas Counties); fatalities: eight; injuries: several (Douglas County) |
| Feb. 2002 | Lane and Linn Counties | DR-1405, Feb 2002: |
| Dec. 2005-Jan. 2006 | Benton, Linn, Polk, and Yamhill Counties | DR-1632; several debris flows in the Oregon coast range. |
| Dec 2006 | Benton, Polk, and Yamhill Counties | DR-1683 |
| Dec. 2007 | Polk and Yamhill Counties | DR-1733; hundreds of landslides |
| Dec. 2008 | Marion, Polk, and Yamhill Counties | DR-1824 |
| Jan. 2012 | Benton, Lane, Linn, Marion, and Polk Counties | DR-4055 |
| Feb. 2014 | Benton, Lane, and Linn Counties | DR-4169 |
| Dec. 2015 | Linn, Lane, Polk, and Yamhill Counties | DR-4258 |
| Dec. 2016 | Lane County | DR-4296; several roads closed from landslides |
| Feb. 2019 | Lane County | DR-4432; Highway 224 closed from rockfall |
| Apr. 2019 | Linn County | DR-4452 |

Sources: Taylor and Hatton (1999); Oregon Department of Transportation Emergency Operations Plan, October 7, 2002; https://www.fema.gov/disasters

### *Probability*

**Table 2-317. Assessment of Landslide Probability in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | H | VH | H | H | H | VH |

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

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in this region in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

#### *Climate Change*

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

### *Vulnerability*

**Table 2-318. Assessment of Vulnerability to Landslides in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | L | M | M | H | L | M |

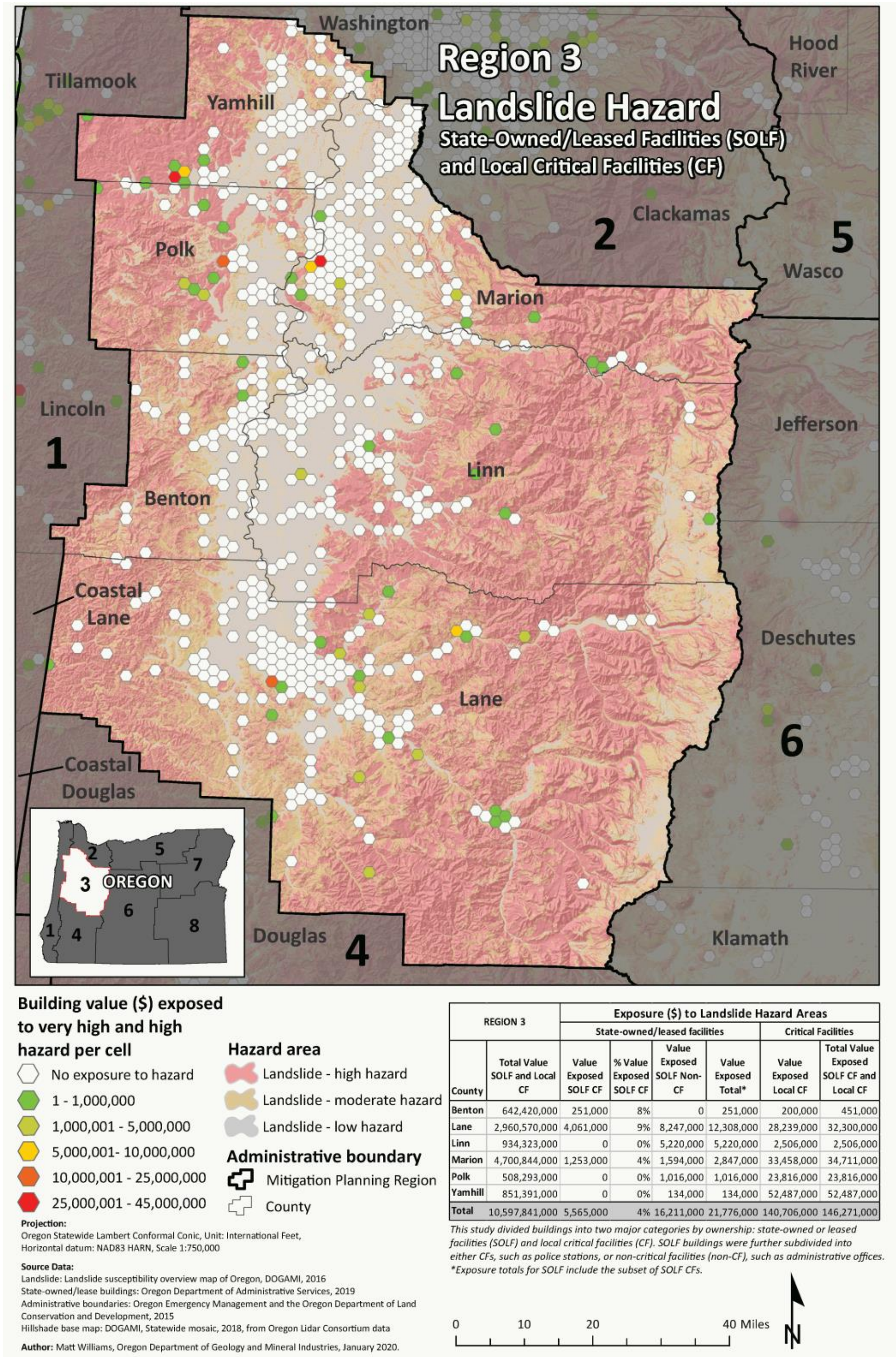
Source: DOGAMI and DLCD, 2020

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

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

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 3. More than $21.7M in value is exposed to landslide hazards in Region 3, over half of it in Lane County. The potential loss to local critical facilities is more than six times the value of state facilities at over $140.7M. Yamhill County has 37% of the value of local critical facilities followed by Polk, Lane, and Marion Counties whose shares range from 17% to 24%. **Figure 2-183** illustrates the potential loss to state buildings and critical facilities and local critical facilities from a CSZ event.

**Figure 2-183. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 3.High-resolution, full-size image linked from Appendix 9.1.22.**




| REGION 3 | | Exposure ($) to Landslide Hazard Areas | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | State-owned/leased facilities | | | | | Critical Facilities | |
| County | Total Value SOLF and Local CF | Value Exposed SOLF CF | % Value Exposed SOLF CF | Value Exposed SOLF Non-CF | Value Exposed Total* | Value Exposed Local CF | Total Value Exposed SOLF CF and Local CF |
| Benton | 642,420,000 | 251,000 | 8% | 0 | 251,000 | 200,000 | 451,000 |
| Lane | 2,960,570,000 | 4,061,000 | 9% | 8,247,000 | 12,308,000 | 28,239,000 | 32,300,000 |
| Linn | 934,323,000 | 0 | 0% | 5,220,000 | 5,220,000 | 2,506,000 | 2,506,000 |
| Marion | 4,700,844,000 | 1,253,000 | 4% | 1,594,000 | 2,847,000 | 33,458,000 | 34,711,000 |
| Polk | 508,293,000 | 0 | 0% | 1,016,000 | 1,016,000 | 23,816,000 | 23,816,000 |
| Yamhill | 851,391,000 | 0 | 0% | 134,000 | 134,000 | 52,487,000 | 52,487,000 |
| Total | 10,597,841,000 | 5,565,000 | 4% | 16,211,000 | 21,776,000 | 140,706,000 | 146,271,000 |

*This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.*
**Exposure totals for SOLF include the subset of SOLF CFs.*

Source: DOGAMI, 2020

#### Historic Resources

Of the 19,731 historic resources in Region 3, two hundred sixty-five or about 1.5% are in an area of very high or high landslide hazard susceptibility; 2,446 or about 12% in moderate; and 16,999 or about 86% in low. The greatest number of historic resources exposed to landslide hazards is in Lane County.

#### Archaeological Resources

Of the 1,854 archaeological resources located in landslide hazard areas in Region 3, seventy percent (1,293) are in high landslide hazard areas. Of those, 21 are listed on the National Register of Historic Places and 47 are eligible for listing. Thirty-two have been determined not eligible, and 1,193 have not been evaluated as to their eligibility. Fifty-seven percent of both the archaeological resources in high landslide hazard areas and those in landslide areas in Region 3 overall are located in Lane County. The resources that are listed and eligible for listing are located in all counties except Yamhill County.

