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Lava Threat Assessment to Hawaiian Homes, Big Island of Hawaii

Problem Overview:

The Big Island of Hawaii is one of the most geologically active locations on earth due to its location above the Hawaiian hotspot. The Kilauea caldera itself has been continuously erupting since 1983 and has produced 3.5 km of lava as of 2011. In general the lava produced from the volcanoes on the Big Island is basaltic and as such are more likely to flow over the landscape rather than erupt violently. While, the island itself is the result of thousands of volcanic eruptions, lava is a potential threat to the 185,000 people living there. The purpose of this project is to assess where the most dangerous areas on the island to communities might for future eruptions, based on lava flow data ranging from 1790 – 1997, and on the 2010 Census of Hawaii.

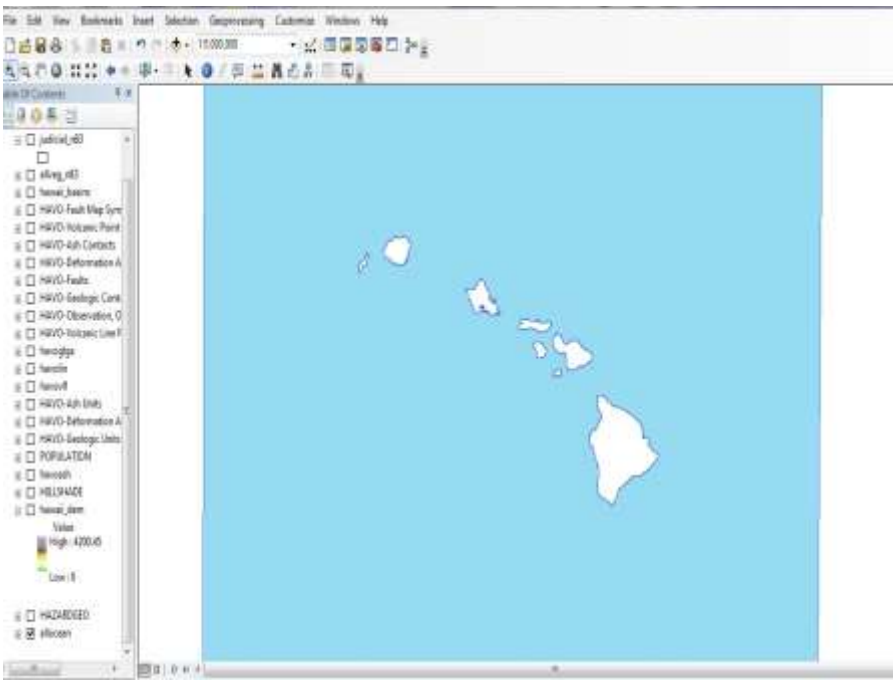
Data Collection:

This assessment required a Geologic Map of Hawaii shapefile feature class with different lava flows separated by the year they occurred that was acquired through the National Park Service's free GIS data library (http://www.nps.gov/gis/). 2010 Census block distributions shapefiles along with a hillshade, ocean shapefile, geographic names shapefile, and state roads shapefile were downloaded from the state of Hawaii's office of planning GIS data page (http://planning.hawaii.gov/gis/download-gis-data/).

Data Processing and ArcGIS Processing:

Because the Hawaiian Islands are split into UTM zone 4N and 5N, all of the datasets were set to a spatial reference frame of NAD 1983 UTM Zone 4N as a Transverse Mercator projection for conformability. The first step was to import all the datasets into ArcGIS 10.2.2, and designate a file for any new layers created during the process. ArcCatalog 10.2.2 was used both to set all the coordinate systems and to import the data into ArcGIS. Figure A. shows the state of Hawaii ocean shapefile, which was implemented as a boundary for all the datasets.

Figure A. : Ocean shapefile for the Hawaiian islands (NAD 1983 UTM 4N)



The next step in the process was to set which attributes would be used to symbolize data. The geologic map of Hawaii dataset was chosen to display data based on the year in which a particular lava flow began. Because volcanic eruption data has only been recorded since 1790, the data set only shows volcanic activity from 1790–1997, displaying older eruptions as a lighter color and more recent eruptions as darker. Furthermore, all geologic data that was not recorded after 1790 was set as one single color. Similarly, the 2010 census block data was set to display data based on population number of people per census block.

