

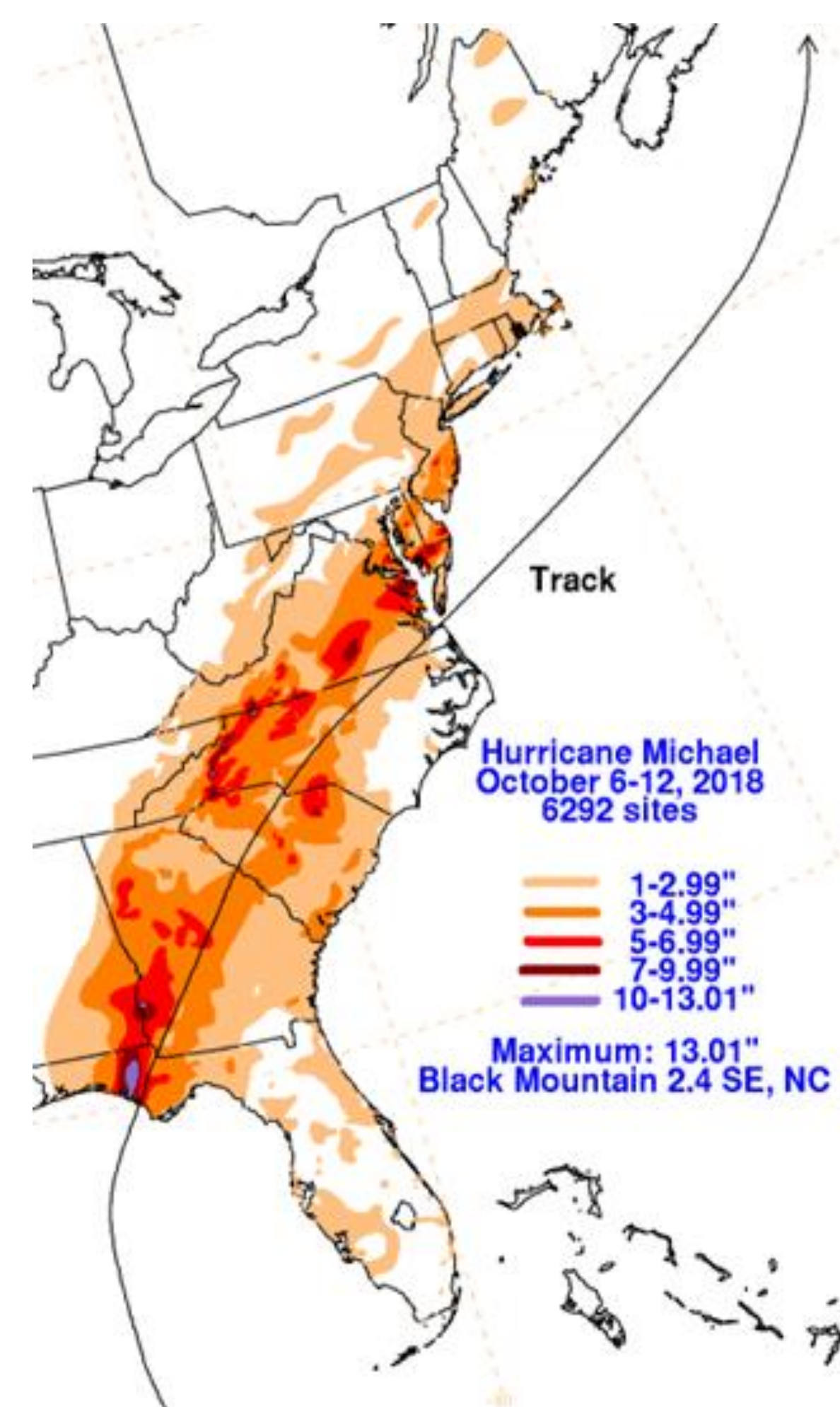
# Assessing the Relationship Between Social Vulnerability and Housing Damage in Hurricane Michael

