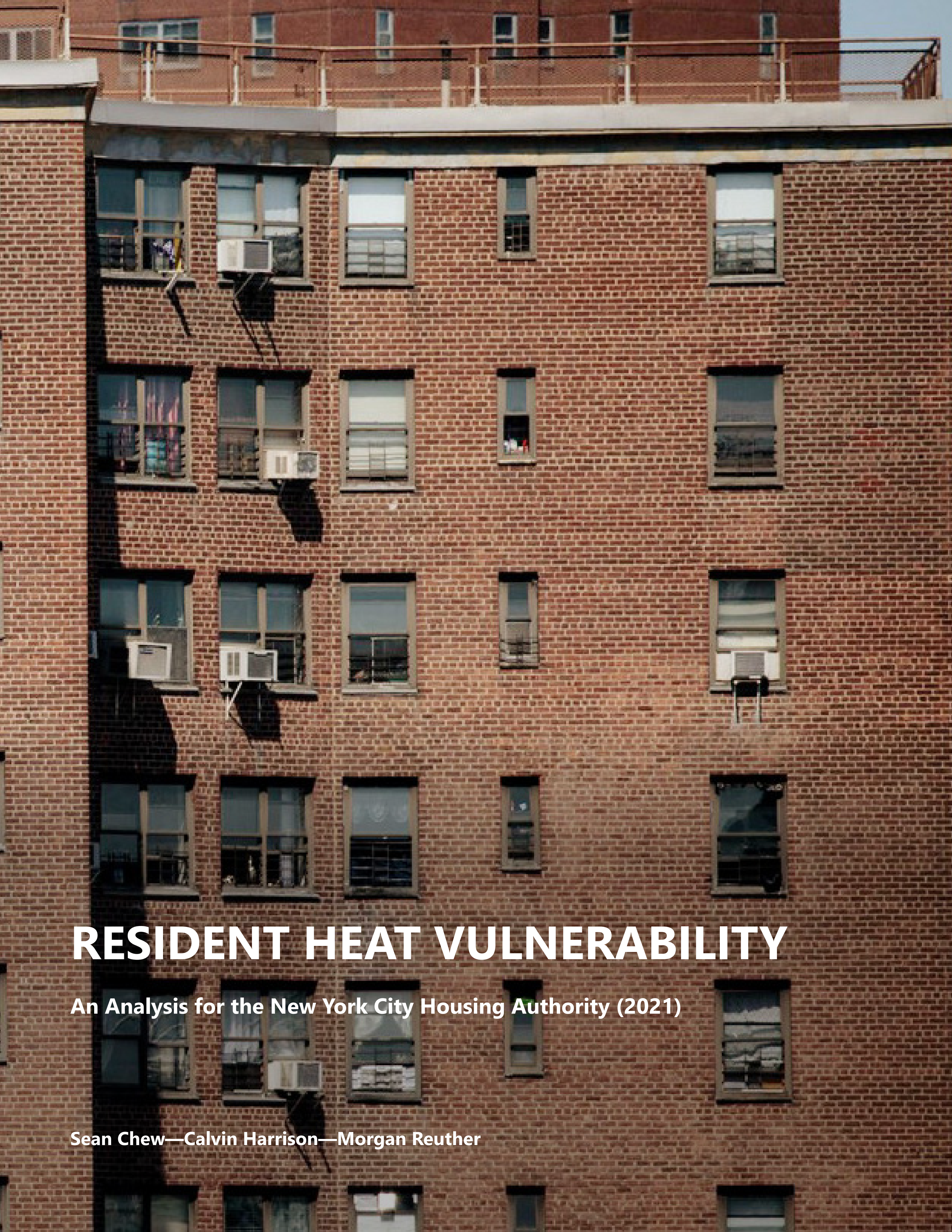


RESIDENT HEAT VULNERABILITY

An Analysis for the New York City Housing Authority (2021)

Sean Chew—Calvin Harrison—Morgan Reuther

Contents

Introduction

In New York City, intense heatwaves from extreme weather pose a serious threat to communities throughout all five boroughs and cause more deaths each year than all other climate-related hazards combined. The NYC Panel on Climate Change predicts that the number of days per year that the city's temperature exceeds 90°F will double by 2050. These rising temperatures exacerbate related environmental hazards, such as the urban heat island effect and poor environmental air quality, placing residents and entire neighborhoods at risk.

New York City currently utilizes its own Heat Vulnerability Index (NYC HVI) to detect neighborhood-level variations in heat vulnerability across the city. However, the tool is not refined enough to distinguish variations in the severity of heat burden faced by the city's most vulnerable populations living in developments owned and operated by the New York City Housing Authority (NYCHA). This analysis provides a targeted HVI for specific use by NYCHA to identify developments where residents are most vulnerable to rising local temperatures and to recommend where the agency's resources can be most effectively allocated.

photo: Mathieu Lewis-Rolland

Research Questions

Where are **CLUSTERS** of **HIGH HEAT VULNERABILITY?**

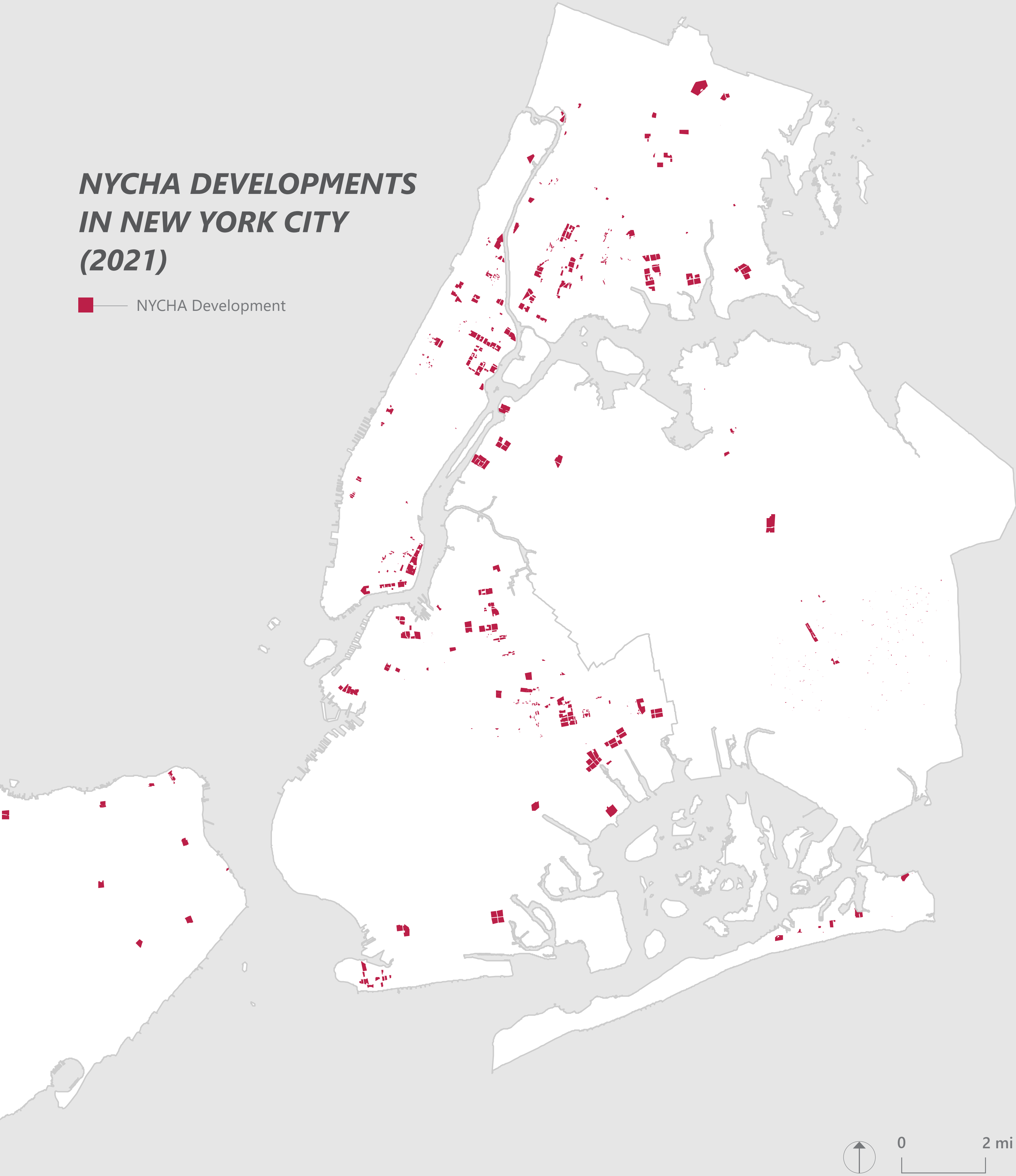
Based on those clusters, where should NYCHA prioritize heat mitigation interventions?

Operationalizing Terms

"HIGHLY HEAT VULNERABLE"
refers to areas indicated as at very high risk of heat-related health impacts, operationalized on a revised HVI based on socioeconomic, health, landcover, environmental, and relief indicators.

"CLUSTERS"
are defined as areas where there is a statistically significant relationship among the vulnerability scores of nearby census tracts, according to the Getis-Ord Gi* spatial statistics test. Because NYCHA developments are unevenly distributed across the city, clustering analysis is performed on census tracts to reflect patterns solely on vulnerability rather than development location. This is based on the premise that a resident is more vulnerable if all areas around them are also vulnerable.

