Integrated Environmental and Social Vulnerability Index for Air Quality in NYC

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Background

- Air Quality in many cities has the potential to be hazardous to human health
- Health impacts on a population often correlate with Social Vulnerability
  - A vulnerable population has fewer resources to respond to disasters or other events
- This project will attempt to merge air quality factors with social vulnerability to determine areas of the city where residents are most prone to acquire negative health impacts from air quality
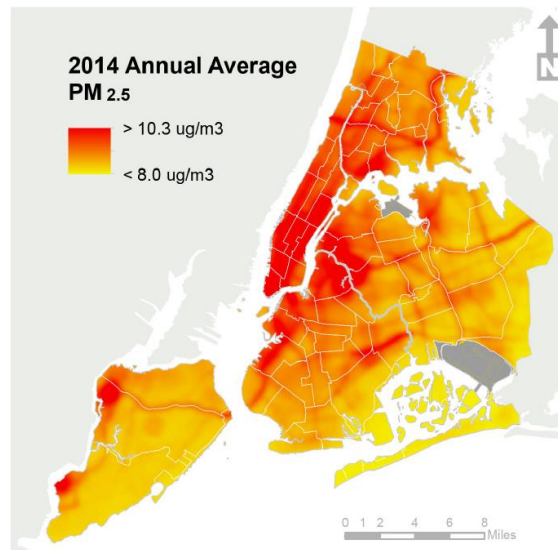
Air Quality Index

- The Air Quality Index is a daily standardized report prepared by many municipalities to inform people of current health hazards
  - Creates a standardized formula to normalize pollutant concentrations by their health effects

When this pollutant has an AQI above 100...	Report these Sensitive Groups
Ozone	People with lung disease, children, older adults, people who are active outdoors (including outdoor workers), people with certain genetic variants, and people with diets limited in certain nutrients are the groups most at risk
PM2.5	People with heart or lung disease, older adults, children, and people of lower socioeconomic status are the groups most at risk
PM10	People with heart or lung disease, older adults, children, and people of lower socioeconomic status are the groups most at risk
CO	People with heart disease is the group most at risk
NO2	People with asthma, children, and older adults are the groups most at risk
SO2	People with asthma, children, and older adults are the groups most at risk

AQI Technical Assistance Document - 2016

Air Quality Index

▸ New York City Community Air Survey
  ◦ Monitoring Program for various pollutants
    ・ $PM_{2.5}$, NO_2, NO, SO_2, O_3
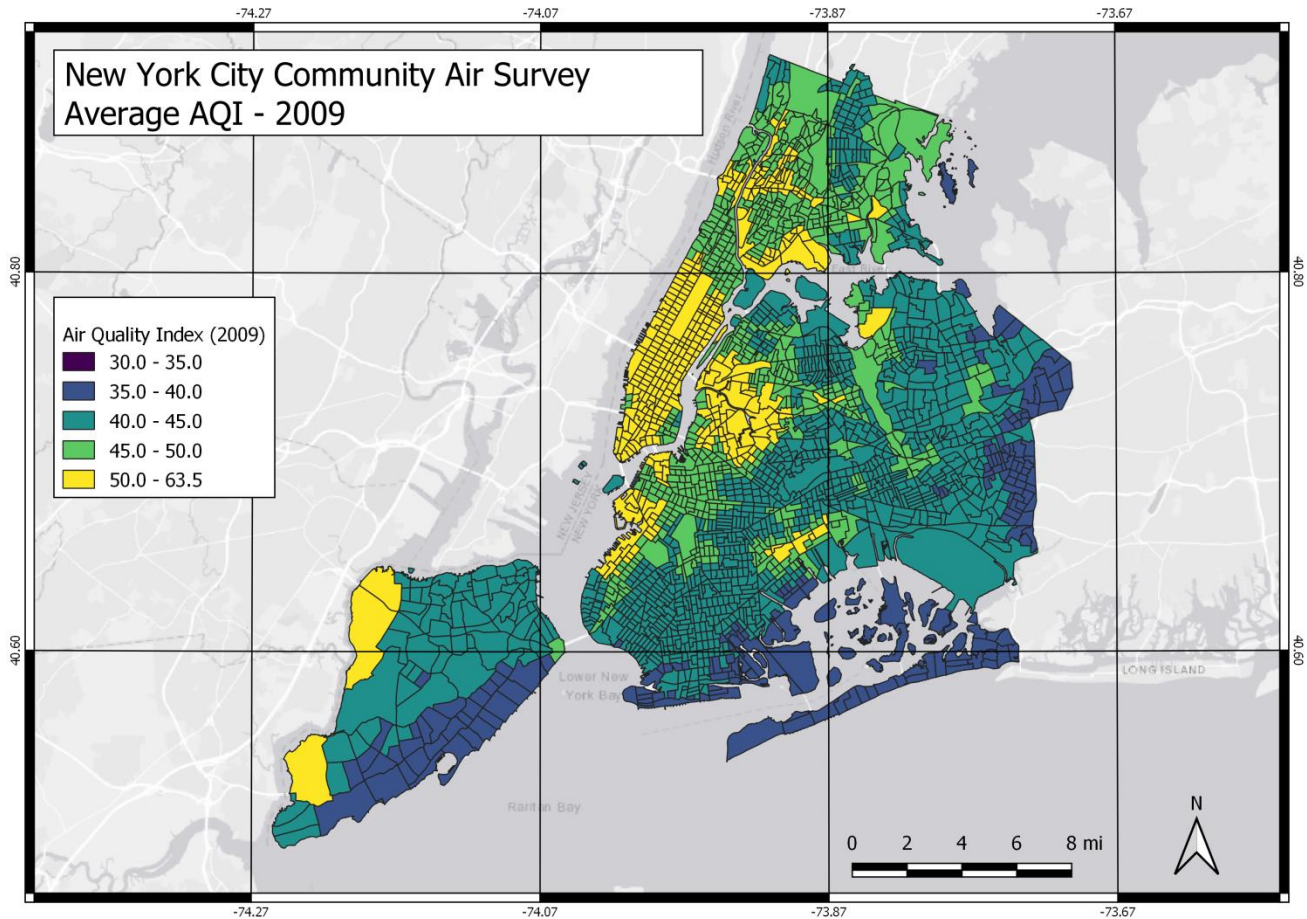   ・ Data available from Dec. 2008
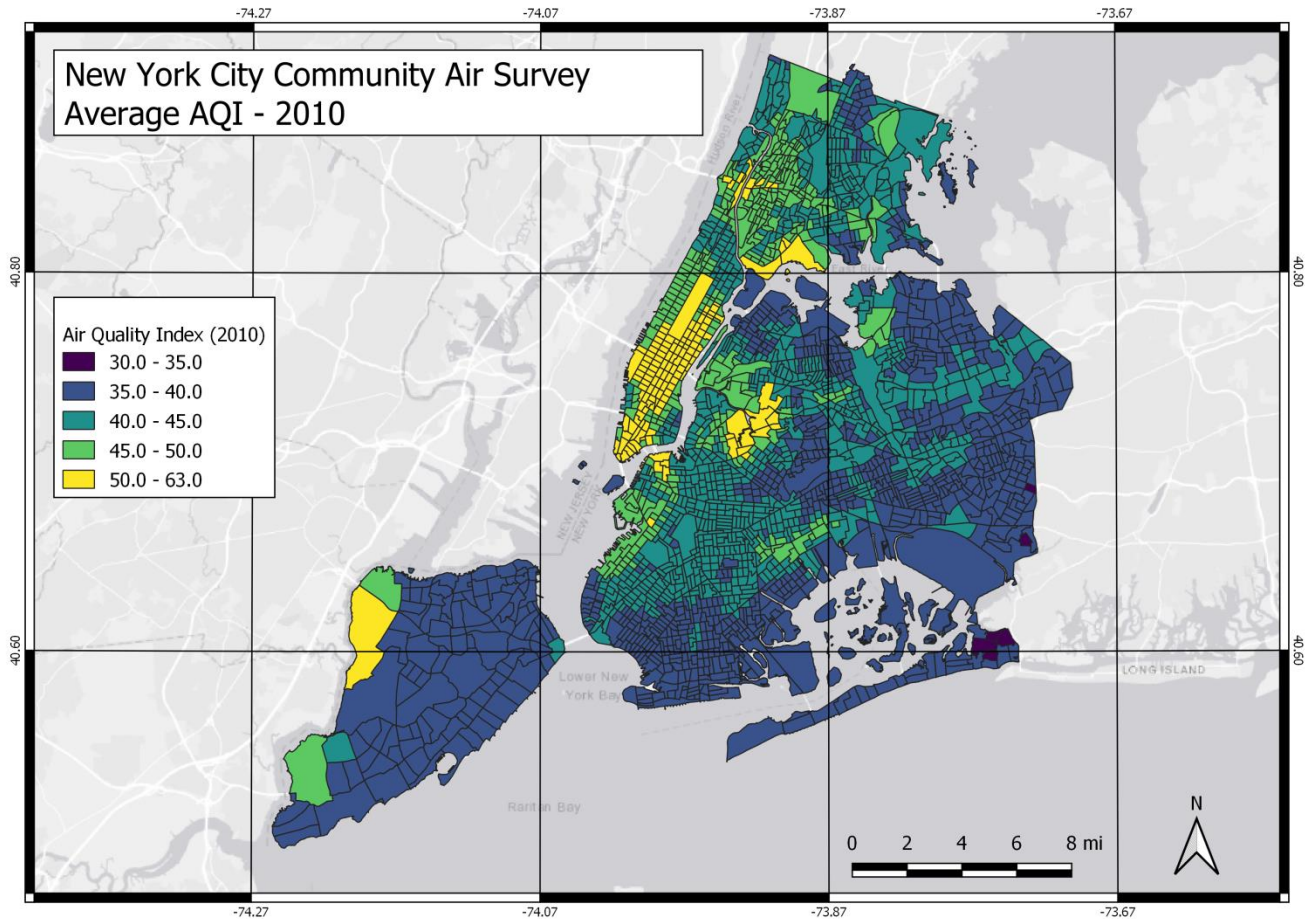   ・ Updated yearly (Dec. – Dec.)

