Tufts UNIVERSITY | School of Engineering

Hurricane Sandy: A Risk Assessment Case Study

Background

Every year, hurricanes inflict $10 billion in damage on the coastal United States. In recent years, these values have only gone up; the past decade has experienced increased hurricane frequency and intensity following a twenty-year period of little Atlantic activity. In 2004 and 2005 alone, nearly $150 billion dollars of damage occurred annually. Hurricanes have the potential to be deadly too; in 2005, Hurricane Katrina claimed the lives of over 1200 people. Clearly hurricanes pose a significant threat to coastal regions of the United States.

Hurricane Sandy represents the largest hurricane to hit the Atlantic to date, costing over $65 billion and killing 285. In response to Hurricane Sandy, the Federal Emergency Management Agency deployed 1600 FEMA Corps to targeted regions, administering the $50 billion in relief aid.

In order to coordinate such expensive, large scale disaster responses, the FEMA Modelling Task Force utilizes GIS tools to target strategic regions susceptible to hurricane damage. The goal of this project was to emulate FEMA's modelling techniques and determine analytical methods to focus emergency response and evacuation.

Methodology

This risk assessment began by identifying seven parameters that impact emergency response and relief following major hurricane events:

1. **Wind Speed**—High winds can lead to building damage and turn unsecured objects into dangerous projectiles.
2. **Flood Depth**—Past flooding data from Hurricane Sandy provides a good analogue for what might be expected in the future. Understanding of flooding allows for better preparedness and use of preventative building techniques (i.e. raised foundations).
3. **Proximity to Major Roads**—Accessibility of hazardous regions must also be considered. Distance to major roadways becomes important when transporting out victims and bringing in emergency response teams.
4. **Proximity to Projected Hurricane Path**—Distance from the edge of the storm greatly impacts severity of damage in the region.
5. **Proximity to Hospitals**—Proximity to the nearest hospitals factors heavily into how emergency response is coordinated.
6. **Elevation**—Elevation has a large influence on depth of flooding (See Figure 1). Regions at elevations greater than 40 ft. typically do not experience dangerous storm surges.
7. **Proximity to Coast**—Coastal regions are most susceptible to storm surges and storm damage. Hurricanes lose energy as they move inland.

