POLICY BRIEF

Inequality, Urban Heat Islands, and Crime

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October 2023

Rockefeller Institute of Government
SUNY

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INEQUALITY, URBAN HEAT ISLANDS, AND CRIME

Introduction[1]

The consequences of climate change and environmental degradation will have inordinate effects on cities.[2] Urban areas are likely to see a range of social, public, and environmental impacts, including, but not limited to, human migration and displacement, cultural disruptions, and urban flooding.[3] This is in addition to the heightened temperatures that cities are subject to, compared to surrounding areas, due to urban heat island (UHI) effects. As we brace for the generally hotter conditions associated with climate change, it’s important to prepare for the social dimensions of their impacts. While past research has documented relationships between environmental and social conditions, including associations between heat and violence, advances in temperature modeling and geographic information systems (GIS) allow for deeper investigation into those relationships on more local scales. This can enable sub-municipal analysis of where heat is likely to impact social outcomes, like crime. In other words, to identify literal hotspots.

Urban heat islands are associated with the built environment conditions that cause cities to warm at a greater rate than surrounding regions; those physical conditions are undergirded by historical, political, and socioeconomic contexts, which have caused UHIs to come into existence. Social inequality has placed marginalized communities, targeted for 'development' and 'renewal,' at greater socioeconomic and environmental vulnerability, including extreme heat. This context is vital to foreground, as to exclude it would be to decouple the political, economic, and historic record from this analysis, and aid shallow and cynical attempts that conflate race and ethnicity—perhaps using the cloak of economics or geography—with a propensity for criminality.

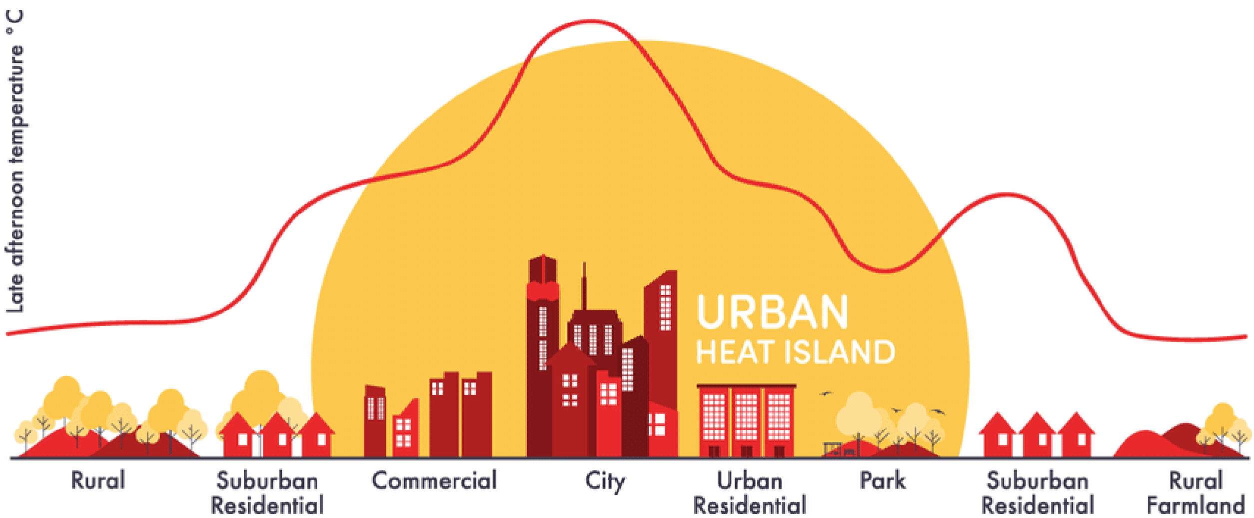
This policy brief begins by providing an overview of urban heat islands—the temperature differences experienced between urban vs. suburban and rural areas as a consequence of the built environment. Within the context of extreme temperatures that urbanites face, it then considers the links between extreme heat, environmental inequality, and crime using advances in temperature modeling techniques and GIS to examine these associations at the sub-municipal scale.

