Hazard Assessment of Lava Flows, Wildfires, and Tsunamis on the Big Island of Hawaii's population

By: Thomas Ditges

The Problem:

The Big Island of Hawaii is the largest and most dangerous of the Hawaiian Islands. The Hawaiian hotspot has triggered 3 active volcanoes: Hualalai, Mauna Loa, and Kilauea. In addition, the Big Island of Hawaii is highly susceptible to tsunamis and wildfires. These can pose a dangerous threat to the surrounding population. The purpose of this project is to assess what regions of the Big Island are the most dangerous and what percentage of the population are affected by these hazards.

Question: What regions and populations of the Big Island are the most susceptible to hazards?

Data Collection:

- Downloaded Transportation shapefile from the Big Island from the USGS National Map Viewer.
  https://viewer.nationalmap.gov/basic/#productSearch
- Downloaded **Census Tracks- 2015 from the 016 Cultural and Demographic tab on the Hawaiian government website from Home<Hawaii Statewide GIS Program<Download GIS Data.
  http://planning.hawaii.gov/gis/download-gis-data/
- Downloaded Lava Flow Hazard Zones from the 009-Human Health and Safety tab on the Hawaiian government website from Home<Hawaii Statewide GIS Program<Download GIS Data. The source of this data is the U.S. Department of the Interior/ Geological Survey and the data is digitized by the Office of Planning for the USGS, Hawaii Volcano Observatory, 1991.
- Downloaded Wildfire Risk Ratings from the 009-Human Health and Safety tab on the Hawaiian government website from Home<Hawaii Statewide GIS Program<Download GIS Data. The source of this data is the Department of Land and Natural Resources, Division of Forestry and Wildlife, Fire Management Program, 2007. Data was collected by state wildland fire-fighting agencies in 2006 and 2007.
- Downloaded Tsunami Wave Heights Ratings from the 009-Human Health and Safety tab on the Hawaiian government website from Home<Hawaii Statewide GIS Program<Download GIS Data. The source of the data is 'Tsunami Wave Runup Heights in Hawaii,' Harold G. Loomis, May, 1976. The data was digitized by the Office of Planning Staff in October,1999.
- Downloaded Boundaries, Names, and Transportation datasets from the USGS national map viewer from data download. These datasets are more accurate because they are regularly updated in the years 2017 and 2018.
- Downloaded United States Board on Geographic names
  https://geonames.usgs.gov/domestic/download_data.htm

Data Preprocessing:

1) Converting GIS Data into ArcGIS-readable format

   I downloaded shapefiles from the Office of Planning Hawaiian Government website
   online and from the USGS national map viewer. I had to extract the files in order to
   import them into ArcMap using ArcCatalog. I saved these extracted files into my flash
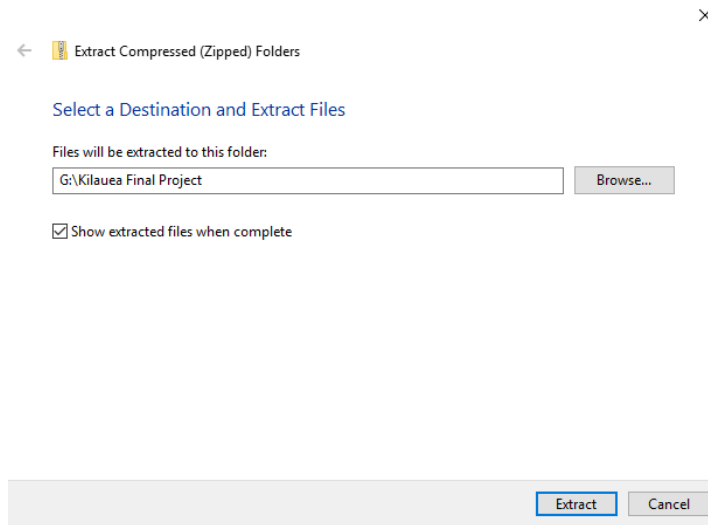   drive (USB Drive(G:).

Figure 1: Extraction of the Shapefiles

ArcGIS Processing:

1) **Changing all the shapefiles into the same projection**

   I changed all the projections to 1983 UTM Zone 4N by going to Properties<XY
   Coordinate System. I also used the Project tool to change the Hawaii State shapefile from
   GCS_North_American_1983 to NAD_1983_UTM_Zone_4N projection.

2) **Clip Analysis Tool**
   I clipped the new Hawaiistate shapefile to the fire risk shapefile with a XY Tolerance of 5
   meters to get rid of the ocean and just have the island. The input feature was Hawaiistate
   and the output feature was fire risk. I clipped the tract15 shapfile to the fire risk shapefile
   with a XY tolerance of 5 meters. The input feature is tract15 and the output feature is fire
   risk. I created a new layer by right clicking in ArcCatalog, and then I right clicked on the
   layer and went to Edit Features<Start Editing<Create Features Tool in Editor
   toolbar<HawaiiClip<Polygon. Then, I selected points to create a polygon around the Big
   Island in order to get tsunami wave heights just for the big island. I edited the vertices, so
   that the polygon lines did not touch the tsunami points. Then, I clipped the tsunhts
   shapefile input feature to the HawaiiClip output feature to create a new tsunamiclip
   shapefile.