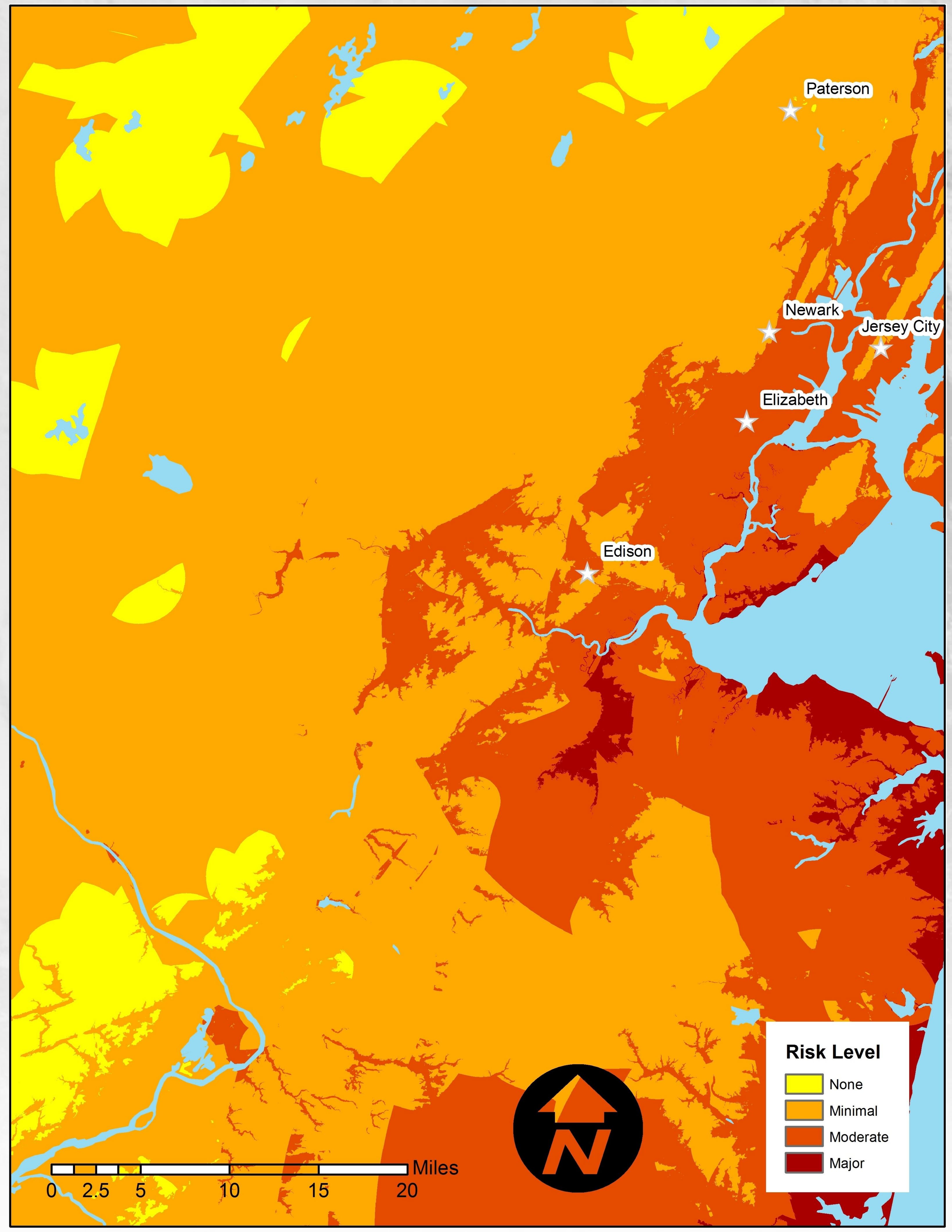
Once these parameters had been identified, a map was generated for each respective risk factor. All data layers were projected via NAD 1983 StatePlane New York Long Island FIPS 3104 (Feet). Flood depth data was converted to a raster from a point dataset compiled by FEMA using ArcMap's Point to Raster tool. Wind speed was found by converting Hurricane Sandy point data from the National Oceanic and Atmospheric Administration using the same technique. A road shape file, hospital point data, water body shape file and a major roads shapefile were all sourced from ESRI. Hurricane Sandy's path was traced from a satellite image from the National Hurricane Center and georeferenced in ArcMap. All distance/proximity raster layers were generated using the Euclidean Distance tool in ArcMap.

Once rasters had been created for each risk parameter, the Reclassify tool was used to classify risk from 1 to 4, 1 being low risk and 4 being high risk. Raster Calculator was used to average each parameter, with elevation, flooding and distance to coast being weighted doubly as much as the other parameters (risk is essentially minimal at high elevations or far from the coast or where flooding is small). This was used to produce the final vulnerability analysis pictured to the right.

Results

The final map highlights regions of high potential risk for future hurricane relief efforts in coastal regions of southern New York State and New Jersey. Risk is classified as follows:

None	Higher elevation inland regions with low to moderate wind speeds. Little chance of flooding. Close to roads and hospitals.
Minimal	Higher elevation inland regions with moderate to high wind speeds. Some degree of flooding. Moderately close to roads and hospitals.
Moderate	Lower elevation coastal regions with moderate to high wind speeds. Moderate flooding, typically less than 4 ft. Farther from roads and hospitals.
Major	Very low elevation coastal regions with high wind speeds. High flooding, greater than 4 ft. Least accessible by road and relatively far from hospitals.



Eastern New Jersey and southern Staten Island represented the most dangerous areas of the risk assessment study. As expected, coastal regions tended to be the most susceptible; these regions have lower elevations and are more susceptible to flooding. They also experience gale-force winds blowing in off the Atlantic.