#### Social Vulnerability

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1-5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in Region 3 is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Marion County is the most vulnerable to landslides in Region 3.

### Risk

**Table 2-319. Assessment of Risk to Landslides in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Risk | M | VH | H | VH | M | VH |

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 Risk Scores and DOGAMI's expert assessment, Lane, Linn, Marion, and Yamhill counties are "most vulnerable communities" with either very high or high risk ratings. All communities should be prioritized for mitigation actions.

*State Assessment*

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

**State-Owned/Leased Facilities and Critical and Essential Facilities**

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

Of the 5,693 state facilities evaluated, 2,134 are located within a landslide hazard zone in Region 3, totaling roughly $4.2 billion (**Figure 2-183**). This includes 455 critical or essential facilities. An additional 2,413 non-state-owned critical or essential facilities are located within a landslide hazard zone in Region 4.

## Volcanoes

### *Characteristics*

The eastern boundaries of Lane, Linn, and Marion Counties coincide with the crest of the Cascade Mountains. Volcanic activity in the Cascades will continue, but questions regarding how, to what extent, and when remain unanswered. Most volcano-associated hazards are local (e.g., explosions, debris, lava, and pyroclastic flows). However, lahars can travel considerable distances downstream, and wind-borne ash can blanket areas many miles from the source.

### *Historic Volcanic Events*

**Table 2-320. Historic Volcanic Events Affecting Region 3**

| Date | Location | Description |
|---|---|---|
| about 10,000 to <7,700 YBP | cones south of Mount Jefferson; Forked Butte and South Cinder Peak | lava flows |
| about 4,000 to 3,000 YBP | Sand Mountain, central Cascades | lava flows and cinder cones in Sand Mountain field |
| about 3,000 to 1,500 YBP | Belknap Volcano, central Cascades | lava flows, tephra |
| about 2,000 YBP | South Sister Volcano | rhyolite lava flow |
| about 1,300 YBP | Blue Lake Crater, central Cascades | spatter cones and tephra |

Note: YBP is years before present.

Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/
Scott et al. (2001); Walder et al. (1999)

### *Probability*

**Table 2-321. Assessment of Volcanic Hazards Probability in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | L | M | M | M | L | L |

Source: DOGAMI, 2020

Region 3 communities are closest to the Three Sisters and Mount Jefferson. Middle and South Sisters are the most active of the group. Because geologic history is fragmentary for these volcanoes, the probability of future explosive eruptions is difficult to estimate. Only two explosive episodes have occurred at the South Sister since the end of the ice age (about 12,000 years ago). Given the fragmentary record, the annual probability of the South and Middle Sister entering a new period of eruptive activity has been estimated from 1 in several thousand to 1 in 10,000 (Schilling et al., 1997). Similar difficulties complicate predictions of future eruptions at Mount Jefferson. There have been four episodes of lava flow eruptions around Mount Jefferson since the end of the Ice Age (about 12,000 years ago). Such a frequency suggests an annual probability of lava flow eruptions of 1 in 4,000 to 1 in 3,000 (Walder et al., 1999).

Table 2-322 provides further information about probability of volcanic eruptions in Region 3.

**Table 2-322. Probability of Volcano-Related Hazards in Region 3**

| Volcano-Related Hazards | Benton | Lane | Linn | Marion | Polk | Yamhill | Remarks |
|---|---|---|---|---|---|---|---|
| Volcanic ash (annual probability of 1 cm or more accumulation from eruptions throughout the Cascade Range) | 1 in 1,000 to 1 in 5,000 | 1 in 1,000 | 1 in 1,000 | 1 in 1,000 | 1 in 1,000 to 1 in 5,000 | 1 in 1,000 to 1 in 5,000 | Sherrod et al. (1997) |
| Lahar | no risk | source: Three Sisters McKenzie River: 3 scenarios: source to Thurston | Source: Mt. Jefferson S. Santiam R. from Mt. Jefferson to Detroit | source: Mt. Jefferson, N. and S. Santiam rivers from Mt. Jefferson to Detroit | no risk | no risk | if the Detroit Lake dam is breached, lahars could reach Mill City, Lyons, and Stayton in Marion County: Walder et al. (1999) (maps); Lane County: Scott et al. (2001) (map) |
| Lava flow | no risk | source: Three Sisters immediate vicinity | Source: Mt. Jefferson Immediate vicinity | source: Mt. Jefferson immediate vicinity | no risk | no risk | Mt. Jefferson: Walder et al. (1999) (maps); Three Sisters: Scott et al. (2001) (maps) |
| Debris flow / avalanche | no risk | source: Three Sisters Proximity | Source: Mt. Jefferson Proximity | source: Mt. Jefferson proximity | no risk | no risk | Mt. Jefferson: Walder et al. (1999) (maps); Three Sisters: Scott et al. (2001) (maps) |
| Pyroclastic flow | no risk | source: Three Sisters Proximity | Source: Mt. Jefferson Pamelia and Minto Creeks | source: Mt. Jefferson Whitewater Cr and S. Fork Santiam | no risk | no risk | Mt. Jefferson: Walder et al. (1999) (maps); Three Sisters: Scott et al. (2001) (maps) |

Sources: Sherrod et al. (1997), Walder et al. (1999), Scott et al. (2001)

### *Vulnerability*

**Table 2-323. Assessment of Vulnerability to Volcanic Hazards in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | L | H | H | VH | L | M |

Source: DOGAMI and DLCD, 2020

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

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 3 (Figure 2-XX). Over $153M in value is exposed to volcanic hazards in Region 3, all of it in Marion, Lane, and Linn Counties.

### *Historic Resources*

Of the 19,731 historic buildings in Region 3, 154 are exposed to moderate volcanic hazards, all in the same three counties. See Appendix X for details.

### *Social Vulnerability*

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1-5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

According to the 2020 vulnerability scores, Marion County is the most vulnerable to volcanic hazards in Region 3 followed by Lane and Linn Counties. Marion County's vulnerability is driven somewhat by the presence of state and local critical facilities, but primarily by social vulnerability. Lane County's vulnerability is driven by the presence of state buildings and state and local critical facilities. Linn County's vulnerability is driven by both the presence of local critical facilities and social vulnerability. Yamhill County has a very low vulnerability score for state buildings and state and local critical facilities, but high social vulnerability accounting for its moderate vulnerability score.