NYCHA DEVELOPMENTS IN NEW YORK CITY (2021)



Methodology

In response to rising local temperatures, the municipal government developed the New York City Heat Vulnerability Index (NYC HVI) to measure the relative risk of heat-related illness or death across neighborhoods. The NYC HVI combines five socioeconomic and environmental indicators to determine neighborhood heat vulnerability:

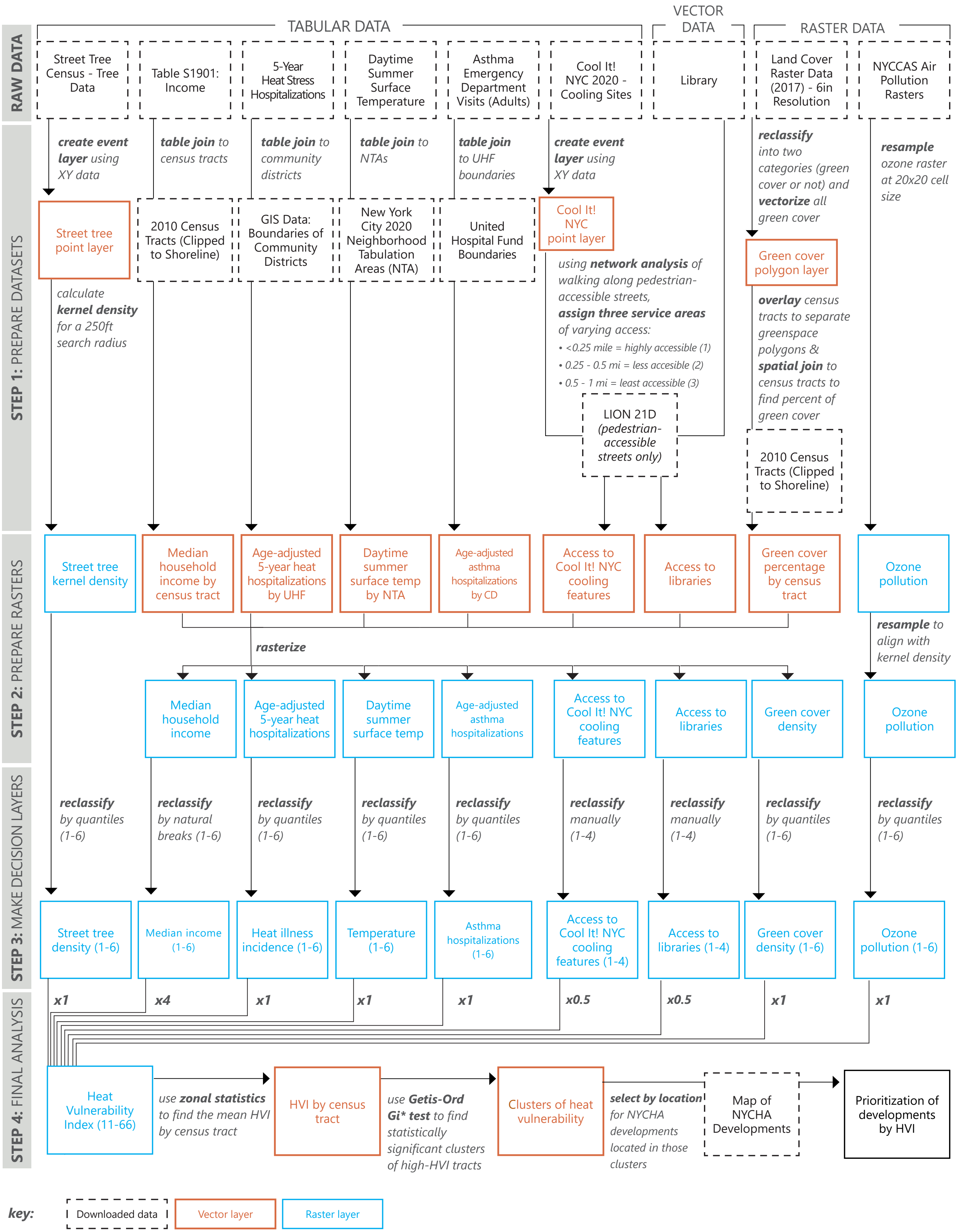
1. Percentage of population who are low-income
2. Percentage of population who are African American or Latinx
3. Daytime surface temperature
4. Green space coverage
5. Access to home air conditioning

Based on these factors, neighborhoods receive a score from 1 (lowest risk) to 5 (highest risk) based on a statistical model. Scores quantify social and environmental factors to estimate the overall risk of heat-related death across New York City neighborhoods.

While the NYC HVI is effective in identifying neighborhood-level variations in heat vulnerability across New York City, the tool is calculated by Neighborhood Tabulation Areas (NTAs), a relatively large aereal unit that is not refined enough to distinguish local patterns in the severity of heat burden faced by the city's most vulnerable populations and cannot differentiate among various NYCHA developments located nearby one another. Furthermore, its reliance on race as a factor is questionable; while race is correlated with various factors that increase heat vulnerability, it is not a cause in and of itself.

For this reason, the analysis employs a multi-criteria decision analysis (MCDA) approach based on rasterized data, allowing for individual scores to be assigned to every 20x20 feet plot in the city. To achieve this scoring, data for the nine indicators identified are rasterized and aligned into nine separate decision layers with the same extents and resolutions. With all cells aligned, the layers were added together with specific weighting (*see Analysis section for further weighting details*).

All factors combined create a map of heat vulnerability scores across the city. Scores are then averaged within each census tract to allow for clustering analysis. The Getis-Ord Gi* test is performed to determine areas of clustered high heat vulnerability that are statistically significant at a 90% confidence level. NYCHA developments with populations above the average for other agency-owned properties within each cluster are identified and recommended for heat mitigation interventions.


RAW DATA
STEP 1: PREPARE DATASETS
STEP 2: PREPARE RASTERS
STEP 3: MAKE DECISION LAYERS
STEP 4: FINAL ANALYSIS
TABULAR DATA
VECTOR DATA
RASTER DATA
Street Tree Census - Tree Data
Table S1901: Income
5-Year Heat Stress Hospitalizations
Daytime Summer Surface Temperature
Asthma Emergency Department Visits (Adults)
Cool It! NYC 2020 - Cooling Sites
Library
Land Cover Raster Data (2017) - 6in Resolution
NYCCAS Air Pollution Rasters
create event layer using XY data
table join to census tracts
table join to community districts
table join to NTAs
table join to UHF boundaries
create event layer using XY data
reclassify into two categories (green cover or not) and vectorize all green cover
resample ozone raster at 20x20 cell size
Street tree point layer
2010 Census Tracts (Clipped to Shoreline)
GIS Data: Boundaries of Community Districts
New York City 2020 Neighborhood Tabulation Areas (NTA)
United Hospital Fund Boundaries
Cool It! NYC point layer
Green cover polygon layer
calculate kernel density for a 250ft search radius
using network analysis of walking along pedestrian-accessible streets, assign three service areas of varying access:
• <0.25 mile = highly accessible (1)
• 0.25 - 0.5 mi = less accesible (2)
• 0.5 - 1 mi = least accessible (3)
LION 21D (pedestrian-accessible streets only)
overlay census tracts to separate greenspace polygons & spatial join to census tracts to find percent of green cover
2010 Census Tracts (Clipped to Shoreline)
Street tree kernel density
Median household income by census tract
Age-adjusted 5-year heat hospitalizations by UHF
Daytime summer surface temp by NTA
Age-adjusted asthma hospitalizations by CD
Access to Cool It! NYC cooling features
Access to libraries
Green cover percentage by census tract
Ozone pollution
rasterize
resample to align with kernel density
Median household income
Age-adjusted 5-year heat hospitalizations
Daytime summer surface temp
Age-adjusted asthma hospitalizations
Access to Cool It! NYC cooling features
Access to libraries
Green cover density
Ozone pollution
reclassify by quantiles (1-6)
reclassify by natural breaks (1-6)
reclassify by quantiles (1-6)
reclassify by quantiles (1-6)
reclassify by quantiles (1-6)
reclassify manually (1-4)
reclassify manually (1-4)
reclassify by quantiles (1-6)
reclassify by quantiles (1-6)
Street tree density (1-6)
Median income (1-6)
Heat illness incidence (1-6)
Temperature (1-6)
Asthma hospitalizations (1-6)
Access to Cool It! NYC cooling features (1-4)
Access to libraries (1-4)
Green cover density (1-6)
Ozone pollution (1-6)
x1
x4
x1
x1
x1
x0.5
x0.5
x1
x1
Heat Vulnerability Index (11-66)
use zonal statistics to find the mean HVI by census tract
HVI by census tract
use Getis-Ord Gi* test to find statistically significant clusters of high-HVI tracts
Clusters of heat vulnerability
select by location for NYCHA developments located in those clusters
Map of NYCHA Developments
Prioritization of developments by HVI
key:
Downloaded data
Vector layer
Raster layer

Analysis

The refined HVI for use by NYCHA combines nine indicators of heat vulnerability across five categories. In order to provide a holistic understanding of what makes a neighborhood heat vulnerable, the following five categories were integrated into the final index:

- **Socioeconomic indicators:** where do people have the means to cope with extreme heat?
- **Health indicators:** where are people already struggling?
- **Landcover indicators:** where does the built environment contribute to extreme heat?
- **Environmental indicators:** where is the air hottest?
- **Relief indicators:** where do people have access to respite and refuge on hot days?

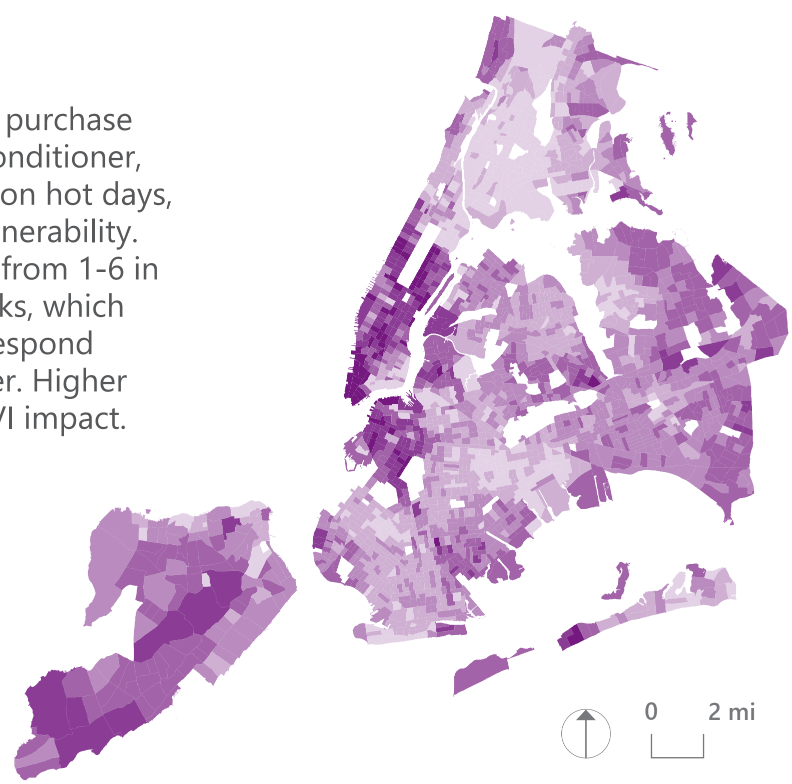
Within these categories, the specific indicators used are median household income, heat hospitalization rate, asthma incidence, green landcover, street tree density, summer daytime temperature, ozone concentration, and access to Cool It! NYC features and libraries. The following section outlines how each indicator was selected and scored to quantify vulnerability.

