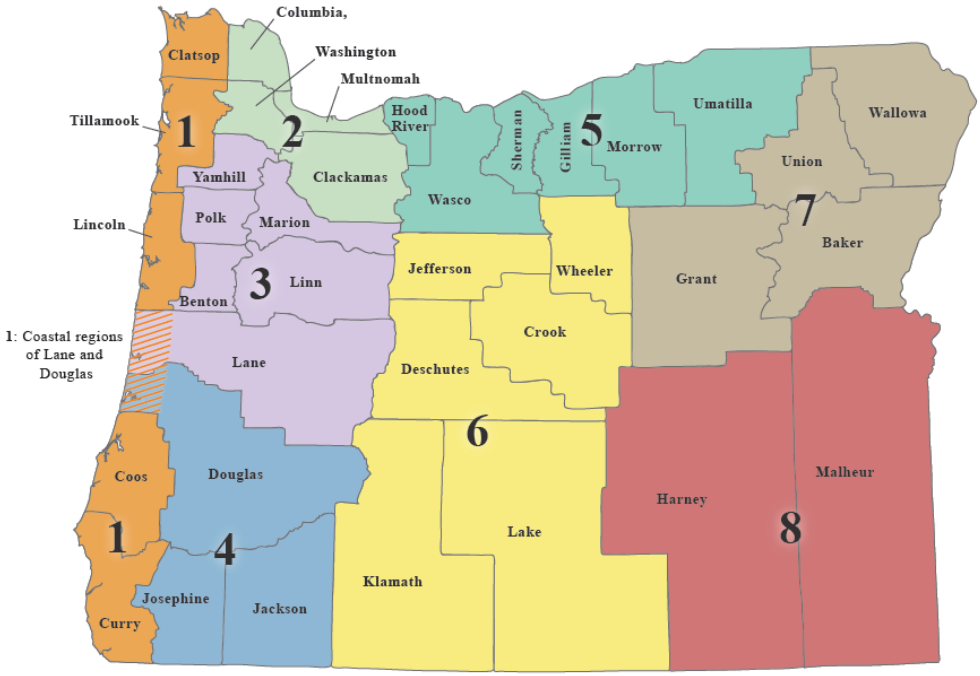
2.3 Regional Risk Assessments

The purpose of the Regional Risk Assessment is to assess risks at a regional scale by profiling the characteristics, natural hazards, and vulnerabilities within the eight Oregon NHMP Natural Hazard Regions (Figure 2-115). Each region has its own Risk Assessment. Together, the eight Regional Risk Assessments combine to describe the State's overall risk to natural hazards.

Figure 2-115. Oregon NHMP Natural Hazards Regions



Each Regional Risk Assessment includes three sections:

1. The **Summary** provides a general overview of (a) the Regional Profile, (b) the Regional Hazards and Vulnerability, and (c) how climate change models predict hazards in the region will be impacted based on statewide data.
2. The **Profile** section provides an overview of the region's unique characteristics including profiles of the natural environment, social and demographic situation, economic environment, infrastructure, and built environment.

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

prepare for, mitigate, and reduce vulnerability (Cutter, Boruff, & Shirley, 2003); (Cutter S. L., 2006).

Margin of Error (MOE)

The sociodemographic data in the regional profiles are primarily sourced from the U.S. Census Bureau's American Community Survey (ACS). The ACS's estimates are subject to sampling and nonsampling errors. Nonsampling errors are the product of survey design and measurement flaws, "while sampling error is when the characteristics of the survey group vary from those of the larger population of interest...causing the true value to fall within a range bounded by a margin of error" (Quinterno, 2014).

Through adding and subtracting the MOE from the estimate, users can calculate the 90% confidence interval for that estimate (U.S. Census Bureau, 2018). For example, in **Table 2-81. People with a Disability by Age Group in Region 1**, data from the 2017 ACS 5-year estimates indicate that 19.1% of all people in Clatsop County have a disability with a MOE of 1.4%. Through adding and subtracting the MOE from the estimate, the user can calculate the 90% confidence interval for that estimate (U.S. Census Bureau, 2018). Doing so indicates that we can be 90 percent confident that the true share of residents in Clatsop County with a disability in the 2013-2017 period falls between 17.7% and 20.5%.

Period Estimates

It should also be noted that the ACS estimates in the plan are period estimates, rather than point-in-time or cumulative counts. “A period estimate shows the average value of the variable over a specific reference period” (Quinterno, 2014). The ACS uses period estimates “to compensate for the fact [that] the sampling frame includes too few households to yield reliable annual estimates for small geographies and small population subgroups” (Quinterno, 2014). If the value presented in a table is a period estimate, the period is noted in the table’s source data.

Coefficient of Variation (CV)

In addition to a MOE, many of the estimates in the plan have a coefficient of variation (CV). “The CV is a relative measure of uncertainty and expresses uncertainty as a percentage of the census estimate” (Jurjevich, et al., 2018). Generally, the lower the CV, the more reliable the data. According to the U.S. Census Bureau, there are “no hard-and-fast rules for determining an acceptable range of error in ACS estimates. Instead, data users must evaluate each application to determine the level of precision that is needed for an ACS estimate to be useful” (U.S. Census Bureau, 2018). This plan adopts CV ranges and data reporting methods recommended by the Population Research Center at Portland State University (Jurjevich, et al., 2018).

Icons are used to indicate the reliability of each estimate using the CV. High reliability (CV <15%) is shown with a green check mark, medium reliability (CV 15–30% — be careful) is shown with a yellow exclamation point, and low reliability (CV >30% — use with extreme caution) is shown with a red cross. However, as mentioned above, there are no precise rules and users should consider the MOE and their need for precision (Jurjevich, et al., 2018).

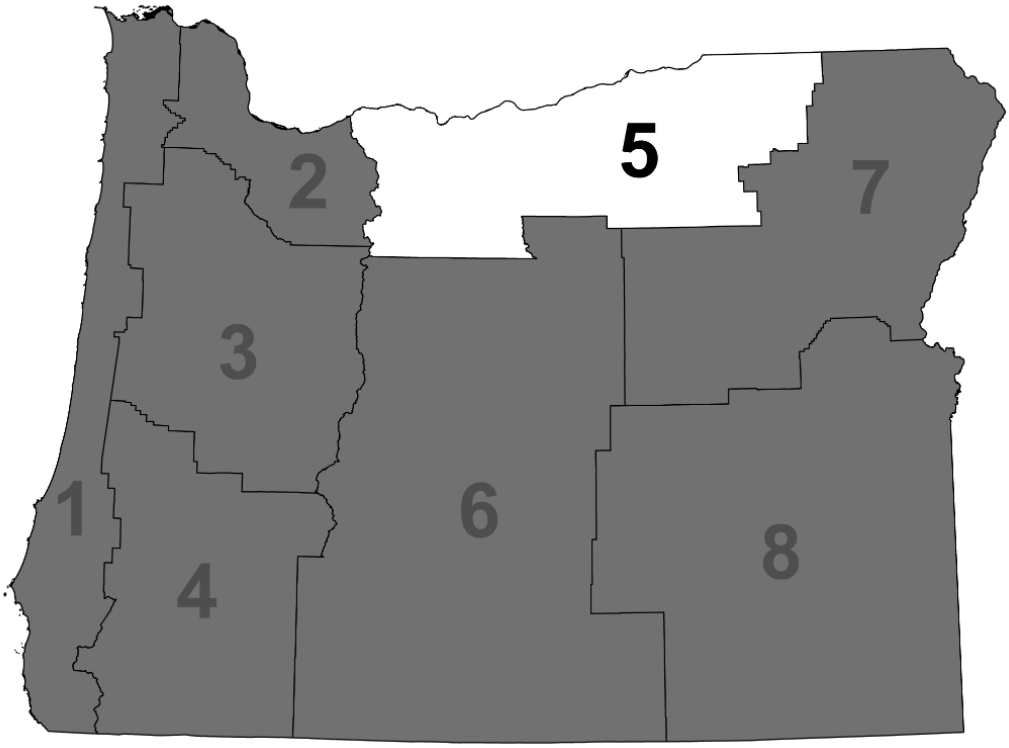
3. The **Hazards and Vulnerability** section first identifies each hazard and its characteristics in the region. Then, the historical events that have impacted the region are listed. Lastly, probabilities and vulnerabilities are discussed as identified by local and state risk assessments. Vulnerabilities

to and potential impacts from each hazard in the region are described including the identification and analysis of the region's State owned/leased facilities and critical/essential facilities located within hazard zones and seismic lifeline vulnerabilities.

Regional Risk Assessments add to the current body of literature and technical resource guides available to Oregon communities. The three levels of government — federal, state, and local — will find the Regional Risk Assessments useful when assessing natural hazards and vulnerabilities and when planning mitigation activities. Local governments can use the Regional Risk Assessments in the development of their jurisdiction's natural hazards mitigation plan. Information from these assessments is intended to be used as a springboard for more detailed community profiles. Likewise, information from local plans helps to inform the Oregon NHMP risk assessment overall.

2.3.5 Region 5: Mid-Columbia

Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties



2.3.5.1 Summary

Profile

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

Across the region, social vulnerability is driven by fewer college degrees and high numbers of housing rentals and vacancies. Children, persons aged under 18, also represent a vulnerable segment of the population. Region 5 has a higher percentage of children than the state as a whole. In Region 5, the share of people who do not speak English "Very Well" is higher than the statewide estimate—especially for Morrow, Hood River, and Umatilla Counties.

At the county level a notably high percentage of residents in Gilliam County have a disability, approximately one-fifth of all residents. According to the US Department of Housing and Urban Development's Point In Time count, between 2015 and 2019 the region reported a 65% increase in the number of people experiencing homelessness. Total number of homeless people is low, but the percentage increase is notable. Gilliam, Sherman, and Wasco Counties all have higher percentages of older adults than the statewide estimate. Within the region, Umatilla and Hood River Counties have the highest share of children. Overall, Region 5 has been rebounding from the financial crisis that began in 2007. Economic vulnerability is driven by high unemployment rates in Morrow and Umatilla Counties and low wages in Morrow and Hood River Counties.

Interstate-84, two rail yards, Amtrak lines, three ports, and one commercial airport support the economy and daily operations in Region 5. These integral transportation systems are susceptible to many natural hazards. Damage or interruption to the services these systems provide could be devastating to the region and state.

There are 31 power-generating facilities in the Mid-Columbia Region, including hydroelectric, natural gas, wind, and coal facilities. Liquid natural gas pipelines run through Gilliam, Morrow, and Umatilla Counties. Four additional wind facilities are proposed for the region. The diverse energy and drinking water systems here help reduce the area's vulnerability to damage and disruptions in service that can happen during a natural hazard event.

Surface water, wells, and springs supply local drinking water. These systems are vulnerable to non-point source pollution, erosion, and sedimentation that can adversely impact water quality. Rigid, buried infrastructure is vulnerable to seismic activity.

Region 5 is largely rural, with urban development occurring in communities along I-84 in Hood River County. Manufactured homes, which are inherently more vulnerable to natural hazards, make up a significant share of the region's housing units. Over 80% of homes in Gilliam and Sherman Counties were built before 1990 and current seismic building standards. With the exception of Morrow and Umatilla Counties where FIRMs were updated in 2007 and 2010 respectively, the region's FIRMs date from the 1980's. A FEMA Risk MAP project is underway to update the Middle Columbia Hood watershed flood maps in Hood River, Sherman and Wasco Counties.

Hazards and Vulnerability

Region 5 is affected by nine of the 11 natural hazards that affect Oregon communities. Coastal hazards and tsunamis do not directly impact this region.

Droughts: Droughts are common in Region 5, particularly within Gilliam, Morrow, and Sherman Counties. Agricultural industries in the region are vulnerable to scarcity of water supplies during drought events. The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $1,080,652,000. Because drought could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought.

Earthquakes: Overall, the region is moderately vulnerable to three types of earthquakes: (a) shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, and (c) the offshore Cascadia Subduction Zone (CSZ) Fault. Primary vulnerabilities are due to shallow crustal and intraplate earthquakes that cause earthquake-induced landslides in the Cascades, ground shaking, and liquefaction. A CSZ event will affect markets to east upon which communities in Region 5. In Region 5, a 2500-year probabilistic earthquake scenario could cause a potential loss of over $17.5M in state building and critical facility assets, 77% of it in Umatilla County alone. The potential loss in local critical facilities is about double, over $34M. Almost half (46%) of the potential loss in local critical facilities is in Umatilla County, and 33% in Hood River County.

Extreme Heat: Extreme temperatures are common in Region 5 and the frequency of prolonged periods of high temperatures has increased. Pendleton has an average of about 31 days per year above 90°F. Extreme heat can affect commerce, agriculture, fisheries, and overall quality of life. As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. Like drought, impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $1,080,652,000.

Floods: Rain-on-snow events during unseasonably warm winters create disastrous riverine flooding events in the Mid-Columbia Region. Flash floods associated with summer thunderstorms are also exceptionally damaging. All of the region's counties are considered moderately vulnerable to flooding. In Region 5, there is a potential loss from flooding of over $9M in state building and critical facility assets, approximately 34% of it in each of Wasco and Umatilla Counties and 16% in Sherman County. There is a three times greater potential loss due to flood in local critical facilities: over $28M, of this forty percent and 36% in Umatilla and Morrow Counties, respectively.

Landslides: Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Rain-induced landslides can occur during winter months. Earthquakes can trigger landslides at any time. For example,

the geology map of the Hood River area and the Mount Hood Multi-Hazard and Risk study both found hundreds of landslides in this area. In February 2014, a large rock slide in Hood River closed I-84 for almost a week. Vulnerability is increased in populated areas within the Columbia River Gorge, along the I-84 corridor and in the Cascade Mountains. Over $32M in value of state facilities is exposed to landslide hazards in Region 5, more than half in Wasco County followed by 40% in Hood River County. The value of local critical facilities is over $18.6M, 72% also in Wasco County.

Volcanoes: There are several active and potentially active volcanoes in the Cascade Range along the western border of the Mid-Columbia Region. Areas particularly vulnerable to volcanic activity include the Cities of Parkdale and Hood River near Mount Hood, and communities along the White River in Wasco County. Though most volcanic activity is considered local, lahars and ashfall can travel many miles, impacting small mountain communities, dams, reservoirs, energy-generating facilities, and highways. DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 5. Just under $11.2M in value is exposed to volcanic hazards in Region 5, all of it in Hood River and Wasco Counties.

Wildfires: This region has unique geographic features, weather characteristics, a history of unmanaged fuels, and an expanding wildland-urban interface that contribute to the region's susceptibility to wildfire. The majority of the forestlands in Region 5 are historically prone to wildfire. Summer weather patterns can produce lightning storms that start many fires. Based on data from the 2013 West Wide Wildfire Risk Assessment, in Region 5, Umatilla and Wasco Counties have high percentages of wildland acres subject to Fire Risk, Wildland Development Areas, Fire Effects, or Fire Threat, making them especially vulnerable. Other areas of vulnerability are within wildland-urban interface communities. In Region 5, there is a potential loss to wildfire of almost $105M in state building and critical facility assets, almost 60% of it in Wasco County and 30% in Umatilla County. Seven percent is located in Hood River County and the remaining three percent in Sherman, Morrow, and Gilliam Counties. There is a slightly greater potential loss in local critical facilities: about $15.6M. Around 25% is located in each of Hood River and Morrow Counties, about 20% in Umatilla County.

Windstorms: High winds within Region 5 in the Columbia River Gorge are legendary, sometimes reaching 80 miles per hour. Windstorms generally impact the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland. Special building codes in this region require tie downs for manufactured homes within 30 miles of the Columbia River. The most vulnerable jurisdictions are those near the Columbia Gorge within Gilliam, Hood River, Morro, and Sherman Counties. The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $1,080,652,000.

Winter Storms: Frigid air emanating from the Wallowa Mountains and traveling through the Columbia River Gorge bring winter storms to this region annually. Though winter storms have the potential to affect the entire region, particularly along the I-84 corridor, the area is known for cold winters so residents and visitors are usually prepared for these storms. The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $1,080,652,000.

Climate Change

The hazards faced by Region 5 that are projected to be influenced by climate change include drought, wildfire, flooding, landslides, and extreme heat.

Climate models project warmer, drier summers for Oregon, including Region 5, which could lead to greater drought conditions. However, projected increases in spring precipitation may counteract some of the effects of warming and result in increases in summer soil moisture and runoff (*low confidence*). It is *very likely* (>90%) that Region 5 will experience increasing wildfire frequency and intensity due to warmer, drier summers coupled with warmer winters that facilitate greater cold-season growth.

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

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

While winter storms and windstorms affect Region 5, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see Section 2.2.1.2, **Introduction to Climate Change**.

2.3.5.2 Profile

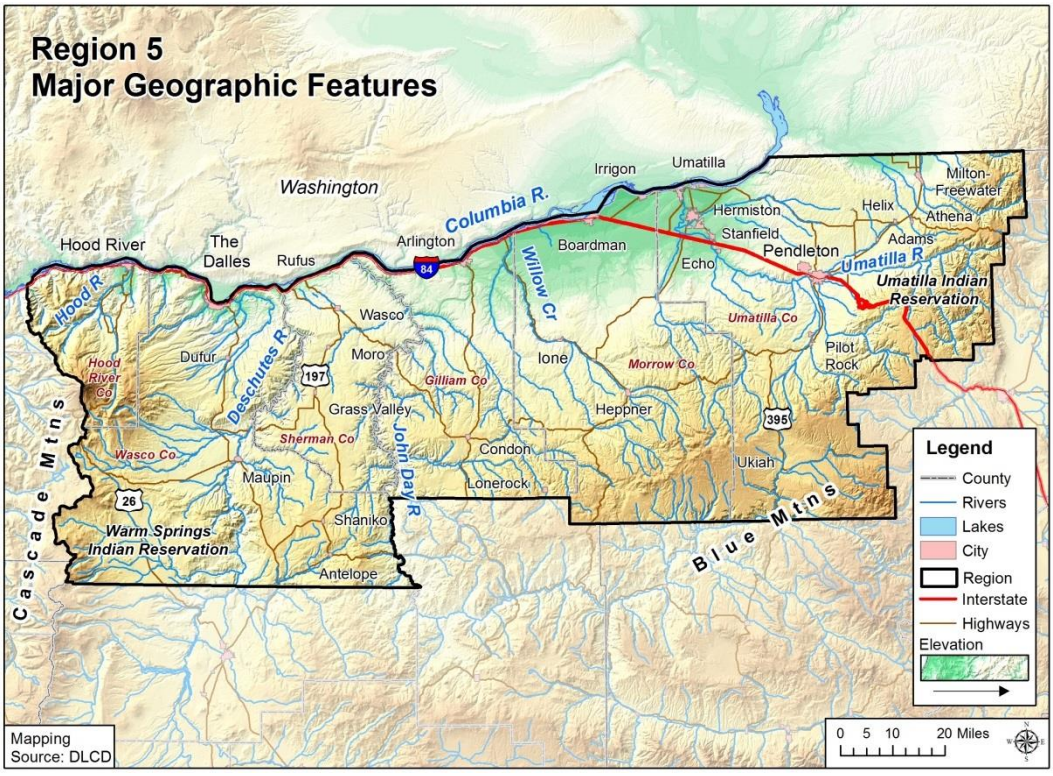
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

Oregon's Mid-Columbia Region is approximately 10,178 square miles in size and includes Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties. The Columbia River and the eastern slope of the Cascades shape the region's topography. Region 5 begins at the Cascades crest in the west and extends east to the Idaho border. The region's northern border is the Columbia River and extends to the northern ridges of the Blue Mountains in the south. The region's major watershed is the Columbia River with all smaller water bodies feeding it as it flows west into the Pacific Ocean. The region supports crop farming as well as livestock grazing.

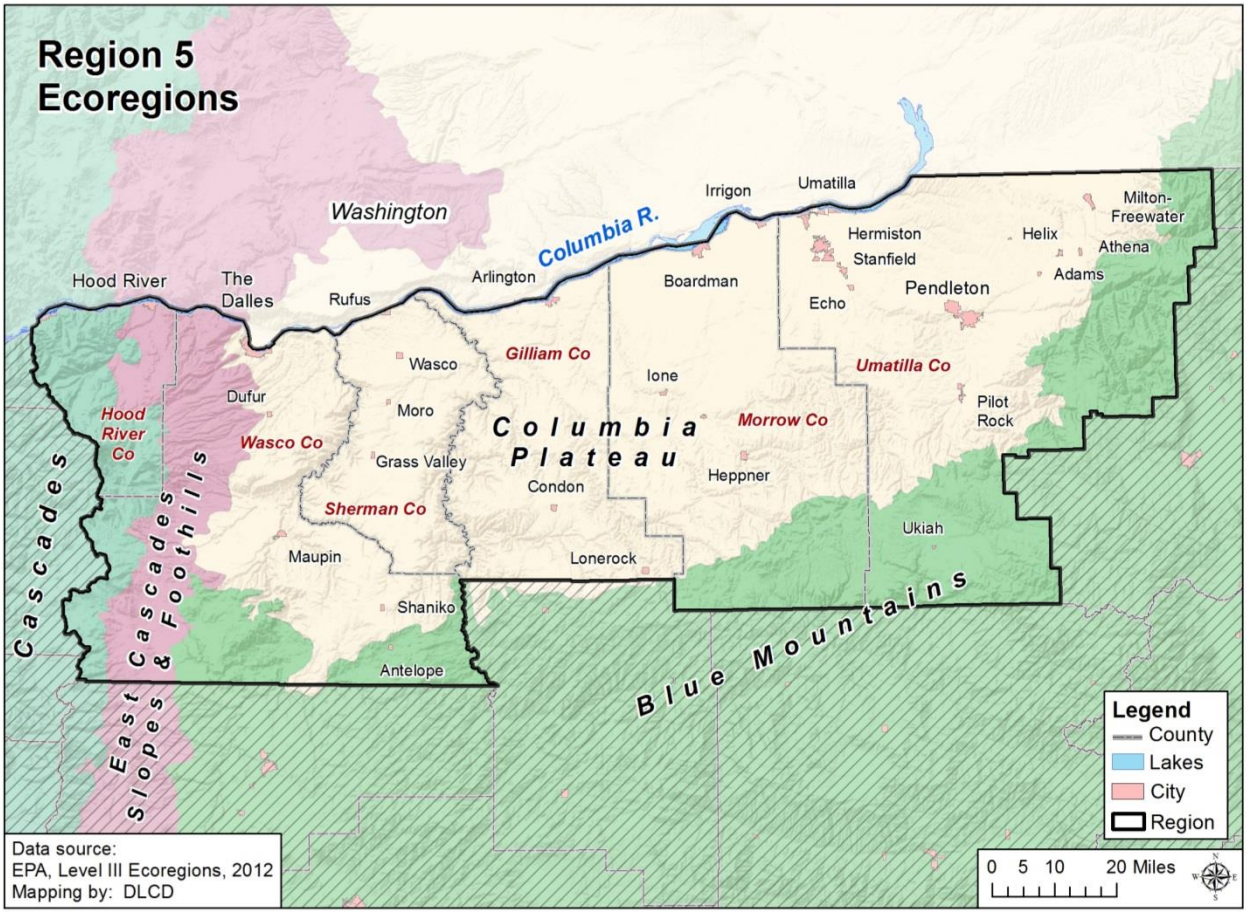
Figure 2-217. Region 5 Major Geographic Features



Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 5 is composed of four ecoregions: the Cascades, the Eastern Cascades Slope and Foothills, the Blue Mountains and, predominantly, the Columbia Plateau (**Figure 2-218**).

Figure 2-218. Region 5 Ecoregions



Blue Mountains: This ecoregion is complex and diverse, with many sub-ecoregions with unique conditions. In general, the Blue Mountains areas of Region 5 have a dry continental climate with marine intrusions because of proximity to the Columbia Gorge. While much of the Blue Mountains are underlain with volcanic rock, land in the Wallowa and Elkhorn Mountain ranges is composed of granitic intrusives, deep sea sediments, and metamorphic rocks. Grazing, logging, and fire suppression regimes have altered land cover throughout the region where juniper woodlands have given way to sagebrush grasslands and grand fir forests have given way to spruce fir forests. Other forests in the region predominantly have either a Douglas fir or ponderosa pine canopy. Ponderosa forests tend toward sparsely vegetated understories. The ecoregion's Douglas fir forests tend toward dense shrub understories, making them more difficult to log. Some high meadows also exist within the Blue Mountains in Region 5 and unchannelized streams tend toward a meandering nature within wide floodplains, moving dynamically through the landscape. Riparian areas of the region have a diverse palette of understory shrubs with black cottonwoods, grand firs, and alders in the canopy layer (Thorson, et al., 2003).

Cascades: This ecoregion is underlain by volcanic soils. Naturally occurring mixed conifer forests have given way to predominantly Douglas fir forests that are managed for commercial logging. Logging activities have put a strain on the ecological health of streams in the area (Thorson, et

al., 2003). Waterways in the steeper valleys support threatened cold-water salmonids including Chinook salmon, steelhead, and bull trout. Streams, lakes, reservoirs, rivers, and glacial lakes at higher elevations are key sources of water. Large volcanic peaks, glaciers and year-round snowfields punctuate the alpine and subalpine areas of the ecoregion (Thorson, et al., 2003).

Columbia Plateau: The Columbia River has shaped this arid, sagebrush steppe. This ecoregion is underlain by basaltic bedrock up to two miles deep. Naturally occurring wheatgrass, sagebrush, sage grass and other drought-tolerant plants have given way to crop farming and grazing. Higher elevation areas support Douglas fir and ponderosa pine forests while narrow canyons provide habitat for riparian species such as white alders and mock orange. Deep loess soil deposits cover some areas, making them more agriculturally productive than areas with spare soils (Thorson, et al., 2003).

Eastern Cascades Slope and Foothills: The Region 5 section of this ecoregion is dominated by grand fir mixed forests in the uplands and mixed oak/conifer forests in the foothills. The Columbia River Gorge influences lower elevations with marine weather systems while the uplands are moister with richer soils. Because of its location in the rain shadow of the Cascades, the ecoregion often experiences dramatic temperature extremes and native plants are adapted to dry climates and frequent wildfires. Logging and recreation are common land uses throughout and rural residential development and agricultural uses can be found in the foothills (Thorson, et al., 2003).

Climate

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

The Mid-Columbia region is characterized by a semi-arid high elevation climate, in which summers and winters can be extreme. The Columbia Plateau's arid climate supports Oregon's major wheat producing area. The region is subject to droughts and wildfires, particularly during dry summers and years with low snowpack. Despite its relative dryness, the region is also subject to floods and landslides. Flooding can be a direct result of rain-on-snow events. Localized variations in temperature and precipitation exist across the region's microclimates. **Table 2-462** displays 1981–2010 average precipitation and temperature for counties and climate divisions within Region 5 based on data from the NOAA National Centers for Environmental Information.

Table 2-462. Average Precipitation and Temperature in Region 5 Counties and Climate Divisions

Sub-Region	Annual Precipitation Mean & Range (1981–2010)	January & July Mean Precipitation (1981–2010)	Annual Mean Temperature (1981–2010)	January & July Average Min/Max Temperature (1981–2010)
Gilliam County	11.71" (7.18"–17.53")	Jan: 1.43" Jul: 0.32"	50.3F	Jan: 27.6°F /40.4°F Jul: 54.3°F /85.5°F
Hood River County	58.89" (40.98"–91.5")	Jan: 9.06" Jul: 0.66"	45.4°F	Jan: 27.3°F /36.9°F Jul: 50.1°F /73.7°F
Morrow County	14.52" (9.59"–20.89")	Jan: 1.67" Jul: 0.39"	49.6°F	Jan: 27.1°F /40.4°F Jul: 53.6°F /84.5°F
Sherman County	13.63" (8.70"–21.22")	Jan: 1.79" Jul: 0.3"	49.9F	Jan: 27.4°F /39.7°F Jul: 54.1°F /84.8°F
Umatilla County	20.8" (14.28"–27.03")	Jan: 2.48" Jul: 0.51"	48.7°F	Jan: 26.4°F /39.4°F Jul: 52.5°F /83.4°F
Wasco County	20.8" (14.42"–33.99")	Jan: 3.13" Jul: 0.38"	48.2°F	Jan: 26.6°F /39.3°F Jul: 51.6°F /82°F
Climate Division 6 "North Central"	18.68" (13.65"–27.79")	Jan: 2.52" Jul: 0.39"	49.5°F	Jan: 27.3°F/40.1°F Jul: 53.3°F/83.9°F

Source: NOAA National Centers for Environmental Information, Climate at a Glance: County & Divisional Time Series, published August 2019, retrieved on August 21, 2019 from https://www.ncdc.noaa.gov/cag/.

Demography

Population

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

Morrow County has experienced slow population growth since 2010. Similar to most areas in the state, the population is aging. Natural increase has been the primary driver of population growth; however, net-out migration has slowed in recent years and in-migration is expected to be the primary driver moving forward (Population Research Center, Portland State University,

2019 [Morrow County]). Umatilla County experienced steady population growth, largely driven by natural increase but net in-migration has also contributed; in the near term, in-migration will play a larger role in population growth because of waning natural increase. The population in Sherman and Gilliam Counties decreased from 2010 to 2018. In both counties, deaths outpaced births in most years and migration patterns have been sporadic; however, since 2010, in-migration has helped to offset natural decrease (Population Research Center, Portland State University, 2019 [GIlliam and Sherman Counties]). Growth in Hood River County has been driven by both natural increase and net in-migration; however, natural increase has been steadily declining since 2010; over the next decade, the county is expected to continue to grow at a modest pace, tempered by the demand and shortage of additional housing (Population Research Center, Portland State University, 2020 [Hood River]). Wasco County has grown at a modest pace since 2010, with net in-migration outweighing natural decrease; the population is expected to continuing growing slowly over the next decade, driven mostly by in-migration (Population Research Center, Portland State University, 2020 [Wasco]).

Table 2-463. Population Estimate and Forecast for Region 5

	2010	2018	Percent Change (2010 to 2018)	2030 Projected	Percent Change (2018 to 2030)
Oregon	3,831,074	4,195,300	9.5%	4,694,000	11.9%
Region 5	138,257	148,930	7.7%	158,131	6.2%
Gilliam	1,871	1,985	6.1%	1,763	−11.2%
Hood River	22,346	25,310	13.3%	29,014	14.6%
Morrow	11,173	11,885	6.4%	12,960	9.0%
Sherman	1,765	1,785	1.1%	1,653	−7.4%
Umatilla	75,889	80,765	6.4%	82,943	2.7%
Wasco	25,213	27,200	7.9%	29,798	9.6%

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

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 5 are largely centered on outdoor activities (hiking/backpacking, visiting national/state parks etc.), touring (traveling to experience scenic beauty, history and culture), and special events (such as fairs, festivals or sporting events) (Longwoods International, 2017e). Approximately two-thirds of trips to the region occur between April and September (Longwoods International, 2017e). The average travel party contains approximately three persons and the on average visitors spend two nights in the region (Longwoods International, 2017e). The majority of tourist stay in Umatilla, Wasco, and Hood River Counties.

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

Table 2-464. Annual Visitor Estimates in Person Nights (x1000) in Region 5

	2016		2017		2018	
	Number	Percent	Number	Percent	Number	Percent
Region 5	4,187		4,354		4,393	
Gilliam	68	100%	69	100%	69	100%
Hotel/Motel	16	23.5%	17	25%	17	25%
Private Home	19	27.9%	19	28%	19	28%
Other	33	48.5%	33	48%	34	49%
Hood River	970	100%	1,021	100%	1,015	100%
Hotel/Motel	480	49%	531	52%	526	52%
Private Home	303	31%	306	30%	301	30%
Other	187	19%	185	18%	188	19%
Morrow	265	100%	267	100%	269	100%
Hotel/Motel	85	32%	89	33%	90	33%
Private Home	113	43%	113	42%	113	42%
Other	66	25%	66	25%	67	25%
Sherman	84	100%	85	100%	86	100%
Hotel/Motel	30	36%	31	36%	31	36%
Private Home	17	20%	18	21%	18	21%
Other	37	44%	36	42%	37	43%
Umatilla	1,651	100%	1,735	100%	1,778	100%
Hotel/Motel	636	39%	693	40%	730	41%
Private Home	757	46%	785	45%	787	44%
Other	259	16%	257	15%	260	15%
Wasco	1,149	100%	1,177	100%	1,176	100%
Hotel/Motel	488	42%	517	44%	515	44%
Private Home	266	23%	268	23%	263	22%
Other	395	34%	392	33%	397	34%

Source: Oregon Travel Impacts: 1992–2018, March 2019. (Dean Runyan Associates, 2019), http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003).

As a whole, the percentage of residents in Region 5 with a disability is similar, but slightly higher than the statewide estimate. A notably high percentage of residents in Gilliam County have a disability, approximately one-fifth of all residents. The share of residents in Sherman and Wasco is also high, just under 20%. Conversely, the share of residents with a disability in Hood River County is smaller than both the region and statewide estimates. The region also has a disproportionate share of older adults (≥ 65) with a disability; however, it should be noted that the margin of error for each county is significant, potentially resulting in a much higher or lower estimate than what's included below. Similarly, accurately measuring the number of children with a disability is challenging, especially in counties with a smaller overall population. Consequently, the estimate of young people (< 18) with a disability for each county should be used with caution or not used at all.

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

Table 2-465. People with a Disability by Age Group in Region 5

	With a Disability (Total Population)			Under 18 Years with a Disability			65 Years and Over with a Disability		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	14.6%	☑	0.10%	4.6%	☑	0.2%	37.1%	☑	0.4%
Region 5	15.3%	☑	0.58%	3.9%	☑	0.7%	43.0%	☑	2.3%
Gilliam	21.2%	☑	3.70%	6.6%	⊗	5.2%	47.5%	☑	7.6%
Hood River	9.9%	☑	1.10%	1.6%	⊗	0.9%	37.8%	☑	5.1%
Morrow	14.1%	☑	1.80%	3.6%	⊗	2.3%	44.8%	☑	7.5%
Sherman	19.2%	☑	3.20%	4.5%	⊗	3.1%	30.0%	☑	6.3%
Umatilla	15.8%	☑	0.80%	4.0%	⊙	1.0%	44.6%	☑	3.1%
Wasco	18.6%	☑	1.50%	5.9%	⊙	1.9%	43.3%	☑	5.1%

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

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

Homeless Population

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

According to the PIT, between 2015 and 2019 the region reported a 65% increase in the number of people experiencing homelessness. Sherman and Morrow Counties both reported significant percent increases, but started with a count of zero and continue to have a small total numbers of unhoused people. Wasco, Umatilla, and Hood River Counties all reported similar rates of increase during the period and have a similar numbers of unhoused individuals.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate their vulnerability. Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

Table 2-466. Homeless Population Estimate for Region 5

	2015	2017	2019	Period Average
Oregon	13,077	13,953	15,800	14,277
Region 5	191	321	315	276
Gilliam	0	0	0	0
Hood River	69	70	90	76
Morrow	0	0	2	1
Sherman	0	1	12	4
Umatilla	75	55	124	85
Wasco	47	195	87	110

Source: Oregon Housing and Community Services (n.d.). Oregon Point in Time Homeless Counts. Retrieved from https://public.tableau.com/profile/oregon.housing.and.community.services#!/vizhome/2019Point-in-TimeDashboard/Story1

Biological Sex and Gender

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

The American Community Survey question was specifically designed to capture biological sex and there are no questions on the survey about gender (U.S. Census Bureau, 2019). According to the survey, there are more men than women in Region 5 (104.99 men to every 100 women) (U.S. Census Bureau, 2019). Within the region, Umatilla County has more men than women (109 men to every 100 women) (U.S. Census Bureau, 2019). Sherman County also has more men than women (118.7 men to every 100 women); however, the margin of error is significant (+/-12%) (U.S. Census Bureau, 2019). Conversely, Gilliam County has more women than men (91.7 men to every 100 women); however, the margin of error is significant for this estimate as well (+/-9.6%) (U.S. Census Bureau, 2019).

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

Age

Older adults, those aged 65 and up, comprise a slightly smaller share of the population in Region 5 than they do in the state as a whole. This is also true for Umatilla, Hood River, and Morrow Counties. Conversely, Gilliam, Sherman, and Wasco Counties all have higher percentages of older adults than the statewide estimate. An older population requires special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities (Morrow, 1999).

Children, persons aged under 18, also represent a vulnerable segment of the population. Region 5 has a higher percentage of children than the state as a whole. Within the region, Umatilla and Hood River Counties have the highest share of children and Sherman County has the smallest share. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. In addition, parents might lose time and money when their children’s childcare facilities and schools are impacted by disasters.