NYCCAS Report – May 2016
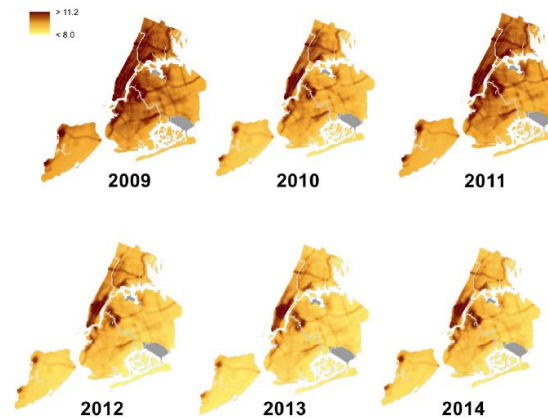
Air Quality Index

- Results from applicable NYCCAS rasters were used to calculate an average yearly AQI
  - Chose Census Tract level (2010)
  - Zonal Statistics used to determine maximum pollutant concentration in each census tract
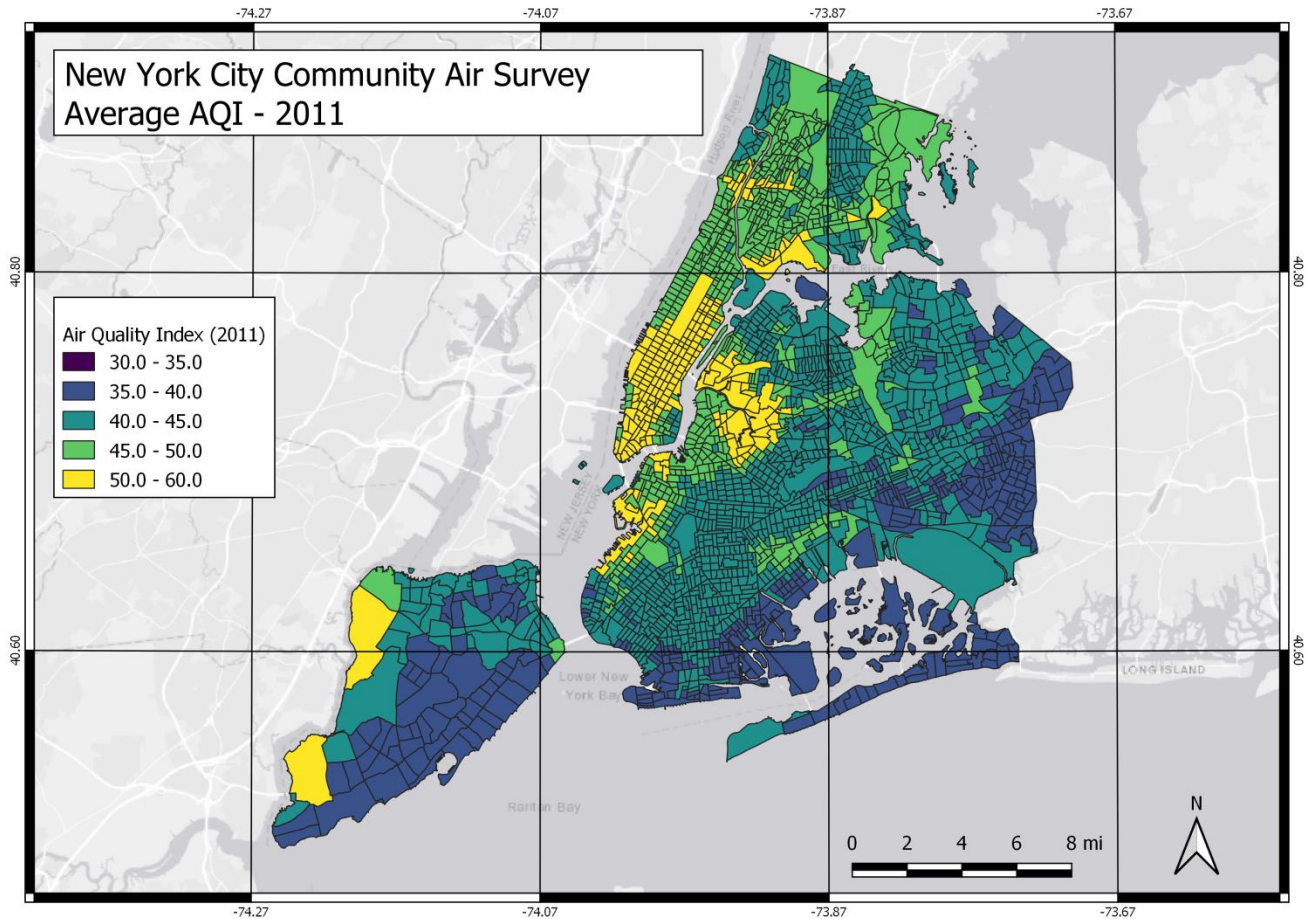 - AQI equation used to calculate normalized index
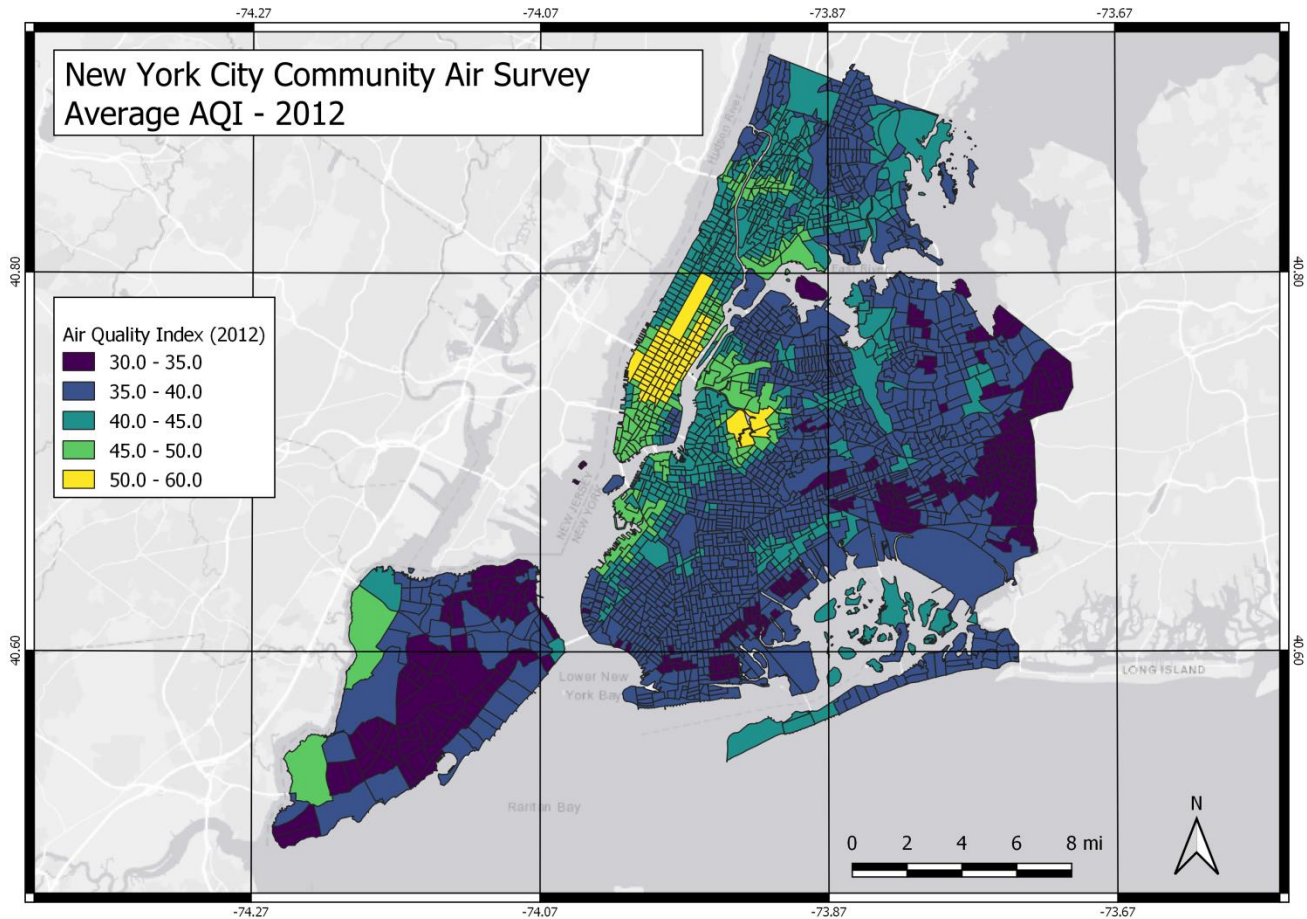
Air Quality Index