## *Risk*

**Table 2-324. Assessment of Risk to Volcanic Hazards in Region 3**

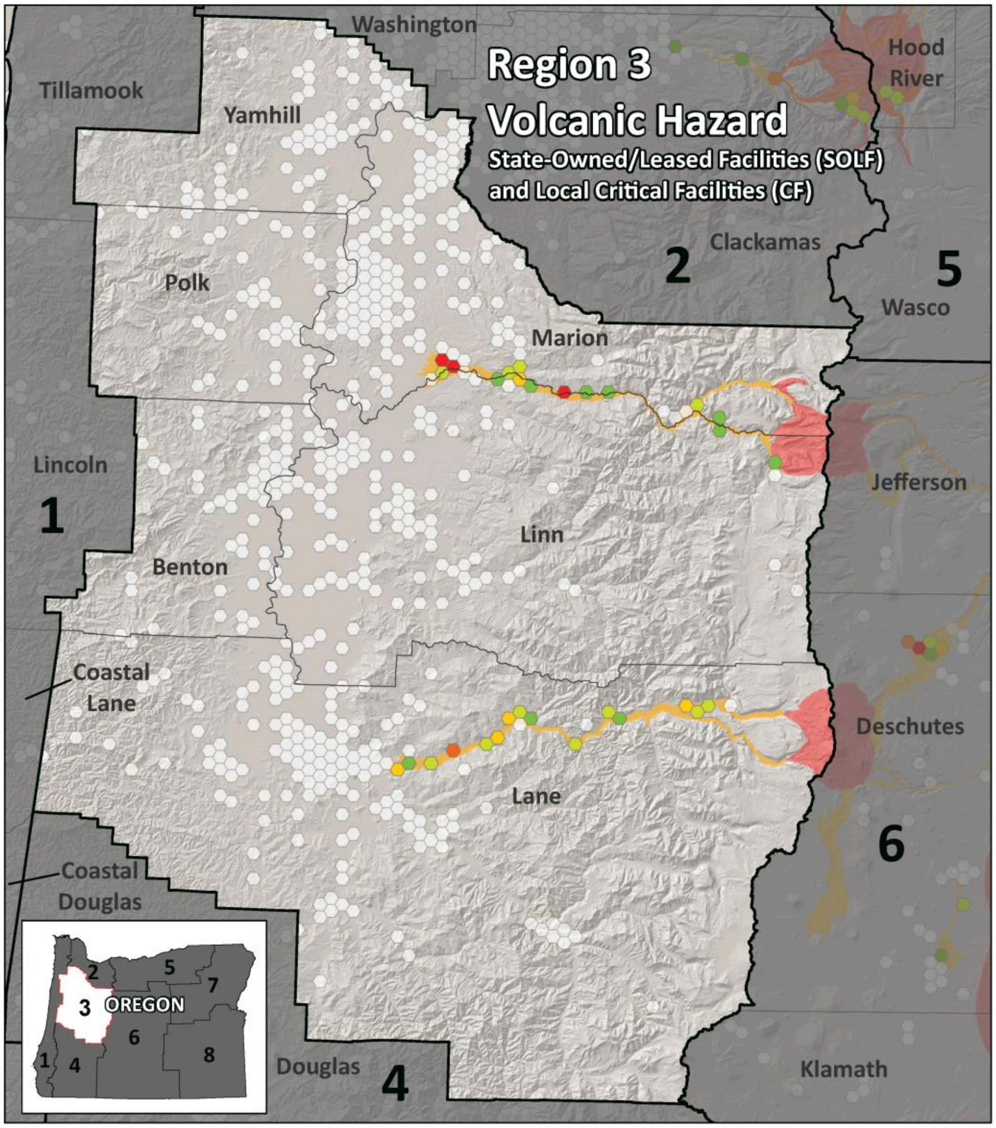
| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| RIsk | VL | H | H | VH | VL | L |

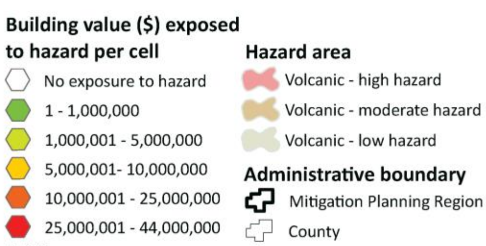
Source: DOGAMI and DLCD, 2020

According to the 2020 risk scores, Marion, Lane, and Linn Counties are the most at risk of volcanic hazards in Region 3 with either very high (VH) or high (H) risk ratings. These communities should be prioritized for mitigation actions. While these three counties all face moderate probability for volcanic hazards, they are more vulnerable than the other counties. Benton, Polk, and Yamhill Counties have either very low (VL) or Low (L) risk ratings.

The U.S. Geological Survey has addressed volcanic hazards at Mount Jefferson (Walder et al., 1999) and the Three Sisters (Scott et al., 2001). These reports include maps depicting the areas at greatest risk. Lane, Linn, and Marion Counties are at risk and should consider the impact of volcano-related activity, such as lahars, on small mountain communities, dams, reservoirs, energy-generating facilities, and highways. These counties also should consider probable impacts on the local economy (e.g., wood products and recreation). There is virtually no risk from volcanoes in Benton, Polk, and Yamhill Counties, although normal prevailing winds could shift and carry ash into those areas.

**Figure 2-184. State-Owned/Leased Facilities and Critical/Essential Facilities in a Volcanic Hazard Zone in Region 3.High-resolution, full-size image linked from Appendix 9.1.22.**



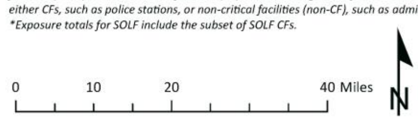

**Projection:**
Oregon Statewide Lambert Conformal Conic, Unit: International Feet,
Horizontal datum: NAD83 HARN, Scale 1:750,000

**Source Data:**
Volcanic: various studies of proximal and distal volcanic hazards from United States Geological Survey
State-owned/lease buildings: Oregon Department of Administrative Services, 2019
Administrative boundaries: Oregon Emergency Management and the Oregon Department of Land Conservation and Development, 2015
Hillshade base map: DOGAMI, Statewide mosaic, 2018, from Oregon Lidar Consortium data

**Author:** Matt Williams, Oregon Department of Geology and Mineral Industries, January 2020.

| REGION 3 | | Exposure ($) to Volcanic Hazard Areas | | | | | |
|---|---|---|---|---|---|---|---|
| | | State-owned/leased facilities | | | | Critical Facilities | |
| County | Total Value SOLF and Local CF | Value Exposed SOLF CF | % Value Exposed SOLF CF | Value Exposed SOLF Non-CF | Value Exposed Total* | Value Exposed Local CF | Total Value Exposed SOLF CF and Local CF |
| Benton | 642,420,000 | 0 | 0% | 0 | 0 | 0 | 0 |
| Lane | 2,960,570,000 | 1,693,000 | 0% | 27,156,000 | 28,849,000 | 27,991,000 | 29,684,000 |
| Linn | 934,323,000 | 0 | 0% | 153,000 | 153,000 | 35,879,000 | 35,879,000 |
| Marion | 4,700,844,000 | 2,865,000 | 0% | 4,851,000 | 7,716,000 | 84,748,000 | 87,613,000 |
| Polk | 508,293,000 | 0 | 0% | 0 | 0 | 0 | 0 |
| Yamhill | 851,391,000 | 0 | 0% | 0 | 0 | 0 | 0 |
| Total | 10,597,841,000 | 4,558,000 | 0% | 32,160,000 | 36,718,000 | 148,618,000 | 153,176,000 |

*This study divided buildings into two major categories by ownership: state-owned or leased facilities (SOLF) and local critical facilities (CF). SOLF buildings were further subdivided into either CFs, such as police stations, or non-critical facilities (non-CF), such as administrative offices.*
**Exposure totals for SOLF include the subset of SOLF CFs.*




Source: DOGAMI

## Wildfires

### *Characteristics*

Forests in Region 3 are quite productive due to the mild temperatures, amount of precipitation, and deep, rich, fertile soils. Historically, this landscape was dominated by oak woodland and savanna with an understory consisting of grasses and forbs. These landscapes tended to burn on a regular basis with low intensity surface fires. This area was also heavily influenced by the Kalapuya Indians. The Kalapuyas frequently burned this area to make the landscape more favorable to elk and deer, which they hunted for food. As Euro-Americans moved in, native tribes moved on. Without prescribed burns, conifer trees have established and have overtopped the oak trees. The understory has changed from grasses and forbs to an understory with more woody shrubs and dead and downed wood. These forests are similar to those of the Oregon Coast Range and have historic fire return intervals of 150-300 years. These fires also tend to be large, stand-replacing fires, rather than the low-intensity, frequent fires of the oak woodland forest type.

Because wildland fires are being effectively suppressed, the patterns and characteristics of fires are changing. Vegetation that historically would have been minimized by frequent fires has become more dominant. Over time, some species have also become more susceptible to disease and insect damage, which leads to an increase in mortality. The resulting accumulation of dead wood and debris creates the types of fuels that promote intense, rapidly spreading fires

### *Historic Wildfire Events*

**Table 2-325. Historic Wildfires Affecting Region 3**

| Year | Name of Fire | Counties | Acres Burned | Remarks |
|---|---|---|---|---|
| 1853 | Nestucca | Tillamook/Yamhill | 320,000 | |
| 1849 | Siletz | Lincoln/Polk | 800,000 | |
| 1865 | Silverton | Marion | 988,000 | |
| 1933 | Tillamook | Tillamook, Yamhill | 240,000 | Human caused. Between 1933 and 1951, the Tillamook forest burned every 6 years. Fires followed drought conditions. Total Tillamook Burn: 350,000 acres (George Taylor, *The Oregon Weather Book*, p.202) |
| 1972 | Yamhill | Yamhill | | |
| 1977 | | Yamhill | | west of Carlton |
| 1987 | Shady Lane | Polk | | |

Note: This list is representative of a lengthy wildfire history. There have been many fires, named and unnamed. Statistics differ, depending on the source. There have been no large, historic wildfires in Region 3 in recent years.