Table 2-467. Population by Vulnerable Age Group, in Region 5

	Total Population	Under 18 Years Old			65 and Older		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	4,025,127	21.5%	☑	0.1%	16.3%	☑	0.1%
Region 5	140,059	25.0%	☑	0.1%	15.8%	☑	0.2%
Gilliam	1,910	22.3%	☑	2.5%	25.1%	☑	3.2%
Hood River	22,938	24.7%	☑	0.1%	14.6%	☑	0.6%
Morrow	11,153	27.6%	☑	0.4%	15.3%	☑	1.0%
Sherman	1,635	14.9%	☑	2.6%	25.7%	☑	3.2%
Umatilla	76,736	25.7%	☑	0.1%	14.6%	☑	0.1%
Wasco	25,687	22.6%	☑	0.1%	19.4%	☑	0.4%

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

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

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations are less likely to be prepared for a natural disaster if special attention is not given to developing language and culturally appropriate outreach materials. In Region 5, the share of people who do not speak English “Very Well” is higher than the statewide estimate—especially for Morrow, Hood River, and Umatilla Counties. The estimates for Gilliam and Sherman County should not be used, as the estimates are unreliable. Communities creating outreach materials used to communicate with and plan for populations who do not speak English very well should take into consideration the language needs of these populations.

Table 2-468. English Usage in Region 5

	Speak English Less Than "Very Well"				
	Estimate	CV **	MOE (+/−)	Percent	% MOE (+/−)
Oregon	222,428	☑	4,116	5.9%	0.1%
Region 5	14,117	☑	751	10.8%	0.6%
Gilliam	38	⊗	47	2.1%	2.6%
Hood River	3,395	☑	375	15.8%	1.8%
Morrow	1,633	☑	214	15.8%	2.1%
Sherman	13	⊗	15	0.8%	1.0%
Umatilla	7,518	☑	563	10.5%	0.8%
Wasco	1,520	☑	242	6.3%	1.0%

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

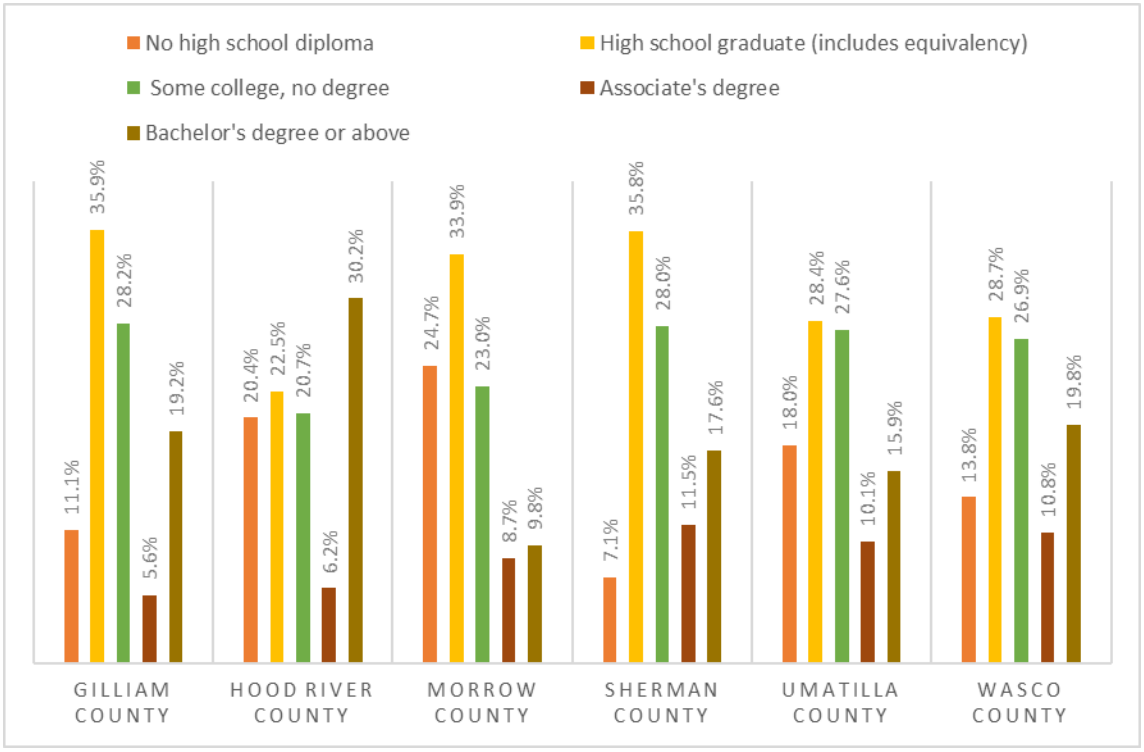
Source: U.S. Census Bureau (2018). Table DP02: Selected Housing Characteristics, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

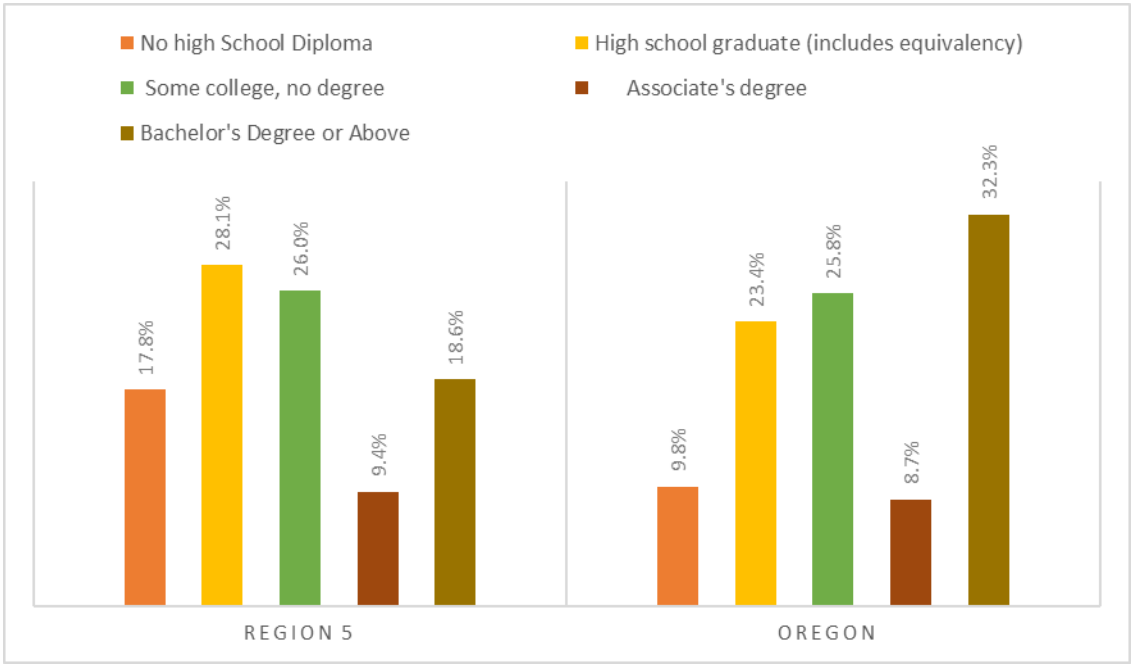
Education Level

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

Approximately 19% of residents in Region 5 have a bachelor's degree or higher, which is roughly thirteen percentage points lower than the share statewide. A slightly higher percentage of residents have an associate's degree compared to the state, however, the share of the population without a high school diploma is considerably higher than the statewide estimate. The percentage of people with some college education is similar to the estimate statewide. Within the region, Hood River has the highest percentage of residents with a bachelor's degree or higher; however, the share is still below the statewide estimate. Gilliam and Hood River Counties have smaller shares of residents with an associate's degree compared to the state as a whole, but at least one-fifth of residents in each county have some college credit. The share of residents without a high school diploma is highest in Morrow and Hood River Counties. Except for Sherman County, all counties in the region have a higher share of residents without a high school diploma compared to the state as a whole.

Figure 2-219. Educational Attainment in Region 5: (top) by County, (bottom) Regional vs. Statewide





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

Income and Poverty

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

Except for Hood River County, median household income in each county is $1,000 – $16,000 below the statewide median. Gilliam County has the highest disparity; however, the margin of error (+/– $8,471) indicates the estimate could be closer to the median or further away. Between 2012 and 2017, there was no statistically significant change in median household income in any county in the region.

Table 2-469. Median Household Income in Region 5

	2008-2012			2013-2017			Statistically Different*
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	
Oregon	$53,427	☑	$338	$56,119	☑	$370	Yes
Region 5	—	—	—	—	—	—	—
Gilliam	$49,024	☑	$8,149	$39,831	☑	$8,471	No
Hood River	$60,745	☑	$3,986	$57,269	☑	$3,838	No
Morrow	$51,826	☑	$4,052	$54,386	☑	$3,538	No
Sherman	$47,687	☑	$8,944	$42,074	☑	$7,268	No
Umatilla	$51,888	☑	$2,596	$50,071	☑	$1,555	No
Wasco	$46,590	☑	$1,622	$48,510	☑	$2,079	No

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

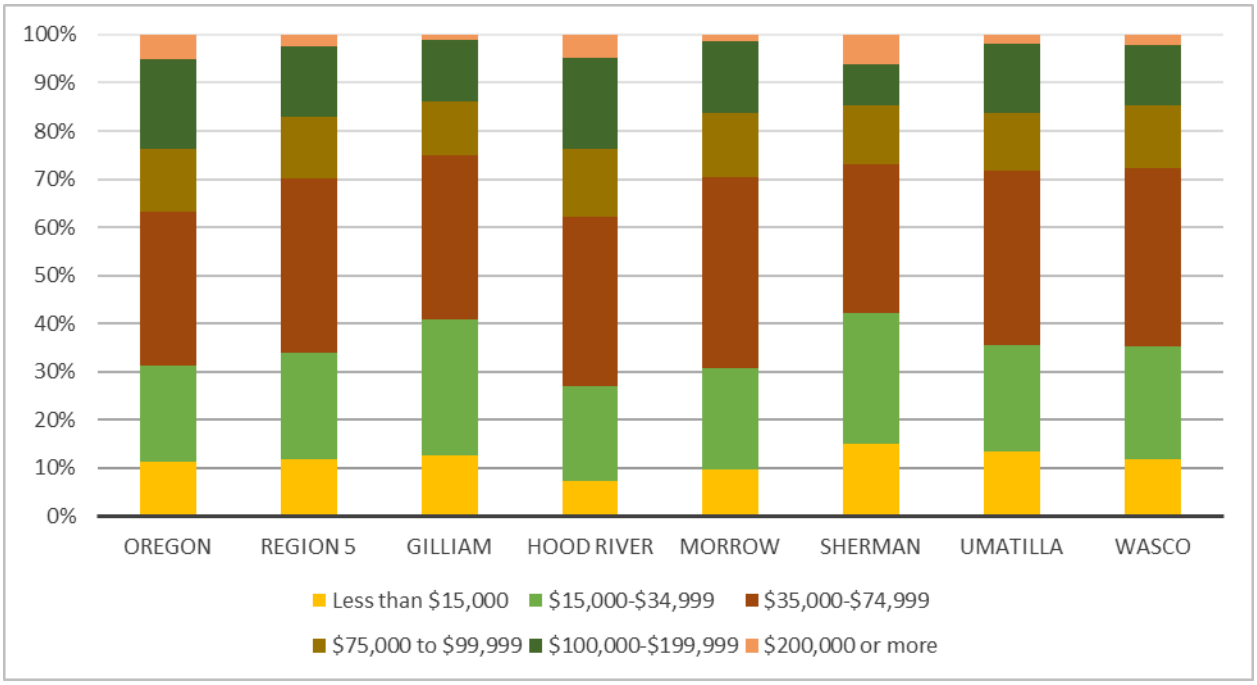
* Yes indicates that the 2013-2018 estimate is significantly different (at a 90% confidence level) than the estimate from 2008-2012. No indicates that the 2013-2017 estimate is not significantly different from the 2008-2012 estimate.

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

Source: U.S. Census Bureau (2018), CP03: Comparative Economic Characteristics, American Community Survey - 5 year estimates, Retrieved from: Data.census.gov.

Region 5 has a slightly higher percentage of households earning less than $35,000 annually vis-à-vis the state. Within the region, Sherman County has the highest percentage of households (42.2 %) earning less than $35,000 per year, while Hood River County has the highest percentage of households (37.9 %) earning more than $75,000 per year. Just over one third of the region's households earn between $35,000 and $75,000 per year.

Figure 2-220. Median Household Income Distribution in Region 5



Source: U.S. Census Bureau. Table DP03: Selected Economic Characteristics, American Community Survey, 2013-2017 American Community Survey 5-Year Estimates

The American Community Survey uses a set of dollar value thresholds that vary by family size and composition to determine who is in poverty (U.S. Census Bureau, 2018). Moreover, poverty thresholds for people living in nonfamily households vary by age—under 65 years or 65 years and older (U.S. Census Bureau, 2018). The poverty rate in Umatilla County is approximately three percentage points higher than the statewide estimate. For all other counties in the region, the share is slightly smaller than the statewide estimate; however, due to sampling error, the estimates for Gilliam and Hood River Counties should be used with caution.

A higher percentage of children in Region 5 are living in poverty compared to the statewide share; however, due to sampling error, estimates of child poverty for individual counties vary in reliability and should be used with caution. Notably, estimates for Gilliam, Hood River, and Sherman Counties should be used with extreme caution.

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

Table 2-470. Poverty Rates in Region 5

	Total Population in Poverty						
	2008-2012			2013-2017			
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Statistically Different*
Oregon	15.5%	☑	0.3	14.9%	☑	0.3%	No
Region 5	15.4%	☑	1.2	15.7%	☑	1.2%	No
Gilliam	12.6%	⊙	3.5	9.9%	⊙	3.5%	No
Hood River	10.1%	⊙	2.6	12.1%	⊙	3.3%	No
Morrow	15.5%	☑	3.4	14.7%	☑	3.4%	No
Sherman	22.4%	☑	4.2	13.7%	☑	3.0%	Yes
Umatilla	15.5%	☑	1.7	17.8%	☑	1.7%	No
Wasco	19.3%	☑	2.6	13.7%	☑	1.8%	Yes

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

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

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Table 2-471. Child Poverty in Region 5

	Children Under 18 in Poverty						
	2008-2012			2013-2017			
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Statistically Different*
Oregon	20.6%	☑	0.5	19.0%	☑	0.6%	Yes
Region 5	21.2%	☑	2.6	22.0%	☑	2.8%	No
Gilliam	11.6%	⊗	8.0	2.3%	⊗	3.4%	Yes
Hood River	12.0%	⊙	5.3	18.2%	⊗	9.9%	No
Morrow	22.9%	⊙	6.5	20.2%	⊙	6.7%	No
Sherman	44.1%	⊙	3.7	13.8%	⊗	8.5%	Yes
Umatilla	22.4%	☑	3.7	25.8%	☑	3.8%	No
Wasco	24.6%	⊙	7.0	15.5%	☑	3.4%	Yes

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

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

Source: U.S. Census Bureau (2018). Table S1701: Poverty Status in Past 12 Months, 2013-2018 American Community Survey 5-Year Estimates. Retrieved from: data.census.gov

Housing Tenure

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

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

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

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

Each county in Region 5 has a higher home-ownership rate compared to the state overall. Morrow County has the highest percentage of owner occupied households while Umatilla has the lowest.

Table 2-472. Housing Tenure in Region 5

	Total Occupied Units	Owner-Occupied			Renter-Occupied		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	61.7%	☑	0.3%	38.3%	☑	0.3%
Region 5	51,174	63.9%	☑	1.2%	36.1%	☑	1.4%
Gilliam	805	64.0%	☑	6.0%	36.0%	☑	6.0%
Hood River	8,543	63.8%	☑	3.3%	36.2%	☑	3.3%
Morrow	3,936	70.9%	☑	3.6%	29.1%	☑	3.6%
Sherman	779	63.8%	☑	5.8%	36.2%	☑	5.8%
Umatilla	26,976	62.9%	☑	1.7%	37.1%	☑	1.7%
Wasco	10,135	64.1%	☑	2.3%	35.9%	☑	2.3%

U.S. Census Bureau (2018), 2013-2017 American Community Survey 5-Year Estimates. https://data.census.gov/cedsci/. Table DP04: Selected Housing Characteristics

Families and Living Arrangements

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

Region 5 is predominately composed of family households. Morrow County has the highest share and Sherman County has the smallest. Sherman and Gilliam Counties also have higher percentages of single-person households; however, the margin of error for each estimate indicates the percentage could be much closer to (or further from) the statewide share. The region has a higher percentage of households with children compared to the state as a whole. Morrow County has the highest share and Sherman has the smallest. Region 5 has a slightly higher share of single-parent households compared to the state. Umatilla County has the highest share, three percentage points above the statewide estimate.

Table 2-473. Family vs. Non-family Households in Region 5

	Total Households	Family Households			Nonfamily Households			Householder Living Alone		
	Estimate	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,571,631	63.3%	☑	0.2%	36.7%	☑	0.2%	27.7%	☑	0.2%
Region 5	51,174	67.1%	☑	1.5%	32.9%	☑	1.4%	26.4%	☑	1.3%
Gilliam	805	63.6%	☑	6.0%	36.4%	☑	6.0%	31.2%	☑	5.6%
Hood River	8,543	64.7%	☑	3.6%	35.3%	☑	3.6%	26.4%	☑	3.1%
Morrow	3,936	75.3%	☑	4.0%	24.7%	☑	4.0%	20.7%	☑	3.4%
Sherman	779	59.1%	☑	5.4%	40.9%	☑	5.4%	32.5%	☑	5.0%
Umatilla	26,976	67.8%	☑	1.9%	32.2%	☑	1.9%	26.0%	☑	1.9%
Wasco	10,135	65.0%	☑	2.4%	35.0%	☑	2.4%	28.7%	☑	2.2%

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

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

Table 2-474. Family Households with Children by Head of Household in Region 5

	Family Households with Children			Single Parent (Male or Female)		
	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	26.2%	☑	0.2%	8.1%	☑	0.2%
Region 5	29.3%	☑	1.2%	9.3%	☑	0.9%
Gilliam	18.1%	☑	4.1%	5.3%	⊙	2.6%
Hood River	25.0%	☑	3.2%	5.7%	⊙	1.9%
Morrow	33.0%	☑	3.8%	7.6%	⊙	2.4%
Sherman	13.5%	☑	2.9%	2.0%	⊗	2.0%
Umatilla	31.8%	☑	1.5%	11.3%	☑	1.5%
Wasco	27.1%	☑	2.1%	1.6%	☑	1.6%

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

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

Social and Demographic Trends

The social and demographic analysis shows that Region 5 is particularly vulnerable during a hazard event in the following ways:

- A notably high percentage of residents in Gilliam County have a disability, approximately one-fifth of all residents. The share of residents in Sherman and Wasco is also high, just under 20%.
- According to the PIT, between 2015 and 2019 the region reported a 65% increase in the number of people experiencing homelessness.
- Region 5 has a higher percentage of children than the state as a whole.
- The share of people who do not speak English "Very Well" is higher than the statewide estimate—especially for Morrow, Hood River, and Umatilla Counties.
- Approximately 19% of residents in Region 5 have a bachelor's degree or higher, which is roughly thirteen percentage points lower than the share statewide. Moreover, except for Sherman County, all counties in the region have a higher share of residents without a high school diploma compared to the state as a whole.
- Except for Hood River County, median household income in each county is $1,000 – $16,000 below the statewide median.
- Sherman and Gilliam Counties have higher percentages of single-person households compared to the state as a whole.

Economy

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

Employment and Unemployment

Natural disasters do not impact all labor market participants equally. Unemployed and underemployed populations are disproportionately affected by disaster events. Research shows that employment outcomes can be especially bad for people physically displaced by a disaster (Karoly & Zissimopoulos, 2010). Moreover, those who are unemployed and many employed in low-wage positions lack access to employee benefit plans that provide income and healthcare supports (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011). Income deprivation and

inaccessible healthcare, ruinous in the best of times, are felt more severely following a disaster. It is important for local policy makers to understand existing labor force characteristics and existing market trends to build a resilient workforce and mitigate the scope and intensity of disruptions and economic pain.

Unemployment rates across Region 5 have been steadily declining since peaking during the Great Recession. In 2018, Umatilla County, which has the largest labor force, also had the highest unemployment rate. From 2014 to 2018, Hood River County consistently had the lowest unemployment rate.

Table 2-475. Civilian Labor Force in Region 5, 2018

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	2,104,516	2,017,155	95.8%	87,361	4.2%
Region 5	72,204	69,004	95.6%	3,200	4.4%
Gilliam	844	811	96.1%	33	3.9%
Hood River	14,533	14,048	96.7%	485	3.3%
Morrow	5,732	5,484	95.7%	248	4.3%
Sherman	898	861	95.9%	37	4.1%
Umatilla	36,813	34,994	95.1%	1,819	4.9%
Wasco	13,384	12,806	95.7%	578	4.3%

Source: Oregon Employment Department, 2019

Table 2-476. Civilian Unemployment Rates in Region 5, 2014-2018

	2014	2015	2016	2017	2018	Change (2014-2018)
Oregon	6.8%	5.6%	4.8%	4.1%	4.2%	−2.6%
Region 5	7.0%	5.8%	4.9%	4.4%	4.4%	−2.6%
Gilliam	8.0%	6.4%	5.8%	4.2%	3.9%	−4.1%
Hood River	5.4%	4.7%	4.1%	3.6%	3.3%	−2.1%
Morrow	6.9%	5.7%	4.8%	4.4%	4.3%	−2.6%
Sherman	7.5%	6.1%	4.6%	4.7%	4.1%	−3.4%
Umatilla	7.7%	6.4%	5.3%	4.8%	4.9%	−2.8%
Wasco	6.6%	5.6%	4.8%	4.2%	4.3%	−2.3%

Source: Oregon Employment Department, 2019

Supersectors and Subsectors

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

(U.S. Bureau of Labor Statistics, 2019, Dec. 20). This plan looks at regional economic activity through these supersectors and then through three-digit NIAICS subsectors.

In 2018 the five major supersectors by share of employment in Region 5 were:

1. Trade, Transportation and Utilities
2. Natural Resources and Mining
3. Local Government
4. Education and Health Services
5. Manufacturing

Identifying supersectors with a large number of business establishments and targeting mitigation strategies to support them can help the region's resiliency. In Region 5, the following supersectors comprise a significant share of all business establishments.

- The Trade, Transportation, and Utilities supersector includes the highest number of establishments in Region 5, 17.2% of all businesses (QCEW, 2018).
- Other Services is second largest, with 16.0% of all business establishments (QCEW, 2018).
- Natural Resources and Mining is third largest supersector by total establishments, with 15.1% of all regional share (QCEW, 2018).
- Professional and Business Services is fourth, with 10% of all business establishments (QCEW, 2018).
- The Education and Health Services and Leisure and Hospitality both have the same number of establishments, each comprising 9.1% of the total (QCEW, 2018).

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

Table 2-477. Covered Employment by Sector in Region 5, 2019

Industry	Region 5	Gilliam County		Hood River County		Morrow County	
	Percent	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	815	100.0%	14,248	100.0%	6,175	100.0%
Total Private Coverage	82.0%	574	70.4%	12,980	91.1%	5,201	84.2%
Natural Resources & Mining	13.7%	45	5.5%	2,491	17.5%	1,344	21.8%
Construction	3.4%	23	2.8%	492	3.5%	113	1.8%
Manufacturing	11.8%	(c)	(c)	1,758	12.3%	1,809	29.3%
Trade, Transportation & Utilities	17.8%	133	16.3%	2,126	14.9%	687	11.1%
Information	1.6%	(c)	(c)	141	1.0%	513	8.3%
Financial Activities	2.0%	17	2.1%	252	1.8%	72	1.2%
Professional & Business Services	5.6%	219	26.9%	1,168	8.2%	158	2.6%
Education & Health Services	12.4%	52	6.4%	1,700	11.9%	251	4.1%
Leisure & Hospitality	10.3%	37	4.5%	2,388	16.8%	188	3.0%
Other Services	3.2%	20	2.5%	453	3.2%	66	1.1%
Unclassified	0.5%	(c)	(c)	13	0.1%	(c)	(c)
Total All Government	17.8%	241	29.6%	1,268	8.9%	973	15.8%
Total Federal Government	1.7%	13	1.6%	116	0.8%	58	0.9%
Total Government	2.9%	6	0.7%	86	0.6%	65	1.1%
Total Government	13.5%	222	27.2%	1,067	7.5%	850	13.8%

Industry	Region 5	Sherman County		Umatilla County		Wasco County	
	Percent	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	100.0%	856	100.0%	30,721	100.0%	11,647	100.0%
Total Private Coverage	82.0%	535	62.5%	23,798	77.5%	9,739	83.6%
Natural Resources & Mining	13.7%	22	2.6%	3,393	11.0%	1,526	13.1%
Construction	3.4%	64	7.5%	1,175	3.8%	353	3.0%
Manufacturing	11.8%	(c)	(c)	3,416	11.1%	637	5.5%
Trade, Transportation & Utilities	17.8%	229	26.8%	6,323	20.6%	1,990	17.1%
Information	1.6%	(c)	(c)	175	0.6%	178	1.5%
Financial Activities	2.0%	(c)	(c)	696	2.3%	262	2.2%
Professional & Business Services	5.6%	28	3.3%	1,403	4.6%	624	5.4%
Education & Health Services	12.4%	36	4.2%	3,622	11.8%	2,343	20.1%
Leisure & Hospitality	10.3%	122	14.3%	2,578	8.4%	1,327	11.4%
Other Services	3.2%	21	2.5%	1,014	3.3%	495	4.3%
Unclassified	0.5%	321	37.5%	(c)	(c)	4	0.0%
Total All Government	17.8%	130	15.2%	6,924	22.5%	1,908	16.4%
Total Federal Government	1.7%	130	15.2%	485	1.6%	290	2.5%
Total State Government	2.9%	42	4.9%	1,391	4.5%	250	2.1%
Total Local Government	13.5%	148	17.3%	5,047	16.4%	1,369	11.8%

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

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

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

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within the Trade, Transportation, and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system.

Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region.

Natural Resources and Mining: The primary industries within this sector regionally are largely crop and animal production. These industries tend to fluctuate seasonally and are vulnerable to a variety of natural hazards (winter storms, floods, etc.). In addition to the loss of farm production, wages could be lost due to natural disasters. In addition, these industries are dependent upon transportation systems that are vulnerable to disasters.

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

Manufacturing: This sector is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons the manufacturing sector may be susceptible to disruptions in transportation infrastructure. However, manufacturers are not dependent on local markets for sales, which may contribute to the economic resilience of this sector.

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

Table 2-478. Industries with Greatest Share of Employment in Region 5, 2018

Industry	Employment Share	Employment (2018)
Crop Production	13%	10,085
Food Services and Drinking Places	8%	5,794
Educational Services	6%	4,626
Food Manufacturing	6%	4,556
Support Activities for Agriculture and Forestry	5%	3,922
Accommodation	4%	2,672
Ambulatory Health Care Services	3%	2,487
Professional, Scientific, and Technical Services	3%	2,134
Nursing and Residential Care Facilities	3%	2,111
Executive, Legislative, and Other General Government Support	3%	2,032

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

Industry Concentration and Employment Change

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

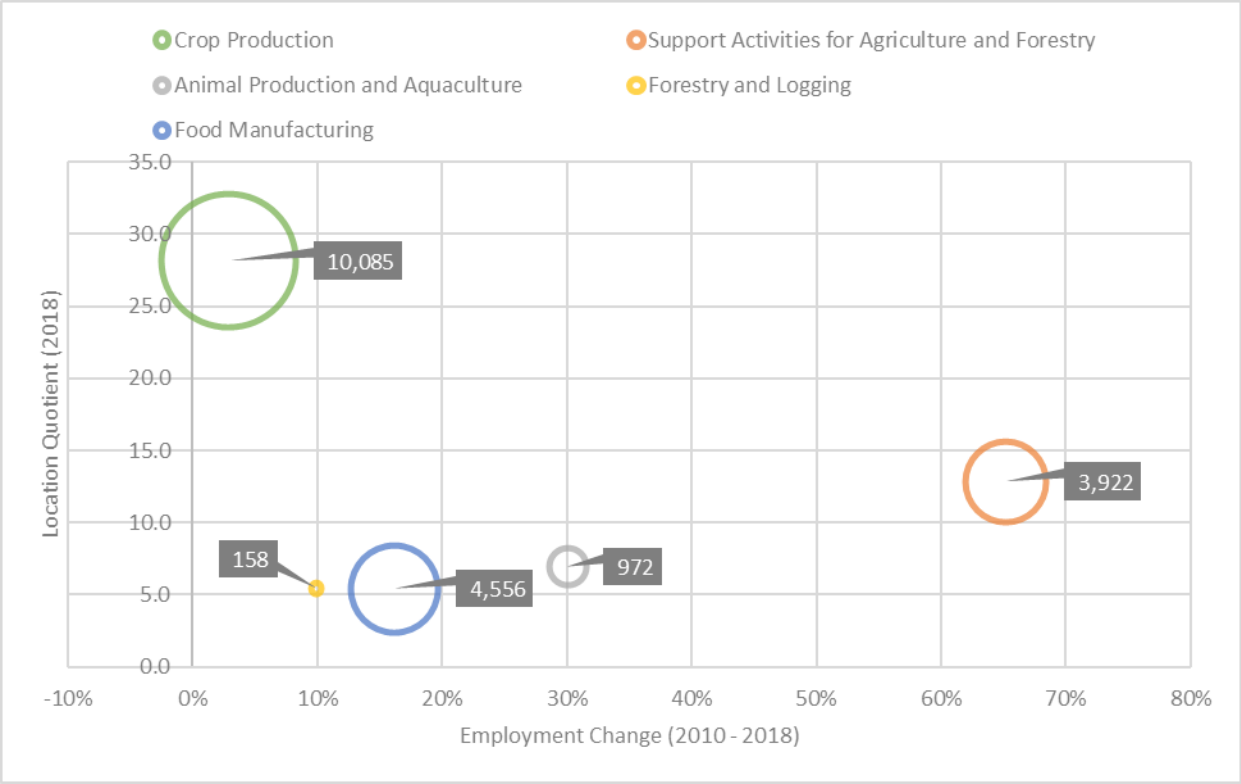
Table 2-479. Most Concentrated Industries and Employment Change in Region 4, 2018

Industry	Location Quotient	Employment (2018)	Employment Change (2010–2018)
Crop Production	28.2	10,085	3%
Support Activities for Agriculture and Forestry	12.9	3,922	65%
Animal Production and Aquaculture	7.0	972	30%
Forestry and Logging	5.4	158	10%
Food Manufacturing	5.4	4,556	16%

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

In addition to an industry's LQ value, it is important to consider the number of jobs and whether the industry is growing or declining. The scatter plot below presents this information for the five industries in Region 5 with the highest LQ values. It shows the percent change in employment over the last eight years, the total number of employees in the industry, and the LQ value.

Figure 2-221. Location Quotients, Employment Change, and Total Employment in Region 5, 2018



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

All five of the region's most concentrated industries are either natural resource based or directly dependent on natural resource industries. Looking at the five most concentrated subsectors as a whole, it's clear that the region has a competitive advantage in growing and processing food products. Although the subsector experienced modest growth from 2010-2018, Crop Production has the highest location quotient within the region and employs over ten-thousand induvial. The region has less of an advantage in Food Manufacturing but the sector grew more quickly than Crop Production and is one of the largest subsectors by employment. Support Activities for Agriculture and Forestry is also one of the region's largest employers and grew most quickly among the five most concentrated industries—adding approximately fifteen-hundred jobs from 2010-2018.

Fastest Growing and Declining Industries

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

Employment change can be caused by internal and external factors. The shift-share analysis helps us understand and separate regional and national influences on a local industry. There are

three separate elements to the analysis that attempt to account for local and national forces. The national-share controls for the broad growth of the national economy; the industry-mix controls for broad national changes within an industry being analyzed; and the local-factor tries to explain what portion of employment change can be attributed to local factors. The bar chart below depicts a shift-share analysis for Region 5's fastest growing and declining industries

Table 2-480. Fastest Growing and Declining Industries in Region 5, 2010-2018

Industry	Employment Change	Employment (2010)	Employment (2018)
Fastest Growing			
Private Households	590%	72	499
Beverage and Tobacco Product Manufacturing	157%	268	688
Performing Arts, Spectator Sports, and Related Industries	147%	57	140
Museums, Historical Sites, and Similar Institutions	108%	53	111
Plastics and Rubber Products Manufacturing	81%	95	172
Fastest Declining			
Furniture and Related Product Manufacturing	−100%	12	0
Nonmetallic Mineral Product Manufacturing	−68%	301	96
Waste Management and Remediation Services	−55%	888	399
Textile Product Mills	−44%	22	13
Motion Picture and Sound Recording Industries	−39%	91	56

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

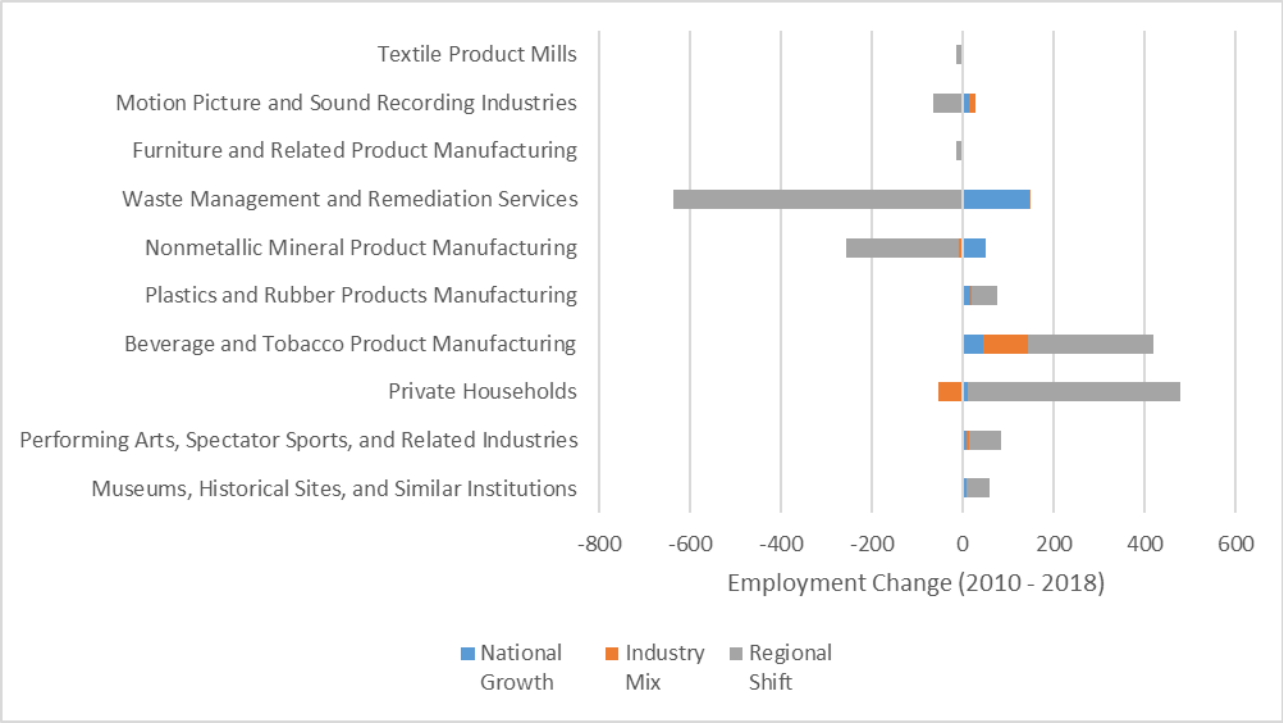
The Private Households industry experienced significant growth from 2010-2018. This sector employs workers "that work on or about the household premises…such as cooks, maids, butlers, gardeners, personal caretakers, and other maintenance workers" (Wallis, 2019). The increase in employment in the Private Households industry mirrors a statewide trend (Wallis, 2019). Demand is driven in part by an aging population's need for in-home care workers (Wallis, 2019).

Beverage and Tobacco Product Manufacturing subsector also grew in employment within the region. Growth in the Beverage and Tobacco Product Manufacturing industry is likely driven by Oregon's thriving craft-beer scene, which continues to grow despite a crowded market (Lehner, 2020). Although the industry has been expanding nationally, the shift-share analysis shows that the growth was driven more by regional factors.

Additionally, the region experienced significant growth—but smaller actual numbers—in the Performing Arts, Spectator Sports, and Related Industries subsector; Museums, Historical Sites, and Similar Institutions subsector; and the Plastics and Rubber Products Manufacturing subsector. According to this shift-share analysis, growth in these industries was also caused by local factors rather than industry trends at the national level.

According to the shift-share analysis, losses in all five of the fastest declining subsectors can also be attributed to regional factors. While the industry experienced slight growth nationally, in Region 5 Waste Management and Remediation Services shed nearly five hundred positions from 2010-2018. The Nonmetallic Mineral Product Manufacturing sector also shed a meaningful number of jobs during this period—approximately two hundred.