Limitations

Procuring data proved to be one of the biggest challenges when utilizing GIS to identify high-risk regions of the eastern U.S. for hurricane response. Digital elevation data was not available for the entire desired region and it was therefore necessary to focus on a small region of New York and New Jersey. Additionally, a high resolution raster of wind speed could not be found, necessitating conversion of a widely spaced point matrix into a low resolution wind speed map. Lastly, weighting factors for each parameter were based on observation and research rather than statistical correlation given the mapping-oriented focus of the project; more in-depth statistical analysis would lead to a more refined vulnerability map.

Conclusions

The final map should aid in emergency response efforts for future East Coast hurricane events. Though somewhat imprecise, the map does provide basic information regarding what areas to target for evacuation and/or relief. Further research and statistical analysis is required to determine how different parameters affect likelihood of hurricane damage, and flooding.

Cartographer Adrian DiCorato

Project Date 15 December 2015

Course CEE 187, Intro to GIS

Projected Coordinate System NAD 1983 StatePlane New York Long Island FIPS 3104

Photo Source IBTimes.co.uk

Data Sources ESRI, FEMA, NOAA, National Hurricane Center

References

"FEMA MOTF Hurricane Sandy Impact Analysis." *ArcGIS*. Esri, 22 July 2015. Web. 03 Nov. 2015.

United States. Federal Emergency Management Agency. Mitigation Assessment. *Foundation Requirements and Recommendations for Elevated Homes*. FEMA, 5 May 2013. Web. 20 Oct. 2015. <http://www.fema.gov/media-library-data/1386073605870-56034eb27952e04bd44eb84b72032840/SandyFS2OpenFoundation_508post2.pdf>.

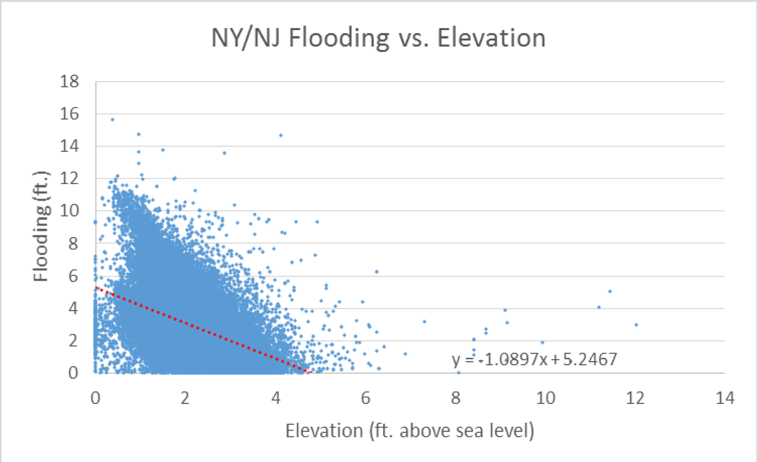


Figure 1.—Plot of regional flooding vs. elevation above sea level indicates a direct inverse correlation between altitude and flooding.

