Assessing Hazards of the Next Potential Mount Shasta Eruption

Introduction

Figure 1. Image showing the location of Mt. Shasta (red) and the extent of the region analyzed (blue) which encompasses area from Northern California and Southern Oregon.

The main objective United States Geologic Survey (USGS) Volcanic Hazards Program (VHP) is to assess the threat of active volcanoes and monitor their eruptive capabilities. A 2005 report by the USGS gave Mt. Shasta (Figure 1) a threat score of 210, making it the fifth most dangerous volcano in the United States[1]. But, this report also noted the USGS's lack of monitoring of Mt. Shasta, giving it a monitoring score (on a scale of 1-5) of 2, even though the required score is 4. While significant attention has been paid to the prediction and modeling of potential eruptions from Rainier and Hood, the same has not been done for Shasta. Mt. Shasta, the most voluminous volcano in the Cascade Range, overshadows several major towns, over 100,000 people, interstates, and airports, making it extremely dangerous if a Plinean eruption were to occur.

Unfortunately, it is next to impossible to predict the volume of ash, lahars, or pyroclastic flows from a Plinean eruption. However, models can be produced to mimic different scenarios, and that is what this project focuses on: using GIS to model and assess potential hazards of the next Mt. Shasta eruption.

Methods

Lahar Modeling Using Laharz_py[2], the ***proximal hazard zone*** (the maximum area likely affected by pyroclastic surges and ballistic ejecta) was determined using slope, stream drainage, and a filled DEM. A ***surface geology map*** of the proximal hazard zone was then digitized and polygons were created for each of the coverages (Figure 2)[3]. Points representing initiation sites (UTM coordinates) of ancient lahars were digitized and plotted within the proximal hazard zone[4]. Lastly, an intersect was performed to determine which points represented likely initiation sites. Laharz_py was used to model ***three different lahar volumes in the distal zones*** (Figure 3). These volumes were selected based on lahars from 1991 Mt. Pinatubo eruption[5] and the 1980 Mt. St. Helens eruption[6].

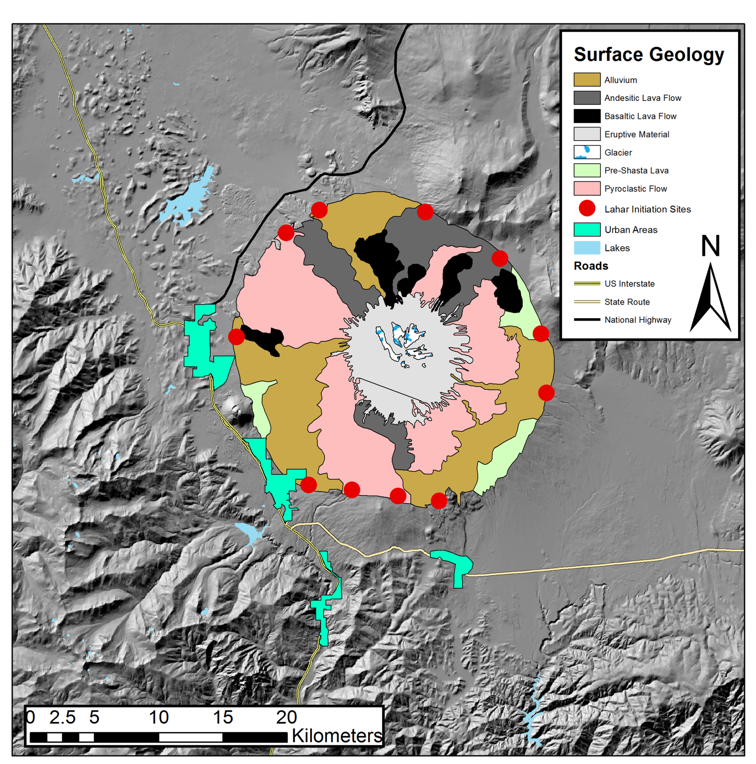


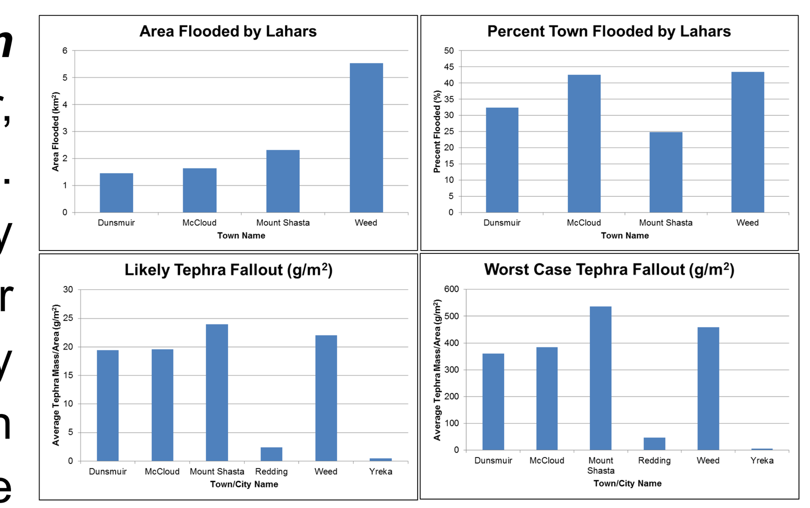
Figure 2. Surface geology of Mt. Shasta, also detailing the location of urban areas, roads, lakes, and lahar initiation sites.