SOCIOECONOMIC INDICATORS

Median Household Income

Income determines whether someone can purchase cooling mechanisms such as a fan or air conditioner, or even escape the city to a second home on hot days, making it a crucial determinant of heat vulnerability. Median income by census tracts is ranked from 1-6 in classes separated using Jenks natural breaks, which creates six distinct income levels that correspond to meaningfully different purchasing power. Higher median income corresponds to a lower HVI impact.

Income (USD)	**HVI Impact**
$9,740—$40,714	6
$40,714—$62,639	5
$62,639—$84,438	4
$84,438—$113,527	3
$113,527—$156,975	2
$156,975—$250,000	1



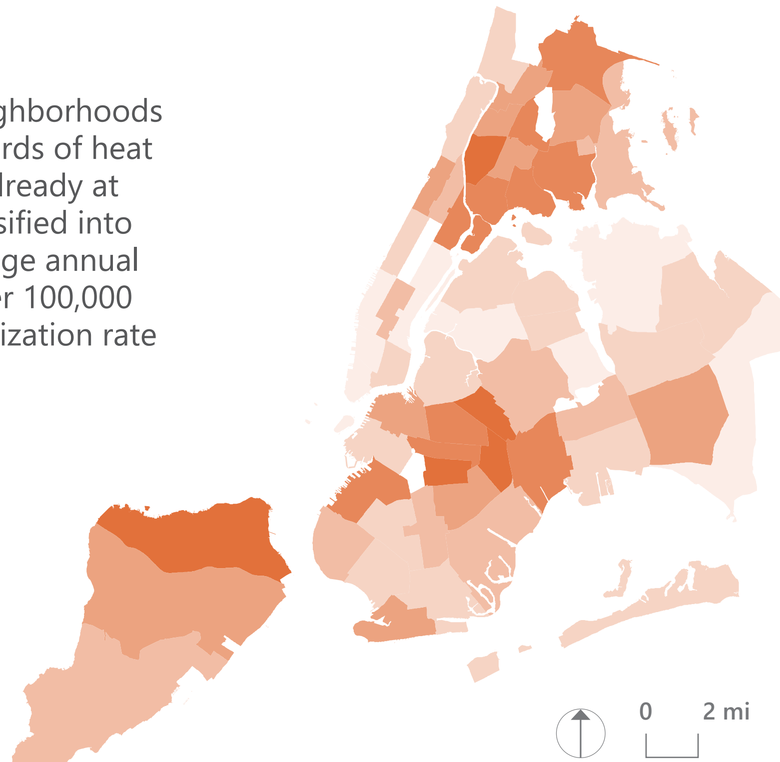
HEALTH INDICATORS

Heat Hospitalization Rate

Heat vulnerability is not a future issue; neighborhoods across the city are already struggling. Records of heat hospitalization show where residents are already at risk. The city's community districts are classified into six ranked quantiles by age-adjusted average annual number of heat-related hospitalizations per 100,000 people from 2012 to 2016. Higher hospitalization rate corresponds to higher HVI impact.

*Annual Hospital. Rate**	HVI Impact
0.30—0.70	1
0.70—1.10	2
1.10—1.50	3
1.50—1.90	4
1.90—2.50	5
2.50—3.60	6

**age-adjusted per 100k*

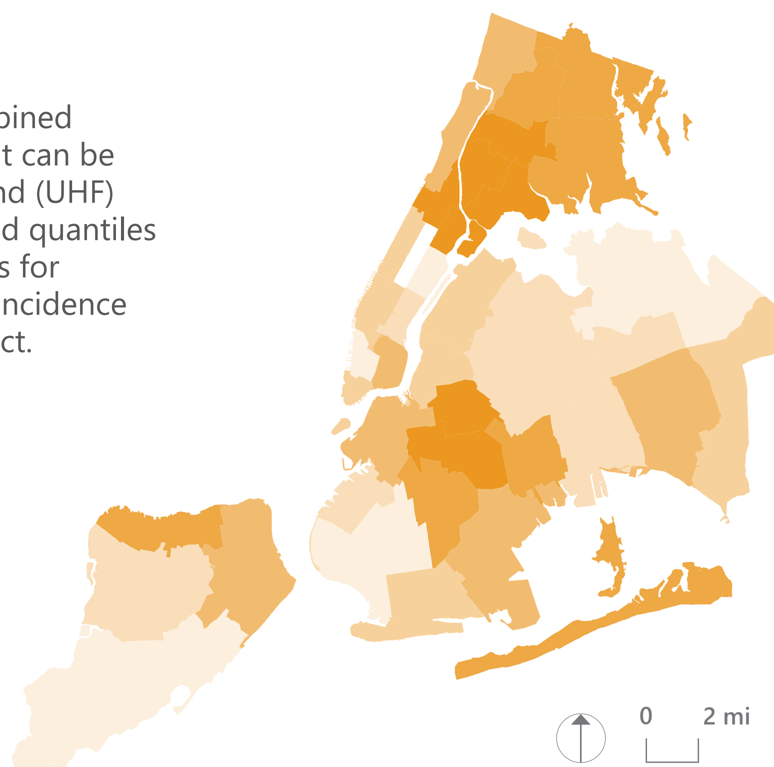


Asthma Incidence

While heat alone is unpleasant, when combined with underlying cardiovascular conditions it can be dangerous and deadly. United Hospital Fund (UHF) neighborhoods are classified into six ranked quantiles by the age-adjusted emergency room visits for asthma attacks per 10,000 people. Higher incidence of asthma corresponds to higher HVI impact.

*Asthma Rate***	HVI Impact
16.7—29.0	1
29.0—50.4	2
50.4—68.9	3
68.9—96.6	4
98.6—205.5	5
205.5—317.4	6

***age-adjusted per 10k*

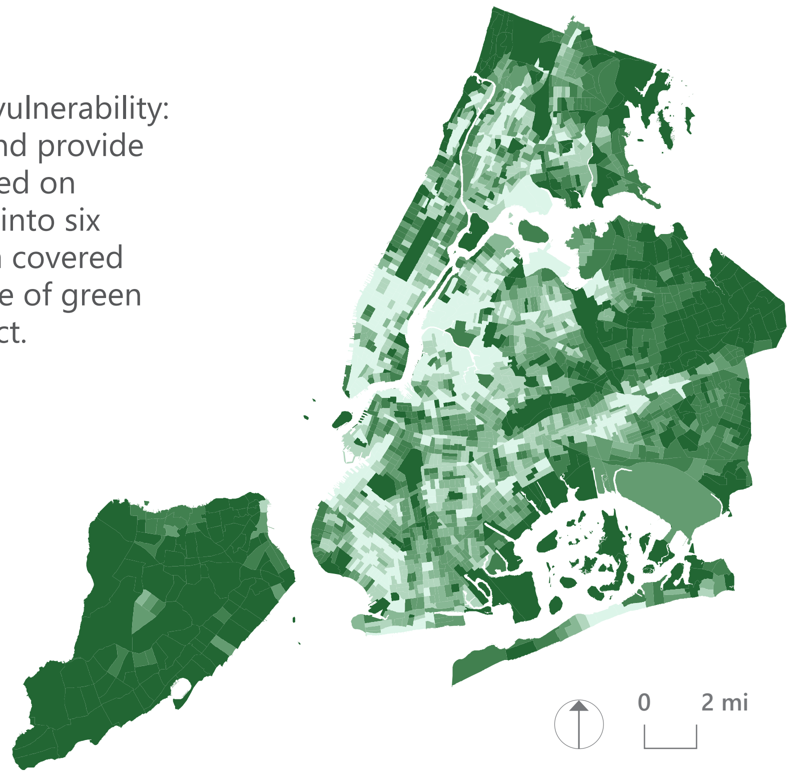


LANDCOVER INDICATORS

Green Landcover

Greenspace has a twofold impact on heat vulnerability: green areas promote the flow of cool air and provide a pleasant refuge for nearby residents. Based on landcover data, census tracts are classified into six ranked quantiles by the percentage of area covered by grass, shrubs, or trees. Lower percentage of green landcover corresponds to higher HVI impact.

Percentage Green Landcover	**HVI Impact**
0.2%—12.7%	**6**
12.7%—17.6%	**5**
17.6%—22%	**4**
22%—28.5%	**3**
28.5%—38%	**2**
38%—99.3%	**1**



Street Tree Density

Street trees combat the urban heat island effect by shading asphalt and concrete and can also filter air pollutants, making them a crucial factor in neighborhood heat vulnerability. The density of street trees, represented by the number of trees per acre within 250 feet of every 20x20 feet square of the city, is classified into six equal quantiles. Lower street tree density corresponds to higher HVI impact.

