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Testimony
Before the United State House of Representatives Committee on Natural Resources
Subcommittee on Energy and Mineral Resources

"Volcano Hazards: Exploring the National Preparation and Response Strategy"

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Chairman Lamborn and members of the Subcommittee, it is my pleasure and honor to appear before you today to discuss the role of basic research in informing domestic volcano monitoring in Oregon and determining the potential impacts on our communities. I would also like to thank Representative DeFazio for this opportunity and for his leadership on the Natural Resources Committee to address a wide array of issues of importance to Oregon and Oregon State University.

I am a professor of Geology and Geophysics at Oregon State University. There I focus my research on understanding volcanic activity and associated hazards around the "Pacific Ring of Fire" that the Cascade Range of North America is part off. Prior to this appointment, I served as Professor and Chairperson of the Department of Space Studies at the University of North Dakota, and the Director of the North Dakota National Aeronautics and Space Administration (NASA) Space Grant Consortium and the North Dakota NASA Experimental Program to Stimulate Competitive Research (EPSCoR) Program. I started my career as a post-doctoral scientist at the Lunar and Planetary Institute, Houston, Texas. I am a Fellow of the Geological Society of America and Science Editor for the journal Geosphere, published by the Geological Society of America.

High Risk Volcanoes in the Cascade Range

The western edge of North America is a zone of intense tectonic and volcanic activity. Two major tectonic plates of the earth, the oceanic Juan de Fuca plate and the continental North American plate, meet at this western edge and their opposing motion results in earthquakes, mountain building, and volcanoes. Consequently this is one of the most hazardous regions in the United States from a natural hazards perspective. Volcanic hazards here are focused on the Cascade Range.

The Cascade Range, stretching from British Columbia to northern California is the most recent manifestation of volcanic activity in this region with eight major eruptions in the last 200 years and at least 50 in the last 4000 years. This represents on average, two multi-year eruptions per century (page 1, Appendix 1). Of the 17 volcanoes in the entire United States that have been identified as Very High Threat, 10 are Cascades volcanoes. Volcanic activity in the Cascades Range therefore presents the greatest volcanic hazard to the states of Oregon, Washington, and California. Eruptions from the Cascade Range volcanoes can also affect adjacent states, such as Idaho, Montana, and Nevada because ash from eruptions can be distributed far downwind.

In the United States, the state of Oregon has the distinction of being one of the regions with the widest array of volcanic features. Virtually every class of volcano and style of activity is represented in Oregon. Effusions of basaltic magma have produced volcanic landforms that range in scale from regional plateaus of flood basalts, shield volcanoes, to cinder cones. At the other end of style spectrum, violent explosive ash-dominated eruptions of andesite and rhyolite produce landforms like caldera volcanoes. These features define an approximately 150 million-year history of volcanic activity in Oregon.

The evidence of Oregon's volcanic legacy is found throughout the state. The Columbia River Plateau on the eastern side of the state, the High Lava plains to the east from Bend, and the John Day region are all the product of now extinct volcanic activity. Recent volcanic activity in Oregon, defined as eruptions that have occurred in the last 10,000 years, and current (historic) volcanic activity is focused along the Cascade Range, where 116 geologically young vents have been identified (page 2, Appendix 1). Many of these are small cinder cones and lava flows that were short-lived (a few months to a year in duration), but include four of the aforementioned 10 Very High Risk volcanoes of the Cascades. These are, from north to south, the large composite volcanoes of Mount Hood, the Three Sisters, Newberry volcano, and Crater Lake. Other large composite volcanoes like Mount Jefferson are considered dormant but not extinct.

Risk of Volcanic Activity in the Cascade Range

Future eruptions in the Cascades are certain and clearly present the greatest volcanic threat to the state of Oregon, including local and regional populations and infrastructure. The city of Portland is built on and around the small volcanoes and lava flows of the Boring Volcanic Field. Bend is built on and surrounded by the products of eruptions from Newberry and the Three Sisters. Mount Hood, located just 50 miles to the east of Portland and an important water resource for the metropolitan area, is of particular concern. The Three Sisters and Newberry volcano are in close proximity to the city of Bend. Eruptions from the Three Sisters, located on the Cascade crest could affect water quality, waterways, and transportation infrastructure in the Eugene and Corvallis areas of the Willamette valley. Significant hazard to infrastructure is therefore to be expected.

The most common young volcanic activity in the Cascades has been the eruption of small cinder cones or lava flows such as those on the crest of the Cascades along the McKenzie Highway. Such eruptions have been a regular and constant feature of the volcanic activity of the Cascades. Probabilistic analysis suggests that this type of eruption is the most likely event in the Oregon Cascades.

The impact of eruptive activity from any of the aforementioned volcanic centers is likely to be mainly local to regional in extent. The most likely eruptions are thought to be effusive lava flow activity and small ash producing eruptions. No major explosive eruptions, such as the 7700 year ago Mount Mazama eruption that formed the caldera of Crater Lake, are considered a short term likelihood, although any form of volcanic eruption cannot categorically be ruled out. Maximum impact from likely eruptions may extend a few kilometers from the volcano, while mudflows may sweep several 10's of kilometers down drainages of the Cascade crest into the Willamette Valley. Ash fall will primarily be to the east based on studies of past deposits and current prevailing winds. Impact on transportation and infrastructure may be significant.

An under-appreciated but growing concern is the impact of volcanic activity on air transportation. Recent eruptions in Europe and South America have brought the potential impact of ash on aviation safety to the entire world. Each day over 2000 flights pass over Oregon, which is approximately 200,000 passengers per day (page 4, Appendix 1). Even a small ash eruption could cause significant disruption.

