Relationships of Tree Canopy and Social Vulnerability to Power Outages in Houston

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Research Question

Which factors affect the frequency and duration of power outages in CenterPoint Energy's electrical circuits?

Project Overview

- Project motivation stems from Hurricane Beryl and the millions of Houstonians left without power. CenterPoint claimed that trees and foliage near its power lines were the most to blame for these outages
- Our sponsor, the Houston Chronicle, is interested in the potential factors that affect power outages in Houston-area neighborhoods throughout the year, separate from extreme weather events like Hurricane Beryl
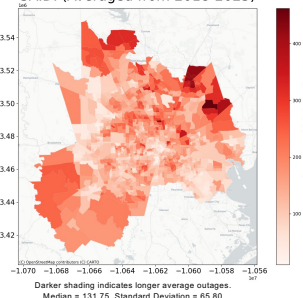
Data

Independent variable

- National Land Cover Database (NLCD) Tree Canopy Cover
- Social Vulnerability Index (CDC)
  - Socioeconomic Status
  - Household Composition
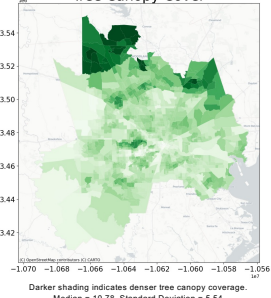 - Racial/Ethnic Status
  - Housing Type & Transportation

Dependent variable

- SAIDI = Total **Duration** of Interruptions / Total Customers
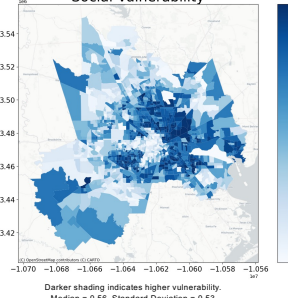- SAIFI = Total **Frequency** of Interruptions / Total Customers

SAIDI (Averaged from 2018-2023)
Darker shading indicates longer average outages.
Median = 131.75, Standard Deviation = 65.80

Tree Canopy Cover
Darker shading indicates denser tree canopy coverage.
Median = 10.78, Standard Deviation = 5.54

Social Vulnerability
Darker shading indicates higher vulnerability.
Median = 0.56, Standard Deviation = 0.53

Data Wrangling

- Gridded tree canopy cover was averaged over each subnetwork's area.
- Predictors with finer resolution were aggregated up to the **Census tract** level using **area weighting.**

Methods

Quantile Regression

Estimates the relationship of specific conditional quantiles of a response variable when regressed on covariates, instead of the conditional mean as in ordinary regression
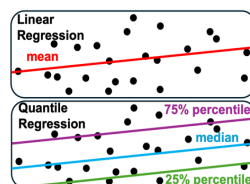
Multiscale Geographically Weighted Regression

Performs many local linear regressions across Census tracts to give localized estimates of variable effects capturing spatial variation.
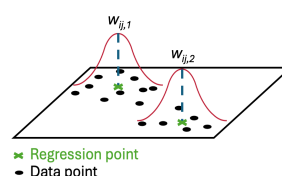

Quantile Regression

| Variable	Significantly Predicts (*p < 0.05*)
Tree Canopy Cover	Duration + Frequency
Socioeconomic Status	Duration
Racial/Ethnic Status, Housing Type	Frequency (at specified quantiles)

Socioeconomic status is not significantly associated with circuit outage frequency but is significantly associated with outage duration which suggests disparities in recovery time across communities.

Social Vulnerability Index Coefficients on Average Outage Duration
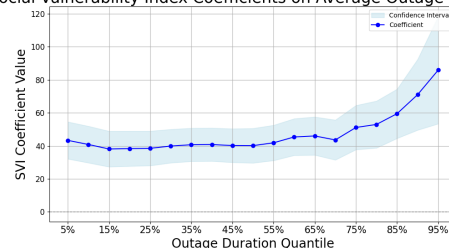
Communities with higher social vulnerability are likely to experience more prolonged outages than those with lower vulnerability. This effect is **stronger** for tracts in the 4th quantile and higher, with outages being relatively stable for values below.

Multiscale Geographically Weighted Regression

MGWR Coefficient: Mean Tree Canopy Cover

MGWR Coefficient: Social Vulnerability
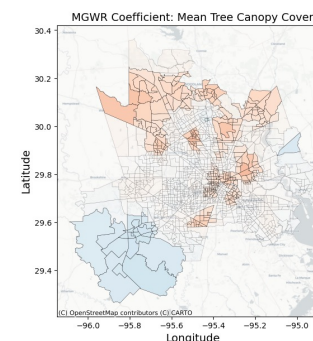
There **is** regional variation in **both relationships** across the metropolitan area.

- **Different Census tracts have different power outage relationships.**
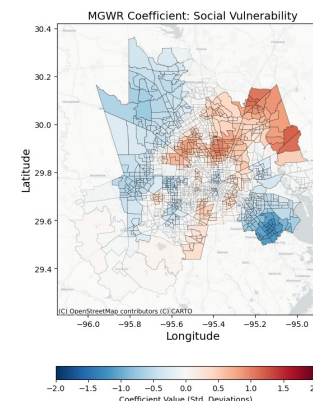
On average, increases in social vulnerability and/or tree canopy are **significantly associated with increases in power outage duration.**

- *Tree coverage has stronger effect than social vulnerability.*

North Houston areas have strongest relationships.

Conclusion

- Tree canopy cover and social vulnerability are significantly associated with power outage duration.
- High-canopy neighborhoods, such as **Willowbrook** (Northwest Houston) and **Kingwood** (Northeast), are most affected by extended outages.
- Socially vulnerable communities, particularly **Kingwood** and **East Houston**, face longer recovery times, likely due to systemic disadvantages.
- Findings support prioritizing:
  - **Vegetation management** in high-canopy areas across the Northside.
  - **Infrastructure upgrades and prioritization of power outage response** in socially vulnerable neighborhoods, particularly in **East and Northeast Houston**.

Future Work

- Filter analysis to solely above-ground subnetworks to better pinpoint effect of vegetation on circuits.
- Examine relationship between individual power outages and storm-specific variables (e.g. wind speed, precipitation) for improved power outage forecasting.