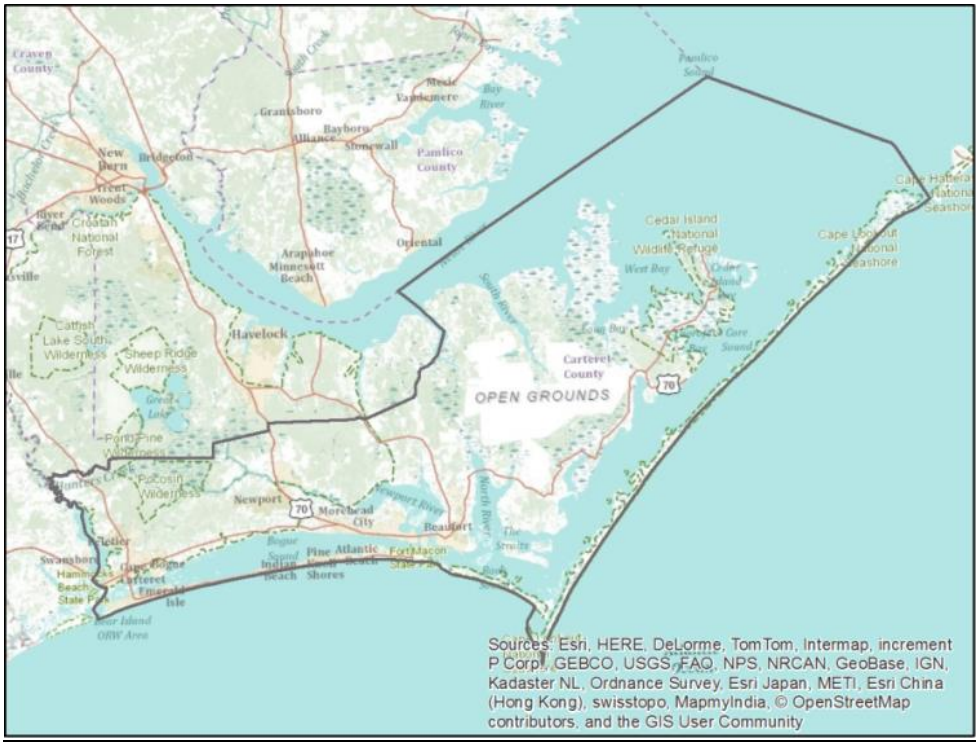
Flood Risk and Prevention in Carteret County, North Carolina



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GEOG 591
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Introduction

In this project, I investigated the potential sources of flood risk in Carteret County, North Carolina. Carteret County is a coastal county in southern North Carolina. As shown in the map below, the terrain is generally very flat, with many areas at or below sea level.

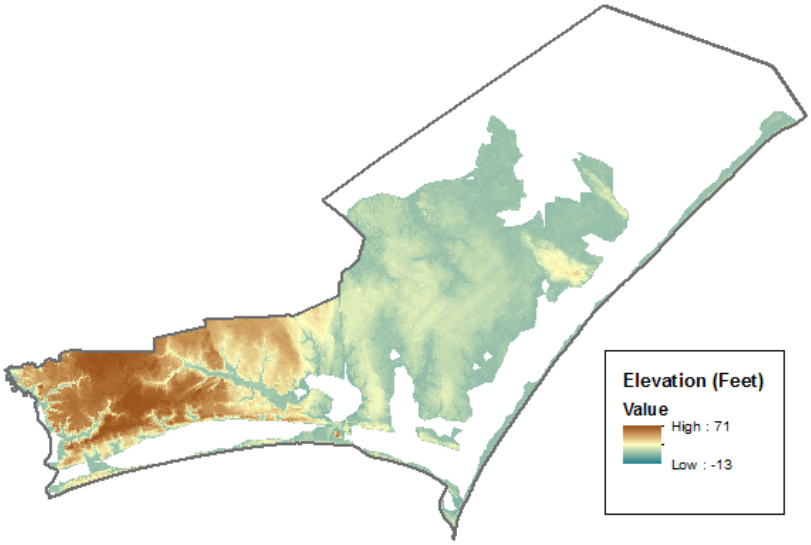

Figure 1: Elevation map of Carteret County

I chose to analyze Carteret County not only because of its low elevation and proximity to the coast, but also because of my familiarity with the area. Last summer, I visited my aunt's beach house in Atlantic City on one of the southern barrier islands. After rain storms, roads all over the area would flood, making travel difficult. For this project, I wanted to see if this was a widespread problem throughout the entire county, and to some degree, uncover the causes of this flooding.