The geologic map data and the 2010 census block data then had to be rasterized. The 'feature to raster' conversion tool in ArcToolbox was used for this purpose, For the geologic map data, the field was set to 'year1' and for the census data the field was set to 'pop10'. This created rasters for the images to display data based on eruption year and number of people per census block, respectively (Figure B-1 and Figure B-2). Both datasets were designated a cell size of 100. The results can be seen in figure B-2 and C-2.

Figure B-1: Rasterization of the Geologic Map shapefile, with Year of eruption as the field.

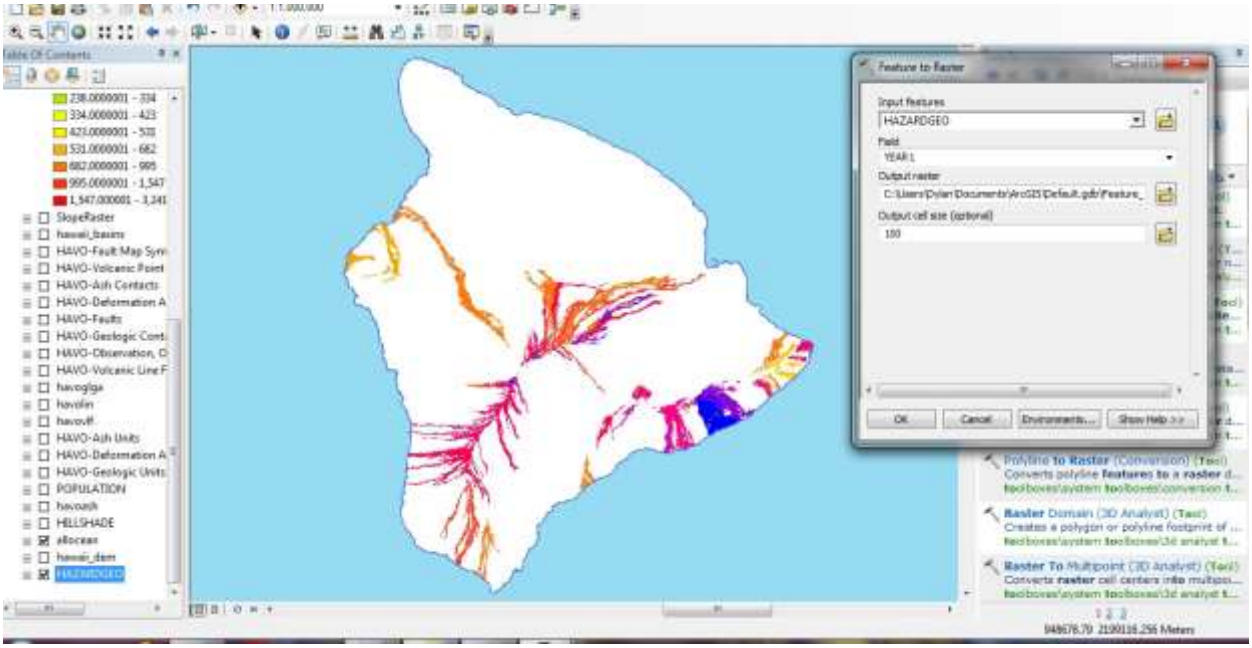


Figure C-1: Rasterization of the 2010 Census Blocks shapefile with population per block as the field.

