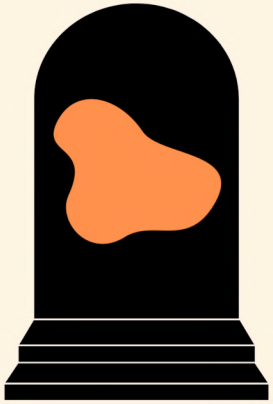

"There is a social responsibility to take care of vulnerable people" - Noam Chomsky -

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Demystifying *the* Urban Oven

on heat vulnerability in the **Bronx**, NY

Tim Yoshimura Small
COLUMBIA
GSAPP

Preface

Heat knows no mercy. **2%** of all summer month fatalities in New York City can be attributed to extreme temperatures. This is an average of **370** deaths per season over roughly the last decade[1].

Consider a bifurcated categorization of urban heat-risk factors.

There are first the physical variables of the built environment. Streams of wheeled metal rushing over conduits of asphalt and tar are to thank for a party of unwanted phenomena, most notably urban heat islands and canyons[2]. This is the *Material Realm*.

Then, there are the socioeconomic facets that render some populations more susceptible to heat illness and death than others[3], often generationally rooted in institutional racism and recurring inequities in policy-making. This is the *Anthropo-realm*.

This study aims to corroborate and add to past heat vulnerability research by bending light through the above two lenses. Through the synthesis of quantitative signals, it is theorized that higher-risk areas will emerge and inform triage for future mitigation.

The geographic scope is the **Bronx, NY**. This borough has a rich cultural history deeply marred by social oppression, careless city development and economic neglect[4]. It also has a marked variation in measured heat extremes across its twelve community districts.

Data

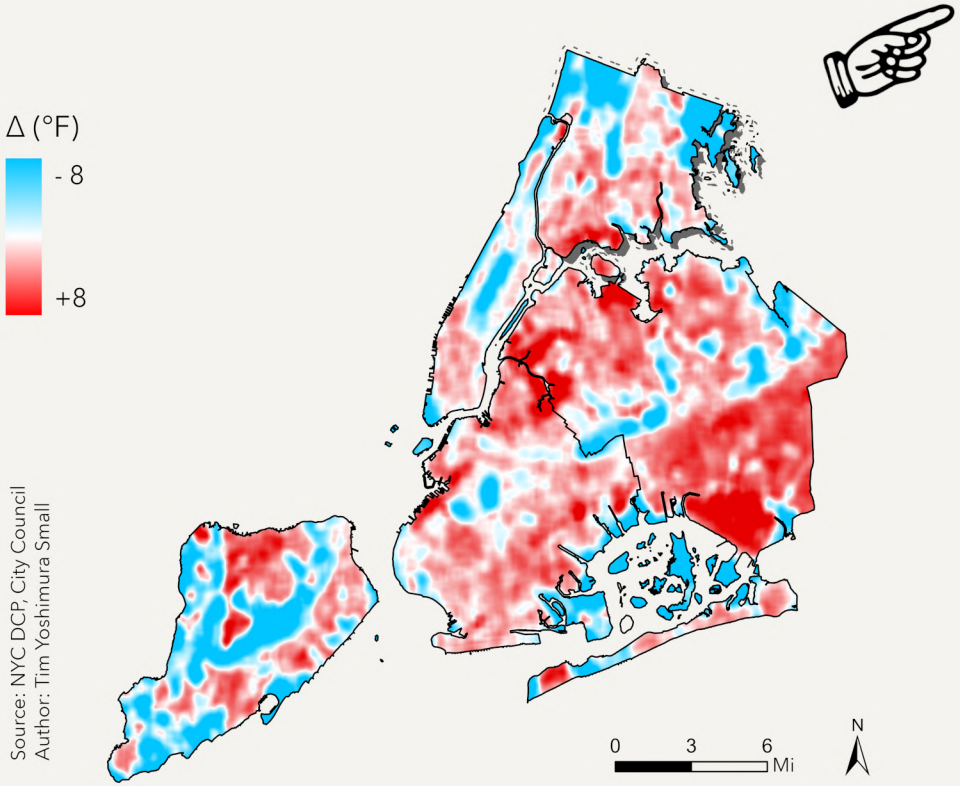
All data was obtained from the following NYC entities: City Planning (DCP), Finance (DOF), City Council, Parks (DPR), Health (DOH), Technology (OTI), and Buildings (DOB). It also drew from the US-wide ACS census populations database. The most recent year was selected across datasets (2023), with the exception of City Council (2020-22) and ACS data (2022).

Contents

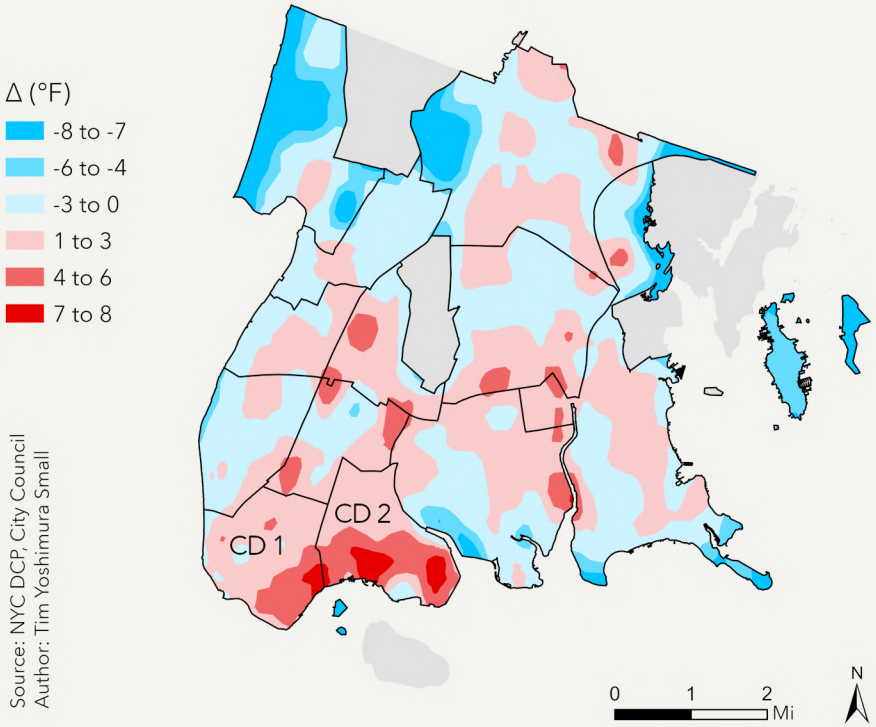
The Urban Oven

What is a *temperature anomaly*? Here, it's the average deviation from New York City's mean temperature in Fahrenheit over the summers of 2020-22 (Junes through Septembers). Unfortunately, the original dataset was transformed from °K, which would have been more standardized and baseline-agnostic.