Tephra Modeling TEPHRA2[7] was used to model the ***tephra distribution from a potential Mt. Shasta eruption***. Eruption parameters and tephra volumes were modeled based on St. Helens[8] (likely scenario) and Pinatubo[9] (worst case scenario; Figure 4a-b). Tephra distribution data (UTM coordinates, mass, min. wt.% φ, max. wt.% φ) was exported to a text file that was then displayed as a raster using the Topo to Raster tool.

Final Results After all data was collected and modeled, Microsoft Excel was used to calculate the area in kilometers squared flooded by the lahars, the percentage of each town flooded, and a value of average mass/area of tephra fallout for each town (Graphs1a-d).

Results & Discussion

Four towns will be destroyed when Mount Shasta erupts: Dunsmuir, McCloud, Mount Shasta, and Weed. Weed will be the town most significantly affected by lahar flooding, losing over 43% of its total urban area, followed by McCloud which will lose of 42%. In total, 9112 people will need to be evacuated from these urban areas. ***These towns will also experience a significant amount of ash accumulation*** (about 20g/m^2 in the likely scenario and 300 to 450g/m^2 in a worst case scenario; Figure 4a-b). Depending on the structural soundness of buildings, continued ash accumulation could be dangerous. ***The city of Redding should also be put on high alert*** in the case of an eruption, because it should expect to receive 46 g/m^2 of ash accumulation given a worst case scenario eruption.