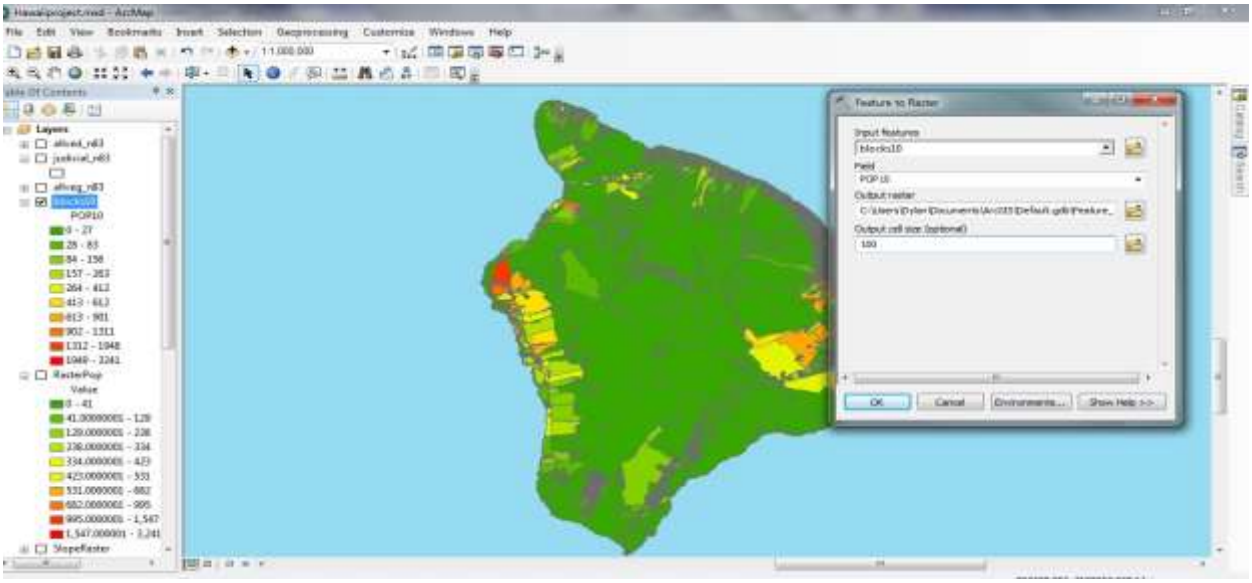


Figure B 2: Rasterized Geologic map, showing blue as eruptions before 1790 and Yellow as eruptions from 1790-1997.

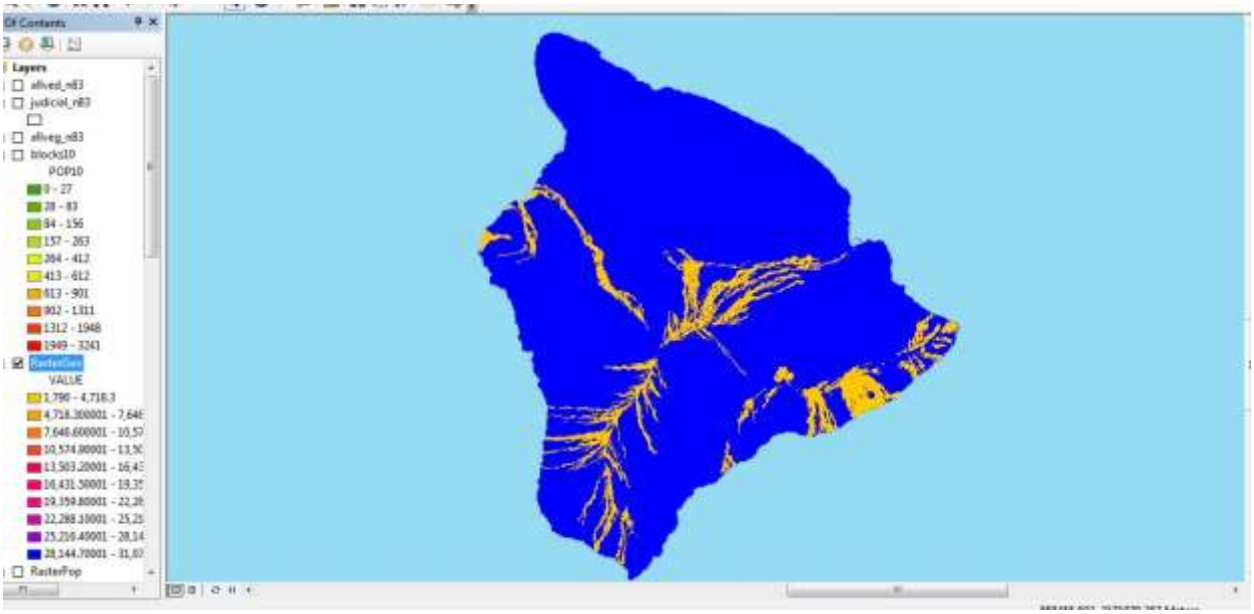
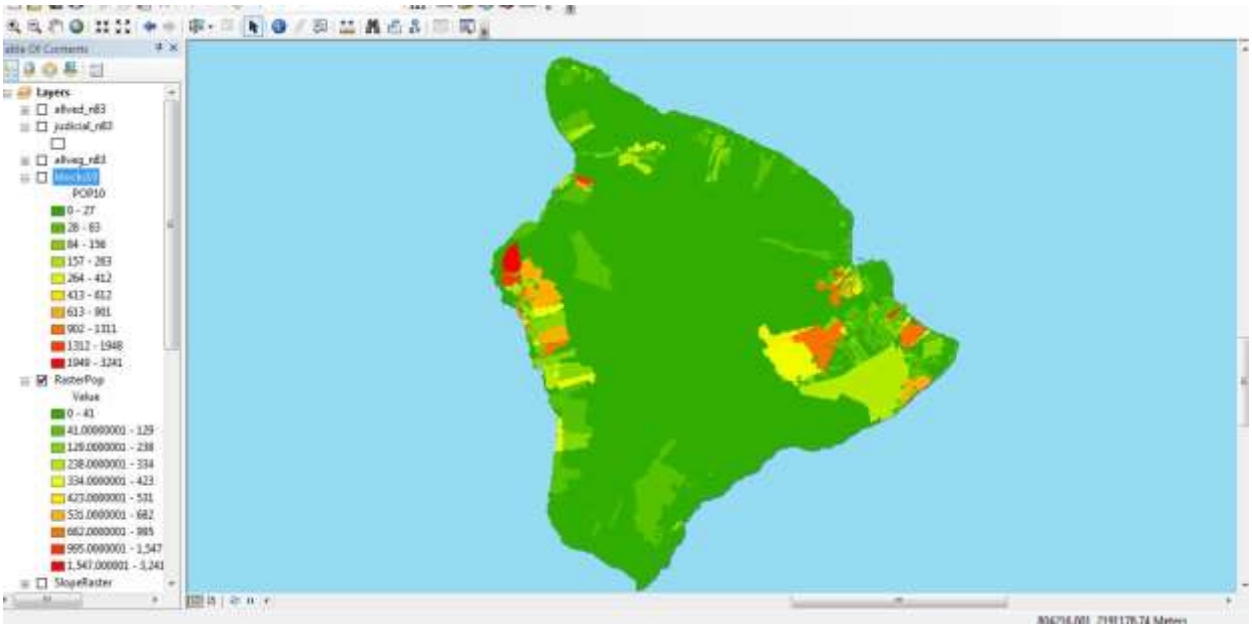