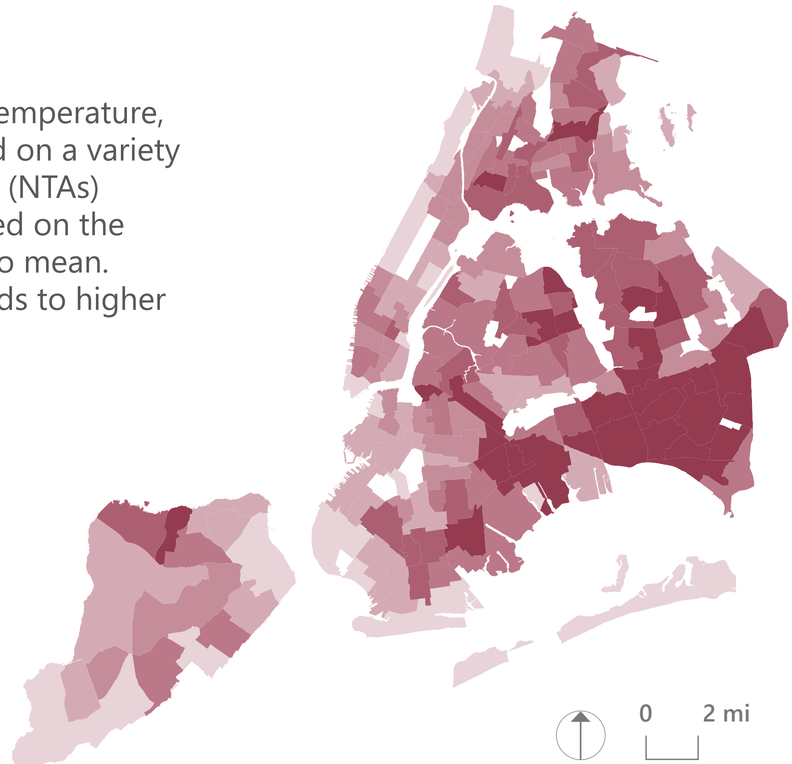
Street Trees per Acre	**HVI Impact**
0.0	**6**
0.0—2.09	**5**
2.09—4.02	**4**
4.02—5.79	**3**
5.79—7.89	**2**
7.89—41.04	**1**

ENVIRONMENTAL INDICATORS

Summer Daytime Temperature

Central to heat vulnerability is, of course, temperature, which can vary widely across the city based on a variety of factors. Neighborhood Tabulation Areas (NTAs) are classified into six ranked quantiles based on the temperature on July 17, 2018 normalized to mean. Higher normalized temperature corresponds to higher HVI impact.

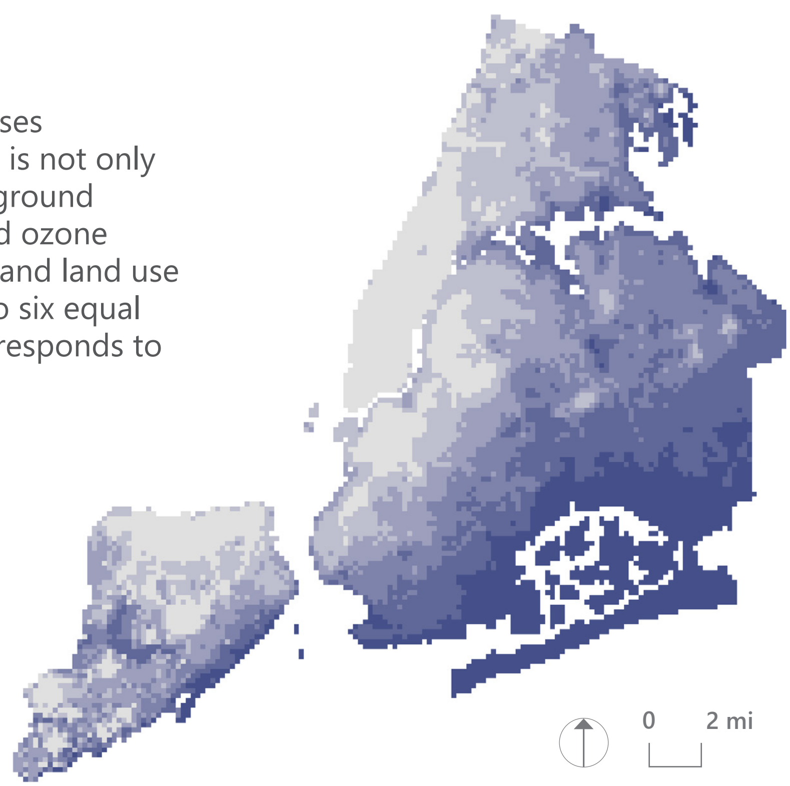
Temp. (normalized to mean)	**HVI Impact**
0.940—0.979	**1**
0.979—0.991	**2**
0.991—.0999	**3**
0.999—1.012	**4**
1.012—1.021	**5**
1.021—1.044	**6**



Ozone

Ozone, which is formed when sunlight causes common small-particle pollutants to react, is not only a health hazard but also traps heat at the ground level, exacerbating summer heat. Estimated ozone concentrations based on local monitoring and land use from 2019 across the city are classified into six equal quantiles. Higher ozone concentration corresponds to higher HVI impact.

Ozone Concentration (ppb)	**HVI Impact**
21.384—28.112	**1**
28.112—29.739	**2**
29.739—30.996	**3**
30.996—32.178	**4**
32.178—33.805	**5**
33.805—40.237	**6**

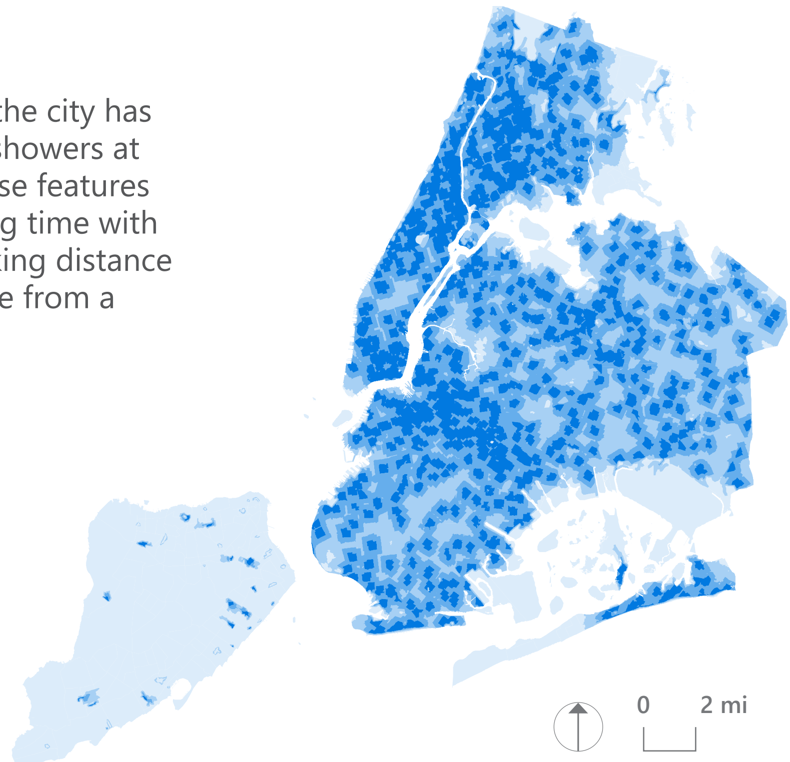


RELIEF INDICATORS

Access to Cool It! NYC Feature

To help residents cope with summer heat, the city has installed features like fountains and spray showers at parks under the Cool It! NYC program. These features help residents feel refreshed while spending time with neighbors. Areas are ranked based on walking distance to any Cool It! NYC feature. Farther distance from a feature corresponds to higher HVI impact.

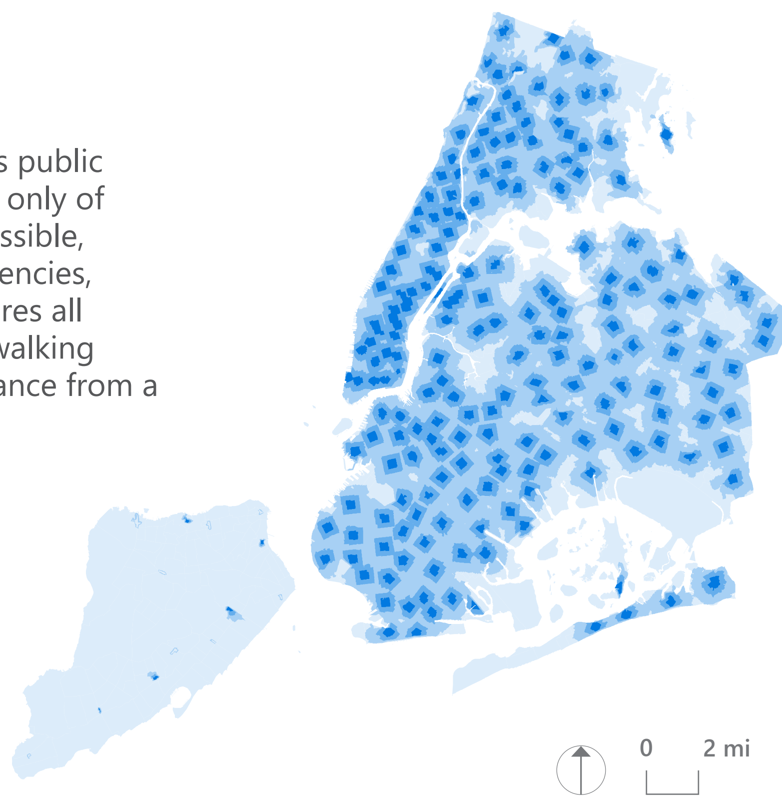
Distance to Cool It! Feature	HVI Impact
0—1,320ft	1
1,320—2,640ft	2
2,640—5,280ft	3
>5,280ft	4



