Oregon Geology Fact Sheet

Mount Hood Multi-Hazards Risk Study

Introduction

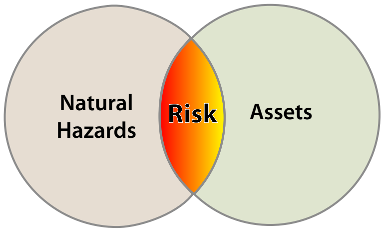
Geologic events like volcanic eruptions, landslides, floods, and earthquakes are the result of naturally occurring processes that have happened throughout the Earth's history. When these processes affect humans and the built environment (assets), they become natural hazards. Natural hazard risk assessment is the characterization of the intersection of natural hazards and assets.

Mount Hood, an active volcano in north-central Oregon, poses significant volcanic landslide, flood, channel migration, and earthquake hazards to nearby communities and to the Portland, Oregon, metropolitan area. Community assets (for example, people, roads, buildings, dams, and electrical systems) around the volcano are at risk from these hazards.

DOGAMI conducted a study in 2009-2011 to assist communities on and near Mount Hood to become more resilient to geologic hazards by identifying and mapping the hazards and the community assets in the study area and by performing exposure and risk analysis. A second purpose of the study was to explore hazard and risk analysis methodologies that could be applied to other volcanic areas.

The study area is approximately 526 square miles. Primary roads in the area are U.S. Interstate 84, U.S. Highway 26, and state routes 35 and 281. The primary hydrologic drainages in the area are Hood River; West, Middle, and East Forks of Hood River; and Sandy River. Cities and communities in the study include The Villages at Mt. Hood, Sandy, Government Camp, Odell, and Hood River; parts of Fairview, Gresham, Troutdale, Wood Village, and Damascus; and some unincorporated areas in Multnomah, Clackamas, and Hood River counties.

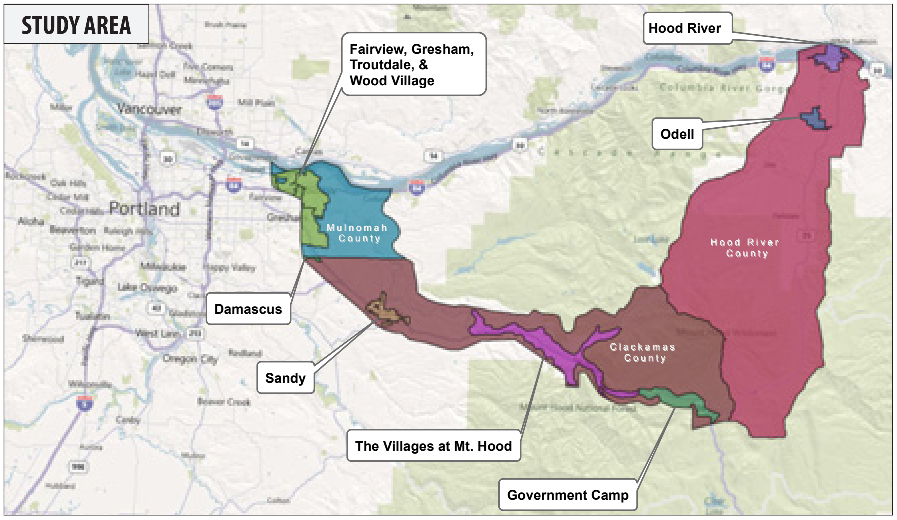
Hazards and community assets were identified through stakeholder input and reviews of existing data. The hazards mapped include volcano, landslide, flood, channel migration, and earthquake. The assets mapped include critical facilities, primary infrastructure, generalized land use/zoning, buildings, and population. **DOGAMI Open-File Report O-11-16** summarizes the methodologies used, presents detailed results of the risk analysis, and includes seven thematic map plates that show hazards and assets. An interactive web map (http://www.oregongeology.org/sub/mthood/) also provides a way to access this information.



Risk analysis can range from very simple to very complicated. In this project we selected two types of risk analysis to explore: 1) hazard and asset exposure and 2) Hazus-MH, a Federal Emergency Management Agency package that estimates physical, economic, and social impacts of a disaster. This study used both methods to explore risk analysis for future studies on other volcanoes.