New York City Community Air Survey
Average AQI - 2009

Air Quality Index (2009)
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 63.5

Air Quality Index

New York City Community Air Survey
Average AQI - 2010

Air Quality Index (2010)
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 63.0

Air Quality Index

New York City Community Air Survey
Average AQI - 2011

Air Quality Index (2011)
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 60.0

Air Quality Index

New York City Community Air Survey
Average AQI - 2012

Air Quality Index (2012)
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 60.0

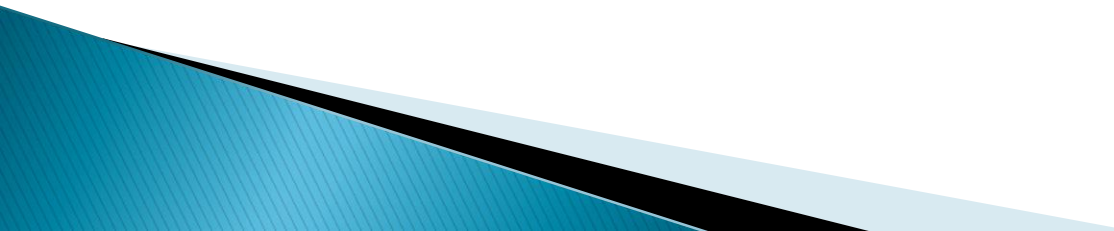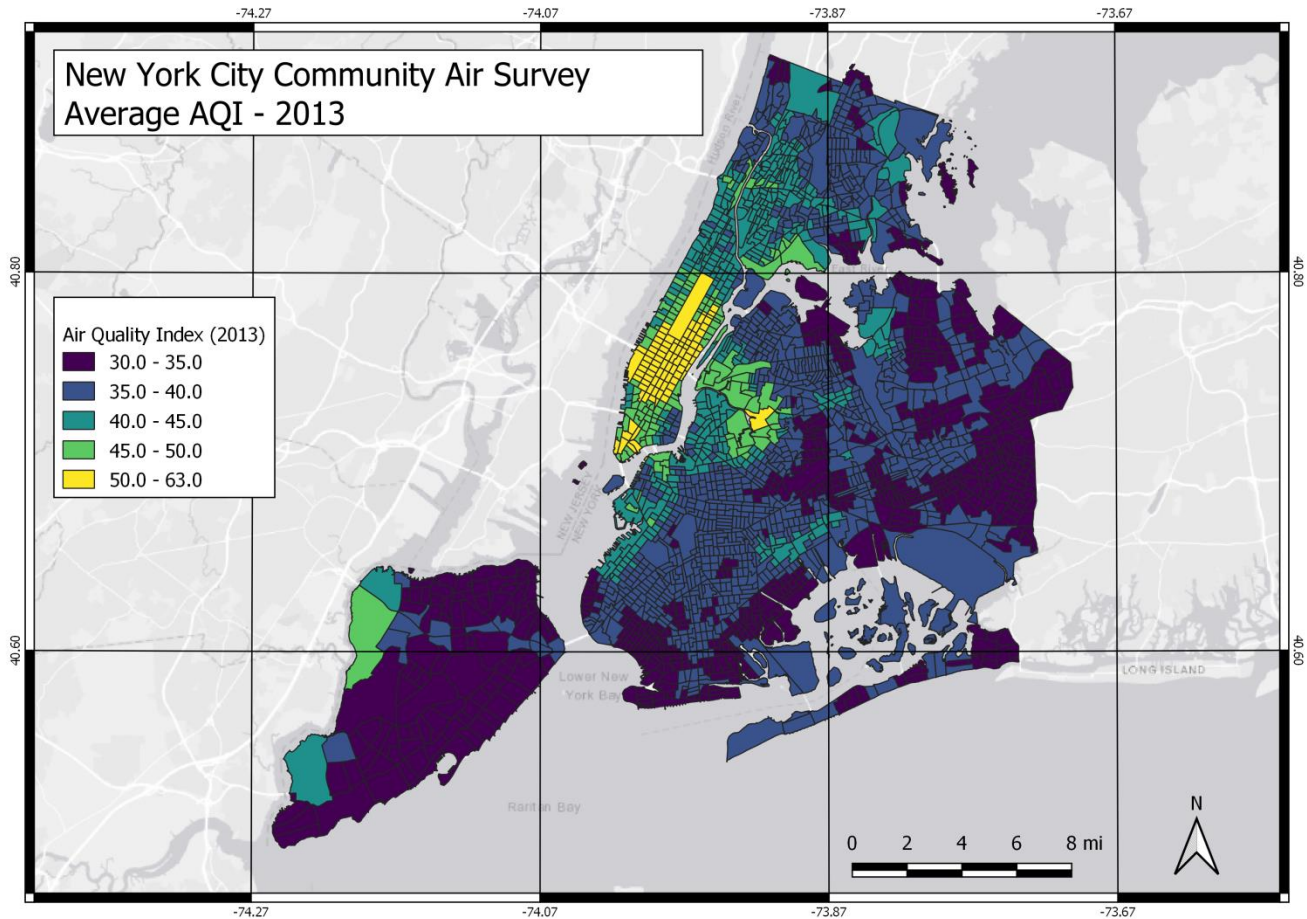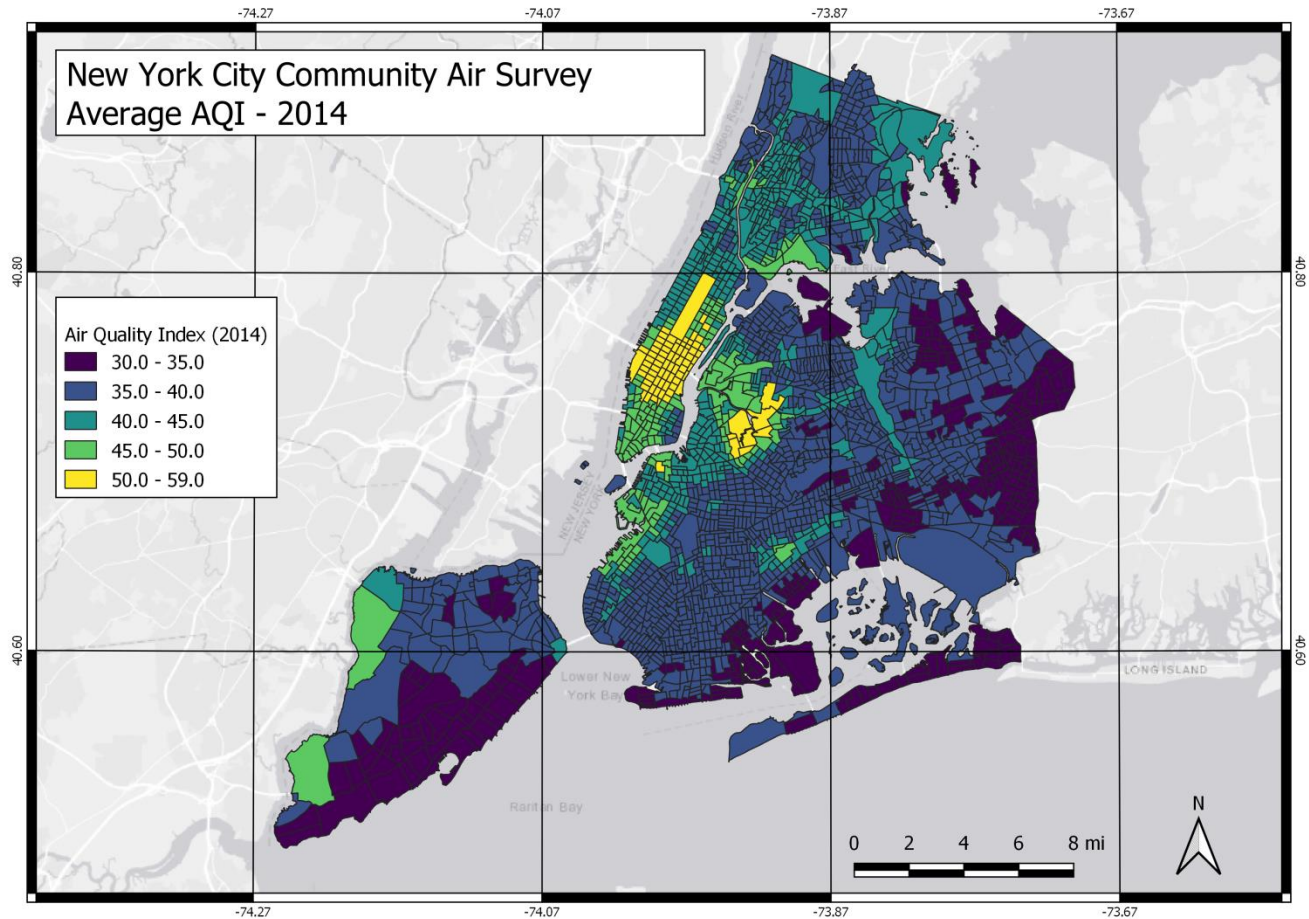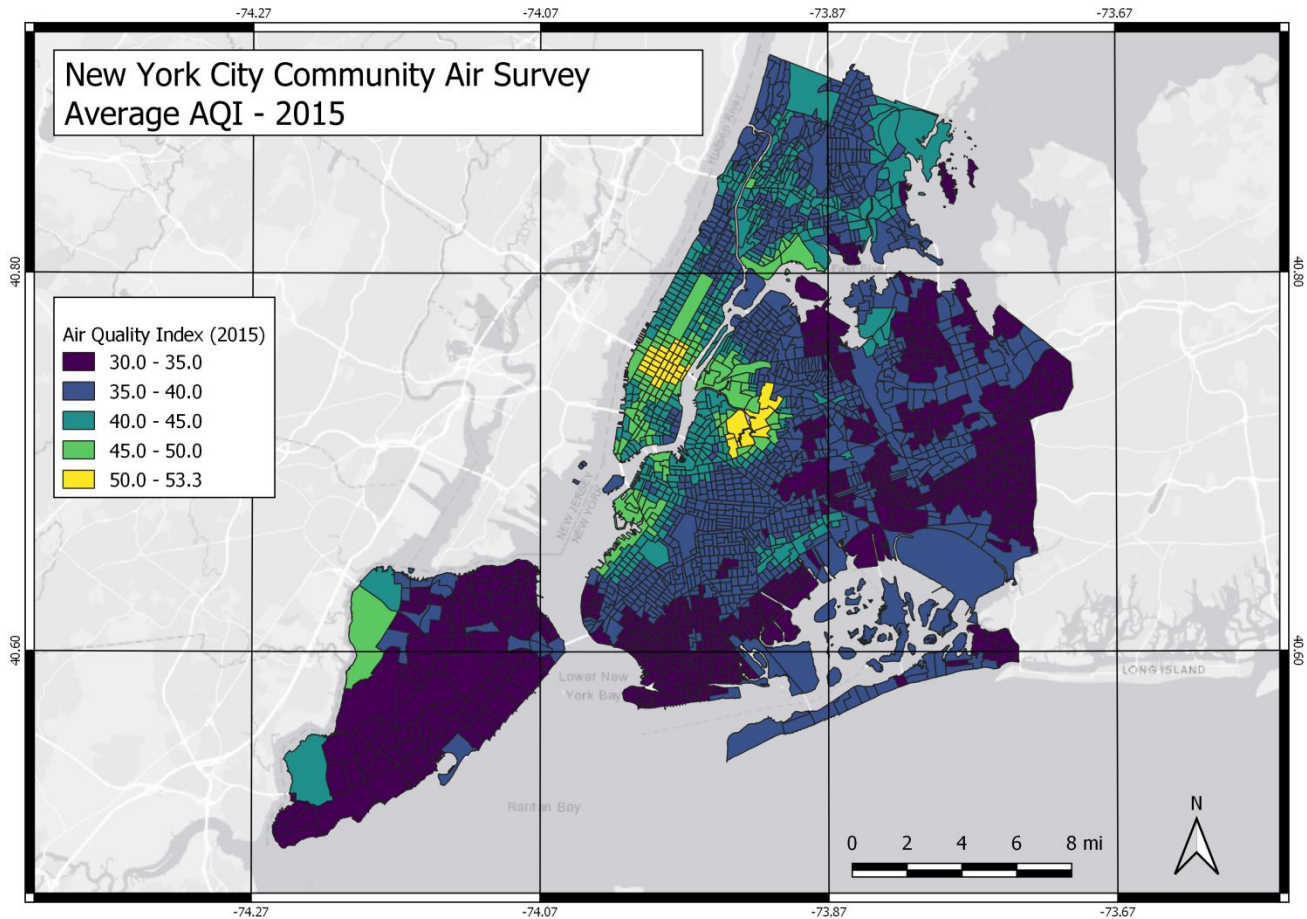# Air Quality Index