Source: Brian Ballou, August 2002, A Short History of Oregon Wildfires, Oregon Department of Forestry, unpublished; Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina.

### *Probability*

**Table 2-326. Assessment of Wildfire Probability in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | L | M | H | H | L | L |

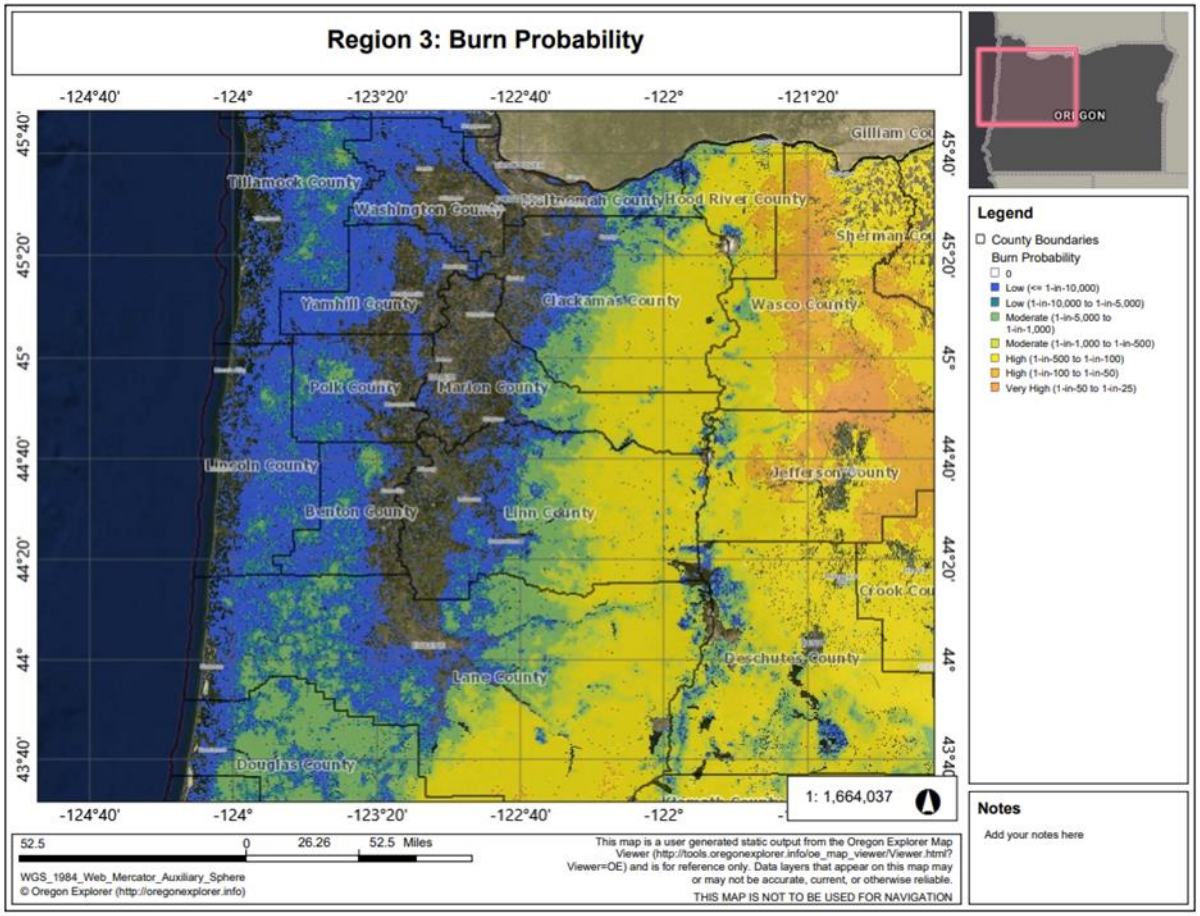
Source: PNW Quantitative Wildfire Risk Assessment and Oregon Wildfire Risk Explorer, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to assess the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-185 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

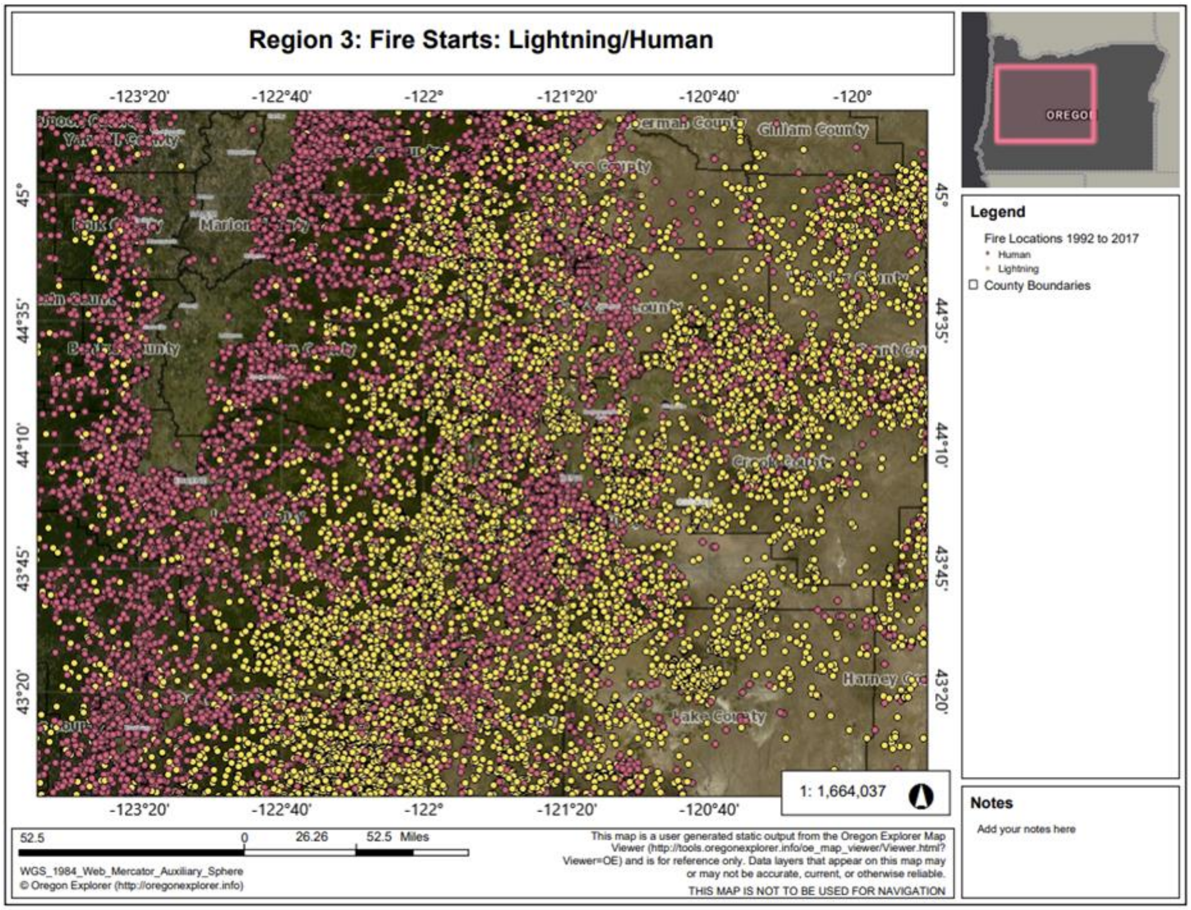
**Figure 2-185. Burn Probability**




Source: Oregon Wildfire Risk Explorer, March 2020

Wildfire always has been a part of the ecosystems in Oregon, sometimes with devastating effects. Some of the state's most devastating wildfires have been in counties within Region 3 (e.g., Marion, Polk, and Yamhill). Wildfire results from natural causes (e.g., lightning strikes), mechanical failure (Oxbow Fire), or human activity (unattended campfire, debris burning, or arson).

**Figure 2-186. Human- and Lightning-Caused Wildfires in Region 3, 1992-2017**




Source: Oregon Wildfire Risk Explorer, March 2020

### *Climate Change*

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton et al., 2017).