Objective

The objective of this project is to analyze flood risk in Carteret County using a variety of data sources. I was especially interested in identifying the areas at greatest risk for flooding and determining what factors contribute to this risk.

Method

I began my project by looking for precipitation data for Carteret County. Unfortunately, I could not find enough precipitation stations in order to determine what I saw as a good overview of the county. I decided instead to examine more generalized precipitation information from the PRISM Climate Group. From the map of North Carolina below, I found that the average annual

precipitation for Carteret County over the last 30 years or so is about 60 to 70 inches per year, one of the highest averages for any costal county in the state.

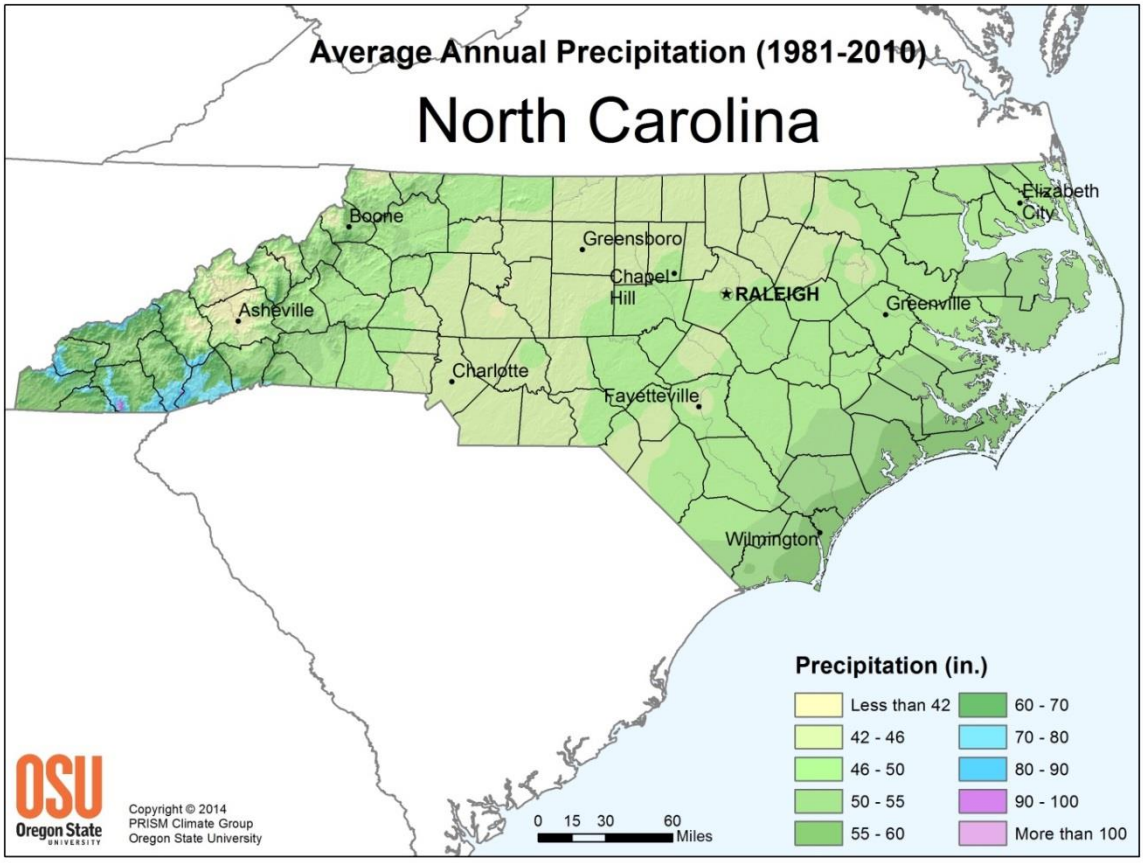

Figure 2: PRISM Map of average annual precipitation in North Carolina

My next task was to determine the topographic wetness index (TWI) of the county. TWI is used to determine wetness conditions in an area by calculating the relationship between flow accumulation and slope using the following equation: $\ln(\frac{"fac"}{\tan("slope")})$. I began with LiDAR data (20 foot cell size) from the North Carolina Department of Transportation's GIS resources website. From this, I created a flow direction, flow accumulation, and slope raster data sets using the corresponding ArcGIS tools. Then, I used the raster calculator to create the flow accumulation raster based on the equation above.