Figure 1A: HawaiiClip polygon with
the tsunhts shapefile clipped
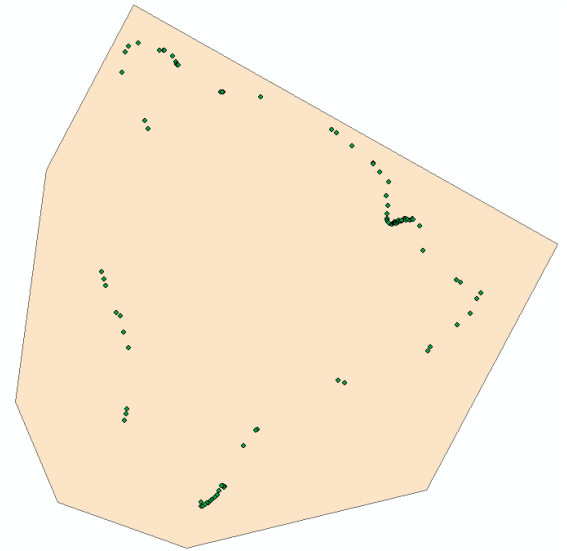
3) Feature to Raster Tool
Converted all the shapefiles into rasters using the Feature to Raster tool in ArcToolbox.
For the tracts15 shapefile, the input features is tract15<Field is Pop15<Output Features is
HawaiiBigpop which is saved to my flash drive under Kilauea Final Project. I set the
output cell size to 80. I renamed the new raster Hawaii Island population and classified it
by going to Layer Properties<Symbology<Classify<Classes(6) and then inputting
appropriate population values at intervals of 2000.

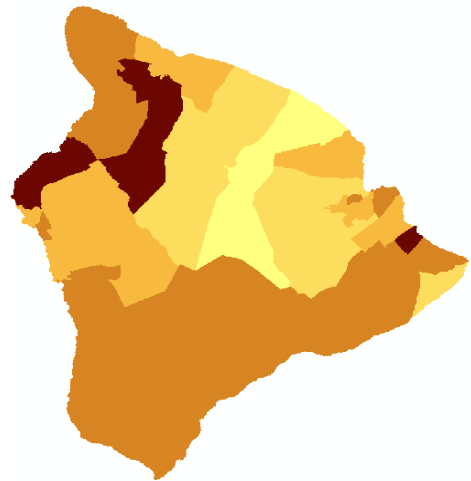Figure 1B: Hawaii
Big Island Raster
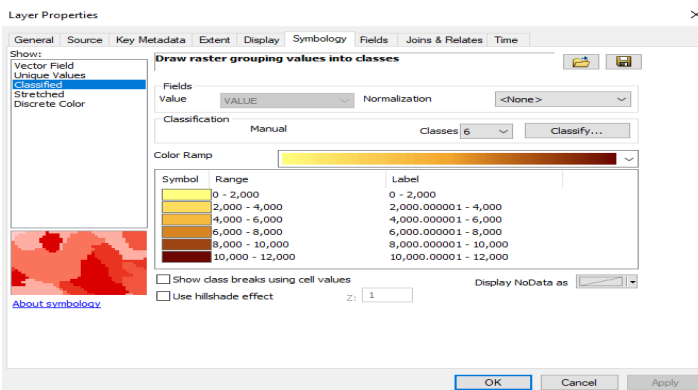
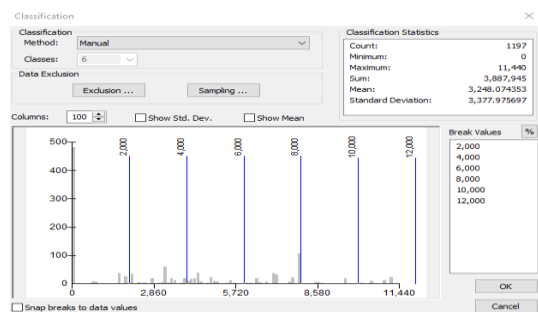Figure 2B: Symbology tab displaying symbols, range   Figure 3A: Classified intervals of 2000
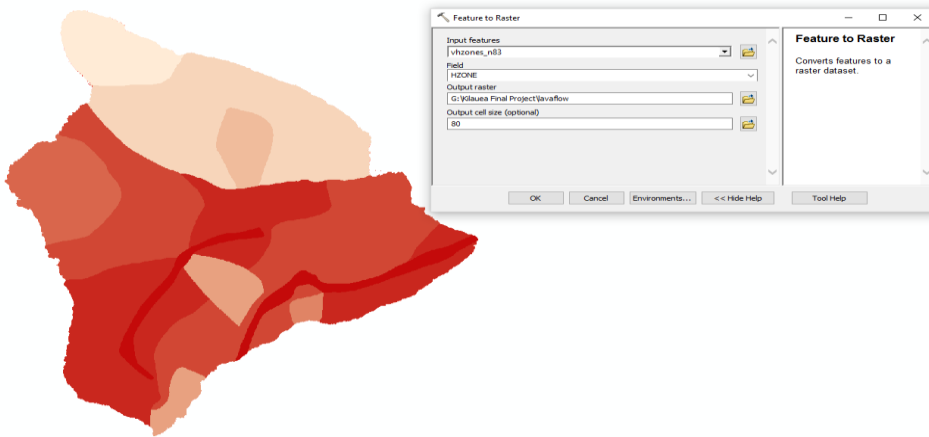
Figure 3B: Lava Flow Raster of the vhzones_83 shapefile

I converted the shapefile, vhzones_n83, into a raster using the Feature to Raster tool in ArcToolbox. Input Features is vhzones_n83<Field is HZONE<Output raster is Lavaflow which is saved to my flash drive under the Kilauea Final Project folder.