In moisture-limited forest systems, such as those in the Coast and Cascade Ranges, warming winters will lead to more fine fuels from greater cold season growth. Hotter and drier conditions will lead to large fuel quantities, which lead to large and severe fires. It is very likely (>90%) that the Coast Range and lower elevations of the Cascade Range in Region 3 will experience increasing wildfire frequency and intensity under future climate change. Modeled projections of future fire frequency indicate more frequent fires for the Pacific Northwest, particularly west of the Cascade Mountains where fires have been infrequent historically. In coastal areas, fire frequency is projected to change from approximately every 100 years to every 60 years.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 3 counties (Table 2-327).

**Table 2-327. Projected Increase in Annual Very High Fire Danger Days in Region 3 Counties by 2050 under RCP 8.5**

| County | # Additional Days | Percent Change |
|---|---|---|
| Benton | 11 | 30% |
| Lane | 12 | 32% |
| Linn | 12 | 33% |
| Marion | 13 | 35% |
| Polk | 11 | 31% |
| Yamhill | 12 | 33% |

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

### *Vulnerability*

**Table 2-328. Assessment of Vulnerability to Wildfire in Region 3 – Communities at Risk**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | L | M | L | L | VL | L |

Source: 2020 ODF Communities at Risk Report

**Table 2-329. Assessment of Vulnerability to Wildfire in Region 3 – 2020 Vulnerability Assessment**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | VL | L | M | H | L | M |

Source: DOGAMI and DLCD, 2020

According to ODF's assessment of Communities at Risk, wildfire vulnerability is generally low to moderate in Region 3. Jurisdictions most vulnerable to wildfire are the result of a dispersed population in close proximity to abundant vegetative fuels. These forestlands contain extensive fuels composed of flammable grasses, brush, slash and timber.

Each year a significant number of people build homes within or on the edge of the forest (wildland-urban interface), thereby increasing wildfire hazards. These communities have been designated "Wildland-Urban Interface Communities" and include those in Table 2-330.

**Table 2-330. Wildland-Urban Interface Communities in Region 3**

| Benton | Lane (Non-Coastal) | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|
| Adair | Bohemia City | Albany | Aumsville | Airlie | Amity |
| Alsea | Coburg | Brownsville | Aurora | Buell | Carlton |
| Blodgett | Cottage Grove | Clear Lake Resort | Drakes Crossing | Dallas | Dayton |
| Corvallis | Creswell | Halsey | Gates | Falls City | Dundee |
| Dawson | Dexter | Harrisburg | Stayton | Fort Hill | Grand Ronde Agency |
| Hoskins | Dorena | Lebanon | Hubbard | Grand Ronde | Lafayette |
| Mary's River Estates | Eugene | Lost Prairie | Idanha | Independence | McMinnville |
| Monroe | Glenwood | Lower Willamette | Jefferson | Pedee | Midway |
| Philomath | Goshen | Lyons | Keizer | West Valley | Nestucca |
| Summit | Hazeldell | Marion Forks | Lyons | | Orchard View |
| Vineyard Mountain | London Springs | Mill City | Marion | | Sheridan |
| | Lorane | New Idanha | Mehama | | Trask |
| | Lowell | Scio | Mill City | | Willamina |
| | Lower McKenzie | South Shore | Mill Creek | | Yamhill |
| | McKenzie | Sweet Home | Monitor | | |
| | Mohawk | Tadmor | Mt Angel | | |
| | Oakridge | Tangent | Orchard View | | |
| | Pleasant Hill | | Salem | | |
| | Rainbow | | Scotts Mills | | |
| | Santa Clara, Eugene | | Silverton | | |
| | Springfield | | St Paul | | |
| | Upper McKenzie | | Sublimity | | |
| | Upper Willamette | | Turner | | |
| | Waldon | | Woodburn | | |
| | West Valley | | | | |
| | Veneta | | | | |
| | Walker | | | | |
| | Westfir | | | | |

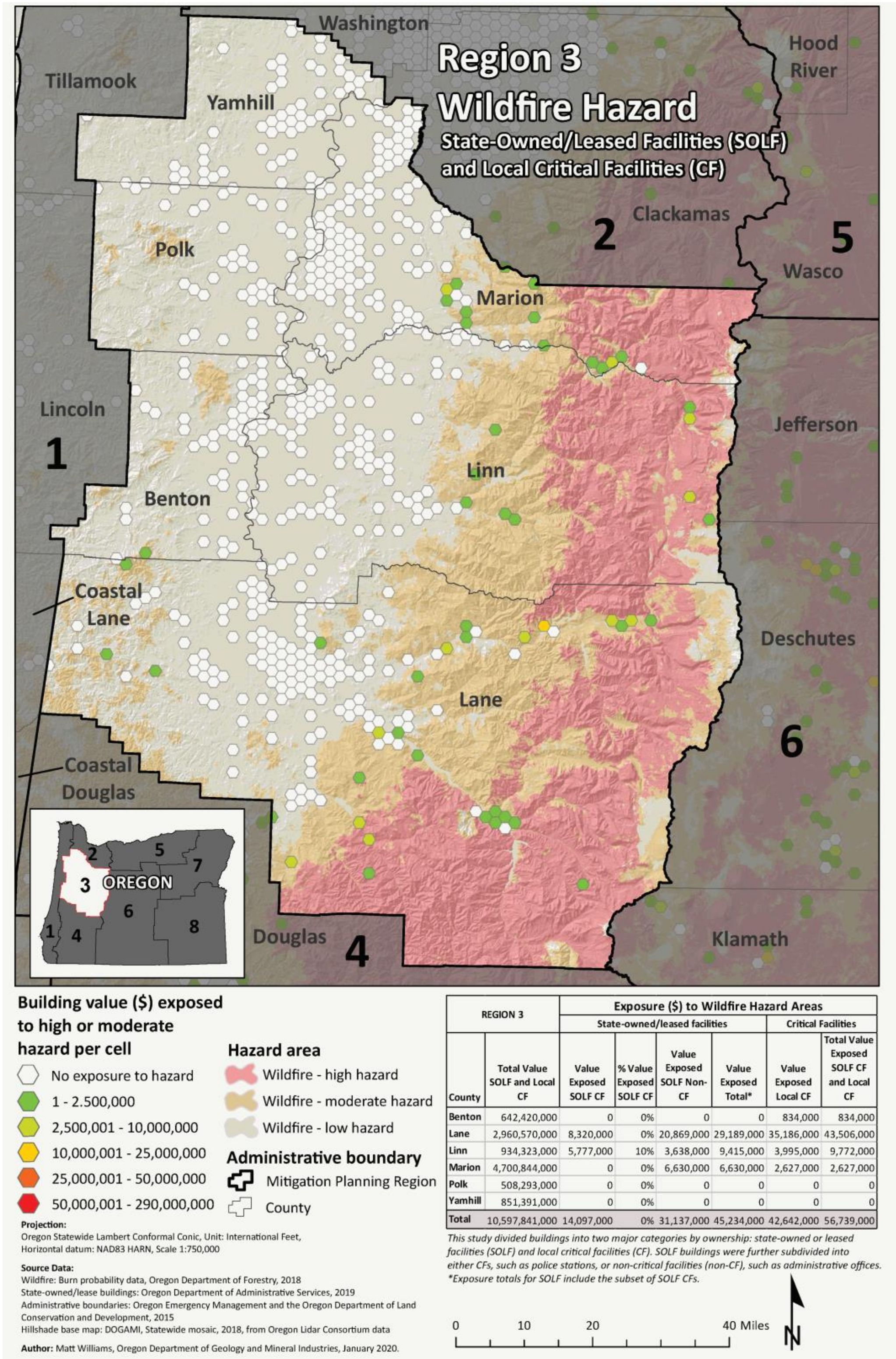
Source: Oregon Department of Forestry 2020 Communities at Risk Report

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

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

In Region 3, there is a potential loss to wildfire of about $45M in state building and critical facility assets, 65% of it in Lane County, 21% in Linn County, and 15%d in Marion County. Benton Polk, and Yamhill Counties have no state assets in wildfire hazard areas. There is a similar potential loss in local critical facilities: about $42.6M. Eighty-three percent of that value is located in Lane County, 9% in Linn County, 6% in Marion County, and 2% in Benton County. , Neither Polk nor Yamhill County has local critical facilities located in a wildfire hazard area.