Access to Cool It! NYC Libraries

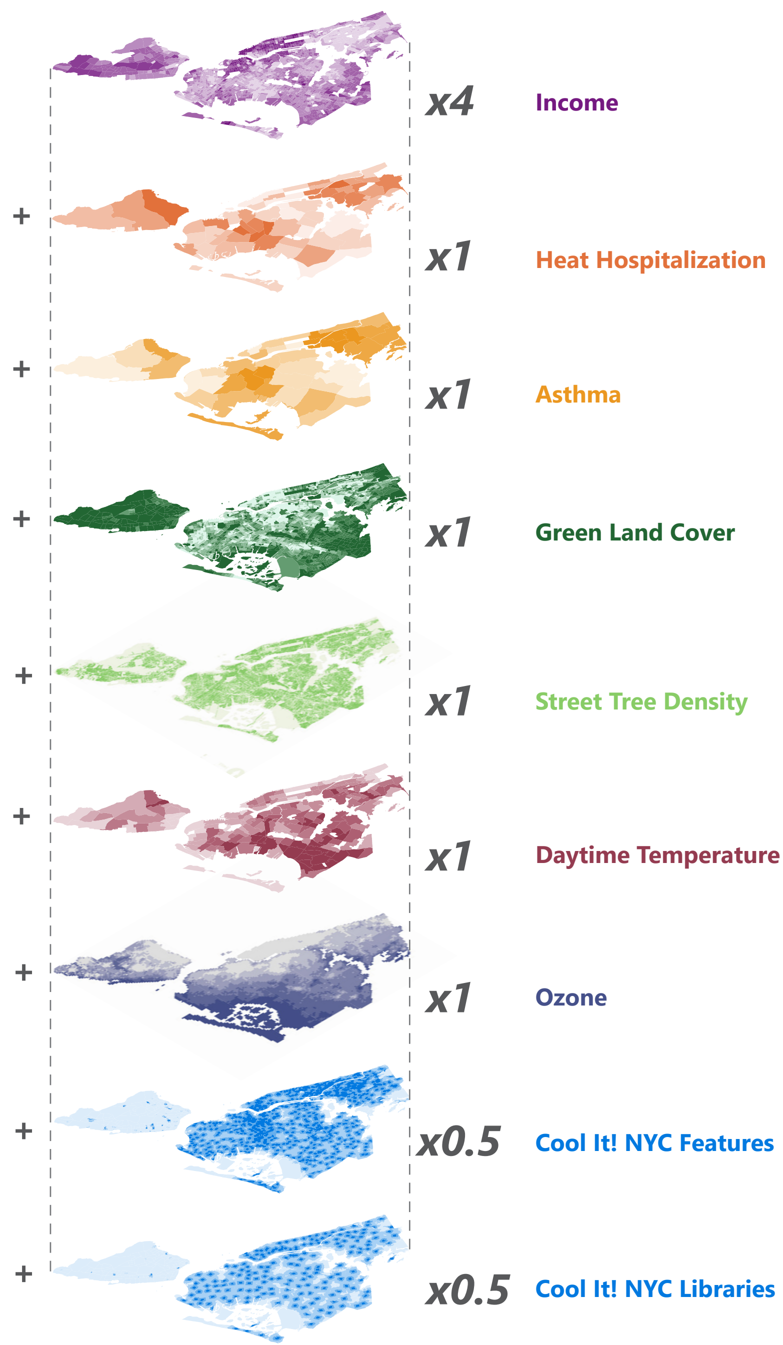
In heat emergencies, the city opens various public spaces as cooling centers. Libraries are the only of those facilities that always offer freely accessible, climate-controlled space outside of emergencies, helping residents cope with hot temperatures all summer long. Areas are ranked based on walking distance to any library branch. Farther distance from a library corresponds to higher HVI impact.

Distance to Library	HVI Impact
0—1,320ft	1
1,320—2,640ft	2
2,640—5,280ft	3
>5,280ft	4



MULTI-CRITERIA DECISION ANALYSIS

When all nine indicators across the five categories are combined for the final HVI score, layers are weighted to reflect the relative impact each category has on vulnerability. Because socioeconomic status provides the most ability to escape heat vulnerability, and because there is only one indicator within this category, the median income layer was weighted by four. The layers for health, landcover, and environmental indicators were each counted only once, meaning that socioeconomic status had twice the impact of each of those other categories. Finally, each of the two relief indicators were weighted by 0.5, reflecting the fact that having access to refuge outside of one's home can help, but still leaves a person vulnerable. By weighting access to Cool It! NYC features and libraries each by 0.5, relief indicators had only half the impact of health, landcover, and environmental indicators.



HEAT VULNERABILITY INDEX

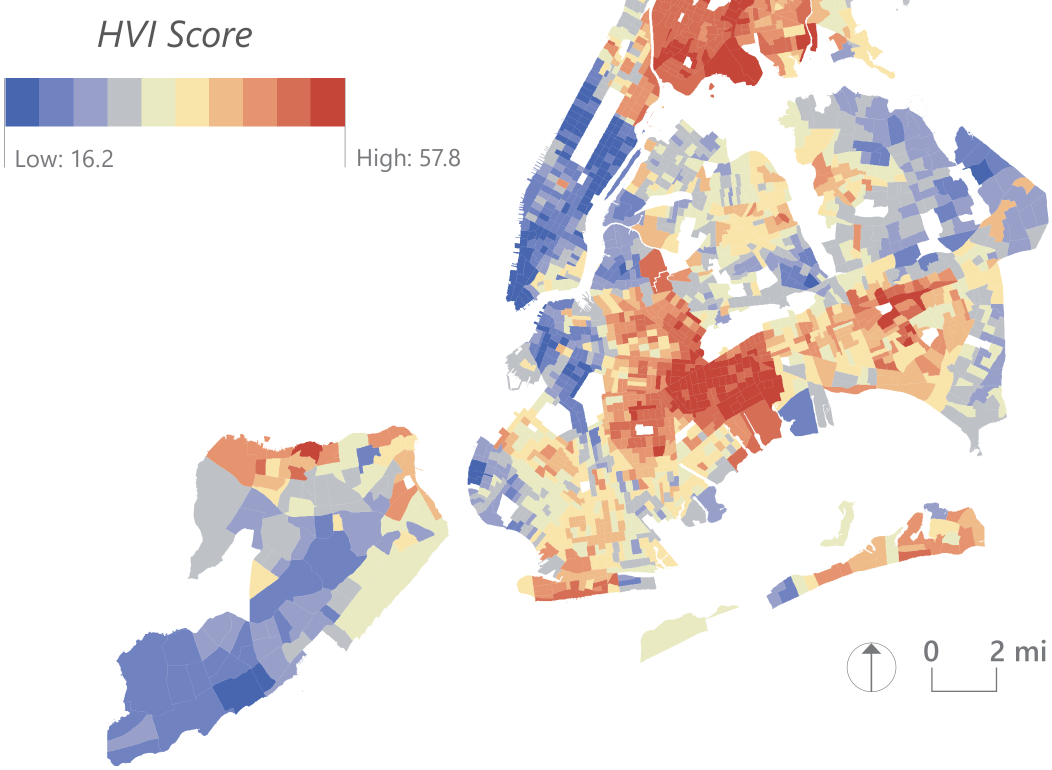
After performing MCDA with the nine heat vulnerability indicators, raster cells of 20x20 feet are assigned total vulnerability scores across the five boroughs. Scores are then averaged and aggregated by census tract to identify which tracts are most vulnerable and if clusters of vulnerable tracts exist.

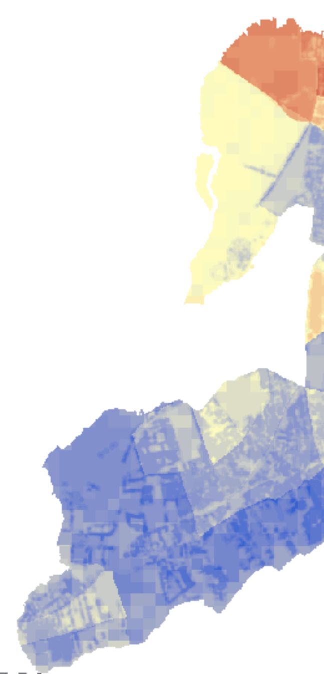
Visually, concentrations of highly heat vulnerable census tracts are apparent in two regions:

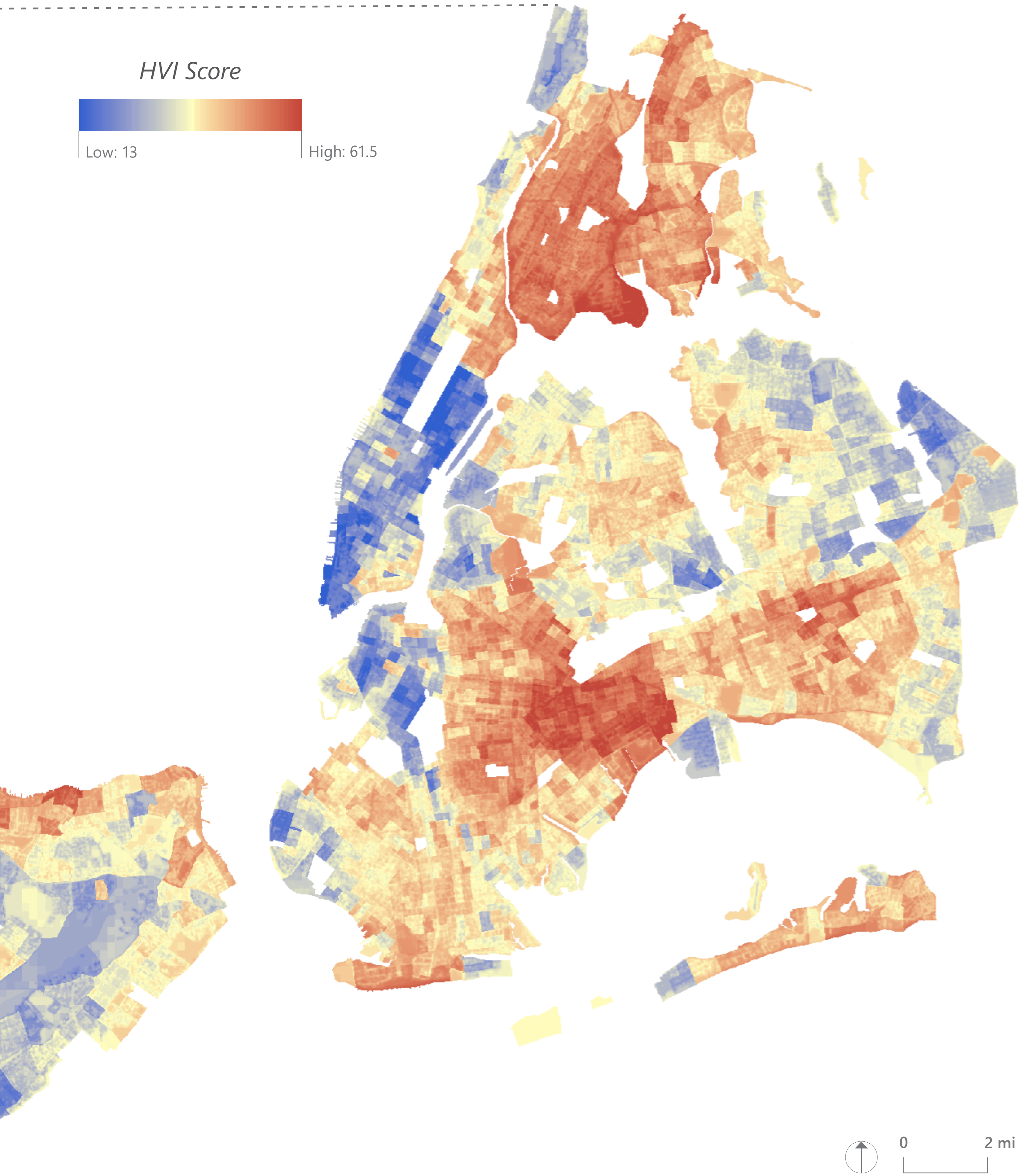
1. Upper Manhattan / Bronx,
2. Northeast Brooklyn / Queens

The Getis Ord Gi* test of local clustering using a fixed-band distance conceptualization of spatial relationships confirms that the two regions of heat vulnerability were clustered and spatially statistically significant to the 90% confidence interval.