I converted the shapefile, fire risk, into a raster using the Feature to Raster tool. The input features is firerisk<Field is Risk_Ratin<Output raster is FireRisk which is saved to my flash drive under Kilauea Final Project folder.

Figure 4: Fire Risk Raster
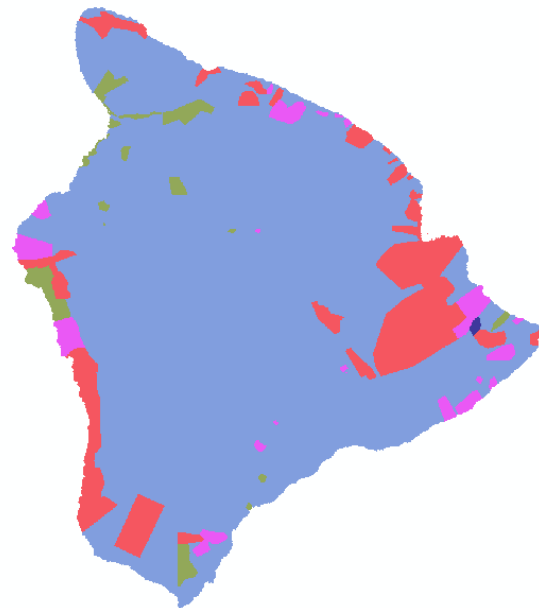
4) **Editor Toolbar**

In addition to creating the polygon around the outside of the tsunami points in step 2, I created another polygon around the inside of the points to get a get an area where I can

get a mask. The steps I did to get this polygon are: HawaiiClip layer<Edit Features<Start Editing<Create Features in Editor toolbar<HawaiiClip<Polygon. Then, I selected vertices around the inside of the tsunami points by inserting vertices and saving my edits.

Figure 4A: Edited polygons

of the HawaiiClip shapefile
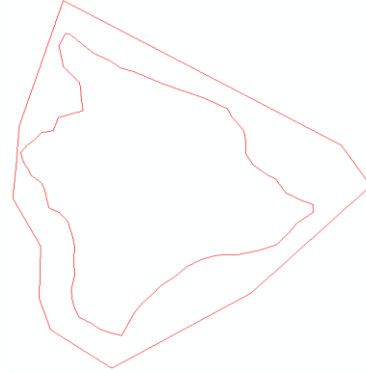
5) **Spline**

In order to get a raster from the tsunami wave height points, I used the spline tool to interpolate a raster surface from the points using a minimum curvature with the surface passing exactly through the points. The input point feature was tsunamiclip<Z Value Field is WAVE1960_F<Output raster=spline3<Output cell size=80<Spline Type=Regularized<Weight=0.1<Number of points=12.
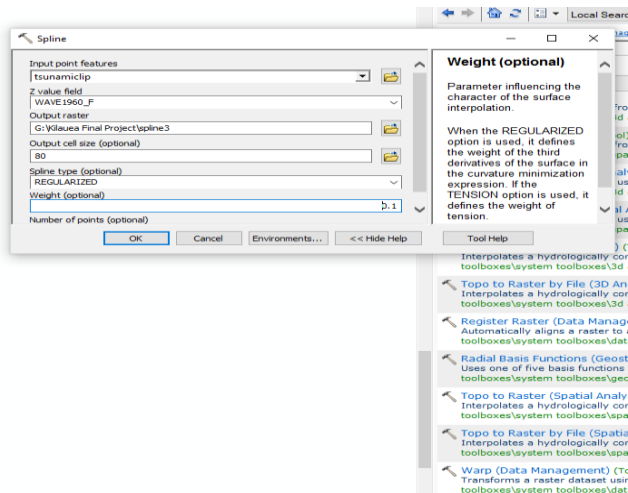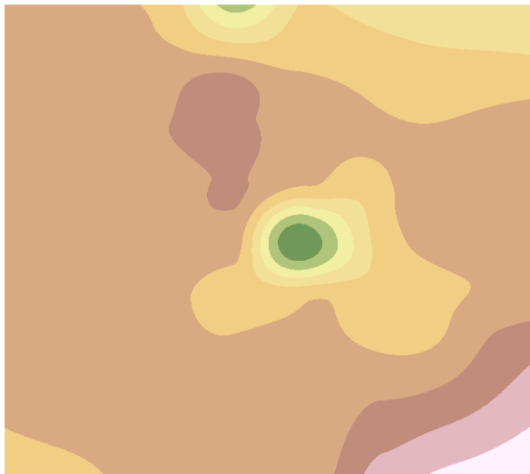

