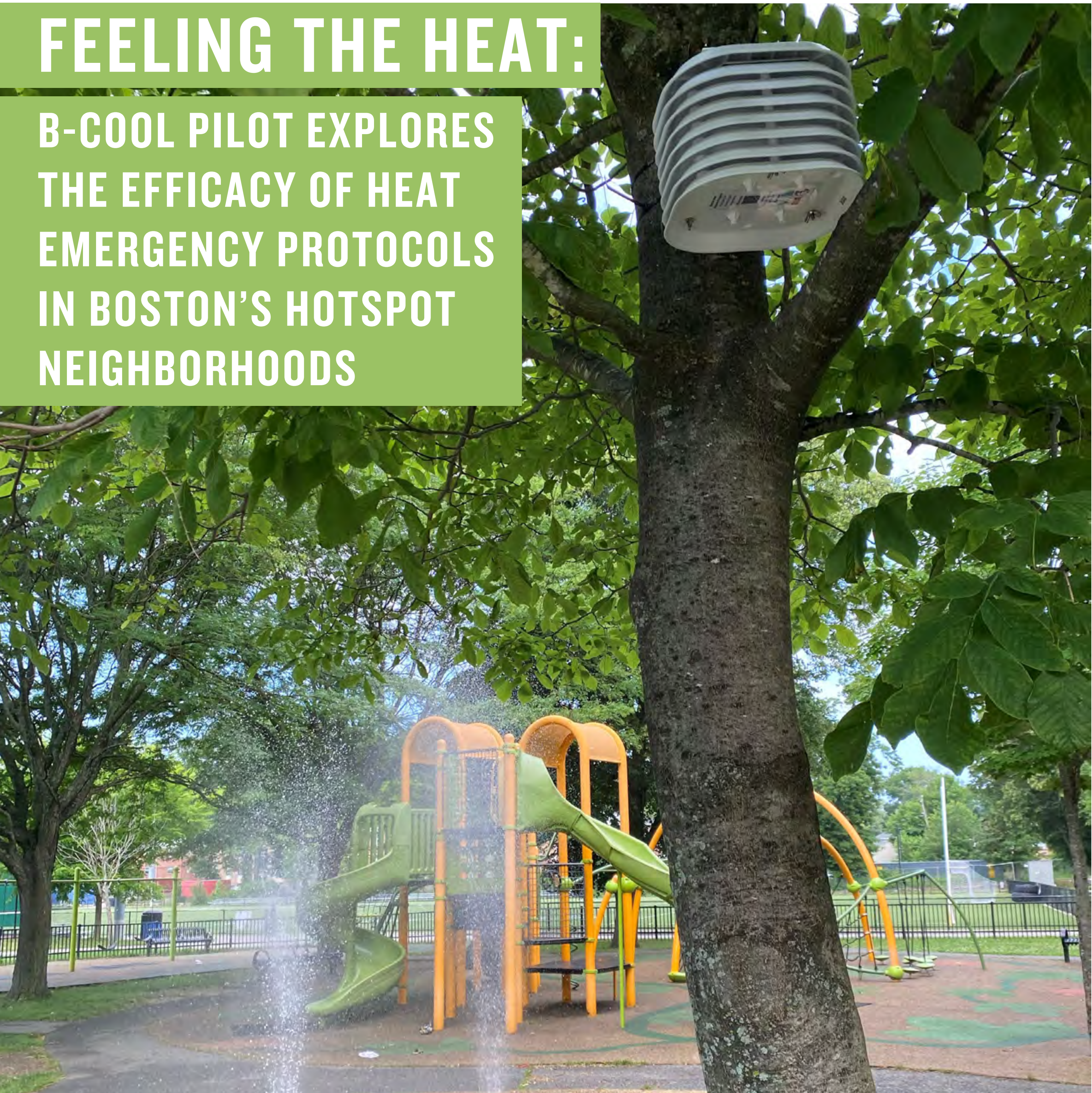
REPORT | AUGUST 2025

FEELING THE HEAT:

B-COOL PILOT EXPLORES THE EFFICACY OF HEAT EMERGENCY PROTOCOLS IN BOSTON'S HOTSPOT NEIGHBORHOODS



ACKNOWLEDGEMENTS

The B-COOL project team is grateful for the partnership of the "Boston Cools" or B-COOL host site community partners: Arnold Arboretum (Harvard University), Bay Cove Human Services, Boston Children's Hospital, Boston Chinatown Neighborhood Center, Boston Green Academy, Boston Medical Center, Charles River Community Health, City of Boston's Urban Forestry Division, Franklin Park Zoo, Greenway Conservancy, Mattapan Food and Fitness Coalition, Museum of Science, and UMass Boston. The B-COOL project would not be possible without the generous support of The Boston Foundation for both the 2024 summer pilot and subsequent summer 2025 B-COOL temperature sensor research. Additional funding for B-COOL team members' time was provided by the Barr Foundation the Paul & Edith Babson Foundation and the National Oceanic and Atmospheric Administration (NOAA).