Information about the different types of terrain in Carteret County was vital in getting some context about the at risk areas. Luckily, ArcGIS online servers provided me easy access to the National Land Cover Dataset (NLCD). Using the Clip tool, I created a map of land cover data only within the boundary of Carteret County.

ArcGIS online servers also gave me access to soil water storage capacity data and water table depth data. After using with Clip tool and with some quick tweaks to the symbology, I created a map for each set of data to be used for comparison later.

One of the most important sets of data in my project is flood hazard information from the National Flood Insurance Rate map, obtained from the Carteret County GIS portal web site. When I first downloaded the data, I was confronted with a zip file containing over forty dBase tables and sixteen shape files. Through some analyzing and experimentation, I discovered one of the included shapefiles contained vector data of flood hazard regions. After tweaking the symbology, I created a color coded map of the various classified flood hazard regions throughout the county.

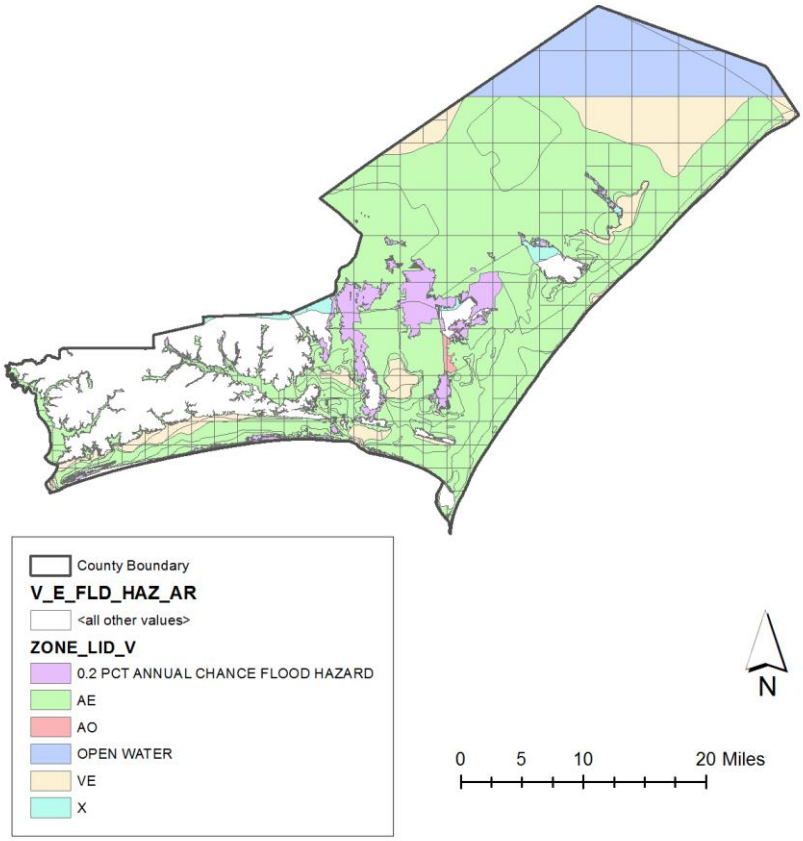

Figure 3: Flood Hazard Map of Carteret County

This map is used many times in my study of flood risk, so I will explain it in detail here. Levels of flood risk are outlined based on the percent chance of a flood will occur during the year. 0.2 percent annual chance is self-explanatory, and is the minimum percent risk for an area to be classified as a Special Flood Hazard Area (SFHA). An AE zone has 1 percent annual chance and a mandatory flood insurance requirement. An AO zone has a 1 percent annual chance of shallow flooding. Open Water indicates water away from shore and therefore has no corresponding flood risk. A VE zone has 1 percent annual chance with wave action. An X zone has 0.2 percent or lower annual chance (still above 0 percent) and therefore does not fall into the category of SFHA.

Since Carteret County is located on the coast, I thought it would also be worthwhile to investigate the impact of hurricane storm surge and how it compares with the rest of my data. I first did some research about the ADCIRC circulation and storm surge model, developed by Rick Luettich in the department of marine science at the University of North Carolina at Chapel Hill.