**Figure 2-187. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in Region 3.High-resolution, full-size image linked from Appendix 9.1.22.**




| REGION 3 | | Exposure ($) to Wildfire Hazard Areas | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | State-owned/leased facilities | | | | | Critical Facilities | |
| County | Total Value SOLF and Local CF | Value Exposed SOLF CF | % Value Exposed SOLF CF | Value Exposed SOLF Non-CF | Value Exposed Total* | Value Exposed Local CF | Total Value Exposed SOLF CF and Local CF | |
| Benton | 642,420,000 | 0 | 0% | 0 | 0 | 834,000 | 834,000 | |
| Lane | 2,960,570,000 | 8,320,000 | 0% | 20,869,000 | 29,189,000 | 35,186,000 | 43,506,000 | |
| Linn | 934,323,000 | 5,777,000 | 10% | 3,638,000 | 9,415,000 | 3,995,000 | 9,772,000 | |
| Marion | 4,700,844,000 | 0 | 0% | 6,630,000 | 6,630,000 | 2,627,000 | 2,627,000 | |
| Polk | 508,293,000 | 0 | 0% | 0 | 0 | 0 | 0 | |
| Yamhill | 851,391,000 | 0 | 0% | 0 | 0 | 0 | 0 | |
| Total | 10,597,841,000 | 14,097,000 | 0% | 31,137,000 | 45,234,000 | 42,642,000 | 56,739,000 | |

Source: DOGAMI, 2020

#### *Historic Resources*

Of the 19,731 historic resources in Region 2, eleven are located in an area of high wildfire hazard in Lane, Linn, and Marion Counties. Forty-three are located in an area of moderate wildfire hazard. Again, all are in Lane, Linn, and Marion Counties. The rest are in areas of low wildfire hazard in all the counties, with 50% in Lane County alone

#### *Social Vulnerability*

The Centers for Disease Control and Prevention (CDC) has calculated a social vulnerability index to assess community resilience to externalities such as natural hazard events. It employs fifteen social vulnerability factors and uses data from the US Census Bureau's American Community Survey. The index is reported in quintiles (1-5). Social vulnerability scores do not vary by hazard.

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well." Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties. Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, vulnerability to wildfire varies from very low to high, but overall it is low to moderate. While the individual county scores differ, this assessment is in general agreement with the scores based on Communities at Risk. The exception is Marion County whose very high social vulnerability drove its vulnerability score higher than that of the other counties.

Marion County is the most vulnerable to wildfire in Region 3.

### *Risk*

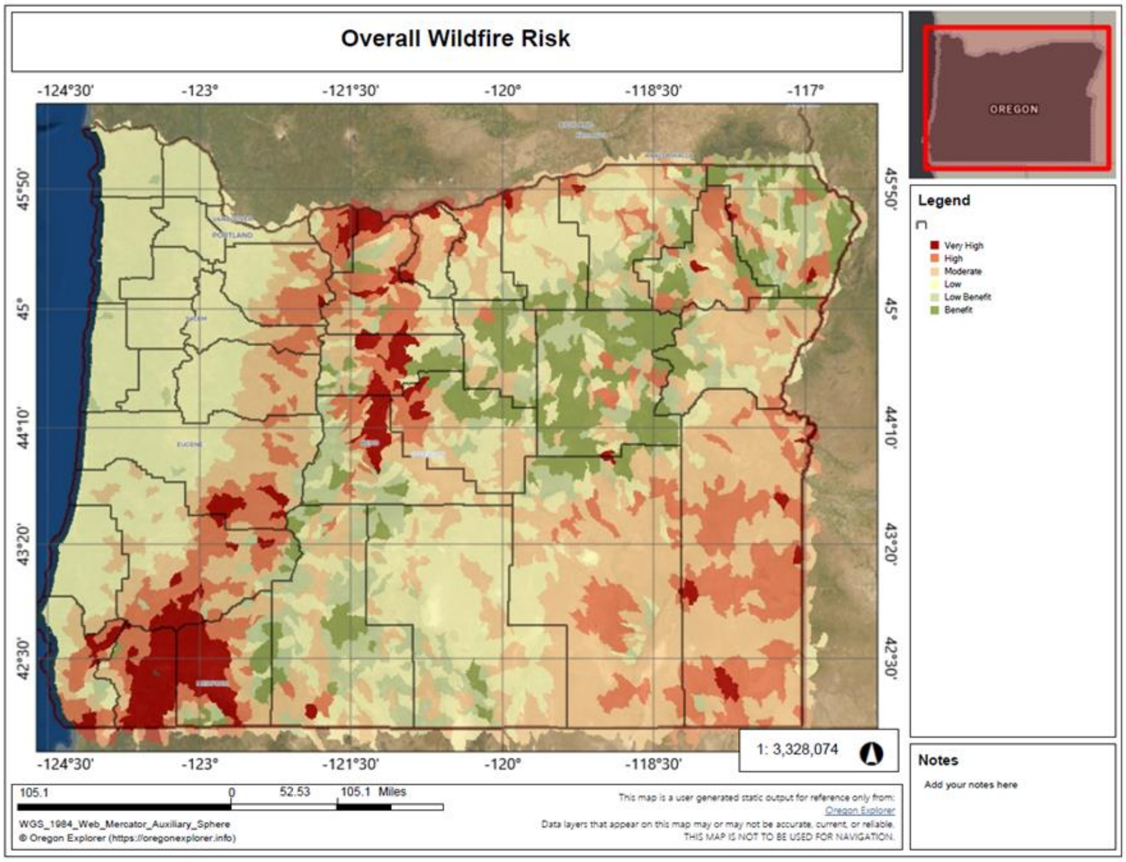
**Table 2-331. Risk of Wildfire Hazards in Region 3**

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

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, overall the risk from wildfire in Region three is low to moderate. In Benton and Polk Counties it is very low. Yamhill County's risk would be lower save for its high social vulnerability. These scores, then, are in agreement with ODF's assessment mapped in Figure 2-188. In addition, the moderate scores of the 2020 risk assessment are in general agreement with that map as the western portions of Lane, Linn, and Marion Counties are shown with low risk and the eastern portions with high or very high risk. The 2020 risk assessment is not granular enough to account for geographic differences in probability, vulnerability, or risk within a county.

**Figure 2-188. Overall Wildfire Risk**




Source: Oregon Explorer, 2020

## Windstorms

### *Characteristics*

High winds are not uncommon in the Willamette Valley. A majority of the destructive surface winds in the region are from the southwest, similar to Region 2. The much more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they may be stronger on the coast than in the interior valleys because of the north-south orientation of the Coast Range and Cascades. These mountain ranges obstruct and slow down the westerly surface winds. The most destructive winds are those which blow from the south, parallel to the major mountain ranges.

The Columbus Day Storm of 1962 was a classic example of such a storm, and its effects were so devastating that it has become the benchmark from which other windstorms in Oregon are measured. The storm caused significant damage in Region 3.

In addition to windstorms, tornadoes have been recorded in Region 3 since 1887. The storms have occurred during all seasons, as described in **Table 2-332**. Fortunately, damage has been slight, and has mostly affected individual farm buildings, orchards, telephone poles and trees.