Figure 2-222. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 5, 2010-2018



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

Table 2-481. Shift-Share-Analysis of Fastest Growing and Declining Industries in Region 5, 2010-2018

Industry	Employment Change	National Growth	Industry Mix	Regional Shift
Fastest Growing				
Museums, Historical Sites, and Similar Institutions	58	9	−1	50
Performing Arts, Spectator Sports, and Related Industries	84	9	5	69
Private Households	426	12	−53	467
Beverage and Tobacco Product Manufacturing	420	44	99	277
Plastics and Rubber Products Manufacturing	77	16	3	58
Fastest Declining				
Nonmetallic Mineral Product Manufacturing	−205	50	−8	−247
Waste Management and Remediation Services	−490	146	2	−637
Furniture and Related Product Manufacturing	−12	2	0	−13
Motion Picture and Sound Recording Industries	−35	15	14	−64
Textile Product Mills	−10	4	−4	−9

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

Economic Trends and Issues

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

- Unemployment in Umatilla County is consistently higher than the statewide average;
- Many of the region's most concentrated industries are natural resource-based or depend on natural resource industries. These sectors are especially vulnerable to the impacts of climate change;
- The region lost employment in many of its manufacturing subsectors from 2010-2018;
- The region lacks a diversity of traded sector industries.

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

Infrastructure

Transportation

Roads

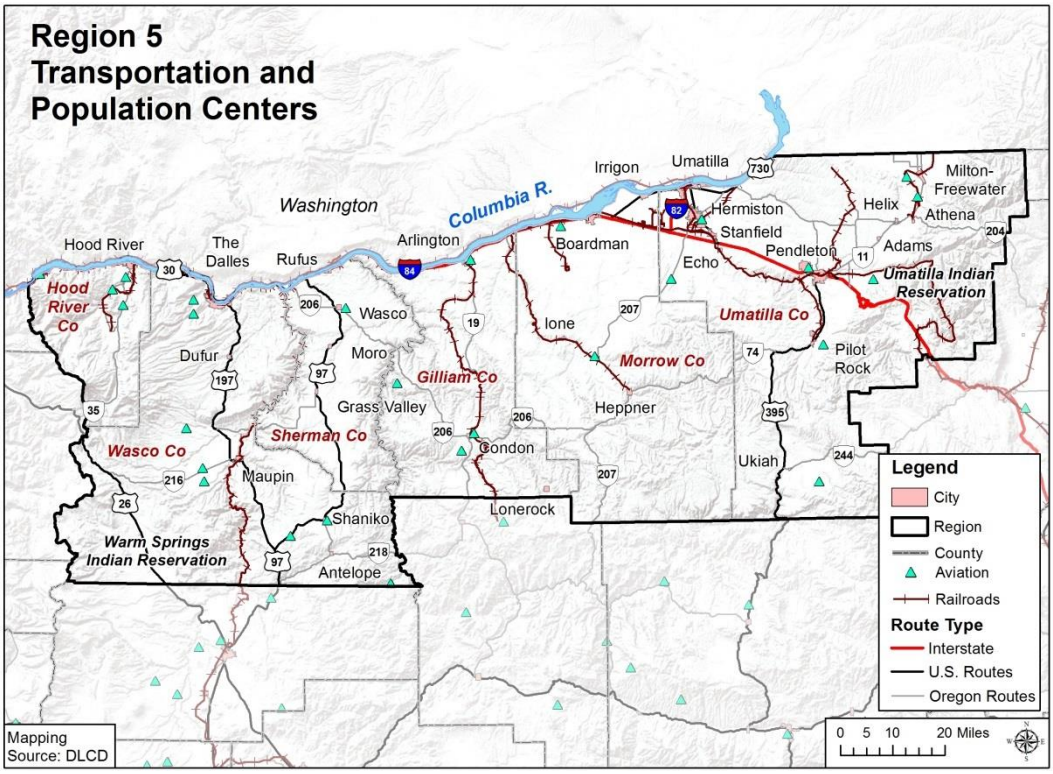
The largest population bases in Region 5 are located along the region's major freeways, I-84. I 84 is the main east-west passage for automobiles and trucks traveling between the northwest and states to the east.

Region 5's growing population centers bring more workers, automobiles and trucks onto roads. A high percentage of workers driving alone to work coupled with interstate and international freight movement on the I-84 corridor create additional stresses on transportation systems. Some of these stresses are added maintenance, congestion, oversized loads, and traffic accidents.

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

According to the Oregon Department of Transportation's (2014, October) Seismic Plus Report (Appendix **9.1.13**), ground shaking from a CSZ event is not expected to cause damage to the region's major highways. The region has relatively low vulnerability to ground shaking from a CSZ event. However, connections to markets and services will likely be disrupted. For information on ODOT's 2012 Seismic Lifelines Report findings for Region 5 5, see **Seismic Lifelines**.

Figure 2-223. Region 5 Transportation and Population Centers



Source: Oregon Department of Transportation (2014, October)

Bridges

ODOT lists 644 bridges in the counties that comprise Region 5.

Because of earthquake risk in Region 5, the seismic vulnerability of the region's bridges is an important issue. Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or that are part of regional and local systems that are maintained by the region's counties and cities.

Table 2-482 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges. The ratings do not imply that a bridge is unsafe (ODOT, 2020). The region has about the same percentage of bridges that are distressed or deficient (5%) as does the state.

Table 2-482. Bridge Inventory for Region 5

	State Owned			County Owned			City Owned			Other Owned			Area Total		
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D
Oregon	42	2,760	2%	258	3,442	7%	30	643	5%	16	121	13%	346	6,966	5%
Region 5	4	293	1%	26	303	9%	3	40	8%	0	8	0%	33	644	5%
Gilliam	0	19	0%	2	15	13%	0	1	0%	0	0	N/A	2	35	6%
Hood River	1	45	2%	1	15	7%	0	0	N/A	0	2	0%	2	62	3%
Morrow	0	24	0%	3	32	9%	1	11	9%	0	3	0%	4	70	6%
Sherman	0	35	0%	1	11	9%	0	1	0%	0	0	N/A	1	47	2%
Umatilla	2	118	2%	12	165	7%	2	22	9%	0	1	0%	16	306	5%
Wasco	1	52	2%	7	65	11%	0	5	0%	0	2	0%	8	124	6%

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

Source: ODOT (2020)

Railroads

Railroads that run through Region 5 support cargo and trade flows. The region's major freight rail providers are the Union Pacific (UP) and the Burlington Northern-Santa Fe (BNSF) railroads. There are two major rail yards in the region — in The Dalles and Hinkle — operated by UP (Cambridge Systematics, 2014). The Hinkle Yard serves as UP's system yard and locomotive service and repair yard for Oregon and the greater northwest area (Cambridge Systematics, 2014).

Amtrak provides passenger rail service along the Columbia Gorge and eastward via the Empire Builder line.

Rails are sensitive to icing from winter storms that can occur in Region 5. Disruptions in the rail system can result economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

The Eastern Oregon Regional Airport is the only commercial airport in the region (City of Pendleton website, http://www.pendleton.or.us/pendleton-airport). It serves one passenger airline, SeaPort Airlines, providing service to Portland and North Bend (Portland International Airport, 2014).

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

Table 2-483. Public and Private Airports in Region 5

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Helipad	Private Helipad	Total
Region 5	9	18	0	8	35
Gilliam	2	2	0	0	4
Hood River	2	2	0	1	5
Morrow	2	0	0	1	3
Sherman	1	0	0	0	1
Umatilla	2	6	0	5	13
Wasco	0	8	0	1	9

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

Ports

Oregon's ports have historically been used for timber transport, and commercial and recreational fishing. With the decline in the timber industry, ports have evolved to embrace economic development and tourism by offering industrial land and river, rail, road, and air infrastructure. There are three ports within Region 5: The Port of Cascade Locks, The Port of The Dalles, and the Port of Hood River. The Port of Cascade Locks includes industrial land, a marine park, and the Bridge of the Gods, and promotes recreation tourism (Port of Cascade Locks website, http://portofcascadelocks.org/). The Port of Hood River encompasses industrial land, business parks, an expo center, the Hood River Marina and waterfront area, Hood River Airport, and the Hood River–White Salmon Bridge (Portland Hood River website, http://www.portofhoodriver.com/). The Port of The Dalles is approximately 425,000 square acres and covers the northern third of Wasco County. It contains industrial land and The Dalles Marina (Port of The Dalles website, http://www.portofthedalles.com/).

Energy

Electricity

The region is served by several investor-owned, public, cooperative, and municipal utilities. The Bonneville Power Administration is the area's wholesale electricity distributor. Pacific Power and Light (Pacific Power) is the primary investor-owned utility company serving portions of Gilliam, Hood River, Morrow, Sherman, and Umatilla Counties. The region's electric cooperatives are: the Hood River Electric Cooperative (Hood River County), Wasco Electric Cooperative (Gilliam, Hood River, Sherman, Wasco), Columbia Basin Cooperative (Gilliam, Morrow, Umatilla), Umatilla Cooperative (Umatilla), Columbia Power Cooperative (Umatilla) and Central Electric Cooperative (Wasco). Two utility districts serve the region: City of Cascade Locks (Hood River) and Milton-Freewater (Umatilla). In addition, the Northern Wasco People's Utility District (Wasco) serves portions of the region.

The region has a total of 31 power-generating facilities: 4 hydroelectric power facilities, 3 natural gas power facilities, 23 wind power facilities, and 1 coal power facility. In total, the

power-generating facilities have the ability to produce up to 11,227 megawatts (MW) of electricity. The region also includes four wind power facilities that are approved but not constructed. The wind power facilities will have the capacity to generate up to 1,205 MW of electricity (Oregon Department of Energy).

Table 2-484. Power Plants in Region 5

	Hydro-electric	Natural Gas	Wind	Coal	Other*	Total
Region 5	4	3	23	1	0	31
Gilliam	0	0	8**	0	0	8
Hood River	1	0	0	0	0	1
Morrow	0	1	3**	1	0	5
Sherman	1	0	7	0	0	8
Umatilla	1	2	5	0	0	8
Wasco	1	0	0	0	0	1
Energy Production (MW)	**6,458**	**1,265**	**3,044**	**460**	**0**	**11,227**

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

**There are four wind power facilities that are located in both Gilliam and Morrow Counties, this table places half of each facility in each county.

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

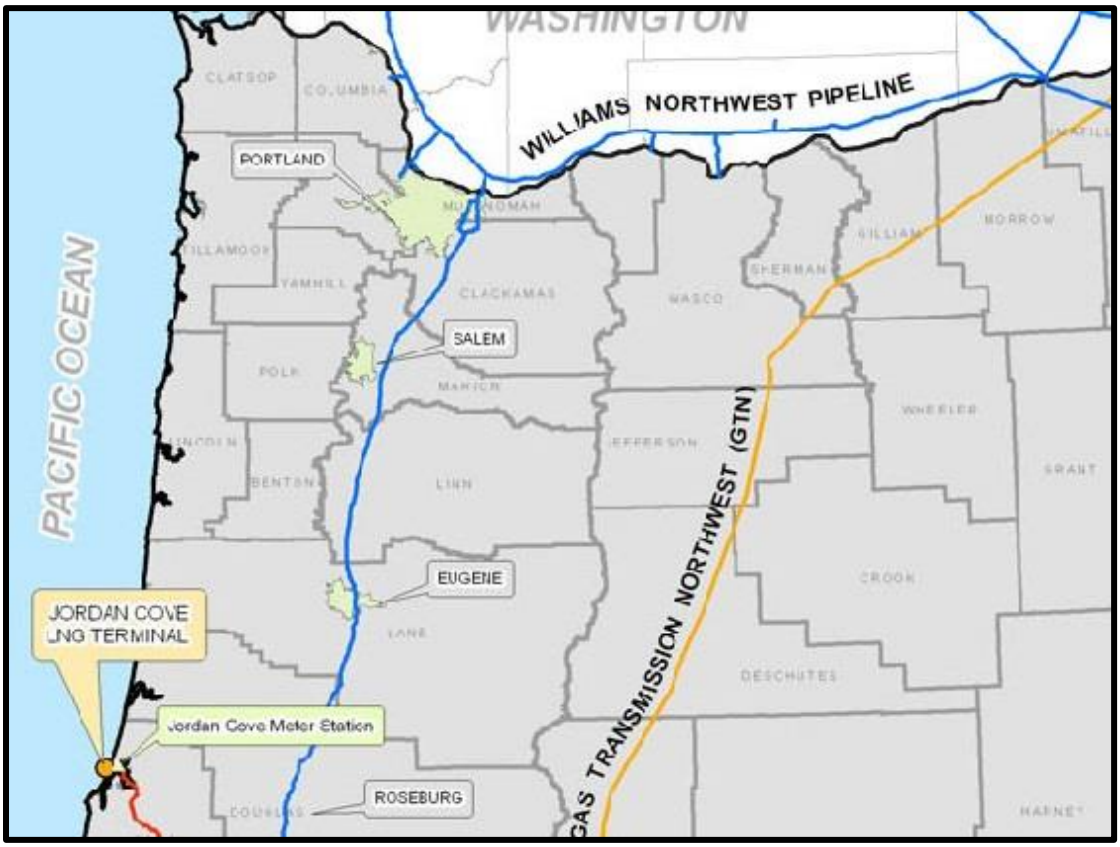
Hydropower

The Bonneville Power Administration (BPA) provides hydro-generated electricity to the state's consumer-owned utilities. The major BPA dams in the region are located on the Columbia River in communities of The Dalles, John Day, and McNary

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to the region's energy portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-224** shows the Gas Transmission Northwest (GTN) line, which runs through Gilliam, Morrow, and Umatilla Counties (in green) (Pipelines International, 2009). LNG pipelines, like other buried pipe infrastructure, are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

Figure 2-224. Liquefied Natural Gas Pipelines in Region 5



Source: Oregon Department of Environmental Quality

Utility Lifelines

The Mid-Columbia region is an important thoroughfare for oil and gas pipelines and electrical transmission lines. The region is also a major producer of hydropower. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe, but infrequent natural hazards, such as earthquakes.

Communities in this region primarily receive oil and gas from Alaska by way of the Puget Sound through pipelines and tankers. The region is at the southern end of this pipeline network. Oil and gas are supplied by Northern California via a separate network. The electric, oil, and gas lifelines that run through the region are both municipally and privately owned (Loy, Allan, & Patton, 1976).

The network of electrical transmission lines running through Region 5 is operated primarily by Pacific Power, regional electrical cooperatives, and Bonneville Power Administration (Loy, et al., 1976). Most of the natural gas Oregon uses originates in Alberta, Canada. Avista Utilities owns the main natural gas transmission pipeline (Loy, Allan, & Patton, 1976).

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Region 5 is part of the Columbia Gorge Operational Area (Hood River, Wasco, Sherman, Gilliam), Central Oregon Operational Area (Wheeler, Southern Wasco), and Eastern Oregon Operational Area (Morrow, Umatilla) under The Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013). There is a memorandum of understanding between these counties that facilitates the launching of emergency messages. Counties in these areas can launch emergency messages by contacting the Oregon Emergency Response System (OERS), which in turn creates emergency messages to communities statewide.

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

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The Oregon State Emergency Alert System Plan does not identify a local primary station for emergency messages.

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 5. Broadband technology including mobile wireless is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless, and mobile wireless. Internet service is readily available throughout most parts the region with a smaller number of providers and service types available in the southern parts of the region (south of I-84) (NTIA, n.d.) Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

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

Radio

Radio is readily available to those who live within Region 5 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for the Columbia Gorge Operational Area are (Oregon Office of Emergency Management, 2013):

- KMSW-FM, 92.7 MHZ, The Dalles, 102.9 MHZ, Hood River;
- KHRV-FM, 90.1 MHZ, Hood River, OPB Radio Network; and
- KOTD, 89.7 MHZ, The Dalles, OPB Radio Network.

Ham Radio

Amateur radio, or ham radio, is a service provided by licensed amateur radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communication is a priority for the Amateur Radio Relay League (ARRL). Region 5 is served by ARES Districts 2 and 3. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters (Oregon Office of Emergency Management, n.d.). The official ham emergency station calls for Region 5 include (American Relay Radio League Oregon Chapter, n.d., www.arrloregon.org):

- Gilliam County: W7ILD;
- Hood River County: K7VEW;
- Morrow County: N7ZHG;
- Sherman County: WB7PPK;
- Umatilla County: N7ZHG; and
- Wasco County: KF7LN.

Water

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

Drinking Water

The drinking water supply in Region 5 is drawn from a combination of surface, well, and spring sources. Surface water is drawn from rivers and smaller tributaries. In the eastern and western portions of the region these surface water sources are often backed up by groundwater that is drawn from an aquifer when surface water levels get low, especially in summer months. However, in the region's central counties municipal wells drawing from the aquifer are primary sources with springs used as a backup where they are available. In this central part of the region water shortages in wells are increasing although flow levels tend to stay consistent throughout the year. Water quality in the region's municipal supply is high. Chemical and fuel spills are a concern when surface waterways intersect with or parallel major roadways. Water quality could

be threatened as older or damaged well infrastructure may not filter coliform and other bacteria as effectively as newer infrastructure.

Rural residents draw water from surface water, groundwater wells, or springs. Surface water is usually used for irrigation, and wells are used as backup source. Groundwater wells serve residential needs. In rural areas storage ponds or small dams are sometimes created on private land to provide additional on-site drinking water storage. Water quality for rural residents is primarily affected by nitrates from agricultural activities and by low flow levels, which can increase the density of pollutants.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. An example of non-point source pollution is stormwater runoff from roadways, agricultural operations, timber harvest, erosion, and sedimentation. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Landslides, flood events, earthquakes, and liquefaction can cause increased erosion and sedimentation in waterways.

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

Stormwater and Wastewater

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

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

In Region 5, most municipal building codes and stormwater management plans (city and county) emphasize use of centralized storm sewer systems to manage stormwater. Requirements for stormwater mitigation vary in Region 5. Low impact development (LID) mitigation strategies can alleviate or lighten the burden on a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, at lower speed, and at lower temperatures. The four largest municipalities in the region, Hood River, Hermiston, The Dalles and Pendleton, do not require LID strategies in their building codes. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems and could increase a community's resilience to many types of hazard events.

Infrastructure Trends and Issues

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

The effects of road, bridge, rail, and port failures could be devastating to the economy and public health in the Mid-Columbia Region. I-84 supports the main east-west passenger and freight transport and is subject to winter storms and windstorms. Rail systems are vulnerable to icy conditions in the Gorge. In Region 5, there are two rail yards that service the state and greater Northwest region. Amtrak provides passenger service through the Columbia River Gorge. Three ports and one commercial airport are economic engines for the region, providing for tourism and recreation and supporting business and industrial parks.

The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy and is vulnerable to severe, but infrequent, natural hazards. A diverse energy portfolio helps increase the area's ability to communicate and transport goods and emergency services after a hazard event. There are 31 power-generating facilities: four hydroelectric, three natural gas, 23 wind, and one coal facility. Four additional wind facilities have been proposed for this region. Three of BPA's large dams and hydroelectric projects are here on the Columbia River. LNG pipelines run through Gilliam, Morrow, and Umatilla Counties.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services may not cover rural areas of the region that are distant from I-84. This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Drinking water is sourced from surface water, wells, and springs. Water quality can be threatened by non-point source pollution from stormwater runoff and agricultural activities in the area. DEQ, ODA, and ODF have programs in place to address water quality concerns caused by land management practices that are nonpoint sources of pollution. However, there continue to be on the 303d list and the Pesticide Stewardship Partnerships identified waterbodies that are not meeting water quality standards and pesticide benchmarks. More work is needed to address these. In general ODA's water quality rules and plans and its Confined Animal Feeding Operations (CAFO) program do provide some protection. However, the CAFO program is designed to provide water quality protection for up to a certain design storm, not for a major

flood or other natural hazard event. In addition, the data defining the design storm need to be updated to provide the intended protection. Erosion and sedimentation caused by natural hazard events could also threaten the water quality. In addition, outdated, damaged, or rigid buried water infrastructure is vulnerable to seismic activity. Though low impact development (LID) stormwater systems can increase the region's capacity to better manage high-precipitation events, no communities in this region require LID practices.

Built Environment

Settlement and Development Patterns

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

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

Urbanization and Population Distribution

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people, or an "urban cluster" of at least 2,500 people (but less than 50,000). Gilliam and Sherman Counties do not meet either definition; therefore even though both counties contain incorporated cities, they are considered 100% rural. Jurisdictions are designated urban or rural after each decennial census. The 2020 Census is currently underway; therefore, the data in **Table 2-485** and **Table 2-486** remain from the 2010 Census.

Between 2000 and 2010, growth in the region's urban areas has been about 10% less than urban growth statewide. While Umatilla County has the greatest number of people and housing in urban areas, urban populations, and homes in Hood River County have grown considerably, by roughly 22% and 32%, respectively. Gilliam and Sherman Counties do not have urban populations and are also losing the greatest share of their rural populations. Rural homes have increased by almost 10% in Gilliam and Wasco Counties.

The region's population is clustered around the I-84 corridor and the cities of Hood River, Pendleton, and The Dalles. The population distribution in Region 5 is presented in Figure 2-225.

Table 2-485. Urban and Rural Populations in Region 5, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	−0.1%
Region 5	79,500	87,442	10.0%	50,094	50,815	1.4%
Gilliam	0	0	—	1,915	1,871	−2.3%
Hood River	8,727	10,687	22.5%	11,684	11,659	−0.2%
Morrow	5,790	6,048	4.5%	5,205	5,125	−1.5%
Sherman	0	0	—	1,934	1,765	−8.7%
Umatilla	49,253	53,831	9.3%	21,295	22,058	3.6%
Wasco	15,730	16,876	7.3%	8,061	8,337	3.4%

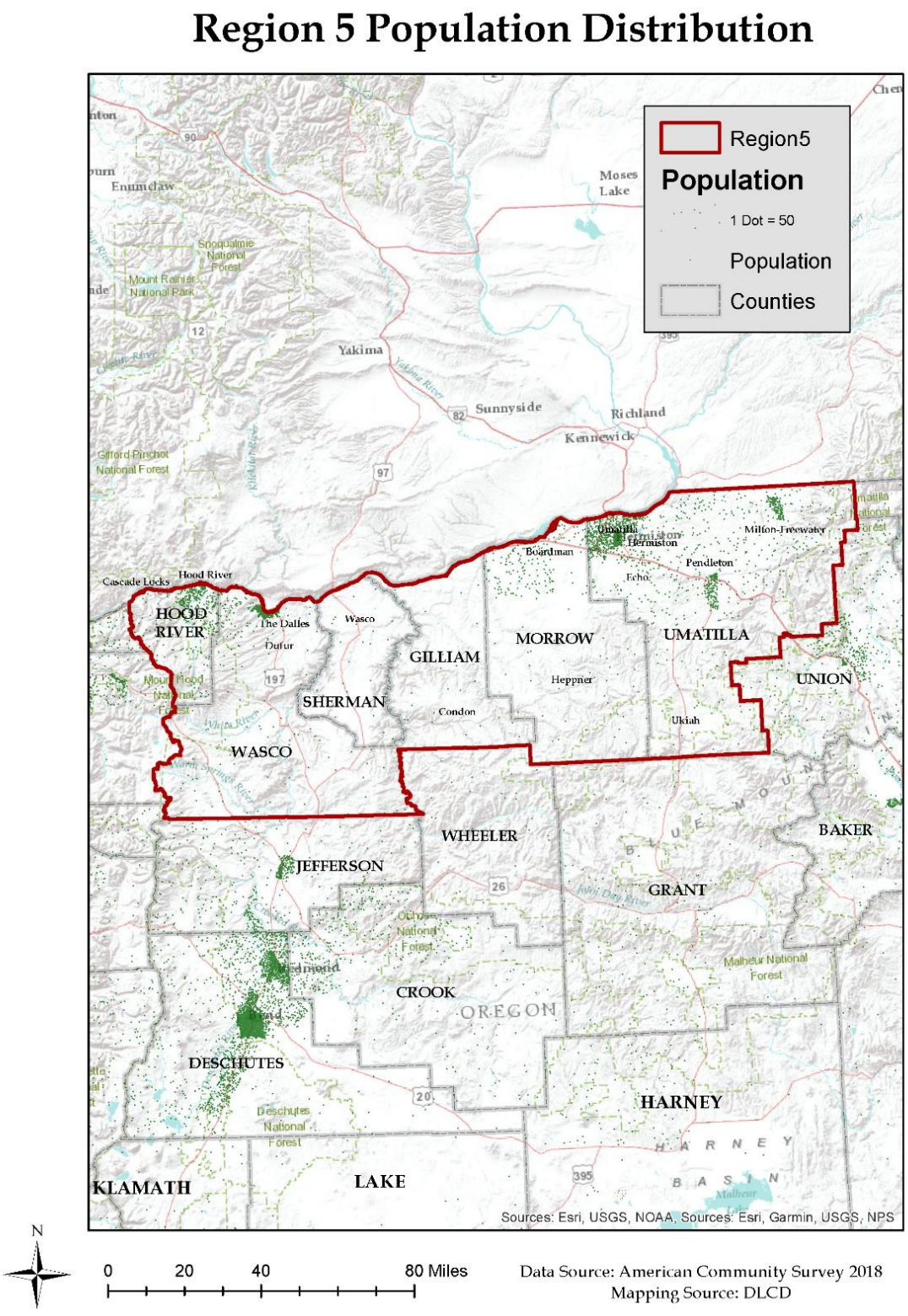
Source: U.S. Census Bureau (n.d.). 2010 Decennial Census, Table P2; U.S. Census Bureau (n.d.). 2000 Decennial Census, Table P002

Table 2-486. Urban and Rural Housing Units in Region 5, 2010

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 5	31,453	34,811	10.7%	20,946	22,156	5.8%
Gilliam	0	0	—	1,043	1,156	10.8%
Hood River	3,681	4,870	32.3%	4,137	4,401	6.4%
Morrow	1,957	2,010	2.7%	2,319	2,432	4.9%
Sherman	0	0	—	935	918	−1.8%
Umatilla	19,124	20,755	8.5%	8,552	8,938	4.5%
Wasco	6,691	7,176	7.2%	3,960	4,311	8.9%

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

Figure 2-225. Region 5 Population Distribution



Source: U.S. Census Bureau, American Community Survey, 2014-2018 5YR

Housing Development

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. **Table 2-487** provides a breakdown by county of housing types: single-family, multi-family, and manufactured housing. Note: The total housing units value also includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category because they represent a small percentage of the overall housing profile. Consequently, adding the percentages horizontally for the state, region, and each county will not equal 100%.

The data show that the majority (68.2%) of the region's housing stock is single-family homes. Multi-family housing represents a smaller portion (15.7%) of housing within the region. Umatilla County has over half of the region's supply of multi-family units (5,297). Manufactured homes make up 15.8% of Region 5's housing. Umatilla County has the highest number of manufactured homes, while almost one third of the total housing units in Morrow County are manufactured homes. In natural hazard events such as earthquakes and floods, manufactured homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of Emergency Services, 1997).

Table 2-487. Housing Profile for Region 5

	Total Housing Units	Single Family			Multi-Family			Manufactured Homes		
		Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)	Estimate	CV **	MOE (+/–)
Oregon	1,733,041	68.1%	☑	0.3%	23.5%	☑	0.3%	8.2%	☑	0.1%
Region 5	58,040	68.2%	☑	1.3%	15.7%	☑	1.3%	15.8%	☑	0.9%
Gilliam	1,070	81.3%	☑	6.1%	5.0%	⊗	2.8%	13.6%	⊙	4.4%
Hood River	9,697	72.1%	☑	3.9%	15.8%	☑	3.8%	12.1%	☑	2.7%
Morrow	4,558	61.3%	☑	3.6%	7.7%	⊙	2.2%	30.5%	☑	3.4%
Sherman	943	70.9%	☑	5.1%	5.2%	⊙	2.2%	21.4%	☑	3.3%
Umatilla	30,172	67.1%	☑	1.8%	17.6%	☑	1.9%	15.0%	☑	1.3%
Wasco	11,600	68.9%	☑	2.2%	16.0%	☑	2.2%	14.7%	☑	1.6%

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

Source: U.S. Census Bureau (2018). Table B25024: Units in Structure, 2013-2017 American Community Survey 5-year estimates. Retrieved from https://data.census.gov/cedsci/

Table 2-488. Housing Vacancy in Region 5

		Vacant^		
	Total Housing Units	**Estimate**	**CV ****	**MOE (+/–)**
Oregon	1,733,041	5.6%	☑	0.2%
Region 5	58,040	7.0%	☑	0.9%
Gilliam	1,070	14.0%	⊙	4.2%
Hood River	9,697	5.7%	⊙	2.1%
Morrow	4,558	6.6%	⊙	2.6%
Sherman	943	13.0%	⊙	5.1%
Umatilla	30,172	7.7%	☑	1.3%
Wasco	11,600	6.1%	⊙	1.5%

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

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

Aside from location and type of housing, the year structures were built has implications (**Table 2-489**). Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events. Moreover, the Judson report did not include manufactured housing in its study, but more recent research concludes that manufactured homes installed prior to 2003 lack adequate anchoring and bracing, and are therefore more vulnerable to damage and loss caused by seismic events (Bauer, et al., 2020).

Also in the 1970s, FEMA began assisting communities with floodplain mapping as a part of administering the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage. Regionally, 42.2% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances (about 60% within both Gilliam and Sherman Counties). Also regionally, approximately 72% of the housing stock was built before 1990 and the codification of seismic building standards. Further, as shown in **Table 2-490**, many communities did not adopt their initial FIRM—and therefore did not adopt floodplain management ordinances—until the mid to late 1980s. This means that some structures built after 1970 could still be at increased risk.

Table 2-489. Age of Housing Stock in Region 5

	Total Housing Units	Pre 1970			1970 to 1989			1990 or Later		
		Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)	Estimate	CV **	MOE (+/−)
Oregon	1,733,041	34.6%	☑	0.3%	30.5%	☑	0.3%	34.9%	☑	0.3%
Region 5	58,040	42.2%	☑	1.7%	29.0%	☑	1.4%	28.8%	☑	1.4%
Gilliam	1,070	59.1%	☑	7.5%	13.7%	⊙	3.8%	27.2%	☑	5.2%
Hood River	9,697	38.7%	☑	4.7%	27.1%	☑	3.6%	34.2%	☑	4.2%
Morrow	4,558	28.5%	☑	3.9%	32.6%	☑	3.9%	38.9%	☑	5.0%
Sherman	943	62.4%	☑	7.7%	19.8%	⊙	5.1%	17.8%	☑	4.1%
Umatilla	30,172	43.3%	☑	2.6%	30.3%	☑	2.1%	26.5%	☑	2.0%
Wasco	11,600	44.4%	☑	3.3%	28.1%	☑	2.3%	27.5%	☑	2.6%

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

Source: U.S. Census Bureau (2018). Table B25034: Year Structure Built, 2013-2017 American Community Survey 5-Year Estimates. Retrieved from https://data.census.gov/cedsci/

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood, damage is minimized. **Table 2-490** shows the initial and current FIRM effective dates for Region 5 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, **Flood** section.

Table 2-490. Community Flood Map History in Region 5

	Initial FIRM	Current FIRM
Gilliam County	Sept. 24, 1984	Sept. 24, 1984 (M)
Arlington	Sept. 24, 1984	Sept. 24, 1984 (M)
Condon	Sept. 24, 1984	Sept. 24, 1984 (M)
Hood River	Sept. 24, 1984	Sept. 24, 1984 (M)
Cascade Locks	Sept. 24, 1984	Sept. 24, 1984 (M)
City of Hood River	Sept. 24, 1984	Sept. 24, 1984 (M)
Morrow County	Apr. 1, 1981	Dec. 18, 2007
Boardman	Dec. 18, 2007	Dec. 18, 2007 (M)
Heppner	Apr. 1, 1981	Dec. 18, 2007
Ione	Apr. 1, 1981	Dec. 18, 2007
Irrigon	Dec. 18, 2007	Dec. 18, 2007
Lexington	Apr. 1, 1981	Dec. 18, 2007
Sherman County	Sept. 24, 1984	Sept. 24, 1984 (M)
Grass Valley	Sept. 24, 1984	Sept. 24, 1984 (M)
Rufus	Sept. 24, 1984	Sept. 24, 1984 (M)
City of Wasco	Sept. 15, 1989	Sept. 15, 1989
Umatilla County	June 15, 1978	Sept. 3, 2010
Adams	May 15, 1984	Sept. 3, 2010
Athena	July 16, 1984	Sept. 3, 2010
Echo	May 15, 1984	Sept. 3, 2010
Helix	June 1, 1984	Sept. 3, 2010
Hermiston	Oct. 28, 1977	Sept. 3, 2010
Milton-Freewater	Sept. 12, 1978	Sept. 3, 2010
Pendleton	Nov. 3, 1978	Sept. 3, 2010
Pilot Rock	Aug. 4, 1988	Sept. 3, 2010
Stanfield	Aug. 15, 1984	Sept. 3, 2010
Ukiah	Sept. 24, 1984	Sept. 3, 2010 (M)
City of Umatilla	Sept. 24, 1984	Sept. 3, 2010 (M)
Weston	Sept. 18, 1987	Sept. 3, 2010
Umatilla Indian Reservation	Sept. 3, 2010	Sept. 3, 2010
Wasco County	Sept. 24, 1984	Sept. 24, 1984 (M)
Dufur	Sept. 24, 1984	Sept. 24, 1984 (M)
Maupin	Sept. 24, 1984	Sept. 24, 1984 (M)
Mosier	Feb. 17, 1989	Feb. 17, 1989
The Dalles	Sept. 24, 1984	Sept. 24, 1984 (M)
Warm Springs Reservation	See Jefferson County	See Jefferson County

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

Note: The Umatilla and Warm Springs Indian reservation information is provided for reference only. The State of Oregon has no jurisdiction over tribal lands.

Source: Federal Emergency Management Agency (2019), Community Status Book Report, https://www.fema.gov/cis/OR.pdf

State-Owned/Leased and Critical/Essential Facilities

In 2020 the Department of Geology and Mineral Industries updated the 2015 Oregon NHMP inventory and analysis of state-owned and –leased buildings, state-owned and –leased critical facilities, and local critical facilities. Results from this report relative to Region 5 are shown in **Table 2-491**. The region contains 5.9% of the total value of all local critical facilities and state-owned and –leased critical and non-critical facilities in the state. Cumulatively, these assets are valued at just under two billion dollars.

Table 2-491. Value of State-Owned/Leased Critical and Essential Facilities in Region 5

	Value of Local and State-Owned/Leased Facilities				
	State Non-Critical	State Critical	Local Critical	State + Local Total	Percent of Total
Oregon	$ 2,630,306,288	$ 4,622,433,011	$ 26,285,277,425	$ 33,538,016,724	100%
Region 5	$ 156,875,214	$ 738,485,535	$ 1,080,651,747	$ 1,976,012,496	5.9%
Gilliam	$ 726,796	$ 2,787,213	$ 38,430,450	$ 41,944,459	0.1%
Hood River	$ 20,147,398	$ 12,295,428	$ 156,277,749	$ 188,720,575	0.6%
Morrow	$ 3,295,908	$ 4,665,416	$ 111,486,000	$ 119,447,324	0.4%
Sherman	$ 2,296,321	$ 2,675,485	$ 25,910,268	$ 30,882,074	0.1%
Umatilla	$ 35,092,950	$ 692,104,032	$ 513,048,000	$ 1,240,244,982	3.7%
Wasco	$ 95,315,841	$ 23,957,961	$ 235,499,280	$ 354,773,082	1.1%

Source: DOGAMI, 2020

Land Use Patterns

Region 5 includes the Columbia River Plateau, where land uses have traditionally been dominated by agriculture and beef cattle. The vast majority of land in the region, approximately 71%, is held privately. Another quarter is owned by the federal government. Very little is owned by the state, roughly 1%, and the remainder is held by other public entities.