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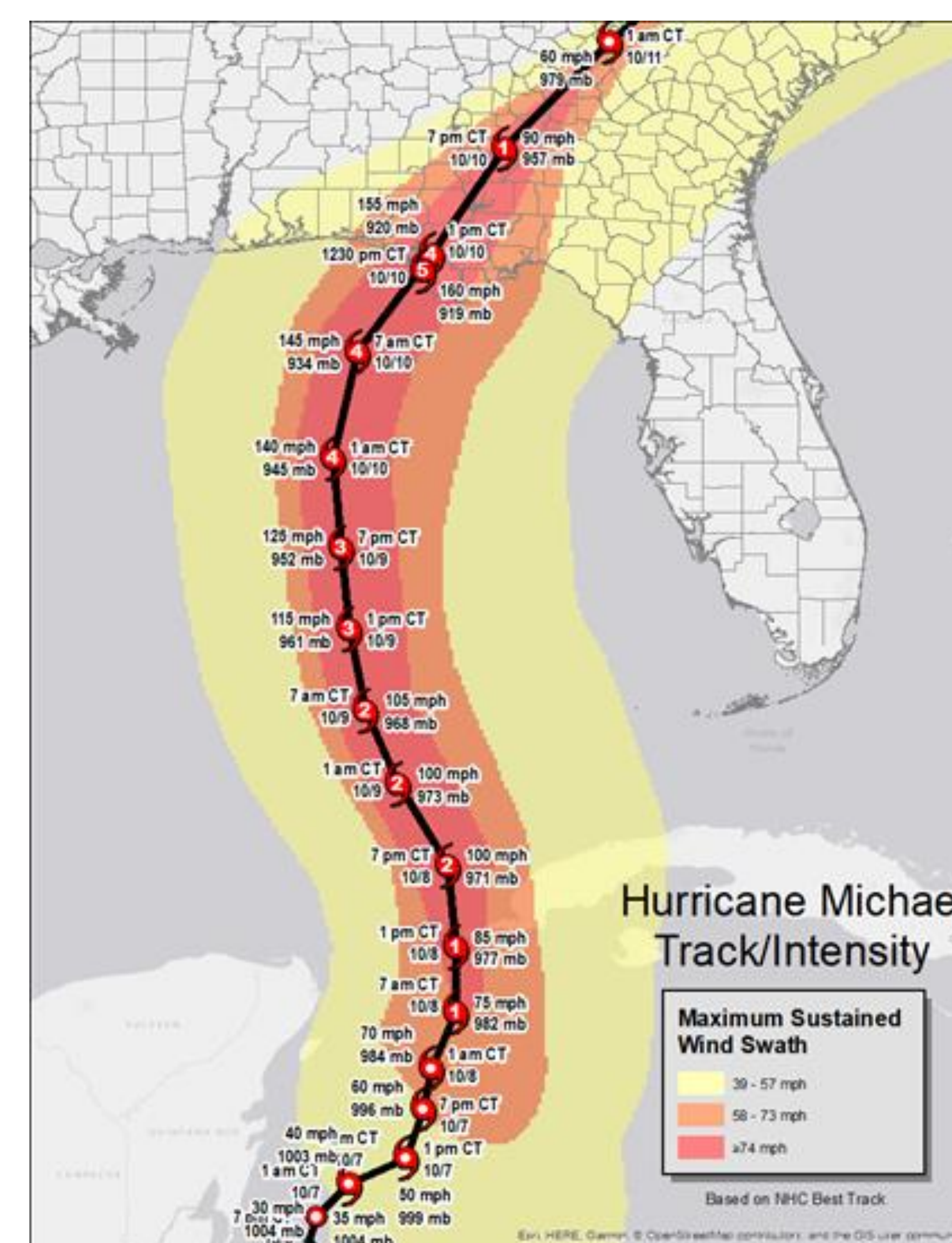
This project combines three different data sets to better understand the interplay between social vulnerability and housing damage that occurred in Florida as a result of Hurricane Michael. The damage data is drawn from an existing FEMA dataset of registrations for individual disaster assistance and the CDC/ATSDR social vulnerability dataset is broken into its four component themes and calculated at the census block group level. Detailed wind and rain data is also incorporated into the analysis at the census block group level, in order to examine the relative strength of the storm in each affected area. We discuss preliminary results that confirm the hypothesis that the combined effects of not only the weather, but also different aspects of social vulnerability, do have a significant impact on the overall housing damages that resulted from the storm.