While the focus of volcanic hazard assessment for Oregon is naturally on the volcanoes within the state borders, it is important to remember that hazards from nearby volcanoes are also a very real threat to the economy, infrastructure, and population of Oregon. Mount St. Helens and Mount Adams in Washington to the north are of particular concern. Ash from the Mount St. Helens eruptions of 1980 – 1986, and 2004 – 2008 caused closure and disruption of operations at Portland Airport. Mount Adams, which has recently been identified as a very weak volcano with a strong for potential flank collapse, could have a severe impact on the Columbia River, and associated commerce. In California, activity from Mt. Shasta, Medicine Lake volcano, and the Lassen Volcanic Complex could impact Oregon.

Risk Assessment and Monitoring

Assessing Volcanic Hazard and Risk is the purview of the Cascade Volcano Observatory (CVO) of the United States Geological Survey (USGS). The Oregon Department of Geology and Mineral Industries (DOGAMI) is the state entity responsible for volcanic hazard assessment. These two organizations work in tandem, with the USGS leading and DOGAMI supporting and augmenting efforts. Volcanic crises are managed by these two agencies and any official voice on hazards and risk is limited to these organizations.

Hazard assessment requires a multitude of complex data. The most fundamental information is a baseline understanding of the volcanic activity through unraveling the volcanic history of a volcano. The past activity at a volcano is the best indicator of any future activity. This is a long term, often decade long endeavor, resulting in a geologic map of the volcano that places the volcanic products in a temporal and spatial context. Allied to this are studies that characterize the chemical and physical character of the erupted products. This defines the long-term character of the volcano.

A “snapshot” of the current state of a volcano is provided through active monitoring through geophysical surveys attempting to detect signals from the volcano (seismic, Global Positioning System (GPS), gas monitoring). This reveals details of the current state of the magma storage and feeder systems to the volcano. In the Oregon Cascades, volcano monitoring infrastructure has been installed at Crater Lake, Three Sisters, Mount Hood, and Newberry over the past 12 years. Such monitoring infrastructure is critical. Over the last 12-month period, over 177 earthquakes have been recorded beneath Mount Hood (page 5, Appendix 1). In 2001 a broad area of uplift was discovered to the west of South Sister. Between 1997 and 2010 this area rose about 10 inches. Although these “signals” have not lead to eruption they are crucial indicators of activity beneath these two hazardous Oregon volcanoes and wouldn't have been detected without a monitoring infrastructure.

The critical importance of basic monitoring infrastructure can be further underscored by the example of Newberry volcano, which from 1980 to 2011 had one seismometer installed. This instrument detected virtually no activity beneath the volcano. In 2011, eight seismic/GPS sites were installed. This new denser network has revealed a 20-fold higher level of earthquakes here. We now know that Newberry volcano is at least as active as Mount Hood, which erupted last 230 years ago (page 6, 7, Appendix 1). Prior to this, the state of Newberry’s activity was not understood.

The small seismic and geodetic network at Crater Lake is another example. This was completed by CVO in 2011. The network consists of just three seismic stations, making earthquake locations difficult to determine unless events are large enough to be recorded on stations outside of Crater Lake National Park. A series of events on October 25, 2013 were too small to be recorded outside Crater Lake (the largest was a M ~0.8), and so locations could not be determined.

These examples clearly promote the need for basic infrastructure at Oregon’s Cascade volcanoes. It often takes several years to fully understand the normal background seismicity level at individual volcanoes, without which a seismic crisis cannot be placed in its correct context. This is why it is important to install seismic networks, as well as networks of other types of sensors, many years before any volcanic unrest begins. At present none of Oregon’s volcanoes are adequately instrumented to fully determine their state of activity, although plans are in place (page 8, Appendix 1).

A third piece of the volcanic hazard puzzle is the delineation of areas likely to be impacted by volcanic activity. Hazard maps such as those for Mount Hood (page 9, Appendix 1) and Three Sisters (page 10, Appendix 1) are based on an analysis of topographic control of surface flows such as lahars (mudflows) and calculation of travel times using knowledge of the fluid dynamics of the flows. Such maps can be used to predict travel paths and warning times to define the hazardous areas. Similar maps are made for ash fall hazard based on knowledge of how ash infections into the atmosphere would be transported by winds.

These geological constraints provide the basis for determining the probability of future activity at a volcano. In anticipation of a volcanic crisis, this information is integrated with efforts of local, county, city, and tribal entities to develop a coordination plan for the volcano. These efforts require significant investment of time, effort, and infrastructure. At present a comprehensive coordination plan in Oregon exists for only Mount Hood.

Importance of Basic Research

The academic community in Oregon supports the mission of the agencies and augments these efforts to the fullest extent we can through basic research. These efforts of my colleagues and I at Oregon State University, the University of Oregon, and Portland State University as well as efforts in community colleges provide vital support to the USGS and DOGAMI.

Most academic research pursues answers to fundamental questions that are vital to an informed hazard assessment. These efforts are driven by the recognition that volcanic hazard research is a geographic imperative in Oregon – it is part of Oregon's geologic heritage. At Oregon State University, the College of Earth, Ocean, and Atmospheric Sciences houses one of the largest groups of volcanologists in the world. Our efforts have recently provided new constraints on how to interpret geophysical signals of unrest at active volcanoes, the time scales over which magmas are stored and induced to erupt, as well as the conditions that lead to eruption. While such studies are based on long-term efforts of individual investigators funded by the U.S. National Science Foundation, some studies are opportunistic. For instance, a recent seismic experiment at Newberry Volcano provided details of the magma storage region that reveals new details of the current state of activity of this important volcano. This experiment, headquartered at the University of Oregon, piggy-backed on a larger scale seismic experiment in eastern Oregon (also funded by the U.S. National Science Foundation) focused on understanding the structure of the Earth not designed for active volcanism or volcanic hazard assessment. Coordinated, multi-institutional efforts also exist. As of May 2014, the iMUSH project has started a series of seismic and magnetic experiments to illuminate the architecture of the Mount St. Helens magmatic system from source to surface. This four-year collaborative research project involves several institutions including Oregon State University and is also supported by the U.S. National Science Foundation.