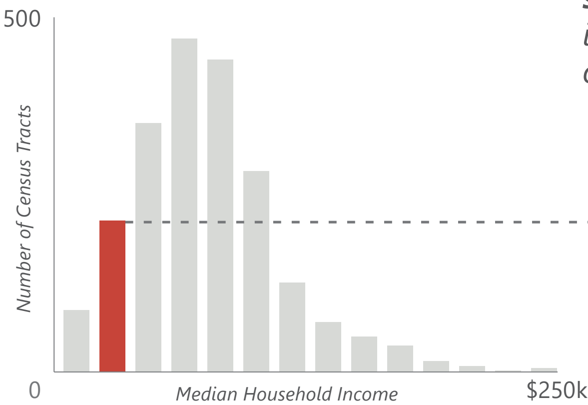
AVERAGE HVI INDEX per CENSUS TRACT





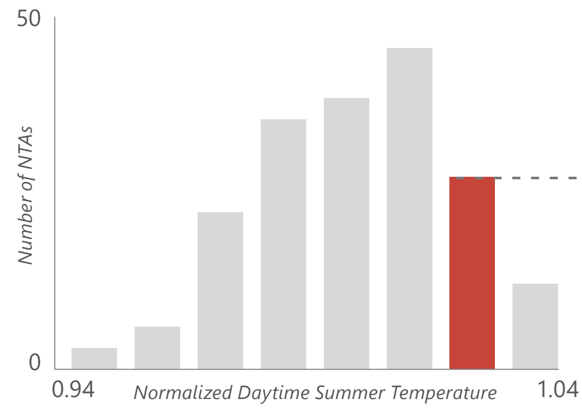

HVI Score
Low: 13
High: 61.5
0
2 mi

The two geographic regions identified as ***statistically significant spatial clusters*** *exhibit indicators that place them at more risk in the event of extreme heat events.*