Figure 4B: New splined raster surface

6) Extract by Mask

I wanted to create an area within my new splined raster that would give me ranges for my tsunami wave heights. So, I used the Extract by Mask Tool with an input raster of spline3

and the feature mask data as HawaiiClip with an output raster name of extractmask. This new mask will give me classified ranges for my tsunami wave heights. I classified the ranges by going to Properties<Symbology<Classes=8<Classify<Broken values of 5 from 0-35 feet.
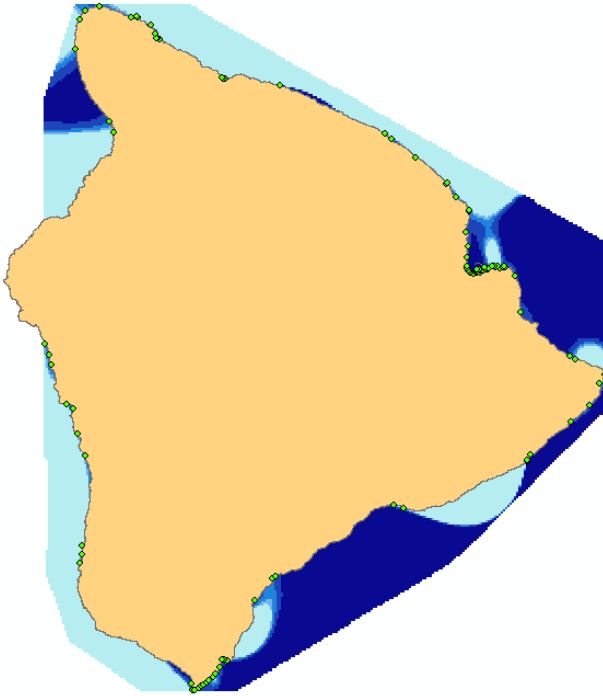

Figure 5: Mask with the Hawaii State shapefile and the tsunami wave height points.

7) Editor Toolbar

I wanted to show two population centers which are the most at risk for hazards on the Big Island of Hawaii, so I created two point shapefiles for the city of Hilo and the census-designated place of Pahoa. I did this by right clicking on my Kilauea Final Project folder<New<Shapefile<Hilo and Pahoa as the name<Feature Type is Point. Then, I go to the Editor toolbar and start editing the two new shapefiles. I created the feature by clicking on the Create Features tab and clicking on the shapefile and the construction tool point. I located the position of Hilo and Pahoa and clicked on those points on the map and saved my edits.

8) Buffer Tool

In order to display the amount of area affected in urban areas where populations were the greatest and the risk was the highest, I used the buffer tool. I used input feature as

Hilo<Output as hilobuffer<LinearUnit=10000 kilometers<Method=Planar. I used Planar method because it automatically determines which buffer or method to use based on the coordinate system. I did the same thing for Pahoa, Milolii, and Kilauea-Kona with the Linear Unit being 10000 kilometers.
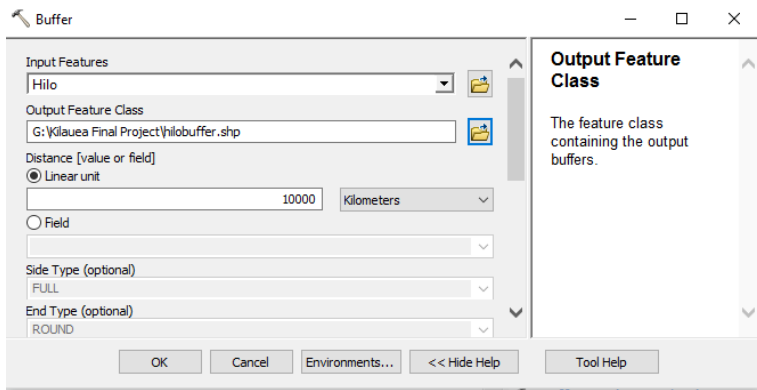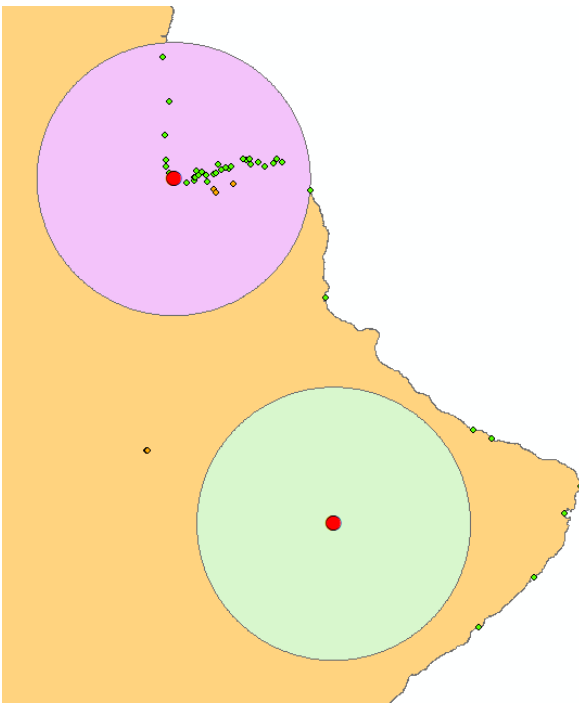

Figure 5A: Buffer tool for Hilo shapefile
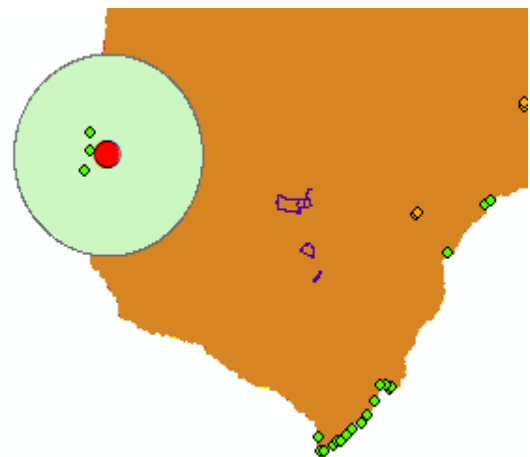