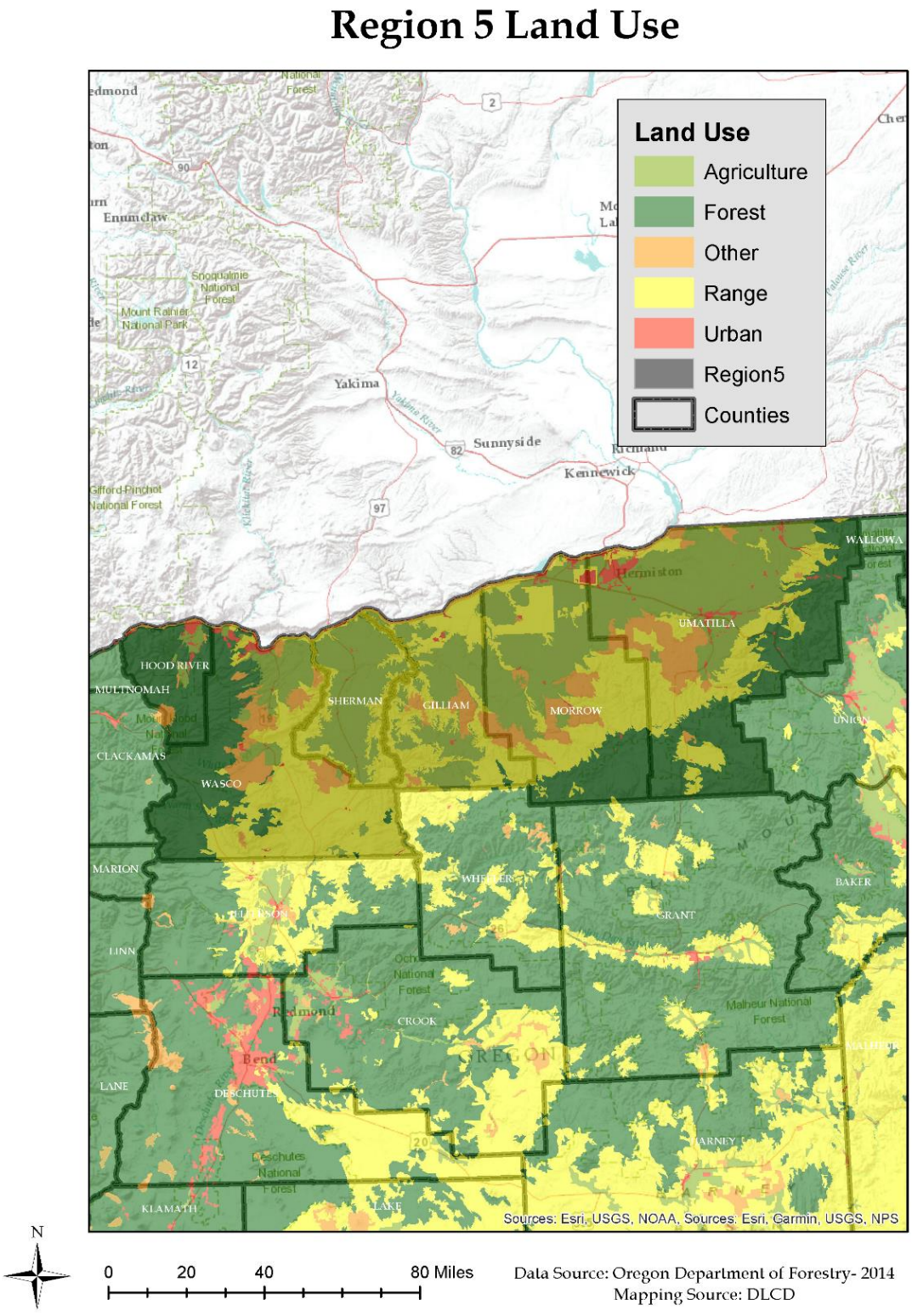
Over the past 40 years — since all counties and incorporated municipalities were required to prepare comprehensive land use plans in accordance with 19 statewide planning goals (the Land Conservation and Development Act in 1973) — little has changed in this region's land use. According to a study by the Department of Forestry, between 1974 and 2009 very little loss in the area of private land in forest, agricultural, and range uses occurred in Wasco, Gilliam, Sherman Counties. The study does note an exception in Morrow County between 1974 and 1984, where private owners converted an estimated 33,000 acres of land in wildland range use to agricultural use (Lettman G. J., 2011).

According to the Oregon Department of Forestry's most recent land-use study, "development of resource lands hit a record low between 2009 and 2014...with roughly 3,000 acres per year of Oregon's farms, forests, and rangeland shifted to low-density residential or urban uses" (Lettman G. J., Gray , Hubner , McKay, & Thompson , 2016). In Region 5, approximately 1,703 acres of resource lands were converted to more urban uses during the six-year period. **Table 2-492** shows that during this time, the percentage of resource lands converted in each county in Region 5 was less than one percent of each county's total acreage. The highest percentage of resource land conversion occurred in Hood River County, while the highest total number of acres converted to more urban uses occurred in Umatilla County.

The community of Arlington (Gilliam County) has maintained a steady growth rate, and the Port of Morrow, 25 miles to the east in Umatilla County, remains the second busiest port in Oregon. Development can be limited in Region 5 along the Columbia River partly due to the geography. For example, buildable land in the community of Hood River is partly constrained by floodplains.

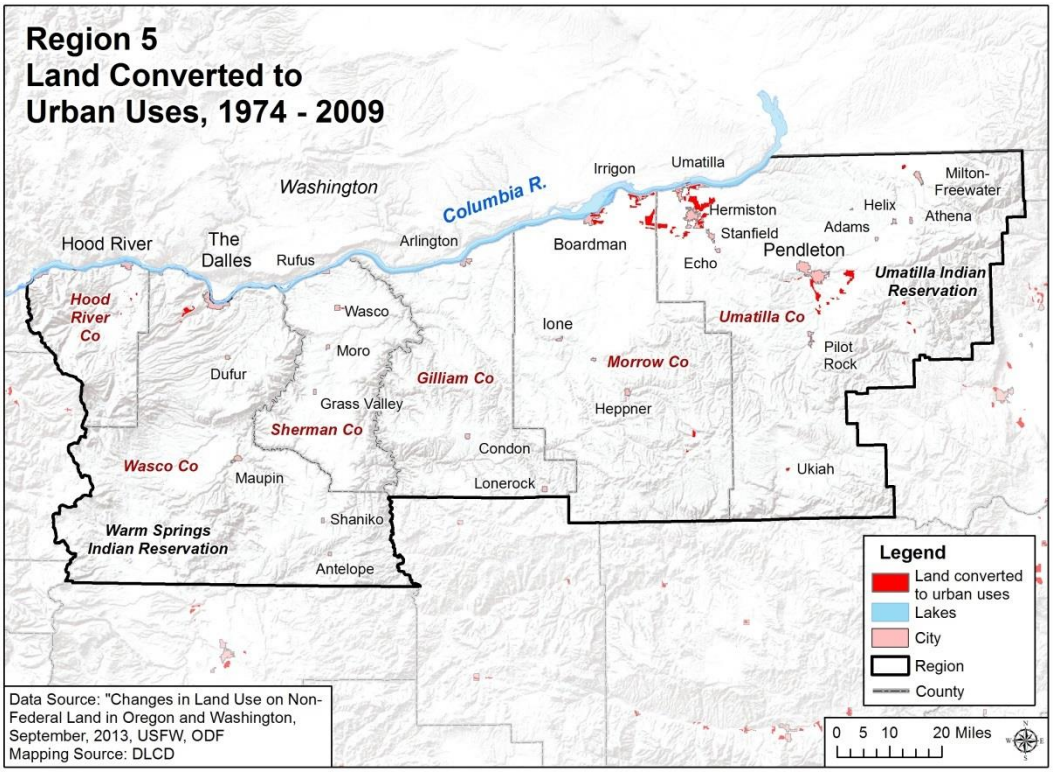
Caithness Shepherds Flat Wind Farm—located in both Morrow and Gilliam Counties—officially opened in 2012 and is one of the largest land-based wind farms in the world. Built entirely on private land, it "deploy[s] 338 wind turbines across 32,100 acres to generate 845 megawatts of clean energy..." (https://caithnessshepherdsflat.com/project-overview-2/, August 2020).

Figure 2-226. Region 5 Land Use



Source: Oregon Department of Forestry 2014

Figure 2-227. Region 5 Land Converted to Urban Uses, 1974–2009



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

Table 2-492. Region 5 Resource Lands Converted to Urban Uses, 2009-2014

	Lost Resource Lands 2009-2014		
	Total Resource Acres (2009)	**Acres Converted to Urban Use**	**Percent Converted**
Region 5	4,678,992	1,703	0.04%
Hood River	113,400	307	0.27%
Wasco	894,879	15	0.00%
Sherman	470,876	17	0.00%
Morrow	1,082,026	239	0.02%
Umatilla	1,409,018	684	0.05%
Gilliam	708,793	441	0.06%

Source: Oregon Department of Forestry, 2014; Oregon Department of Land Conservation and Development, 2020

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 5 is largely rural with urban development focused along I-84 and around the population centers of Hood River, The Dalles and Pendleton. Hood River County has the fastest growing urban population in the region, while Gilliam and Sherman Counties are entirely rural. Over the next decade, Gilliam and Sherman Counties are expected to experience population decline. Please refer to the Region 5 Risk Assessment **Demography** section for more

information on population trends and forecast. The results of the 2020 U.S. Census will better illustrate what has happened in the region over the last decade in terms of urbanization and population dispersion.

The region's housing stock is largely single-family homes. However, there is nearly double the state's percentage of manufactured homes. The region's housing stock is also older than that of the state's. Although the estimates should be used with caution, it is clear that a significant share of homes in Gilliam and Sherman Counties were built before 1990 and current seismic building standards. With the exception of Morrow and Umatilla Counties, none of the region's FIRMs have been modernized or updated, leaving this region's flood maps less up to date than those of other regions.

2.3.5.3 Hazards and Vulnerability

Droughts

Characteristics

Region 5 has experienced drought conditions on several occasions. Most recently, Gilliam and Morrow County had drought emergencies declared by the Governor in 2018. Region 5 is susceptible to drought impacts, particularly since this region is predominantly supported by an agriculturally based economy.

Agricultural industries in the region are vulnerable to scarcity of water supplies during drought events. In addition, high temperatures and low precipitation associated with drought conditions reduce soil moisture, dry vegetation, and tend to enhance winds. These conditions increase the amount of soil entrained in high winds, particularly in semi-arid regions where temperatures are increasing and precipitation is decreasing, and where areas of substantial land disturbance and/or development is occurring. Thus, during extended dry and drought conditions, productive soils are vulnerable to loss, further impacting agriculture.

Historic Drought Events

Table 2-493. Historic Droughts in Region 5

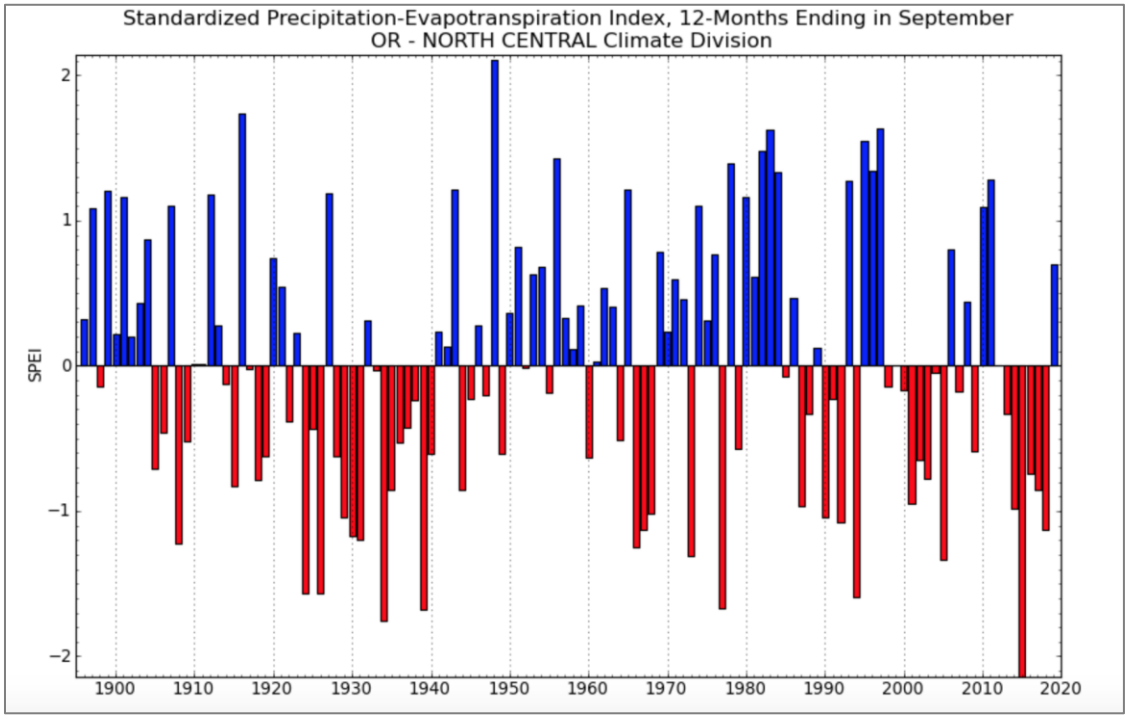
Water Year	Location	Description
1939	statewide 1938-1939, extreme drought in Region 5 in 1939-1940	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country
1977	Regions 4–8	the 1976-1977 drought was the most severe drought in the region with significant agricultural impacts
1994	Regions 4–8	in 1994 the Governor's drought declaration covered 11 counties located within regions 4, 5, 6, 7, and 8
2001	Regions 4–8 (18 counties)	Governor declared drought in Hood River, Wasco, Sherman, Gilliam, and Morrow Counties
2002	Regions 1 and 4–8	2001 drought declaration still in effect; Governor declares 5 additional counties, including Umatilla County
2003	Regions 5–8	eight counties declared; for Region 5, this included Sherman County; Hood River, Wasco, Gilliam, Morrow, and Umatilla County drought declarations from 2001 and 2002 were in effect through June 23, 2003; other counties outside of Region 5 under a drought declaration included Wheeler and Crook County from Region 6; Baker, Union, and Wallowa from Region 7; and Malheur and Harney County from Region 8; the Klamath County (Region 6) 2001 drought declaration remained in effect through December 31, 2003
2004	eastern Oregon	Governor declared drought for Morrow County in Region 5; three other counties also declared in neighboring regions
2005	Regions 5–7	all six counties within Region 5 declared drought by the Governor, along with five counties in Region 6, and two counties in Region 7
2008	Region 5 only	Governor issued a drought declaration for Sherman and Gilliam Counties in September
2013	Regions 5–8	five counties affected statewide; for Region 5: Gilliam and Morrow; Region 6: Klamath County, Region 7: Baker County, and Region 8: Malheur County
2015	statewide	All 36 Oregon Counties receive federal drought declarations, including 25 under Governor's drought declaration
2018	Regions 1, 4–8	Gilliam and Morrow County receive Governor's drought declarations, including 9 other counties in 5 other regions

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

Historical drought information can also be obtained from the West Wide Drought Tracker, which provides climate data showing wet and dry conditions, using the Standard Precipitation-Evapotranspiration Index (SPEI) that dates back to 1895. **Figure 2-228** shows years where drought or dry conditions affected the Hazard Region 5, the north central area of Oregon (Climate Division 6).

Based on this index, 2015 was the most extreme drought year. During the 1930s, there were many moderate and severe drought years. 1977 and 1994 were other severe drought years. 2018 was a moderate drought year. Years with at least moderate drought have occurred 19 times during 1895–2019 in Region 5 (Climate Divisin 6) (**Table 2-494**).

Figure 2-228. Standard Precipitation-Evapotranspiration Index for Region 5



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

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

Table 2-494. Years with Moderate (<-1), Severe (<1.5), and Extreme (<-2) Drought in Oregon Climate Division 6 according to Standard Precipitation-Evapotranspiration Index

Moderate Drought (SPEI < -1.0)	Severe Drought (SPEI < -1.5)	Extreme Drought (SPEI < -2.0)
2003	1934	2015
1973	1939	
1966	1977	
1908	1994	
1931	1924	
1930	1926	
1967		
2018		
1992		
1929		
1990		
1968		

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

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

Probability

Table 2-495. Probability of Drought in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	M	H	H	M	M

Source: OWRD, DLCD

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

Gilliam and Morrow Counties have received drought declarations in 31% of the years since 1992 and Sherman in 28%. Umatilla has received drought declarations in 21% of the years since 1992, Hood River and Wasco 17%. These differences account for their High and Moderate probability ratings.

Climate Change

Climate models project warmer, drier summers for Oregon, including Region 5. With less confidence, climate models project increases in summer runoff and summer soil moisture for lowland parts of eastern Oregon, including Region 5. Increases in summer soil moisture are the result of increased precipitation in the spring, which dominates the effects of warming temperatures (Gergel, et al., 2017). However, Region 5, like the rest of Oregon is projected to experience an increase in the frequency of summer drought conditions as summarized by the standard precipitation-evaporation index (SPEI) due largely to projected decreases in summer precipitation and increases in potential evapotranspiration (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

Vulnerability

Table 2-496. Local Assessment of Vulnerability to Drought in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	—	H	—	H

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

Table 2-497. State Assessment of Vulnerability to Drought in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	M	VH	VL	VH	VH

Source: OWRD, DLCD

Oregon has not undertaken a comprehensive statewide analysis to identify which communities are most vulnerable to drought.

Social Vulnerability

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5. Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income. Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger. Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters. Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma. Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

Region 5's economy is based in agriculture which is very vulnerable to the impacts of drought. Impacts of drought on state-owned facilities related to agriculture would include impacts to research conducted in outdoor settings, such as at extension stations and research farms. There is no single comprehensive source or other sources for information to assess economic impacts.

Morrow, Umatilla, and Wasco Counties all have very high social vulnerability ratings meaning that any natural hazard would have a significant impact on their populations. Hood River County's social vulnerability rating is moderate; Gilliam and Sherman Counties' social vulnerability ratings are very low. Morrow, Umatilla, and Wasco Counties are considered those most vulnerable to drought in Region 5.

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

The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to drought. The value of locally owned critical facilities is $1,080,652,000. Because drought could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to drought. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 5 since the beginning of 2015. Nevertheless, none of the recorded losses was due to drought.

Risk

Table 2-498. Risk of Drought in Region 5

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

Source: OWRD, DLCD

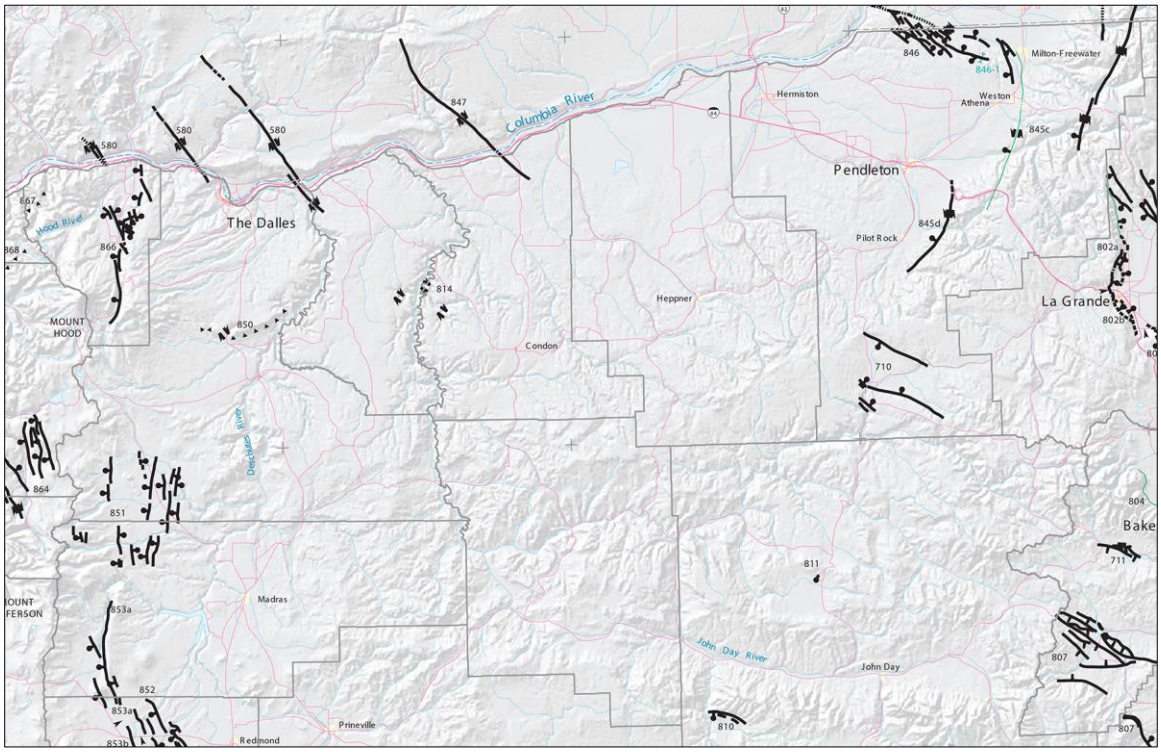
With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. Based the history of drought declarations, the counties' social vulnerability ratings, and the potential for drought to impact the agricultural economy, Morrow County is considered to be at very high risk from drought, and Umatilla and Wasco Counties at high risk. Hood River is considered to be at moderate risk, Gilliam and Sherman Counties at low risk.

Earthquakes

Characteristics

The geographic position of this region makes it susceptible to earthquakes from three sources: subduction zone, intraplate, and crustal events. The map below shows the location of the known crustal faults which could affect the region. Because only certain faults have been studied in detail and determined to be active, there may be many more crustal faults in the region capable of producing earthquakes which have not yet been identified. **Figure 2-229** shows the locations of faults in Region 5.

Figure 2-229. Quaternary Faults and Folds in Region 5

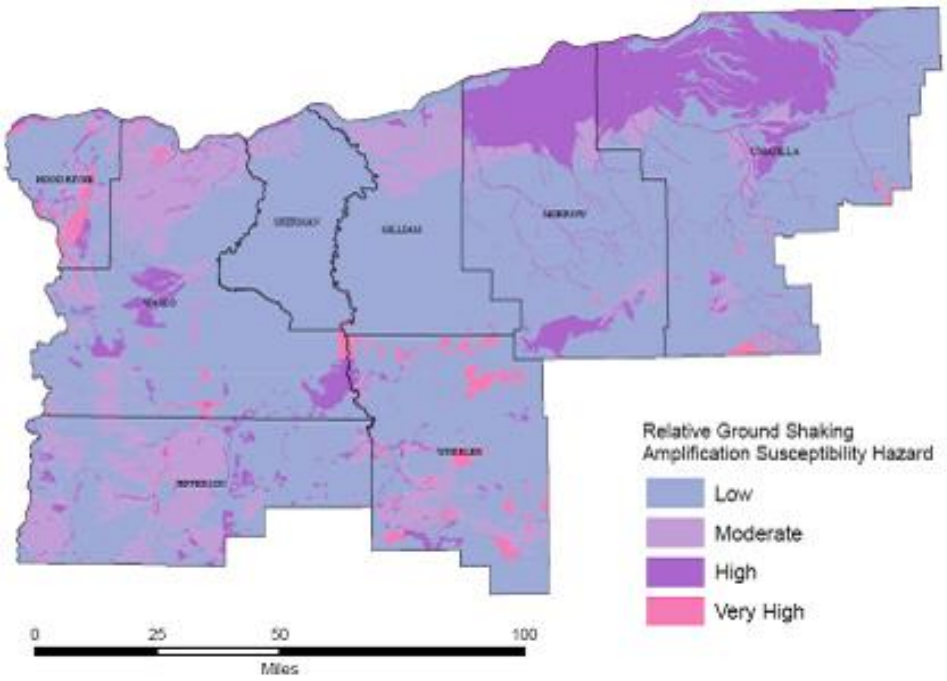


Source: Modified from Personius, et al. (2003)

When all of these earthquake sources are added together, the general earthquake hazard in the region can be displayed as a whole and is reflected in the USGS national seismic hazard maps. When compared to the rest of the United States, most of the region is within a relatively moderate seismicity area, except for Hood River and Wasco Counties which are mostly within relatively moderate to high zones.

Figure 2-230 displays the relative ground shaking amplification hazard throughout Region 5.

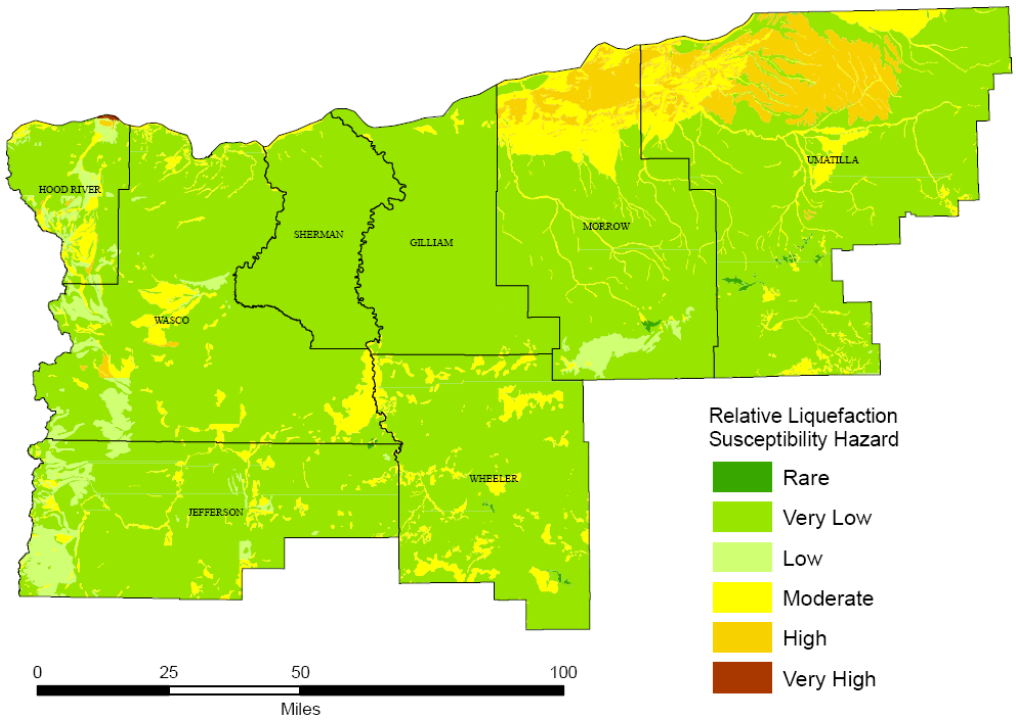
Figure 2-230. Relative Ground Shaking Amplification Hazard in Region 5



Source: Burns, 2007

During seismic shaking, deposits of loose saturated sands can be subjected to contraction resulting in an increase in pore water pressure. If the increase in pore water pressure is high enough, the deposit becomes "liquefied," losing its strength and its ability to support loads. Figure 2-231 displays the relative liquefaction hazard throughout Region 5.

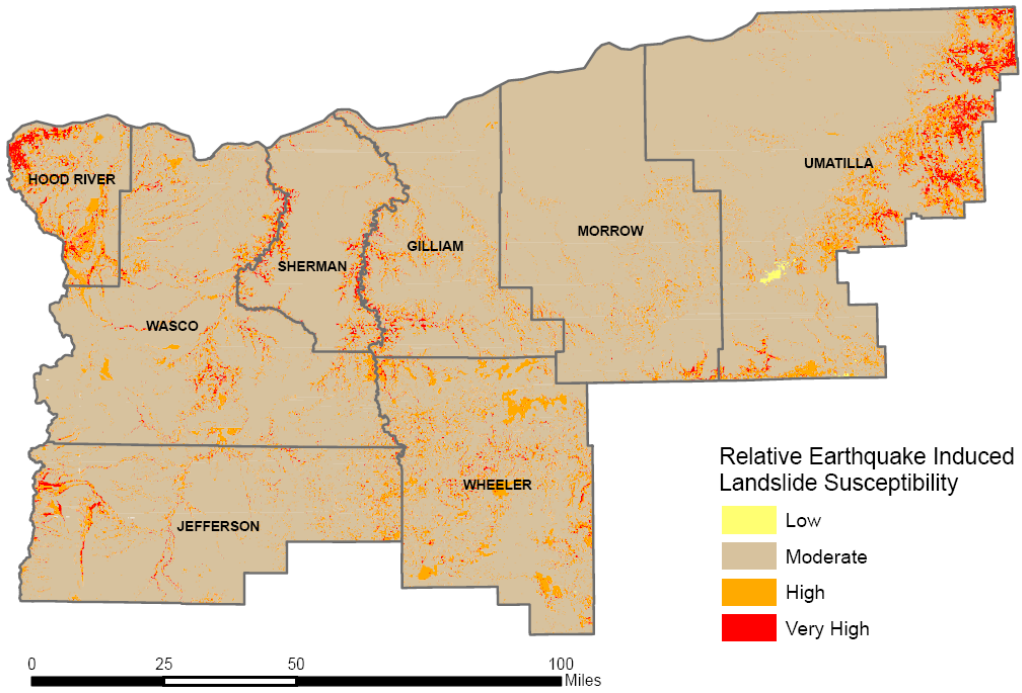
Figure 2-231. Relative Liquefaction Susceptibility Hazard in Region 5



Source: Burns, 2007

Strong ground shaking can also cause landslides and reactivate dormant landslides. Commonly, slopes that are marginally stable prior to an earthquake become unstable and fail. Some landslides result from liquefaction that causes lateral movement of soil, or lateral spread. **Figure 2-232** displays the relative earthquake induced landslide hazard throughout Region 5.

Figure 2-232. Relative Earthquake-Induced Landslide Susceptibility Hazard in Region 5

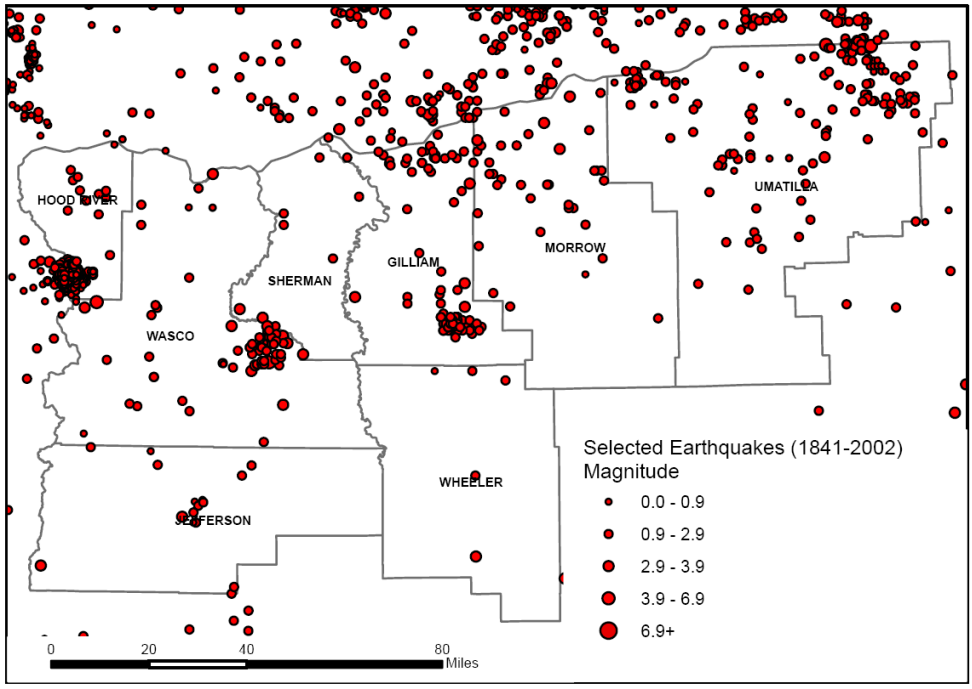


Source: Burns, 2007

Region 5 has experienced many earthquakes as shown in **Figure 2-233** and **Table 2-499**. Three historic earthquakes of significance that were centered in the region are the 1893 Umatilla, 1936 Milton-Freewater (M6), 1951 Hermiston, and 1976 Maupin area (M4.8), all shallow crustal earthquakes. There are faults in the region that have been active in the last 20,000 years. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area.

The map displays over 1,000 earthquakes that have been recorded in the region during the last century. Because the instrument network in the region was very sparse until the mid-2000s, it is likely that thousands of earthquakes have occurred in the region but were not recorded and thus do not appear on this map.

Figure 2-233. Selected Earthquakes in Region 5, 1841–2002



Source: Niewendorp and Neuhaus (2003)

Historic Earthquake Events

Table 2-499. Significant Earthquakes Affecting Region 5

Date	Location	Magnitude (M)	Comments
Approximate years: 1400 BCE, 1050 BCE, 600 BCE, 400, 750, 900	offshore, Cascadia subduction zone	probably 8-9	these are the midpoints of the age ranges for these six events
Jan. 26, 1700	offshore, Cascadia Subduction zone	about 9	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Nov. 23, 1873	near Brookings, Oregon, at the Oregon-California border	6.8	may have been an intraplate event because of lack of aftershocks; felt as far away as Portland and San Francisco
Mar. 1893	Umatilla, Oregon	VI-VII (Modified Mercalli Intensity)	damage: unknown
July 15, 1936	Milton-Freewater, Oregon	6.4	two foreshocks and many aftershocks felt; damage: $100,000 (in 1936 dollars)
Apr. 13, 1949	Olympia, Washington	7.1	fatalities: eight; damage: $25 million (in 1949 dollars); cracked plaster, other minor damage in northwest Oregon
Jan. 1951	Hermiston, Oregon	V (Modified Mercalli Intensity)	damage: unknown
Nov. 5, 1962	Portland, Oregon and Vancouver, Washington	5.5	shaking up to 30 seconds; chimneys cracked, windows broke, furniture moved
May- June 1968	Adel	5.1	Increased flow at a hot spring
Apr. 12, 1976	near Maupin, Oregon	4.8	sounds described as distant thunder, sonic booms, and strong wind
Apr. 25, 1992	Cape Mendocino, California	7.0	subduction earthquake at the triple-junction of the Cascadia subduction zone and the San Andreas and Mendocino faults
Mar. 25, 1993	Scotts Mill	5.6	center: Mount Angel-Gates Creek fault; damage: $30 million, including Molalla High School and Mount Angel church
Sep. 20, 1993	Klamath Falls	5.9 and 6.0	fatalities: two; damage: $10 million, including county courthouse; rockfalls

Note: No significant earthquakes have affected Region 5 since September 1993.

*BCE: Before Common Era.

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

Probability

Table 2-500. Local Probability Assessment of Earthquakes in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	L	VH	L	L	L	M

Source: DOGAMI, 2020

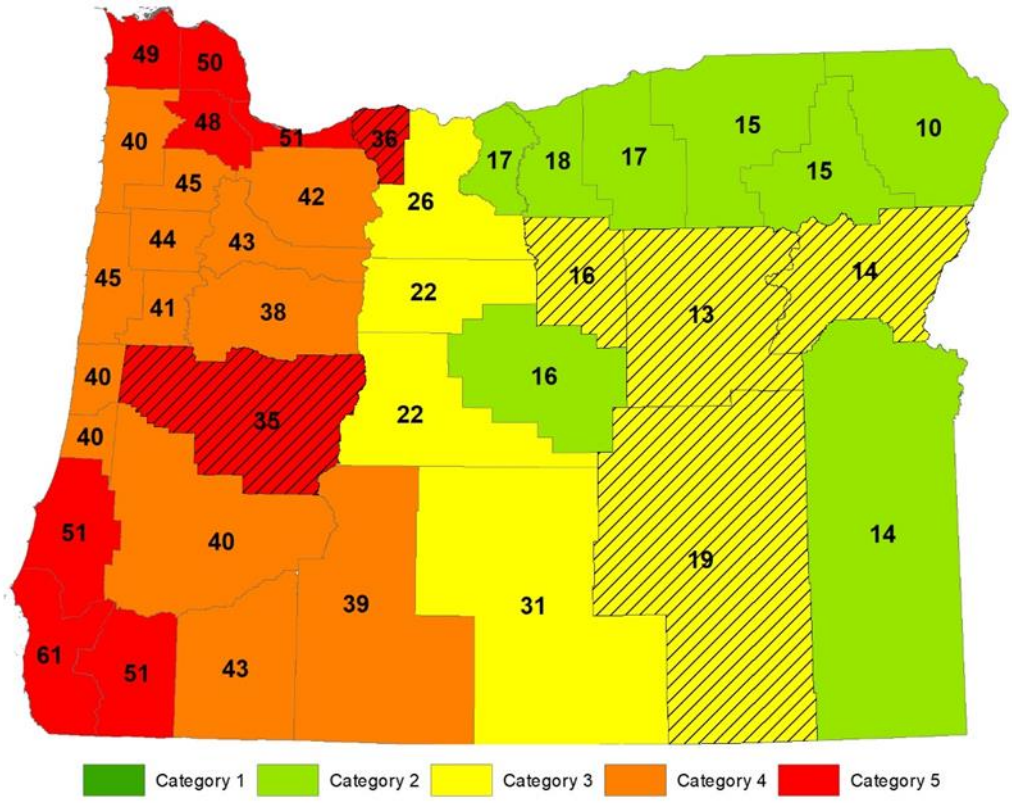
The probability of damaging earthquakes varies widely across the state. In Region 5, the hazard is dominated by local faults and background seismicity.

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

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

The probability levels for Baker, Grant, Harney, Hood River, and Wheeler Counties, and the non-coastal portion of Lane County were all increased in this way. The results of this ranking are shown in **Figure 2-234**.