What is *urban heat island*? UHI is a primarily night-time phenomenon that stems from heat having trouble dissipating in urban jungles. This is largely due to city materials that over-absorb solar radiation, and leads to the suppression of other natural cooling effects like the evaporation cycle.



Source: NYC DCP, City Council
Author: Tim Yoshimura Small



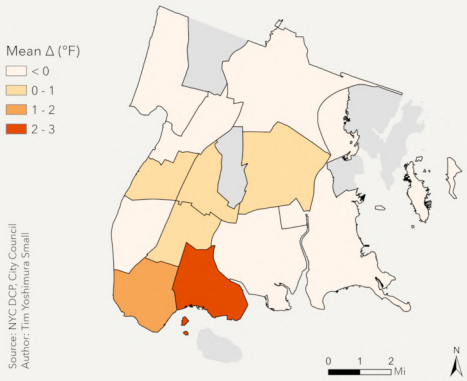
Source: NYC DCP, City Council
Author: Tim Yoshimura Small

To the left, anomalies are presented city-wide in rasterized form at an approximately 400 ft resolution. Above, a focal centering of the Bronx renders the data in vectorized form.

This study's areal units are *community districts* (CDs).

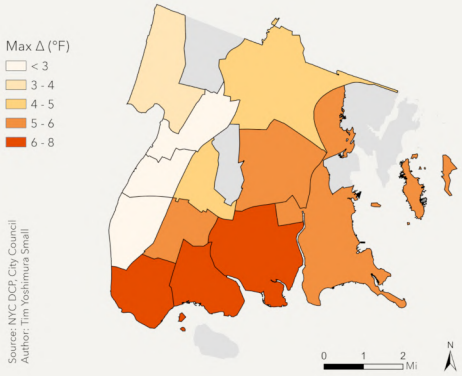
The worst of the extremes in the Bronx are clustered around Mott Haven, Port Morris and Hunts Point in the southwestern section of the borough. The grouping of community districts 1 and 2 to represent this region will be termed $\mathbf{B}^{\mathbf{SW}}$.

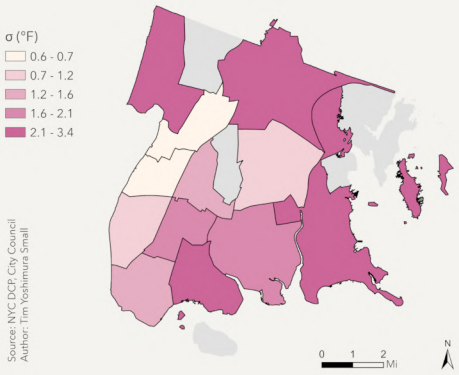
Of note is the lack of data for Rikers Island, which probably endures unbearable heat due to its location and primary infrastructural materials.



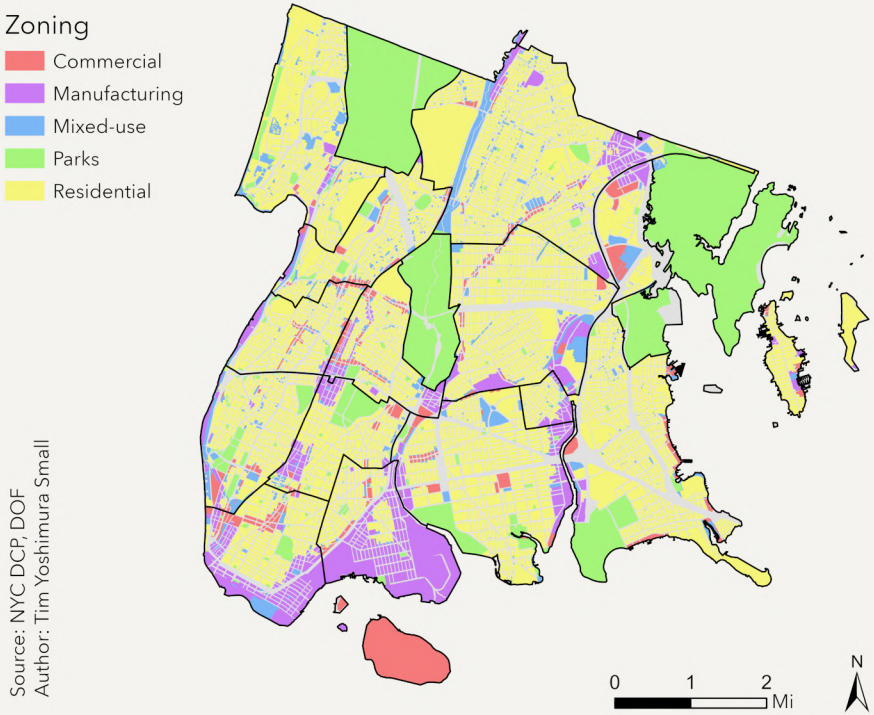
The *mean* temperature anomaly across community districts offers a collapsed look at the spatial heat distribution.

The *maximum* temperature anomaly shows how worst-case heatwaves might be distributed.





The *standard deviation* of the temperature anomaly reflects the spread in heat observations.