Air Quality Index

Air Quality Index

New York City Community Air Survey
Average AQI - 2015

Air Quality Index (2015)
- 30.0 - 35.0
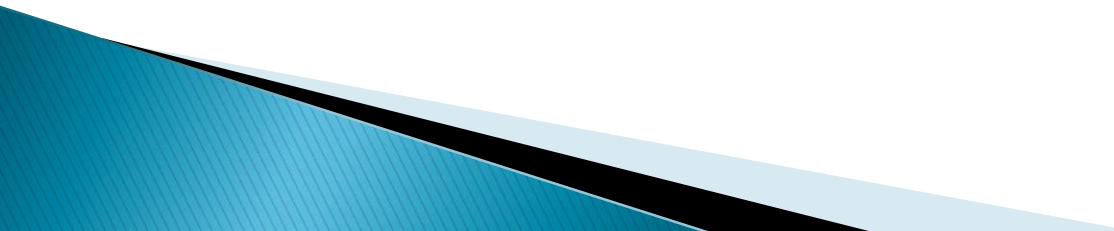- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 53.3

Social Vulnerability Index

- Based on various factors from 4 topics
  - Socioeconomic Status
  - Household Composition and Disability
  - Minority Status and Language
  - Housing and Transportation
- Compiled from 2010-2014 ACS Data
  - Shapefile by Census Tracts (2010)
- Overall Percentile Ranking used in index

Social Vulnerability Index

NYC Social Vulnerability Index
Based on 2010-2014 ACS Data

Social Vulnerability Index
- N/A
- 0 - 0.5
- 0.5 - 0.75
- 0.75 - 0.9
- 0.9 - 1
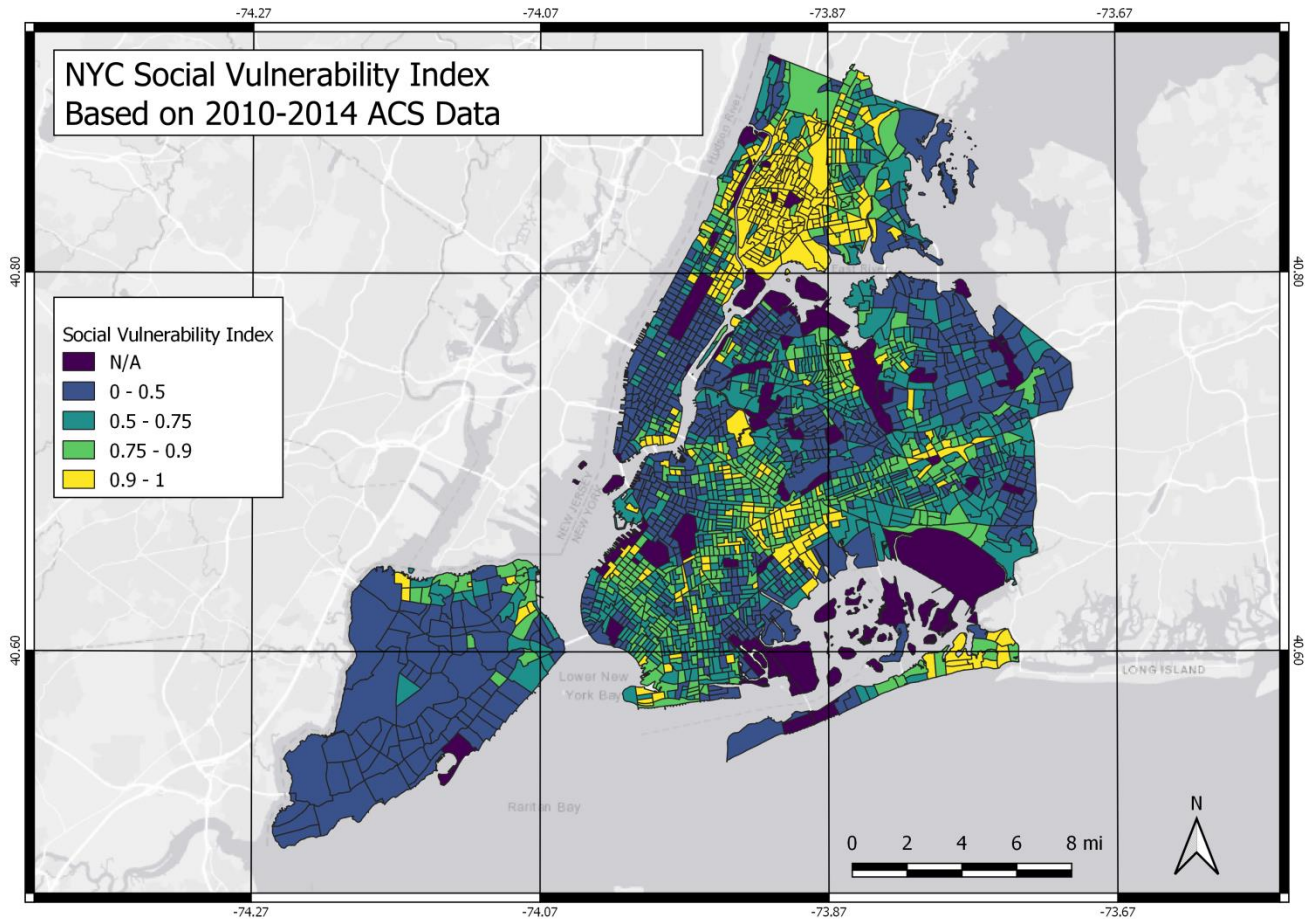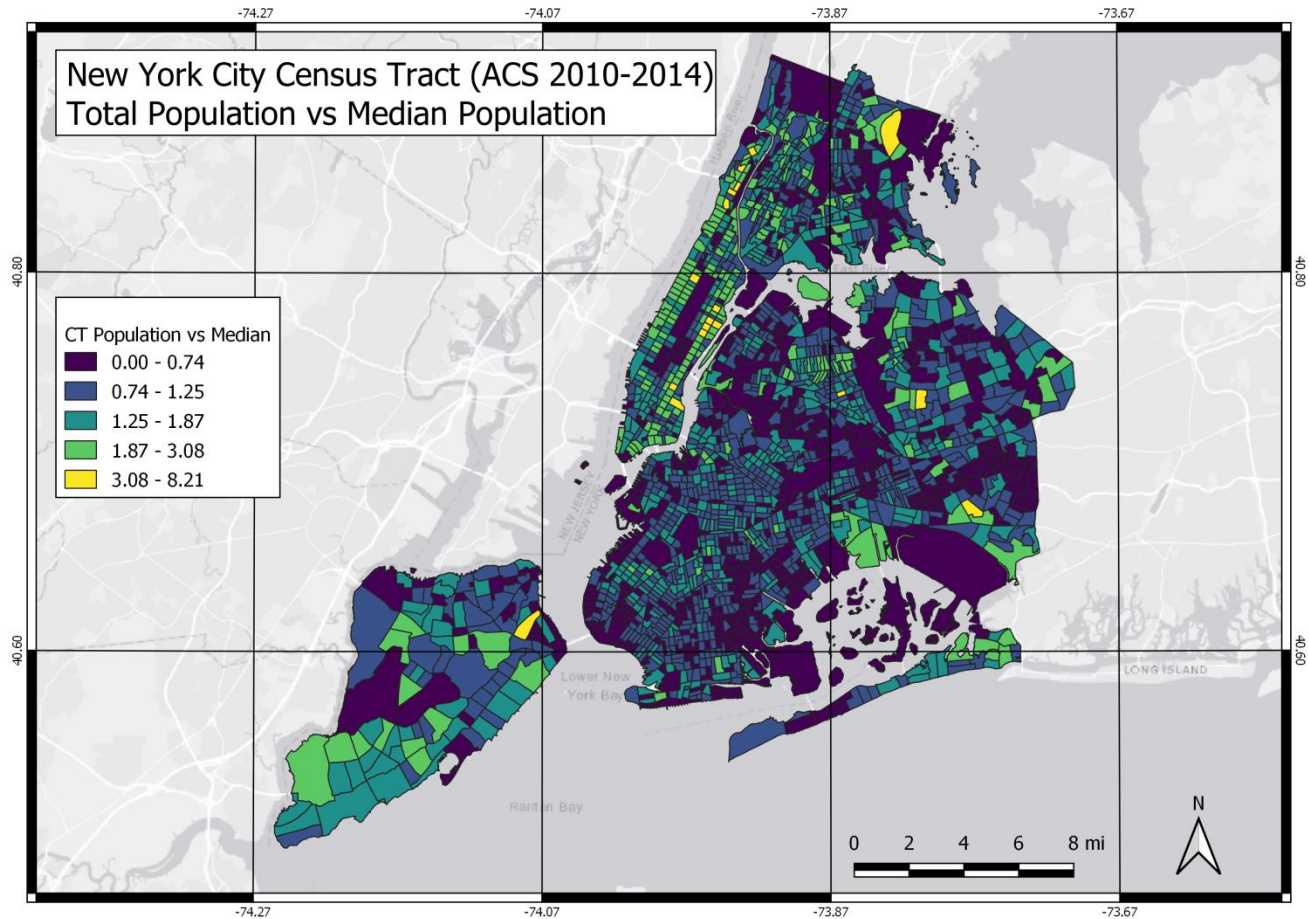
Residential Population Location

