Mt. St. Helens Potential Eruption Hazard Analysis

By Aleksandr Kirpach

EOS 104: Geological Applications of GIS

Introduction:

The 1980 eruption of Mt. St. Helens has often been referred to as the most disastrous volcanic eruption in US History. The volcano is located in Skamania County in Washington State and reaches an elevation of 2,549 meters. When it erupted in 1980, it released an ash column that reached 24,400 meters within 15 minutes. Within 15 days, the ash had reached all around the world. The eruption also created the largest landslide in recorded history. The eruption was triggered by a 5.1 magnitude earthquake and shortly after it began, the volcano's entire north face came rushing down at speeds of up to 155 miles per hour. The total mass of the landslide covered 60 km^2 and contained a volume of 2.8 km^3. This natural disaster resulted in a total of 64 deaths and cost the region millions of dollars. The purpose of this study is to determine which areas of Washington State would be most severely impacted if Mt. St. Helens were to erupt again. The final result is a hazard map that shows where the most precautionary measures should be taken in order to minimize damages in the event that an eruption like this happens again.

Figure 1. Ash Fall Estimation

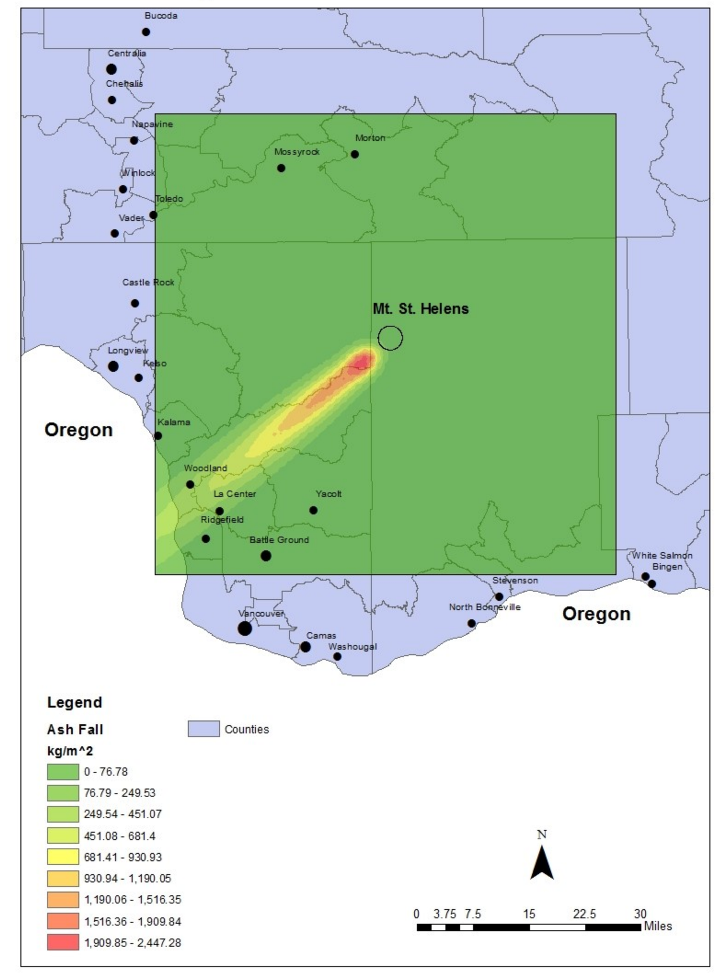


Figure 2. Population Density

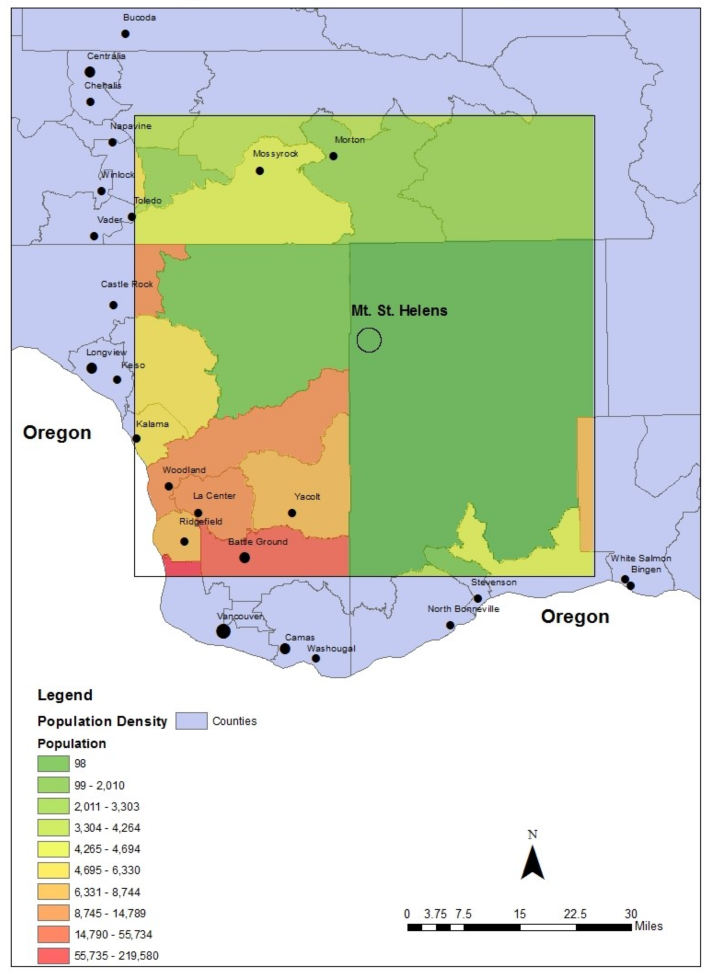
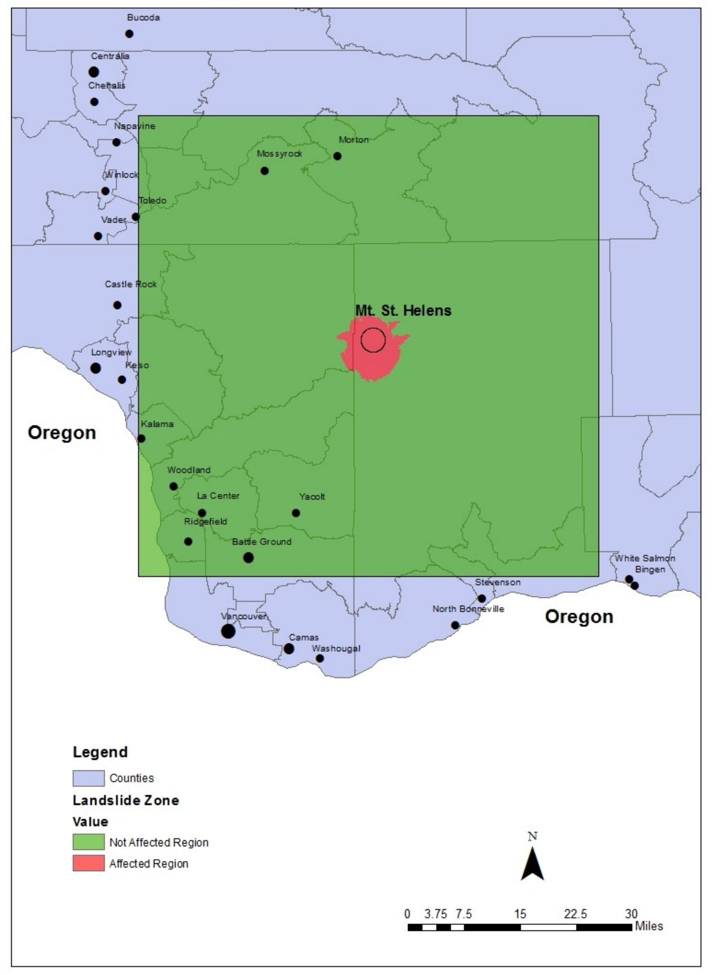


Figure 3. Landslide Zone



Methods:

The GIS methods I used in this study were primarily reclassifications and raster calculations. I considered 5 variables that determine the impact of a volcano and I combined them in the end to create a final hazard map. The 5 variables were:

1. **The distribution of the ash column based on local wind patterns**
2. **The population density of the local regions**
3. **The region affected by the landslide**
4. **The streams/rivers that become flooded as a result of the landslide**
5. **The major roads in the area and the distance that needs to be traveled to get to them**