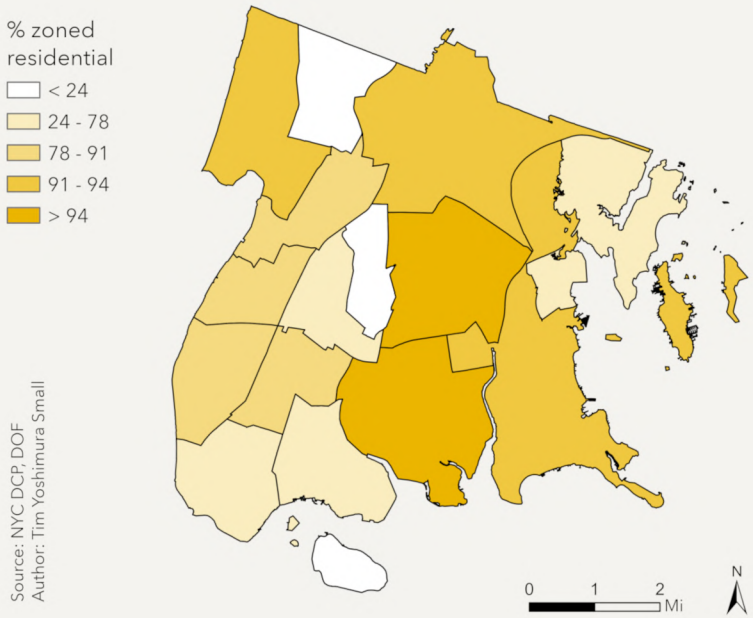


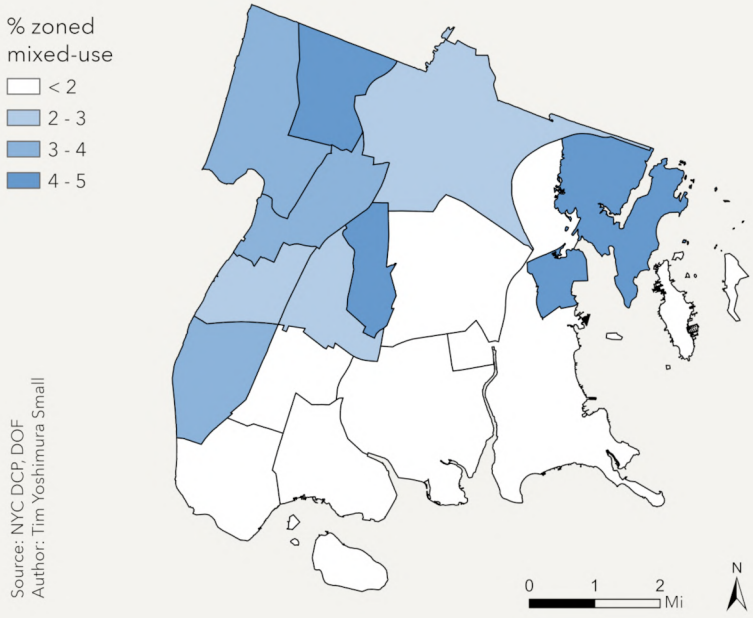
The rigid way in which land is zoned for use has resounding impacts on how we inhabit and interact with our environs. Prescribing land-use is not organic. Landscapes hold the years in their palms - we lie along only one crease.

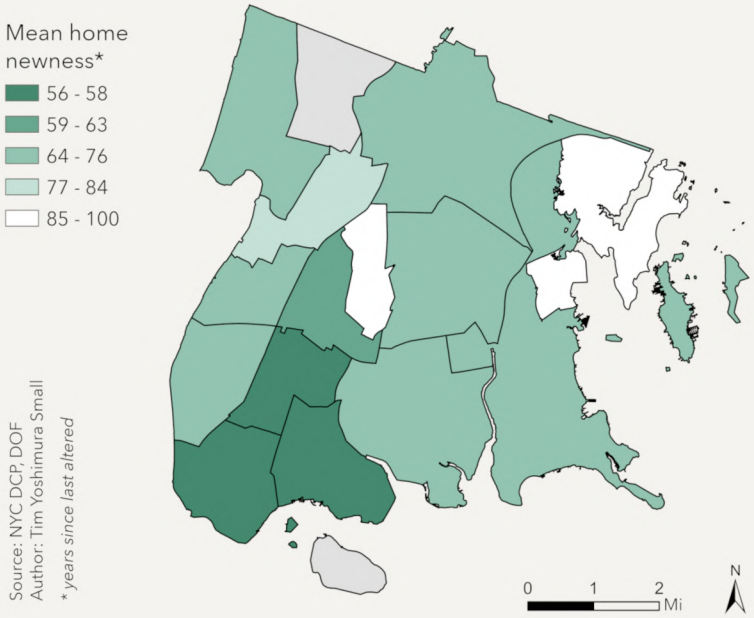
Our systems of zoning affect public health. Residential areas near parks differ from those near manufacturing zones in quality of life and access to critical city services[5].

Referring to the above map, B^{SW} sits in the cradle of the borough's largest manufacturing district (see centerfold). A proximity of industrial areas to residential blocks not only concentrates temperature extremes, but often results in pernicious health hazards like pollutant aerosols.

Landscape Hermeneutics







It is interesting how stratified the already meager mixed-use zoning is across the Bronx - all but absent in fact, in that east-west band in the lower third of the borough (bottom left).

The home newness map above shows that even across the upper percentile of community districts, residences have experienced an average **55** year alteration drought. In some cases, this number approaches three quarters of a century.

This variable will be considered a proxy for the energy efficiency and resilient effectiveness of a home's physical materials, and therefore the quality of its ability to dispel heat.


