Quake-triggered landslides pose significant hazard for Seattle, new study details potential damage

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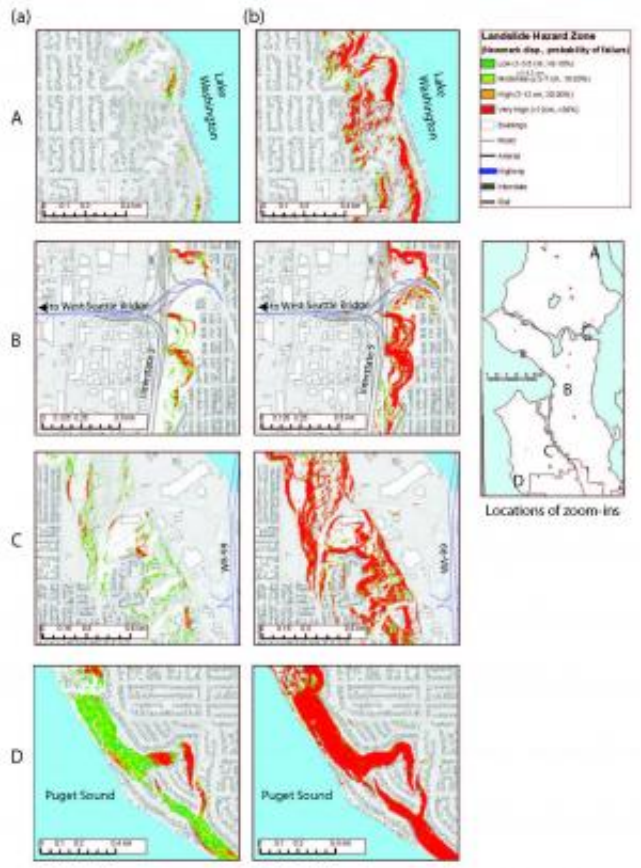

Locations of each zoom-in are shown on the map of Seattle at right. A) Coastal bluffs in the northern part of Seattle are most affected when soils are saturated. B) There are several areas along the I-5 corridor that are highly susceptible to landsliding for all soil saturation levels, such as the area shown here near the access point to the West Seattle bridge. C) The hillsides in West Seattle along the Duwamish valley are at risk of seismically induced landsliding, such as the area

shown here. There are industrial as well as 59 residential buildings that could be affected by runout from landsliding in these areas. D) The coastal bluffs along Puget Sound in West Seattle on the hanging wall of the fault, such as the area shown here, are the most highly susceptible areas to landsliding in the city; numerous residential structures are at risk from both potential landslide source areas and runout. Credit: Allstadt/BSSA

A new study suggests the next big quake on the Seattle fault may cause devastating damage from landslides, greater than previously thought and beyond the areas currently defined as prone to landslides. Published online Oct. 22 by the *Bulletin of the Seismological Society of America* (*BSSA*), the research offers a framework for simulating hundreds of earthquake scenarios for the Seattle area.

"A major quake along the Seattle fault is among the worst case scenarios for the area since the fault runs just south of downtown. Our study shows the need for dedicated studies on seismically induced landsliding" said co-author Kate Allstadt, doctoral student at University of Washington.

Seattle is prone to strong shaking as it sits atop the Seattle Basin – a deep sedimentary basin that amplifies ground motion and generates strong seismic waves that tend to increase the duration of the shaking. The broader region is vulnerable to earthquakes from multiple sources, including deep earthquakes within the subducted Juan de Fuca plate, offshore megathrust earthquakes on Cascadia subduction zone and the shallow crustal earthquakes within the North American Plate.

For Seattle, a shallow crustal earthquake close to the city would be most damaging. The last major quake along the Seattle fault was in 900 AD, long before the city was established, though native people lived in the area. The earthquake triggered giant landslides along Lake Washington,

causing entire blocks of forest to slide into the lake.

"There's a kind of haunting precedence that tells us that we should pay attention to a large earthquake on this fault because it happened in the past," said Allstadt, who also serves as duty seismologist for the Pacific Northwest Seismic Network. John Vidale of University of Washington and Art Frankel of the U.S. Geological Survey (USGS) are co-authors of the study, which was funded by the USGS.

While landslides triggered by earthquakes have caused damage and casualties worldwide, they have not often been the subject of extensive quantitative study or fully incorporated into seismic hazard assessments, say authors of this study that looks at just one scenario among potentially hundreds for a major earthquake in the Seattle area.

Dividing the area into a grid of 210-meter cells, they simulated ground motion for a magnitude 7 Seattle fault earthquake and then further subdivided into 5-meter cells, applying anticipated amplification of shaking due to the shallow soil layers. This refined framework yielded some surprises.

"One-third of the landslides triggered by our simulation were outside of the areas designated by the city as prone to landsliding," said Allstadt. "A lot of people assume that all landslides occur in the same areas, but those triggered by rainfall or human behavior have a different triggering mechanism than landslides caused by earthquakes so we need dedicated studies."

While soil saturation—whether the soil is dry or saturated with water – is the most important factor when analyzing the potential impact of landslides, the details of ground motion rank second. The amplification of ground shaking, directivity of seismic energy and geological features that may affect ground motion are very important to the outcome of

ground failure, say authors.

The authors stress that this is just one randomized scenario study of many potential earthquake scenarios that could strike the city. While the results do not delineate the exact areas that will be affected in a future earthquake, they do illustrate the extent of landsliding to expect for a similar event.

The study suggests the southern half of the city and the coastal bluffs, many of which are developed, would be hardest hit. Depending upon the water saturation level of the soil at the time of the earthquake, several hundred to thousands of buildings could be affected citywide. For dry soil conditions, there are more than 1000 buildings that are within all hazard zones, 400 of those in the two highest hazard designation zones. The analysis suggests landslides could also affect some inland slopes, threatening key transit routes and impeding recovery efforts. For saturated soil conditions, it is an order of magnitude worse, with 8000 buildings within all hazard zones, 5000 of those within the two highest hazard zones. These numbers only reflect the number of buildings in high-risk areas, not the number of buildings that would necessarily suffer damage.

"The extra time we took to include the refined ground motion detail was worth it. It made a significant difference to our understanding of the potential damage to Seattle from seismically triggered landslides," said Allstadt, who would like to use the new framework to run many more scenarios to prepare for future earthquakes in Seattle.

More information: "A Scenario Study of Seismically Induced Landsliding in Seattle Using Broadband Synthetic Seismograms," December 2013 print edition of *BSSA*.