Figure 5B: Buffers of Hilo and Pahoa

Figure 6: Buffer of Milolii

9) Selection by Location Tool
In order to figure out which populations are inside each buffer, I used the Selection by Location tool.
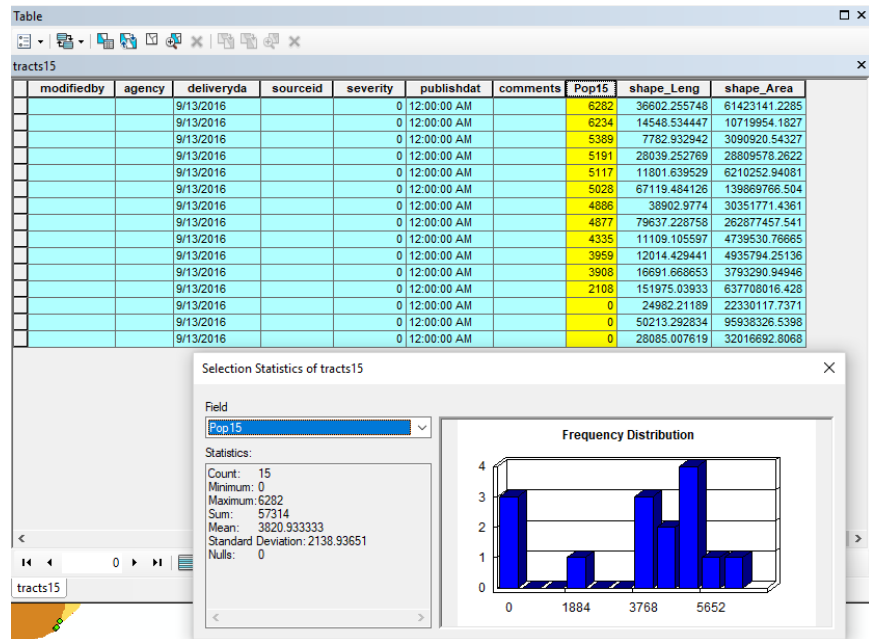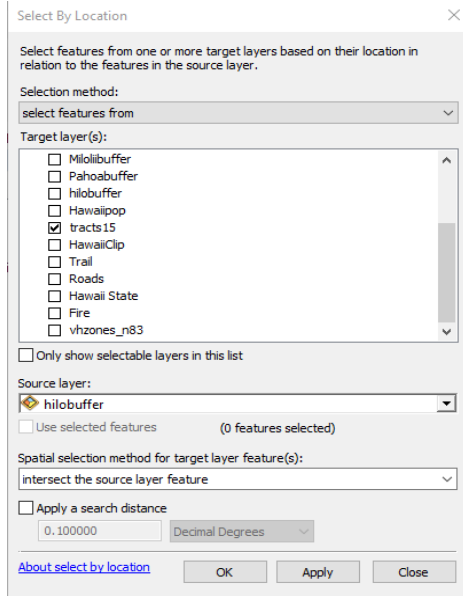
Figure 6A: Selection by Location tool of population intersecting the Hilo buffer.

Figure 6B: Attribute table with Selection Statistics giving the sum of the Field, Pop15.