The dominoes of defeated asphalt smoked like incense, the taste of burning rooftar a
pyramid separating the industrial from the living.
suspension
ONE WAY
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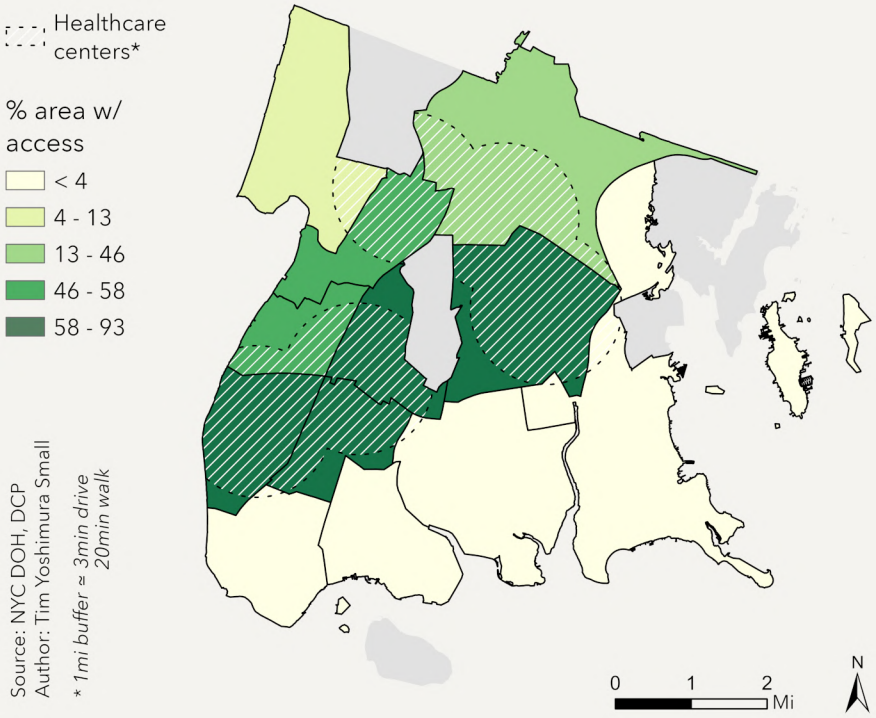


Source: NYC DOH, DCP
Author: Tim Yoshimura Small
** 1mi buffer ≈ 3min drive 20min walk*

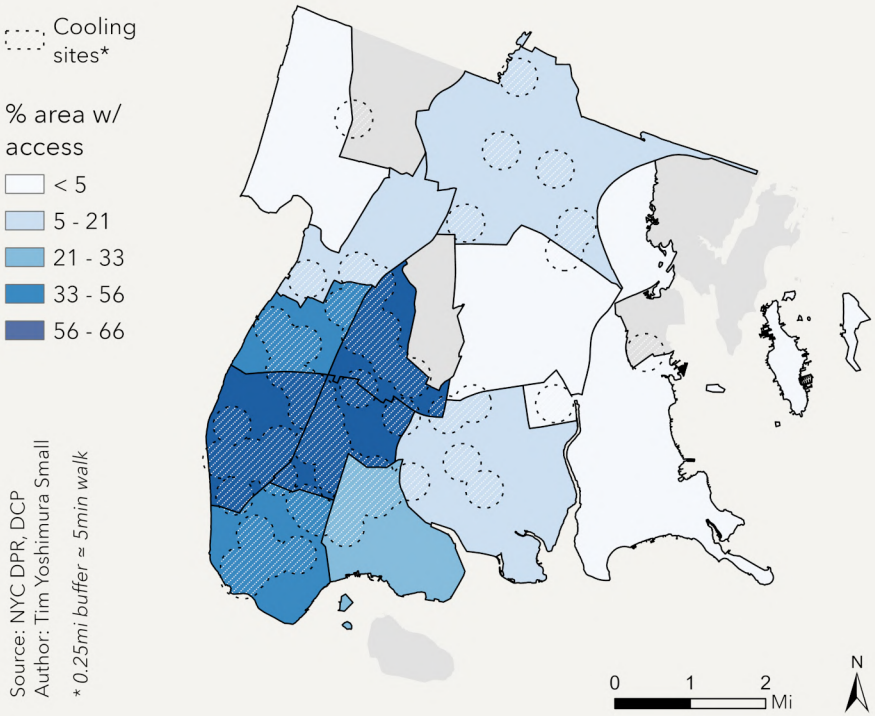
The above map shows the distribution of healthcare centers across the Bronx. These are defined in the DOH dataset as acute care facilities, so the collection may differ from a full set of health-related entities in the borough.

Areal access is defined by creating one mile buffers around each facility to emulate a 3 minute drive or 20 minute walk. The relative area of buffers that overlaps with each community district is then calculated.

Below is the distribution of cooling sites, which includes drinking fountains, spray showers, and misting stations.

Areal access is defined by creating quarter mile buffers around each site to emulate a 5 minute walk.

Note the overlaps and differences in spatial distributions between healthcare and cooling access among community districts, especially in the B^{SW} region.