Figure C 2: Rasterized Census Block data, ranging from dark green as low 0-60 people, and dark red as 1,200-3,200 people.

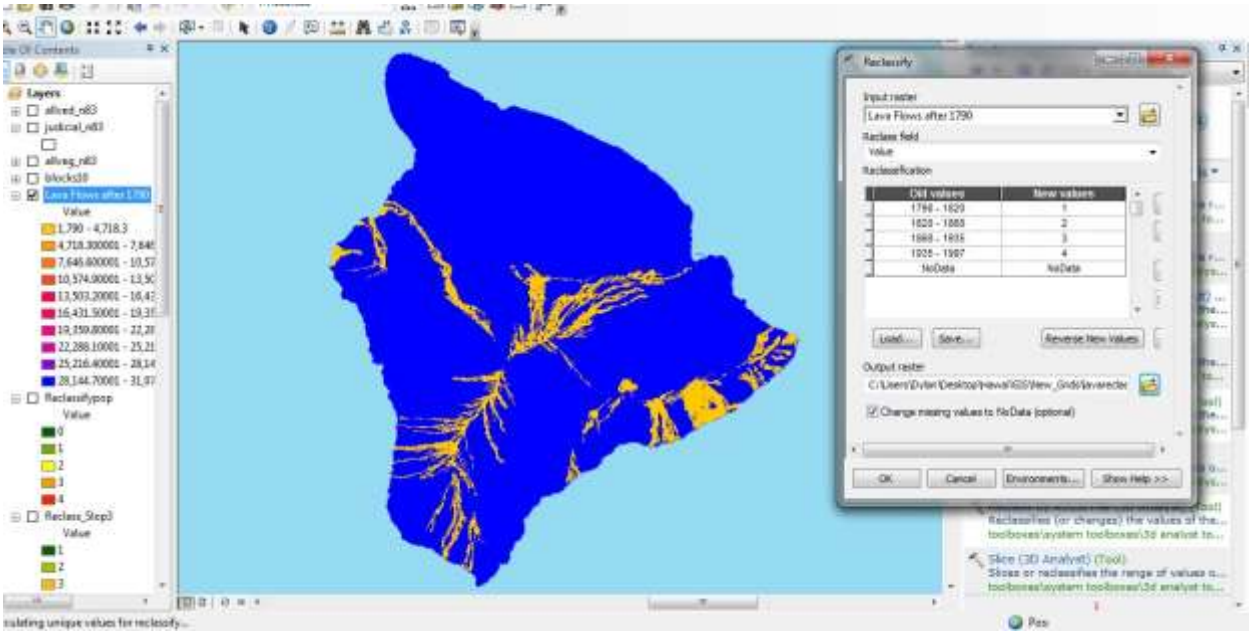


The next step in the process was to create hazard levels signifying lava threats to the population. I chose to make lava flows that are more recent to be the most hazardous to the population. I chose this under the assumption that the Hawaiian Islands are shifting westward