REPORT TEAM

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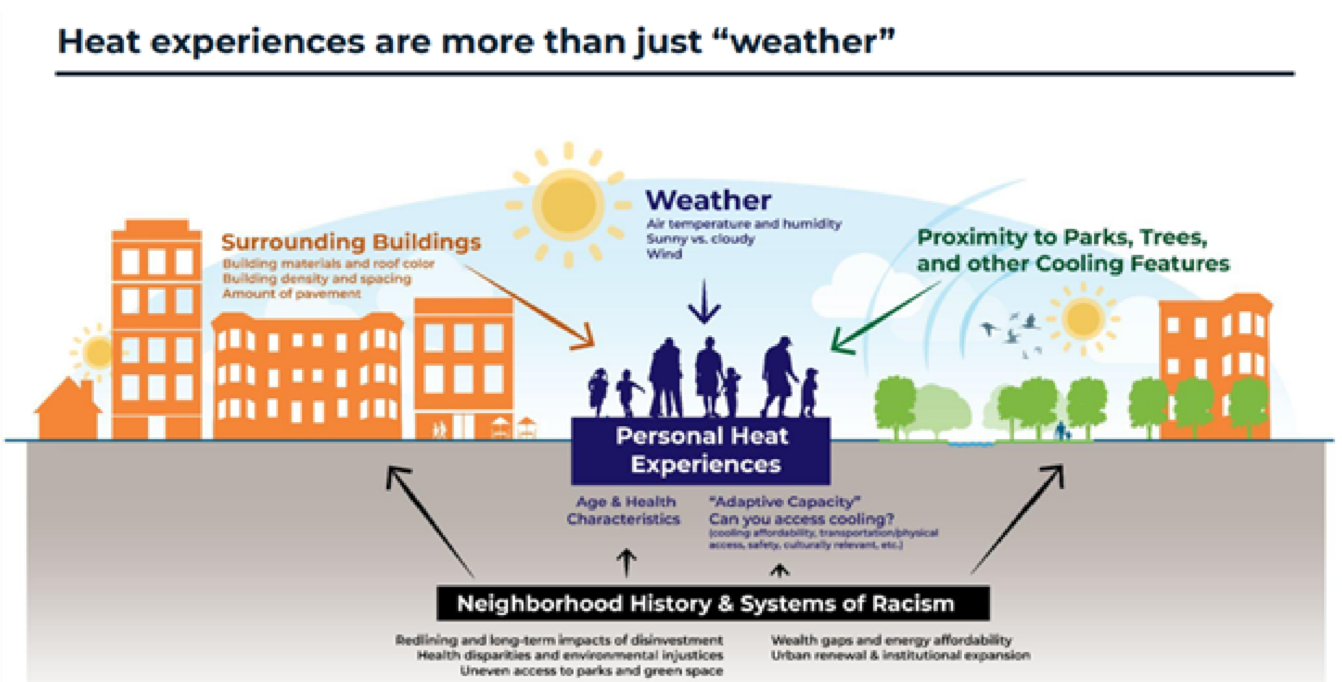
BACKGROUND CONTEXT

Boston is fortunate to have strong leadership on all aspects of climate resilience, including extreme heat and urban forestry through the Office of Climate Resilience and the Urban Forestry Division respectively. In addition to City leadership, Boston benefits from regional academic, nonprofit, private sector, community-based organization, and institutional leadership on climate resilience and equitable climate solutions.

With the publication of Boston's 2022 Heat Plan and 20-Year Urban Forest Plan, it became clear that extreme heat is not felt equally by all Boston neighborhoods, and that interventions for heat relief would have to be approached in an equitable way. Due to Boston's urban context, the entire city experiences urban heat island conditions. However, some neighborhoods are "hotspots" and can experience temperatures 10-15 degrees Fahrenheit (F) warmer than surrounding neighborhoods.[1] As highlighted in both the Boston Heat Plan and 20-Year Urban Forest Plan, the location of these hotspot neighborhoods in places like Chinatown, Dorchester, East Boston, Mattapan, and Roxbury, is not by accident, but by design. Decades of disinvestment in our communities of color and lower income communities have led to less access to wealth-building and community investment opportunities, fewer park spaces and urban tree canopy, and limited resources to cope with extreme heat.