UHIs and Climate Change

Urban heat islands occur, according to the National Integrated Heat Health Information System (NIHHIS), because "cities tend to get much warmer than their surrounding rural landscapes" largely due to the density of "unshaded roads and buildings [that] gain heat during the day and radiate that heat into the surrounding air."[4] For example, when a weather forecast indicates local temperature to be 90˚F, UHIs can be substantially hotter—daytime temperatures can regularly be 15–20˚F warmer than in outlying areas with vegetation.[5] While there is no universally accepted definition of a heat wave, a sustained period of ≥90˚F days is a commonly accepted metric. Consider that only a few degrees increase in temperature can prolong periods of extreme heat and heat waves (i.e., pushing neighborhood temperatures above the 90˚F threshold, mentioned above). Equally ominous is the intensifying of nighttime temperatures, which can rise to 22˚F greater in UHIs than nearby rural communities, as buildings and urban surfaces retain and slowly release daytime heat. This heightens the potential for human morbidity and mortality as typical relief from heat associated with nighttime cooling doesn't occur and communities remain artificially warmer.[6]

Rising temperatures are one of the most acute consequences of climate change. Both the frequency of heat waves and the duration of heat wave season (i.e., the number of days between a season's first and last heat wave) have generally increased in the US's 50 largest cities since the early 1960s;[7] these cities, which faced an average of two heat waves per year in the 1960s, would see six on average by the 2010s, while the length of heat wave seasons has climbed from an average of 22 days to over 68 days.[8] Climate projections reveal that temperatures in urban areas may increase up to two times as much as the warming generally associated with climate change.[9] Because population densities and heat-trapping infrastructure within these areas are not uniformly distributed, projected temperature increases won't be evenly experienced and will disproportionately impact some areas, further exacerbating the impacts of UHIs.[10]

FIGURE 1. Urban Heat island Temperatures Across Land-Use Types



SOURCE: "Urban heat island," World Meteorological Organization, 2020, courtesy of Kamyar Fuladlu, https://community.wmo.int/en/activity-areas/urban/urban-heat-island.

While the NIHHIS definition above recognizes that urbanized areas are warmer than other parts of the surrounding region, it does not capture that this warming is not uniform and that heat isn't evenly dispersed within municipal boundaries. That is, like other local weather conditions, such as wind and precipitation, temperature can vary considerably within a relatively confined geographical area. There is considerable temperature variation within urban heat islands, much of which is influenced by the prevalence of streets, trees, and vegetation, and other land-use patterns. A recent US Forest Service-sponsored study demonstrated UHI-related air temperature differences in excess of 10°C (≥20°F) within Syracuse, New York, neighborhoods containing and adjacent to interstates.[11] This includes Interstate 81—the main thoroughfare through the city—which is dominantly sited in a succession of predominantly Black neighborhoods.[12]

The Roots and Consequences of Urban Heat Inequality

As referenced above, urban heat islands are largely a consequence of urban development and land use patterns that have resulted in areas with sparse tree cover and limited greenspace and vegetation. Impervious surfaces (including streets and highways, sidewalks, and buildings) that retain high levels of heat, in large part due to greater absorption of solar energy, are ubiquitous in cities.[13]

Environmental justice communities, those neighborhoods with majority person of color populations and higher poverty levels, are unequally exposed to heightened environmental threats.[14] That these neighborhoods are disproportionately impacted by UHIs is a consequence of historical urban planning policies, such as redlining and interstate siting, that have concentrated heat-trapping infrastructure within environmental justice communities.[15]

Beginning in the 1930s, the Home Owners Loan Corporation (HOLC), sponsored by the federal government under the New Deal, enacted a practice, which would come to be known as redlining.[16] This practice involved using overtly racist language and criteria (e.g., classifying ethnic groups as infiltrating populations and appraisement of community investment based on area demographics) to evaluate neighborhoods within urban areas across the US to determine where banks should issue mortgages and otherwise invest, ultimately codifying and amplifying residential segregation.[17] Black neighborhoods, which were shaded red on federal maps (denoting HOLC's designation of high risk investment areas) today suffer from a range of consequences, including fewer trees, less green space, and more impermeable infrastructure, resulting in higher temperatures than other neighborhoods.[18] Structural inequality, resulting in high concentrations of poverty within many of these neighborhoods, leave them less resourced to combat the negative effects induced by those higher temperatures and other environmental threats.

Interstate siting in the 1950s and 1960s disproportionately placed highways in neighborhoods of color and were especially prolific in bisecting, displacing, and gutting Black neighborhoods in cities across the nation.[19] Unsurprisingly, many of the neighborhoods targeted for highway construction were those same communities that HOLC deemed unworthy of investment in the 1930s and 1940s. Recent research has found that neighborhoods with highways are more vulnerable to temperature extremes associated with the UHI effect.[20] Because the siting of highways and interstates (as well as buildings and other infrastructure, such as civic centers) have disproportionately been placed in Black communities, these communities have inordinately suffered associated environmental harms, including impacts from UHIs.