over the Hawaiian hotspot, and as such the locations of eruptions are more frequent in one particular region of the island at a given time. Also, I decided that census blocks that contain more people would receive a greater hazard level from the imposing lava than blocks with fewer homes. I used the reclassify spatial analysis tool in ArcToolbox to create 5 hazard levels for each of the two datasets. My hazard scale goes from 0 to 4 with 0 as not threatening to homes, and 4 as very threatening to homes.

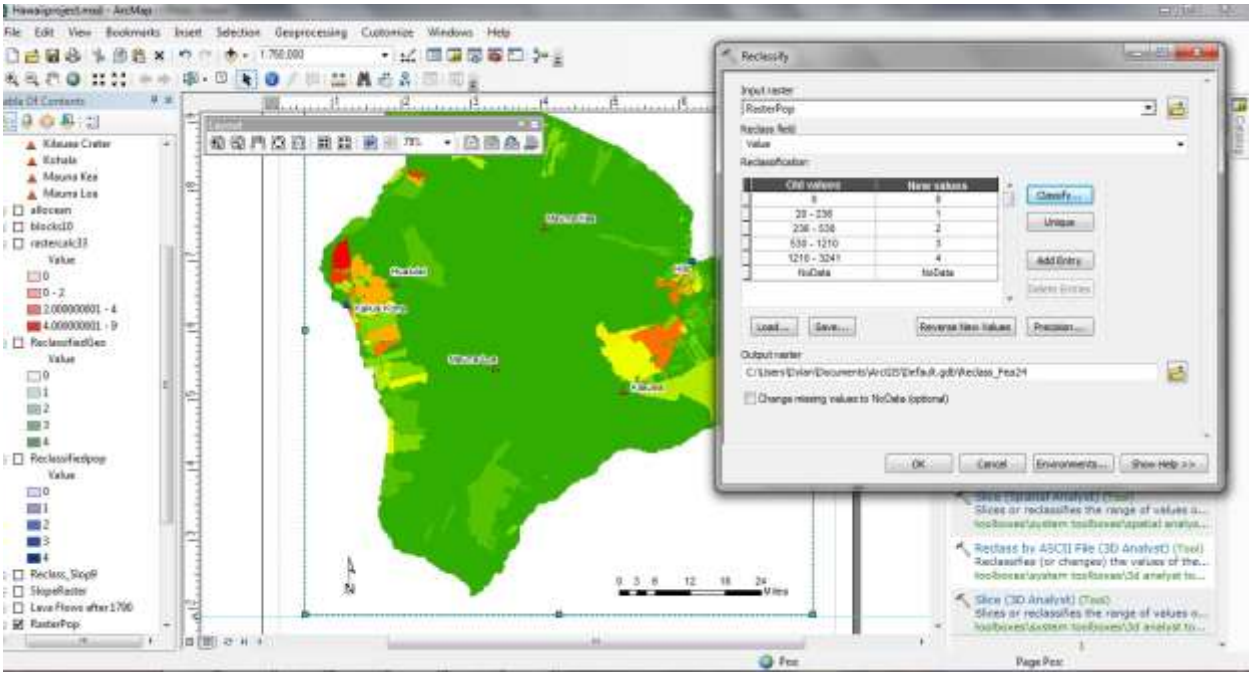
For the geologic map raster, I decided that eruptions occurring from 1790-1820 would receive a hazard rating of 1, eruptions from 1820-1868 would receive a rating of 2, eruptions from 1868-1935 would receive a rating of 3, and eruptions from 1935-1997 would receive a rating of 4. Every lava flow before 1790 was designated a 0 rating. This process is shown in Figure D.

Figure D. : Reclassifying the Geologic Map of Hawaii, replacing old values with new values, and using a 5 category system.



To reclassify the census block raster, I also used the reclassify tool. I designated a hazard value of 0 to any location that had absolutely no people living there at all. A hazard value of 1 was given to any area that had between 20-236 people, a value of 2 was given to areas with 236-530 people, a value of 3 was given to areas with 530-1210 people, and any area with, set to 5 classes, in the reclassify tool and on the idea that if there are no people in a given area, then the lava is not a threat. This process is shown in Figure E.