## Hurricane Michael

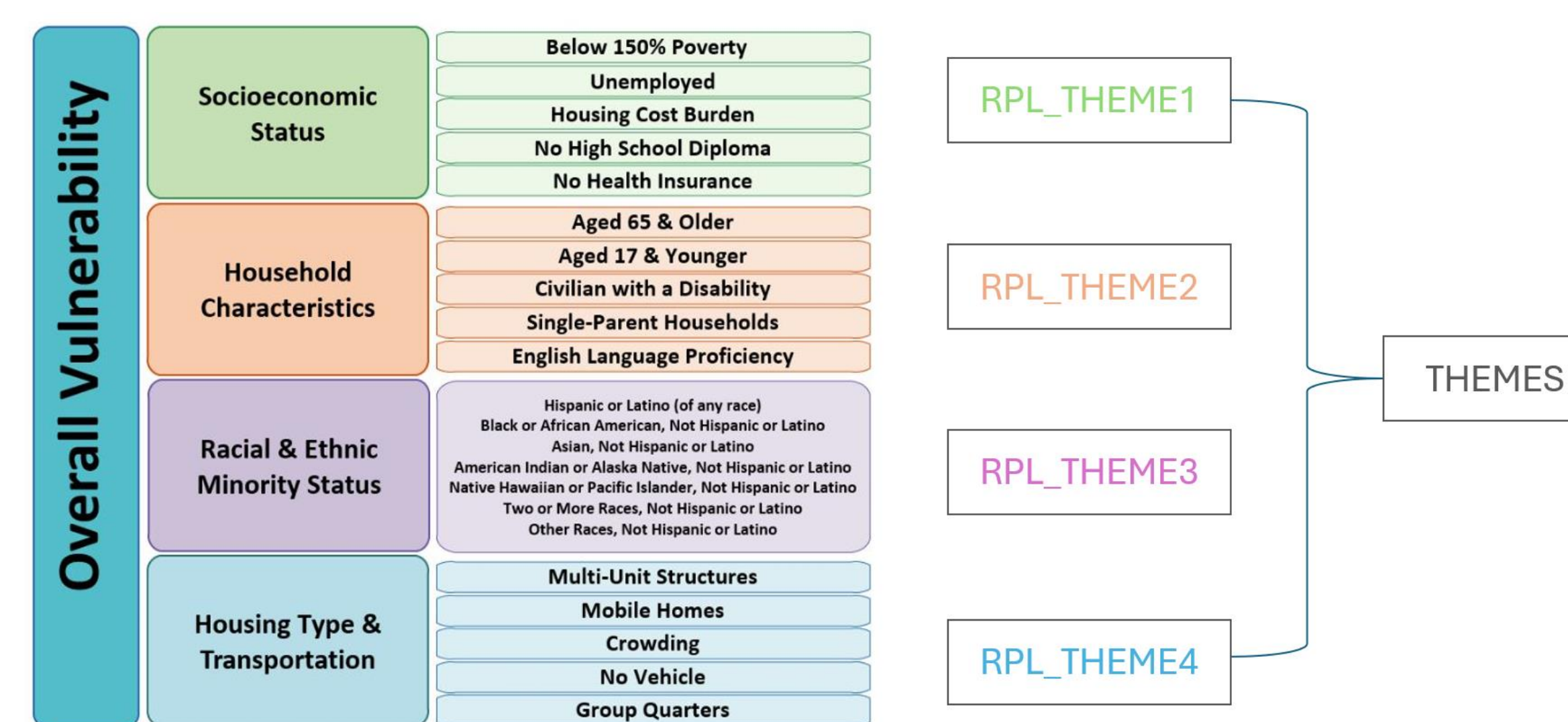


Hurricane Michael made landfall in the Florida Panhandle on October 10, 2018. The storm was the first Category 5 hurricane to hit the contiguous United States since 1992. Maximum sustained wind speeds were 140 mph after landfall, and the storm remained a Category 1 hurricane into Georgia. There were 59 deaths in the United States due to the storm, and an estimated \$25 billion in damages. FEMA Disaster Declaration 4399 covered 14 counties in Florida.

Data was collected from NOAA and USGS and interpolated in ArcGIS to find the maximum wind speed, maximum amount of rainfall, and maximum flood level for each block group.