Public health and medical experts have long understood that the health of a community is more than its sum of morbidity and mortality statistics. The US Department of Health and Human Services defines social determinants of health (SDOH) as "the conditions in the environments where people are born, live, learn, work, play, worship, and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks."[21] Racism, discrimination, disinvestment, and economic inequality are critical social determinants of health that shape the uneven and layered environmental health impacts communities experience.[22, 23] Heat-related mortality climbs at an accelerating rate the more temperatures increase in UHIs.[24] A recent 10-year study showed that heat-related emergency room hospitalizations rose most significantly for African Americans, increasing by 67 percent (compared to 27 percent for white Americans, just over 50 percent for Asian Americans, and 63 percent for those that identified as Latino/a).[25] Exposures to excessive heat—which annually leads to over a thousand heat-related deaths and many more hospitalizations in the US alone[26]—are likely to compound disparities associated with the legacies of environmental racism (the heightened and targeted exposure of minoritized populations to environmental hazards) by threatening not just health, but environmental, material, and economic resources to mitigate heat within communities, as the nation and planet warms. For example, evidence shows that within UHIs, each degree Celsius increase in temperature corresponds to an increase in electricity demand by as much as 8.5 percent.[27] Further research is needed regarding the direct relationship and correlation between degree increase and consequent human health, ecological, and economic impacts.

The combined economic, environmental, and public health legacies of twentieth-century urban planning policies thereby inform a heat inequality paradox, i.e., that Black and low-income communities, made artificially warmer as a consequence of twentieth-century environmental racism, are further exposed to high temperature-related public health vulnerability, economic burdens associated with cooling costs, and wider threats to local ecosystems, while having less capacity to address those conditions due to systemic inequality. Black urbanites are at inordinate risk to these pressures and consequently suffer more acute health and livelihood challenges.[28]

From a public policy perspective, the planned deconstruction of highways in cities across the US in recent years presents a unique opportunity to address these disproportionate temperatures and their impacts if redevelopment is mindful of past injustices and emphasizes replacing heat trapping impervious surfaces like interstates with trees and vegetation.[29] Cities like Syracuse, New York, with its planned razing of its I-81 viaduct, which hovers over Pioneer Homes, New York State's oldest public housing complex, have the potential to be at the vanguard of this change.

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Existing Research on Heat and Crime

Research has, for some time, explored the relationships between environmental conditions and criminality.[30] These efforts have used an assortment of approaches including spatial, statistical, and temporal analysis, which seek to illuminate the relationships between local environmental conditions (e.g., weather, temperature, and environmental attributes, such as the prevalence and type of tree canopy) and violence. Analysis has also explored how residents perceive local environments and the environment's capacity to act as a setting for, or aid in, the facilitation of crime.[31, 32] Past studies have produced a range of findings, including associations between heightened tree density (and size of canopy) and lower occurrences of homicide and crime rates generally.[33] Further research has reflected that the prevalence of trees in public right-of-ways are associated with lower crime rates, while the relationship of crime to trees located on private property is not as clear.[34]

Findings within the literature directly looking at heat and crime generally support environmental-behavioral linkages between temperature and crime, however, causal pathways remain largely undetermined. Though widespread across the literature, the temperature/crime association within studies is not universal, with outcomes diverging based on the type of crime. For example, increases in temperature and seasonal weather variations may be associated with certain crimes (assault and theft), while showing no significant difference in another area (fraud).[35] Socioeconomic factors, including neighborhood income levels and structural factors (housing age and greenspace), are also noted to influence outcomes within the heat-crime nexus.[36] It's important to consider a range of factors as potential co-influences and root causes of crime, along with temperature and heat. Theoretically, a desert may have brutal temperatures, but not contain population levels high enough that would allow for any (meaningful) analysis assessing a heat-crime nexus. We've seen, particularly in US cities, urban forests made expendable, through the felling of trees, which have immense cooling properties, to accommodate high population levels. Similarly, while crime is intuitively influenced by population levels, blanket associations between crime rates and population density are contested and incomplete—an exhaustive New York State-based analysis has reflected as much.[37] What is clear, however, is that heat and crime analysis are not, respectively, environmental or social issues; the two are intertwined.