◀ *Majestic Mount Hood is home to many people and playground to even more. But this picturesque giant can generate a multitude of geologic hazards. The White River drainage, in the foreground, is an example — in 2006 very damaging debris flows destroyed a stretch of Highway 35.*

▼ *Risk study extent.*



Key findings from Mount Hood multi-hazards risk study

Hazard	Permanent Population Exposed	Buildings Exposed	Critical Facilities Exposed*	Roads (Miles) Exposed	Economic Value (B = billion; M = million)
Study area inventory	83,000	47,700	104	1,600	$12.5B (**$15.5B**)
Volcano (500-year)	3,843	3,731	7	271	$1,515M (**$571M to $963M**)
Landslide (large deep landslides and debris flow fans)	1,027	1,419	1	142	$336M
Flood (500-year)	764	235 (**279†**)	0	13	$93M (**$92M**)
Channel migration (100-year)	1,054	985	0	34	$274
Earthquake (500-year shaking)	65,329 (**casualties & fatalities ~50 to 500**)	36,018 (**9,047†**)	59 (**51 with functionality >50% 1 day after event**)	793	$9,163M (**$1,214M**)

The results are primarily from the exposure analysis with Hazus-MH (boldface) results in parentheses. Boldface is used only to help visually differentiate the results; one should not infer that these results are necessarily more accurate or more valid.

*Critical facilities include school, police, fire, and hospital buildings.

†Moderate to total damage.

Assets Mapped

- **Critical Facilities**

Critical facilities are typically defined as school buildings and emergency facilities such as hospitals and fire and police stations. Because of their function and capacity, these facilities are especially important should a disaster strike.

- **Primary Infrastructure**

Primary infrastructure includes high-voltage electric transmission lines and substations, major dams and reservoirs, wastewater treatment plants, railroads and rail bridges, airports, and all highways, arterial roads, and bridges.

- **Land Use/Zoning**

Evaluating risk includes understanding how land and the built environment may be affected in a disaster and what the economic impacts may be.

- **Population**

Population density is needed to accurately estimate losses from disasters. The data were divided into four population density classes: very low to none, low, moderate, and high.

Hazards Mapped

- **Volcano**

The Cascade Range is part of a chain of volcanoes that parallel the coast of northern California, Oregon, Washington, and southern British Columbia. Mount St. Helens is an example of a recently active volcano in this chain. Volcanic activity can produce hazardous events including fallout of tephra (volcanic ash), lahars (volcanic mudflows or debris flows), pyroclastic flows (avalanches of hot volcanic material), lava flows, and landslides.

Proximal hazard zones–Volcano hazard zones can be divided into proximal (near the volcano) and distal (far from the volcano) Only proximal hazard zones and lahars (a distal hazard) were evaluated in this study. Proximal hazard zones extend from the summit out to around 15 miles and are areas subject to several types of hazards such as rapidly moving landslides, pyroclastic surges, and debris avalanches.

Lahar hazard zones–Lahars, or volcanic debris flows, are water-saturated mixtures of soil and rock fragments that can travel very long distances (over 60 miles) and as fast as 50 miles per hour in steep channels close to a volcano.

- **Landslide**

Landslides include rock falls, debris flows, earth slides, and other mass movements. Three types of landslide hazards were mapped:

Deep-seated landslides have failure surfaces usually tens of feet below the surface and can cover large areas from acres to square miles. These types of landslides tend to move relatively slowly (less than an inch per year) but can lurch forward if shaken by an earthquake or if disturbed by removal of material from the toe, by addition of material to the head, or by addition of water into the slide mass. Deep-seated landslides are hazards because they can fail again. **Debris flows** start in the upper portion of a drainage, then pick up water, sediment, and speed as they travel down a drainage. When debris flows reach the mouth of the confined or steep portion of the drainage, they tend to spread out and deposit most of their material in a fan-shaped area. Other types of landslides that occur on slopes near a channel or accelerated erosion during heavy rainfall or snowmelt can initiate debris flows. Debris flow deposits are hazards because future debris flows are likely to cover some of the same areas as past events and loose material can move again if disturbed by earthquakes or heavy rains. **Steep slopes** are areas that are more susceptible to landsliding.

Summary of selected asset inventory data for the entire study area (B = billion)

Asset	Count/Area/Value	Percent of Study Area
Permanent population	82,937	
Residential parcels/area/value	31,665 / 54 mi^2 / $3.65 B	74% / 11% / 63%
Commercial parcels/area/value	9,856 / 147 mi^2 / $1.79 B	23% / 30% / 31%
Public parcels/area/value	1,517 / 283 mi^2 / $0.30 B	4% / 58% / 5%
Residential buildings/value	35,094 / $4.56 B	74% / 70%
Commercial buildings/value	11,655 / $1.81 B	24% / 27%
Public buildings/value	795 / $0.67 B	2% / 9%
Hospital buildings	2	
School buildings	71	
Law enforcement buildings	7	
Fire department buildings	24	
Roads	1,446 miles	
Road bridges/crossings	340	
Electric transmission lines	615 miles	
Primary dams	13	
Wastewater treatment	7	
Airports	8	

Parcels and buildings are shown as separate items to highlight the difference between land (i.e., parcels) and land improvement (i.e. buildings) data.