### *Historic Windstorm Events*

**Table 2-332. Historic Windstorms Affecting Region 3**

| Date | Location | Description |
|---|---|---|
| Apr. 1931 | western Oregon | unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber |
| Nov. 10-11, 1951 | statewide | widespread damage; transmission and utility lines; Wind speed 40-60 mph; gusts 75-80 mph |
| Dec. 1951 | statewide | wind speed 60 mph in Willamette Valley; 75-mph gusts; damage to buildings and utility lines |
| Dec. 1955 | statewide | wind speeds 55-65 mph with 69-mph gusts; considerable damage to buildings and utility lines |
| Nov. 1958 | statewide | wind speeds at 51 mph with 71-mph gusts; every major highway blocked by fallen trees |
| Oct. 1962 | statewide | Columbus Day Storm; Oregon's most destructive storm to date; 116-mph winds in Willamette Valley; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million |
| Mar. 1971 | most of Oregon | greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County |
| Nov. 1981 | most of Oregon | highest winds since Oct. 1962; wind speed 71 mph in Salem; marinas, airports, and bridges severely damaged |
| Jan. 1990 | statewide | heavy rain with winds exceeding 75 mph; significant damage; one fatality |
| Dec. 1995 | statewide | followed path of Columbus Day Storm; wind speeds 62 mph in Willamette Valley; damage to trees (saturated soil a factor) and homes (FEMA-1107-DR-Oregon) |
| Nov. 1997 | western Oregon | wind speed 52 mph in Willamette Valley; trees uprooted; considerable damage to small airports |
| Feb. 2002 | western Oregon | strongest storm to strike western Oregon in several years; many downed power lines (trees); damage to buildings; water supply problems (lack of power); estimated damage costs: $6.14 million (FEMA-1405-DR-Oregon) |
| July 2003 | Marion County | $15,000 in property damage |
| Dec. 2004 | Marion, Lane, and Polk Counties | $6,250 in property damage — property damage estimate includes counties outside of Region 3 |
| Dec. 2005 | Mario and Linn Counties | $3,000 in property damage |
| Apr. 2004 | Lane County | $5,000 in property damage |
| Jan. 2005 | Linn and Marion Counties | windstorms cause $6,000 of damage in Linn and Marion Counties; a storm total of $15,000 in damages spread out among, Linn, Marion, Clackamas, Multnomah, and Washington Counties |
| Jan. 2006 | Yamhill, Marion, and Polk Counties | wind storm with winds up to 58 mph causes a total of $500,000 in damages spread out over all four counties and includes Clackamas, Columbia, Washington, and Multnomah Counties as well |
| Feb. 2006 | Linn, Marion, Lane, Benton, Polk, and Yamhill Counties | wind storms with gusts up to 77 mph cause $227,000 in damages in Linn, Lane, Marion, Benton, Polk, and Yamhill Counties; storm causes damages in region 2 and region 1 as well for a total storm damage of $575,000 |
| May 2006 | Lane County | $5,000 in property damage in Eugene, approximately 13,000 customers out of power |
| May 2007 | Marion County | hail storm causes $5,000 in damages |
| Mar. 2008 | Marion County | heavy winds measured at 40 mph cause $15,000 in damage near Woodburn |
| Dec. 2015 | Regions 1-4 | FEMA-4258-DR: severe winter storms, straight-line winds, flooding, landslides, and mudslides |
| Apr. 2019 | Curry, Douglas, Linn, Wheeler, Grant, and Umatilla | FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides |

Sources: Taylor and Hatton (1999); FEMA-1405-DR-OR: February 7, 2002, Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon; Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [online database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org

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

**Table 2-333. Recorded Tornadoes in Region 3**

| Date | County | Damage Description |
|---|---|---|
| Jan. 1887 | Lane | fences damaged; livestock losses; trees uprooted |
| Nov. 1925 | Polk | buildings, barns, and fruit trees damaged |
| Feb. 1926 | Polk | house and trees damaged |
| Sep. 1938 | Linn | observed in Brownsville; no damage |
| Dec. 1951 | Lane | barn destroyed |
| Jan. 1953 | Benton | observed; no damage |
| Mar. 1960 | Marion | several farms damaged near Aumsville; trees uprooted |
| May 1971 | Yamhill | house and barn damaged near McMinnville |
| Aug. 1975 | Lane | metal building destroyed near Eugene |
| Aug. 1978 | Yamhill | minor damage near Amity |
| Apr. 1984 | Yamhill | barn roof destroyed |
| May 1984 | Lane | barn and shelter damaged near Junction City |
| Nov. 1989 | Lane | telephone poles and trees uprooted near Eugene |
| Nov. 1991 | Marion | barn damaged near Silverton |
| Sep. 2007 | Linn | a tornado rated at F0 near Albany and Lebanon causes $20,000 in damage to buildings and $22,000 to crops |
| Dec. 2010 | Marion | a tornado rated at F2 damaged 50 buildings in the community of Aumsville, causing a total of $1.2 million in property damage |
| Jun. 2013 | Yamhill | McMinnville; tornado took ¼ mile path through town, some structural damage; $100K in crop damage |
| Apr. 2015 | Lane | Eugene; EF0; $25K in property damage |
| Sep. 2017 | Linn | Lacomb; EF1; $240K in property damage |
| Oct. 2017 | Marion | Aurora Airport; EF0; $40K in property damage |
| Oct. 2018 | Marion | Jefferson; EF0; $200 in property damage |

Sources: Taylor and Hatton (1999, pp. 130-137); U.S. Department of Commerce. National Climatic Data Center. Available from http://www.ncdc.noaa.gov/stormevents/; https://www.ncdc.noaa.gov/stormevents/

## *Probability*

**Table 2-334. Assessment of Windstorm Probability in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | H | H | H | H | H | H |

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

The 100-year event for a windstorm in Region 3 is 1-minute average winds of 75 mph. A 50-year event has average winds of 68 mph. A 25-year event has average winds speeds of 60 mph.

### *Climate Change*

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

## *Vulnerability*

**Table 2-335. Assessment of Vulnerability to Windstorms in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | M | M | M | H | H | M |

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

Many buildings, utilities, and transportation systems within Region 3 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair. Benton, Lane, Marion, and Polk Counties are listed by PUC as being most vulnerable to wind damage in this region.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, uprooted or shattered trees can down power and other utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed by uprooted ancient trees growing next to a house. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establish a tree maintenance and removal program.

Bridges, which may be closed during periods of high wind, are an additional consideration.

### *Social Vulnerability*

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

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties.

Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well."

Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties.

Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

Marion County's very high social vulnerability indicates that the effects of windstorms will be felt more intensely by its population than by the populations of the other Region 3 counties and will require more resources for preparation, mitigation, and response. Social vulnerability in Linn and Yamhill Counties is high. Marion, Linn, and Yamhill Counties are the most vulnerable to windstorms in Region 3.

### *Risk*

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

Due to their greater vulnerability, Marion, Linn, and Yamhill Counties are at greater risk from windstorms than the other counties in Region 3. Marion County is the most at risk in Region 3 and with Morrow County in the state overall.

## Winter Storms

### *Characteristics*

Severe winter weather in Region 3 is characterized by extreme cold, snow, ice, and sleet. Although such conditions may be expected in the Cascade Mountains and eastern Oregon, they are considered to be unusual in the Willamette Valley. Some Region 3 communities are unprepared, financially and otherwise, to handle severe winter storms. There are more moderate annual winter storms in the region; severe winter storms occur approximately every 4 years in the Valley. Severe weather conditions do not last long in Region 3, and winter-preparedness is a moderate priority.

### *Historic Winter Storm Events*

**Table 2-336. Severe Winter Storms in Region 3**

| Date | Location | Description |
|---|---|---|
| Dec. 1861 | statewide | snowfall varied between 1 and 3 feet; did not leave Willamette Valley floor until late February |
| Dec. 1864 | Willamette Valley and Columbia Basin | heavy snowfall; Albany (Linn County) received 16 inches in one day |
| Jan. 1916 | statewide | two snow storms, each totaling 5 inches or more |
| Dec. 1919 | Corvallis (Benton County | Corvallis received 22 inches of snow and set an all-time low temperature record of 14 °F |
| Jan.- Feb. 1937 | statewide | heavy snow throughout the Willamette Valley; Dallas (Polk County) had 24 inches; Salem (Marion County) had 25 inches |
| Jan. 1950 | statewide | heaviest snowfall since 1890; many highway closures; considerable property damage |
| Jan. 1956 | western Oregon | packed snow became ice; many automobile accidents throughout the region |
| Mar. 1960 | statewide | snowfall: 3–12 inches, depending on location; more than 100 snow-related accidents in Marion County |
| Jan. 1969 | statewide | Lane County surpassed old snowfall record; Eugene (Lane County) had a total snow depth of 47 inches; three to $4 million in property damage |
| Jan. 1980 | statewide | a series of storms bringing snow, ice, wind, and freezing rain; six fatalities |
| Feb. 1985 | statewide | western valleys received 2–4 inches of snow; massive power failures (tree limbs broke power lines) |
| Dec. 1985 | Willamette Valley | heavy snowfall throughout valley |
| Mar. 1988 | statewide | strong winds and heavy snow |
| Feb. 1989 | statewide | heavy snowfall and record low temperatures; Salem (Marion County) received 9 inches |
| Feb. 1990 | statewide | average snowfall from one storm about 4 inches (Willamette Valley) |
| Dec. 1992 | western Oregon | heavy snow; interstate highway closed |
| Feb. 1993 | western Oregon | record snowfall at Salem airport |
| Winter 1998-99 | statewide | series of storms; one of the snowiest winters in Oregon history |
| Dec. 2003 -Jan. 2004 | statewide | DR-1510. Benton, Lane, Linn, Marion, Polk, and Yamhill declared in Region 3. Wet snow blanketed highways in the Willamette Valley, causing power lines and trees to topple; Oregon 34 east of Philomath was closed for 30 hours January 5 and 6 while crews removed trees; Presidential disaster declaration for 30 of Oregon's 36 counties |
| Mar. 8–10, 2006 | Lane, Linn, Benton, Marion, Polk, Yamhill Counties | snow fell up to a few inches at the coast and through the Willamette Valley; many school closures |