- Census tracts have a range of population densities
- People often do not live in areas of highest AQI
- Population data from 2010-2014 ACS was used to weigh AQI impact more highly in areas of higher population

Residential Population Location

New York City Census Tract (ACS 2010-2014)
Total Population vs Median Population

CT Population vs Median
- 0.00 - 0.74
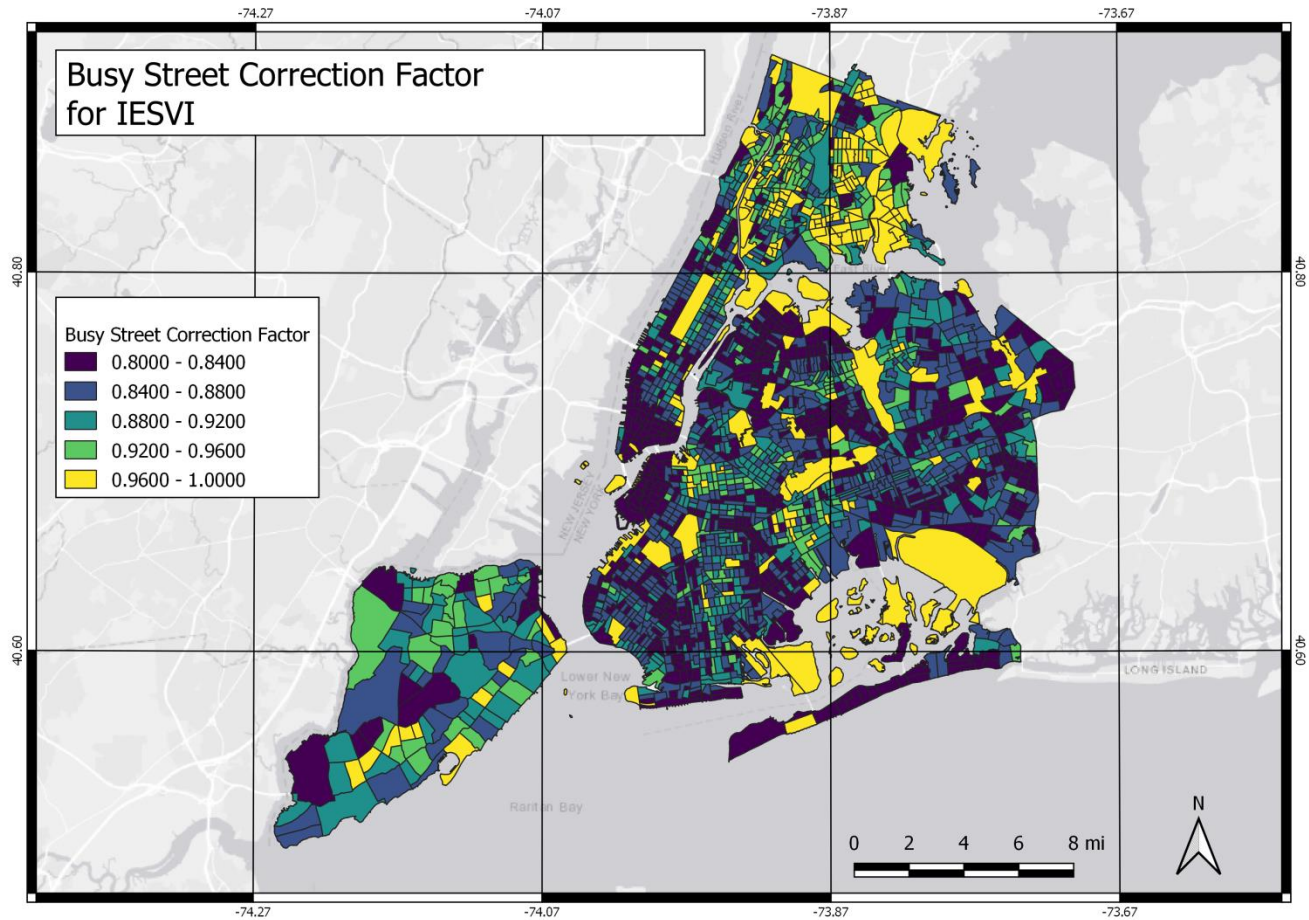- 0.74 - 1.25
- 1.25 - 1.87
- 1.87 - 3.08
- 3.08 - 8.21

Other Factors

- Building height was hypothesized to contribute to exposure
  - Lower AQI at greater heights
  - However, this is not the case
    - Several studies show that AQI (especially PM-driven) stays relatively constant with building height in dense cities
    - This is due to turbulent airflows and mixing between buildings

Other Factors

▸ Distance from busy streets was shown to have an effect on pollution exposure

- ◦ MapPLUTO data was used to find tax lots located on Avenues
- ◦ NYCCAS data showed an approximate decrease of 20% in pollutants on smaller streets
- ◦ Lots on Avenues assigned factor of 1
- ◦ Lots not on avenues assigned factor of 0.8
- ◦ Average correction factor for each census tract was used as an additional AQI weight

Other Factors

Busy Street Correction Factor for IESVI

Busy Street Correction Factor
- 0.8000 - 0.8400
- 0.8400 - 0.8800
- 0.8800 - 0.9200
- 0.9200 - 0.9600
- 0.9600 - 1.0000