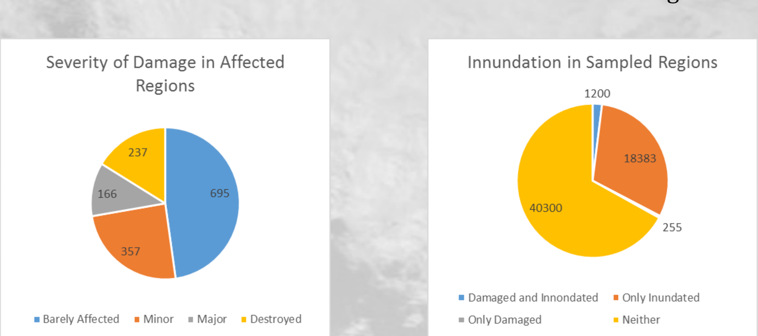
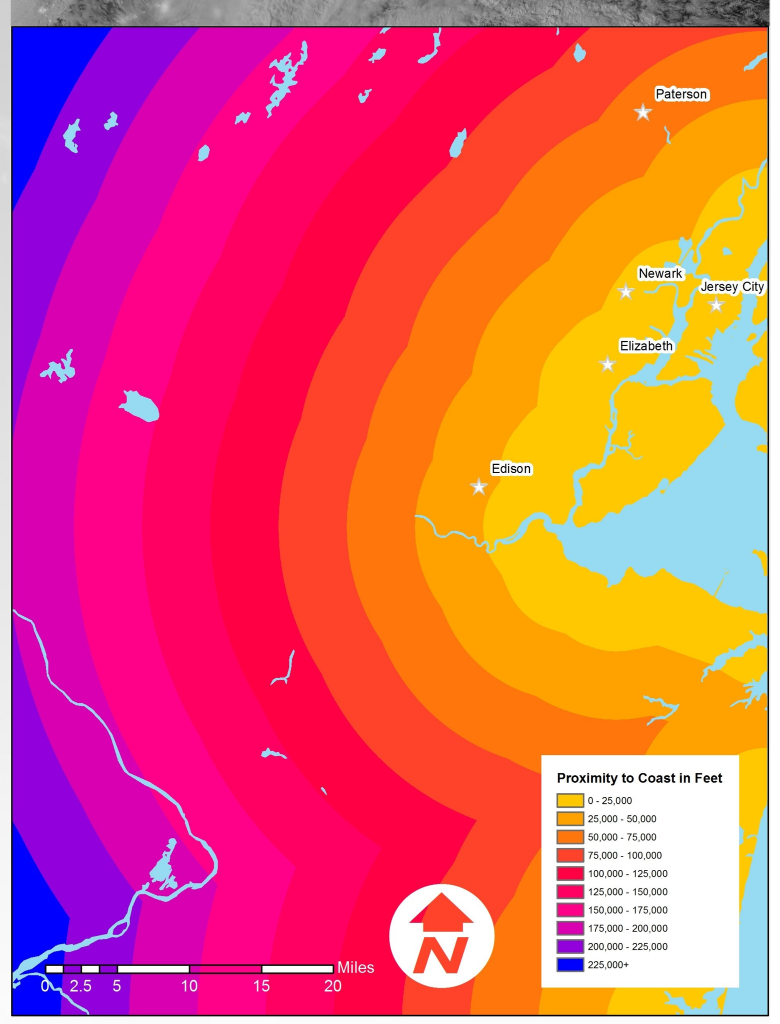
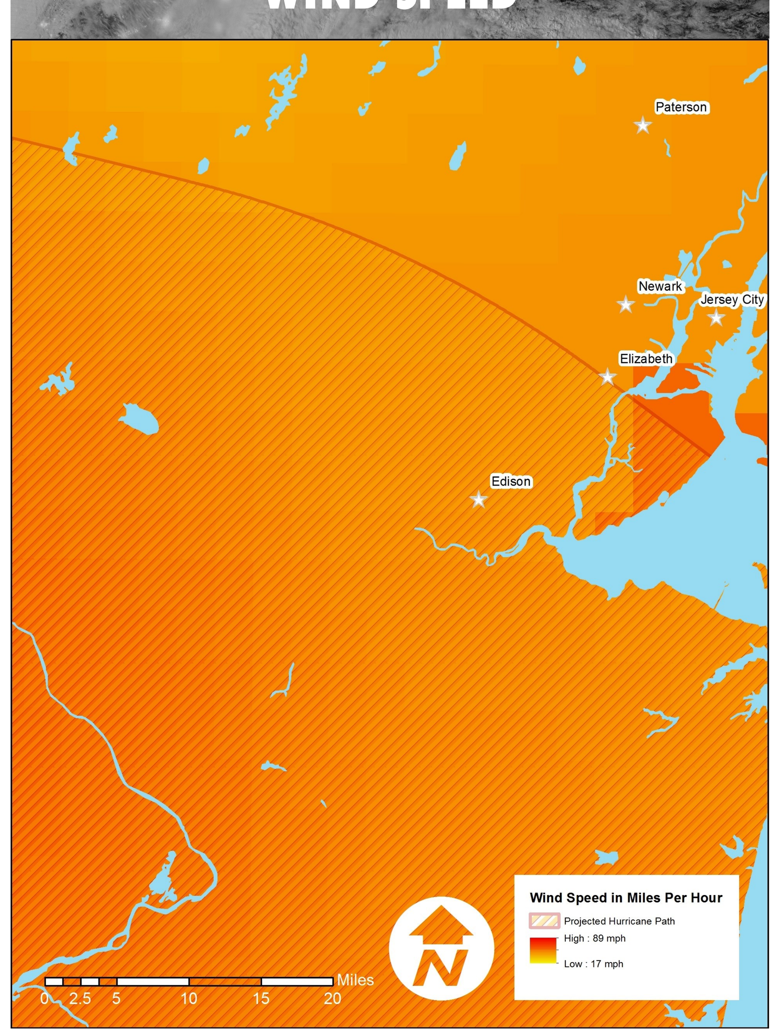