As part of the City of Boston's preparation for and response to extreme heat events, the Heat Plan identifies the use of heat sensor networks to inform operations and communications. During extreme heat events, data from the National Weather Service (NWS) is used to determine Boston's official heat emergency or advisory declarations. These readings are currently based on a single temperature sensor located at the NWS weather station at Logan Airport in East Boston. Data from a network of local temperature sensors could be used in addition to data from the NWS to better inform the implementation of cooling interventions in hotspot neighborhoods.

Figure 1. How Buildings, Proximity to Green and Open Space, and Systemic Racism Impact Lived Heat Experiences



Source: City of Boston Heat Plan

1 City of Boston 2022 Heat Plan: https://www.boston.gov/departments/climate-resilience/heat-resilience-solutions-boston

In addition to the Heat Plan's call for heat sensor networks, previous research projects from local groups like C-HEAT and Wicked Hot Boston documented differences in neighborhood-specific temperature data. C-HEAT found that temperatures in Chelsea and East Boston are on average 6 degrees F warmer than the NWS temperature (see the C-HEAT report), and Wicked Hot Boston's citizen science research demonstrated temperature differences as high as 10-15 degrees F across Boston neighborhoods (see the Wicked Hot Boston mapping here and a case study writeup of both C-HEAT and Wicked Hot Boston here). In learning about significant temperature differences across neighborhoods and that Boston's heat emergency response is informed by only one temperature sensor owned by the NWS, members of A Better City's Extreme Heat Working Group had concerns. A lack of neighborhood-specific temperature data from Boston's hottest neighborhoods meant resource allocation prior to and during high heat events was not being informed by data from the most heat-vulnerable neighborhoods. Ideally, emergency declaration protocols would be responsive to temperature data from these communities.

Figure 2: 26 Citywide Strategies for Heat Resilience

Souce: Boston Heat Plan, 2022

To reach a declared heat advisory or emergency in Boston, the NWS sensor at Logan must forecast 95 degrees F or higher for two consecutive days, or 90 degrees F or higher for three consecutive days, where nighttime temperatures do not fall below 75 degrees F. Given the documented differences in neighborhood temperatures, B-COOL partners hypothesized that temperatures in hotspot neighborhoods reached these thresholds earlier and remained over the threshold longer than what is reflected in official emergency or advisory declarations for Boston.

FORMING THE B-COOL PARTNERSHIP

The "Boston Cools" or B-COOL partnership formed in spring 2024 with four core partners: A Better City (local nonprofit and business organization); Boston University School of Public Health (research institution); the City of Boston's Office of Climate Resilience (City climate expert); and The Boston Foundation (the City's community foundation).

The B-COOL team built upon deep heat expertise and leadership in Boston, including from the Wicked Hot Boston study by the Museum of Science, the C-HEAT project's work in Chelsea and East Boston, and the City of Boston's 2022 Heat Plan, mentioned above, which identified five hotspot environmental justice neighborhoods.

The B-COOL team set out to launch a local temperature sensor network across neighborhoods in Boston to measure differences in outdoor heat exposures across the summer, from June 2024 through the end of September 2024. With the initial project concept in early 2024, community partner outreach in spring 2024, and sensor deployment in summer 2024, the B-COOL team was then able to begin analysis in fall 2024.