Figure 4. Clogged Streams

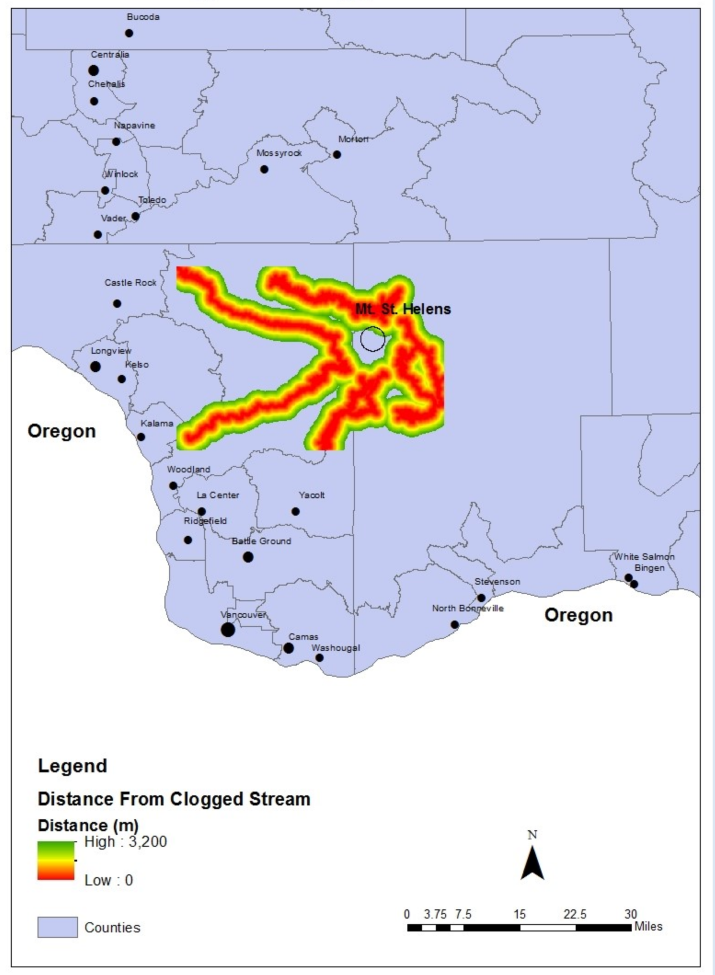
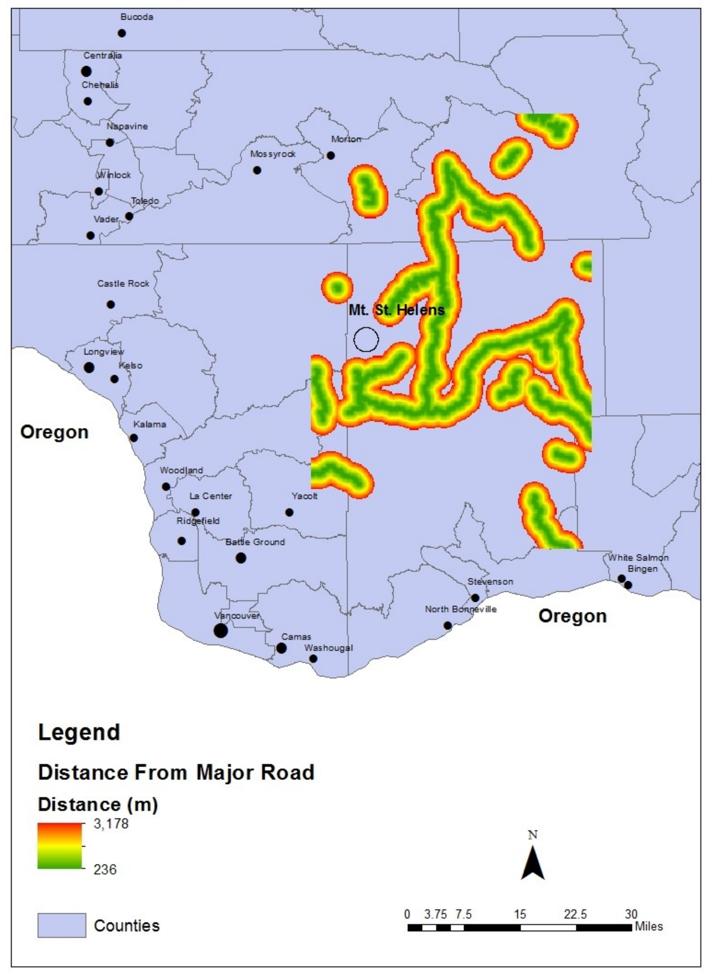