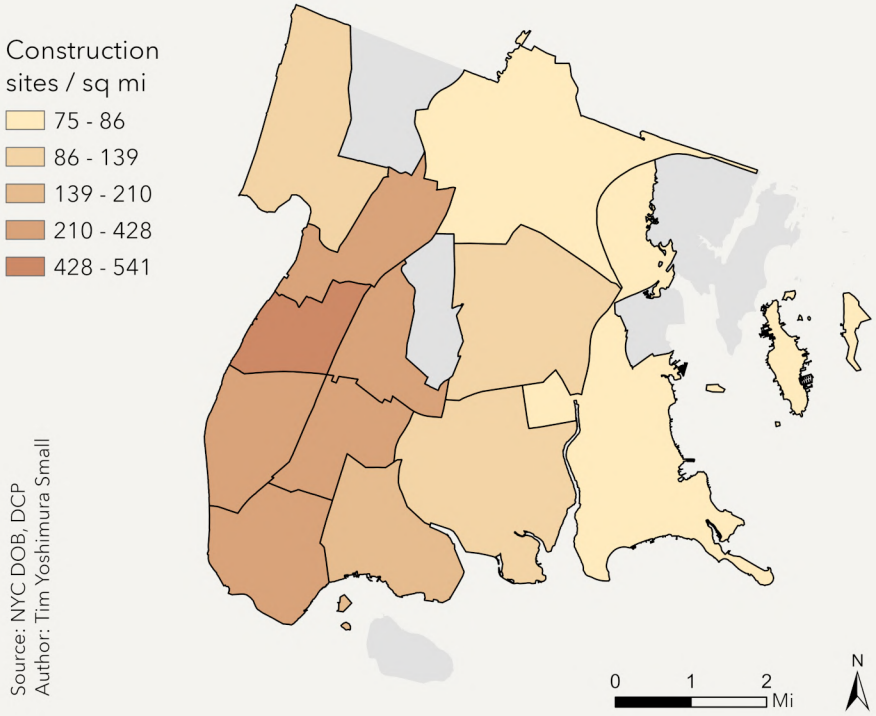


Source: NYC DPR, DCP
Author: Tim Yoshimura Small
** 0.25mi buffer ≈ 5min walk*

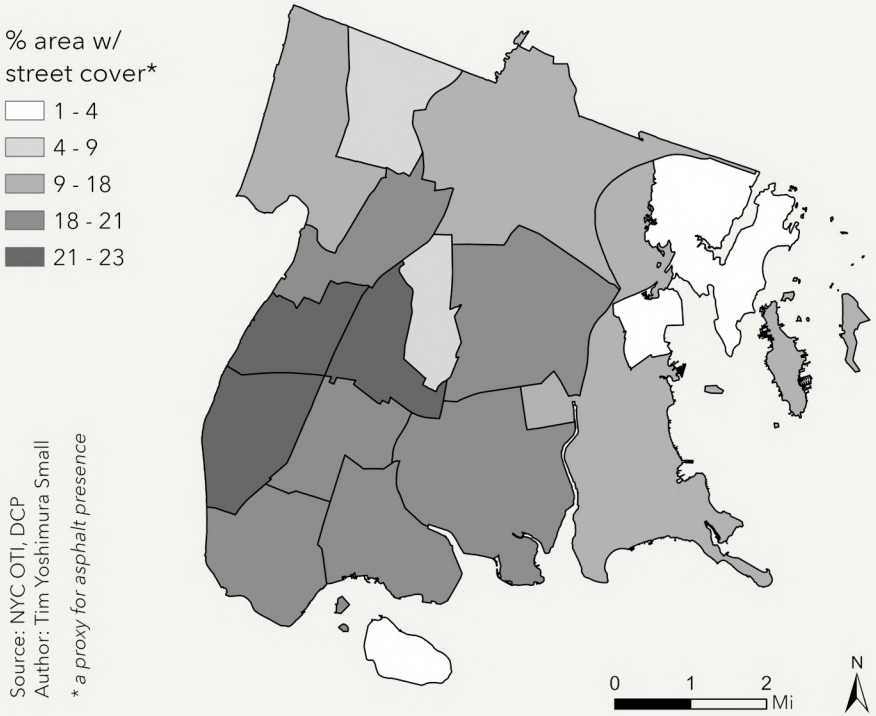
The below map of construction site density can be considered a proxy for the rate of modernization.

The top right map shows the percentage of land area that comprises streets. Street lines are clipped to community district borders and multiplied by respective widths to obtain areal cover. This represents asphalt concentration and by association, relative UHI susceptibility.

The Bronx Expressway casts a literal and figurative shadow on this map. A legacy of inequity relevant nearly 70 years later.



Source: NYC DOB, DCP
Author: Tim Yoshimura Small

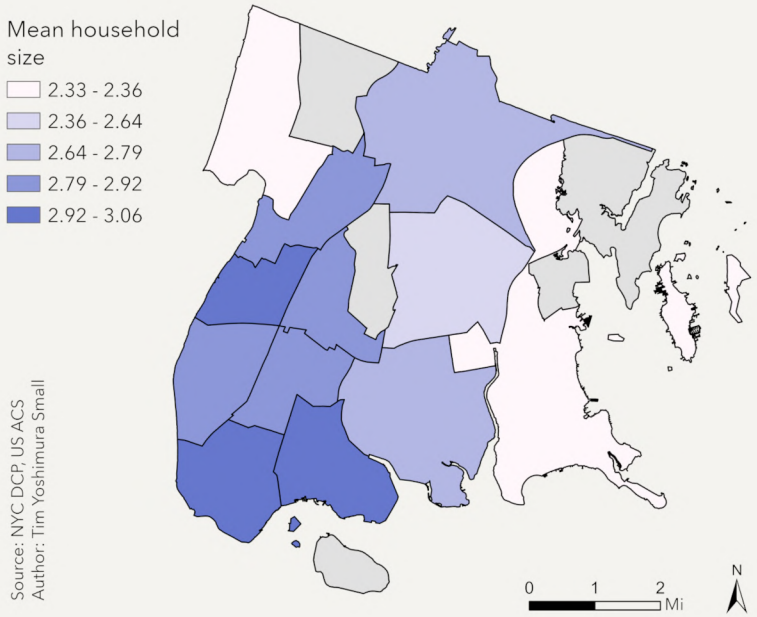


Source: NYC OTI, DCP
Author: Tim Yoshimura Small
** a proxy for asphalt presence*

The next pages show seven socioeconomic distributions across the Bronx. These are selected as a (conjectural) heat-focused subset of the typical social vulnerability indices[6]. Percentages are of total community district populations.

Children and the elderly who are especially sensitive to heat are defined using rough age cutoffs of 10 and 65 respectively.

Note that B^{SW} has lower relative incomes, higher concentrations of minority populations (especially Hispanic), larger families, and more children.


