Continued Development of a Forecast Tool for Precipitation-Triggered Shallow Landslides in Washington State

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Wednesday, September 11, 2013 from 9:00am to 5:00pm
Thursday, September 12, 2013 from 9:00am to 5:00pm
Friday, September 13, 2013 from 9:00 to 11:30am

Abstract

Every year Washington State experiences hundreds to thousands of precipitation-triggered shallow landslides, some of which damage property and in rare instances injure or kill people. The Washington Division of Geology and Earth Resources (DGER) is continuing development of a landslide forecast tool to identify areas of precipitation-triggered shallow landslides. The tool identifies shallow landslide initiation thresholds primarily based on cumulative precipitation. Model outputs were county-wide landslide warning levels from low to very high with county emergency managers as the intended users. The initial tool was based on a simple numerical model derived from the sum of one- to seven-day precipitation for the Puget Sound area and later extrapolated to statewide coverage. Recent development to the model include 1) adding National Weather Service (NWS) 24- and 48-hour precipitation prediction models; 2) dissecting county-wide landslide warnings into smaller NWS public forecast zones and; 3) calibrating the model for areas of differing climatic properties such as rain shadows and orographic lift. Calibration of the tool has been ongoing as we compare outputs to reports of shallow landslides, NWS precipitation prediction models, and analyzing precipitation data to shallow landslide initiation. Future development includes reducing forecast zone area, evaluating a gridded forecast, and including soils and geology.

Shallow landslides - 2009 storm

In January 2009, rain and melting snow from a strong Pacific storm triggered hundreds of landslides in western Washington. The impacts ranged from minor mud and debris deposition on lawns or pastures to significant structural damage to homes and outbuildings. Our model was created to identify these precipitation events where shallow landslide initiation, especially widespread initiation, can be identified to alert county and city emergency managers. Below are some images from the storm.

A debris flow missed this house in Whatcom County. Photo: Jeff Grizzel

Landslide initiated in 30-40 year old managed forest land in Thurston County.

A very large landslide initiated in >100 year old timber and transformed into a debris flow. It damaged two forest roads and delivered sediment and wood into Canyon Creek in Clark County.

Western Washington experiences a variety of precipitation amounts (Fig. 1). For example, on the Olympic Peninsula precipitation in vampire-laden Forks exceeds 118 inches annually whereas 100 km east the town of Sequim receives less than 18 inches. These dramatic differences in annual precipation complicate development of a landslide forecast model.

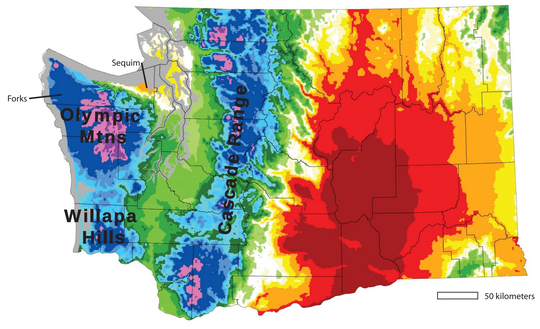

Figure 1. Annual precipitation of Washington state. The rain shadow of the Olympic Mountains, Wilapa Hills, and Cascade Range are apparent and create areas of differing climactic properties. This complicates calibration of our model.

The majority of shallow landslides are triggered by precipitation. Figure 2 is an incomplete inventory of some 40,000 shallow landslides, many of which were likely initiated by precipitation.

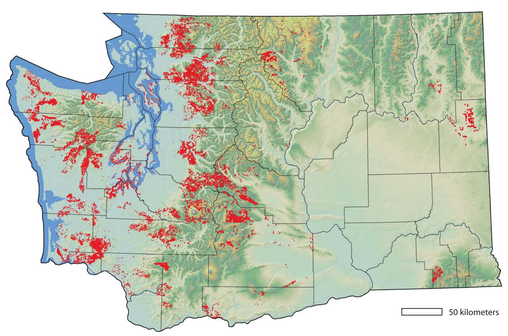

Figure 2. Incomplete shallow landslide inventory for Washington State.