Central to the academic community efforts is education and outreach. The academic environment is the primary outlet for education and community outreach and classes about volcanism in the Cascades abound. Over a 1000 students enroll in classes where they are exposed to aspects of volcanic hazards in the Cascades each year at Oregon State University, and similar numbers can be expected at other institutions. These formal efforts are allied to regular community outreach, as well as web and social media based outreach that expand the knowledge throughout Oregon and worldwide.

A core mission of the academic community is also the training of the next generation of volcanologists. Oregon's volcanic legacy has attracted a world-renowned human and intellectual capital and scientific infrastructure that in turn attracts the best and brightest graduate students to Oregon. Oregon is thus a destination for the best and brightest young minds interested in volcanoes. This provides a significant human capital that can be invested in studies that inform volcanic hazard in Oregon and the Cascades in general. At present this capital is deployed in a piecemeal way driven largely by the research agendas of individual professors. While this has served volcanic hazard research in the Cascades well, opportunities to better integrate the efforts of the academic community with agency efforts exists.

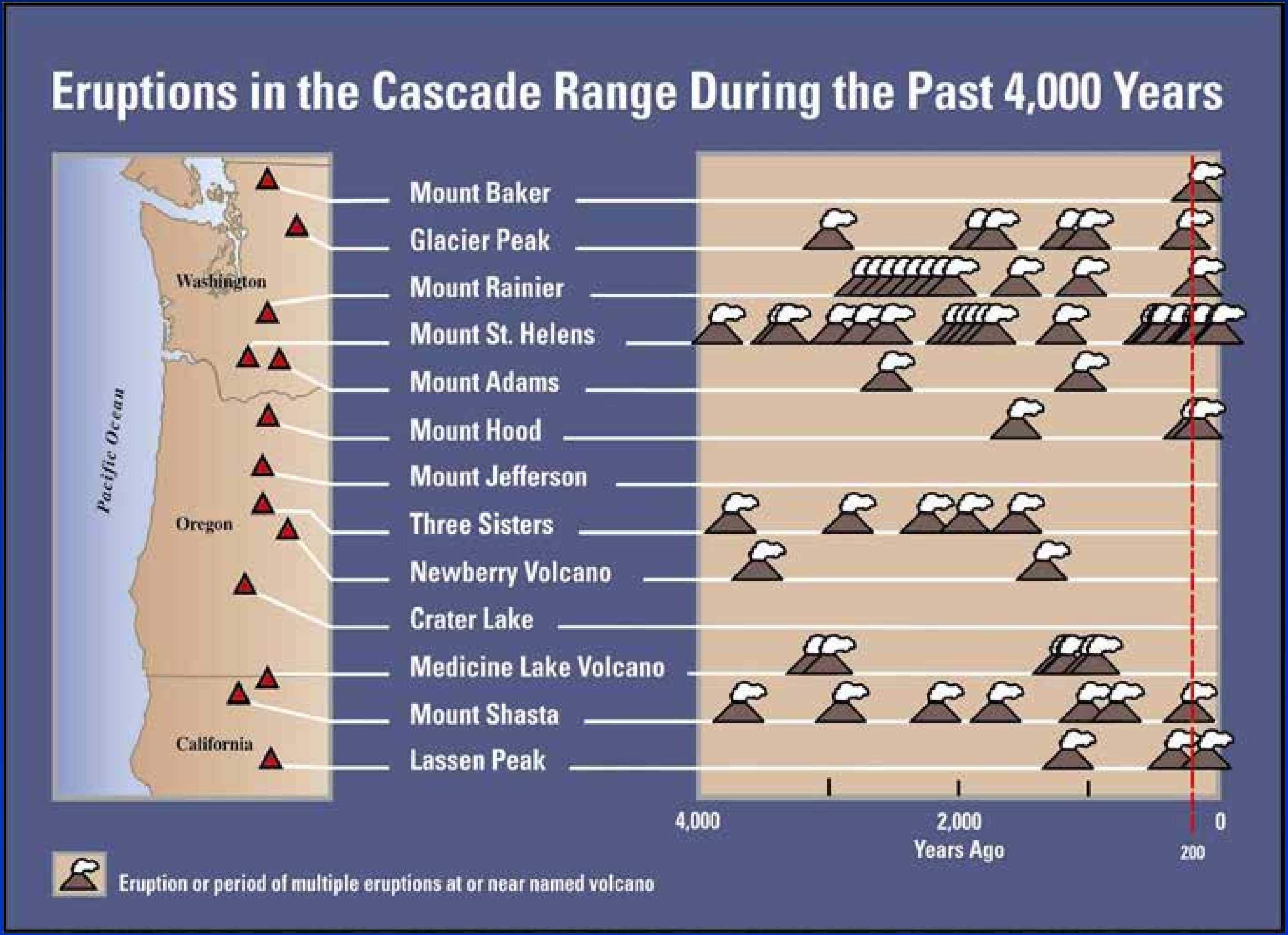
Academic institutions thus play a vital role in conducting basic research to inform volcanic hazard analysis and monitoring, educating our next generation of scientists, and facilitating outreach to the community to prepare for any potential impact. A significant human and intellectual capital is available in the academic community to assist with volcanic hazard assessment and this could be deployed in a coordinated way to relieve some of the strain on agency resources.

I am honored to have had this opportunity to appear before you today and I am pleased to address any questions that the Committee may have on Oregon State University's role in conducting research to expand our understanding on volcanic activity in the Cascade Range and for helping our state and federal partners to assess and prepare for any potential impacts.

Thank you.