Graphs 1a-d. Final Results

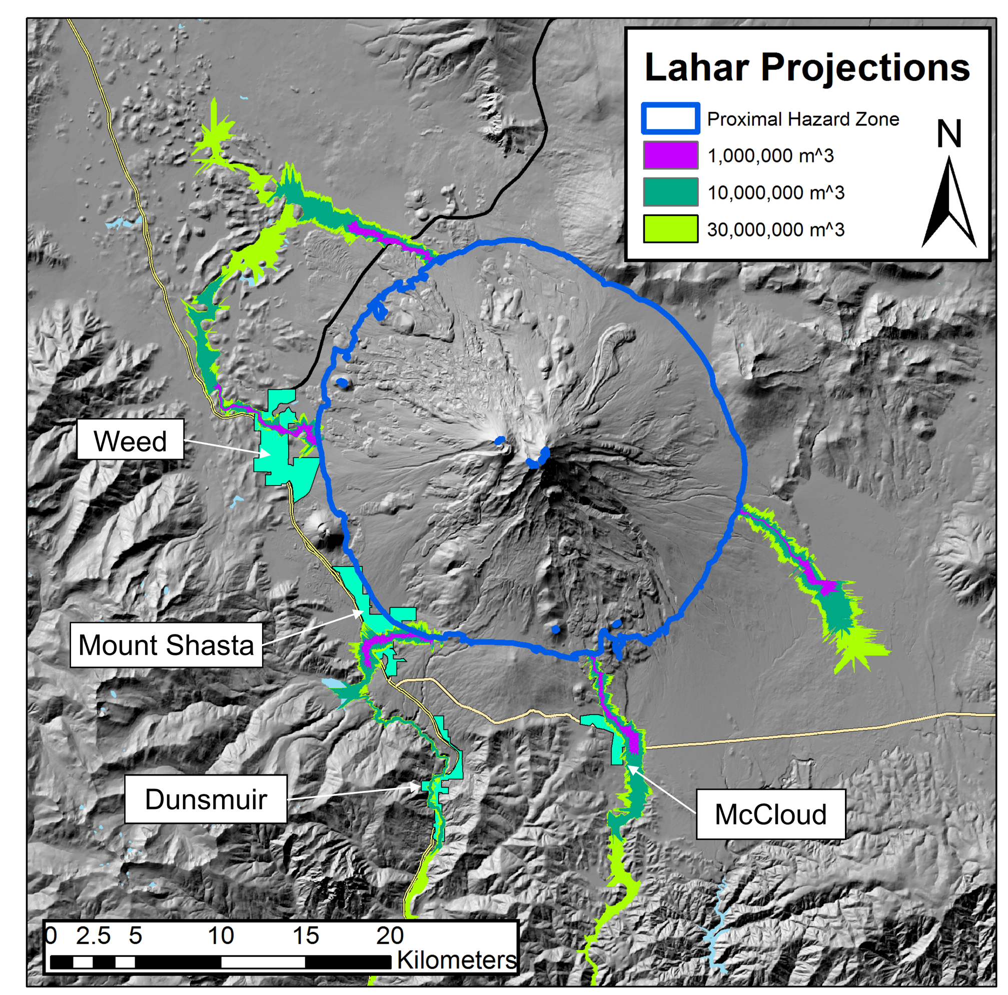


Figure 3. Lahar projections for three separate debris volumes. The proximal hazard zone and urban areas affected are also shown.

The Laharz_py program does not take into account the change in water levels of preexisting lakes or rivers. The ash model may also not be entirely accurate, because it does not take into account changes in wind direction by the day. This wind data was collected as a monthly average over two years. Finally, stratovolcanic eruptions in essence are very unpredictable. The scale of the eruption, the style (blowout vs. vertical plume), and duration are factors that scientists have never been able to predict, partially due to the infrequency of major eruptions like Pinatubo and St. Helens.

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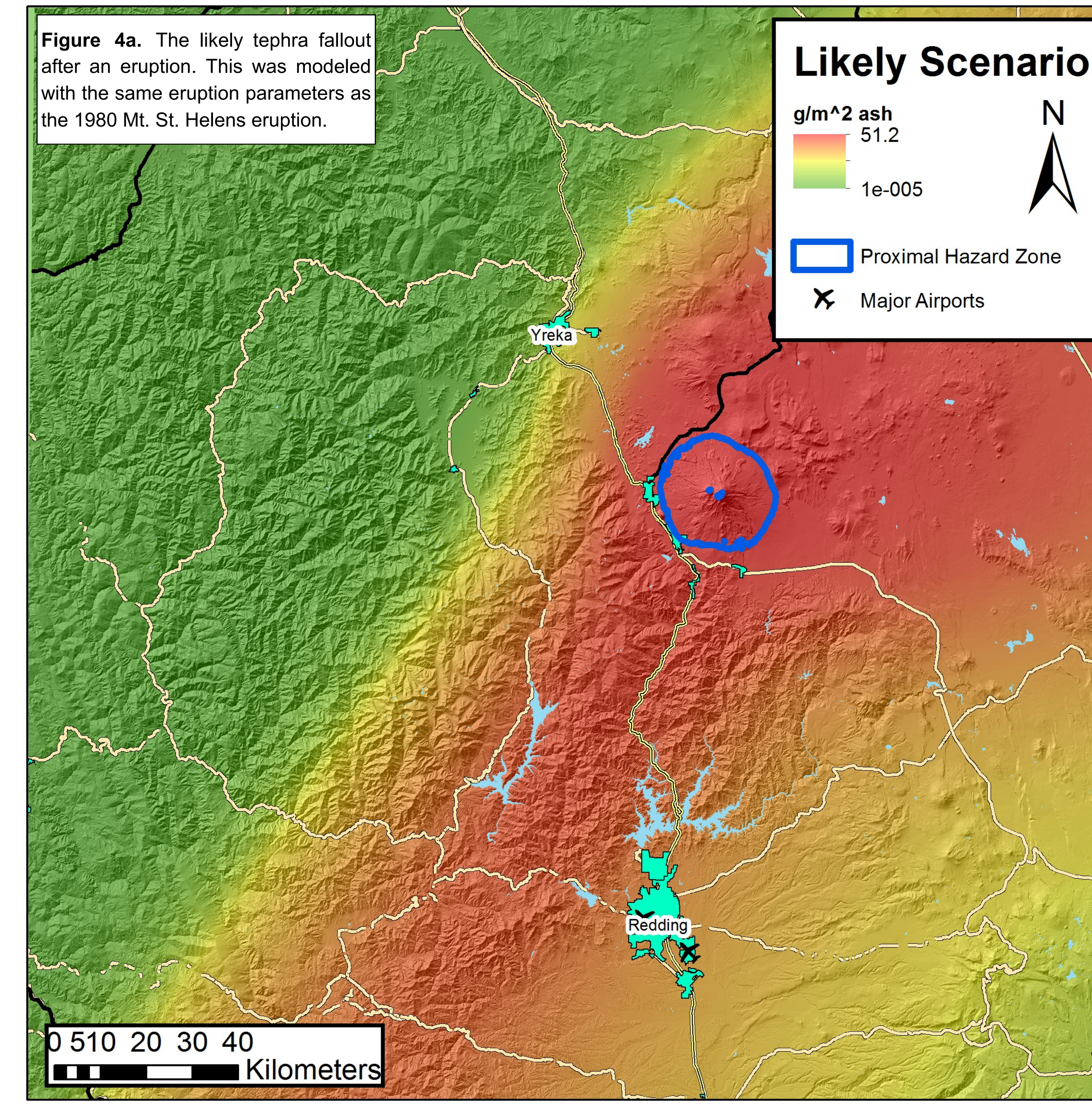

Figure 4a. The likely tephra fallout after an eruption. This was modeled with the same eruption parameters as the 1980 Mt. St. Helens eruption.