Figure 5. Major Road Distance



Results:

Figure 1 shows a map of the distribution of the ash column based on the local wind patterns. I created this distribution using vhub's Tephra2 tool, which requires various input parameters such as plume height, eruption mass, and grain size distribution. In order to estimate these parameters, I reviewed literature and used values from the 1980 eruption. Once I calculated the ash distribution with Tephra2 and generated a raster map of the data, I reclassified on a scale from 1 to 10, where 10 contains cells with maximum ash fall and 1 contains cells with minimum ash fall.

Figure 2 shows a distribution of the population density of the region based on county. This factor is important to consider when evaluating hazard potential because regions with higher population densities are of greater concern. In order to create this map, I downloaded population data from Washington's Office of Financial Management website. I then symbolized the map based on 2010 population data. I went on to rasterize and reclassify it on a scale from 1 to 10 where 10 contains cells with high population densities and 1 contains cells with low population densities.

Figure 3 shows the region that will be affected by debris flow. In order to create this map, I used vhub's Laharzpy tool. This tool required various inputs including an accurate digital elevation model, an average slope for the volcano, and an estimated volume of debris flow. The outputs of this tool included a debris flow hazard zone, an estimation of various stream/river locations, and a prediction of how those streams will flood based on the size of the debris flow. After I created this map, I reclassified it so that cells within the debris flow zone were given values of 10 and cells outside of the zone were given values of 1.

Figure 4 shows the flooding of various streams and rivers that would occur as a result of the debris flow. After acquiring the flood regions from Laharzpy, I applied the Euclidian distance tool in order to rank areas based on their distance from the flooded streams. Areas closer to the flooding are the most at risk so those areas were assigned a 10. Areas farther away from the flooding were given values of 1.