With respect to scale, recent heat-crime research has looked at a cross-section of geographies, mostly focusing on singular contiguous areas, including Los Angeles[38] and New South Wales.[39] Nevertheless, the evaluation of a wide array of municipalities is not unprecedented, including one effort looking at over two dozen US cities, though it did not feature intracity temperature analysis.[40] It should be noted that most of these studies aren't looking specifically at the impacts of urban heat islands, particularly on the neighborhood scale. Crimes evaluated across studies have varied and used assorted methodologies to ascertain links between said crimes and heat implications. The New South Wales study[41] evaluated three types of crime: theft, assault, and fraud. The multicity US study, noted above,[42] evaluated three classes of crime: homicide, robbery, and aggravated assault. And the Los Angeles study[43] considered a wider range of crimes using violent, property, and domestic crime designations, as well as looking at daytime/nighttime differences, along with a range of other environmental factors (precipitation, air pollution levels, traffic) across income levels. Overall, findings from the studies were mixed, and concluded that seasonal variations between temperature and crime exist (e.g., warmer winters and spikes in robbery)[44] and that there's an upward slope in robbery and homicide during upward shifts in temperature.[45] The multicity analysis reflected that crime rates increased by 1.9 percent during days where the maximum temperature exceeded 90˚F.[46] Unsurprisingly, at least one study showed a more complex relationship between heat and crime. While assaults rose with temperatures in excess of 30˚C, the rate of increase for assaults and overall theft rates dropped in temperatures in excess of 30˚C, while no apparent relationship between temperature and fraud existed.

Regarding heat and crime, previous efforts have largely looked at singular municipalities or regions that treat heat (and to a degree crime) uniformly across an urban area. That is, efforts generally haven't looked at the heterogeneous nature of temperature across the city on a given day and especially on high-temperature days within UHIs.

This distinction is imperative for both research and policy implications. Understanding relationships within the precise conditions in which they unfold allows for not only clearer analysis but policy responses that can directly address the uneven conditions in which heat and crime may operate within.

While, historically, research looking at heat and crime doesn't reflect the uneven spread of urban heat within cities, improved modeling of temperature allows for analysis well beyond isolated weather stations and enables accurate analysis at the scale of meters or yards, well below the regional or even municipal thresholds. Evaluating the relationships between extreme heat and crime at sub-municipal scales is important to understand the complexity of viewing them in concert. Just as incidences of crime or gun violence are not geographically uniform, we need to apply that same lens to heat and how extreme heat (at least two to three consecutive days of ≥90˚F)[47] may impact and intensify where violence occurs within small geographies. If there are causal relationships between extreme heat and crime, then understanding the geographic components is essential for public safety purposes and related policy efforts that work to mitigate the impacts of both extreme heat and violence.

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New Research and Policy Avenues

A critical challenge to better understanding the relationship between heat and crime in much of the existing literature are the geographic limitations of the analysis, with much of the prior work being case study based and limited to single cities. Just as sophisticated local analysis of temperature hotspots can inform policy interventions that are catered to areas impacted by extreme temperatures (whether it be cooling centers, hazard alerts, or targeted hydration efforts), policy can also be reflective of the nuanced conditions in which heat and crime overlap to promote safety for residents and neighborhoods that are impacted by both. Recent advances in UHI mapping, using readily assessable research tools, including i-Tree Cool Air—which models the impacts of trees/vegetation on air temperatures—allows for high-resolution, national-scale maps to be produced with sophisticated neighborhood-level analysis of heat variability. Sub-municipal evaluation can better inform potential causal relationships than broader geographic analysis affords, as nongranular analysis obscures where heat and violence are most intense.

As the impacts of climate change are increasingly and conspicuously experienced (e.g., historically unprecedented global land temperatures, ocean warming, and large-scale wildfires),[48] understanding how evolving environmental conditions will impose socioeconomic and public health impacts is critical for addressing consequent health and safety concerns and disparities. This includes concerns directly related to societal violence. Given long intractable violence, the wide availability of firearms, and the proliferation of mass shootings in the US,[49] understanding heat/crime relationships and potentially causal forces is critical, particularly in a society that hasn't, legislatively, shown an appetite to adopt and enact meaningful gun control and safety control measures. While heat policy is no substitute for broader action that addresses the drivers of socioeconomic inequality or gun violence, by addressing the most brutal impacts of UHIs, the spillover impacts are likely to not be contained to the realms of public health, but also make positive impacts in the social dimensions, including crime.

Emerging mapping technologies utilized in this research have enabled us to take an initial look at the variability of heat and violent crime in UHIs across a handful of cities on the East Coast of the United States.[50] Complimenting broader work looking at urban heat islands, ecosystem services, and public health, the research engages in an analysis of urban heat on a sub-municipal/neighborhood scale, mapping disparities in four moderate-sized (less than one million population) US cities: Atlanta (GA), Charlotte (NC), Rochester (NY), and Syracuse (NY). These locations were chosen due to the understudied nature of each within the context of urban heat. To evaluate the relationship in these cities between urban heat islands and violent crime at the neighborhood level, temperature maps were developed using national data processed from i-Tree Cool Air.[51] For the crime data, the project used data from the FBI's Uniform Crime Reporting (UCR) Program.[52]