Figure 2-234. 2020 Oregon Earthquake Probability Ranking Based on Mean County Value of the Probability of Damaging Shaking and Presence of Newly Discovered Faults



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

Source: DOGAMI, 2020

Vulnerability

Table 2-501. Local Assessment of Vulnerability to Earthquakes in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	M	L	M	M

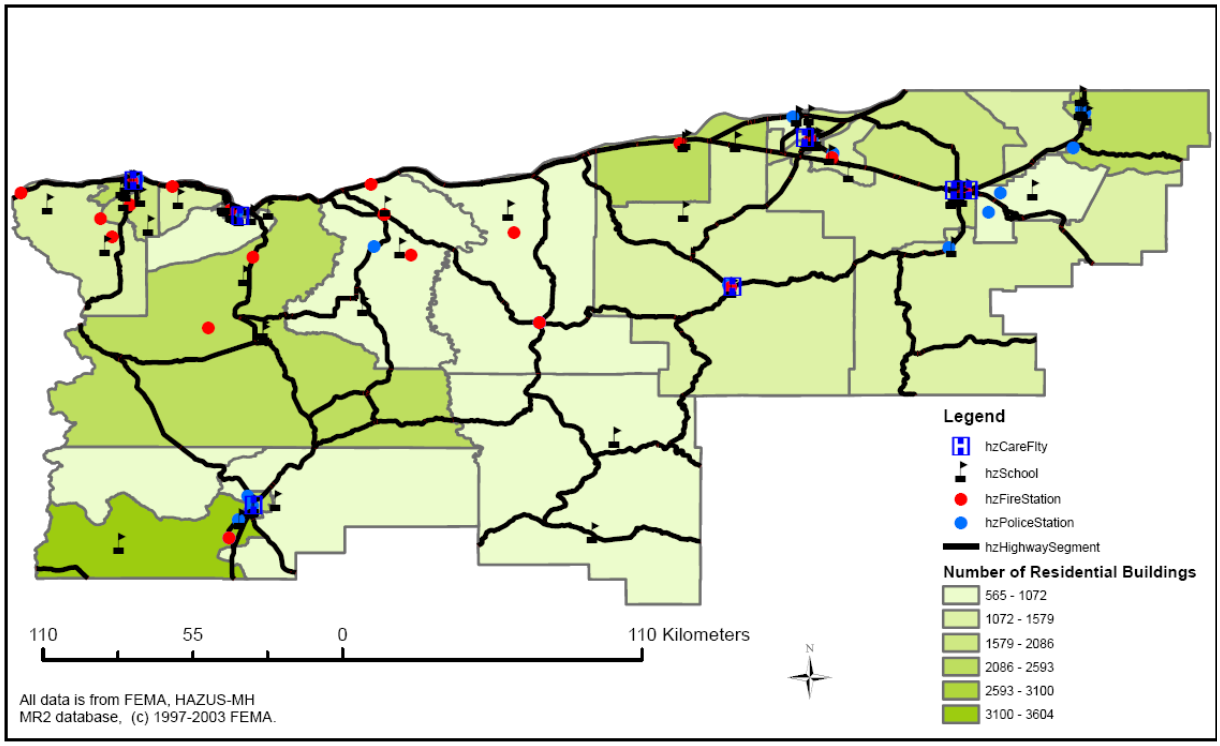
Source: Most recent local hazard vulnerability analyses (Table 2-4)

Table 2-502. State Assessment of Vulnerability to Earthquakes in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	VH	VH	VL	VH	H

Source: DOGAMI and DLCD, 2020

Figure 2-235. Region 5 Generalized Earthquake Hazard Exposure



Data are from Hazus-MH MR2 database.

Source: Burns (2007)

Most of the people and infrastructure are along the I-84 corridor, which runs along the northern portion of the region. This multimodal transportation corridor is vital to Oregon's economy and includes a major interstate highway (I-84); two transcontinental rail lines, Union Pacific and Burlington Northern Santa Fe; the Columbia River inland water navigation; major electric power and gas lines; and communication conduits. Roughly $14 billion worth of goods are carried

through the corridor each year (Wang & Chaker, 2004). **Figure 2-236** displays the general exposure of the region.

The geographic size of the region is roughly 13,700 square miles and contains 36 census tracts. There are over 54,000 households in the region and it has a total population of over 150,000 people (FEMA, 2006). There are an estimated 52,000 buildings in the region with a total building replacement value (excluding contents) of $8.5 billion. Approximately 99% of the buildings (and 84% of the building value) are associated with residential housing. The replacement values of the transportation system and utility lifeline systems are estimated to be approximately $16.5 billion and $4.8 billion, respectively.

Table 2-503 shows the number of school and emergency response buildings surveyed in each county and their respective rankings.

Table 2-503. School and Emergency Response Buildings Collapse Potential in Region 5

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100%)
Gilliam	4	2	5	4
Hood River	18	14	7	13
Morrow	11	10	7	5
Sherman	5	4	3	—
Umatilla	40	24	46	16
Wasco	23	7	10	—

Source: DOGAMI 2007. Open-File Report 07-02, Statewide Seismic Needs Assessment Using Rapid Visual Assessment.

As mentioned in the State Risk Assessment, DOGAMI developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) a M6.5 Arbitrary Crustal event and (b) a 2,500 year mean return period probabilistic earthquake scenario (2,500-year Model). Both models are based on Hazus-MH, a computer program currently used by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The arbitrary crustal event is based on a potential M6.5 earthquake generated from an arbitrarily chosen fault using the Hazus software, and assuming a worst-case scenario. The 2,500-year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults, each with a 2% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single “average” earthquake during this time.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models do provide some approximate estimates of damage. Results are found in **Table 2-504**, **Table 2-505**, and **Table 2-506.**

Table 2-504. Total Building, Transportation, and Utility Exposure and Potential Losses in Region 5 from a 2,500-Year-Return Interval Ground Motion

Region 5 Counties	Building Exposure	Transportation Exposure	Utility Exposure	Total Exposure
Gilliam	$148,000,000	$1,777,000,000	$153,000,000	$2,078,000,000
Hood River	$1,282,000,000	$1,413,000,000	$702,000,000	$3,397,000,000
Jefferson	$1,009,000,000	$1,185,800,000	$405,910,000	$2,600,710,000
Morrow	$517,000,000	$1,592,600,000	$740,040,000	$2,849,640,000
Sherman	$124,000,000	$1,299,700,000	$117,520,000	$1,541,220,000
Umatilla	$3,837,000,000	$4,956,900,000	$1,390,340,000	$10,184,240,000
Wasco	$1,513,000,000	$3,305,400,000	$1,162,950,000	$5,981,350,000
Region Total	**$8,430,000,000**	**$15,530,400,000**	**$4,671,760,000**	**$28,632,160,000**

	Building Losses	Transportation Losses	Utility Losses	Total Losses	Loss % of Total
Gilliam	$6,300,000	$12,700,000	$6,040,000	$25,040,000	1.2%
Hood River	$153,510,000	$85,900,000	$102,990,000	$342,400,000	10.1%
Jefferson	$54,580,000	$15,600,000	$16,790,000	$86,970,000	3.3%
Morrow	$178,540,000	$49,300,000	$106,800,000	$334,640,000	11.7%
Sherman	$5,600,000	$45,300,000	$5,810,000	$56,710,000	3.7%
Umatilla	$736,640,000	$200,600,000	$135,480,000	$1,072,720,000	10.5%
Wasco	$191,010,000	$82,400,000	$116,890,000	$390,300,000	6.5%
Region Total	**$1,326,180,000**	**$491,800,000**	**$490,800,000**	**$2,308,780,000**	**8.0%**

Source: W. J. Burns, 2007, unpublished report: Hazards, Earthquake and Landslide Hazard Maps, and Future Earthquake Damage and Loss Estimates for Seven Counties in the Mid-Columbia River Gorge Region Including Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Jefferson, and Wheeler

Table 2-505. Estimated Losses in Region 5 Associated with an Arbitrary M6.5 Crustal Event

	Region 5 Counties					
	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Injuries (5 pm time frame)	3	120	126	4	208	220
Deaths (5 pm time frame)	0	6	7	0	10	13
Displaced households	3	419	521	6	1,048	720
Economic Losses for buildings	$9.21 mil	$189.96 mil	$109.9 mil	$8.4 mil	$248.68 mil	$307.09 mil
Operational the day after the event:						
Fire stations	100%	60%	50%	0%	75%	50%
Police stations	100%	0%	100%	0%	79%	0%
Schools	100%	21%	43%	33%	88%	27%
Bridges	100%	100%	100%	88%	99%	98%
Economic losses to infrastructure:						
Highways	$0.1 mil	$37.2 mil	$43.5 mil	$33.1 mil	$77 mil	$35.5 mil
Airports	$3.2 mil	$7.3 mil	$1.7 mil	$2 mil	$16.5 mil	$13.3 mil
Communications	0	$0.08 mil	0	0	$0.05 mil	$0.08 mil
Debris generated (million tons)	0	0	0	0	0	0

Source: W. J. Burns, 2007, DOGAMI unpublished report: Geologic hazards, earthquake and landslide hazard maps, and future earthquake damage and loss estimates for seven counties in the Mid-Columbia River Gorge Region including Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Jefferson, and Wheeler

Table 2-506. Estimated Losses in Region 5 Associated with a 2,500-Year Probable M6.5 Driving Scenario

	Region 5 Counties					
	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Injuries (5 pm time frame)	2	111	164	2	623	136
Deaths (5 pm time frame)	0	6	8	0	32	8
Displaced households	0	303	768	1	2,957	373
Economic Losses for buildings	$6.3 mil	$153.51 mil	$178.54 mil	$5.68 mil	$736.64 mil	$191.01 mil
Operational the day after the event:						
Fire stations	100%	20%	0%	66%	25%	75%
Police stations	100%	100%	50%	100%	21%	67%
Schools	100%	14%	14%	100%	28%	33%
Bridges	100%	82%	100%	76%	93%	96%
Economic losses to infrastructure:						
Highways	$6.3 mil	$71.9 mil	$36.4 mil	$42.2 mil	$173.8 mil	$63.1 mil
Airports	$5.7 mil	$7.6 mil	$5.2 mil	$1.8 mil	$19.7 mil	$15.8 mil
Communications	$0	$0.05 mil	$0	$0	$ 0.24 mil	$0.05 mil
Debris generated (million tons)	0	0	0	0	0	0

Source: W. J. Burns, 2007, DOGAMI unpublished report: Geologic hazards, earthquake and landslide hazard maps, and future earthquake damage and loss estimates for seven counties in the Mid-Columbia River Gorge Region including Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Jefferson, and Wheeler

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

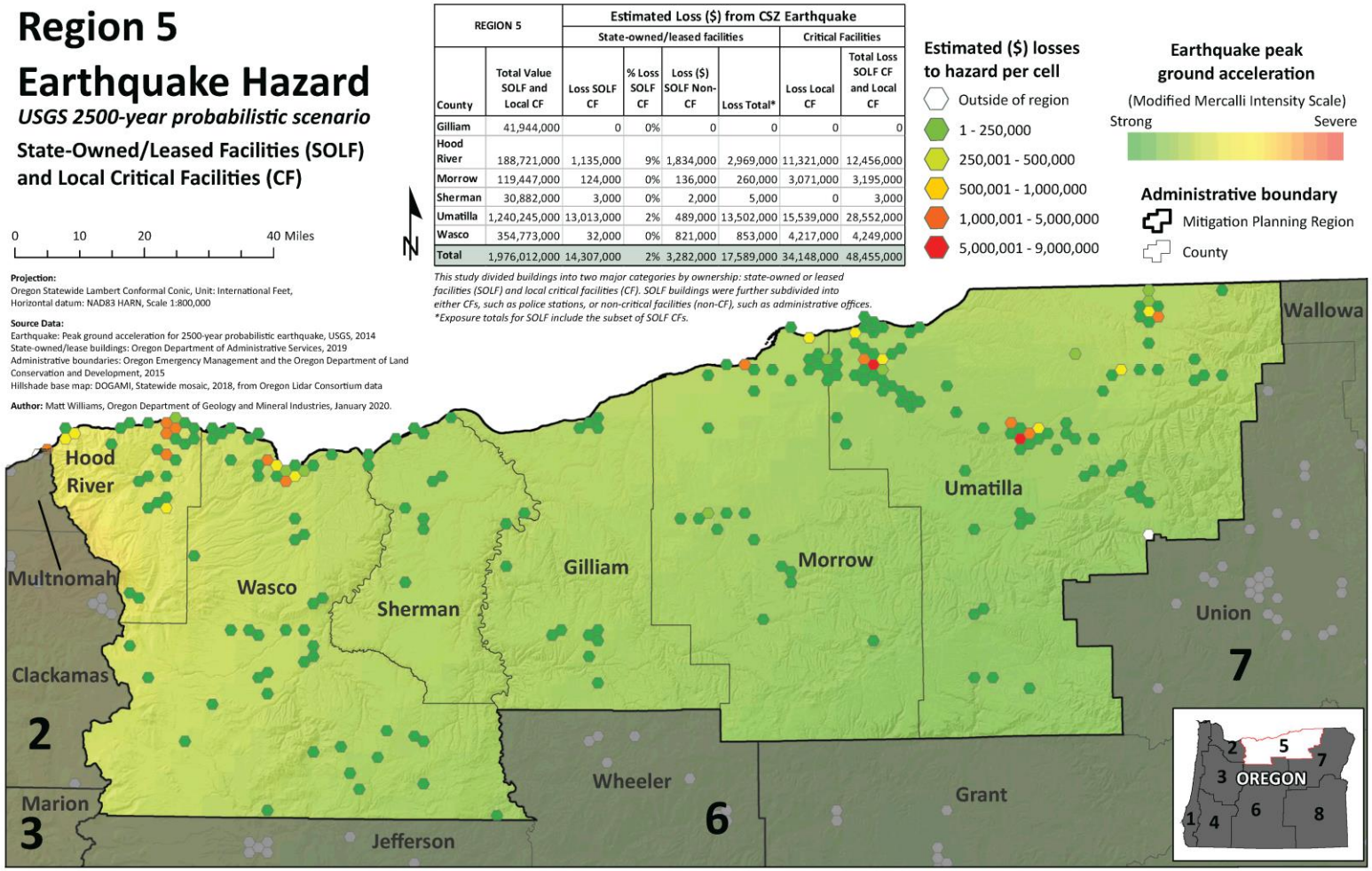
For the 2020 vulnerability assessment, DOGAMI used Hazus-MH to estimate potential loss from a 2500-year probabilistic earthquake scenario in Region 5. The analysis incorporated information about the earthquake scenario (such as coseismic liquefaction and landslide potential), as well as building characteristics (including the seismic building code and building material). The results of the analyses are provided as a loss estimation (the building damage in dollars) and as a loss ratio (the loss estimation divided by the total value of the building) reported as a percentage at the county level.

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

In Region 5, a 2500-year probabilistic earthquake scenario could cause a potential loss of over $17.5M in state building and critical facility assets, 77% of it in Umatilla County alone. The potential loss in local critical facilities is about double, over $34M. Almost half (46%) of the potential loss in local critical facilities is in Umatilla County, and 33% in Hood River County.

Figure 2-236 illustrates the potential loss to state buildings and critical facilities and local critical facilities from a 2500-year probabilistic earthquake scenario.

Figure 2-236. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in an Earthquake Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Estimated Loss ($) from CSZ Earthquake					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Loss SOLF CF	% Loss SOLF CF	Loss ($) SOLF Non-CF	Loss Total*	Loss Local CF	Total Loss SOLF CF and Local CF
Gilliam	41,944,000	0	0%	0	0	0	0
Hood River	188,721,000	1,135,000	9%	1,834,000	2,969,000	11,321,000	12,456,000
Morrow	119,447,000	124,000	0%	136,000	260,000	3,071,000	3,195,000
Sherman	30,882,000	3,000	0%	2,000	5,000	0	3,000
Umatilla	1,240,245,000	13,013,000	2%	489,000	13,502,000	15,539,000	28,552,000
Wasco	354,773,000	32,000	0%	821,000	853,000	4,217,000	4,249,000
Total	1,976,012,000	14,307,000	2%	3,282,000	17,589,000	34,148,000	48,455,000

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

Source: DOGAMI

Historic Resources

Of the 2, 456 historic resources in Region 5, only 72 are in an area of high or very high liquefaction potential. Seventy of the 72 are in Umatilla County. However, 1,764 (72%) of Region 5's historic resources are located in areas of high or very high potential for ground shaking amplification. Most of those are located Hood River County followed by Umatilla County.

Archaeological Resources

Two thousand five hundred twenty archaeological resources are located in earthquake hazard areas in Region 5. Only 13 are located in an area of high earthquake hazards, and only one of them is listed on the National Register of Historic Places. The other twelve have not been evaluated as to their potential for listing. Most archaeological resources in earthquake hazard areas in Region 5 are located in Wasco County, followed by Umatilla and Gilliam Counties.

Social Vulnerability

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5. Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income. Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger. Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters. Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma. Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Hood River, Morrow, and Umatilla Counties are very highly vulnerable to earthquake hazards. Wasco County is highly vulnerable. Gilliam and Sherman Counties have very low vulnerability.

Seismic Lifelines

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

Transportation Lifeline Vulnerabilities, and the full report can be accessed at Appendix **9.1.16**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification* (OSLR). According to that report, seismic lifelines in Region 5 have the following vulnerabilities.

The following geographic zones identified in the OSLR are located within Region 5:

- Cascades Geographic Zone: OEM Mitigation Planning Region 5 is located in part within the OSLR Cascades Geographic Zone. Two crossings of the Cascades from western to central Oregon are partly within this zone and connect the highly seismically impacted western portion of the state to the less seismically impacted central portion of the state. The area contains one Tier 1 route: I-84. It also contains part of the Tier 2 route: OR-212 and US-26.
- Central Geographic Zone: Region 5 also encompasses the northerly part of the Central Geographic Zone, which contains Tier 1 routes I-84 from The Dalles to Biggs Junction and US-97. These roadways are subject to rockfall risks in several areas. There are no Tier 2 routes in this region, and one Tier 3 corridor: the north end of US-197.

REGIONAL IMPACT.

- Ground shaking: Ground shaking damage from a CSZ event is not expected to be significant in Region 5.
- Landslides and rockfall: Landslide and rockfall damage are not anticipated to be activated by a CSZ event in Region 5.
- Liquefaction: Structures in wetland, alluvial, and other saturated areas may be subject to liquefaction damage, particularly in areas associated with the Columbia River near the western end of Region 5.
- Other: Damage to shipping channels and shore facilities, and failure of Columbia River bridges west of Region 5 may have long-term impacts on freight shipments into and out of Region 5.

REGIONAL LOSS ESTIMATES. The highway-related losses include disconnection from supplies and replacement inventory, and the loss of tourists and other customers who must travel to do business with affected businesses.

MOST VULNERABLE JURISDICTIONS. Gilliam, Hood River, Morrow, Sherman, Umatilla and Wasco Counties have similar, relatively low vulnerability to ground shaking from a CSZ event. However, connections to markets and services will likely be disrupted due to the vulnerability of river transportation, ports, and surface routes to freight intermodal connections in the Portland Metro area.

Risk

Table 2-507. Assessment of Earthquake Risk in Region 5

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

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the earthquake probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Hood River is at greatest risk from earthquakes in Region 5 followed by Morrow, Umatilla, and Wasco Counties.

Extreme Heat

Characteristics

Extreme temperatures are common in Region 5 and the frequency of prolonged periods of high temperatures has increased. Pendleton has an average of about 31 days per year above 90°F. Extreme heat can affect commerce, agriculture, fisheries, and overall quality of life.

Historic Extreme Heat Events

Table 2-508. Historic Extreme Heat Events in Region 5

Date	Location	Notes
July 10–14, 2002	Region 5–7	A record breaking heat wave shattered many daily record high temperatures across the state, with a few locations breaking all-time records.
June 24–26, 2006	Region 1–3, 5	A broad upper ridge of unusually high height coupled with a thermally induced surface trough of low pressure lingered over the Pacific Northwest for several days. This pattern resulted in persistent offshore flow, and therefore many days of record-smashing high temperatures. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row.
July 20-24, 2006	Region 1–3, 5, 7	An unusually strong ridge of high pressure brought several days of record breaking hot and humid weather to NW Oregon. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row. Many daily maximums were between 10 and 20 degrees above normal. A few sites reported record high minimum temperatures during this very humid event; a couple broke all-time record high minimums as well. 4500 homes lost power during this event. In north central and eastern Oregon, daily maximum temperatures between 100 and 113 degrees were observed at lower elevations, with temperatures 90 to 100 degrees at elevations up to 4000 feet. Several people were treated for heat related illness.
June 28–30, 2008	Region 2, 3, 5, 7	An upper level ridge and thermal trough across the Pacific Northwest produced temperatures above 100 degrees for two consecutive days breaking records in many locations. Two people died of heat-related illness.
August 15–17, 2008	Region 5–7	Excessive Heat Event: An upper level ridge and dry air brought excessive heat into eastern Oregon. Many locations experienced multiple days of at least 100 degree temperatures.
July 25–26, 2010	Region 5, 7	Excessive Heat Event: Temperatures topped 100 degrees for two successive days in Hermiston, Pendleton, 5 miles northeast of Pendleton, Ione, Echo, Arlington, and Umatilla.
August 1, 2011	Region 5	A dry weak westerly flow aloft under a broad upper level high pressure system combined with a surface thermal trough to bring several days of temperatures in the 90s.

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

Probability

The relative probability of extreme heat was determined by dividing the counties by quintiles based on historic and projected future frequency of days with heat index above 90°F (as shown in **Figure 2-62**). Counties in the bottom quintile had the lowest frequency of days with heat index above 90°F relative to the rest of the state and were given a score of 1 meaning "very low." Region 5 relative probability rankings are shown in **Table 2-509**. Extreme heat frequency relative to the rest of the state is very high, highest in the state. Hood River County is an exception here in that it is climatically similar to Region 2.

Table 2-509. Probability of Extreme Heat in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	VH	VL	VH	VH	VH	VH

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

Climate Change

It is *extremely likely* (>95%) that the frequency and severity of extreme heat events will increase over the next several decades across Oregon due to human-induced climate warming (*very high confidence*). Region 5 experiences some of the hottest temperatures in the state and is projected to experience greater frequency of extreme temperatures under future climate change. **Table 2-510** lists the number of days exceeding the heat index of 90°F in the historical baseline and future mid-21st century period under RCP 8.5 for counties in Region 5.

Table 2-510. Annual Number of Days Exceeding Heat Index ≥ 90°F for Region 5 Counties

County	Historic Baseline	2050s Future
Gilliam	14	43
Hood River	2	12
Morrow	12	38
Sherman	13	42
Umatilla	10	35
Wasco	9	34

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

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

Vulnerability

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

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

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

Because extreme heat is common in Region 5 ("high" probability), many people are accustomed or prepared in terms of air conditioning when an extreme heat event occurs ("high" adaptive capacity). In Cooling Zone 3, which includes Wasco and Umatilla counties, 91% of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf). In Cooling Zones 1 and 2, which includes Hood River, Sherman, Gilliam, and Morrow counties, just over half of single-family homes have air-conditioning (https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf).

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

Table 2-511 displays the total vulnerability rankings as well as ranking for sensitivity and adaptive capacity for each county in NHMP Region 5. **Table 2-512** provides the summary descriptors of Region 5's vulnerability.

Combining sensitivity and adaptive capacity, Region 5's relative vulnerability to extreme heat is "Moderate". With high relative vulnerability, Morrow County is the most vulnerable to extreme heat in Region 5.

Table 2-511. Relative Vulnerability Rankings for Region 5 Counties

County	Sensitivity	Adaptive Capacity	Vulnerability
Region 5	**3**	**2**	**3**
Gilliam	1	3	2
Hood River	3	3	3
Morrow	5	3	4
Sherman	1	3	2
Umatilla	5	1	3
Wasco	5	1	3

Source: Oregon Climate Change Research Institute

Table 2-512. State Assessment of Vulnerability to Extreme Heat in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	L	M	H	L	M	M

Source: Oregon Climate Change Research Institute

Region 5 counties did not rank vulnerability to extreme heat.

As with drought, prolonged elevated temperatures pose risks to agriculture, involving the health and welfare of farmers and other farm workers, crops and livestock. In hotter conditions, crops, livestock and humans require more water. For example, on average, for each degree Fahrenheit increase in temperature, plants use 2.5% - 5% more water. High temperature and insufficient water stunt plant growth and cause areas of crops to wither. Some livestock, especially dairy cattle, are also sensitive to heat. Milk production decreases and susceptibility to death increases during and for some time after a heat wave. Since risks to human health and welfare are also elevated during heat waves, Oregon and the federal government have regulations and guidelines to help prevent injury to those who work on farms.

Like drought, impacts of extreme heat on state-owned facilities related to agriculture may include impacts to research conducted in outdoor settings, such as at extension stations and research farms. However, the appropriate data are not available to assess impacts of heat waves on agriculture and subsequent effects on the state economy.

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

The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to extreme heat. The value of locally owned critical facilities is $1,080,652,000. Because extreme heat could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to extreme heat. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 5 since the beginning of 2015. Nevertheless, none of the recorded losses was due to extreme heat.

Risk

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

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

Table 2-513 displays the relative risk ranking as well as rankings for probability and vulnerability for each county in NHMP Region 5. Table 2-514 provides the summary descriptors of Region 5's risk to extreme heat.

Combining probability and vulnerability, Region 5's relative risk to extreme heat is "High." Morrow County's relative risk is "Very High."

Table 2-513. Risk Rankings for Region 5 Counties

County	Probability	Vulnerability	Risk
Region 5	**4**	**3**	**4**
Gilliam	5	2	4
Hood River	1	3	2
Morrow	5	4	5
Sherman	5	2	4
Umatilla	5	3	4
Wasco	5	3	4

Source: Oregon Climate Change Research Institute

Table 2-514. Risk of Extreme Heat in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	H	L	VH	H	H	H

Source: Oregon Climate Change Research Institute

Floods

Characteristics

Region 5 is subject to a variety of flood conditions. The most common type of flooding is associated with unseasonably warm weather during the winter months, which can quickly melt snow. This condition has produced devastating floods throughout the region. Flash floods, another type of flooding experienced in the region, are almost always a summer phenomenon associated with intense local thunderstorms. The flash flood of June 1903 in the City of Heppner (Morrow County) is a benchmark event. No flood in Oregon has been more lethal: 247 fatalities. Heppner's vulnerability to flash flood hazards has since been reduced through the construction of the Willow Creek Dam. The region's other flood events are linked to normal seasonal snowmelt and runoff from agricultural fields.

There are several rivers in the region that produce natural extreme flood conditions. Surprisingly, the Columbia is not one of them, nor is the lower Deschutes or the John Day. The Columbia is regulated by up-stream dams. A swollen Columbia River, however, can back up tributary streams to the point where they constitute a significant hazard. This has occurred on a number of occasions. The lower Deschutes and John Day are confined to fairly deep canyons with small floodplains. Consequently, they do not present the flood problems associated with smaller rivers, such as the Umatilla, the Walla Walla, and their tributaries.

The Federal Emergency Management Agency (FEMA) has mapped most flood-prone streams in Oregon. The maps depict the 1% flood (100-year) upon which the National Flood Insurance Program is based. All of the Region 5 counties have Flood Insurance Rate Maps (FIRM); however, some of the maps are old and could be outdated. The FIRM maps were issued at the following times:

- Gilliam, September 24, 1984;
- Hood River, September 24, 1984;
- Morrow, December 18, 2007;
- Sherman, September 24, 1984;
- Umatilla, September 2010; and
- Wasco, September 24, 1984.

Updates to FIRMS using high definition LiDAR are underway for Wasco, Sherman and Hood River counties through the Middle Columbia Hood Watershed Risk MAP project.

Historic Flood Events

Table 2-515. Significant Historic Floods Affecting Region 5

Date	Location	Description	Type of Flood
June 1894	main stem Columbia River (Region 5 communities)	largest flood observed on the Columbia River (1,200,000 cfs); City of Umatilla inundated; widespread damage	snow melt
June 1903	Morrow County (Willow Creek)	very devastating flash flood; 40-ft wall of water in City of Heppner; 247 fatalities; 141 homes destroyed	flash flood
Jan. 1923	Mid-Columbia region	widespread flooding; unusually warm weather, intense rain	rain on snow

Date	Location	Description	Type of Flood
Jan. 1933	Mid-Columbia region	widespread flooding; heavy mountain snowpack followed by rain and mild temperatures	rain on snow
Dec. 1955	Mid-Columbia region	mild temperatures and rain; farms, highways flooded	rain on snow
Dec. 1964	entire state	record-breaking floods throughout state; heavy snow in mountains followed by intense rain; considerable flood damage	rain on snow
July 1965	Lane/Spears Canyons (Umatilla County)	thunderstorm; 8–10 ft wall of water from canyon; considerable damage; one fatality; several people injured	flash flood
Dec. 1980	Polallie Creek (Hood River County)	debris flow from vicinity of Mount Hood; debris dam formed a small lake that was later breeched; damage to highways and utilities	debris flow
Feb. 1985	Umatilla County	warm rain on snow at higher elevations; flooding throughout county	rain on snow
Feb. 1986	entire state	warm rain on snow; widespread flooding; considerable damage	rain on snow
May 1998	central and eastern Oregon	widespread flooding; rain melting mountain snow	rain on snow
Aug. 2003	Gilliam County	$7,000 in property damage	
Aug. 2003	Sherman County	Flash flood (Gerking Canyon) *excerpted from State Plan, 2006	flash flood
Apr. 2005	Morrow County	$2,000 in property damage	
Apr. 2005	Umatilla County	$170,000 in property damage	
Mar. 2006	Morrow County	flash flood from a collapsed irrigation dike embankment floods the south side of I-84 near Boardman, closing down the road	flash flood
Nov. 2006	Hood River County	Hood River near the City of Hood River caused extensive damage on OR-35 closing the highway for a month; moderate damage done to irrigation works; total $30 million in damage	riverine
May/June 2011	Morrow County	intense rainfall in the Heppner and Lexington areas resulting in damage to roads, bridges, and the Morrow County Fairgrounds; total of $164,000 in damage	flash flood
June 2011	Heppner	persistent showers with heavy rainfall of 1 to 2 inches produced flooding on Willow and Hinton Creeks; flash flooding on Hinton and Willow Creeks damaged roads, bridges, and the Morrow County Fairgrounds; the Heppner elementary school was evacuated as a precaution	flash flood

Date	Location	Description	Type of Flood
Jan. 2012	Columbia, Hood River, Tillamook, Polk, Marion, Yamhill, Lincoln, Benton, Linn, Lane, Douglas, Coos, and Curry Counties	heavy rain and wind; ice (DR-4055); flooding in the Willamette Valley; 130 homes and seven businesses were damaged in the City of Turner; 21 streets were closed in the City of Salem; the state Motor Pool lost 150 vehicles and thousands of gallons of fuel; Thomas Creek in the City of Scio overtopped, damaging several buildings	winter storm
March 2014	Union, Umatilla, and Grant Counties	Heavy rain fell across much of the northern Blue Mountains and Wallowa County throughout the first week of March. March 9th received very heavy rain with snow levels around 6000ft. This allowed for a significant increase in runoff, which lead to a quick rise in rivers for the period	rain on snow
Dec. 2015	Tillamook, Lincoln, Washington, Clackamas, Multnomah, Lane, Columbia, Hood River, Polk, Coos, Douglas, Jackson and Curry Counties	A moist pacific front produced heavy rainfall across Northwest Oregon which resulted in river flooding, urban flooding, small stream flooding, landslides, and a few sink holes. After a wet week (December 5 through Dec 11), several rivers were near bank full ahead of another front on December 12th. Flooding from the Nehalem River and Rock Creek in Vernonia resulted in evacuation of homes and the implementation of the Vernonia Emergency Command Center. Heavy rain resulted in a land slide that closed OR47 at mile marker 8. More than $15 million dollars in property damage reported in these counties combined.	winter storm
March 2017	Malheur, Harney, Wallowa, Umatilla and Wheeler Counties	An extended period of snow melt, combined with a period of heavy rain, caused an extended period of flooding along portions of the John Day River, the Umatilla and the Silvies Rivers. Flooding occurred on the Snake River near Ontario.	rain on snow
June 2017	Umatilla County	In Pendleton, the heavy rain caused several small debris flows along Airport Road and several intersections were flooding with water about 5 to 6 inches deep. Rainfall amounts include 1.54 inches of rain at the NWS office at the Pendleton Airport, with 0.88 inch falling in 30 minutes.	riverine
Feb. 2018	Umatilla County	Two to three inches of rain fell along the west slopes of the Blue Mountains from February 1st through 4th. The increased runoff caused high water levels and minor flooding along the Umatilla and Walla Walla Rivers.	Feb. 2018
Oct. 2018	Morrow County	Moist upslope flow into the Blue Mountains produced heavy rain with rainfall rates of up to one inch per hour and storm total accumulations between one and three inches. Localized flooding was reported near the town of Heppner where water inside a residence forced an evacuation.	riverine
April 2019	Union, Grant, Umatilla, Wallowa and Wheeler Counties	DR-4452. Grant, Umatilla, and Wheeler Counties declared. Snow water equivalents near 200% of normal in the Blue Mountains coupled with warm temperatures and near record rainfall totals for April produced significant river flooding across eastern Oregon.	rain on snow
Aug. 2019	Crook and Wasco Counties	A powerful upper storm system combined with modest low and mid-level moisture to yield scattered strong to severe storms and flash flooding. Storms developed first across the higher terrain of central Oregon nearer the Cascades and adjacent Ochoco mountains. Storms then built northward with hail and damaging winds along the way.	flash flooding
Feb. 2020	Umatilla, Union, Wallowa	DR-4519: severe storms, flooding, landslides, and mudslides	

Sources: Taylor and Hatton (1999); Hazards and Vulnerability Research Institute (2007); The Spatial Hazard Events and Losses Database for the United States, version 5.1 [online database]. Columbia, SC: University of South Carolina, available from http://www.sheldus.org; State Interagency Hazard Mitigation Team (2006). National Climatic Data Center, Storm Events, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

Table 2-516. Principal Flood Sources by County in Region 5

Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Columbia River Thirty Mile Creek	Columbia River Hood River Indian Creek	Columbia River Hinton Creek Little Blackhorse Canyon Creek Shobe Creek Willow Creek Rhea Creek	Columbia River	Columbia River Birch Creek McKay Creek Mill Creek Patawa Creek Stage Gulch Tutuilla Creek Umatilla River Walla Walla River Waterman Gulch Pine Creek Greasewood Creek	Columbia River Spanish Hollow Creek Fifteen Mile Creek Mosier Creek

Source: FEMA Flood Insurance Studies for Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties

Probability, Vulnerability, and Risk

Different methods are used to assess probability and vulnerability at local and state levels. These methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. A description of the "OEM Hazard Analysis Methodology" used by local governments is provided in Section 2.1, **Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in Appendix **9.1.19**.

Probability

Local Assessment

Based on the OEM hazard analysis conducted by county emergency program managers during the development of recent county NHMPs, the probability as estimated by participants in these county NHMPs that Region 5 will experience flooding is shown in **Table 2-517**.

Table 2-517. Local Assessment of Flood Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	M	M	H	L	M	M

Source: Gilliam County MJNHMP (2018) p. 2-30; Hood River MJNHMP (2018) p. 2-23; Morrow County MJNHMP (2016); Pt.1, p. 34; Sherman County MJNHMP (2018) p.3-28; Umatilla County NHMP (2014) p.102; Wasco County MJNHMP (2018 p. 2-25

State Assessment

Using the methodology described in the Section 2.2.7.1, Floods/Probability, the state assessed the probability of flooding in the counties that comprise Region 3. The results are shown in Table xx.

Table 2-518. State Assessment of Flood Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	H	H	H	H	H

Source: DOGAMI

Climate Change

It is very likely (>90%) that Oregon will experience an increase in the frequency of extreme precipitation events and extreme river flows (high confidence). The likelihood of increase in extreme precipitation events is greater east of Cascades than west. Extreme river flow, while affected by extreme precipitation, is also driven by antecedent conditions (soil moisture, water table height), snowmelt, river network morphology, and spatial variability in precipitation and snowmelt. Most projections of extreme river flows show increases in flow magnitude at most locations across Oregon. Overall, it is more likely than not (>50%) that increases in extreme river flows will lead to an increase in the incidence and magnitude of damaging floods (low confidence), although this depends on local conditions (site-dependent river channel and floodplain hydraulics). Increases in extreme river flows leading to damaging floods will be less likely where storm water management (urban) and/or reservoir operations (river) have capacity to offset increases in flood peak.

Vulnerability

Table 2-519. Local Assessment of Vulnerability to Flood in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	L	M	M	M	M

Source: Oregon Gilliam County MJNHMP (2018) p. 2-37; Hood River MJNHMP (2018) p. 2-23; Morrow County MJNHMP (2016); Pt.1, p. 34; Sherman County MJNHMP (2018) p.3-43; Umatilla County NHMP (2014) p.102; Wasco County MJNHMP (2018 p. 2-25

Table 2-520. State Assessment of Vulnerability to Flood in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	L	VH	L	H	H

Source: Oregon Gilliam County MJNHMP (2018) p. 2-37; Hood River MJNHMP (2018) p. 2-23; Morrow County MJNHMP (2016); Pt.1, p. 34; Sherman County MJNHMP (2018) p.3-43; Umatilla County NHMP (2014) p.102; Wasco County MJNHMP (2018 p. 2-25

A flood loss analysis was performed by DOGAMI in Wasco County by overlaying building locations on the 100-year flood extent. This analysis showed that of 18,481 buildings, 1,999 buildings are at risk of flood loss in Wasco County potentially displacing 2,115 people.