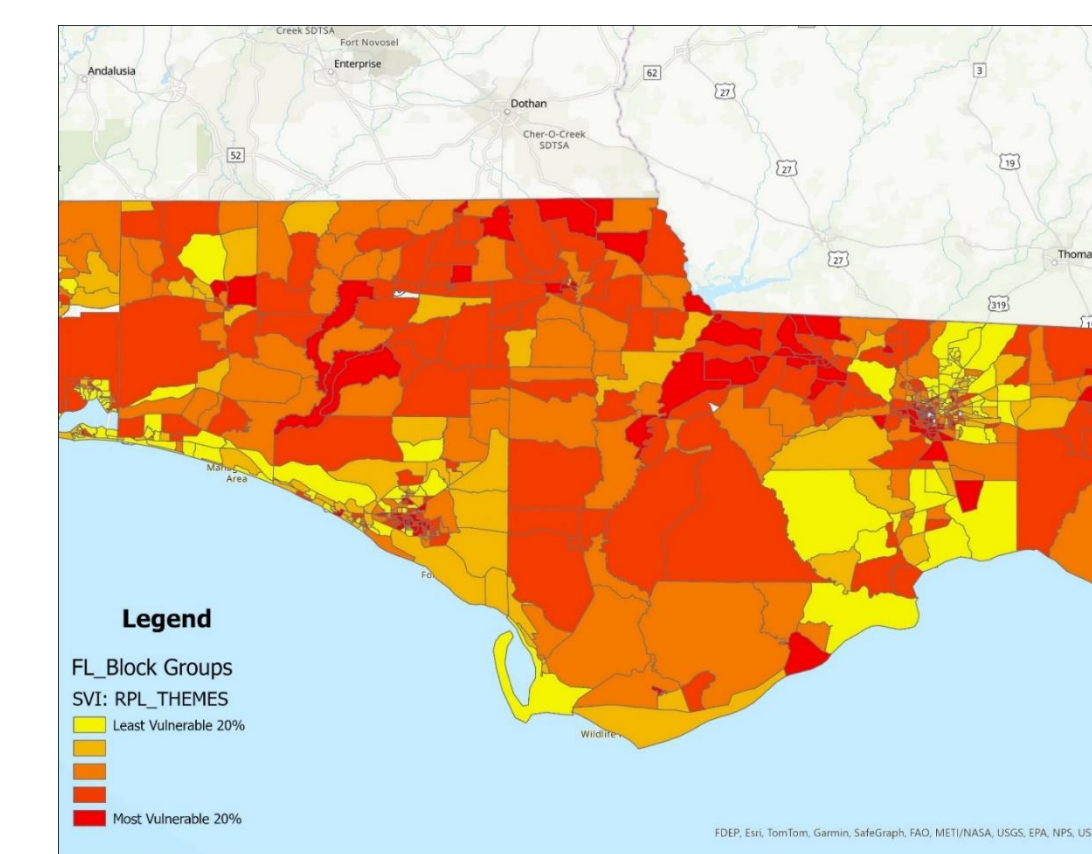


## Social Vulnerability



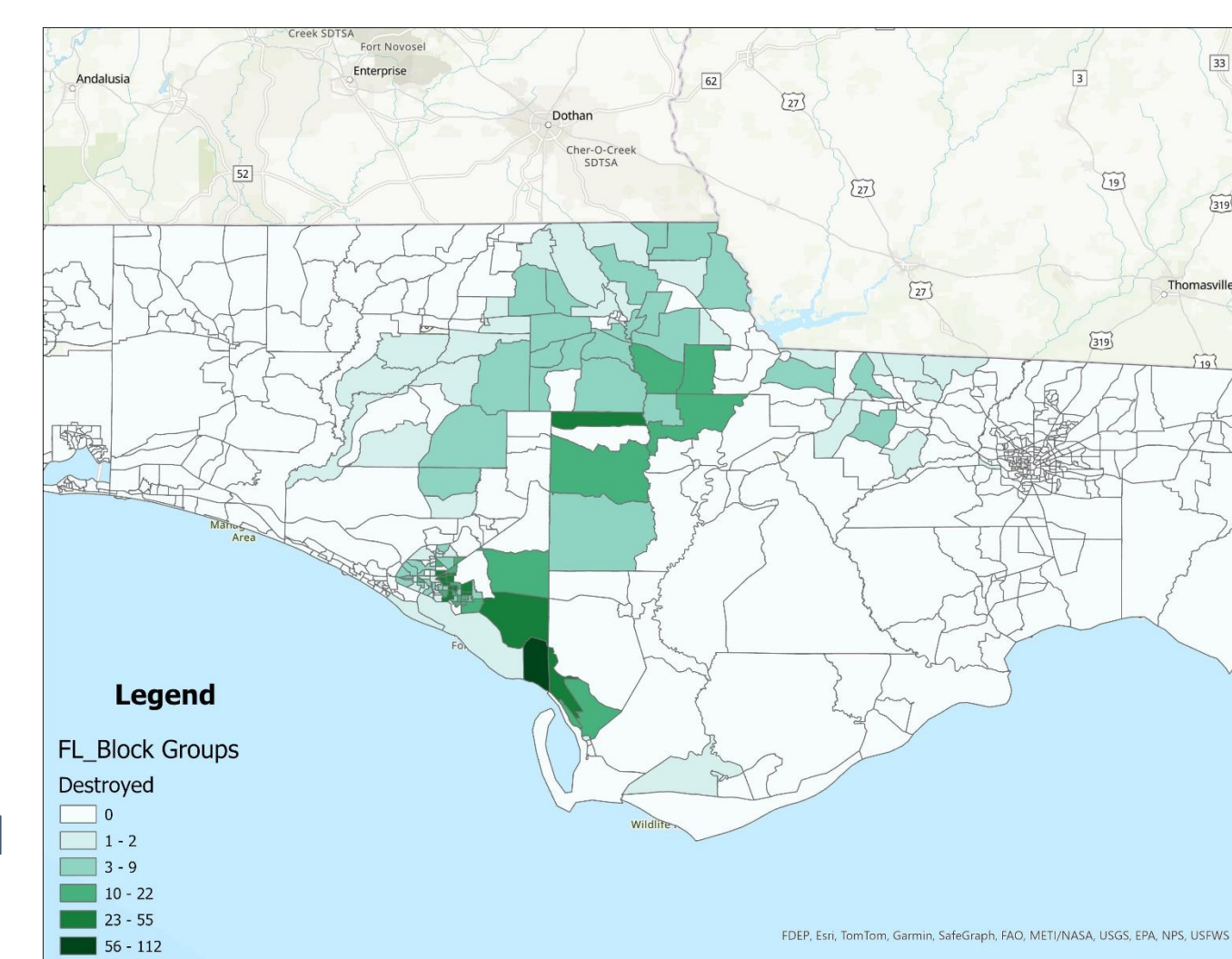
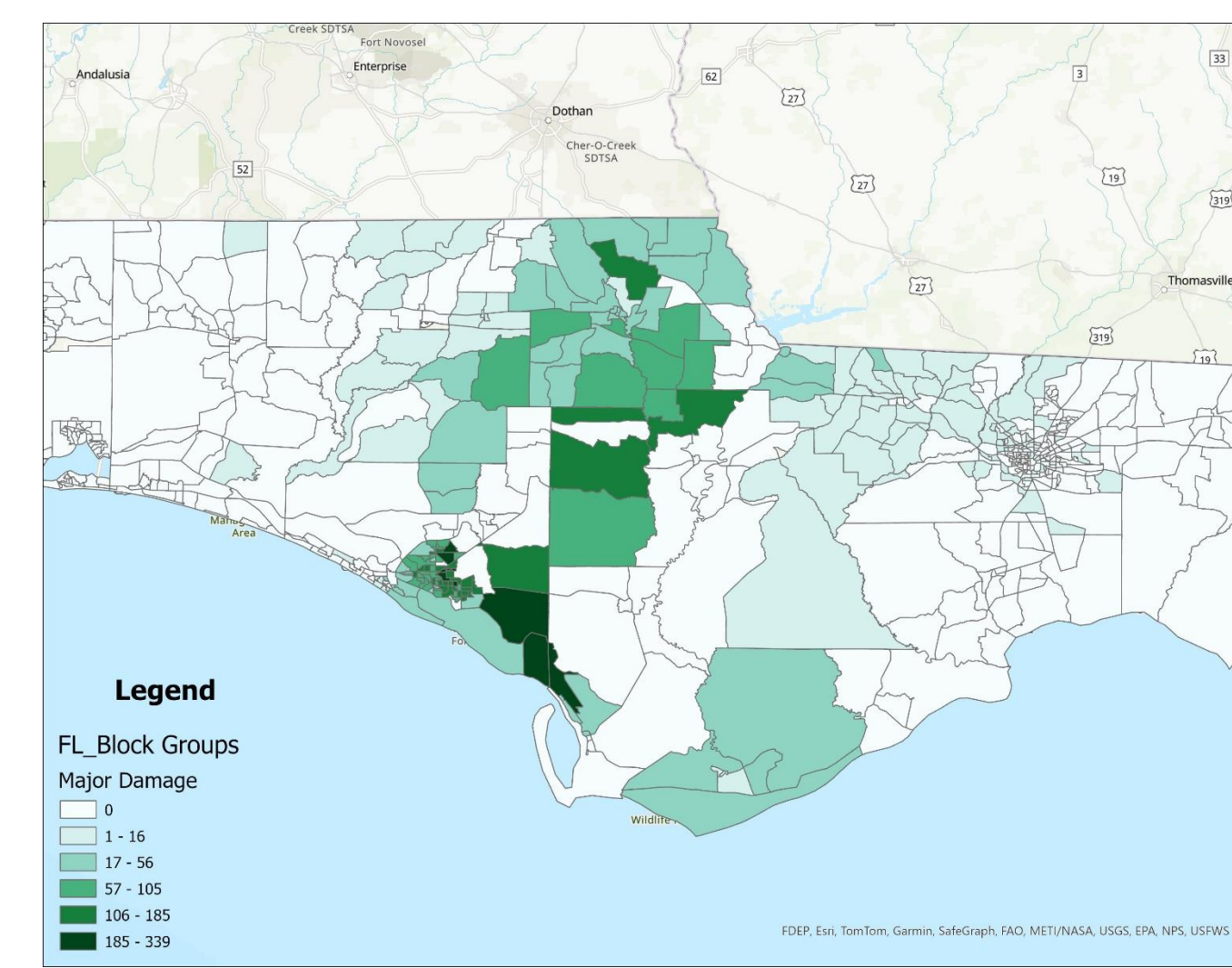
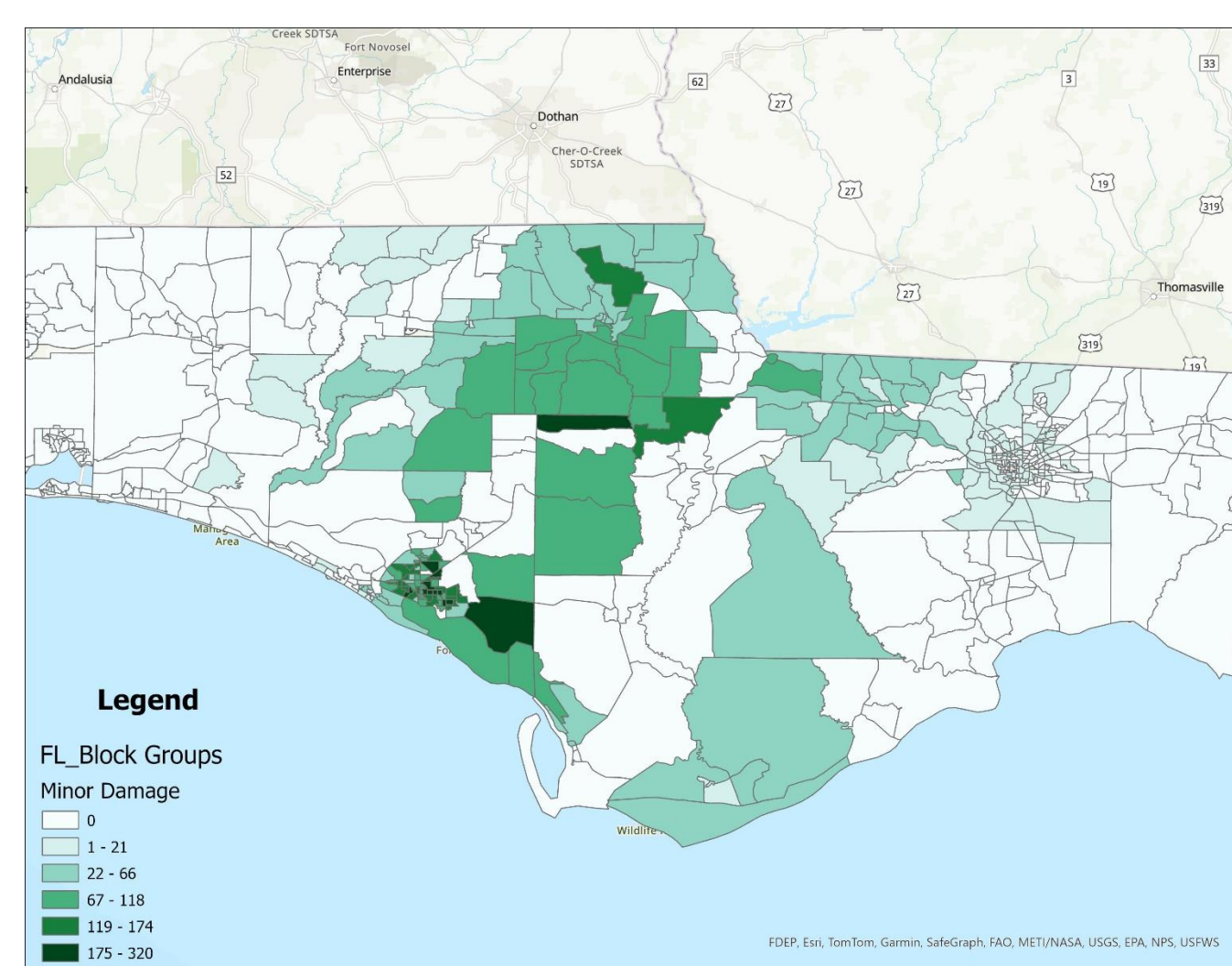
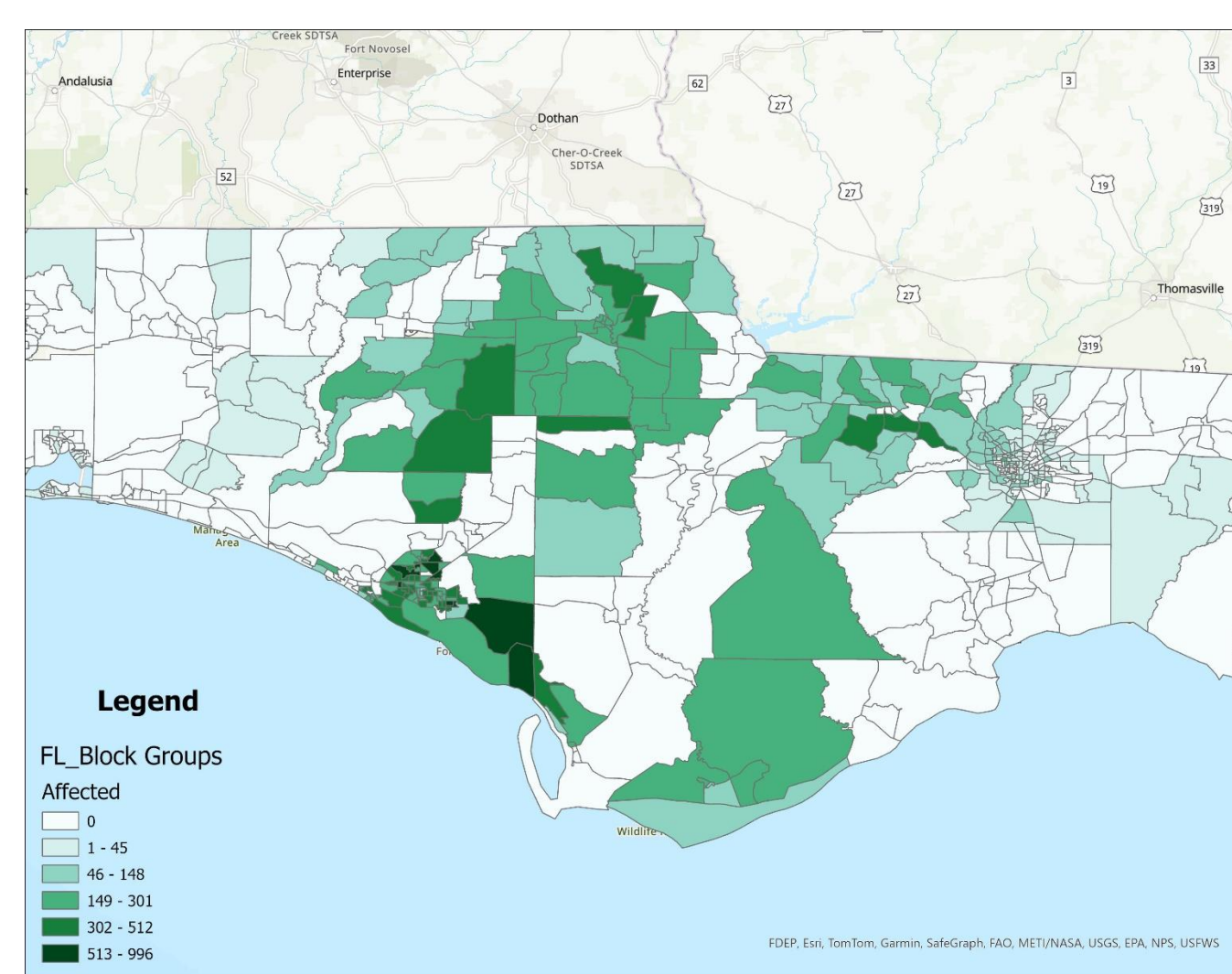
Social vulnerability is a measure of the effect that socio-economic and demographic characteristics have on a community in the face of a disaster (natural or anthropogenic). This project focuses on the Social Vulnerability Index (SVI) created by the Centers for Disease Control and Prevention (CDC), in conjunction with the Agency for Toxic Substances and Disease Registry (ATSDR), which is widely used by government agencies and NGOs such as the Red Cross. The SVI utilizes 16 different variables drawn from US Census data, combining them into four categories (themes) based on the type of data, as well as providing an overall theme value. The CDC provides this analysis at the county and tract level for each state, and then ranks each Census unit (county or tract) for each state.