Figure E. : Reclassifying the Census Block data, replacing old values with new values for 5 categories as seen in the toolbox.



The results of the reclassifications can be seen in Figure F. and Figure G. for the lava flow dates map and the 2010 population map, respectively.

The final step in the process was to combine the two rasters together in order to symbolize areas with lots of people and more recent lava flows as very dangerous, and areas with few people and flows that happened hundreds of years ago flow as least dangerous. To do this, I used the raster calculator and multiplied the two reclassified raster together (Figure H.), to show the intersection of lava flows and population. Figure I. shows the result of the multiplication. The scale ranges from 'no threat' to 'high threat' corresponding to a range of 0-4 hazard rating.

Results and Conclusion:

My results show that only 3% of the island can be considered a lava threat to the Hawaiian population. Furthermore, only .75% of the island is considered to have a high lava threat to the population. The most threatening flows are located to the southeast coast, mostly around the Kilauea volcano (Figure I.). This makes sense, because Kilauea has been erupting since 1983 and is where most of the volcanic activity on the island is taking place today. It can be seen from Figure F. that Mauna Loa was active all the way up at least until the early 1900's, and as such there are a few areas to the southwest coast of the island and to the east of Mauna

Loa that are potentially hazardous to people living in the area (Figure I.). It is interesting to note, that the Hualalai volcano last erupted sometime between 1790 and 1820 (Figure F.). However, there are a few areas around mainly to the immediate east and west of the volcano that are considered moderately threatening because of the amount of people in the area (Figure I.). The safest places on the island are in the Northeastern portion of the island, mainly around the Kohala Volcano and Mauna Kea.

By taking into account the dates of volcanic eruptions from 1790 – 1997 and combining them with 2010 Census data, a map of lava threats to Hawaiian homes was created for the Big Island of Hawaii. While the process is simple, it was able to highlight where people living on the island may want to consider relocating their homes. This assessment should be used as a general map, as lava can change course sporadically on the island. In the future I would like to use earthquakes, crustal deformation, and more recent lava flows to create a better lava threat assessment.

Figure F: Map of Hawaii Island Lava flows from 1790-1997.