Digitized FIRM data was not available for the other counties in the region and therefore, did not allow meaningful flood loss analysis. DOGAMI has utilized more detailed flood mapping data to develop depth grids for other flood zones in the state. In combination with detailed information on structure elevation, this data allows the calculation of potential flood losses, and also an estimate of the number of residents that might not have access to evacuation routes due to surrounding water.

Critical facilities

The DOGAMI Risk Assessment and flood loss analysis for Wasco County found that 5 critical facilities in that county are at risk of flood damage.

Absent a flood loss analysis performed using depth grids in the Special Flood Hazard Area, vulnerability of critical infrastructure was assessed by local NHMP steering committees. Steering committee members catalogued critical facilities in Sherman, Umatilla, Gilliam, Hood River and Morrow Counties and rated the anticipated risk to each critical facility posed by the range of hazards considered in the NHMPs.

In Sherman County during the 2018 NHMP update, the steering committee catalogued 42 critical facilities, 19 of which are vulnerable to flooding. These include Sherman Elementary School, Sherman Jr/High School, John Day Dam, Sherman County Medical Clinic, Sherman County Ambulance Sherman County Emergency Management office, City of Grass Valley City Hall and city water supply infrastructure, South Sherman Fire Dept and the City of Moro Fire Department, North Sherman Rufus Fire Station, and Moro Rural Fire Department, Moro, Wasco and Rufus Wastewater Treatment plants, Rufus City Hall and Fire Station, Wasco Water Supply and the Wasco State Airport.

In Umatilla County, 7 critical facilities were named as being at risk of impact from flooding. These include the McKay Reservoir, McNary Dam and Three Mill Dam, Stanfield Sewer Facility, the County Road Department and the Port of Umatilla docks.

In Gilliam County 27 critical facilities were listed by participants in the NHMP, 11 of which were believed to be at risk of flood damage These include a number of bridges, the Union Pacific Rail line, I-84, route 206, and 97, Arlington Medical Clinic, Condon and Arlington wastewater treatment facilities and Water system, the Lonerock Community Hall, Fire station/outpost and the water system.

In Hood River County, the NHMP Steering Committee catalogued vulnerabilities in the areas of population, economy, land development and environment. A number of vulnerable assets were identified in this manner including the Odell Creek chemical storage facility on Odell Highway, the Waste water facilities near Odell and Columbia River, and local, state and national park lands. Cascade Locks the Fire Station is located in the floodplain.

In Morrow County, the City of Heppner Annex notes that the Elementary School was evacuated during the May 2011 flood event and that the Lexington City Hall was relocated with FEMA funds prior to the update. No other critical facilities were mentioned in the 2016 Morrow County NHMP.

Region 5 is exposed to flood hazards, but is less vulnerable to flood damage than other regions.

Among the most vulnerable assets of Region 5 are elements of the transportation and utility infrastructure. Most of the people and infrastructure are along the I-84 corridor, which runs along the northern portion of the region. This multimodal transportation corridor is vital to Oregon's economy and includes a major interstate highway (I-84); two transcontinental rail lines, Union Pacific and Burlington Northern Santa Fe; the Columbia River inland water navigation; major electric power and gas lines; and communication conduits. Roughly $14 billion worth of goods are carried through the corridor each year (Wang & Chaker, 2004).

The vulnerability from the hazard can be examined through the spatial relationship of the percent of a city's total area versus the percent of the city's area within the 100 year flood zone. Four of the top 10 cities in Oregon examined using this metric are located in Region 5: Helix, Ione, Adams, and Athena. This indicates that damaging floods are indeed possible in developed areas of the Region, but lower than average vulnerability is due to low populations in those cities. Nevertheless, floods can devastate these small cities.

Repetitive Losses

FEMA has identified no Repetitive Loss properties in Region 5 (FEMA NFIP BureauNet, http://bsa.nfipstat.fema.gov/, accessed 12/1/2014).

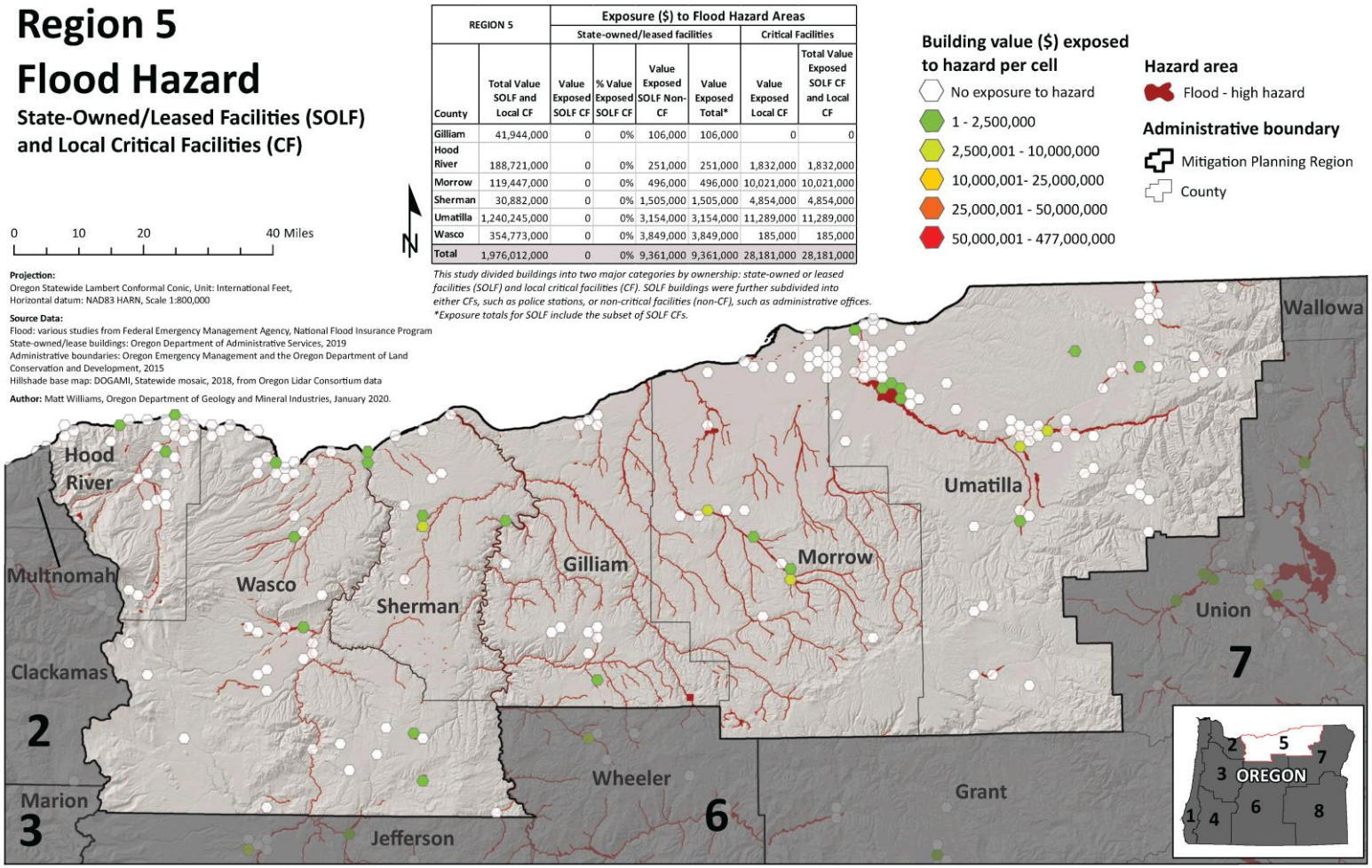
Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. The city of Heppner belongs to CRS with a current rating of 9.

State-Owned/Leased Facilities and Critical/Essential Facilities

For the 2020 Risk Assessment, DOGAMI used a combination of FEMA effective and preliminary flood zone data (FEMA National Flood Hazard Layer, 2019) and FEMA Q3 data (an unpublished digital dataset of paper flood insurance rate maps). All FEMA data that DOGAMI used was current as of 2019. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. Rather, when a building was located within a floodway, 100-year floodplain, or 500-year floodplain, a "High" flood hazard was designated. When there was insufficient information to determine whether a flood hazard exists for a given site, the flood hazard was designated "Other." Sites with "Other" designations could conceivably face relatively high flood hazards or no flood hazard at all.

In Region 5, there is a potential loss from flooding of over $9M in state building and critical facility assets, approximately 34% of it in each of Wasco and Umatilla Counties and 16% in Sherman County. There is a three times greater potential loss due to flood in local critical facilities: over $28M. Forty percent and 36% in Umatilla and Morrow Counties, respectively. Figure 2-176 illustrates the potential loss to state buildings and critical facilities and local critical facilities from flooding.

Figure 2-237. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Flood Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Exposure ($) to Flood Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Gilliam	41,944,000	0	0%	106,000	106,000	0	0
Hood River	188,721,000	0	0%	251,000	251,000	1,832,000	1,832,000
Morrow	119,447,000	0	0%	496,000	496,000	10,021,000	10,021,000
Sherman	30,882,000	0	0%	1,505,000	1,505,000	4,854,000	4,854,000
Umatilla	1,240,245,000	0	0%	3,154,000	3,154,000	11,289,000	11,289,000
Wasco	354,773,000	0	0%	3,849,000	3,849,000	185,000	185,000
Total	1,976,012,000	0	0%	9,361,000	9,361,000	28,181,000	28,181,000

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

Source: DOGAMI, 2020

Historic Resources

Of the 2,456 historic resources in Region 5, three hundred thirteen (13%) are located in an area of high flood hazard. Of those, 215 (69%) are located in Umatilla County. The rest are spread throughout Region 5.

Archaeological Resources

Of the 340 archaeological resources located in high flood hazard areas in Region 5, one hundred sixteen (34%) are located in Gilliam County. Only 4 are listed on the National Register of Historic Places and 20 are eligible for listing. Sixteen have been determined not eligible and 300 have not been evaluated as to their eligibility. The listed resources are located in Umatilla and Wasco Counties. The eligible resources are located in all Region 5 counties except Umatilla.

Social Vulnerability

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma. Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes.

Gilliam County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Morrow County is very highly vulnerable to the impacts of flooding; Umatilla and Wasco

Counties are highly vulnerable. In all three cases, their vulnerability scores are driven primarily by their very high social vulnerability. Morrow County's score is also due in part to somewhat greater values of state buildings and local critical facilities in the County.

Most Vulnerable Jurisdictions

Morrow, Umatilla, and Wasco Counties are the most vulnerable to flood hazards in Region 3.

Risk

Table 2-521. Risk of Flood Hazards in Region 5

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

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Morrow, Umatilla, and Wasco Counties are at greatest risk from flooding in Region 5.

Dam Safety

The Oregon Water Resources Department (OWRD) is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were re-written by HB 2085 which passed through the legislature and was signed by Governor Brown in 2019. This law becomes operative on July 1, 2020, with rules and guidance have been drafted and are currently in the public review and comment period.

OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure.

Analysis and Characterization

Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons. Many dams that fall below this threshold have water right permits for storage from OWRD.

Under normal loading conditions dams are generally at very low risk of failure. Specific events are associated with most dam failures. Events that might cause dams to fail include:

- An extreme flood that exceeds spillway capacity and causes an earthen dam to fail;
- Extended high water levels in a dam that has no protection against internal erosion;
- Movement of the dam in an earthquake; and
- A large rapidly moving landslide impacting the dam or reservoir.

Landslides are a significant hazard in many parts of Oregon, and some dams are constructed on landslide deposits. Though not common, a large and rapidly moving landslide or debris flow may generate a wave that can overtop a dam, causing significant flooding, especially if it causes a dam to fail.

Wildfires may increase the risk of debris flows (though wildfire generated debris flows are typically on the smaller size scale). Wildfires and windstorms can also result in large woody debris that can block spillways, also a risk to dam integrity. Oregon will be evaluating both landslide and wildfire risks during its HHPD grant funded risk assessments of dams currently eligible for the program.

Most of the largest dams, especially those owned or regulated by the Federal Government are designed to safely withstand these events and have been analyzed to show that they will. However, there are a number of dams where observations, and sometimes analysis indicates a deficiency that may make those dams susceptible to one or more of the events. The large majority of state regulated dams do not have a current risk assessment or analysis, and safe performance in these events is uncertain.

Failures of some dams can result in loss of life, damage to property, infrastructure, and the natural environment. The impacts of dam failures range from local impacts to waters below the dam and the owner's property to community destruction with mass fatalities. The 1889 Johnston Flood in Pennsylvania was caused by a dam failure, and resulted in over 2000 lives lost.

Oregon's first dam safety laws were developed in response to the St. Francis dam failure in California in 1928. That failure was attributed to unsafe design practice, and because of this about 500 persons perished. In modern times (2006) a dam owner filled in the spillway of a dam on the island of Kauai causing dam failure that killed 7 people. This dam had no recent dam safety inspections because the hazard rating was incorrect.

Where a dam's failure is expected to result in loss of life downstream of the dam, an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations.

Table 2-522. Historic Significant Dam Failures in Region 5

Year	Location	Description
1959	Currant Creek dam east of Antelope in Wasco Co.	Property damaged
2005	Simplot Lagoon south of Hermiston in Umatilla Co.	Washed out State Highway, major irrigation ditch and made 1 home unrepairable

Source: Oregon Water Resources Department Dam Safety Program records

Dam Hazard Ratings

Oregon follows national guidance for assigning hazard ratings to dams and for the contents of Emergency Action Plans, which are now required for all dams rated as "high hazard." Each dam is rated according to the anticipated impacts of its potential failure. The state has adopted these definitions (ORS 540.443–491) for state-regulated dams:

- "High Hazard" means loss of life is expected if the dam fails.
- "Significant Hazard" means loss of life is not expected if the dam fails, but extensive damage to property or public infrastructure is.
- "Low Hazard" is assigned to all other state-regulated dams.
- "Emergency Action Plan" means a plan that assists a dam owner or operator, and local emergency management personnel, to perform actions to ensure human safety in the event of a potential or actual dam failure.

Hazard ratings may change for a number of reasons. For example, a dam's original rating may not have been based on current inundation analysis methodologies, or new development may have changed potential downstream impacts.

There are 17 High Hazard dams and 6 Significant Hazard dams in the region.

Table 2-523. Summary: High Hazard and Significant Hazard Dams in Region 5

	Hazard Rating		
	State		Federal
	High	Significant	High
Region 5	7	6	10
Gilliam	0	0	0
Hood River	0	2	1
Morrow	0	2	1
Sherman	0	0	1
Umatilla	0	2	4
Wasco	7	0	3

Source: Oregon Water Resources Department, 2019

Table 2-524. High Hazard and Significant Hazard Dams in Region 5

County	Name	Rating	Regulator
Hood River	Clear Branch Creek Dam	High	Federal
Hood River	Green Point-Lower (No. 1)	Significant	State
Hood River	Green Point-Upper (No. 2)	Significant	State
Morrow	Willow Creek (Morrow)	High	Federal
Morrow	Carty Reservoir	Significant	State
Morrow	Sand Dunes Wastewater Lagoon Dam	Significant	State
Sherman	John Day Dam	High	Federal
Umatilla	Cold Springs Reservoir (USBR)	High	Federal
Umatilla	Indian Lake Dam	High	Federal
Umatilla	Mckay Reservoir (USBR)	High	Federal
Umatilla	Mcnary Dam	High	Federal
Umatilla	Meacham Lake Dam	Significant	State
Umatilla	Simplot Waste Lagoon #1	Significant	State
Wasco	Happy Canyon	High	Federal
Wasco	The Dalles Dam	High	Federal
Wasco	Wasco Dam	High	Federal
Wasco	Crow Creek	High	State
Wasco	Currant Creek	High	State
Wasco	Pine Hollow	High	State
Wasco	Rock Creek (Wasco)	High	State
Wasco	Younglife Waste A (Lower)	High	State
Wasco	Younglife Waste B (Middle)	High	State
Wasco	Younglife Waste C (Upper)	High	State

Source: Oregon Water Resources Department, 2019

Probability

Engineering risk assessment and analysis of a dam is the best indicator of the probability of failure. Without that, the condition of a dam as determined by OWRD engineering staff is a helpful indicator OWRD has for of the failure potential of a dam.

Dam safety regulators determine the condition of high hazard rated dams, both state- and federally regulated. A dam's condition is considered public information for state-regulated

dams, but the conditions of federally regulated dams are generally not subject to disclosure. State-regulated significant hazard dams do not yet have condition ratings.

Oregon uses FEMA's condition classifications. These classifications are subject to change and revisions are being considered at the national level. Currently, FEMA's condition classifications are:

- "Satisfactory" means no existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
- "Fair" means no existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
- "Poor" means a dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. A poor rating may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary.
- "Unsatisfactory" means a dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
- "Not Rated" means the dam has not been inspected, is not under State jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Four of the seven state-regulated high hazard dams in Region 5 are in satisfactory condition and three are in fair condition.

Table 2-525. Summary: Condition of High Hazard State-Regulated Dams in Region 5

	Condition of State-Regulated High Hazard Dams				
	Satisfactory	**Fair**	**Poor**	**Unsatisfactory**	**Not Rated**
Region 5	4	3	0	0	0
Gilliam	0	0	0	0	0
Hood River	0	0	0	0	0
Morrow	0	0	0	0	0
Sherman	0	0	0	0	0
Umatilla	0	0	0	0	0
Wasco	4	3	0	0	0

Source: Oregon Water Resources Department, 2019

Table 2-526. Condition of High Hazard State-Regulated Dams in Region 5

County	Dam Name	Condition
Wasco	Crow Creek	Fair
Wasco	Currant Creek	Fair
Wasco	Rock Creek (Wasco)	Fair
Wasco	Pine Hollow	Satisfactory
Wasco	Younglife Waste A (Lower)	Satisfactory
Wasco	Younglife Waste B (Middle)	Satisfactory
Wasco	Younglife Waste C (Upper)	Satisfactory

Source: Oregon Water Resources Department, 2019

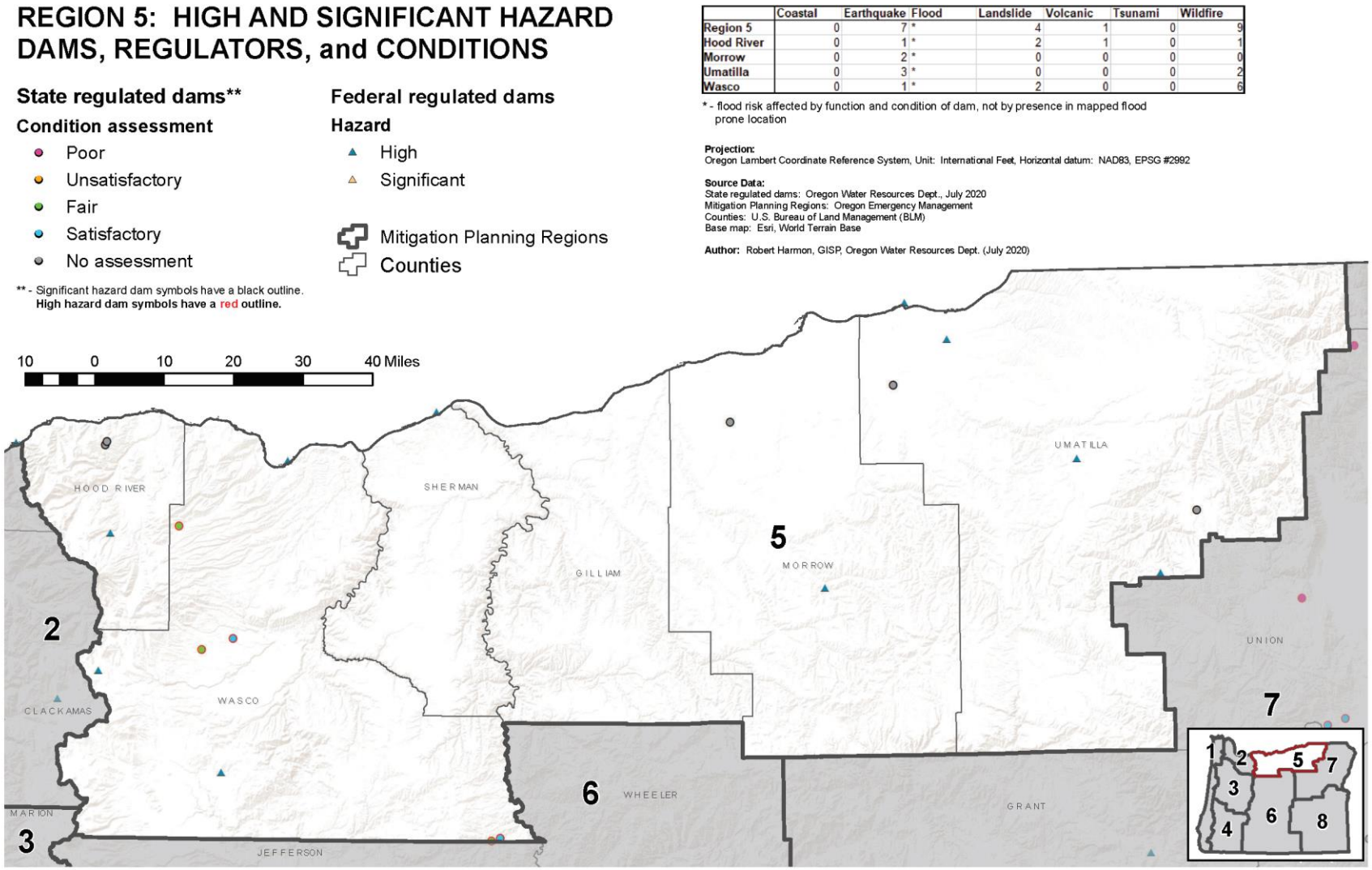
State-Regulated High Hazard Dams not Meeting Safety Standards

There are no state-regulated high hazard dams in Region 5 that are currently assessed to be below accepted safety standards (in Poor or Unsatisfactory Condition). When Oregon's new dam safety laws take effect July 1, 2020, the condition of some of these dams may be reclassified as unsafe or potentially unsafe.

It is important to note that many state regulated dams have not received a deep level of risk analysis and review, so the number of dams not meeting minimum standards may increase as additional analyses are performed.

Figure 2-238 shows state- and federally regulated high and significant hazard dams as well as the condition of state-regulated dams in Region 5. The table on the map shows the total number of these dams in each of the seven mapped hazard areas.

Figure 2-238. High- and Significant-Hazard Dams, Regulators, and Conditions in Region 5



	Coastal	Earthquake	Flood	Landslide	Volcanic	Tsunami	Wildfire
Region 5	0	7	*	4	1	0	9
Hood River	0	1	*	2	1	0	1
Morrow	0	2	*	0	0	0	0
Umatilla	0	3	*	0	0	0	2
Wasco	0	1	*	2	0	0	6

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

Projection:
Oregon Lambert Coordinate Reference System, Unit: International Feet, Horizontal datum: NAD83, EPSG #2992

Source Data:
State regulated dams: Oregon Water Resources Dept., July 2020
Mitigation Planning Regions: Oregon Emergency Management
Counties: U.S. Bureau of Land Management (BLM)
Base map: Esri, World Terrain Base

Author: Robert Harmon, GISP, Oregon Water Resources Dept. (July 2020)

Climate Change

Most climate change models indicate there may be more extreme precipitation due to the increased energy in the oceanic and atmospheric systems. Of main concerns for dams is the potential for larger floods than experienced in the past. Almost half of the historical dam failures around the world have been due the floods that exceed the flow capacity of the spillway and overtop the dam. Another issue for the Pacific coast is the shorter record of precipitation and flood events in the data records. Even without climate change there is uncertainty in the extreme storms that could occur in an extreme atmospheric river event (about which there is much to learn). If the actual flood is larger than the design flood, spillway capacity may be exceeded and the dam may overtop, or the spillway may erode so that it can rapidly empty the reservoir. These scenarios can present real risks to some dams in Oregon, risks that depending on the location may be greater than earthquake related risks.

Vulnerability

State-regulated high hazard dams in Region 5 are currently meeting safety standards.

Dams in Region 5 tend to have lower risk from natural hazards, except in Hood River County where natural hazards pose risks more like those of Region 2: potential for high risks from earthquakes and moderately increased risk from landslide and wildfire, with some risk of large woody debris from wildfire. State-regulated dams in this region are less likely than federally regulated dams to be subject to volcanic hazards.

There are no dams meeting FEMA HHPD eligibility criteria in Region 5.

Most Vulnerable Jurisdictions

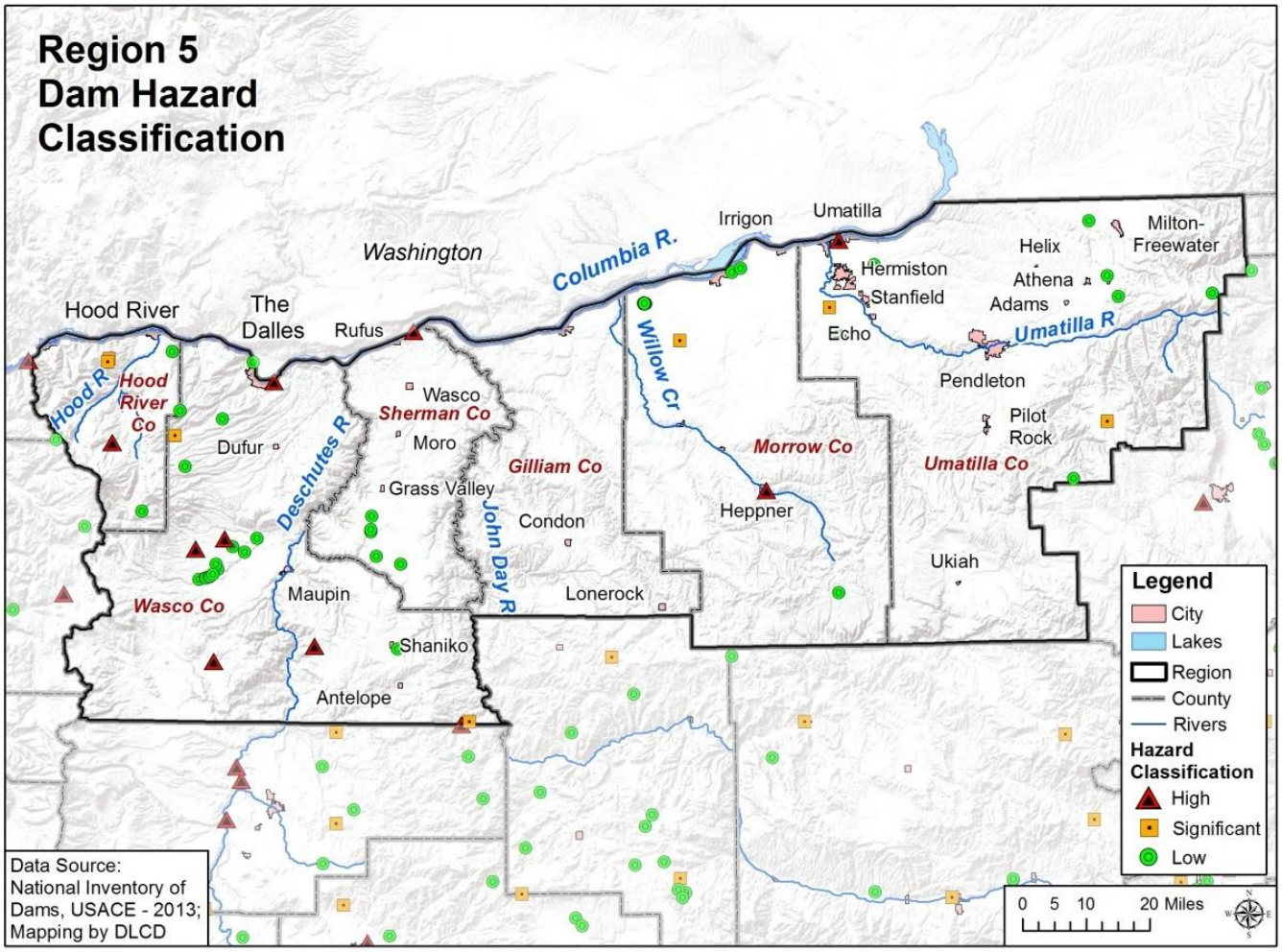
Given the information presented about state-regulated high hazard dams (county and condition; failure expected to result in loss of life) and significant hazard dams (county; failure expected to result in extensive property or infrastructure damage), no Region 5 counties are considered "most vulnerable jurisdictions" because none have high hazard dams in poor or unsatisfactory condition.

As with high hazard dams, whether counties with significant hazard dams are actually "most vulnerable jurisdictions" depends on the conditions of those dams. Since the dams' conditions have not yet been rated, we cannot determine the counties' vulnerability with respect to significant hazard dams. Hood River, Morrow, and Umatilla Counties each have two state-regulated significant hazard dams.

Risk

The potential for damage to a dam from extreme floods, lack of protection against internal erosion, earthquakes, or landslides and debris indicates greater potential for failure. Coupled with the potential for loss of life and extensive damage to property and public infrastructure, risk is qualitatively determined.

Figure 2-239. Region 5 Dam Hazard Classification



Source: National Inventory of Dams, USACE, 2013

Note: Federally regulated significant hazard dams are not shown.

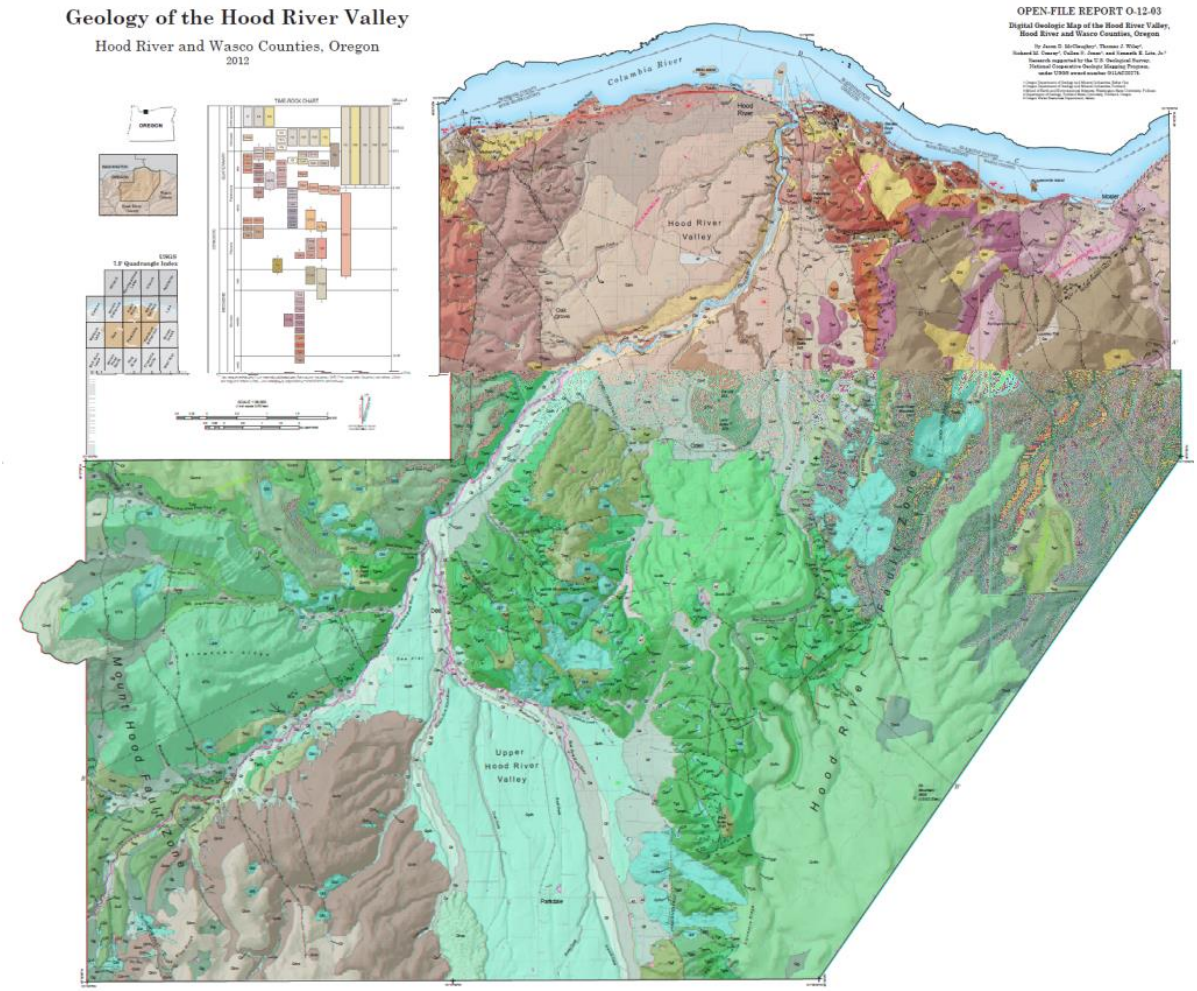
Landslides

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the Cascade Mountains and the Columbia River Gorge have very high incidence of landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage.

For example, the geology map of the Hood River area and the Mount Hood Multi-Hazard and Risk study both found hundreds of landslides in this area (McClaughry, Wiley, Conrey, Jones, & Lite, 2012) (Burns W. J., et al., 2011c). In February 2014, a large rock slide in Hood River closed I-84 for almost a week.

Figure 2-240. Geology of the Hood River Valley



Source: McClaughry, et al. (2012).

Historic Landslide Events

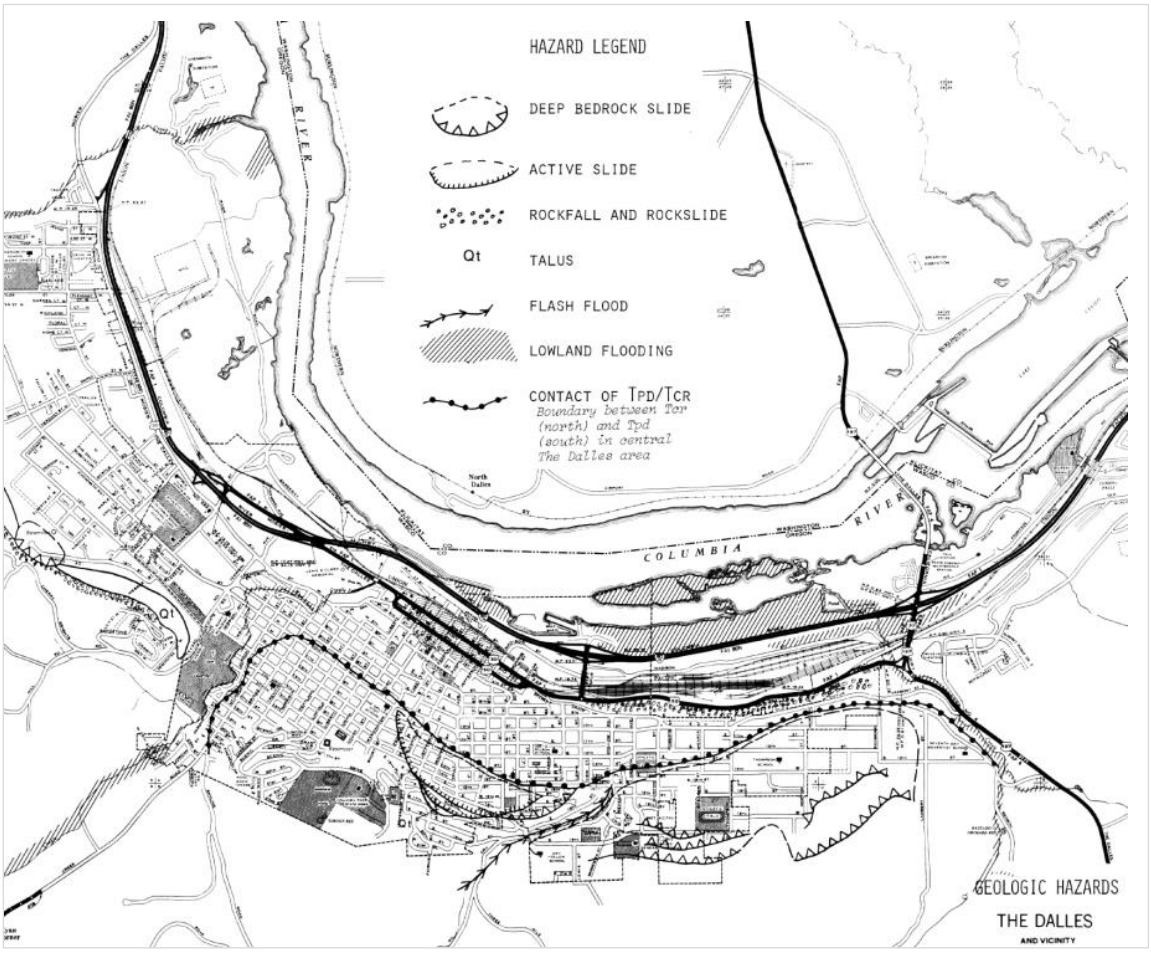
Table 2-527. Historic Landslides in Region 5

Date	Location	Description
Unknown	The Dalles	affected significant portions of the city
Dec. 1964	Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties	DR-184
Jan. 1974	Hood River and Wasco Counties	DR-413
Jul. 1995	Wasco County	DR-1061
Feb. 1996	Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties	DR-1099; hundreds of landslides
Dec. 1996-Jan. 1997	Gilliam, Morrow, and Umatilla Counties	DR-1160; hundreds of landslides
Dec. 2003-Jan. 2004	Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties	DR-1510
2005	Sherman and Wasco Counties	property damage: $35,000 (includes Jefferson County)
Dec. 2005-Jan. 2006	Sherman and Gilliam Counties	DR-1632
Nov. 2006	Hood River County	DR-1672; massive debris flows on Mt Hood caused $50M in damage to Highway 35 alone; many other landslides.
Dec. 2006	Wasco County	DR-1683
Dec. 2008	Hood River County	DR-1824
2009	Hood River County	property damage: $78,571
Jan. 2012	Hood River County	DR-4055
2014	Hood River County	rock slide on I-84; interstate closed for days
Jan. 2017	Hood River County	DR-4328
Apr. 2019	Umatilla County	DR-4452

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

Another existing landslide area affecting significant portions of the City of The Dalles was mapped in DOGAMI Bulletin 91 (**Figure 2-241**). The date of movement is unknown.