Creating IESVI
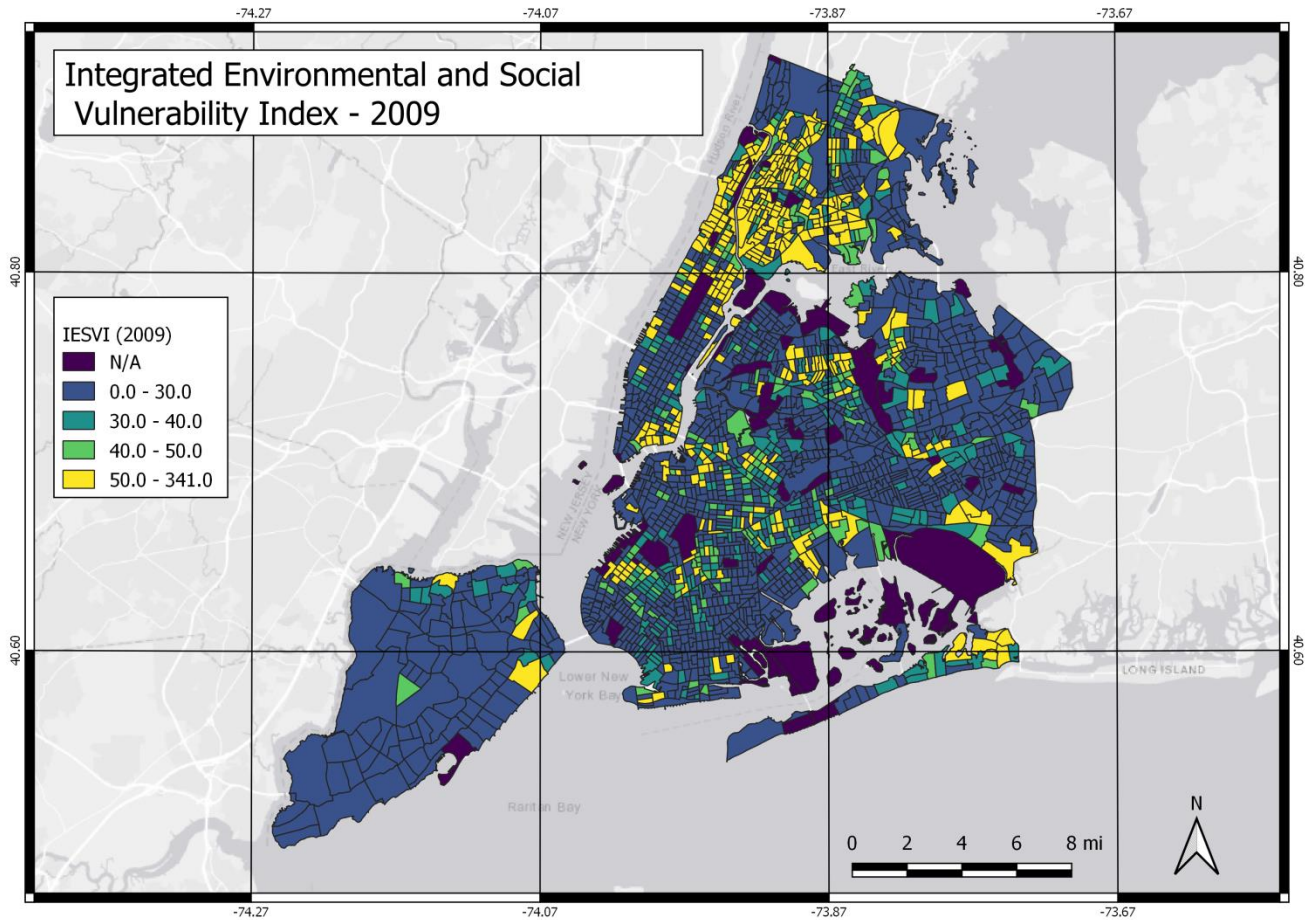
- An article from the International Journal of Environmental Research and Public Health was used create a IESVI equation

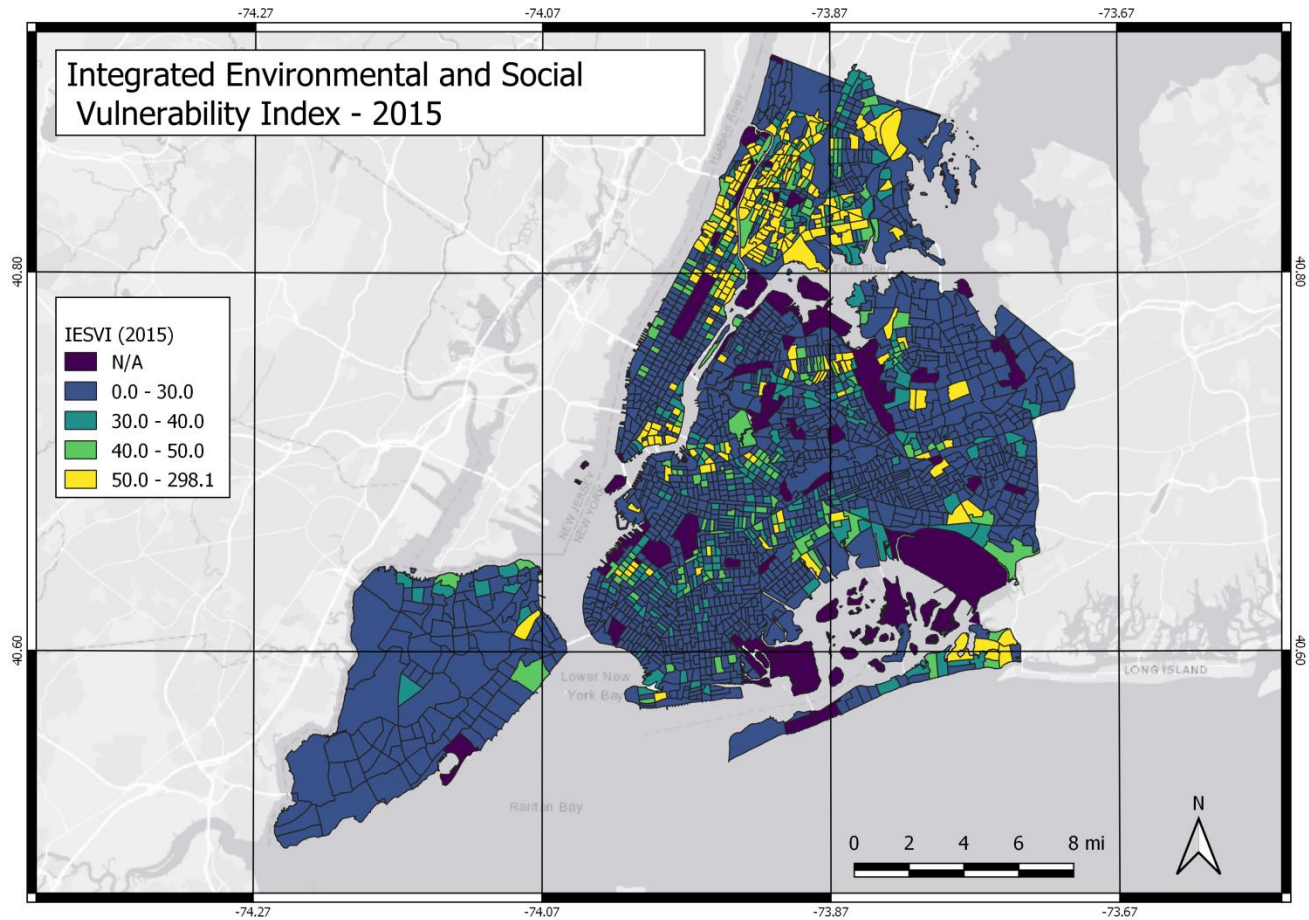$$EI_j = \prod_{i=1}^{n} \left(w_i r_{ij} \right)^{\frac{1}{n}}$$