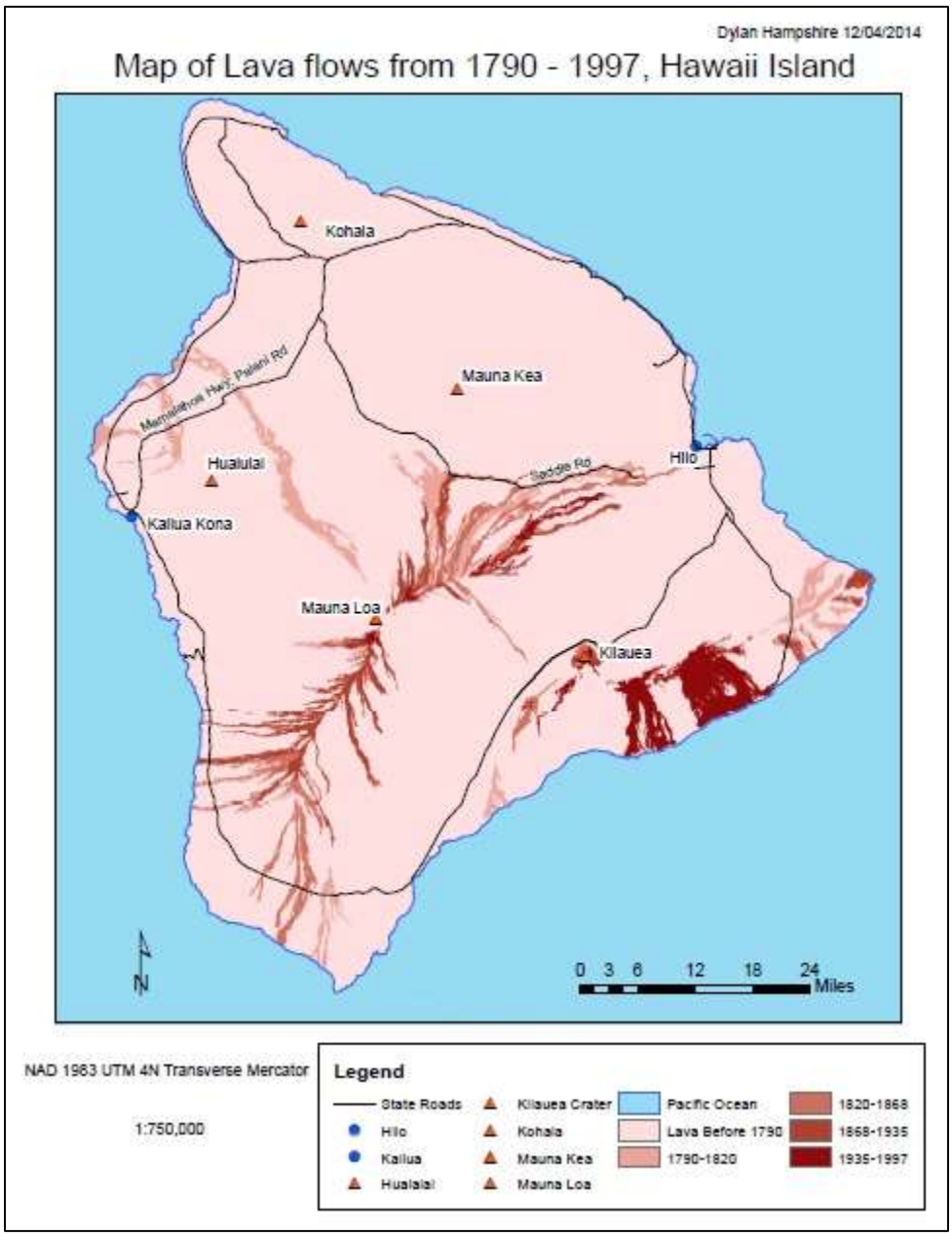


Figure G. Map of 2010 Population Per Census Block, Hawaii Island

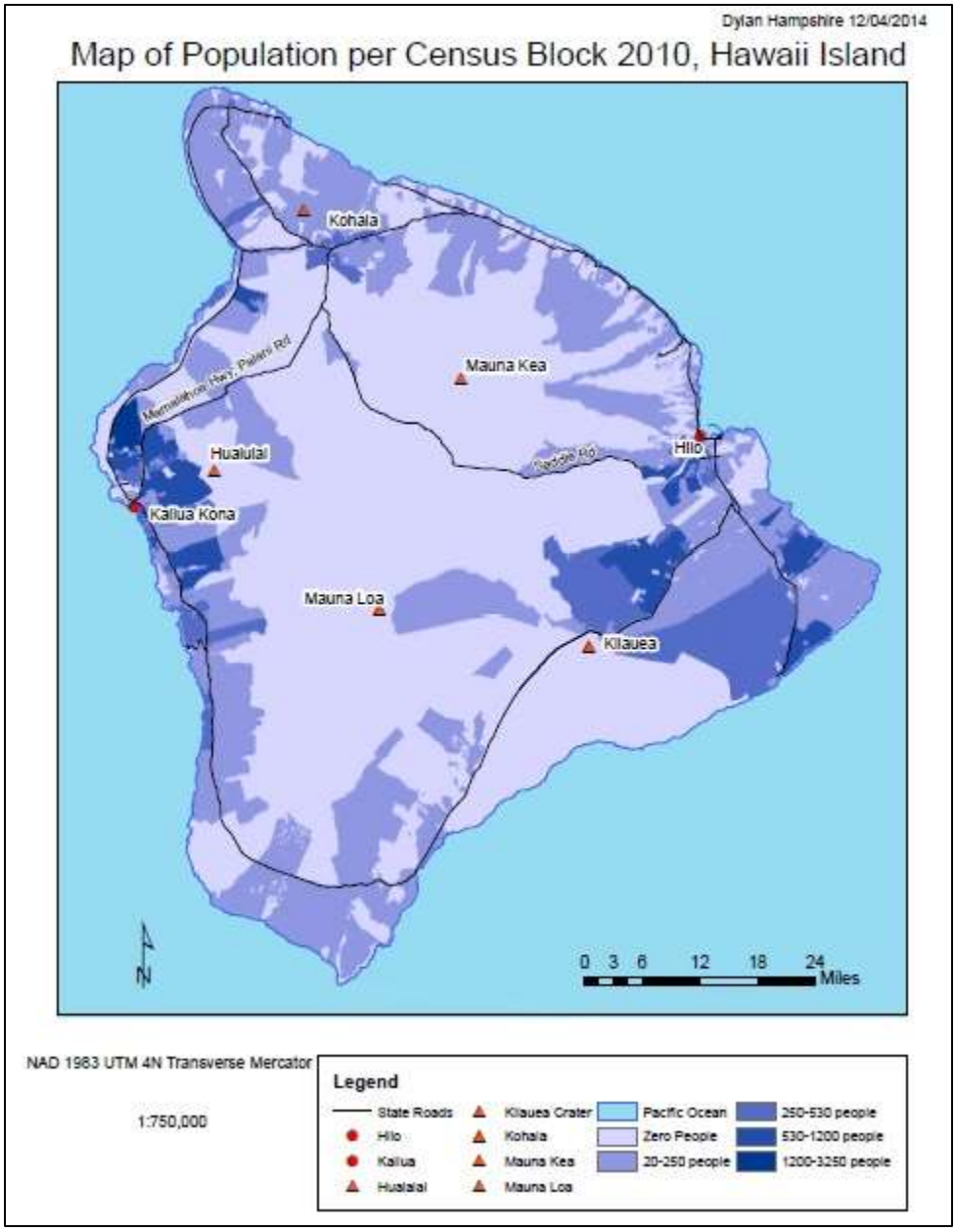


Figure H. : Using the Raster Calculator to