Cascades volcanoes will erupt again

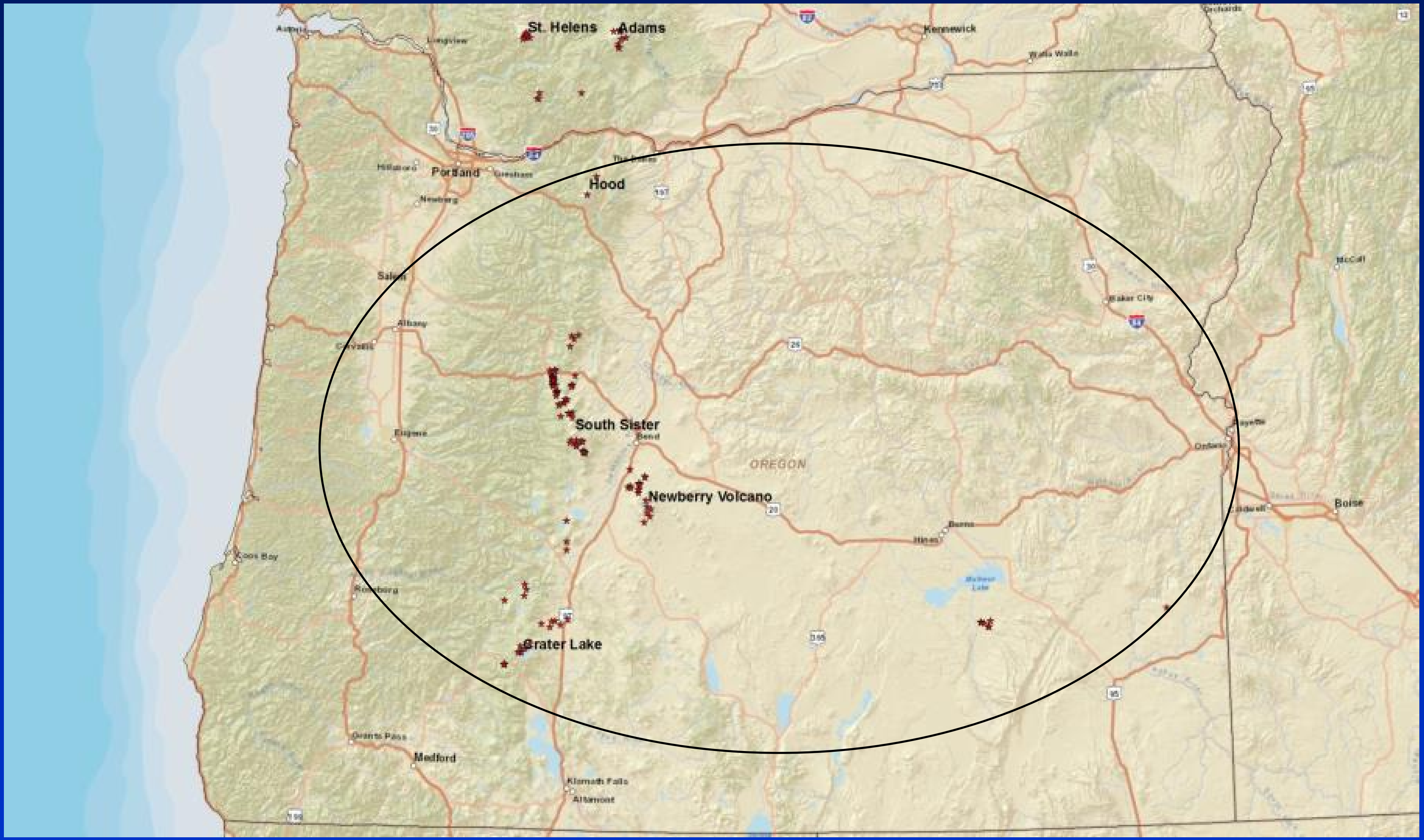
Cascade volcanoes have long life spans and recent histories



On average, two multi-year eruptions per century.

USGS

At least 116 geologically young volcanic vents in Oregon!