I also looked at the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model developed by the NOAA. During my search, I came upon an ArcGIS layer file containing information about hurricane storm surge inundation areas of fast and slow moving storms based on the SLOSH model. Though the data was from 1993, I thought it would still be useful for my purposes, and was already in a simple format for me to manipulate in ArcMap.

Now that all of my data and maps were on hand, I began comparing different factors to see if I could find any interesting correlations. By comparing maps side by side and overlaying flood risk on some maps, I was able to produce a variety of results for analysis.

Results

Using the raster calculator to create a TWI raster produced the following result.

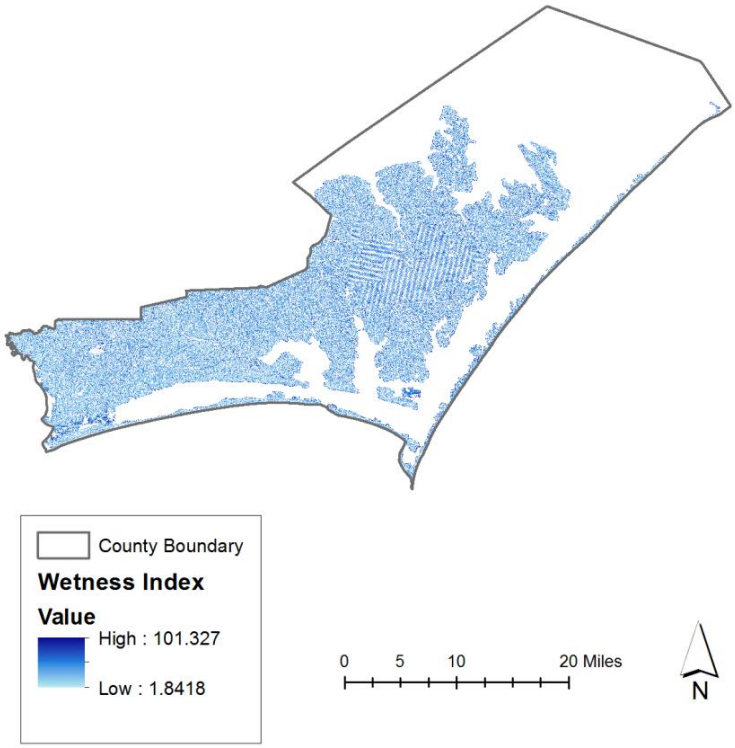

Figure 4: Map of wetness index of Carteret County

Unfortunately, this map did not tell me much in terms of flood risk. Looking at the map as a whole, wetness index appears to be pretty consistent across the entire county, save for a small select spot or two. Considering the flat topography of the county, this result makes sense. The speckled-like appearance of the raster is actually due to the many tiny canals and waterways that run through the landscape. The straight parallel and perpendicular lines that can be seen in the northeast section of the county are due to the large amount of land devoted to agriculture in this area.

The clipped land cover raster provided an important picture of the different types of land use in Carteret County.