FIGURE 2. Part 1: Offenses and UHI—Atlanta

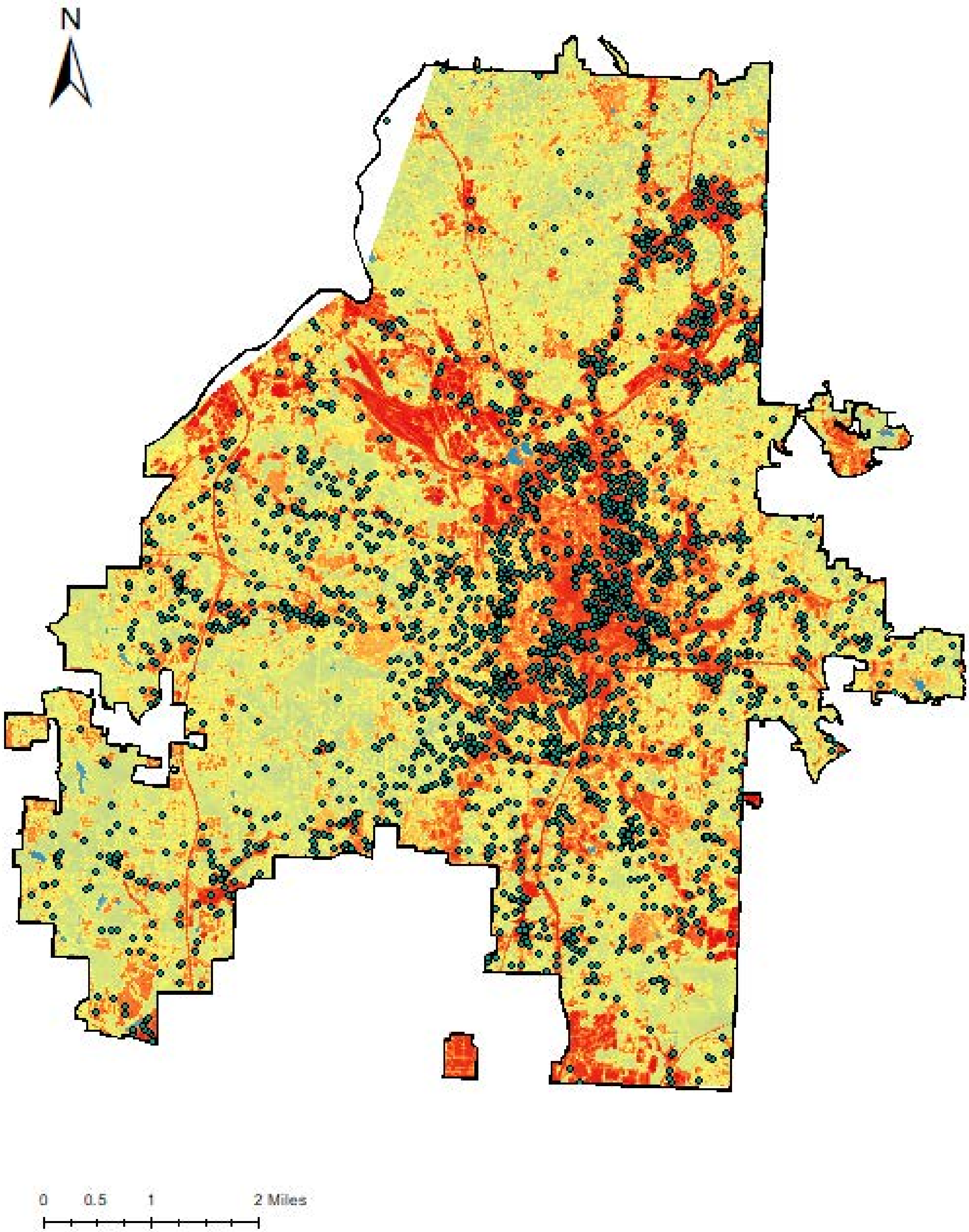