2 at Mount Hood
6 at Crater Lake

16 at South Sister
19 at Newberry

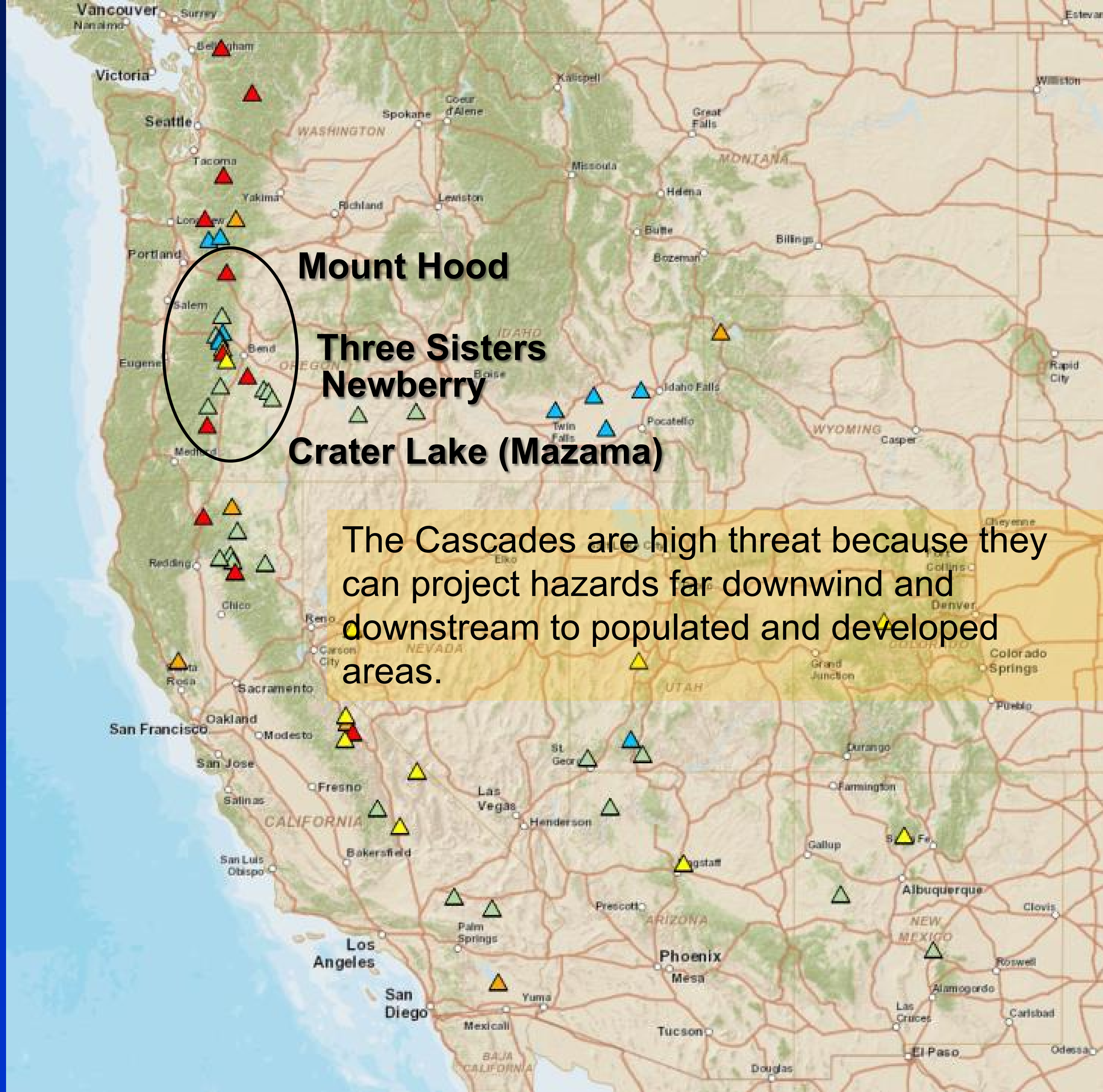
All are on Federally-managed lands

USGS

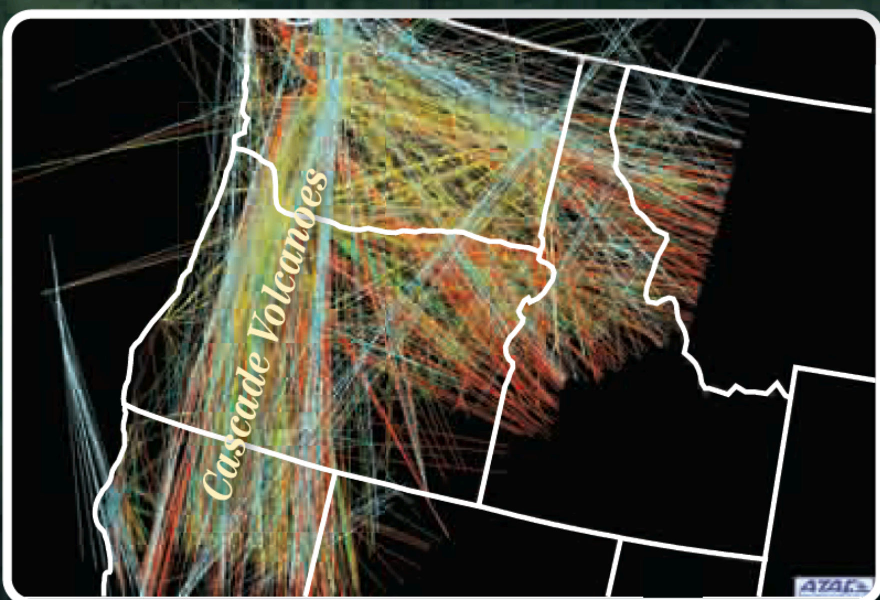
2005 National Volcanic Threat Assessment

Threat Level

- *Very High*
- *High*
- *Moderate*
- *Low*
- *Very Low*



10 of 17 U.S. volcanoes identified as Very High Threat are Cascades volcanoes. Four of these are in Oregon.