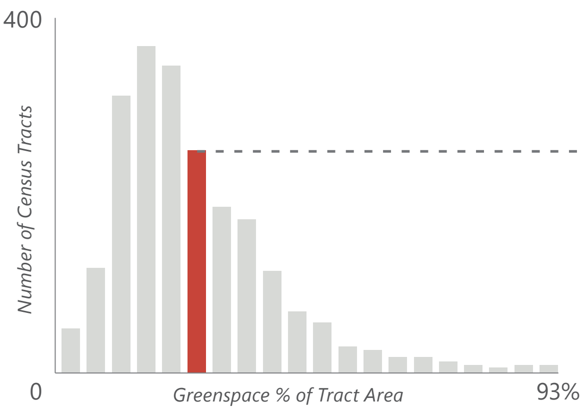
$29,000

Median Household Income



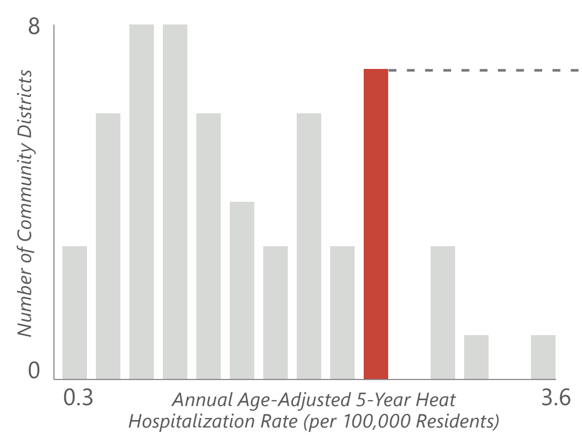
1.01

Normalized Daytime Summer Temperature



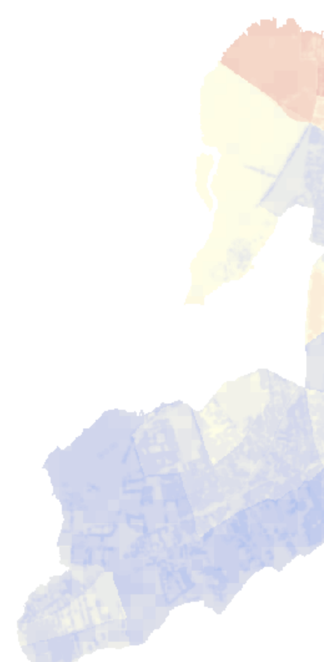
26%

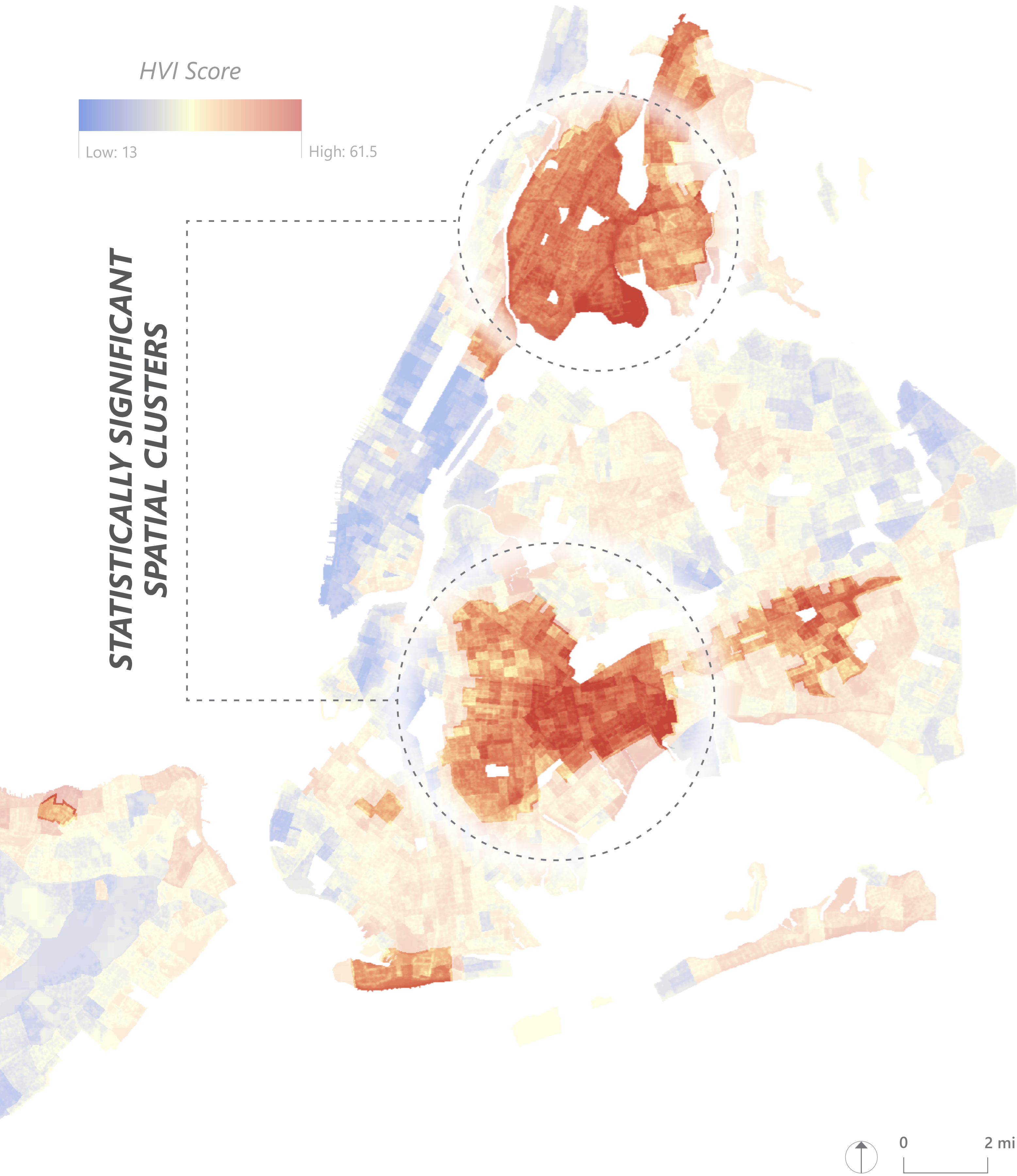
Greenspace Coverage per Census Tract



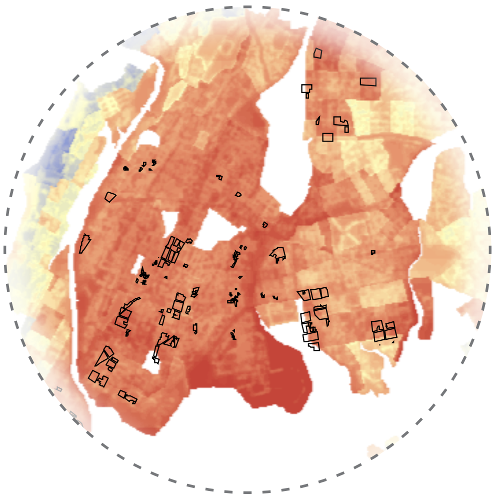
2.4 / 100k residents

Age-Adjusted Heat Hospitalization Rate



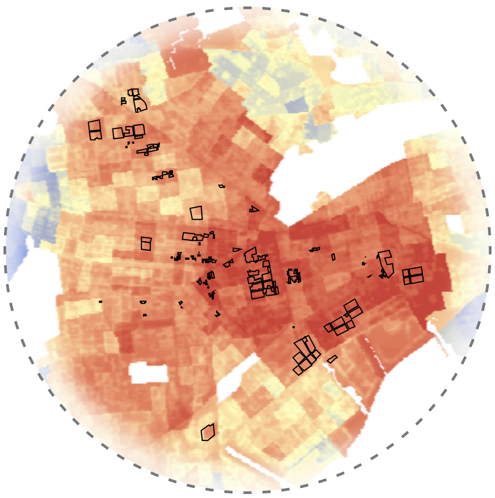

HVI Score
Low: 13
High: 61.5
STATISTICALLY SIGNIFICANT SPATIAL CLUSTERS
0
2 mi

HIGHLY VULNERABLE NYCHA DEVELOPMENTS



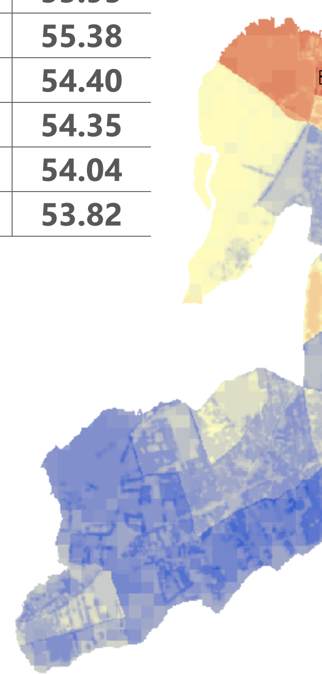
UPPER MANHATTAN / BRONX

Development	*Population*	*Year Built*	**HVI Score**
MELROSE	2,418	1971	**54.59**
GUN HILL	1,470	1975	**54.50**
JACKSON	2,203	1972	**53.35**
WEBSTER	1,562	1951	**53.25**
EASTCHESTER GARDENS	2,051	1964	**53.06**
ADAMS	2,310	1960	**52.77**
SAINT MARY'S PARK	2,299	1986	**52.74**
PATTERSON	4,194	1985	**52.20**
BUTLER	4,297	1941	**52.02**
MORRISANIA AIR RIGHTS	1,681	1965	**51.75**



NORTHEAST BROOKLYN / QUEENS

Development	*Population*	*Year Built*	**HVI Score**
UNITY PLAZA (SITES 4-27)	1,133	1951	**56.66**
LOW HOUSES	1,358	1955	**56.53**
HOWARD	1,835	1960	**56.06**
HUGHES APARTMENTS	1,366	1970	**56.05**
VAN DYKE I	3,855	1957	**55.95**
PINK	3,651	1976	**55.38**
TILDEN	2,556	1954	**54.40**
BOULEVARD	2,696	1965	**54.35**
CYPRESS HILLS	3,250	1955	**54.04**
LINDEN	3,611	1988	**53.82**



*Both statistically significant clusters of heat vulnerability contain a number of NYCHA developments that would benefit from investments in heat mitigation, including retrofits or the construction of cooling centers. In order to direct investment to have the greatest impact, **ten developments with populations above the average** for NYCHA properties within each cluster are recommended.*

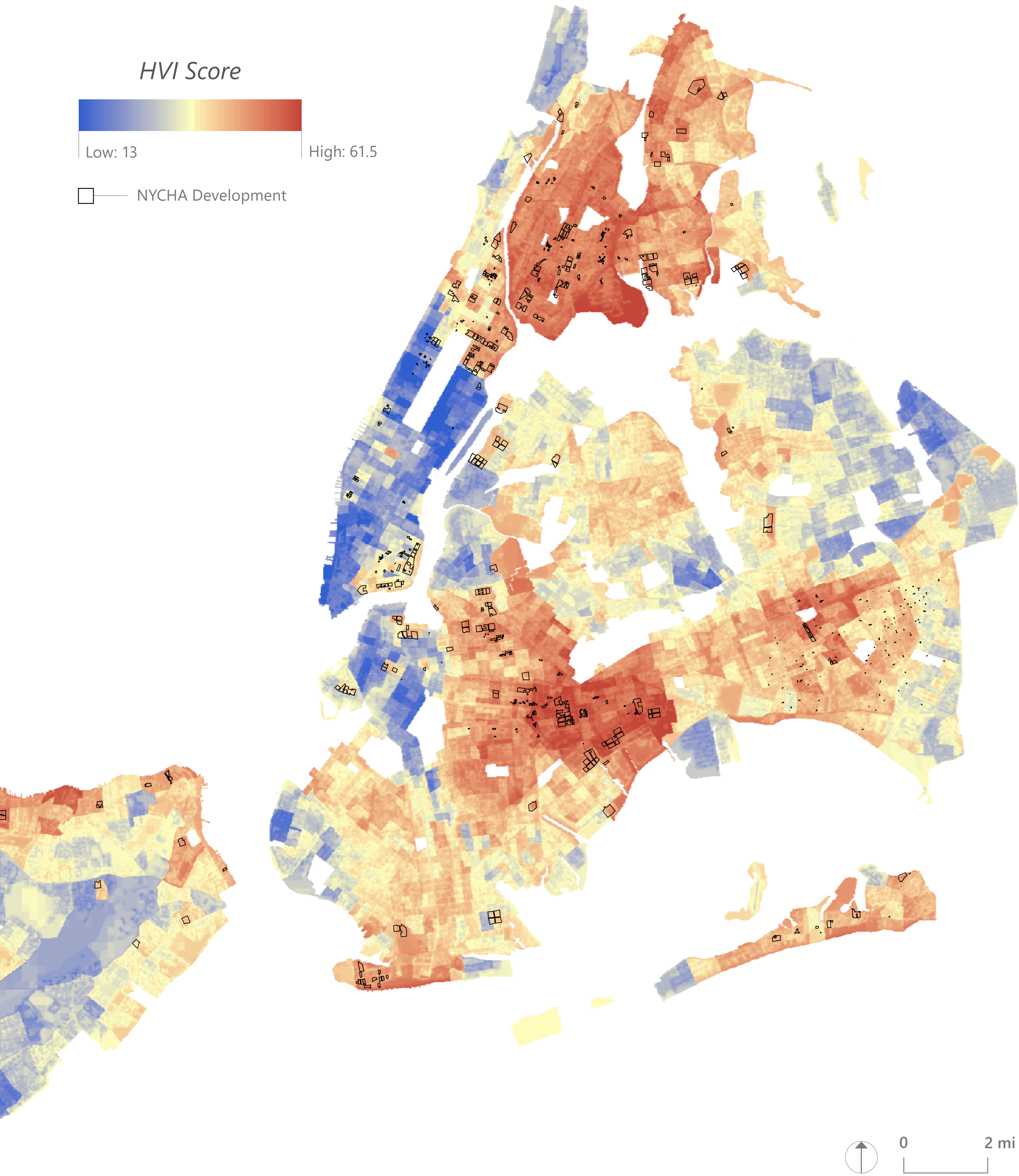

HVI Score
Low: 13
High: 61.5
NYCHA Development
0
2 mi

photo: Mathieu Lewis-Rolland

Conclusion

Multi-Criterion Decision Analysis and the Getis Ord Gi* test for spatial statistical significance confirm the existence of two clusters of census tracts within New York City containing NYCHA developments that are particularly vulnerable. The two clusters of census tracts are, on average, areas that exhibit: a lower income population, higher instances of heat-related illness, higher average summer temperatures, higher instances of ozone concentration, higher instances of asthma related illnesses, and lower percentages of greenspace per census tracts. As a result, NYCHA should prioritize these clusters of census tracts for solution strategies, with particular emphasis on the twenty developments identified (10 in each cluster) that are particularly vulnerable.

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Appendix

Scope & Assumptions

This analysis was made with a limited scope and several assumptions.

This analysis is intended to identify which New York City Housing Authority (NYCHA) developments the agency should prioritize for extreme heat mitigation strategies and potential building retrofits and repairs. The analysis does not take into account other factors that may impact NYCHA's ultimate decisions for prioritization, such as building age, intensity/cost of retrofit, etc. It is assumed that the Authority's internal building-level data will guide those decisions; this analysis only identifies geographic areas where efforts should be focused.

Several assumptions are also made regarding access. Increasing service areas around Cool It! NYC features and libraries, three breaks are used: 0.25 miles, 0.5 miles, and 1.0 mile. Based on human-scale thinking, it is assumed that a person would be very willing to walk less than 0.25 miles, fairly willing to walk up to 0.5 miles, and would consider walking between 0.5 and one mile,but that this distance was undesirable. It is assumed no one would be willing to walk more than one mile for relief on a hot day, so anything more than one mile received the same score for access.

A similar assumption is made when, in performing the Getis-Ord Gi* test, a fixed-distance band of 0.5 miles (2,640 feet) is specified for the conceptualization of spatial relationship. This conceptualization is chosen because, in this analysis, a cluster is conceptualized as an area where residents living within a high-HVI census tract cannot easily access a lower-HVI census tract. Here, it is assumed that a person would walk up to 0.5 miles to access an area with lower HVI, but would not exceed that distance to access a lower-HVI neighbor.