Mean household size
2.33 - 2.36
2.36 - 2.64
2.64 - 2.79
2.79 - 2.92
2.92 - 3.06
Source: NYC DCP, US ACS
Author: Tim Yoshimura Small
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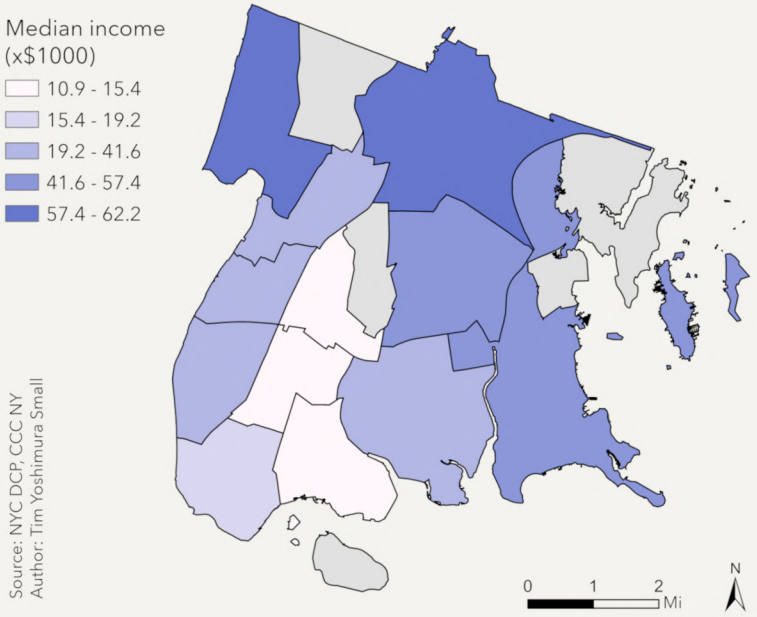
Median income (x$1000)
10.9 - 15.4
15.4 - 19.2
19.2 - 41.6
41.6 - 57.4
57.4 - 62.2
Source: NYC DCP, CCC NY
Author: Tim Yoshimura Small
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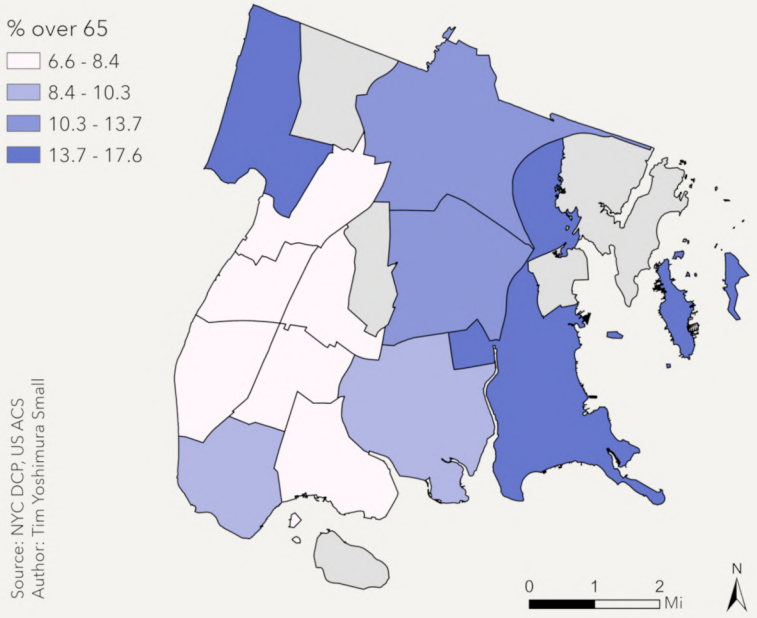
% over 65
6.6 - 8.4
8.4 - 10.3
10.3 - 13.7
13.7 - 17.6
Source: NYC DCP, US ACS
Author: Tim Yoshimura Small
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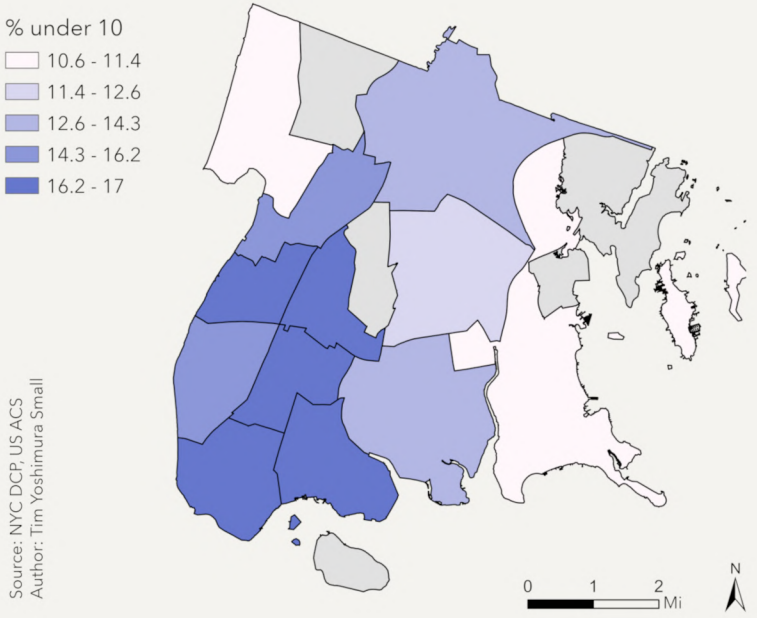
% under 10
10.6 - 11.4
11.4 - 12.6
12.6 - 14.3
14.3 - 16.2
16.2 - 17
Source: NYC DCP, US ACS
Author: Tim Yoshimura Small
0 1 2 Mi
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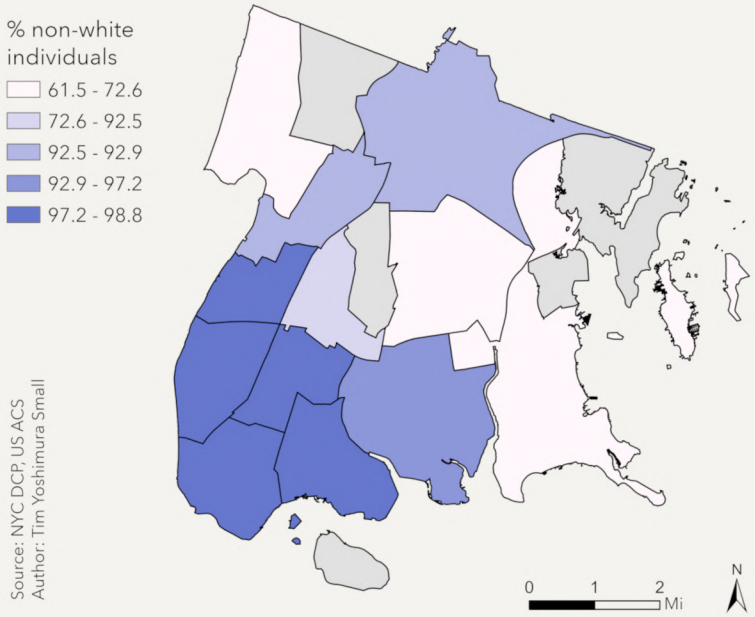
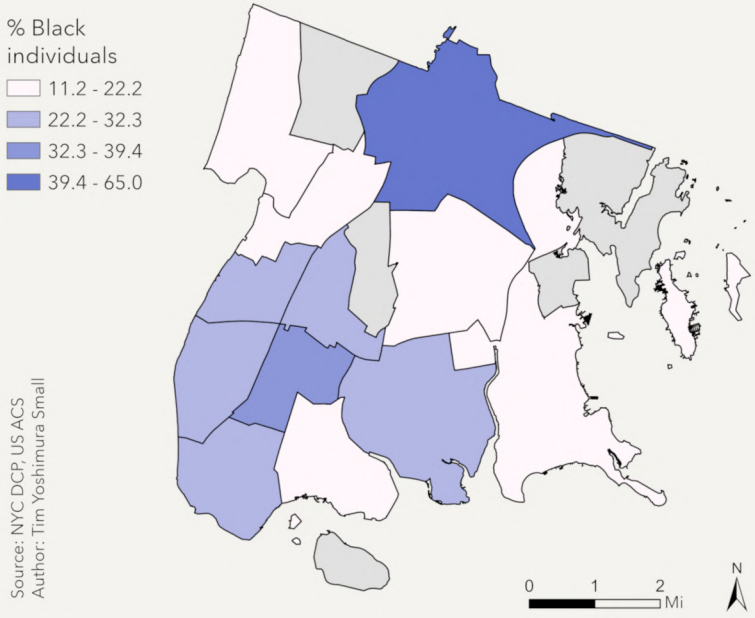
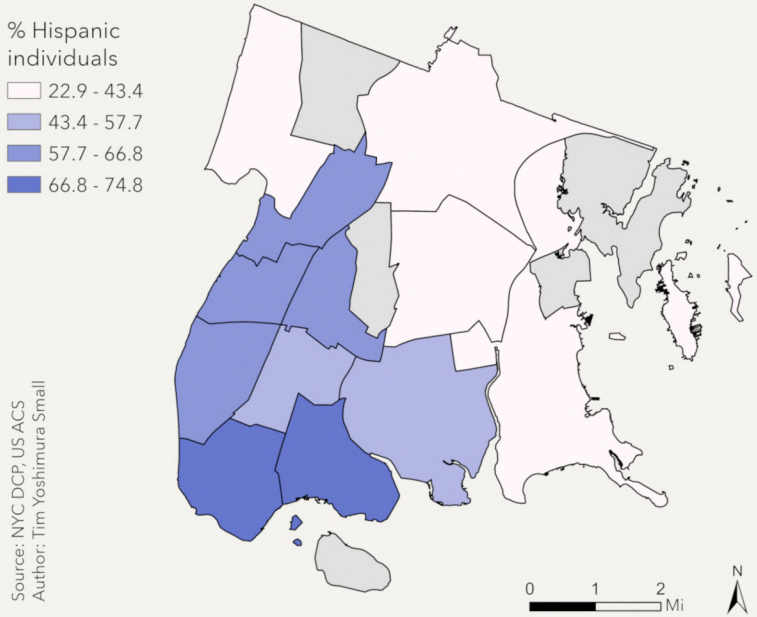