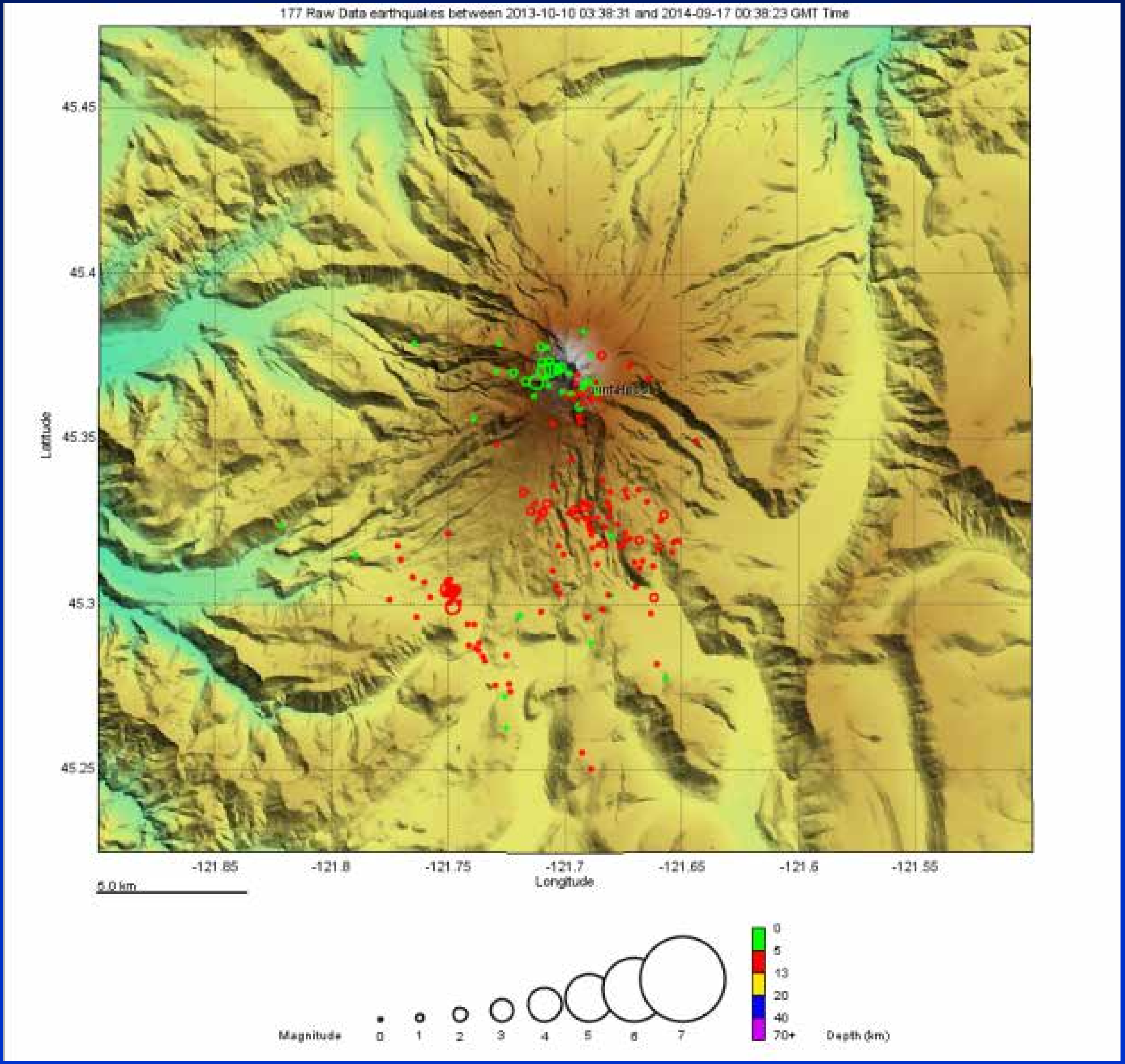


Source:Federal Aviation Administration, Seattle Air Route Traffic Control Center

The tracks of typical jet air traffic in a 24 hour period over the Oregon Cascades. There are approximately 2,000 flights over Oregon per day — that's a minimum of 200,000 passengers! Ash from eruptions would be a major hazard because the ash, composed of silica, reacts with the heat from jet engines turning it into molten glass coating the engine's components.

Activity at Mount Hood

The previous 12 months of earthquake activity at Mount Hood includes 177 located earthquakes.



USGS

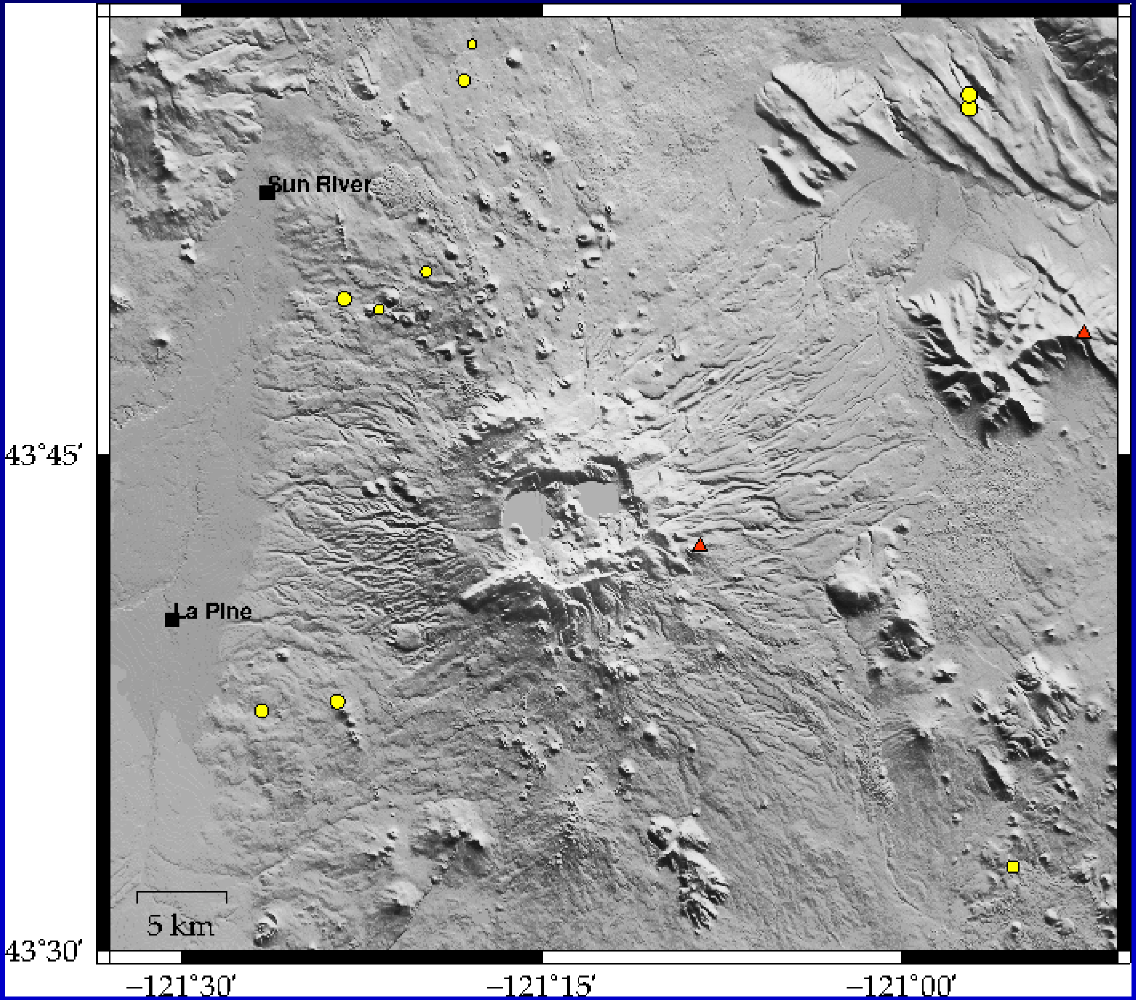
Activity at Newberry Volcano

Seismic monitoring

1980-2011:

- 10 earthquakes
- 0 within 10 km.
- Only 1 seismometer

Most recent eruption was ~1300 years ago.