Figure 2.—Degree of damage and inundation in sampled regions

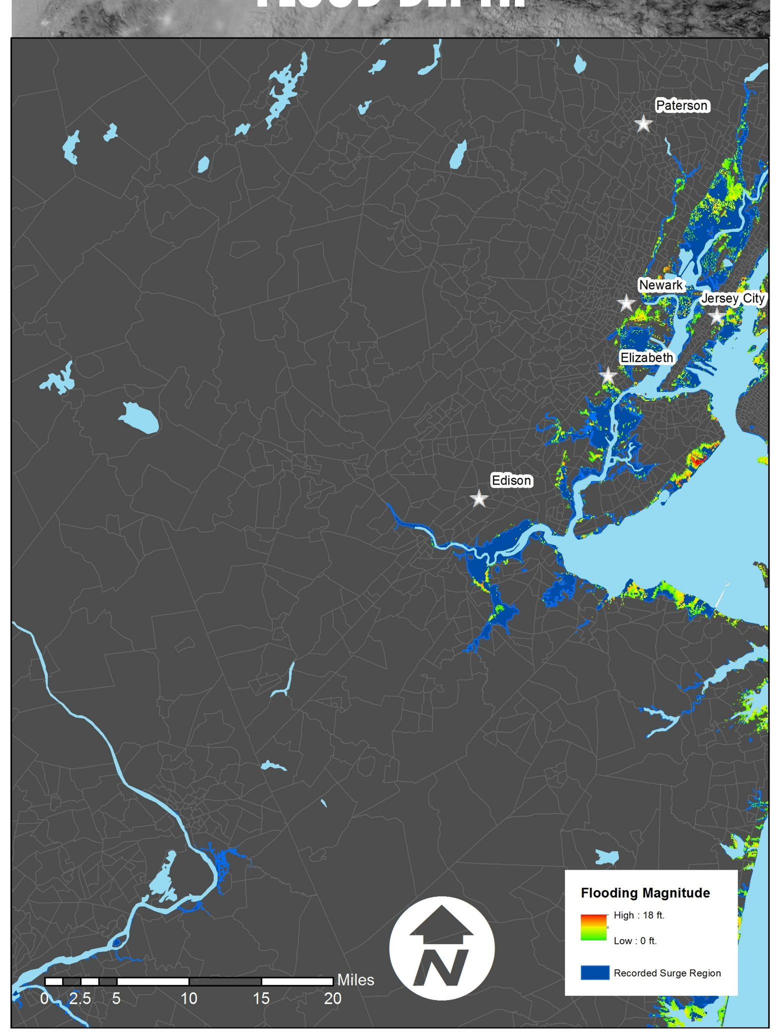
Proximity to Coast