Among much of the expected spatial patterning in these demographic maps, one outlier stands out.

The Bronx-wide distribution of Black and Hispanic populations are almost mirror images of one another, making the naively aggregated "minorities" category perilous.

This will be revisited.

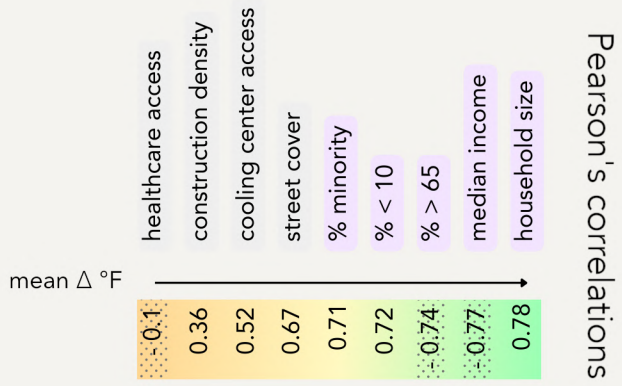
The next page contains correlation coefficient tables summarizing the relationships between the material and anthropo-realms, as well as their ties to the measured 2020-22 heat anomalies.

Numero-diptychs

	construction density	street cover	cooling center access	healthcare access
% minority	0.62	0.73	0.75	- 0.2
household size	0.71	0.83	0.76	- 0.26
% > 65	- 0.77	- 0.86	- 0.8	0.35
% < 10	0.81	0.81	0.87	- 0.32
median income	- 0.62	- 0.58	- 0.74	0.03

Pearson's correlations

Healthcare access is the only weak link (above table). Correlations are strong between all other variable pairs. Hatching is an indication of negative correlation.



The above quantifies the strength of the relationships between all of the predictive measures and the mean temperature anomaly across community districts.

Many of the indicator variables correlate strongly with the heat anomaly data, particularly the socioeconomic ones, which dominate overall.

Street cover as a proxy for asphalt density is the strongest contender in the material realm. The other physical variables suffer from sample size limitations to varying degrees.

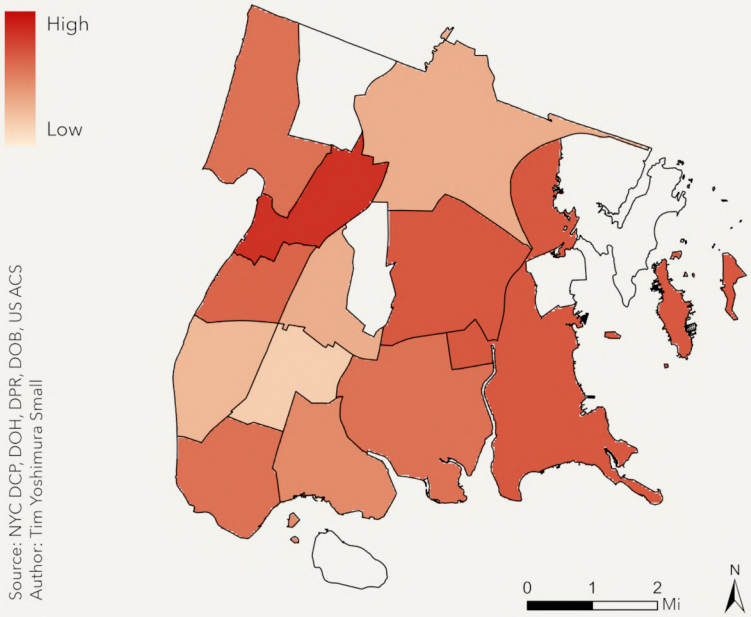
A final aggregation of variables in the form of weighted overlays is on the next two pages.