$$SVI_{\hat{j}} = \sum_{k=1}^{m} w_k p_{k\hat{j}}$$

$$IESVI = EI \times SVI$$

IESVI Map

Integrated Environmental and Social Vulnerability Index - 2009

IESVI (2009)
- N/A
- 0.0 - 30.0
- 30.0 - 40.0
- 40.0 - 50.0
- 50.0 - 341.0

IESVI Map

Integrated Environmental and Social
 Vulnerability Index - 2015

IESVI (2015)
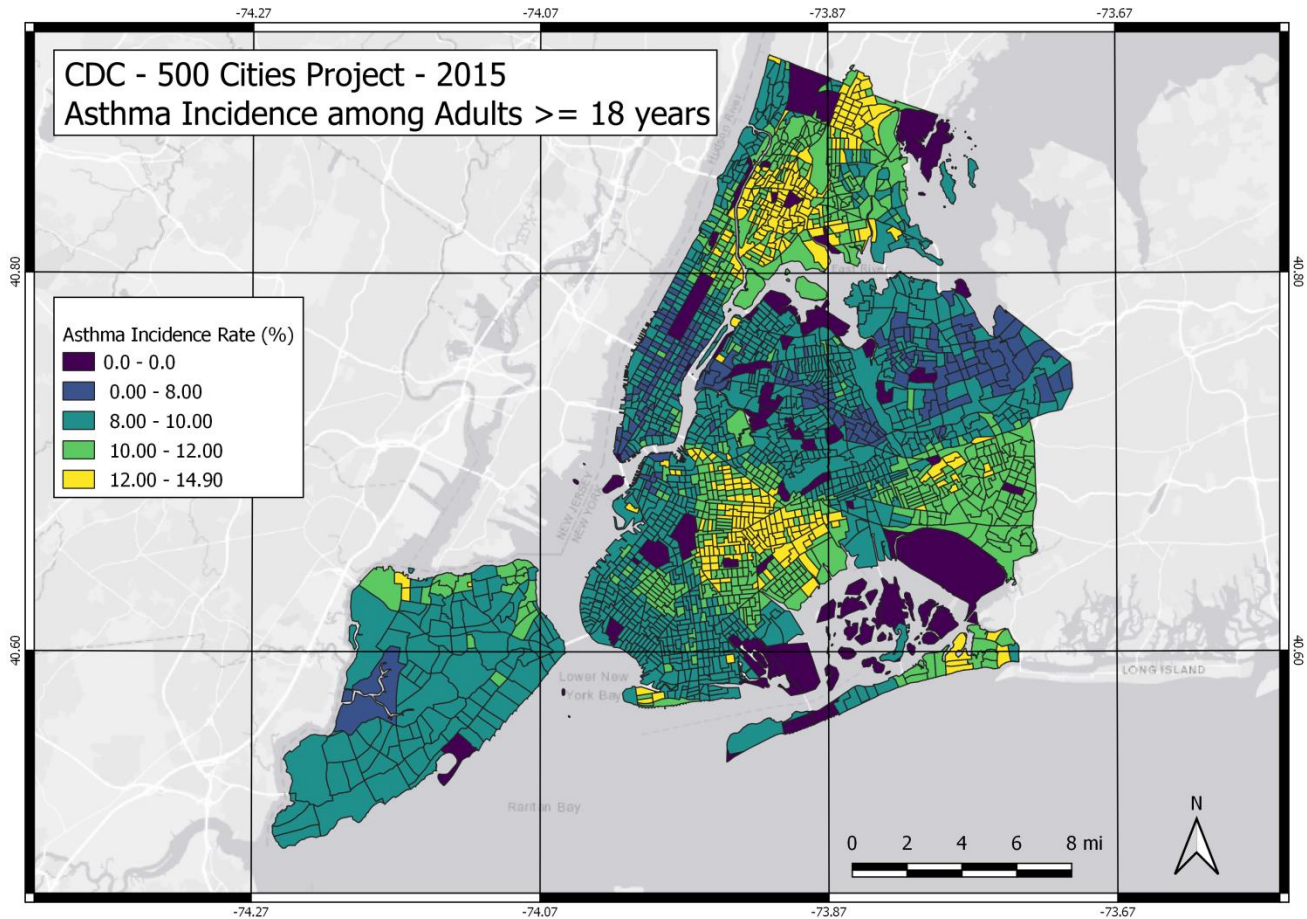- N/A
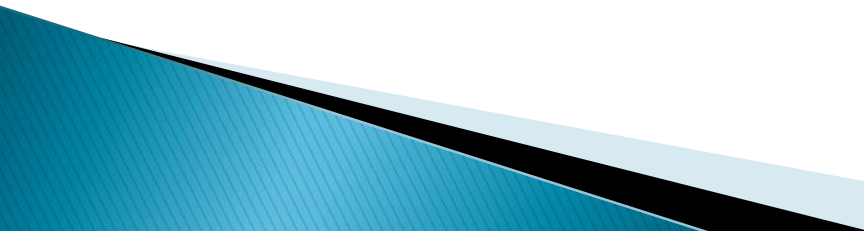- 0.0 - 30.0
- 30.0 - 40.0
- 40.0 - 50.0
- 50.0 - 298.1

Verifying Suitability of Index

- CDC 500 Cities Project (2015)
  - Self-reported surveys of various socioeconomic and health factors
  - Asthma data was used
    - However, data only available for individuals over 18
    - Can only be used for a general comparison

Verifying Suitability of Index

CDC - 500 Cities Project - 2015
Asthma Incidence among Adults >= 18 years

Asthma Incidence Rate (%)
- 0.0 - 0.0
- 0.00 - 8.00
- 8.00 - 10.00
- 10.00 - 12.00
- 12.00 - 14.90

Limitations of Index

- Not all factors taken into account
- Only provides a general overview
  - Due to zonal statistics method of extracting raster data, some areas may have high values
  - Residences on major streets were counted in a very simple way, and may not be accurate enough
  - People do not spend all day at home
  - Does not account for indoor air pollutants

Benefits of IESVI

- Provides a starting point for targeting areas of study
  - With further refinement can have impact on air pollution mitigation policies

Thank You!
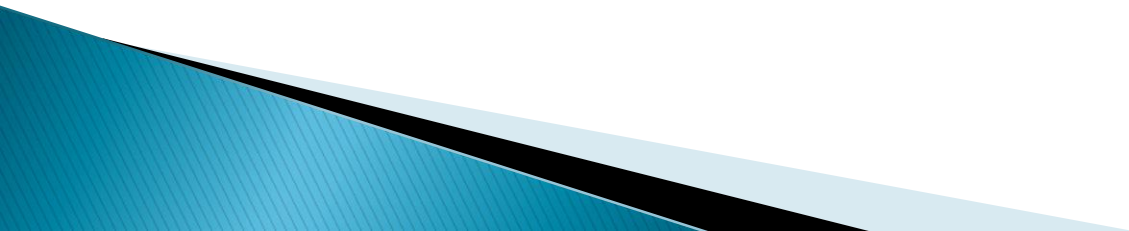
References

- Shrestha, R. et al. Environmental Health Related Socio-Spatial Inequalities: Identifying "Hotspots" of Environmental Burdens and Social Vulnerability. *International Journal of Environmental Research and Public Health*, 9 July 2016
- Kheirbek, I. et al. The New York City Community Air Survey: Neighborhood Air Quality 2008 – 2014. *NYC Health*, April 2016
- Technical Assistance Document for the Reporting of Daily Air Quality – the Air Quality Index (AQI). *US Environmental Protection Agency*, May 2016
- CDC 500 Cities Project: https://www.cdc.gov/500cities/
- The Social Vulnerability Index (SVI): https://svi.cdc.gov/