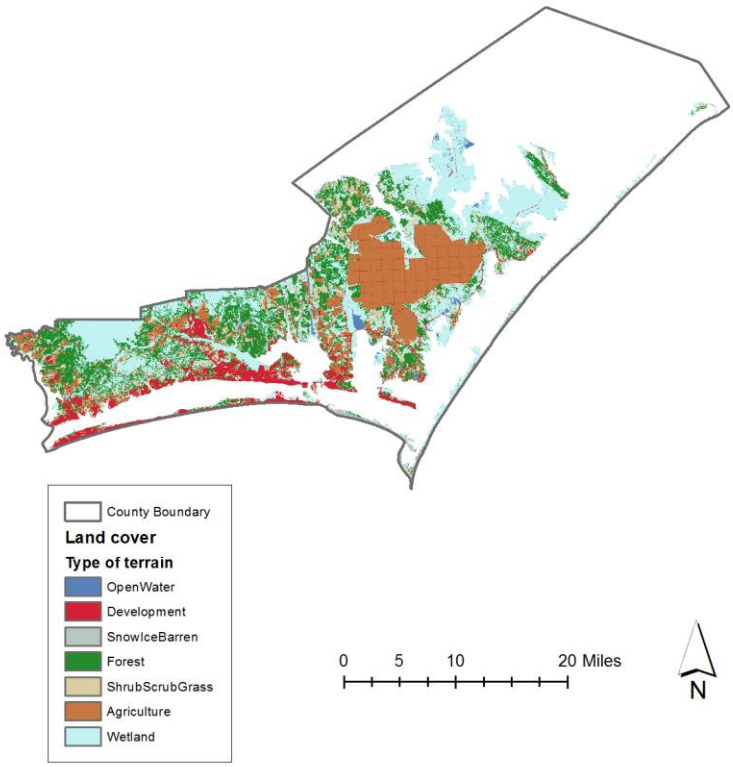

Figure 5: Land cover map of Carteret County

The majority of terrain is forest or wetland. Agriculture dominates the north eastern part of the county, while the majority of development in concentrated in the south west.

The finished soil water storage capacity map details locations of soils with a potential to store a high or low volume of water. Comparing this map to the land cover map gave me some interesting clues about the landscape

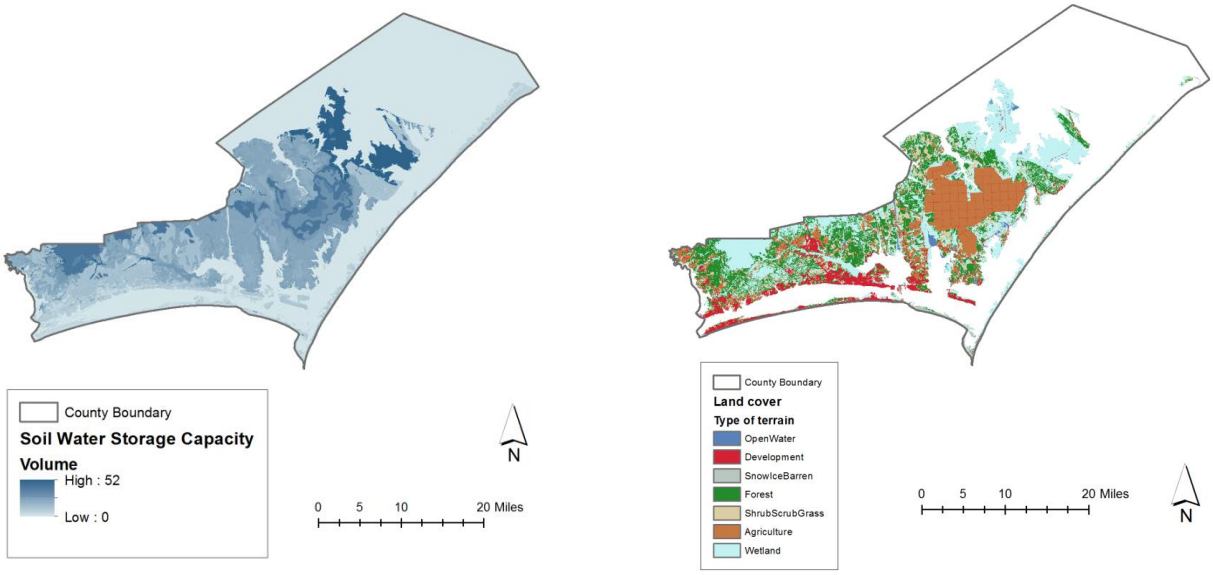

Figure 6: Map of soil water storage capacity compared to land cover

Soil water storage capacity is greatest in some inland areas and the north eastern coast. As the land cover map shows, these are wetland areas, so the high storage capacity makes sense. What is most of note for my study of flood risk is the low storage capacity of soils in the southern part of the county and the barrier islands. The areas with the lowest storage capacity are also the areas with a large amount of development

Comparing the water table depth and land cover maps is not as telling, but seems to indicate that deepest water tables are located in the area with development.