The Red Cross would like to look at block group-level data, if possible, to capture varying levels of vulnerability within counties. One of the motivations for choosing to use the SVI, in particular, for this project is that the Harvard Open Environment Dataverse has an available block group-level data set that has been calculated to mimic the SVI.



## Damage

The Red Cross conducts initial damage assessment after a disaster. This information is provided to FEMA and serves as the starting point for claims to be processed. Both organizations utilize a four-level damage assessment tool, going from least severe to most severe as follows: affected, minor, major, and destroyed. For Hurricane Michael, there were 75,546 claims filed by property owners with FEMA in 624 (of 13,338) block groups, with 66% of those being classified as affected, 18.4% as minor damage, 14.1% as major damage, and 1.4% as destroyed. This ratio was not consistent across all block groups, however, with multiple block groups only having affected properties, but one block group having 8.9% of its claims associated with properties that were destroyed.



## Preliminary Results

A negative binomial regression model was created to assess relationships between social vulnerability, weather, and damage. The dependent variable was the number of households that fell within each of the four damage categories, along with the total number of households damaged, within each block group. The independent variables included the four SVI themes, the three weather values (wind, rain, flood), and the total housing units in each block group, to adjust for scale differences. Models were created for all different possible combinations of independent variables, with the model that provides the lowest AIC value in each case shown in the table below. All models have an acceptable level of multicollinearity, with VIF values <5. The model for the Destroyed category shows the strongest predictive capability.

The results show that weather has a significant impact on the damage that is incurred, which is to be expected. With respect to the four SVI themes, Theme 1 (socioeconomic status) has the greatest significance across all five models, followed by Theme 2 (household composition & disability) and Theme 4 (housing type & transportation) both showing lower levels of significance. Theme 3 (minority status & language) is only slightly significant in one model.

Additional models are being developed for further analysis, including comparisons between behavior at the block group and county levels. The ultimate goal of this long-term research is to help the American Red Cross better prepare for sheltering and feeding needs in future disasters by taking social vulnerability data into account, as well as helping them to better understand where to focus their damage assessment efforts after a disaster.

| Number of Households by Block Group | (Intercept) | Theme1   | Theme2   | Theme3  | Theme4   | Wind     | Rain     | Flood Level | Total Housing Units | McFadden R-sq | AIC     | Max VIF |
|-------------------------------------|-------------|----------|----------|---------|----------|----------|----------|-------------|---------------------|---------------|---------|---------|
| Affected                            | -2.64 ***   | 1.32 *** | 0.33 *   |         | -0.57 *  | 4.87 *** | 2.70 *** | 1.34 ***    | 0.96 *              | 0.24          | 4491.21 | 3.97    |
| Minor Damage                        | -6.76 ***   | 2.10 *** | 1.02 *** |         | -1.20 ** | 5.89 *** | 4.65 *** | 2.77 ***    | -1.76 *             | 0.23          | 2664.29 | 3.73    |
| Major Damage                        | -7.42 ***   | 1.86 **  | 1.40 *** | -0.70 . | -1.19 *  | 5.12 *** | 5.69 *** | 4.31 ***    |                     | 0.24          | 2186.20 | 4.27    |
| Destroyed                           | -9.01 ***   | 2.99 *** | 1.60 **  |         | -2.30 ** | 3.84 *** | 5.89 *** | 3.29 ***    | -3.07 *             | 0.31          | 959.56  | 3.39    |
| All Damaged                         | -2.77 ***   | 1.45 *** | 0.40 **  |         | -0.65 ** | 4.92 *** | 3.20 *** | 1.70 ***    | 0.61                | 0.24          | 4704.16 | 3.97    |

.p < 0.1, \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001