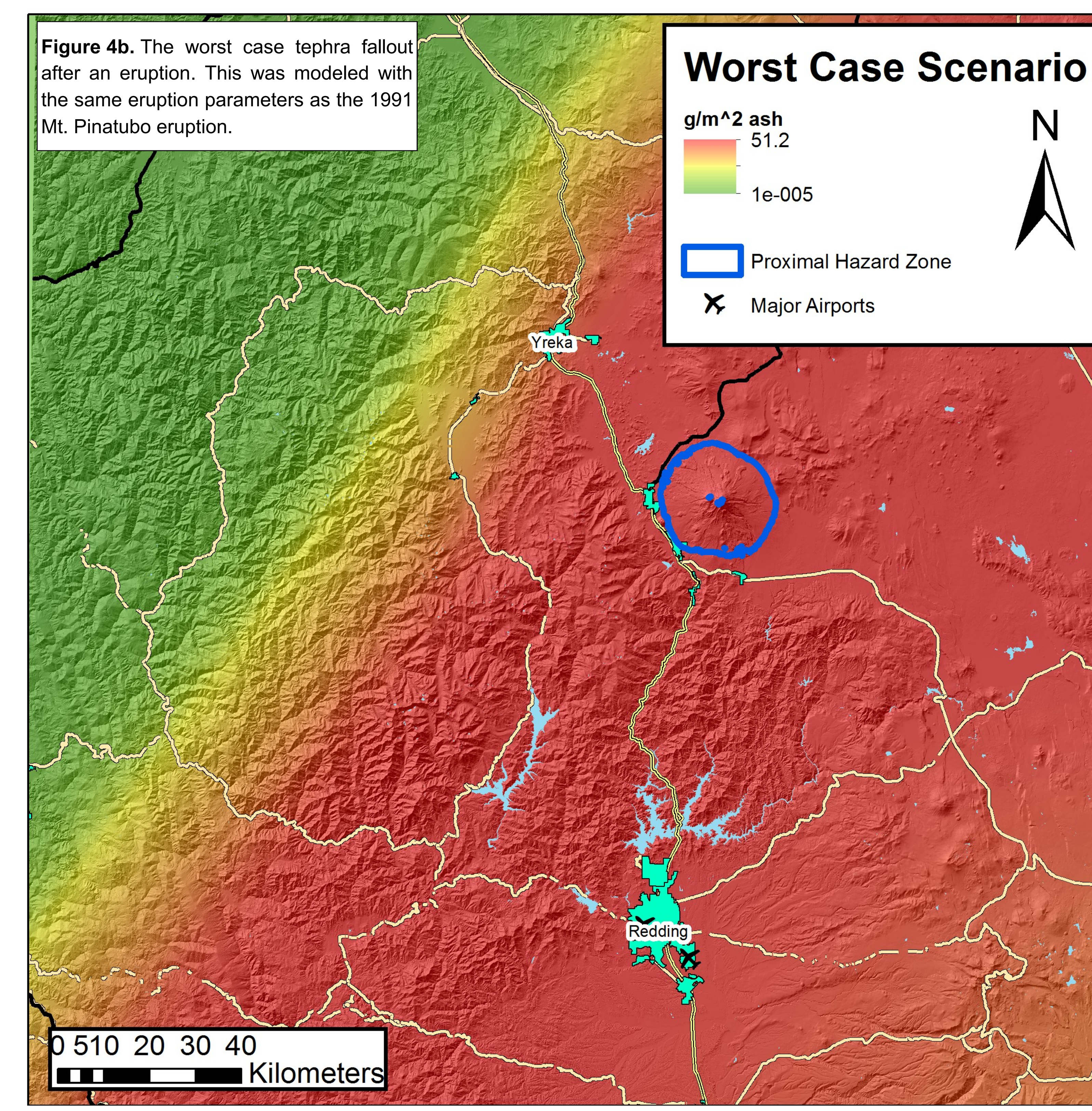

Figure 4b. The worst case tephra fallout after an eruption. This was modeled with the same eruption parameters as the 1991 Mt. Pinatubo eruption.

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