Figure 2-241. Landslides in the The Dalles, Oregon Area



Source: Beaulieu (1977)

Probability

Table 2-528. Assessment of Landslide Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	VH	L	M	M	H

Source: DOGAMI, 2020

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in this region in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or a future earthquake.

Climate Change

Landslides are often triggered by heavy rainfall events when the soil becomes saturated. It is *very likely* (>90%) that Oregon will experience an increase in the frequency of extreme

precipitation events (*high confidence*). Because landslide risk depends on a variety of site-specific factors, it is *more likely than not* (>50%) that climate change, through increasing frequency of extreme precipitation events, will result in increased frequency of landslides.

Vulnerability

Table 2-529. Local Assessment of Vulnerability to Landslides in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	—	M	L	L	—	L

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

Table 2-530. State Assessment of Vulnerability to Landslides in Region 5

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

Source: DOGAMI and DLCD, 2020

Most of the people and infrastructure in the Mid-Columbia Region are located along the I-84 corridor which runs along the northern portion of the region. This multimodal transportation corridor is vital to Oregon's economy and includes a major interstate highway (I-84); two transcontinental rail lines, Union Pacific and Burlington Northern Santa Fe; the Columbia River inland water navigation; major electric power and gas lines; and communication conduits. Roughly $14 billion worth of goods are carried through the corridor each year (Wang & Chaker, 2004). Many of the communities in this region are vulnerable to landslide hazard; for example, the cities of Hood River and The Dalles have a moderate to high exposure to landslides.

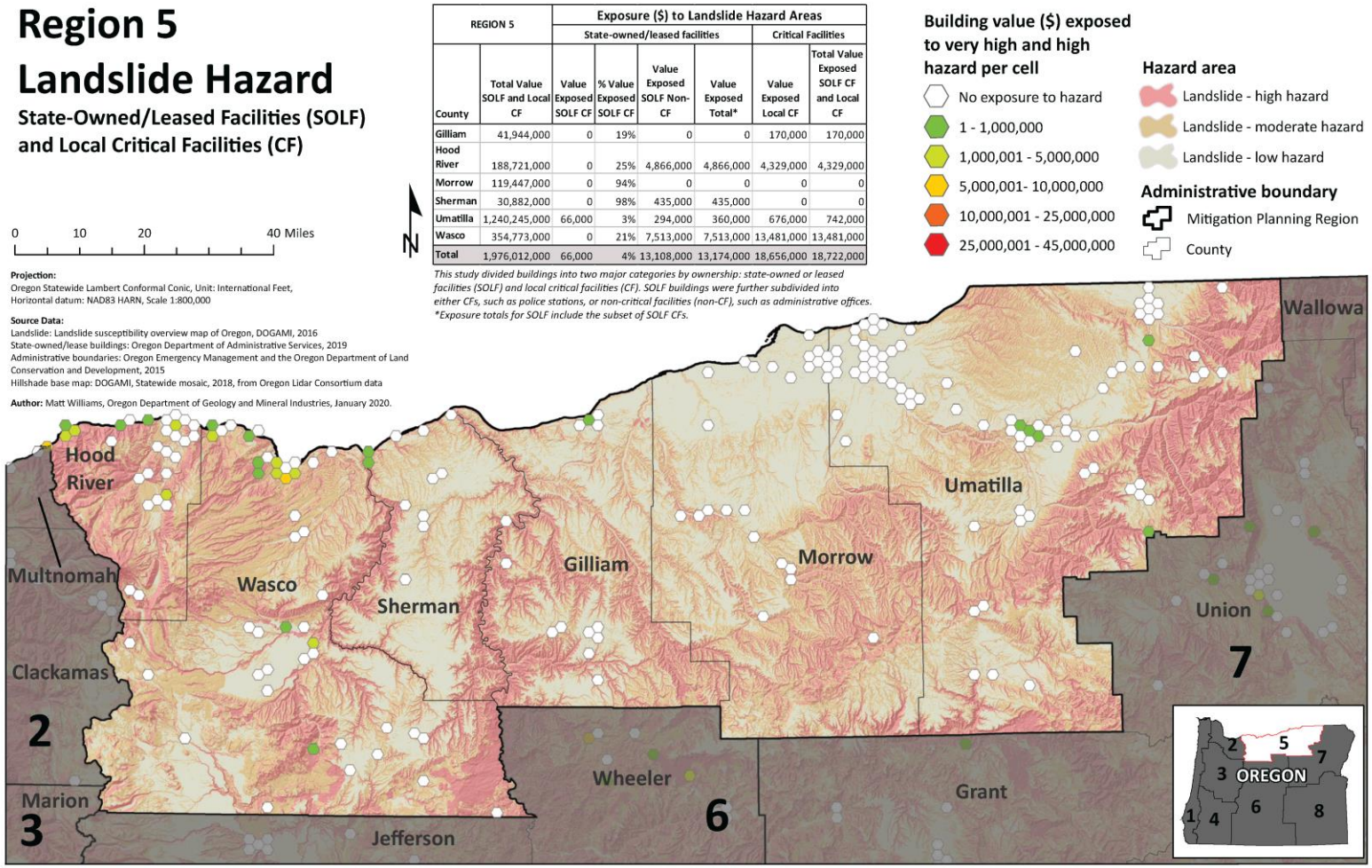
DOGAMI has recently published numerous earthquake and natural hazard reports. **Open-File Report O-11-16, Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon** (Burns W. J., et al., 2011b) provides details about the landslide hazard and risk in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

According to the 2020 risk assessment, Morrow and Umatilla Counties are highly vulnerable to landslides, and Wasco County is very highly vulnerable. All three counties' scores are driven by very high social vulnerability, and Wasco's score is driven even higher by the dollar value of its local critical facilities located in landslide hazard areas.

State-Owned/Leased Facilities and Critical and Essential Facilities

DOGAMI analyzed the potential dollar loss from landslide hazards to state buildings and critical facilities as well as to local critical facilities in Region 5. Over $32M in value of state facilities is exposed to landslide hazards in Region 5, more than half in Wasco County followed by 40% in Hood River County. The value of local critical facilities is over $18.6M, 72% also in Wasco County. Figure 2-242 illustrates the potential loss to state buildings and critical facilities and local critical facilities from landslide hazards.

Figure 2-242. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Landslide Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Exposure ($) to Landslide Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Gilliam	41,944,000	0	19%	0	0	170,000	170,000
Hood River	188,721,000	0	25%	4,866,000	4,866,000	4,329,000	4,329,000
Morrow	119,447,000	0	94%	0	0	0	0
Sherman	30,882,000	0	98%	435,000	435,000	0	0
Umatilla	1,240,245,000	66,000	3%	294,000	360,000	676,000	742,000
Wasco	354,773,000	0	21%	7,513,000	7,513,000	13,481,000	13,481,000
Total	1,976,012,000	66,000	4%	13,108,000	13,174,000	18,656,000	18,722,000

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

Source: DOGAMI, 2020

Historic Resources

Of the 2,456 historic resources in Region 5, all but one are exposed to landslide hazards: 177 are in an area of very high or high landslide hazard susceptibility; 807 in moderate; and 1,471 in low. The greatest numbers of historic resources exposed to landslide hazards are in Hood River and Umatilla Counties with 952 and 899, respectively.

Archaeological Resources

Of the 1,291 archaeological resources located in landslide hazard areas in Region 5, sixty-nine percent (887) are in high landslide hazard areas. Of those, three are listed on the National Register of Historic Places and 48 are eligible for listing. Forty-two have been determined not eligible, and 794 have not been evaluated as to their eligibility. Wasco County has the most archaeological resources in high landslide hazard areas followed by Gilliam and Sherman Counties. Wasco County also has the most archaeological resources in landslide hazard areas in Region 5 overall, 734 (57%).

Social Vulnerability

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger. Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment,

Wasco County is the most vulnerable to landslides in Region 5 followed by Morrow and Umatilla Counties. All three counties' scores are driven by very high social vulnerability, and Wasco's score is driven even higher by the dollar value of its local critical facilities located in landslide hazard areas.

Risk

Table 2-531. Assessment of Risk to Landslides in Region 5

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

Source: DOGAMI and DLCD, 2020

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment methodology combined the probability of landslide hazards occurring with the potential cost of damage to exposed state buildings and state and local critical facilities and with an assessment of the social vulnerability of the local population.

According to the 2020 Risk Scores and DOGAMI's expert assessment, Hood River, Umatilla, and Wasco Counties are "most vulnerable jurisdictions" with either very high or high risk ratings. All communities should be prioritized for mitigation

Volcanoes

Characteristics

The western boundary of Region 5 coincides with the Cascade Range, which are mountains derived from volcanic activity. Within this range of mountains are several active and potentially active volcanoes. Mount Hood, Mount Jefferson, and Mount Adams are all potentially active volcanoes close to Region 5 that can impact these communities.

Volcanic activity can produce many types of hazardous events including landslides, ashfall, lahars, pyroclastic flows, and lava flows (Scott, Iverson, Schilling, & Fisher, 2001). Pyroclastic flows are fluid mixtures of hot rock fragments, ash, and gases that can move down the flanks of volcanoes at speeds of 50 to more than 150 kilometers per hour (30 to 90 miles per hour) (Scott, Iverson, Schilling, & Fisher, 2001). Lahars or volcanic debris flows are water-saturated mixtures of soil and rock fragments that can travel very long distances (over 100 km) as fast as 80 kilometers per hour (50 miles per hour) in steep channels close to a volcano (Scott, et al., 1997a). Lahars can be very localized (only meters across) or can affect areas hundreds of kilometers away (Walder, Gardner, Conrey, Fisher, & Schilling, 1999).

Mount Hood's eruptive history can be traced to late Pleistocene times (15,000–30,000 years ago) and will no doubt continue. But the central question remains: When? The most recent series of events (1760–1810) consisted of small lahars and debris avalanches; steam explosions and minor tephra falls occurred between 1859 and 1865. Mount Hood's recent history also includes ashfalls, dome building, lahars, pyroclastic flows, and steam explosions.

Historic Volcanic Events

Table 2-532. Historic Volcanic Activity Affecting Region 5

Date	Location	Description
about 20,000 to 13,000 YBP	Polallie Eruptive episode, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
about 7,700 YBP	Parkdale, north-central Oregon	eruption of Parkdale lava flow
about 1,500 YBP	Timberline eruptive period, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
1760–1810	Crater Rock/Old Maid Flat on Mount Hood	pyroclastic flows in upper White River; lahars in Old Maid Flat; dome building at Crater Rock
1859–1865	Crater Rock on Mount Hood	steam explosions and tephra falls
1907 (?)	Crater Rock on Mount Hood	steam explosions

Note: YBP is years before present.

Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/; Scott, et al. (1997a)

Probability

Table 2-533. Assessment of Volcanic Hazards Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	L	M	L	L	L	M

Source: DOGAMI, 2020

Mount St. Helens remains a probable source of ashfall. It has repeatedly produced voluminous amounts of this material and has erupted much more frequently in recent historical time than any other Cascade volcano. It blanketed Yakima and Spokane, Washington during the 1980 eruption and continues to be of concern. The location, size, and shape of the area affected by ashfall are determined by the vigor and duration of the eruption and the wind direction. Because wind direction and velocity vary with both time and altitude, it is impossible to predict the direction and speed of ash transport more than a few hours in advance.

Geoscientists have provided some estimates of future activity in the vicinity of Crater Rock, a well-known feature on Mount Hood. They estimate a 1 in 300 chance that some dome activity will take place in a 30-year period (1996–2026). For comparison, the 30-year probability of a house being damaged by fire in the United States is about 1 in 90.

The probability of 1 cm or more of ashfall from eruptions anywhere in the Cascade Range, include:

- Gilliam County: 1 in 1,000;
- Hood River County: Between 1 in 500 and 1 in 1,000;
- Morrow County: 1 in 1,000;
- Sherman County: 1 in 1,000;
- Umatilla County: Between 1 in 1,000 and 1 in 5,000; and
- Wasco County: Between 1 in 500 and 1 in 1,000.

Vulnerability

Table 2-534. Local Assessment of Vulnerability to Volcanic Hazards in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	L	L	—	H

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

Table 2-535. State Assessment of Vulnerability to Volcanic Hazards in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	VH	H	VL	H	H

Source: DOGAMI and DLCD, 2020

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

DOGAMI analyzed the potential dollar loss from volcanic hazards to state-owned and –leased buildings and critical facilities as well as to local critical facilities in Region 5 (**Figure 2-243**). Just under $11.2M in value is exposed to volcanic hazards in Region 5, all of it in Hood River and Wasco Counties.

Historic Resources

Of the 2,456 historic buildings in Region 5, 114 are exposed to volcanic hazards, all in Hood River County. Four are located in a high hazard area; 36 in a moderate hazard area; and 74 in a low hazard area. See Appendix **9.1.12** for details.

Social Vulnerability

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5. Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income. Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger. Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters. Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma. Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

According to the 2020 vulnerability scores, Hood River County is the most vulnerable to volcanic hazards in Region 4 followed by Morrow, Umatilla, and Wasco Counties. Hood River's vulnerability score is driven largely by the presence of state and local critical facilities with a moderate social vulnerability rating, while Morrow, Wasco and Umatilla Counties' high vulnerability scores are driven primarily by very high social vulnerability. Wasco County's high vulnerability rating is also influenced by the presence of state buildings.

Risk

Table 2-536. Assessment of Risk to Volcanic Hazards in Region 5

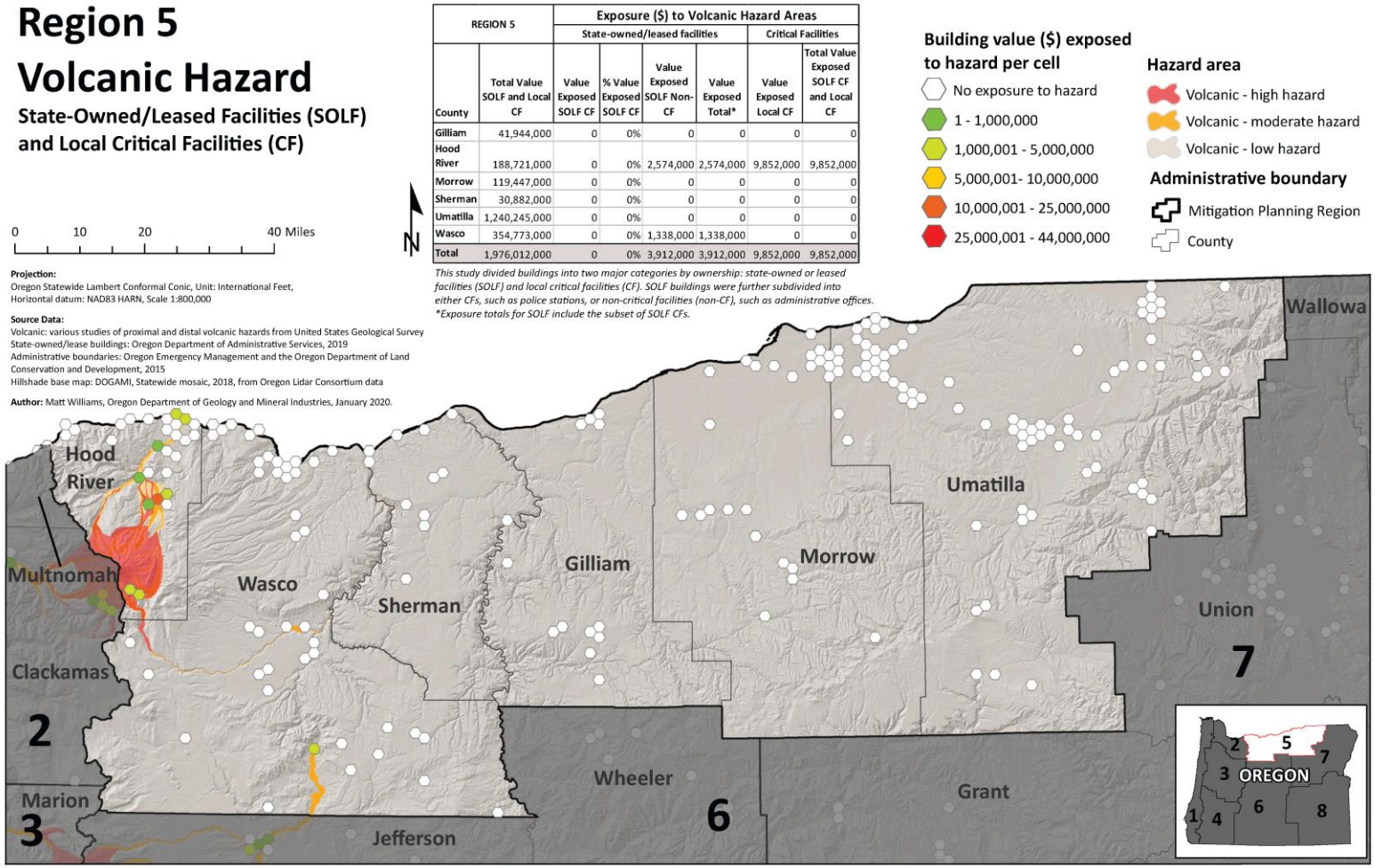
	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Risk	VL	VH	M	VL	M	H

Source: DOGAMI and DLCD, 2020

According to the 2020 Risk Scores, Hood River and Wasco Counties in Region 5 are "most vulnerable jurisdictions" with very high and high risk ratings, respectively. Morrow and Umatilla Counties have moderate risk ratings. These communities should be prioritized for mitigation actions. Gilliam and Sherman Counties, in Region 5 have very low risk ratings.

The U.S. Geological Survey has addressed volcanic hazards at Mount Hood (Scott, et al., 1997a). This report includes maps depicting the areas at greatest risk. The communities which are closer to Mount Hood, such as the Parkdale and the City of Hood River in Hood River County, are at risk from proximal as well as the distal hazards, such as lahars and ashfall. In Wasco County, communities situated along the White River may be at risk from pyroclastic flows and far-reaching lahars. Counties in Region 5, farther east of Mount Hood, are only at risk from the distal hazards such as ashfall.

Figure 2-243. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Volcanic Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Exposure ($) to Volcanic Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Gilliam	41,944,000	0	0%	0	0	0	0
Hood River	188,721,000	0	0%	2,574,000	2,574,000	9,852,000	9,852,000
Morrow	119,447,000	0	0%	0	0	0	0
Sherman	30,882,000	0	0%	0	0	0	0
Umatilla	1,240,245,000	0	0%	0	0	0	0
Wasco	354,773,000	0	0%	1,338,000	1,338,000	0	0
Total	1,976,012,000	0	0%	3,912,000	3,912,000	9,852,000	9,852,000

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

Source: DOGAMI

Wildfires

Characteristics

In Region 5, wildfires burn primarily in vegetative fuels outside the urban areas, and can generally be categorized as agricultural, forest, range, or wildland-urban interface fires.

Region 5 has unique geographic features, weather characteristics, a history of unmanaged fuels, and an expanding urban interface. Douglas fir, grand fir, and western hemlock (fire interval 150–400 years) dominate in the wetter forests of the western Columbia River Gorge, while ponderosa pine, Oregon white oak brush, and grass are more characteristic toward the east (15 year fire intervals). Historically, the region consisted of pine forests. More recently, due to decay in forest health and changes in forest practices, ponderosa pine has given way to brush and mixed conifer (Douglas fir, grand fir, and subalpine fir) at higher elevations. North and east facing slopes are typically forested while south and westerly aspects are generally open and grass covered.

This region is subject to weather patterns that can contribute significantly to extreme fire behavior. Annual precipitation levels vary from 8 to 10 inches along the Columbia River, to as high as 60 inches in the higher elevations of the Blue Mountains. Wind in the gorge is a constant variable. Wind at the east end of the gorge tends to be minimal; however, the west portion experiences 20–30 mph winds daily and, at times, winds exceed 40 mph. Significant drying occurs as sustained winds, coupled with high daytime temperatures and drier air from the desert, pushes toward the coast.

OEM Weather Statement

Extreme winds are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge. The Columbia River Gorge is the most significant east-west gap in the mountains between California and Canada. It serves as a funnel for east and west winds, where direction depends solely on the pressure gradient. Once set in motion, the winds can attain speeds of 80 mph, halt truck traffic, and damage a variety of structures and facilities. The average wind speed at Hood River is 13 mph.

Land ownership and resultant management and suppression capabilities and protocols in this area also affect the potential for wildfires. In region 5, the most significant land ownership falls to federal agencies, and includes forested and wilderness areas. Federal lands in this area are characterized by dense stands, heavy underbrush, and ladder fuels, increasing the potential for wildfires. County, state, and private lands contribute to the remainder. These lands have a variety of management practices resulting in a mix of stand conditions and resultant fire potential.

Regardless of ownership, the majority of the forestlands in Region 5 are historically prone to wildfire. As the number of dwellings extends into these areas the potential for ignition and losses increases. Many of these communities in the wildland-urban interface fall just outside of any agency's primary protection coverage, which reduces their likelihood of surviving a wildfire.

Historic Wildfire Events

Table 2-537. Historic Wildfires in Region 5

Year	Name of Fire	Location	Acres Burned	Remarks
1977		Wasco		
1979	Pine Grove/Juniper Flat			
1983	Moro	Sherman		
1985	Maupin	Wasco		
1988		Wasco		
1991	Falls		1,100	fire along the Columbia Gorge
1994	Smith Canyon			
1998	Rowena	Wasco	2,208	
1998	Reith Barnhart/Coombs Canyon	Umatilla	45,000	
2000	Willow Creek	Morrow and Gilliam	27,000	
2000	Antelope	Wasco		
2001	Two Rivers	Umatilla	7,011	
2001	Bridge Creek	Umatilla	9,230	
2002	Sheldon Ridge	Wasco	12,681	
2003	Herman Creek	Wasco	300	3 structures were lost in this fire that affected Cascade Locks
2003		Umatilla County		$40,000 in property damage, $200,000 in crop damage
2003		Umatilla County		$15,000 in property damage, $500 in crop damage
2004		Gilliam, Morrow and Umatilla Counties		$6,000 in property damage
2005		Sherman and Wasco Counties		$1,000 in property damage *damage estimate includes Jefferson County
2005		Morrow and Umatilla Counties		$2,500 in property damage and $11,500 in crop damage
Mar. 2005		Gilliam, Morrow and Umatilla Counties		$113,900 in crop damage
July 2005		Umatilla and Morrow Counties		$5,000 in property damage, $23,000 in crop damage
May 2006		Gilliam, Morrow and Umatilla Counties		$10,000 in property damage
June 2006		Gilliam, Morrow and Umatilla Counties		$500,000 in property damage
2009	Microwave Fire	Wasco County		fire threatened Maupin, burned 2 residences
2011	High Cascade Complex	Wasco County	101,292	fire burned into Warm Springs
2013	Government Flats Complex	Wasco County	11,450	fire burned four homes in The Dalles; fire suppression costs more than $15 million
2018	Boxcar	Wasco County	100,207	started due to lightning
2018	Substation	Wasco County	78,425	moved over 18 miles in just days

Source: Oregon Department of Forestry, 2020

Probability

Table 2-538. Assessment of Wildfire Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	H	H	H	H	H

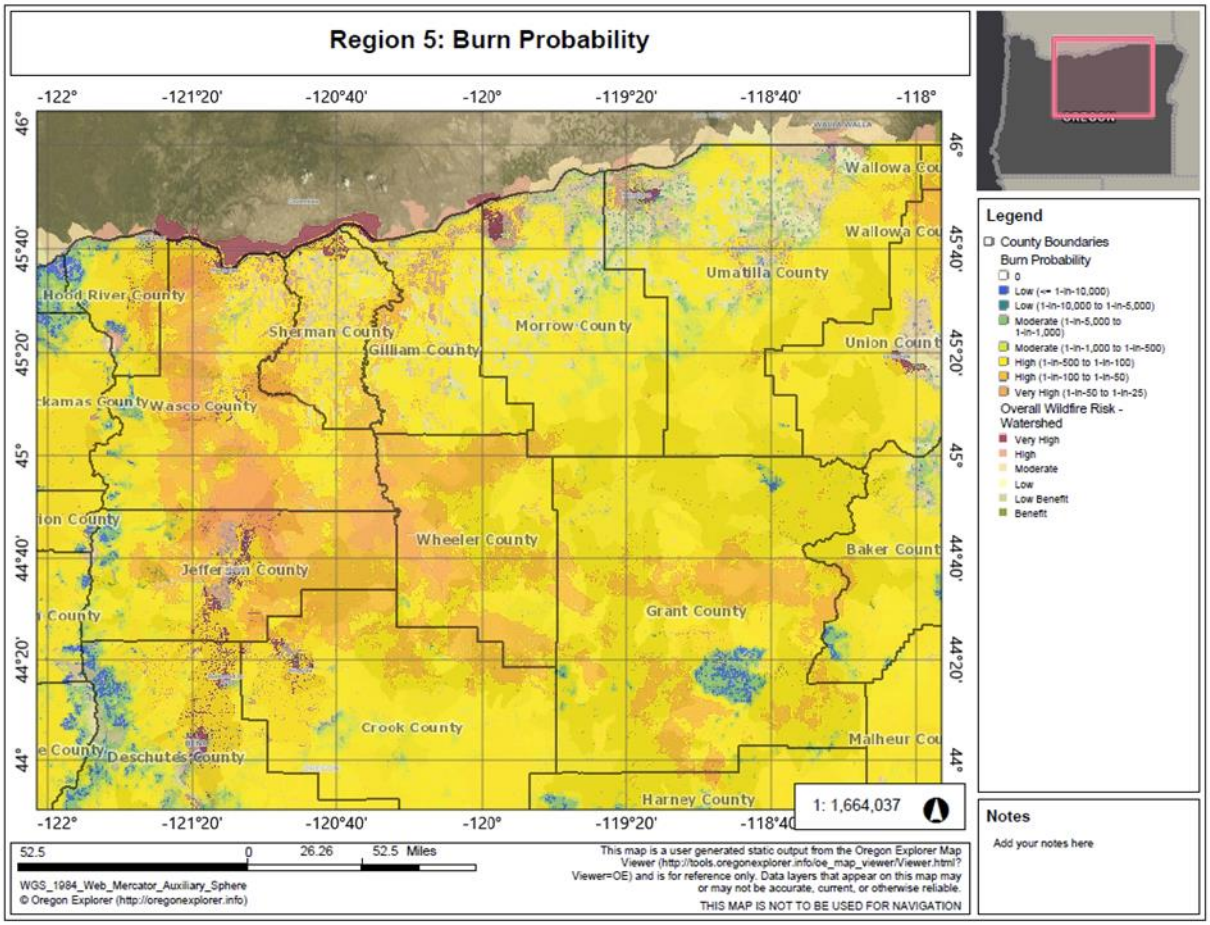
Source: Oregon Wildfire Risk Explorer: Burn Probability layer; PNW Quantitative Wildfire Risk Assessment, 2020

In the PNW Quantitative Wildfire Risk Assessment, Burn Probability was used to look at the likelihood of a large wildfire (>250 acres occurring). In conjunction with that data, examining the number of fire starts reported by ODF for all acreage sizes, gives a full picture of probability of wildfire.

These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these statewide assessments and methodologies is that the scale of the data is not necessarily reflective of the probability at the local and parcel levels, so the fire start data is utilized to help reflect that local level assessment to a certain extent.

Figure 2-244 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. Be aware that conditions vary widely with local topography, fuels, and weather, especially local winds. In all areas, under warm, dry, windy, and drought conditions, expect higher likelihood of fire starts, higher fire intensities, more ember activity, a wildfire more difficult to control, and more severe fire effects and impacts.

Figure 2-244. Burn Probability



Source: Oregon Wildfire Risk Explorer, March 2020

In Region 5, weather patterns can produce summer lightning storms that start many fires. These multiple starts can put a strain on the wildland firefighting resources spread across the county. With the drying of fuels over time and the low relative humidity factored in, the probability for large fires can significantly increase during these lightning events. The number of days per season that forest fuels are capable of producing a significant fire event is also important to consider. Oregon Department of Forestry has determined that eastern Oregon is at the highest hazard rating for weather. This value was assigned through an analysis of daily wildfire danger rating indices in each regulated use area of the state.

The west side of the region includes the heavily wooded hills and mountains of the Cascades; the east side is lined with hills that are also wooded but drier, along with significantly more oak and grasses; the west end of the heavily wooded region is pinched between the Columbia River and the near vertical sides of the river gorge.

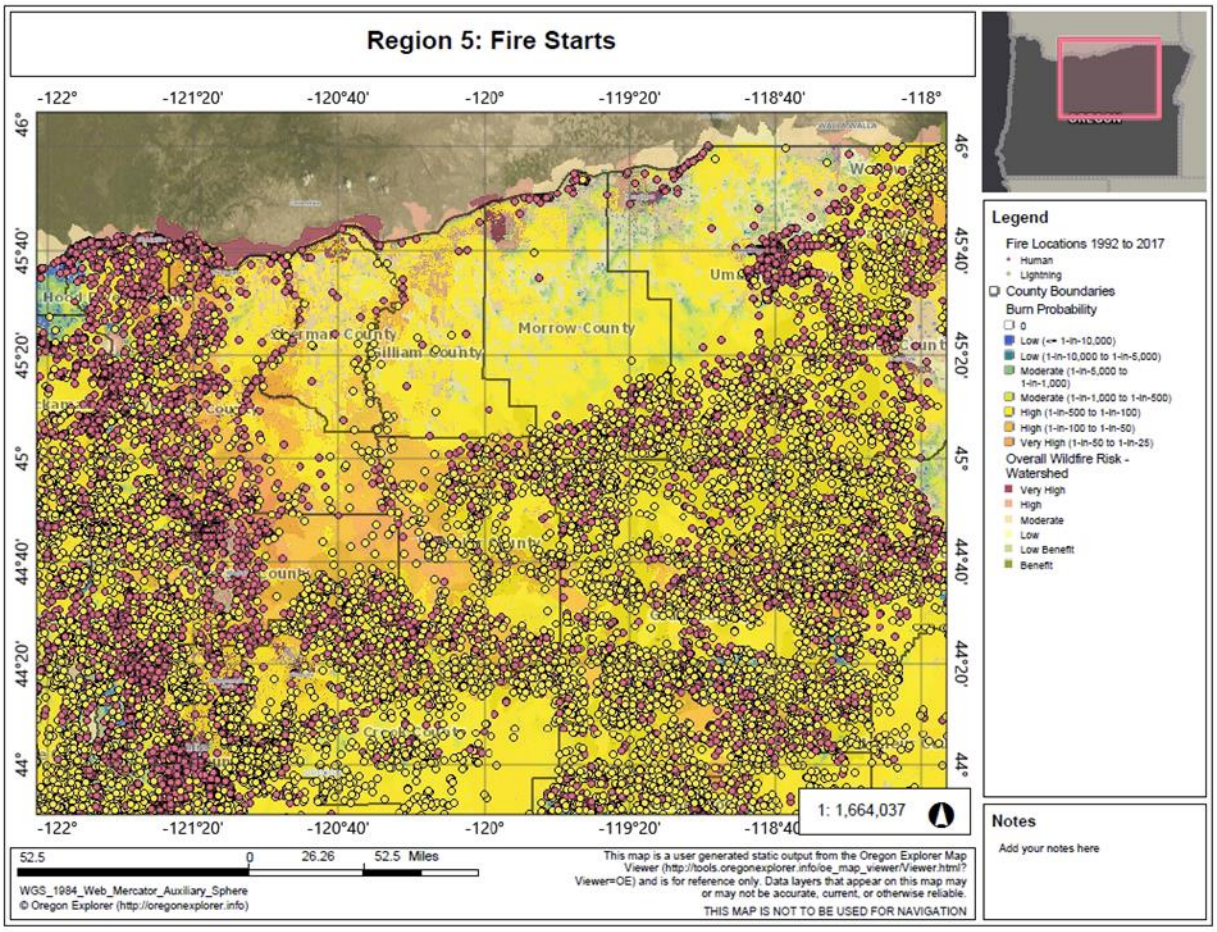
A healthy forest across this region is never free of insects, disease, or other disturbances, and infestations can increase the likelihood of ignition and fire spread. The potential for extreme fire behavior is of concern for any valued property, whether it be a structure or scenic vista at the

top of a bluff, hill, or canyon that has enough fuel to sustain a fire. The more fuels on a bluff, hill, or canyon, the more active the fire will become. As the percentage of slope increases more preheating of fuels preceding the fire front will occur. The fire front will proceed up the hill at a faster rate and the fire will burn more intensely. Coupled with high winds and low humidity, this region has the potential for a severe wildfire.

This region is susceptible to wildfire when favorable east wind conditions prevail. Fires have the potential to spread from Washington State across the river into Oregon via long-range spotting.

Sources of human-caused ignition include discarded cigarettes, motor cars and trucks, railroads, mowing, acts of nature, and fire emanating from adjoining land. Most fires adjacent to the freeway start in fine grasses and can rapidly progress into conifers that line the safety zone for almost the entire breadth of the region's west end.

Figure 2-245. Human- and Lightning-Caused Wildfires in Region 5, 1992-2017



Source: Oregon Wildfire Risk Explorer, March 2020

Climate Change

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season across the western United States. Human-cause climate change is partially responsible for these trends, which are expected to continue increasing under continued climate warming (Dalton, Dello, Hawkins, Mote, & Rupp, 2017).

In ignition-limited forest systems, found on the east side of the state, a long history of fire suppression has resulted in high fuel loads and, forests that have closer canopies and experience greater water competition. These forests experience long, dry fire seasons and are frequently at high fire danger and have a very high potential to burn if exposed to an ignition source. Winter warming will lead to more fine fuels due to greater growth during the cold season; hotter and drier conditions combined with a suppression management regime will lead to large quantity of fuel and closer canopies. Large and severe fires ("unsuppressable megafires") are a result of this large fire debt and climate change combined. Fuel-limited systems, such as those in eastern and southeastern Oregon, have non-contiguous fuels including sagebrush and bunchgrasses. As invasive annual grasses increase (e.g., Cheatgrass), fuels become contiguous since invasive grasses regrow quickly outcompeting other vegetation. Warming winters will lead to more fine fuels from greater cold season growth. Also, conditions conducive to conversion to invasive grasses can lead to frequent fires and conversion to invasive-dominated systems as climate changes, including reduction in habitat for sage grouse. It is likely (>66%) that Region 5 will experience increasing wildfire frequency and intensity under future climate change.

One proxy for future change in wildfire risk is a fire danger index called 100-hour fuel moisture (FM100), which is a measure of the amount of moisture in dead vegetation in the 1–3 inch diameter class available to a fire. A majority of climate models project that FM100 would decline across Oregon under future climate scenarios. This drying of vegetation would lead to greater wildfire risk, especially when coupled with projected decreases in summer soil moisture. The number of "very high" fire danger days—in which fuel moisture is below the 10th percentile—is projected to increase across the state and in Region 5 counties (**Table 2-539**).

Table 2-539. Projected Increase in Annual Very High Fire Danger Days in Region 5 Counties by 2050 under RCP 8.5

County	# Additional Days	Percent Change
Gilliam	15	41%
Hood River	15	40%
Morrow	15	42%
Sherman	15	40%
Umatilla	15	40%
Wasco	14	38%

Note: Very High fire danger days are defined as days in which the fuel moisture is below the 10th percentile. By definition, the historical baseline has a 36.5 Very High fire danger days. These numbers represent the multi-model mean change.