- **Flood**

Most flooding in the study area occurs during large winter and spring storms when heavy, warm rain falls on accumulations of low-elevation snow. Floods cause damage to buildings and infrastructure by simple inundation and by erosion.

- **Channel Migration**

Channel migration hazards can occur slowly over time or very rapidly during storm events. Loose sediment is easily eroded and transported during floods, amplifying channel migration processes downstream. Rapid migration can destroy structures and even remove the land under structures.

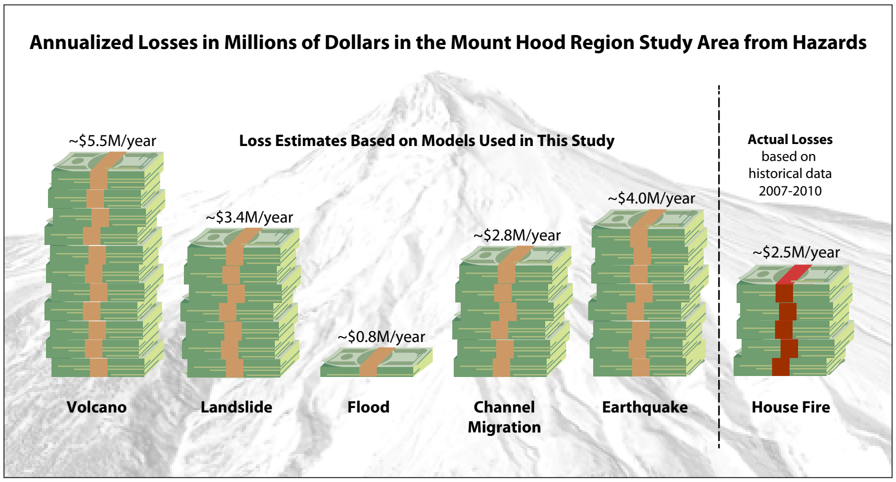
- **Earthquake**

Earthquake effects are a significant threat in the study area and come from three main sources: the Cascadia Subduction Zone, crustal faults, and volcanic activity. When an earthquake occurs, seismic waves radiate away from the epicenter. The strength and duration of shaking at a site are dependent on the size of the earthquake, distance from the epicenter, and soil characteristics at the site. The damaging effects of earthquakes can be enhanced by amplification of shaking in soft soils, by liquefaction, or by earthquake-induced landsliding.

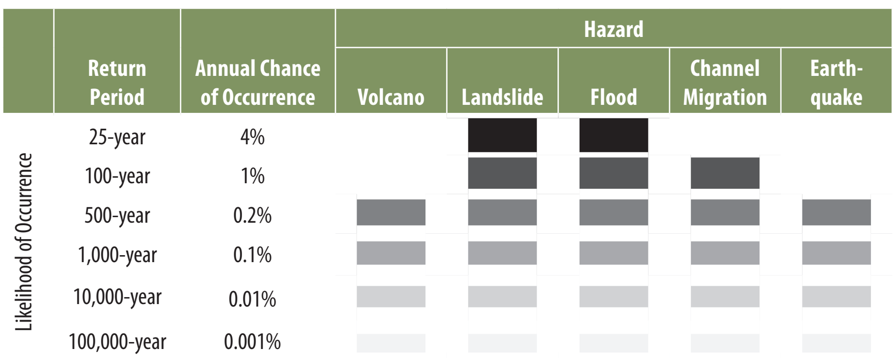
Shaking–The 500-year probabilistic shaking layer shows the estimated shaking strength from all sources and includes the likely amplification of ground shaking due to soft soils at a site.

Liquefaction–During earthquake shaking, deposits of loose saturated silt, sand, and gravel can become "liquefied," thereby losing strength and thus the ability to support loads. Structures can tilt or sink, and soil can spread and flow on very gentle slopes, often moving inches to yards. The damage resulting from liquefaction can be far greater than that caused by earthquake shaking alone.

Faults–Movement on geologically recent faults can produce earthquakes; if faults rupture to the surface, they can cause ground failure.