| Date | Location | Description |
|---|---|---|
| Jan.-Feb. 2008 | Marion County | a series of vigorous winter storms brought record setting snow accumulation to Detroit, Oregon; three dozen Oregon National Guard personnel were called in to help with snow removal in Detroit and Idanha; the towns received over 12 feet of snow in several weeks |
| Dec. 9–11, 2009 | Marion, Linn, Lane Counties | freezing rain covered the central valley with a coating of ice; south of Salem, numerous road closures due to accidents caused by icy roadway; I-84 from Troutdale to Hood River closed for 22 hours |
| Feb. 6–10, 2014 | Lane, Benton, Polk, Yamhill, Linn, and Marion Counties | DR-4169. Linn, Lane, and Benton Counties declared in Region 3. A strong winter storm system affected the Pacific Northwest during the February 6–10, 2014 time period bringing a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon; a much warmer and moisture-laden storm moved across northwest Oregon after the snow and ice storm (Feb. 11-14), which produced heavy rainfall and significant rises on area rivers from rain and snowmelt runoff; during the 5-day period Feb. 6–10, 5 to 16 inches of snow fell in many valley locations and 2 to10 inches in the coastal region of northwest Oregon; freezing rain accumulations generally were 0.25 to 0.75 inches; the snowfall combined with the freezing rain had a tremendous impact on the region |
| Feb. 11–14, 2014 | Lane, Benton, Polk, Yamhill, Linn, and Marion Counties | DR-4169 Linn, Lane, Benton and Lincoln Counties declared. Another weather system moved across northwest Oregon during the February 11–14 time frame; this storm was distinctly different from the storm that produced the snow and ice the week prior and brought abundant moisture and warm air from the sub-tropics into the region; as this storm moved across the area, 2 to 7 inches of rain fell across many counties in western Oregon; the heavy rainfall combined with warm temperatures led to snowmelt and rainfall runoff that produced rapid rises on several rivers, which included flooding on three rivers in northwest Oregon |
| Nov. 13, 2014 | Marion, and Linn Counties (North Cascade foothills) | An early cold snap hit the Pacific Northwest before moist Pacific air moved in and resulted in one of the earliest snow, sleet, and freezing rain events in northwestern Oregon. Farther south, 1/2 of freezing rain accumulated on trees in the coast range foothills outside of Corvallis and Dallas, Oregon. Upwards of a quarter of an inch of ice fell around Dallas, Oregon. Some snow fell, but accumulations were primarily restricted to the Cascade valleys and the central Columbia River Gorge. Spotters reported around 6 to 8 inches of snow for the Cascade Foothills followed by a quarter of an inch of ice. |
| Dec. 6-23, 2015 | Statewide storm events | DR-4258. Yahmill, Polk, Linn, and LaneCounties declared in Region 3. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Each storm system brought several inches of snow to the mountain areas. At first the snow was limited to higher elevations...but lowered with time to some of the west side valley floors. Moist onshore winds produced a steady stream of showers over the foothills of the Cascades with snow levels between 1000 and 2000 feet. |
| Mar. 13, 2016 | Marion, Linn and Lane Counties (North Oregon Cascades and Cascades in Lane County) | A strong low pressure system generated frequent and persistent snow showers over the northern and central Oregon Cascades. Several SNOTEL stations measured 16 to 24 inches of snow over a 24 to 30 hour period above 3500 feet. |
| Dec. 14-15, 2016 | Lane, Benton, Marion, and Linn Counties (Southern Willamette Valley, Cascade foothills in Lane County, Northern Cascade foothills) | DR-4296. Lane County declared in Region 3. Severe winter storm and flooding. East winds ahead of an approaching low pressure system brought temperatures down below freezing across the area ahead of the approaching precipitation. This lead to a mix of freezing rain, sleet, and snow across the area. While areas farther north saw more of a snow/sleet mix before a changeover to freezing rain then rain, areas in Lane County saw freezing rain for most of this event, causing power outages, damage to trees, and many car accidents around Eugene and Springfield. Snow followed by sleet and freezing rain. The freezing rain turned into a major ice storm occurred in Eugene and the vicinity with 0.5 to 1.0 inch of ice accumulation observed. There was significant damage to trees and power lines, and fairly widespread power outages across the region. 15,000 people were without power. There was a report of 0.4 inch of ice accumulation near Sodaville. |

| Date | Location | Description |
|---|---|---|
| Dec. 26-27, 2016 | Linn and Marion, Counties (North Oregon Cascades) | A frontal system brought high winds to the Central Oregon Coast, heavy snow to the Cascades and a mix of ice and snow in the Columbia River Gorge and Hood River Valley. SNOTELs and other stations reported a range of 12 to 25 inches of snow in the Cascades. Some specific reports include 25 inches at Mt Hood Meadows, 22 inches at Timberline, 14 inches at Government Camp and 12 inches at McKenzie Snotel. |
| Jan. 7-8, 2017 | Lane, Benton, Polk, Yamhill, Linn, and Marion Counties(Central and Southern Willamette Valley, North Cascades foothills) | DR-4328. No counties in Region 3 declared. Severe Winter Storms, Flooding, Landslides, And Mudslides. A broad shortwave trough brought multiple rounds of precipitation, including a wintry mix of snow and ice for many locations across Northwest Oregon. Strong easterly pressure gradients generated high winds through the Columbia River Gorge as well on January 8. General snowfall totals of 2-4 inches were reported, with the greatest total being 4.5 inches. Major ice accumulations occurred after the snow, with several locations reporting 0.50-1.00. The combination of snow and ice resulted in significant power outages and closures across the area. |

Source: Taylor and Hatton (1999); unknown sources; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

### *Probability*

**Table 2-337. Assessment of Winter Storms Probability in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Probability | H | H | H | H | — | H |

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

Winter storms occur annually in Region 3. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

#### *Climate Change*

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

### *Vulnerability*

**Table 2-338. Assessment of Vulnerability to Winter Storms in Region 3**

| | Benton | Lane | Linn | Marion | Polk | Yamhill |
|---|---|---|---|---|---|---|
| Vulnerability | M | H | H | H | — | H |

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

The I-5 corridor through this region is key to intermodal transportation; severe winter storms can have an adverse impact on the economy if the interstate has to be closed for any extended period of time.

### *Social Vulnerability*

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

According to the CDC Social Vulnerability Index, social vulnerability in the region is highest in Marion County, followed by Linn and Yamhill Counties. Marion County ranks in the 90th percentile for its share of persons aged 17 or younger, percentage of single-parent households, and percentage of occupied housing units with more people than rooms. The county is also the 90th percentile for its share of residents that speak English less than "well."

Linn County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county is in the 80th percentile for its share of single-parent households and has a smaller per-capita income and a higher percentage of persons aged 17 and younger than 70 percent of all counties.

Vulnerability in Yamhill County is also driven by moderately high scores across the CDC index. The county is in the 80th percentile for its share of multi-unit structures and the percentage of people living in institutionalized group quarters.

Marion County's very high social vulnerability, indeed among the highest in the state, coupled with its vulnerability to closure of Interstate 5 make it the county most vulnerable to the adverse impacts of winter storms in Region 3. Linn and Yamhill's high social vulnerability make them relatively more vulnerable than the other counties in the region.

## *Risk*

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

Marion County is at the greatest risk from winter storms in Region 3 followed by Linn and Yamhill Counties.