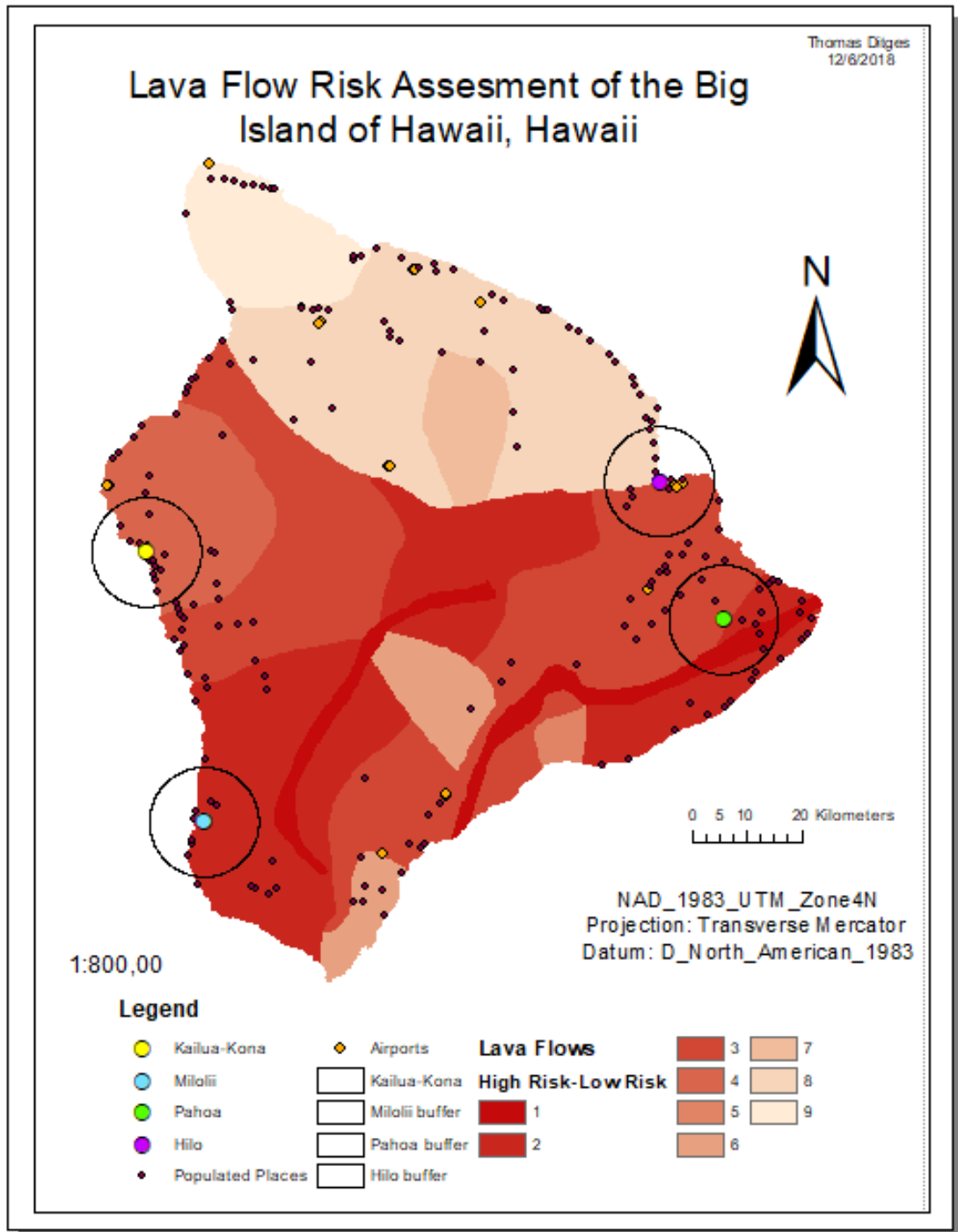| Area of Interest	Populations intersecting the buffer	Census Tracts Affected by the Hazards
Milolii	14,959	212.02, 213, and 9900
Hilo	57,314	206, 208.02, 207.02, 209,205,210.3, 208.1, 201,207.01, 204,203,202.02,9907,9908, and 9906.
Pahoa	40,694	210.05, 210.03,211.06, 210.10, 210.13, 211.01
Kailua-Kona	41, 213	215.07,216.01,216.04,215.09,215.04,215.02,9915,9914, and 9916

Table 1: Populations and census tracts intersecting the area of interest's buffers.

This approach is not an accurate way to display populations within the buffers because the census tract polygons are outside of the buffers. My data for the populations within the census tracts just calculates populations within the tracts intersecting the buffers. In order to get more accurate data, I got data from the United States Board on Geographic Names to show populated areas on the Big Island.
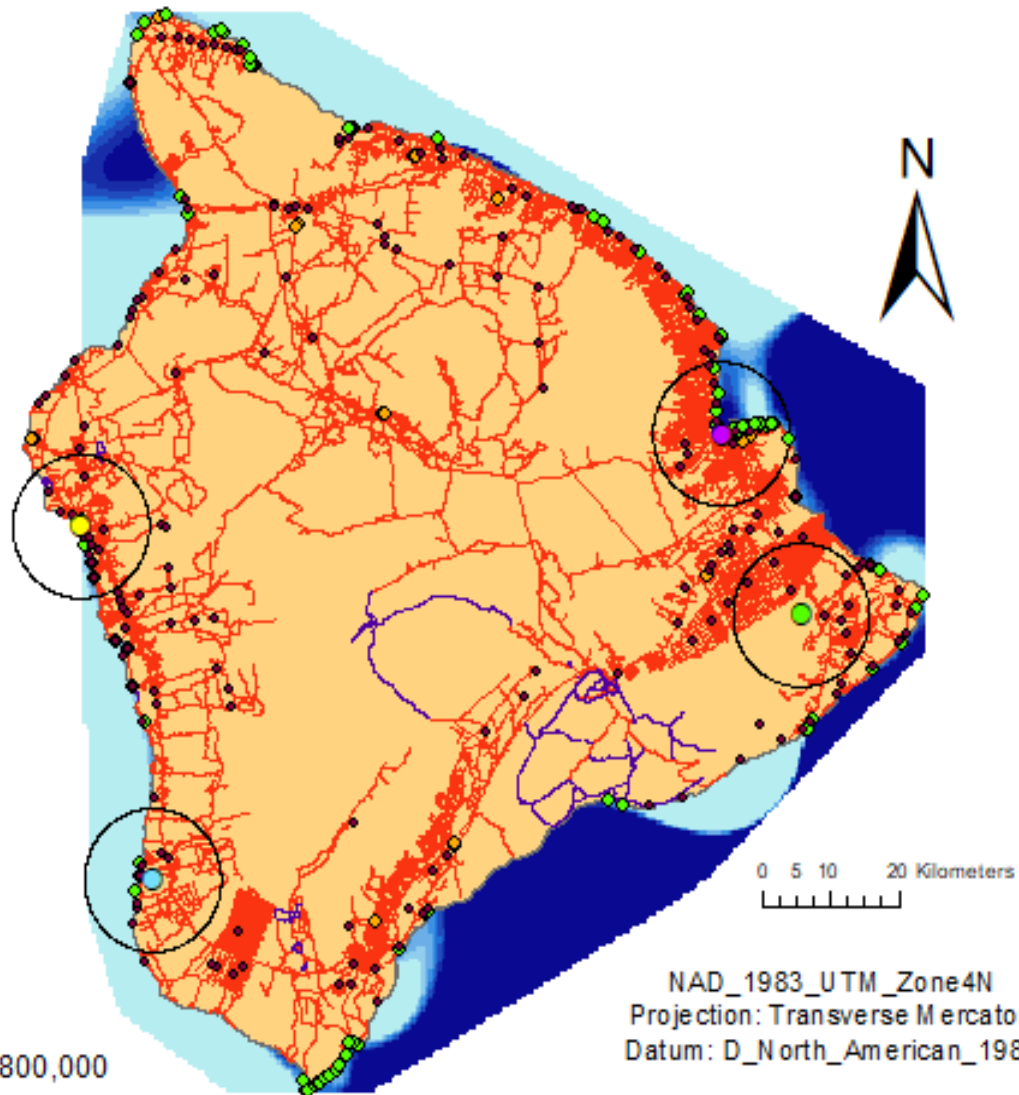
Conclusion: ArcMap is a very effective software for assessing hazards in a given area, especially for the Big Island of Hawaii. The main hazards that I have assessed in this study are wildfires, lava flows, and tsunamis. These studies are very important for Hawaii especially since there are 3 active volcanoes. I marked the census-designated places of Hilo, Milolii, and Pahoa as places