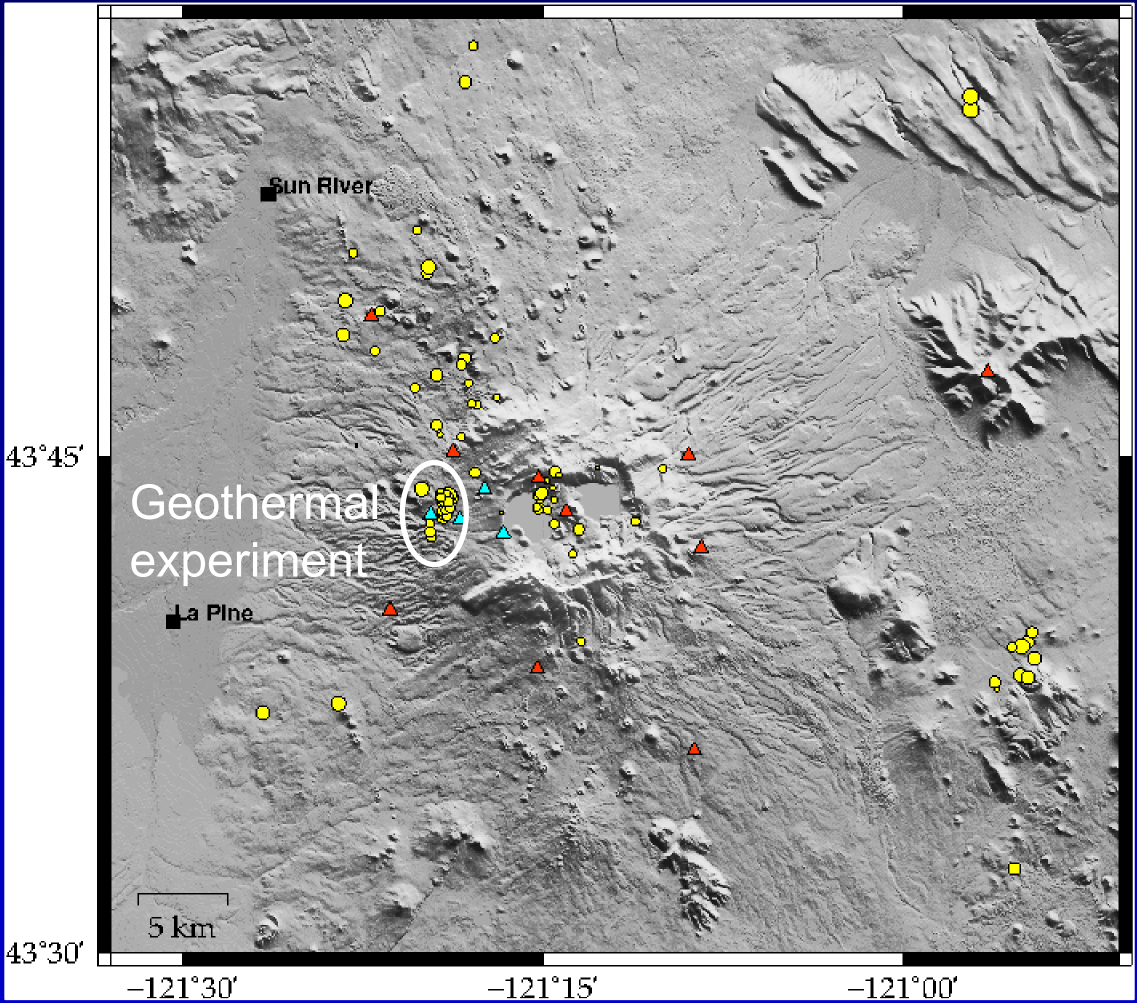
What changes when modern monitoring is installed??