FIGURE 3. Part I: Offenses and UHI—Charlotte

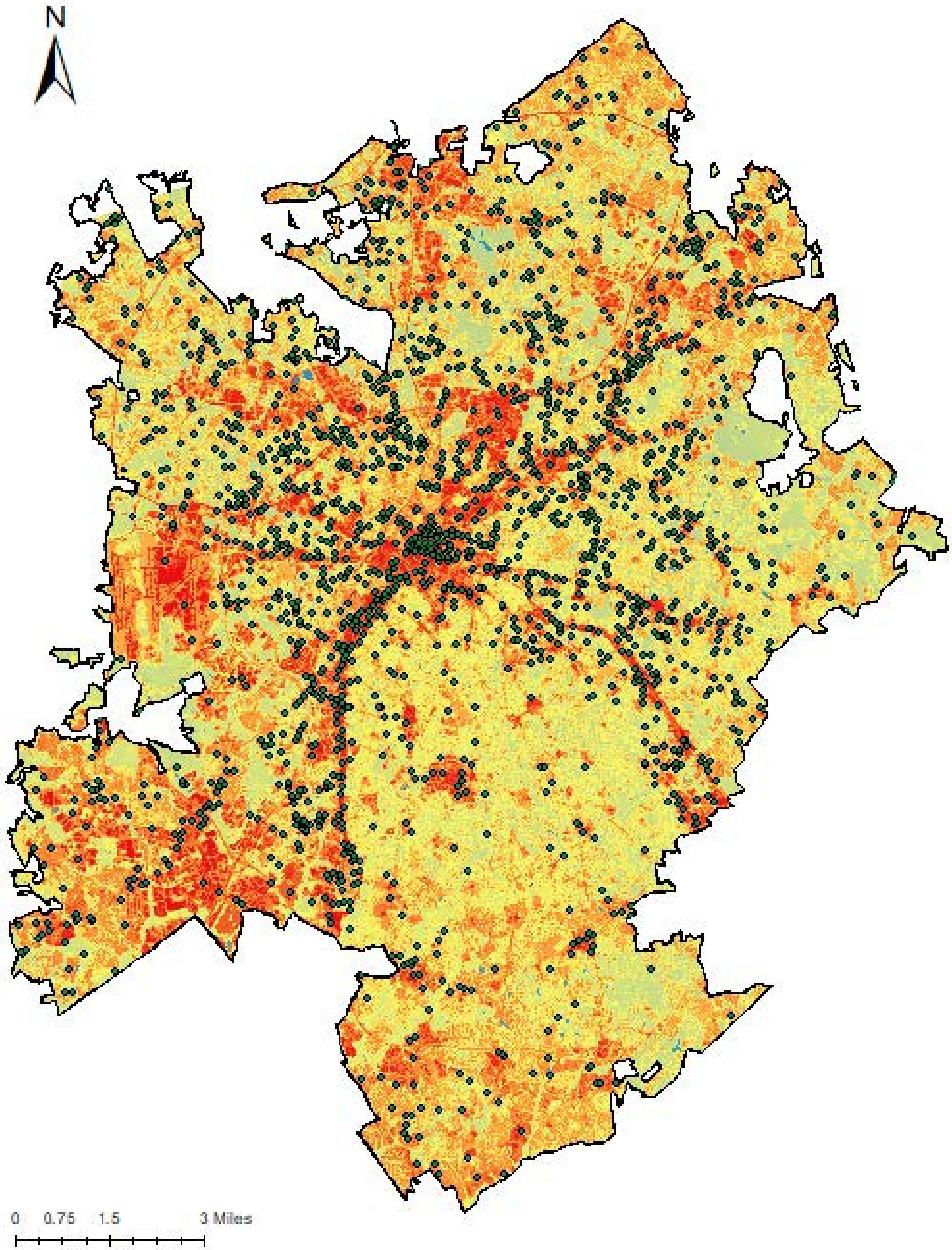


FIGURE 4. Part I: Offenses