Figure 6. Overall Risk Potential

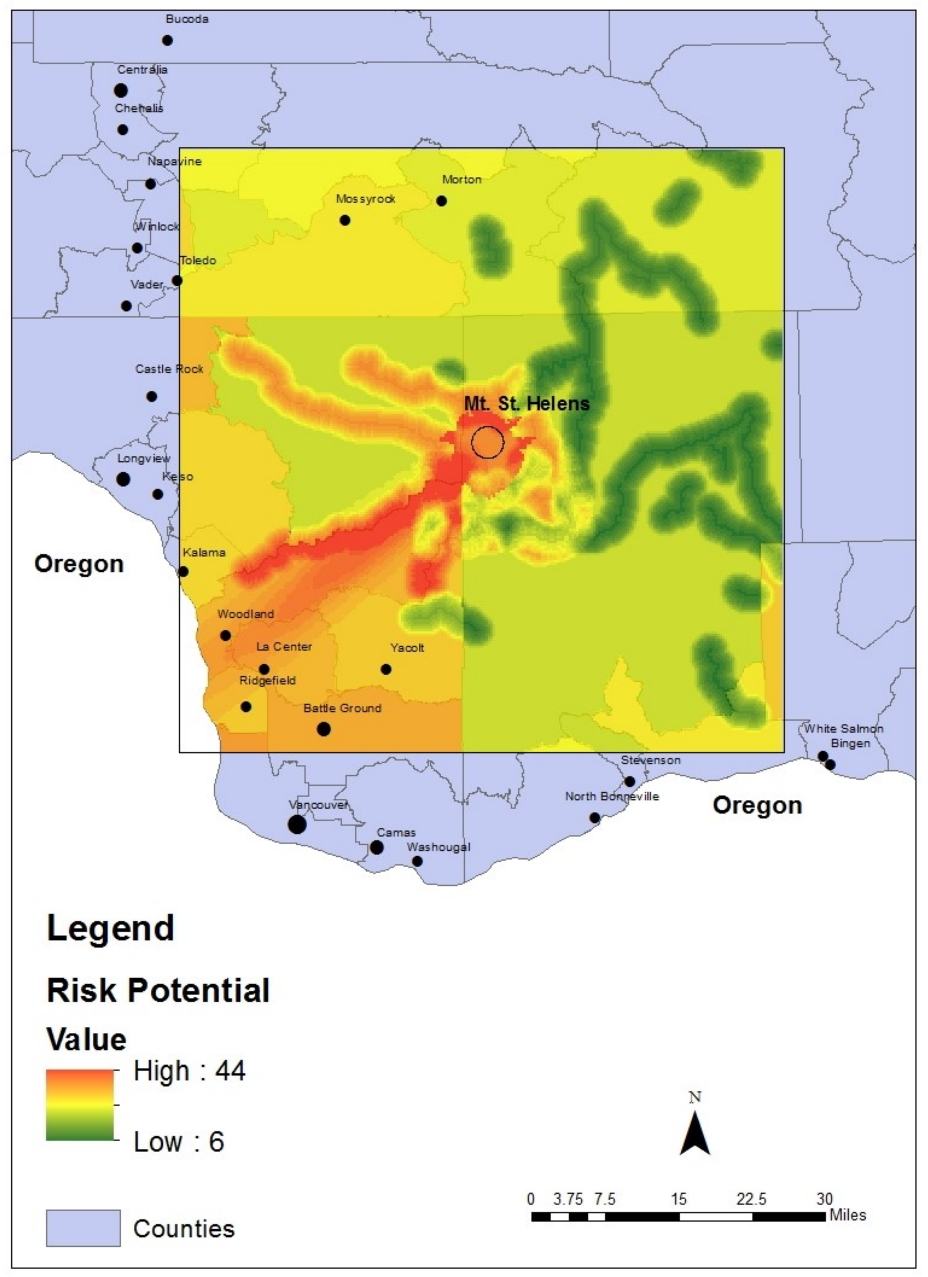


Figure 5 shows the locations of major roads in the Mt. St. Helens region. I acquired this data from the US Forest Service. I then applied the Euclidian distance tool in order to rank raster cells based on their distances from the road. Cells that were closer to the road were given values of 1 because the people living in those regions are better off since they have quick access out of the region in the event of an emergency. Meanwhile, the cells farthest from the roads were given values of 10 because the people living there would have very limited access and would therefore be the most at risk.

Figure 6 shows the final result of the combination of the 5 variables. I used the raster calculator in order to sum all 5 factor maps (which were scaled from 1 to 10) in order to create a final hazard map that shows the overall vulnerability of various regions on a scale from 0 to 50. This final result reveals that the immediate region surrounding the volcano and the regions to the Southwest would be in the most danger in the event of an eruption. This makes sense because those regions will be significantly impacted by both the debris flow and the ash deposits. This map also shows that the northern region (yellow) is in more danger than some northeastern regions (green) which does not seem entirely true because there is no difference in the volcanic impact between those 2 regions. However, in the sense of the analysis, it makes sense because the northern regions have higher populations and less access to major roads while the northeastern regions have lower populations with more access to major roads.

Conclusions:

These results should be interpreted with caution because there are a number of inaccuracies associated with the data. One of these is that the ash calculation does not account for changes in elevation, which means that the predicted ash distribution might be different from the actual distribution because higher elevations may receive more ash fall than lower elevations. In addition, the wind data was based solely on 1 day (rather than an average) due to processing limitations. Similarly, flooding was not shown for some of the other streams in the local area due to similar limitations and the inability of the Laharzpy tool to accurately model every stream. Various input parameters for the vhub tools (such as lithic and pumice density) had to be assumed due to a lack of data. However, the most significantly limitation to this study is that it is based on data from the 1980 eruption and that future eruptions could be vastly different. The future direction is to acquire field data from Mt. St. Helens in its current state in order to accurately generate input parameters to model a future eruption.

Sources:

Roads: https://www.fs.fed.us/r6/data-library/gis/gifford-pinchot/index.shtml

DEM: http://gis.ess.washington.edu/data/raster/thirtymeter/index.html

Counties: https://www.ofm.wa.gov/washington-data-research/population-demographics/gis-data/census-geographic-files

Cities: https://www.ofm.wa.gov/washington-data-research/population-demographics/gis-data/census-geographic-files

Eruption Parameters for plume height and eruption mass: https://en.wikipedia.org/wiki/1980_eruption_of_Mount_St._Helens

Laharzpy: https://pubs.usgs.gov/of/2014/1073/

Tephra2: https://vhub.org/resources/tephra2

Washington State