Original model

- Three times the total precipitation for the day plus the total precipitation for the previous seven days exceeding 2.5 inches
- $H=3P_1+P_7-2.5$

  Where, H is the hazard rating, P_1 is the total precipitation of the day, and P_7 is the total precipitation for the previous 7 days (all values in inches)
- The hazard rating (H) are:
  H=0-5 is low
  H=5-7 is moderate
  H=7-10 is high
  H>10 is extreme
- The model was calibrated specifically for the Puget Trough (Fig. 3) and the rail route between Seattle and Everett (Fig 4).

Figure 3. The original equation was established for the Puget Trough (orange area), which runs the length of Washington rising to about 300 meters (1000 ft) elevation between the Cascase Mountains to the east and the Olympic Mountains andWilapa Hills to the west.

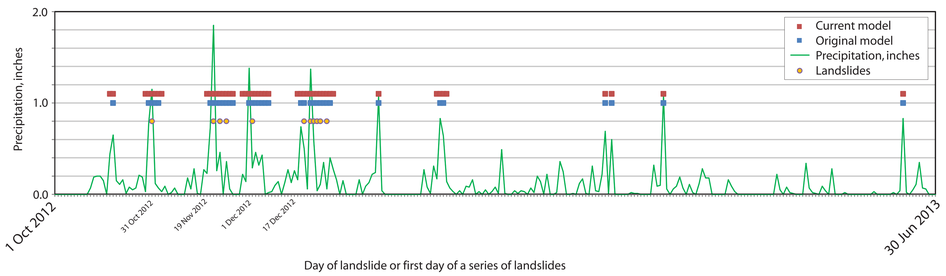

Figure 4. Above is a plot of landslides on the Seattle to Everett rail route compared to outputs from the original and current landslide forecast models. Daily precipitation is from October 1, 2012 to June 30, 2013 at Everett Paine Field. Landslide dates are from twitter.com updates from @Sound_Transit. Model outputs show when the forecast model identified increased landslide hazard and does not reflect hazard level.

Future model

Considerations include:

- Gridded forecast (Fig. 6)
- Include NWS snow water equivalent (SWE), SWE change, snowpack temperature to capture rain-on-snow events
- Include soils and/or geology recognized as shallow landslide
- Forecast for eastern Washington summer storm cells?
- Eliminate hazard levels?

Current model (beta)

- Includes NWS 24- and 48-hour precipitation forecast data
- Calibrate model to compensate for rain shadows and ographic effects outside of the Puget Trough
- Subdivide forecast zones from counties to NWS public forecast zones, with slight modifications (Fig. 5)

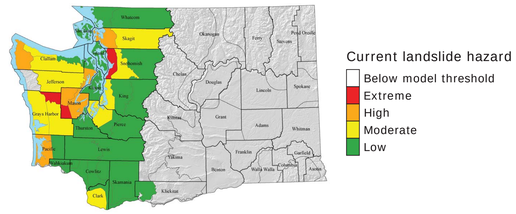

Figure 5. Example of the updated landslide forecast site and potential outputs during an extended period of precipitation or winter storm.

- Check out the landslide warning webpage:
  https://fortress.wa.gov/dnr/landslidewarning/
  Note: it hasn't been raining, so there isn't much to see!

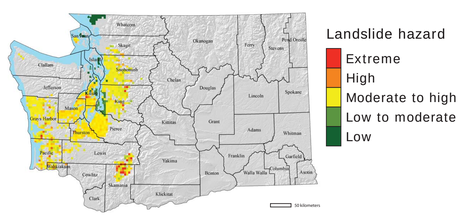

Figure 6. A gridded forecast could be used to better forecast potential shallow landslide areas. For instance, during an intense precipitation event flooding may occur and a traffic reroute be necessary. A gridded forecast may assist emergency managers in avoiding an alternative route that may have an increase likelihood of shallow landslide initiaion.