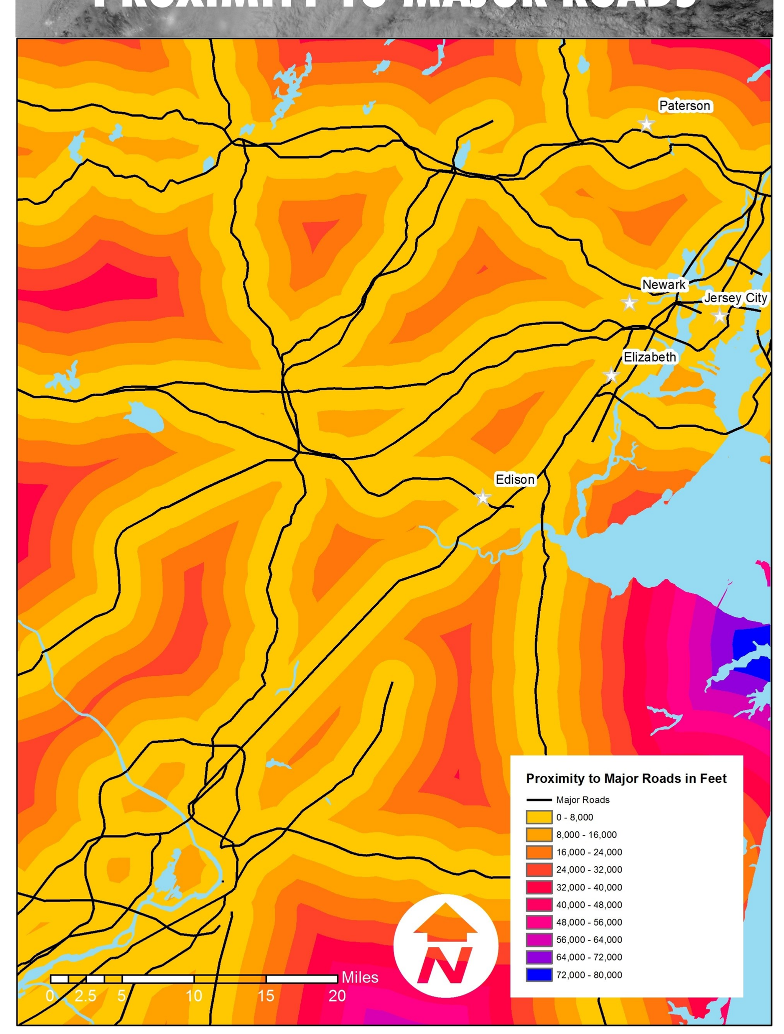
Wind Speed



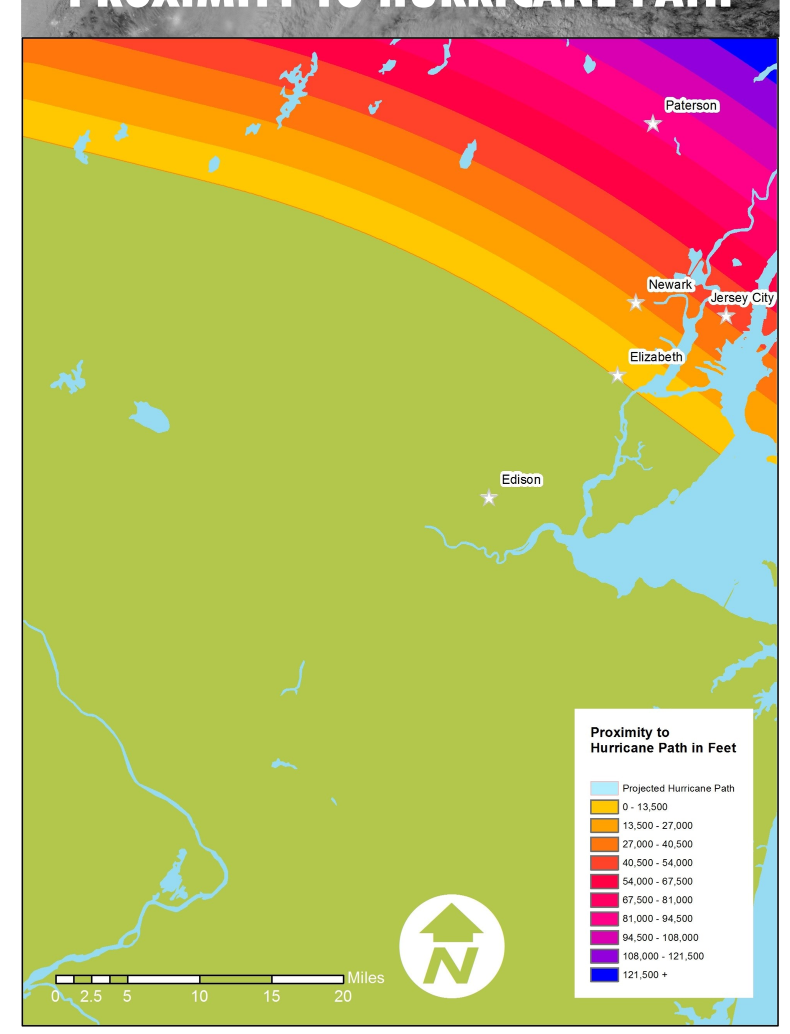
Flood Depth