The weights used in the multiple-criteria decision analysis are taken from a normalized set of the relative correlation strengths from the bottom left diagram on this page.

Physical heat vulnerability is an overlay of material variables: access to cooling centers and healthcare facilities, the areal density of construction sites, and street cover.

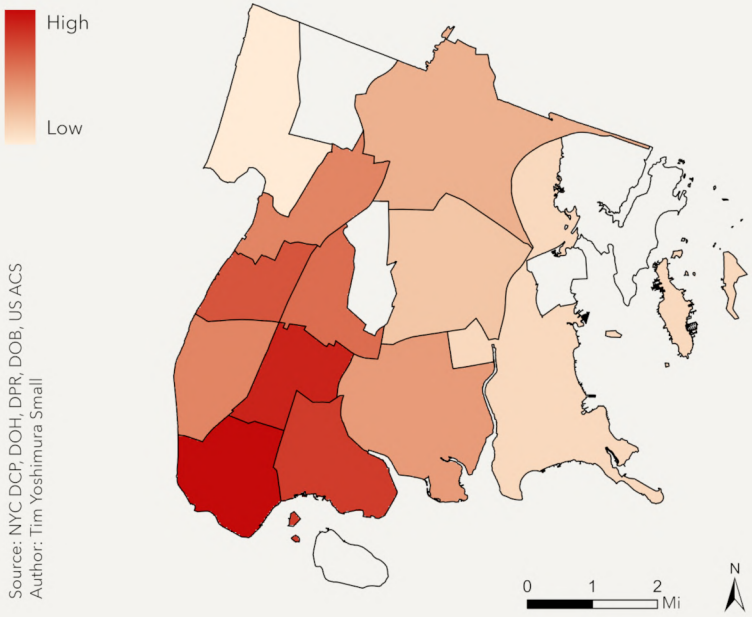
Socioeconomic heat vulnerability is an overlay of anthropo-variables: proportions of seniors and children, proportions of Hispanic and Black individuals, median income, and household size.

Physical Heat Vulnerability



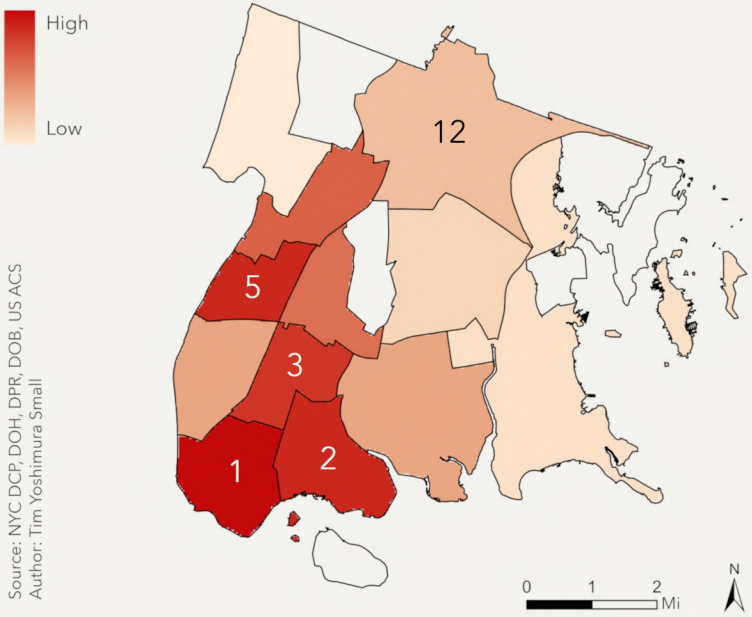
Source: NYC DCP, DOH, DPR, DOB, US ACS
Author: Tim Yoshimura Small

Socioeconomic Heat Vulnerability



Source: NYC DCP, DOH, DPR, DOB, US ACS
Author: Tim Yoshimura Small

Unified Heat Vulnerability



Source: NYC DCP, DOH, DPR, DOB, US ACS
Author: Tim Yoshimura Small

Unified heat vulnerability combines all of the physical and socioeconomic heat indices to generate a blended score.

Community districts 1, 2, 3 and 5 are most exposed to heat according to this analysis (top right). Of these, the B^{SW} region (CDs 1, 2) is one of the most prominent.

The heat vulnerability index[7] proposed by NYC Health and Columbia University in 2020 mostly supports these results despite using different indicator variables. One notable divergence is in community district 12, housing the largest population of Black individuals in the Bronx.

My methods fail to consider the anomalous character of that community, resulting in an artificially low assignment of risk. This is a clear study limitation.

Given that the B^{SW} region persists in its high level of heat-risk while having one of the higher concentrations of cooling sites (pg. 12), the exploration of alternative mitigation avenues is vital.

The ineffectiveness of this particular set of cooling sites can in large part be attributed to a failure to consider stigmatization and transportation access[8]. There is also the limitation that emergency cooling *centers* like libraries and community centers are not present in the dataset.

If a persistent list of cooling *centers* was made available, it would be worth rerunning the correlations and weighted overlays. Due to the recent library budget cut, shelter on Sundays at NYPL locations will be no more. A time-series investigating the effects of this would be eye-opening.

The unhoused and people living within informal economic frameworks face a particularly uphill battle. Often, formal aid systems are not an option for such individuals due to a lack of documentation and the dark cloud that is ICE. Fortunately, New York City is the largest sanctuary city in the country.

Leaning into informality then, temporarily repurposing green spaces embedded in B^{SW}'s neighborhoods as cooling centers with canopies, water coolers, and portable AC units could provide an emergency solution with fewer barriers to participation. Of course, this would likely require volunteers.

Formally, an immediate start could be to subsidize AC costs[9] for all housed individuals and families in the B^{SW} area.

In recent summers, the utilities cost-burden has become an impediment to many[10]. Nobody should have to choose between starvation and heat illness.

As we continue to search for solutions, we need to collectively remember that shelter from extreme heat is a human right.

Where...

To?

Sources

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