▲*Comparison of annualized estimated future losses in the study area in millions of dollars compared with actual losses from fire hazard. Volcano, landslide, flood, channel migration, and earthquake losses are based on modeled analysis in this study. Fire data are from Oregon State Fire Marshall 2007-2010 historical records.*



Conclusions

- Flood, channel migration, and landslide hazards generally have shorter return periods on the order of 10 to 100 years with economic loss ratios (ratio of total value of assets in the study area to estimated loss value from the hazard) estimated to be in the range of 0.5% to 5%. Earthquakes and volcanic eruptions have generally longer return periods on the order of hundreds to thousands of years, but these hazards have much higher estimated loss ratios, in the range of 5% to 25%. The Villages at Mt. Hood have the highest multi-hazard risk within the study area.
- This report demonstrates the necessity of high-resolution lidar data for multi-hazard mapping including locating landslides and faults, and redelineating flood and volcanic lahar inundation hazard zones. The accuracy and fine-scale resolutions of the hazard, asset, and risk data make the results more credible and thus more likely to be useful in risk reduction.
- Two methods of risk analysis, hazard and asset exposure analysis and Hazus-MH based risk analysis, were used. Hazus-MH (Hazards U.S. Multi-Hazard), a nationally applicable standardized methodology that estimates potential losses from earthquakes, hurricane winds, and floods, was developed by FEMA. Depending on the hazard being studied and the end objective, both methods have advantages and disadvantages. Both methods should be used to help understand where limited resources should be directed.

◄ *Some hazards occur more frequently, every few decades or centuries, while others are less frequent, occurring every few centuries to millennia.*

Summary of hazards and community asset exposure for the study area (M = million)

	Permanent Population (Count)	Buildings (Building Count/$Value)	Generalized Land Use/Zoning Parcels (Count / $ Value)	Critical Facilities	Primary Infrastructure (All Roads, Miles)
Volcanic Hazard					
Proximal	2,129	1,604 / $242 M	2,995 / $208 M	8	287
Lahar 10-year	163	120 / $32 M	520 / $19 M	0	22
Lahar 100-year	473	531 / $92 M	1,633 / $71 M	0	91
Lahar 500 to 10,000-year	3,843	3,731 / $663 M	7,120 / $402 M	7	271
Lahar 100,000-year	14,635	9,897 / $1,510 M	13,082 / $1,364 M	21	525
Landslide Hazard					
Deep-seated landslides	319	169 / $17 M	737 / $31 M	0	32
Debris flow fans	708	1,250 / $180 M	3,180 / $108 M	1	110
Steep Slopes	958	42 / $9 M	2,591 / $90 M	0	38
Flood and Channel Migration					
Flood 25-year	624	114 / $16 M	2,340 / $41 M	0	7
Flood 500-year	764	235 / $36 M	2,631 / $57 M	0	13
Channel migration 100-year	1,054	985 / $154 M	2,509 / $120 M	0	34
Earthquake Hazard					
Shaking 500-year	65,329	36,018 / $5,058 M	32,932 / $4,105 M	59	793
Liquefaction	18,686	12,640 / $1,877 M	15,070 / $1,878 M	32	598
Fault zone	5,900	2,631 / $347 M	3,021 / $238 M	7	111

WHAT IS THE RELATIONSHIP BETWEEN RETURN PERIOD AND ANNUAL CHANCE OF OCCURRENCE?

Return Period	Annual Chance of Occurrence
25-year	4%
100-year	1%
500-year	0.2%
1,000-year	0.1%
10,000-year	0.01%
100,000-year	0.001%

For example, a 100-year flood has a return period of 100 years, which means that it occurs on average once every 100 years; or, it has a 1% chance of occurring in any one year.