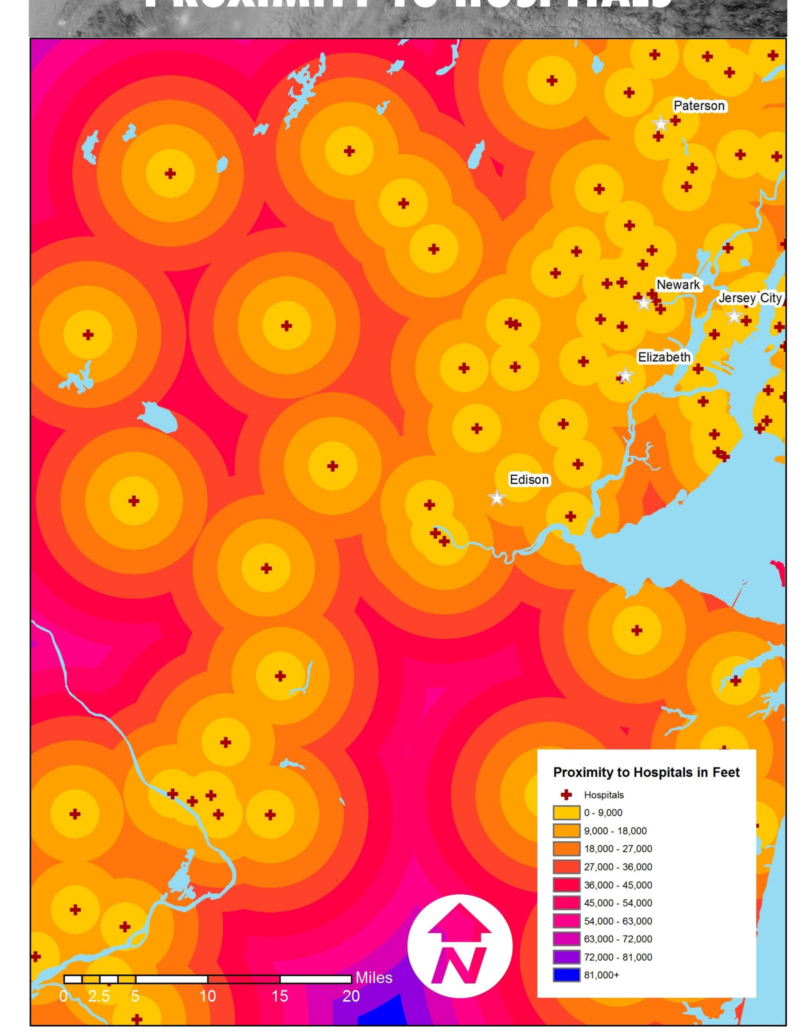
Proximity to Major Roads



Proximity to Hurricane Path



Proximity to Hospitals



Elevation