of the higher risk with Milolii being the place of the highest risk from lava flows. The northeast part of the Big Island, however, is the place of the lowest risk for hazards like wildfires, tsunamis, and lava flows. The city of Kailua-Kona is the highest risk towards wildfires which I included. The roads near Mauna Loa and Kilauea on the south side of the island are susceptible to large lava flows, so it would be advisable to take an alternative route to evacuate to a safe location. The populated areas within the buffers are also at risk to hazards. Frequent eruptions occur on the Big Island every tens of years and with this data the people can better prepare and know where places of lower risk are on the island.

Maps:

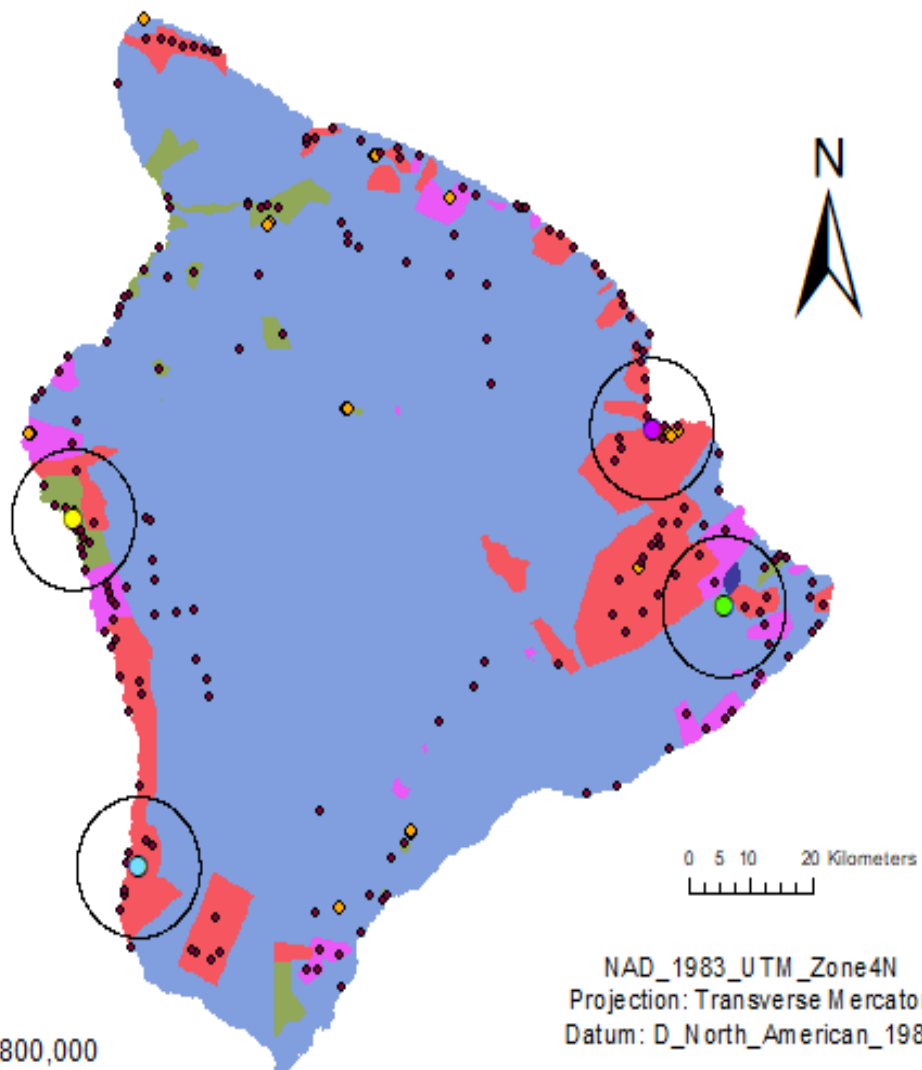# Tsunami Hazard Assessment of the Big Island of Hawaii, Hawaii