and UHI—Rochester

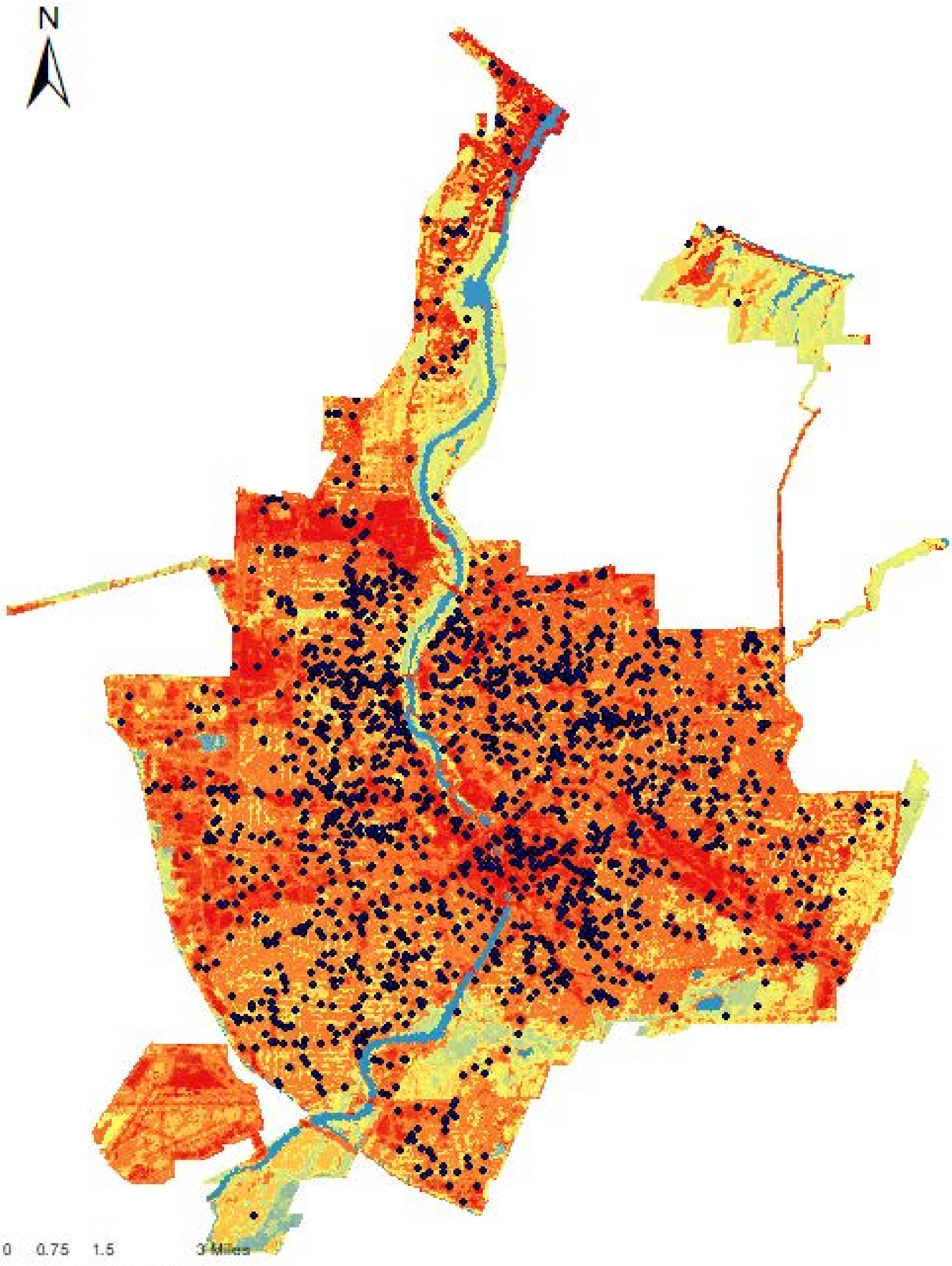
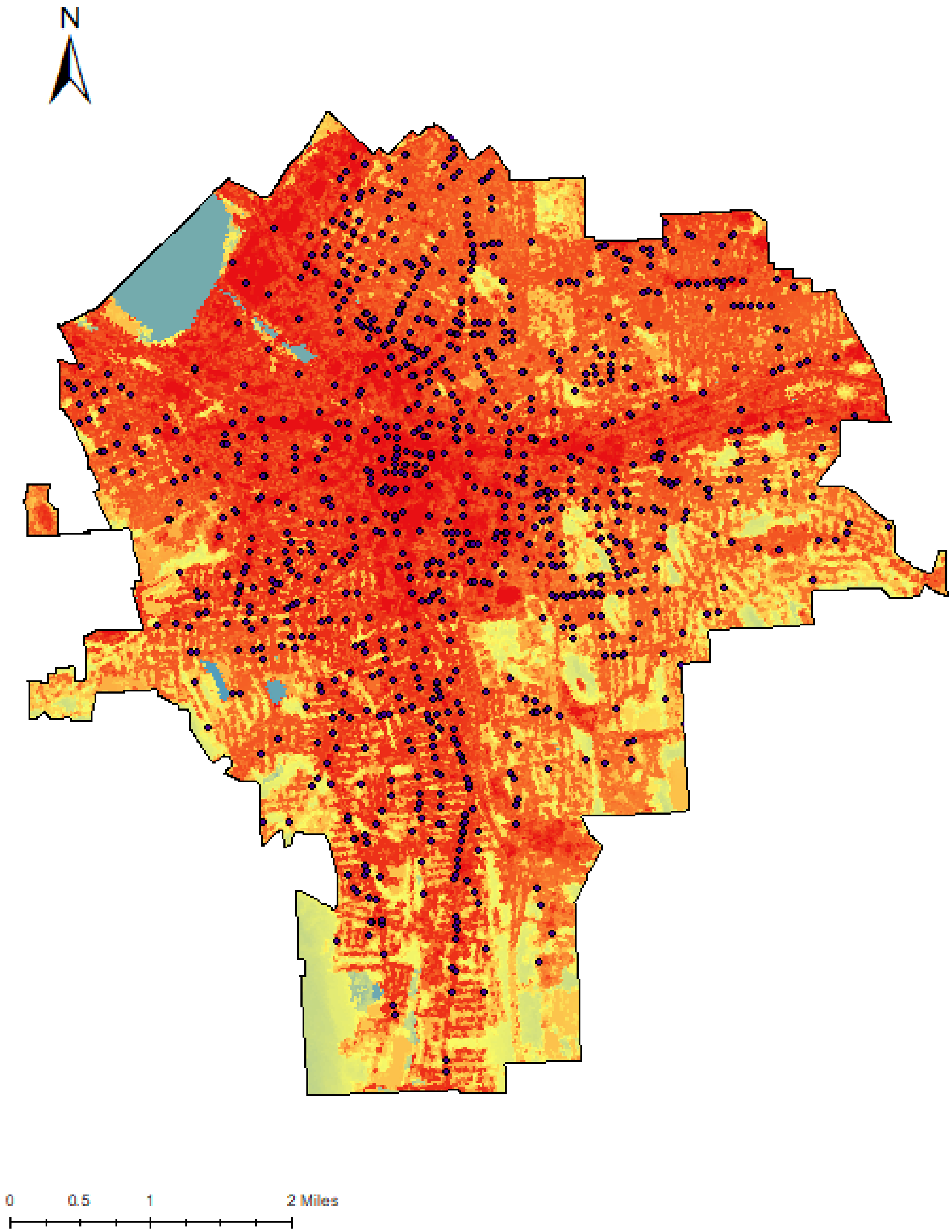