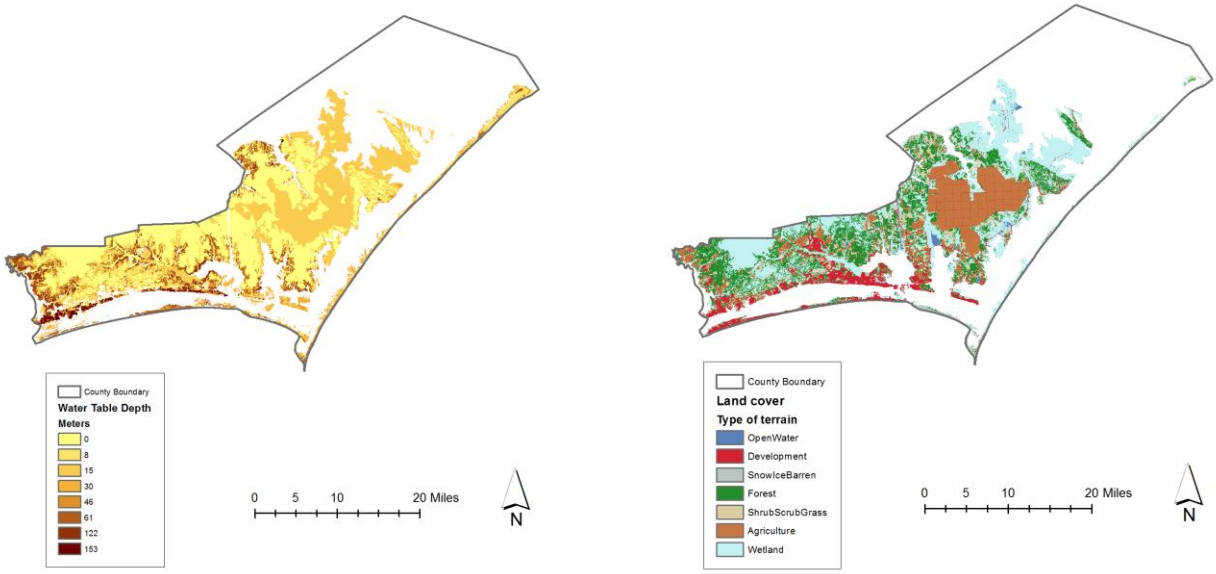

Figure 7: Map of water table depth compared to land cover

The following map was created by overlaying the flood risk vector data with the land cover raster data in order to determine what types of terrain are located in the flood hazard zones, specifically SFHAs. A map of just the land cover raster is next to it for comparison.

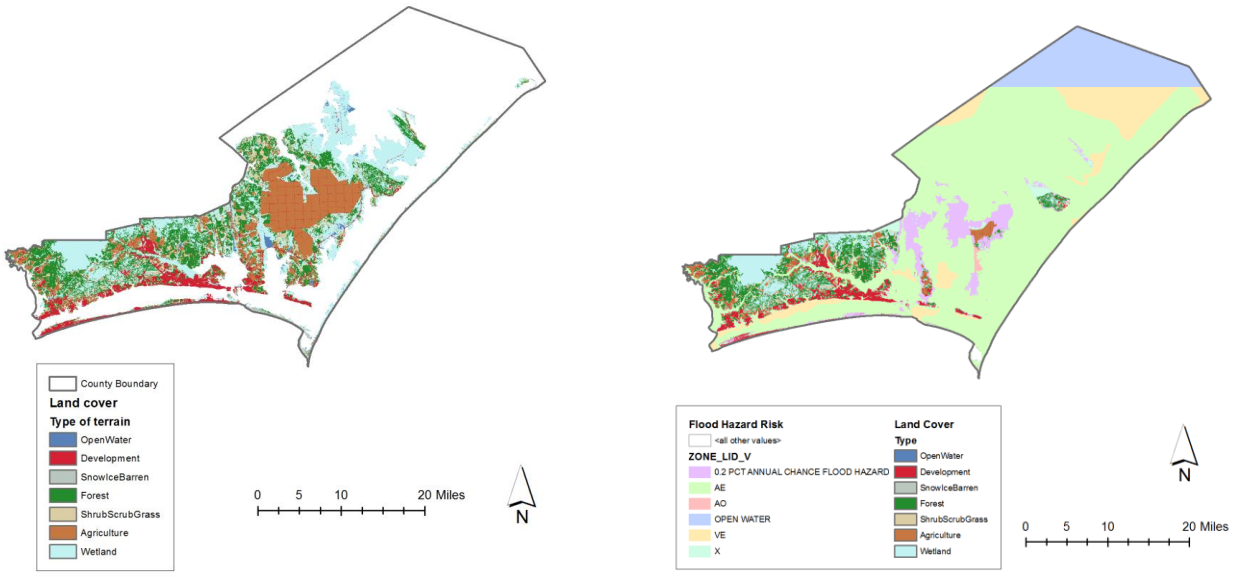

Figure 8: Land cover map and land cover map with flood hazard zone overlay

According to statistics provided by the Carteret County government website, 33% of the population, 47% of the land area, 24% of critical facilities, and 39% of roads are within a SFHA. These statistics are supported by the map, as most of the development in the county, and therefore, most of the population is not in a hazard zone. However, nearly the entirety of the land used for agriculture is in a SFHA; aside from tourism, agriculture is the most important part of the county's economy.

