Introduction

Having lived in Utah my entire life, we are taught from a fairly early age what to do when we experience an earthquake. Unlike tornado drills for those that live in tornado alley, earthquake drills are what are practiced here. But unlike tornados which occur generally in the spring and fall predominantly, earthquakes can occur at any time of the year. For a brief period of time, there was a noticeable drop in how often earthquake drills were performed in the state. Along with this drop, people did not really mention much about the fact that if there were to be an earthquake, a lot of people would not be ready for it in either knowing what to do when it happened but also what to do after the fact.

In the last five years however, there has been a significant increase in the number of earthquake drills being put on by the state. One of the noticeable things that occurred during this time was a report from the United States Geological Survey in conjunction with the University of Utah and the Utah Department of Natural Resources outlining the likelihood of an earthquake across the region. This report highlighted the possibility of a 43% probability that the region could experience one or more 6.75 magnitude or greater earthquakes. Along with this, the report outlined a 53% probability of one or more magnitude 6.0 earthquakes across the region. Both of these probabilities being witin the next 50 years at the time the report was published (DuRoss, 2016). With the release of this report, people really started to take notice of the fact that there could be a significant earthquake in Utah, especially along the Wasatch Front in their lifetimes.

The real wake up for people though came on March 18th, 2020 when the Wasatch Front experienced a magnitude 5.7 earthquake; the strongest earthquake for the area since the 1934 Hansen Valley earthquake which measured a magnitude 6.6. The main quake was 5 miles from Salt Lake International Airport and 10 miles from downtown Salt Lake City (University of Utah, 2020). This made a lot of people realize just how close they are to faults across the region along with reinforcing the need for people to have an emergency preparedness kit along with knowing what to do when an earthquake happens.

Mapping out the faults along with the population, it showed that a lot of the population is located along the major fault that cuts through the northern third of the state. The number of earthquakes that were recorded across the Intermountain west region was fairly surprising to see. Even after eliminating most of the ones that were not located in the state or above a certain threshold for strength, over five hundred remained. This was a significant reduction from the almost from almost fifty-eight thousand entries at the start.

Data Sources

Gathering the data for this project ended up being relatively easy overall when it came to finding most of the parts. The state of Utah runs a GIS database that is accessible to the general public with a variety of different topics to pick from. Along with a lot of this data being located in one place, there were many different options available to download this data as well including shapefiles, KMLs, and spreadsheet layouts. This was beneficial for this project because it allowed for a lot of data that I needed without having to visit multiple sources. By visiting the one location, I was able to get the county boundary map that is created by the United States

Census Bureau and maintained by the state of Utah. The other thing that I was able to obtain from the state of Utah was the population map for the state. This was also provided by the United States Census Bureau and maintained by the state. One of the advantages to this is all of the data was already formatted in a shape file, so no modification was needed to get the data into a plottable format.

For the fault data, I was able to gather this from the Utah Geological Survey and the state of Utah GIS database. This was the same place that I got the other data involving the state. The data was also formulated in a shapefile so there was no need to modify the data before plotting it on the map. It was also easy to plot without having to change the formatting for how it was plotted either since they were plotting using the same coordinate system as well.

For the earthquake records, I turned to the University of Utah to see if they would have a record long enough to contain from at least the middle of the twentieth century. The file was not formatted in a shapefile like the county and population data files. It was in an CSV format for Excel, so the data had to be plotted using an X and Y plot with the latitude and longitude being the values used. Once this was plotted, it was able to be exported from a CSV into a shapefile so there wouldn't have to be a repeat of plotting it on an XY plane using latitude and Longitude as the reference system.

Methods

Map 1

For the first map, I went ahead and did just an overall view of the state with the faults and population plotted in comparison. For a map of the state, I used the county boundary map from the United States Census Bureau so there would be some base map to start from. This map was one of the easier ones to do because it involved just plotting the population blocks from the Census and then the faults to compare. Formatting was not an issue as the only thing that required any kind of formatting was the county boundary map. The faults and population blocks all loaded in quite easily and made for a quick job. The only thing after that was to create a legend and scale bar to go with the map along with a north arrow and title for it.

Map 2

With the second map, I decided to plot the earthquakes in comparison to the faults. For this map, I still used the county and fault shapefiles for a base to the map. The faults I included to show the relationship between the know faults and locations of earthquakes in the state. While the first two loaded easily into the ArcMap, the same couldn't be said for the file containing the earthquakes. This was saved as a CSV file, so it had to be loaded in and then plotted using the X axis as latitude and the Y axis for longitude.

After loading the earthquake data and plotting it on the map, I went into the data and selected only earthquakes that had a magnitude of 3.0 or greater so there would be less noise from all of the smaller magnitude earthquakes on the map. Once the smaller earthquakes were cleared out, I had to go through and remove move of the earthquakes that were located outside of the state since the University of Utah collects earthquake not only from the state of Utah but also the surrounding states as well. In order to filter these out, the latitude and longitudes were used to filter out ones that were located outside the state. While this was able to clear out most of the earthquakes outside the state, it did leave some in southwest Wyoming because of the state that leaves a small corner missing. After filtering out the smaller earthquakes, the next concern was setting a color scale for the magnitude of the earthquakes so they could be differentiated. With picking the color scale, the color had to be different than that of the faults. For this map, the faults were colored blue when I loaded them so the color stayed the same and used a red color ramp for the earthquakes so the earthquakes and faults would not blend together in the map.