Source: Oregon Climate Change Research Institute (OCCRI)

Vulnerability

Table 2-540. Local Assessment of Vulnerability to Wildfire in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	M	H	M	M

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

Table 2-541. Assessment of Vulnerability to Wildfire in Region 5 – Communities at Risk

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	H	M	H	VH

Source: ODF Communities at Risk Report, 2020

Table 2-542. Assessment of Vulnerability to Wildfire in Region 5 – 2020 Vulnerability Assessment

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	VL	H	VH	L	H	VH

Source: DOGAMI and DLCD, 2020

According to ODF's assessment of Communities at Risk, Umatilla, Morrow, and Wasco Counties have a high percentage of wildland acres subject to Fire Risk, Wildland Development Areas, Fire Effects, or Fire Threat, making them especially vulnerable.

In addition, each year a significant number of people build homes within or on the edge of the forest (urban-wildland interface), thereby increasing vulnerability. These communities have been designated "Wildland-Urban Interface Communities" and listed in **Table 2-543**.

There is also critical infrastructure beyond the wildland-urban interface that is vulnerable to wildfire. Disruption to the municipal water supply and irrigation water supply from wildfires would negatively impact all of the residents and agricultural operators that depend on this resource by reducing water quality and availability. Roads, bridges, and evacuation routes could be compromised, limiting the ability of firefighters to reach the fire as well as inhibiting evacuation procedures. Utilities including Bonneville Power Administration power lines, Portland General Electric and Northwest Natural Gas electrical and gas distribution lines and communication infrastructure are also at risk.

The economic stability of the Region is dependent on a major interstate highway (I-84). This highway runs east-west, paralleling the Columbia River from MP 35 to MP 69. This four lane highway is considered part of the "National Defense Highway System" and as such some federal entities are sensitive to highway closures that impede or stop the flow of traffic. Most frequently, closures or restrictions are for motor vehicle accidents; however, closures can also be expected in the face of low or no visibility secondary to wildfire or inclement winter weather. Additional economic sectors that could be affected by wildfire are agriculture, forest products, tourism, manufacturing, recreation, and power generation. Community values and natural resources at risk of wildfire include agriculture and livestock, wildlife and salmonids, and historic buildings.

Table 2-543. Wildland-Urban Interface Communities in Region 5

Gillam	Hood River	Morrow	Sherman	Umatilla	Wasco
Arlington	Cascade Locks	Black Mountain	Grass Valley	Adams	Antelope
Condon	Dee	Boardman	Moro	Athena	Big Muddy Ranch
Gilliam	Hood River	Cutsforth Park	Rufus	Battle Mountain	Chenoweth
Lonerock	Odell	Heppner	Sherman	Dry Creek	Dufur
	Parkdale	Ione	Wasco	Echo	Juniper Flat
	Pine Grove	Irrigon		Helix	Maupin
	West Side	Lake Penland		Hermiston	Mid-Columbia
		Lexington		Lehman Hot Springs	Mosier
		Morrow CO OHV Park		McKay Creek	Pine Grove
				Milton-Freewater	Pine Hollow
				Mission	Rail Hollow
				Pendleton	Shaniko
				Pilot Rock	The Dalles
				Rieth	Tygh Valley
				Riverside	Wamic
				Stanfield	Warm Springs
				Tollgate Spout Springs	Wasco
				Ukiah	White River
				Umapine	
				Umatilla	
				Walla Walla River Corridor	
				Weston Mountain	

Source: ODF Communities at Risk Report, 2020

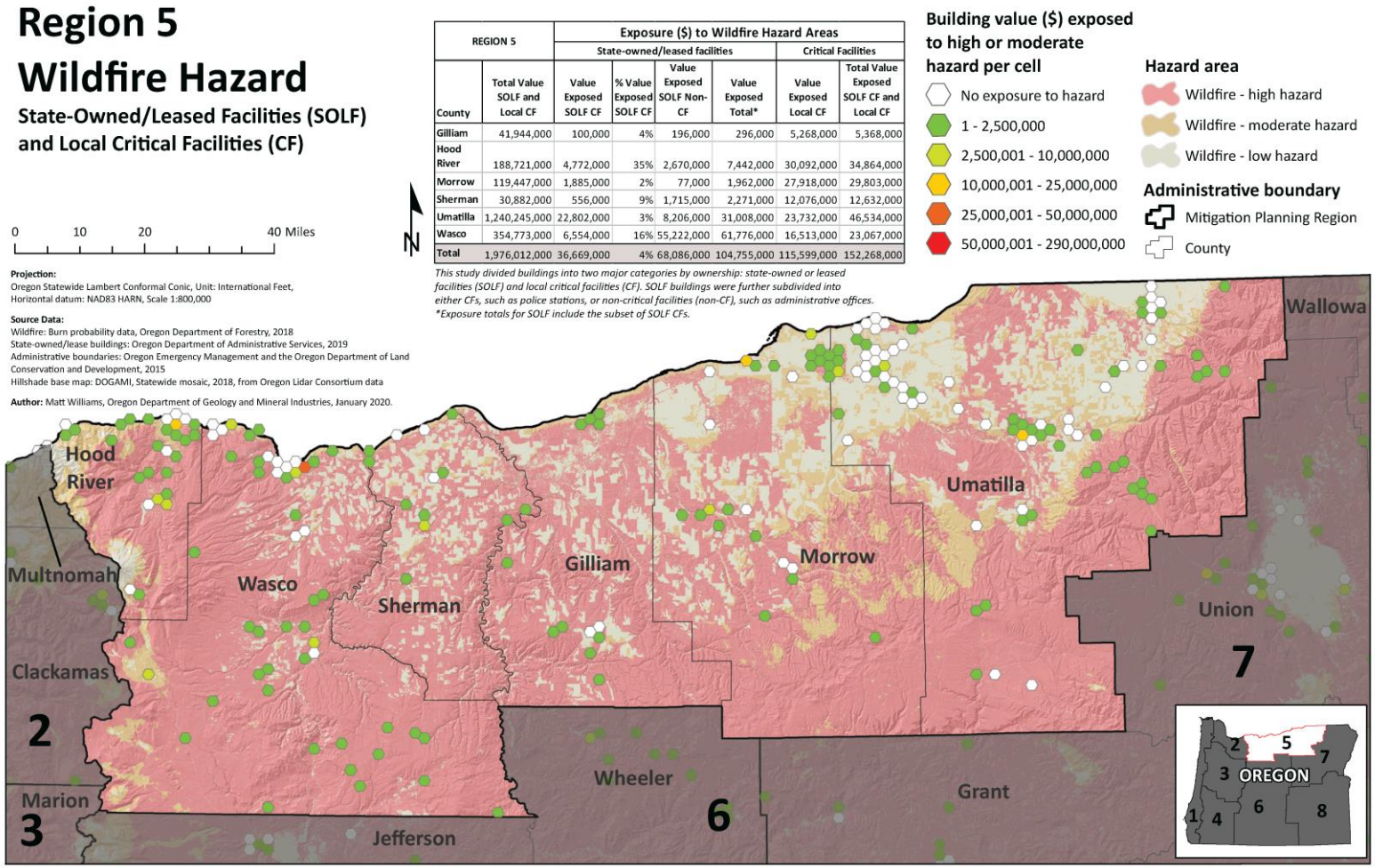
State-Owned/Leased Buildings and Critical Facilities and Local Critical Facilities

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

In Region 5, there is a potential loss to wildfire of almost $105M in state building and critical facility assets, almost 60% of it in Wasco County and 30% in Umatilla County. Seven percent is located in Hood River County and the remaining three percent in Sherman, Morrow, and Gilliam Counties. There is a slightly greater potential loss in local critical facilities: about $15.6M. Around 25% is located in each of Hood River and Morrow Counties, about 20% in Umatilla County.

Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. According to Department of Administrative Services records, there has been one reported loss to a state asset caused by a wildfire since the beginning of 2015. It was located in the Columbia River Gorge; whether in Region 5 or Region 2 is not clear. The net claim paid was under $2,000.

Figure 2-246. State-Owned/Leased Facilities (SOLF) and Local Critical Facilities (CF) in a Wildfire Hazard Zone in Region 5.High-resolution, full-size image linked from Appendix 9.1.26.



REGION 5		Exposure ($) to Wildfire Hazard Areas					
		State-owned/leased facilities				Critical Facilities	
County	Total Value SOLF and Local CF	Value Exposed SOLF CF	% Value Exposed SOLF CF	Value Exposed SOLF Non-CF	Value Exposed Total*	Value Exposed Local CF	Total Value Exposed SOLF CF and Local CF
Gilliam	41,944,000	100,000	4%	196,000	296,000	5,268,000	5,368,000
Hood River	188,721,000	4,772,000	35%	2,670,000	7,442,000	30,092,000	34,864,000
Morrow	119,447,000	1,885,000	2%	77,000	1,962,000	27,918,000	29,803,000
Sherman	30,882,000	556,000	9%	1,715,000	2,271,000	12,076,000	12,632,000
Umatilla	1,240,245,000	22,802,000	3%	8,206,000	31,008,000	23,732,000	46,534,000
Wasco	354,773,000	6,554,000	16%	55,222,000	61,776,000	16,513,000	23,067,000
Total	1,976,012,000	36,669,000	4%	68,086,000	104,755,000	115,599,000	152,268,000

Source: DOGAMI, 2020

Historic Resources

Of the 2,456 historic resources in Region 5, sixty-six (3%) are located in an area of high wildfire hazard. Of those, 42% are located in Wasco County. Of the 87 (4%) located in a moderate wildfire hazard area, 53% are located in Umatilla County and 39% in Hood River County.

Social Vulnerability

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

For the 2020 vulnerability assessment, DLCD combined the social vulnerability scores with the vulnerability scores for state buildings, state critical facilities, and local critical facilities to calculate an overall vulnerability score for each county. According to this limited assessment, Morrow County and Wasco County are very highly vulnerable to wildfire; Hood River and Umatilla Counties highly vulnerable. Sherman County's vulnerability is low and Gilliam County's very low. This assessment is consistent with the Communities at Risk assessment for Umatilla and Wasco Counties, and close for Morrow County, but inconsistent for the other counties. This is indicative of the different criteria used for these assessments.

Wasco, Umatilla, and Morrow Counties are most vulnerable to wildfire in Region 5.

Risk

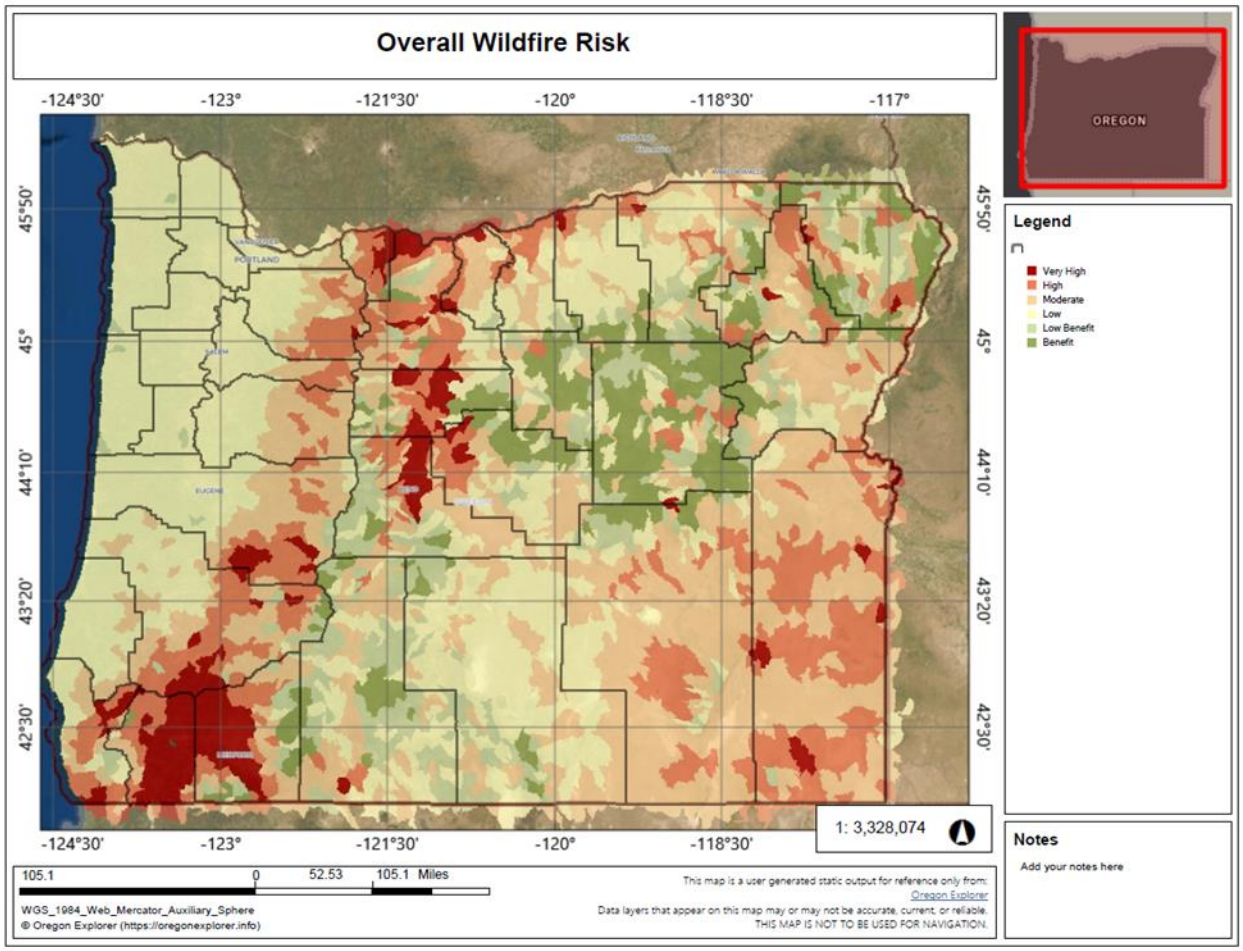
Table 2-544. Risk of Wildfire Hazards in Region 5

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

Source: DOGAMI, DLCD

With respect to natural hazards, risk can be expressed as the probability of a hazard occurring combined with the potential for property damage and loss of life. The 2020 risk assessment combined the wildfire probability with the vulnerability assessment to arrive at a composite risk score. According to the 2020 risk assessment, Morrow, Umatilla, and Wasco Counties are at very high risk from wildfire and Hood River is at high risk. This is only partially consistent with ODF's assessment, mapped in **Figure 2-247**. The map shows that primarily the areas of Umatilla and Morrow Counties in the Columbia River Gorge are at very high risk from wildfire, while most of Wasco and Hood River Counties are at very high risk. The 2020 risk assessment is not granular enough to account for geographic differences in probability, vulnerability, or risk within a county.

Figure 2-247. Overall Wildfire Risk



Source: Oregon Explorer, 2020

Windstorms

Characteristics

Extreme winds are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge, so much so that these areas have special building code standards. All manufactured homes in Region 5 that are within 30 miles of the Columbia River must meet special anchoring standards. High winds in this area of Oregon are legendary. The Columbia Gorge is the most significant east-west gap in the mountains between California and Canada. It serves as a funnel for east and west winds, where direction depends solely on the pressure gradient. Once set in motion, the winds can attain speeds of 80 mph, halt truck traffic, and damage a variety of structures and facilities. The average wind speed at Hood River is 13 mph, not much less than the notoriously windy Texas and Kansas plains whose wind speeds average 15 mph (Taylor & Hatton, 1999).

Though their occurrence is somewhat less frequent, Region 5 has also experienced tornadoes. For the most part, these tornadoes have not resulted in major damages **Table 2-546** lists historic tornadoes in the region.

Historic Winter Storm Events

Table 2-545. Historic Windstorms Affecting Region 5

Date	Affected Area	Characteristics
Apr. 1931	N. Central Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Dec. 1935	W. Columbia Gorge, Oregon	damage to automobiles; wind gusts at 120 mph
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; wind speed 40–60 mph; gusts 75–80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 75 mph gusts; damage to buildings and utility lines
Dec. 1955	statewide	wind speeds 55–65 mph with 69 mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71 mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon's most destructive storm to date; 116 mph winds in Willamette Valley.; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Nov. 1981	statewide	severe wind storm
Dec. 1987	Umatilla County	damaging wind storm; two fatalities
Mar. 1991	Mid-Columbia / NE Oregon	severe wind storm
Dec. 1991	N. central Oregon	severe wind storm; blowing dust
Jan. 1993	northern Oregon	severe wind storm; damage to utilities
Dec. 1995	statewide	severe wind storm; widespread damage
Oct. 2003	Umatilla County	$1,000 in property damage
Jan. 2004	Morrow and Umatilla Counties	$2,500 in property damage
Feb. 2004	Umatilla County	$3,000 in property damage *damage estimate includes Jefferson County

Date	Affected Area	Characteristics
Apr. 2004	Hood River County	$25,000 in property damage
Apr. 2004	Wasco County	$1,000 in property damage
Oct. 2004	Gilliam, Morrow and Umatilla Counties	$333.33 in property damage
Dec. 2004	Gilliam, Morrow and Umatilla Counties	$166.66 in property damage
Dec. 2004	Sherman and Wasco Counties	$3,333.33 * damage estimate includes Jefferson County
Feb. 2005	Gilliam, Morrow and Umatilla Counties	$3,000 in property damage
Mar. 2005	Sherman and Wasco Counties	$2,500 in property damage *damage estimate includes Jefferson County
Nov. 2005	Umatilla County	$400 in property damage
Apr. 2006	Umatilla County	$10,000 in property damage in Hermiston
May 2006	Morrow County	$500,000 in property damage with a high wind gust measured at 117 mph; $1 million in crop damage
May 2006	Sherman County	$50,000 in property damage in Grass Valley; winds ranged from 70 to 80 mph
Nov. 2006	Morrow and Umatilla Counties	$35,000 in property damage from 80 mph winds; property damage also occurred in Union and Wallowa Counties, for a total storm damage of $70,000
Jan. 2007	Gilliam, Morrow, Sherman, Wasco and Umatilla Counties	$5,000 in property damage from 64 mph winds; damage estimate includes Jefferson County
June 2008	Umatilla County	powerful windstorm with wind speeds at 58 mph caused $10,000 in damage to buildings in Pendleton
June 2008	Morrow and Umatilla Counties	wind damage downed several trees and power lines, caused $250,000 in property damage and $100,000 crop damage in Morrow County, and $108,000 in property damage in Umatilla County
July 2010	Umatilla County	64 mph winds caused $40,000 in property damage in the Hermiston area
Nov. 2012	Wasco, Sherman, Umatilla, Gilliam, Morrow, Union and Wallowa Counties	74 mph winds $120,000 in damage *includes Jefferson County
Apr. 2019	Curry, Douglas, Linn, Wheeler, Grant, and Umatilla	FEMA-4452-DR: Severe storms, straight-line winds, flooding, landslides, and mudslides
Feb. 2020	Regions 5 and 7: Umatilla, Union, Wallowa Counties	FEMA-4519-DR: Severe storms, tornadoes, straight-line winds and flooding
Jan. 2004	Morrow and Umatilla Counties	$2,500 in property damage
Feb. 2004	Umatilla County	$3,000 in property damage *damage estimate includes Jefferson County

Sources: Taylor and Hatton (1999); FEMA-1405-DR-OR, February 7, 2002, Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon. and Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org and U.S. Department of Commerce. National Climatic Data Center. Available from http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms; https://www.fema.gov/disaster/

Table 2-546. Historic Tornadoes in Region 5

Date	Location	Result
June 1888	Morrow County (Lexington, Sand Hill, Pine City)	30 buildings, including two schools destroyed; six people killed (including two children); four people injured
Apr. 1925	Gilliam County	warehouse and automobiles destroyed in Condon; about $10,000 in damages
Apr. 1957	Gilliam and Morrow Counties	minor damage (rangeland)
Apr. 1970	Wasco County	observed; no damage
May 1991	Umatilla County	some damage to wheat fields
July 1995	Umatilla County	some damage to wheat fields
May 2006	Morrow County	$20,000 in property damage, F1 intensity
May 2009	Umatilla County	$50,000 in property damage, F1 intensity
April 2011	Morrow County (Lexington)	damage to pump house

Note: No tornadoes reported since April 2011 (https://www.ncdc.noaa.gov/stormevents/)

Sources: Taylor and Hatton (1999); U.S. Department of Commerce. National Climatic Data Center. Available from http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Probability

Table 2-547. Assessment of Windstorm Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	H	M	H	H	H

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

High winds occur yearly in the Columbia River Gorge. The 100-year event in this region consists of 1-minute average winds of 90 mph. A 50 year event has average winds of 80 mph. A 25-year event has average winds of 75 mph.

Climate Change

There is insufficient research on changes in the likelihood of windstorms in the Pacific Northwest as a result of climate change. While climate change has the potential to alter surface winds through changes in the large-scale free atmospheric circulation and storm systems, there is as yet no consensus on whether or not extratropical storms and associated extreme winds will intensify or become more frequent along the Pacific Northwest coast under a warmer climate.

Vulnerability

Table 2-548. Local Assessment of Vulnerability to Windstorms in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	M	M	M	M	H	H

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

Table 2-549. State Assessment of Vulnerability to Windstorms in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	L	H	M	M	H	H

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

Many buildings, utilities, and transportation systems within Region 5 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, uprooted or shattered trees can down power and/or utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Uprooted trees growing next to a house have destroyed roofs when they fall as a result of windstorms. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies to identify problem areas and establish a tree maintenance and removal program.

Social Vulnerability

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

Gilliam, Hood River, Morrow, Sherman and Wasco Counties are the most vulnerable to windstorms because of their proximity to the Columbia River. Social vulnerability in Morrow and Wasco Counties is very high. In. Hood River it is moderate, and in Gilliam and Sherman Counties very low. Therefore, Morrow and Wasco Counties are considered the most vulnerable to windstorms in Region 5.

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

The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to windstorms. The value of locally owned critical facilities is $1,080,652,000. Because windstorms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to windstorms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 5 since the beginning of 2015. Eight losses were due to windstorms statewide. Of those, it is possible that one or two may have been located in the eastern portion of Region 5. One claim was for approximately $6,200 and the other has not been settled.

Risk

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

All the counties in Region 5 are at risk of windstorms, particularly on their northern boundaries along the Columbia River. Morrow County is the most at risk in Region 8 and with Marion County in the state overall.

Winter Storms

Characteristics

Severe winter weather in Region 5 can be characterized by extreme cold, snow, ice, and sleet. Winter storm events are an annual occurrence in Region 5; most communities are prepared for them. This is particularly true through the Columbia River Gorge where frigid air sometimes moves westward out of the Wallowa Mountains. During these periods, it is not unusual to receive snow or ice storms. Severe weather conditions do not last long in Region 5; consequently, winter-preparedness is a moderate priority. This is advantageous in at least one respect: in general, the region is prepared, and those visiting the region during the winter usually come prepared. However, there are occasions when preparation cannot meet the challenge.

Historic Winter Storm Events

Table 2-550. Historic Winter Storms Affecting Region 5

Date	Location	Remarks
Dec. 1861	entire state	storm produced 1–3 feet of snow throughout Oregon
Dec. 1884	Columbia Basin, Oregon	heavy snowfall; 29.5 inches in The Dalles in one day
Dec. 1885	Wasco County, Oregon	most snow recorded (6–10 feet); trains had difficulty reaching Portland
Dec. 1892	northern counties, Oregon	15–30 inches of snow throughout northern counties
Jan. 1916	entire state	two storms; very heavy snowfall, especially in mountainous areas
Jan. and Feb. 1937	entire state	deep snow drifts
Jan. 1950	entire state	record snowfalls; property damage throughout state
Mar. 1960	entire state	many automobile accidents; two fatalities
Jan. 1969	entire state	heavy snow throughout state
Jan. 1980	entire state	series of storms across state; injuries and power outages
Feb. 1985	entire state	2 feet of snow in northeast mountains; downed power lines; fatalities
Feb. 1986	central/eastern Oregon	Heavy snow in Deschutes Basin; traffic accidents; broken power lines
Mar. 1988	entire state	strong winds; heavy snow
Feb. 1990	entire state	heavy snow throughout state
Nov. 1993	Cascade Mountains, Oregon	heavy snow throughout region
Mar. 1994	Cascade Mountains, Oregon	heavy snow throughout region
Winter 1998-99	entire state	one of the snowiest winters in Oregon history (snowfall at Crater Lake: 586 inches)
Dec.28, 2003–Jan. 9, 2004	statewide storm	DR-1510. Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties declared in Region 5. The most significant winter storm in several years brought snowfall to most of Oregon. ODOT closed I-84 through the Columbia Gorge twice, for almost 70 hours total. Freight trucks and passenger cars had to detour over Mount Hood where, ironically, road conditions were better than they were in downtown Portland where all vehicles were required to chain up. A frigid arctic air mass, heavy snow, sleet and freezing rain, strong east winds and blizzard conditions through and near the Columbia River Gorge snarled travel, forced school and business closures, and resulted in widespread power outages and properly damage in Northwestern Oregon. Blizzard conditions in the Columbia River Gorge: • closed I-84 between Troutdale and Hood River • closed Washington State Route 14 between Washougal, and White Salmon, Washington • Halted east-west travel through the Gorge and stranded hundreds of trucks at both ends of the Gorge
Jan. 2005	Gilliam, Morrow, and Umatilla Counties	33 injuries
Nov. 2006	Hood River County	heavy freezing rain along I-84, closed the highway near Hood River
Dec. 2006	Hood River County	freezing rain and sleet caused ice conditions from Cascade Locks to Hood River; black ice on I-84
Jan. 2008	Hood River, Wasco, Sherman, Gilliam, Morrow, and Umatilla Counties	heavy freezing rain from Bonneville westward through Columbia Gorge causing accidents on I-84; one fatality

Date	Location	Remarks
Nov. 29-30, 2010	Hood River and Wasco Counties	4-5 inches of snow reported in Cascade Locks and Hood River; 1/2 inch of ice in Corbett
Jan. 12–18, 2012	Hood River, and Wasco Counties	4.5 inches of new snow reported in Hood River; I-84 closed due to ice and snow east of Troutdale
Feb. 6–10, 2014	Hood River County	a strong winter storm system affected the Pacific Northwest during the February 6–10, 2014 time period bringing a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon.
Feb. 11–14, 2014	Hood River County	Another weather system moved across northwest Oregon during the February 11–14 time frame; this storm was distinctly different from the storm that produced the snow and ice the week prior and brought abundant moisture and warm air from the sub-tropics into the region; as this storm moved across the area, 2 to 7 inches of rain fell across many counties in western Oregon; the heavy rainfall combined with warm temperatures led to snowmelt and rainfall runoff that produced rapid rises on several rivers, which included flooding on three rivers in northwest Oregon
March 2, 2014	Hood River County, Upper Hood River Valley, Central Columbia River Gorge	East winds brought very cold air from east of the Cascades through the Columbia River Gorge as a moist front pushed in from the Pacific. The combination of the cold air mass and frontal precipitation resulted in snow and ice for the Gorge. There were numerous reports of snow and ice in the Central Columbia River Gorge with generally 6 to 8 inches of snow. There was a quarter of an inch of ice on top of the snow in Hood River and White Salmon, and as much as 0.4 to 0.5 inch of ice in Parkdale where the cold air held on the longest.
Nov. 13, 2014	Hood River County (Western Columbia River Gorge)	An early cold snap hit the Pacific Northwest before moist Pacific air moved in and resulted in one of the earliest snow, sleet, and freezing rain events in northwestern Oregon. Sleet and freezing rain in particular created hazardous commutes for tens of thousands in the western and eastern suburbs of Portland. Snow accumulations were primarily restricted to the Cascade valleys and the central Columbia River Gorge. Spotters reported around 6 to 8 inches of snow for the Cascade Foothills followed by a quarter of an inch of ice. A combination of heavy snow and ice resulted in slick driving conditions for the Western Columbia River Gorge. Areas in the gorge measured a quarter of an inch of ice whereas other areas had 5 to 8 inches of snow.
Dec. 6-23, 2015	Statewide storm events	DR-4258 Clatsop, Columbia, Multnomah, Clackamas, Washington, Tillamook, Yamhill, Polk, Lincoln, Linn, Lane, Douglas, Coos, and Curry Counties declared. Several pacific storm systems moved across the region over the Dec 12-13 weekend. Each storm system brought several inches of snow to the mountain areas.
Dec. 8, 2016	Hood River County (Western Columbia River Gorge)	A strong frontal system brought strong east winds to the North Willamette Valley and a mix of snow, sleet, and freezing rain down to the Valley Floor. Ice accumulations were higher in the West Hills and near the Columbia River Gorge.

Date	Location	Remarks
Dec. 19, 2016	Hood River County (Upper Hood River Valley and Central Columbia River Gorge)	A warmer low pressure system moved into to Northwest Oregon, bringing high winds along the North and Central Oregon Coast. Cold east winds through the Columbia River Gorge continued for the first part of the event, leading to light accumulations of snow and sleet in portions of far northwest Oregon and higher accumulations in the Columbia River Gorge and Hood River Valley. Estimate the Columbia Gorge had around 0.2 to 0.5 inch of ice accumulation as temperatures in the lower 30s with reports of snow and freezing rain in Hood River. A frontal system brought high winds to the Central Oregon Coast, heavy snow to the Cascades and a mix of ice and snow in the Columbia River Gorge and Hood River Valley. SNOTELs and other stations reported a range of 12 to 25 inches of snow. Some specific reports include 25 inches at Mt Hood Meadows, 22 inches at Timberline, 14 inches at Government Camp and 12 inches at McKenzie Snotel.
Jan. 7-8, 2017	Hood River County (Western and Central Columbia Gorge, Upper Hood River Valley)	DR-4328 Columbia, Hood River, Deschutes and Josephine Counties declared. A broad shortwave trough brought multiple rounds of precipitation, including a wintry mix of snow and ice for many locations across Northwest Oregon. Strong easterly pressure gradients generated high winds through the Columbia River Gorge as well on January 8. General snowfall totals of 2-4 inches were reported, with the greatest total being 4.5 inches. Major ice accumulations occurred after the snow, with several locations reporting 0.50-1.00. The combination of snow and ice resulted in significant power outages and closures across the area.
Feb. 3-4, 2017	Hood River County (Western and Central Columbia River Gorge, Upper Hood River Valley)	Fronts associated with a low pressure system passing north into the Olympic Peninsula brought heavy snow and ice to the Columbia Gorge. The Hood River area reported 4 to 6 inches of snow turning to ice in the western-most part of this zone.
Feb. 8-9, 2017	Wasco, Sherman, Gilliam, (Eastern Columbia River Gorge)	A strong Pacific storm system brought snow, sleet and freezing rain to many areas of the Interior Northwest February 7th through 9th. Winter storm produced a total snow accumulation of 5.25 inches with an ice accumulation of 0.25 inches on top of the snow. Occurred 5 miles SSW of Chenoweth in Wasco county.
Dec. 24, 2017	Hood River County (Western Columbia River Gorge	Low pressure system moving into the Pacific Northwest pulled cold air from the Columbia Basin west into the Willamette Valley, through the Columbia River Gorge. As this system started to bring moisture and precipitation into NW Oregon, temperatures were around or below freezing, allowing for a mix of snow and ice to fall all the way to the Valley Floor around the Portland Metro, in the Columbia River Gorge, and the Hood River Valley. Local Broadcast Meteorologist reported getting 2.5 inches of snow and 0.2 inch of ice in Corbett. Also, a Skywarn Spotter in Cascade Locks reported getting 4.8 inches of snow.
Feb. 22-26, 2019	Wasco, Sherman, Gilliam, Morrow, and Umatilla, Counties (Eastern Columbia River Gorge)	Persistent troughing off the coast of the Pacific Northwest focused a stream of mid-level moisture over the Inland Northwest resulting in a long duration snow event as the plume drifted north and south several times between the 22nd and 27th of February.

Date	Location	Remarks
Jan. 15-16, 2020	Hood River County (Western and Central Columbia River Gorge)	A low pressure zone located near 45N/130W along with an attendant warm front moved into the southern Oregon Coast and overran a cold air mass originating from the Columbia River Gorge. This resulted in snow that gradually transitioned to freezing rain in the Gorge on Wednesday night into Thursday. The amounts of snow and ice varied greatly across the Columbia River Gorge, with heaviest amounts in the Central Columbia River Gorge zone. The combination of snow, ice, and wind resulted in the closure of I-84 between Troutdale and Cascade Locks. Based on ODOT and spotter reports, 4 to 10 inches fell in the stretch from Corbett to Cascade Locks, followed by a few hours of light freezing rain. Additionally, east winds gusted to 56 mph at Corbett, with higher gusts at Crown Point.

Taylor and Hatton (1999); Hazards and Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; https://www.fema.gov/disaster; https://www.ncdc.noaa.gov/stormevents

Probability

Table 2-551. Assessment of Winter Storms Probability in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Probability	H	H	H	H	H	H

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

Winter storms occur annually in Region 5. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Climate Change

There is no current research available about changes in the incidence of winter storms in Oregon due to changing climate conditions. However, the warming climate will result in less frequent extreme cold events and high-snowfall years.

Vulnerability

Table 2-552. Local Assessment of Vulnerability to Winter Storms in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	H	H	H	H	H	H

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

Table 2-553. State Assessment of Vulnerability to Winter Storms in Region 5

	Gilliam	Hood River	Morrow	Sherman	Umatilla	Wasco
Vulnerability	H	H	H	M	H	H

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

Within the State of Oregon, Region 5 communities are known for cold winter conditions. This region is the commodity flow route to Eastern Oregon. With long road closures the communities suffer from the loss of traffic and revenue. Drifting, blowing snow has brought highway traffic to a standstill. Also, windy and icy conditions have closed Oregon's principal east-west transportation route, I-84, for hours. In these situations, travelers must seek accommodations — sometimes in communities where lodging is very limited. For local residents, heating, food, and the care of livestock and farm animals are everyday concerns. Access to farms and ranches can be extremely difficult and present a serious challenge to local emergency managers.

Winter storms, particularly east of the Cascades where snow storms are typically more intense, bring larger amounts of snow and last longer. They can strand livestock in pastures, leaving them without food and water and exposed to extreme cold for long periods of time. As a consequence, substantial losses in livestock from starvation, dehydration and freezing, significantly impact producers, and state and local economies. In addition, water quality and health hazards develop when dead livestock are not retrieved until roads are cleared and vehicles can be used to remove the carcasses. Livestock buried under snow may not be found until the snow melts. The snowmelt may carry the carcasses to streams and wash them downstream.

Social Vulnerability

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

According to the CDC Social Vulnerability Index, Wasco, Umatilla, and Morrow Counties are highly socially vulnerable and the most vulnerable in Region 5.

Vulnerability in Morrow County is driven by an assortment of factors. The county is the most vulnerable in the state in terms of the share of residents without a high school diploma, the share of persons aged 17 or younger, the percentage of residents that speak English less than "well," the percentage of manufactured homes, and the percentage of occupied housing units with more people than rooms. The county is also in the 90th percentile for the percentage of minority residents and its low per-capita income.

Umatilla County has the highest percentage of single-parent households in the state and is in the 90th percentile for its low per-capita income, the share of residents without a high school diploma, and the percentage of persons aged 17 or younger.

Wasco County's high vulnerability is driven by moderately high scores across the CDC index. Notably, however, the county scores in the 80th percentile for its share of residents without a high school diploma, percentage of residents that speak English less than "well," and percentage of persons living in institutionalized group quarters.

Hood River County is moderately socially vulnerable; it scores in the 90th percentile for the percentage of minority residents, the share of residents that speak English less than "well," and the percentage of the population that lacks a high-school diploma.

Sherman County is one of the least socially vulnerable counties in the state but is in the 90th percentile for its share of manufactured homes. Gilliam County has low social vulnerability.

All the counties in Region 5 are vulnerable to the adverse economic impacts of winter storms. Morrow, Umatilla, and Wasco Counties are among those with the greatest social vulnerability in Oregon. Their very high social vulnerability indicates that the effects of winter storms will be felt more intensely by their populations than by those of other counties and will require more resources for preparation, mitigation, and response. Considered in combination with the importance of large truck commodity transport through this region and the costs associated with road closures, Morrow, Umatilla, and Wasco Counties are the counties most vulnerable to winter storms in Region 5.

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

The value of state-owned and leased buildings and critical facilities in Region 5 is approximately $895,361,000 representing the total potential for loss of state assets due to winter storms. The value of locally owned critical facilities is $1,080,652,000. Because winter storms could impact the entire region, these figures together represent the maximum potential loss to state assets and local critical facilities due to winter storms. Because the state is self-insured, FEMA funds are rarely used to cover damage to state assets from natural hazards. It is unclear from the Department of Administrative Services' records whether any losses to state facilities were sustained in Region 5 since the beginning of 2015. Thirteen losses were due to winter storms statewide. Of those, it is possible that up to four may have been located in the eastern portion of Region 5. These claims totaled a little over $72,000.

Risk

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

While the risk of winter storms for all counties in Region 5 is great, Morrow, Umatilla, and Wasco Counties' elevated vulnerabilities put them at greater risk than the others.