The hurricane storm surge data I obtained is displayed in the map below. For convenience, I displayed the data for fast and slow moving hurricanes together as there was a lot of overlap between the two.

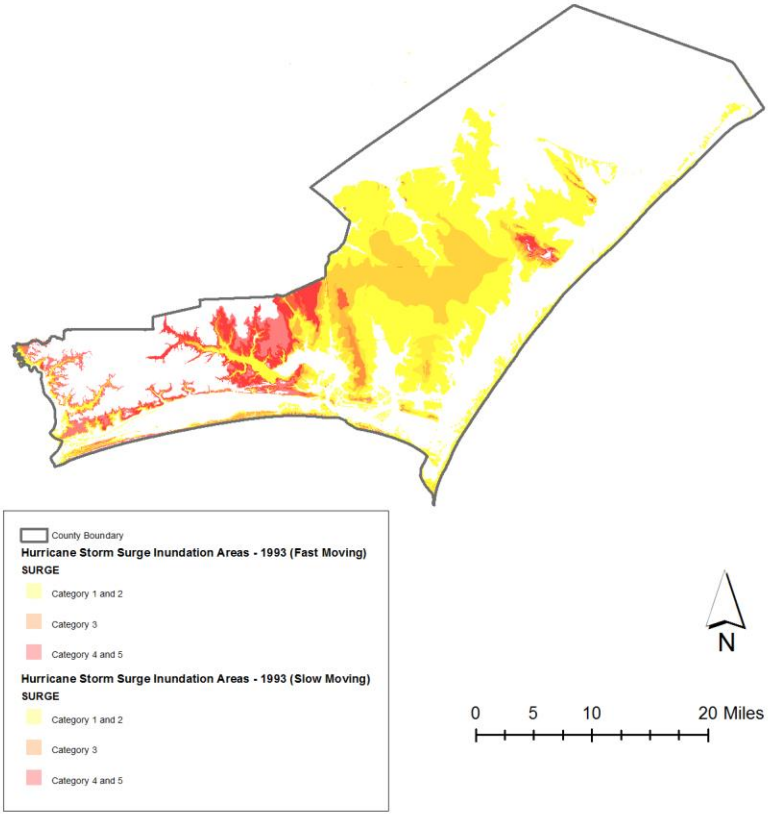

Figure 9: Map of hurricane storm surge inundation area for by hurricane strength (1993)

Nearly the entire eastern part of the county falls within the area that would be affected by storm surge in a category 1 or category 2 hurricane. This is not surprising, as the elevation in the area is for the most part at or below sea level. Most of the southern part of the county, the same area where most development is located, is in the category 4 or category 5 hurricane storm surge zone. The barrier islands are the worst off in this regard, as to be expected, nearly all of them falling under the category 1 or category 2 hazard zone.

The final map I created is an overlay of the flood risk vector data over the hurricane storm surge data, shown below.