Map 3

For the third map, I wanted to focus more on the northern third instead of the whole state because most of the population for the state lives in this region. This is also where the most development near faults has occurred. For this, I wanted to include not only the faults but also the population that were made by the United States Census. This allows us to see just how close people are to the faults across this portion of the state. After adding these in, the map still felt like it could have used more data across it.

At this point, I decided to add in the earthquake data from the other map to show the earthquake activity across the region. With using this data over again, I did not change the magnitude that was being plotted. The one benefit with this closer view of northern Utah is that I did not have to worry about the earthquakes that occurred outside the state because the map frame was zoomed in enough to cut them out. But instead of using the same color scale as map two, I switched it up because the color for the faults had to be switched from blue to red to stand out against the population blocks. This meant that the earthquakes had to be something other than a red shade so they would stand out in relation to the faults. For this reason, I went ahead and applied a different color ramp that was a shade of blue instead of one that uses red or yellow. The reason being for this is that the red color ramp blends in too well with the red fault lines already. And with the population blocks being green already, that ruled out using green as a color possibility. With this switch though, the color of the earthquakes had to be a shade that would not blend in with the green for the population blocks.

Findings

When plotting the maps, I knew that a lot of people were located near the Wasatch fault system that runs through Northern Utah, but I did not expect to see that two thirds of the state population was located near the Wasatch fault. One thing I did not expect to find though was that there were so many faults that are spurred of the main Wasatch fault. These smaller faults are thought to be the reason as to why there was the earthquake on March 18th, 2020 in the Salt Lake valley (2020 Magna Earthquake Sequence, 2020).

Another surprising thing that I found was that there were earthquakes across the state not located anywhere near a known fault on the fault map. This leads to the question of there being more faults out there that do not show at the surface but are buried beneath the surface. While there are new techniques for mapping faults, there still a some out there that have yet to be discovered. Some of these areas where a fault might also be located in fairly remote areas in the desert.

When looking at the map for the earthquakes across the state, we do see that there are some fairly active faults across the state. Most of these happen to follow the mountains that extend from northern Utah down the southern Utah. The southern end of this appears to be more active than the rest with the exception of the recent earthquake activity just outside of

Salt Lake City. A big thing that stood out to me was just how many earthquakes there were that came in at a magnitude 3.0 or greater across the state.

Conclusions

While trying to find most of the data for this project was fairly simple and straight forward, there were some issues with trying to get some of it, and then plotting it. Coincidentally it was all with the same dataset that produced the most issues. This was all involving the data for the earthquake database from the University of Utah. At first, I was able to find only a database that dated back to 2016 and did not include anything that was recent. I was however able to find an updated one that included earthquakes dating up to September 2020. The next issue came with trying to get this to plot nicely with everything else after assigning how it should be plotting using the X and Y axes.

Unfortunately, the dataset included over 50,000 rows of data with 10 columns so trying to get it all to plot at first took some time. After whitling it down to include only earthquakes magnitude 3.0 or greater was it able to run through it faster. Another issue that I ran into while plotting the different data is that some of the data extended belong the boundaries of the state line. This occurred with both the faults along with the earthquake maps. The fault because the Wasatch fault extends into southern Idaho and the earthquakes because the University of Utah also monitors earthquakes across the Intermountain west. With most of the earthquakes, I was able to eliminate them based off of latitude and longitude outside the state.

Even though it is portrayed as a straight line in maps, the boundaries of the state are not so there are minor deviations. This led to some out of state earthquakes having to be included because they are just barely outside the boundary. Another issue with this is that earthquakes in southwest Wyoming would be harder to eliminate from the map. While one could go through and eliminate them one by one from the dataset, I figured it best to just leave them due in part to there being a fairly limited number of earthquakes across that region.

One of the ideas that I floated for map 3 was possibly plotting the towns on the map in relation to the other variables. This idea was one that sounded great in theory, but in practice, it was not that great because of how many smaller towns that have formed across the region, we see a lot of dots clumped together. And eliminating them by population numbers leaves a weird hole if too high of a population value is used as it eliminates the smaller towns towards the outskirts of the population blocks.

An idea that I had floated of possibly doing but was shot down by the inability to access the aerial imagery from the state was not easy to come across. The idea was to plot the aerial imagery for the northern third of the state, and then overlay the fault information on top of this to produce an aerial view that shows the surrounding area for those.

Postscript

I thought this was an interesting class that provided some challenge but also showed me what felt like a huge introduction into ArcGIS along with other programs used for creating maps using GIS. Some of the hardest parts of the class had to be trying to pull data down for a lab when the site the data was located on changed from when the lab was written so it provided a lot of confusion as to what to do. The grading by the TA was kind of confusing at first because I wasn't sure how much was being subtracted from my score because the comments on Canvas read as whole numbers and not decimal points.

Works Cited

2020 Magna Earthquake Sequence. (2020, September 18). Retrieved from University of Utah Seismograph Stations: https://quake.utah.edu/monitoring-research/2020-magna-earthquake-sequence

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