Learn more about Oregon's geology at www.OregonGeology.org

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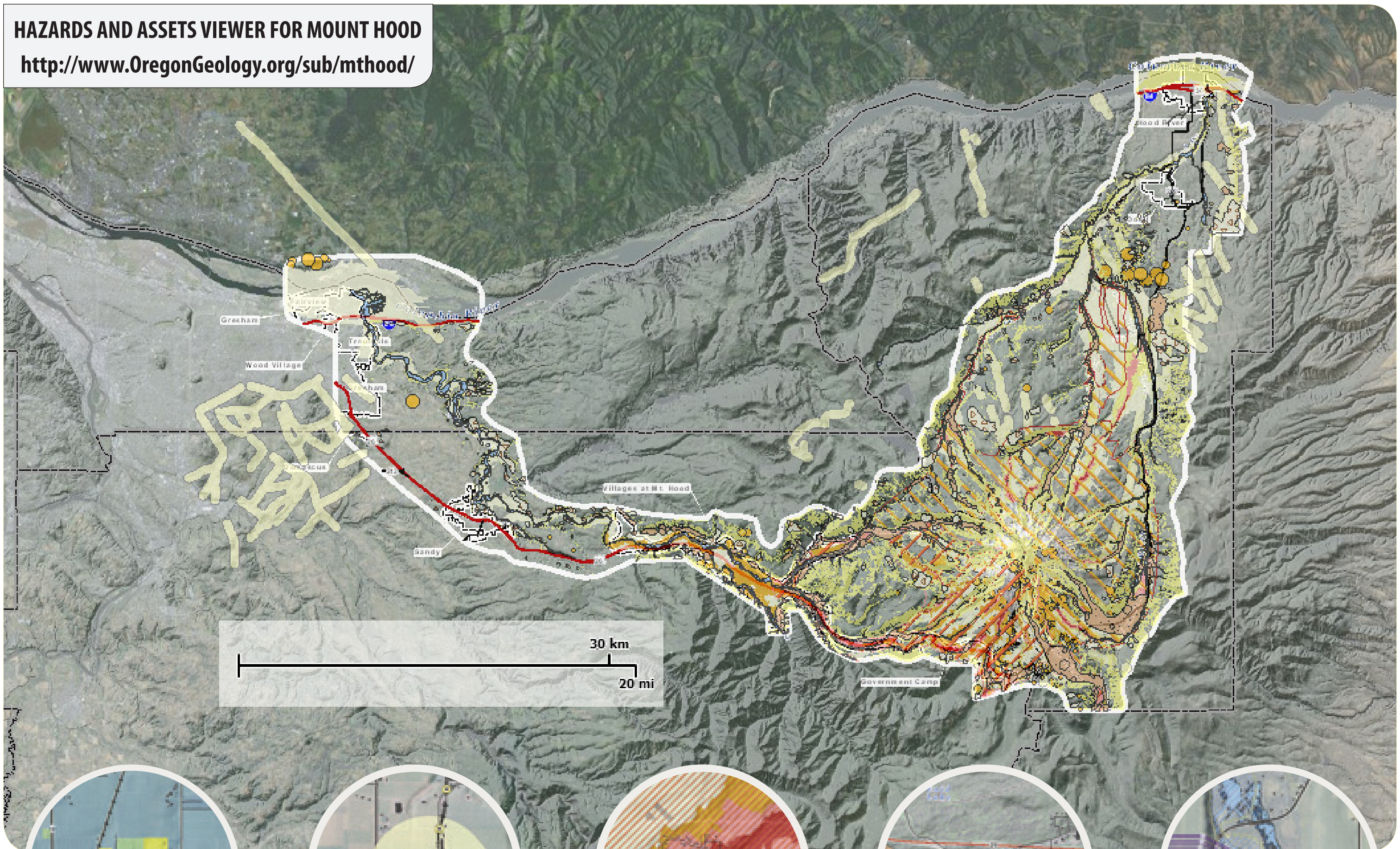
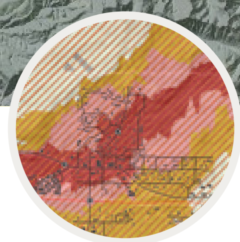
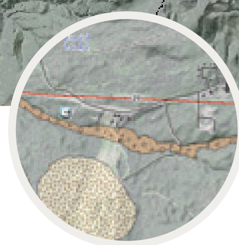


Population / Infrastructure / Building Footprints / Zoning / Critical Facilities

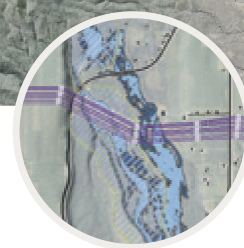
Earthquake / Fault / Shaking / Liquefaction



Volcano / Lahar



Landslide / Debris Flow



Flood / Channel Migration

RESOURCES AND PARTNERS

For more information about this study, its methods, limitations, conclusions, and results, contact:
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DOGAMI Mount Hood Hazards and Assets Viewer
http://www.oregongeology.org/sub/mthood/

Federal Emergency Management Agency
http://www.fema.gov/

Oregon Emergency Management
http://www.oregon.gov/OMD/OEM/

U.S. Geological Survey Cascades Volcano Observatory
http://vulcan.wr.usgs.gov/

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Mount Hood Coordination Plan: Coordinating Efforts Among Governmental Agencies in the Event of Volcanic Unrest at Mount Hood, Oregon
http://www.oregon.gov/DOGAMI/earthquakes/MtHood.shtml

Oregon Lidar Consortium (OLC)
http://www.oregongeology.org/sub/projects/olc/default.htm

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