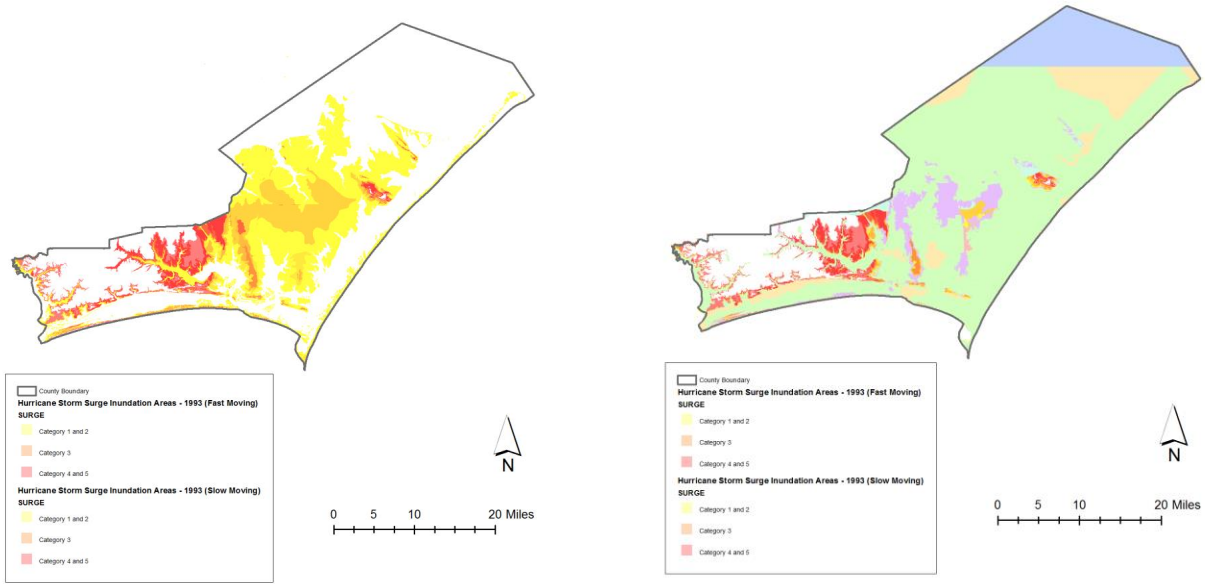

Figure 10: Map of hurricane storm surge inundation and with flood hazard zone overlay

Nearly all of the land that would be affected by storm surge in a category 1 or category 2 hurricane is within a SFHA. A correlation between the two is to be expected, as coastal areas already vulnerable to flooding are likely to be affected by storm surge from even a weak hurricane. Historically, North Carolina has be hit by more category 1 and category 2 hurricanes than category 3 or above since 1851 (35 versus 12).

Discussion

According to these results, the factors most important to understanding flood risk in Carteret County are elevation, soil water storage capacity, and hurricane storm surge risk. The areas at highest risk for flooding are the eastern part of the county and the barrier islands. In this section, I will discuss both of these regions in detail.

The barrier islands of Carteret County, especially the Bogue Banks region to the south, are mostly covered with development (aside from some preserved natural areas). This is the region I am most personally familiar with. Expensive beach houses, hotels, restaurants, and attractions are plentiful due to the area's large tourism industry. As shown in the elevation map, the barrier islands are very flat and close to sea level. In addition, the soil water storage capacity is very low compared to the rest of the county. Both of these factors contribute to flood risk. In addition, barrier islands are extremely vulnerable to hurricane storm surge due to lack of natural barriers.

The eastern side of Carteret County is very flat and low, with some areas with elevation ten feet or more below sea level. The terrain is very suitable for agriculture, with farms in the region producing a wide variety of crops including corn, soybeans, and vegetables. At the same time, however, the terrain is extremely vulnerable, with the entire area at risk for storm surge inundation during even a category 1 or 2 hurricane, much less a stronger storm. Thankfully, the majority of the population lives in the southern, inland part of the county at higher elevation.

Conclusion

Overall, my study of flood risk in Carteret County has lead me to the conclusion that the threat of hurricane storm surge is the most prevalent factor influencing risk, though by no means the only one. Thankfully most of the population and development is out of flood zones, but as I have experienced firsthand, small localized flooding can still be an issue. I believe this is just one of the tradeoffs of living on a heavily settled coastal area; however, an economy built around tourism cannot afford to just pack up and move, but rather must adapt and accept flood risk as part of life.

Information Sources

Carteret County flood information [Fact sheet]. (n.d.). Retrieved December 4, 2014, from Carteret County website: http://www.carteretcountync.gov/244/Carteret-County-Flood-Information

Flood zones [Fact sheet]. (2014, July 24). Retrieved December 4, 2014, from FEMA website: https://www.fema.gov/floodplain-management/flood-zones#

Data Sources

ESRI ArcGIS Online

National Land Cover Dataset

NC OneMap

NCDOT GIS Resources

NCDOT Hurricane Storm Surge Info

North Carolina Flood Risk Information System – Carteret County Data
http://fris.nc.gov/fris/Download.aspx?FIPS=031&ST=NC&user=General%20Public

PRISM Climate Group, Oregon State University