multiply the Geologic Map reclassified raster and the Census Block reclassified raster.

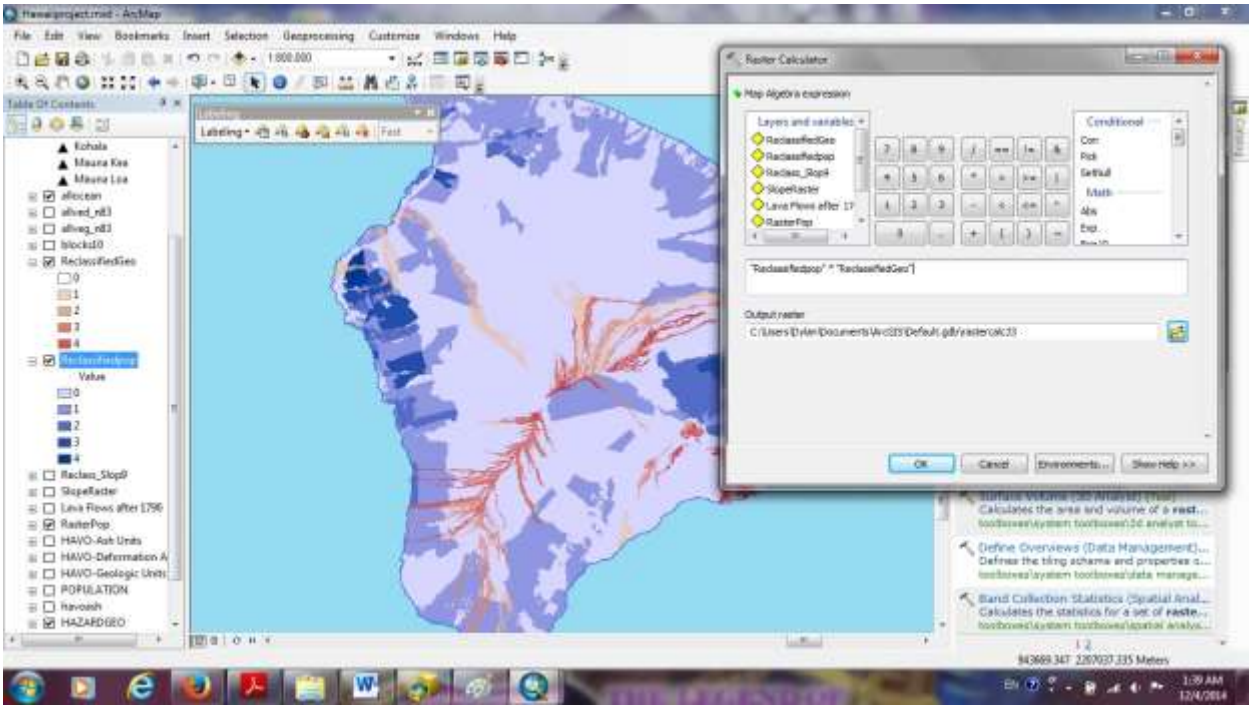


Figure I. : Map of Lava Threats to Hawaiian Homes, Hawaii Island