FIGURE 5. Part I: Offenses and UHI—Syracuse



Preliminary Results and Conclusions

While this ongoing research draws no final conclusions about causal relationships between heat and violent crime (i.e., that heat causes violence to spike), preliminary results show meaningful associations at the sub-municipal scale. This modeling has demonstrated intracity temperature variances of ~20°F in neighborhoods that are just a few blocks apart—an alarming contrast considering the close proximity—and violent crime clusters in neighborhoods exposed to these urban heat disparities. The resultant maps reflect that both heat and crime are clustered and unevenly distributed throughout the cities (see Figures 2–5). But what relationships and geographic and temporal parallels exist between the two?

In attempting to understand these relationships, it is critical to consider the underlying factors that propel both environmental inequality and the prevalence of crime.

The twentieth-century urban planning legacies of racial and socioeconomic inequality will continue to exacerbate environmental inequality and public health vulnerabilities related to climate change impacts. Understanding whether and how heat and vulnerability to crime are interconnected stressors, which influence social vulnerability within and across neighborhoods, is necessary to promote meaningful efforts, policy or otherwise, to address underlying socioeconomic disparities and their harmful impacts. Consider a tool such as the Social Vulnerability Index,[53] which illuminates how external stressors lead to wider vulnerability for communities, by accounting for population characteristics including access to medical services and educational level. While not presently included, it's advisable that exposure to UHIs be viewed as a critical driver of vulnerability and consequently be included in efforts capturing inequality and social vulnerability.

With planetary and urban warming expected to increase due to climate change, the future outlook for cities and their inhabitants in the face of UHIs is alarming considering the expected increases in temperature, weather anomalies, and heat waves.[54] Due to the uneven distribution of UHIs and the disproportionate impacts on environmental justice communities, these threats may very well be catastrophic for impacted neighborhoods already overly exposed and burdened with environmental risks, public health disparities, and socioeconomic inequality.[55] Increased understanding of environmental and public health threats, and their relationships to each other, must inform policy solutions moving forward. It's essential that our enhanced understanding be matched with centering communities on the frontlines of environmental threats in those solutions and transitions to lessen the impacts of climate change and violence. As this research continues, it is imperative to develop greater insight on the links between vulnerability to extreme heat and violence, which can ultimately inform measures to counteract both.

Endnotes

1 The impetus for the following analysis was born in 2022 while attending a series of neighborhood association meetings and presenting my work on community forestry and urban heat islands in Syracuse, New York. Invariably, a police officer, presenting on local crime, would be positioned on the agenda either just before or right after my presentation. Intuitively, I saw that many of the same neighborhoods and blocks that were at greatest risk of exposure to urban heat anomalies, largely due to inordinate amounts of impervious surface cover and a complimentary deficit of trees and other vegetation, were the neighborhoods that seemed most exposed to reported crimes, shots fired, and gun crimes. I'd like to thank Mr. Jimmy Rakotovao, whose keen GIS analysis was critical in moving this project from the conceptualization phase to its current form.

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