Thomas Ditges
12/6/2018

N

1:800,000

0 5 10   20 Kilometers

NAD_1983_UTM_Zone4N
Projection: Transverse Mercator
Datum: D_North_American_1983

Legend

⬤ Kailua-Kona	◆ Tsunami Wave Heights	☐ Hilo buffer	**Tsunami Wave heights**
⬤ Miloli	◆ Airports	Trails	☐ 0
⬤ Pahoa	☐ Kailua-Kona	Roads	☐ 0 - 5
⬤ Hilo	☐ Miloli buffer	☐ Hawaii	
• Populated Places	☐ Pahoa buffer		

Tsunami Wave heights: 5 - 10, 10 - 15, 15 - 20, 20 - 25, 25 - 30, 30 - 35

Fire Risk of the Big
Island of Hawaii, Hawaii

Thomas Dilges
12/6/2018

N

0 5 10   20 Kilometers

NAD_1983_UTM_Zone4N
Projection: Transverse Mercator
Datum: D_North_American_1983

1:800,000

Legend

Kailua-Kona	Hilo	Kailua-Kona	Hilo buffer	**Fire Risk**
Milolii	Populated Places	Milolii buffer		Low
Pahoa	Airports	Pahoa buffer		High
				N/A
				Medium

Population of the Big Island of Hawaii, Hawaii

Thomas Ditges
12/6/2018

N

0 5 10   20 Kilometers
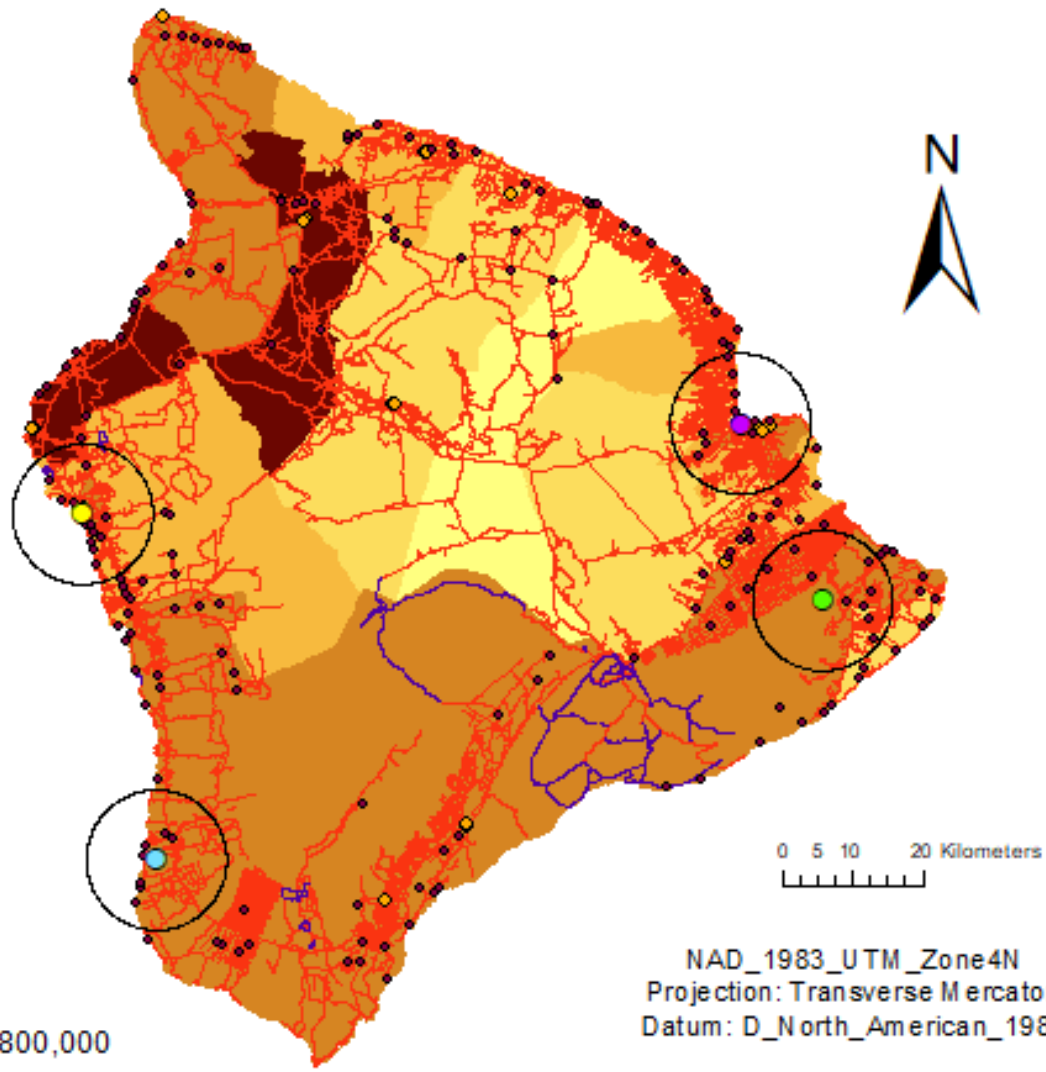
1:800,000

NAD_1983_UTM_Zone4N
Projection: Transverse Mercator
Datum: D_North_American_1983

Legend

				Hawaii Big Island Population	
● Kailua-Kona	● Populated Places	☐ Pahoa buffer			6,000 - 8,000
● Milolii	◆ Airports	☐ Hilo buffer	0 - 2,000		8,000 - 10,000
● Pahoa	☐ Kailua-Kona	— Trails	2,000 - 4,000		10,000 - 12,000
● Hilo	☐ Milolii buffer	— Roads	4,000 - 6,000		