USGS

Newberry
seismic monitoring

1980-2013:
- **189 earthquakes**
- **160 within 10 km**

Eight seismic/GPS sites were installed in 2011

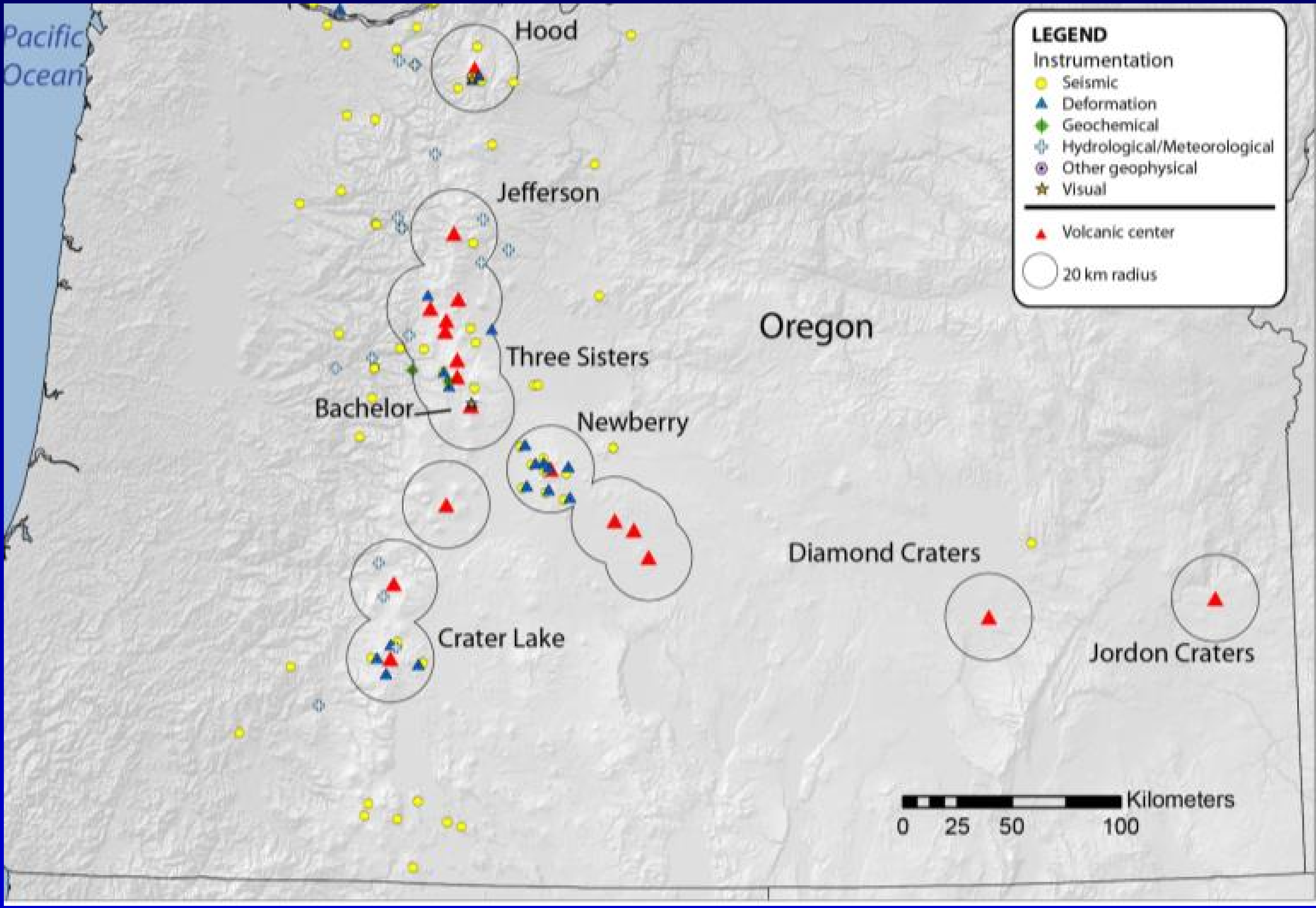


We now know that Newberry volcano is at least as active as Mount Hood (which erupted 230 years ago).

USGS

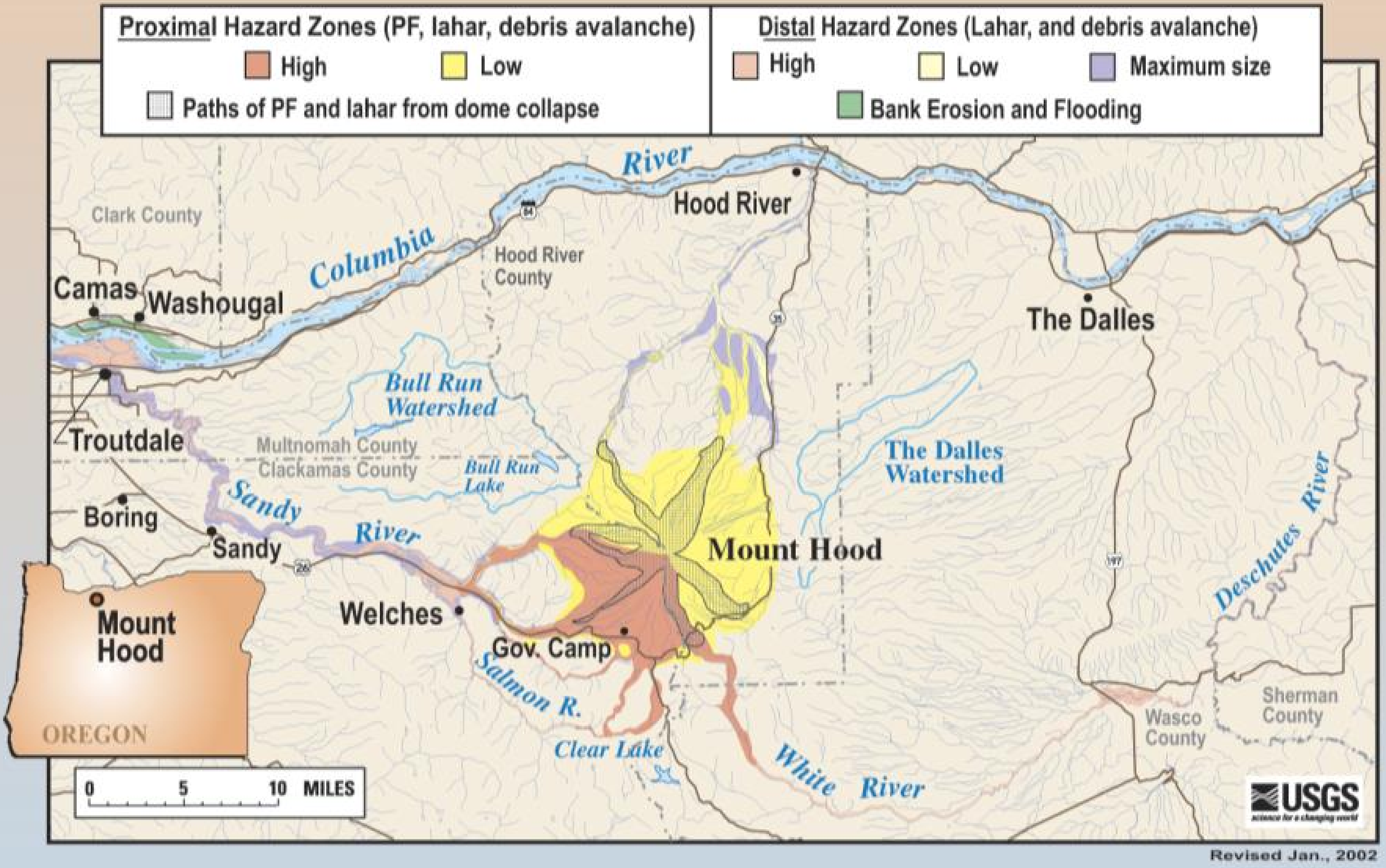
Current status of volcano monitoring networks in Oregon

Since 2001:
Seismic and GPS instruments added at Three Sisters, Crater Lake, and Newberry Volcanoes. Permitting process underway at Mount Hood.



USGS

Mount Hood



USGS

*Three Sisters Hazards*s