Limitations

This analysis is limited by the aerial units for which data is available. Several indicator datasets, namely air temperature, asthma incidence, and heat hospitalizations, are only available at the Neighborhood Tabulation Areas (NTA), United Hospital Fund of New York (UHF) neighborhood, and Community District scale, all of which are relatively coarse and likely do not reflect variations present when analyzed at a more granular scale. This represents a major limitation due to the Modifiable Areal Unit Problem (MAUP), as the coarse data presentation forces the assumption that temperature, asthma incidence, and heat hospitalization are the same across larger swathes of the city. However, because the analysis includes other factors available at more granular scales (including the highest weighted factor, Median Household Income), the final HVI score will still show local variation despite the lack of granular data for all factors. Other instances of the MAUP include the following:

- Greenspace Density is operationalized as the percentage of a census tract that is covered by green space. This operationalization also highlights the environmental effects that green space provides in limiting heat capture and release. However, green spaces also provide respite, and so could have been operationalized as a location to which access is mapped.
- In the final stages of the analysis, raster scores are aggregated to the census tract level by averaging all raster cells within a tract, which reduces variation. This step was performed to facilitate spatial statistics and identify larger clusters. In order to provide data to NYCHA that is less impacted by this, HVI scores were also aggregated to NYCHA developments by averaging all raster cells within a NYCHA-owned plot.

Another limitation is the definition of "access" to Cool It! NYC Cooling features and libraries. Walking distance is the only mode of transportation considered and excludes Cool It! NYC resources located outside this radius that resident might access via air-conditioned public transport.

Appendix

Step-by-Step Methodology

Network Analysis:

1. Import "LION 21D" shapefile
2. Isolate pedestrian streets and export as Lion_PedStreets only using the following commands:
    a. Select by attributes for pedestrian access by removing non-street features (TraffDir <> ' ')
    b. Remove from selection ferries (FeatureTyp = 'F')
    c. Remove from selection paper streets (FeatureTyp = '9')
3. In ArcCatalog, create new Feature Dataset NYC_PedStreetNetwork with the following settings:
    a. Projection: NAD1983 StatePlane New York Long Isl FIPS 3104 (US Feet)
    b. No vertical coordinate, default tolerance values
4. Import Lion_PedStreets to NYC_PedStreetNetwork using all default settings
5. Create new network dataset NYC_PedStreetND within NYC_PedStreetNetwork using the following settings:
    a. NYC_PedStreets as input
    b. Model turns, global turns
    c. Default connectivity
    d. Modeling of elevation: none
    e. Specify Length as cost, remove RoadClass
    f. No travel mode, no driving directions
    g. Select option to build service area index
6. Import NYC_PedStreetND to ArcMap and make a Service Area Layer
    a. Input analysis network: NYC_PedStreetND
    b. Output layer name: CoolItNYC_ServiceArea
    c. Impedance attribute: Length
    d. Specify TRAVEL_TO
    e. Default Break Values: 1320ft, 2640ft, 5280ft

Street Tree Density:

1. Import "2015 Street Tree Census - Tree Data | NYC Open Data"
2. Create street tree event layer by plotting X, Y coordinates for each street tree using NAD 1983 Long Island State Plane projection
3. Calculate kernel density using a 250ft search radius and cell size of 20ft, with processing extent set to the extent of the TIGER census tract file and export as StreetTrees_Kernel_250feet
4. Reclassify StreetTrees_Kernel_250feet by six quantiles, with decreasing quantiles classified 1-6 (ie highest kernel density class reclassified at 6, etc.) and save as StreetTrees_Kernel_250feet_Reclass

Asthma:

1. Download and clean "Asthma Emergency Department Visits (Adults)," import to ArcMap and export as a table into geodatabase
2. Table join to UHF polygon layer to create Asthma_by_UHF shapefile
3. Rasterize Asthma_by_UHF using 20ft cell size, processing extent and snap raster to match StreetTrees_Kernel_250feet to create Asthma_byUHF_RASTER
4. Reclassify Asthma_byUHF_RASTER by six quantiles, with increasing quantiles classified 1-6 and save as Asthma_byUHF_RASTER_Reclass

Cooling Centers:

1. Import "Library" shapefile
2. Input points from "Library" as facilities to NYC_PedStreetND network
3. Solve service areas and export polygons as CoolingCenters_LibraryProxy_ServiceAreas
4. Add field "DistanceScore" to attribute table and assign values as follows:
    a. <1,320ft polygon = 1
    b. 1,320-2,640ft polygon = 2
    c. 2,640-5,280 polygon = 3
5. Rasterize CoolingCenters_LibraryProxy_ServiceAreas using 20ft cell size, processing extent and snap raster to match StreetTrees_Kernel_250feet to create CoolingCenters_LibraryProxy_ServiceAreas_RASTER
6. Reclassify so that 1=1, 2=2, 3=3, and NoData=4 and save as CoolingCenters_LibraryProxy_ServiceAreas_RASTER_Reclass

Cool It! NYC Features:

1. Import "Cool It! NYC 2020 - Cooling Sites," export as table to geodatabase
2. Create event layer by plotting X, Y coordinates for each street tree using NAD 1983 Long Island State Plane projection
3. Input points from event layer as facilities to NYC_PedStreetND network (clearing libraries from network)
4. Solve service areas and export polygons as CoolItNYC_ServiceAreas
5. Add field "DistanceScore" to attribute table and assign values as follows:
    a. <1,320ft polygon = 1
    b. 1,320-2,640ft polygon = 2
    c. 2,640-5,280 polygon = 3
6. Rasterize CoolItNYC_ServiceAreas using 20ft cell size, processing extent and snap raster to match StreetTrees_Kernel_250feet to create CoolItNYC_ServiceAreas_RASTER
7. Reclassify so that 1=1, 2=2, 3=3, and NoData=4 and save as CoolItNYC_ServiceAreas_RASTER_Reclass

Step-by-Step Methodology, cont.

Daytime Temperature:

1. Download and clean "Daytime Summer Surface Temperature," import to ArcMap and export as a table into geodatabase.
2. Table join to NTA polygon to create Daytime_temp_by_NTA shapefile
3. Rasterize Daytime_temp_by_NTA using 20ft cell size, processing extent and snap raster to match StreetTrees_Kernel_250feet to create DaytimeTemp_byNTA_RASTER
4. Reclassify DaytimeTemp_byNTA_RASTER by six quantiles, with increasing quantiles classified 1-6 and save as DaytimeTemp_byNTA_RASTER_Reclass

Green Landcover:

1. Import "Land Cover Raster Data (2017) - 6in Resolution"
2. Resample to 20ft cell size
3. Reclassify raster so that 1, 2=1 (for green space); and 3, 4, 5, 6, 7, 8=0 (for non-greenspace) and save as LandUse_Raster_Reclass
4. Use raster-to-polygon to create new polygon feature class LandUse_Polygon_RastertoPolygon with the following settings
    a. Input Raster: LandUse_Raster_Reclass
    b. Field: Value
    c. Simplify polygons: checked
    d. Create multipart features: unchecked
    e. Maximum vertices: blank
5. Select by attribute from LandUse_Polygon_RasterToPolygon for all green space (gridcode = 1) and export as new feature class GreenCover_Polygons
6. Use Overlay (Intersect) with TIGER census tract layer to split GreenCover_Polygons and export as GreenCover_Split.
7. Dissolve GreenCover_Split to create one greencover polygon per census tract and export as GreenCover_Dissolved_byCT.
8. Calculate each dissolved polygon area as SUM_Green_Area_Acres, then export data as table GreenCover_Dissolved_Table_CSV
9. Table join GreenCover_Dissolved_Table_CSV to Tiger Line Census Tracts.
10. Calculate the greenspace density as the "SUM_Green_Area_Acres"/ "acre" where "acre" is the total area of the census tract in acres, then export as Greenspace_Density_by_Tract

Heat Hospitalizations:

1. Download and clean "5-Year Heat Stress Hospitalizations," import to ArcMap and export as a table into geodatabase
2. Table join to community district polygon to create Heat_Hospitalizations_by_CD shapefile
3. Rasterize Heat_Hospitalizations_by_CD using 20ft cell size, processing extent and snap raster to match StreetTrees_Kernel_250feet to create HeatHospitalizations_byCD_RASTER

4. Reclassify HeatHospitalizations_byCD_RASTER by six quantiles, with increasing quantiles classified 1-6 and save as HeatHospitalizations_byCD_RASTER_Reclass

Income by Census Tract:

1. Download and clean "2019 ACS 5-Year Estimates," import to ArcMap and export as a table into geodatabase.
2. Table join to TIGER census tract polygon to create Income_by_CensusTract shapefile
3. Rasterize Income_by_CensusTract using 20ft cell size, processing extent and snap raster to match StreetTrees_Kernel_250feet to create Income_byCensusTract_RASTER
4. Reclassify Income_byCensusTract_RASTER into six classes by Jenks natural breaks, with decreasing classes classified 1-6 (ie highest median income class reclassified as 6, etc.) and save as Income_byCensusTract_RASTER_Reclass

Ozone:

1. Import ozone raster layer from "NYCCAS Air Pollution Rasters | NYC Open Data"
2. Resample using 20ft cell size, processing extent and snap raster to match StreetTrees_Kernel_250feet and save as Ozone_2019_Resample20x20
3. Reclassify into six quantiles, with increasing quantiles classified 1-6 and save as Ozone_2019_Resample20x20_Reclass

Final Analysis:

1. Perform map algebra using raster calculator with the following expression:

(.5 * "CoolItNYC_ServiceAreas_RASTER_Reclass") + (.5 * "CoolingCenters_LibraryProxy_ServiceAreas_RASTER_Reclass")+ (4 * "Income_byCensusTract_RASTER_Reclass")+ "Greenspace_Density_byTract_RASTER_Reclass" + "StreetTrees_Kernel_250feet_Reclass" + "DaytimeTemp_byNTA_Normalized_RASTER_Reclass" + "Ozone_2019_Resample20x20_Reclass" + "HeatHospitalizations_byCD_RASTER_Reclass" + "Asthma_byUHF_RASTER_Reclass"

2. Use zonal statistics to table:
   a. Input Feature zone: Tiger_Census_Tracts_Clipped_3
   b. Value: MCDA_Formula_5
   c. Statistics: MEAN
   d. Output: MCDA_Zonal_byCT
3. Table join MCDA_Zonal_byCT to Tiger_Census_Tracts_Clipped_3, export as MCDA_Score_byCT
4. Perform Getis-Ord Gi* test using the fixed distance band conceptualization of spatial relationship with 2640 ft cutoff

COLUMBIA GSAPP

Geographic Information Systems, 2021

Sean Chew sc4931@columbia.edu
Calvin Harrison cch2196@columbia.edu
Morgan Reuther mar2356@columbia.edu