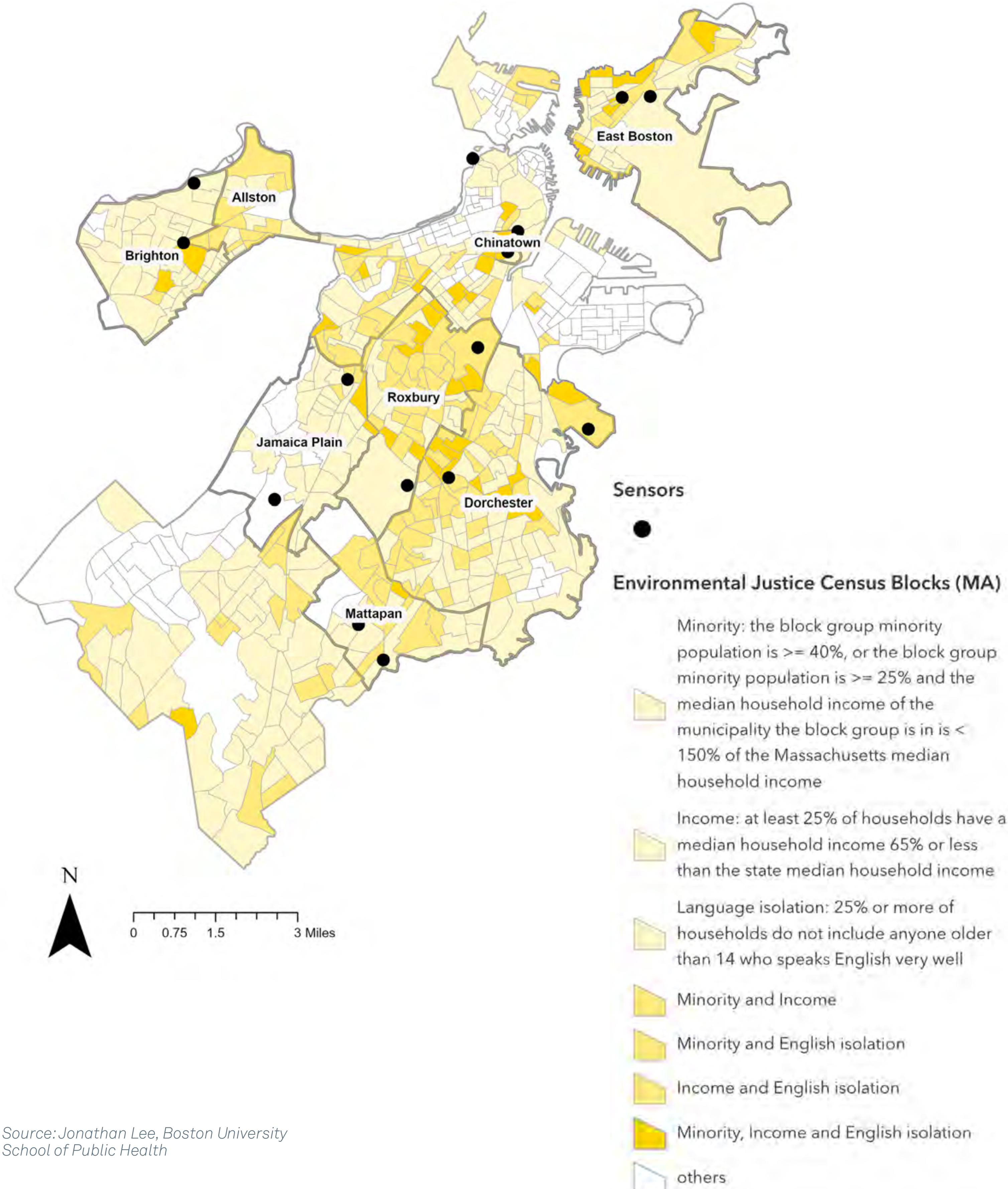
The near-term goals of the B-COOL 2024 temperature sensor pilot were: to engage organizations interested in extreme heat in Boston; to measure temperatures in the five environmental justice neighborhoods identified in the City of Boston's Heat Plan, plus other reference neighborhoods; to compare the occurrence of heat advisories and emergencies in the five neighborhoods based on local temperature measurements; and to document the resources and logistics required to monitor neighborhood-specific temperature across Boston.

METHODOLOGY

In summer 2024, the B-COOL team deployed 15 temperature and relative humidity sensors across the five neighborhoods identified in Boston's Heat Plan: Chinatown, Dorchester, East Boston, Mattapan, and Roxbury, as well as Allston-Brighton and Jamaica Plain. Two sensors were deployed in each neighborhood, one "hot" sensor located in a part of the neighborhood anticipated to be warmer based on land surface temperature maps, as well as one "cool" sensor in a different part of the neighborhood anticipated to be cooler. Locations designated as environmental justice communities, as defined by the state definition for environmental justice community, were prioritized, and locations within these neighborhoods were further informed by their proximity to socially vulnerable and heat-vulnerable populations, including outdoor workers, transit-dependent commuters, students and children, and other heat-vulnerable patients (e.g., unhoused populations). Additionally, for a cooler neighborhood comparison not located in a hotspot neighborhood, a sensor was located at the Museum of Science on the Charles River.

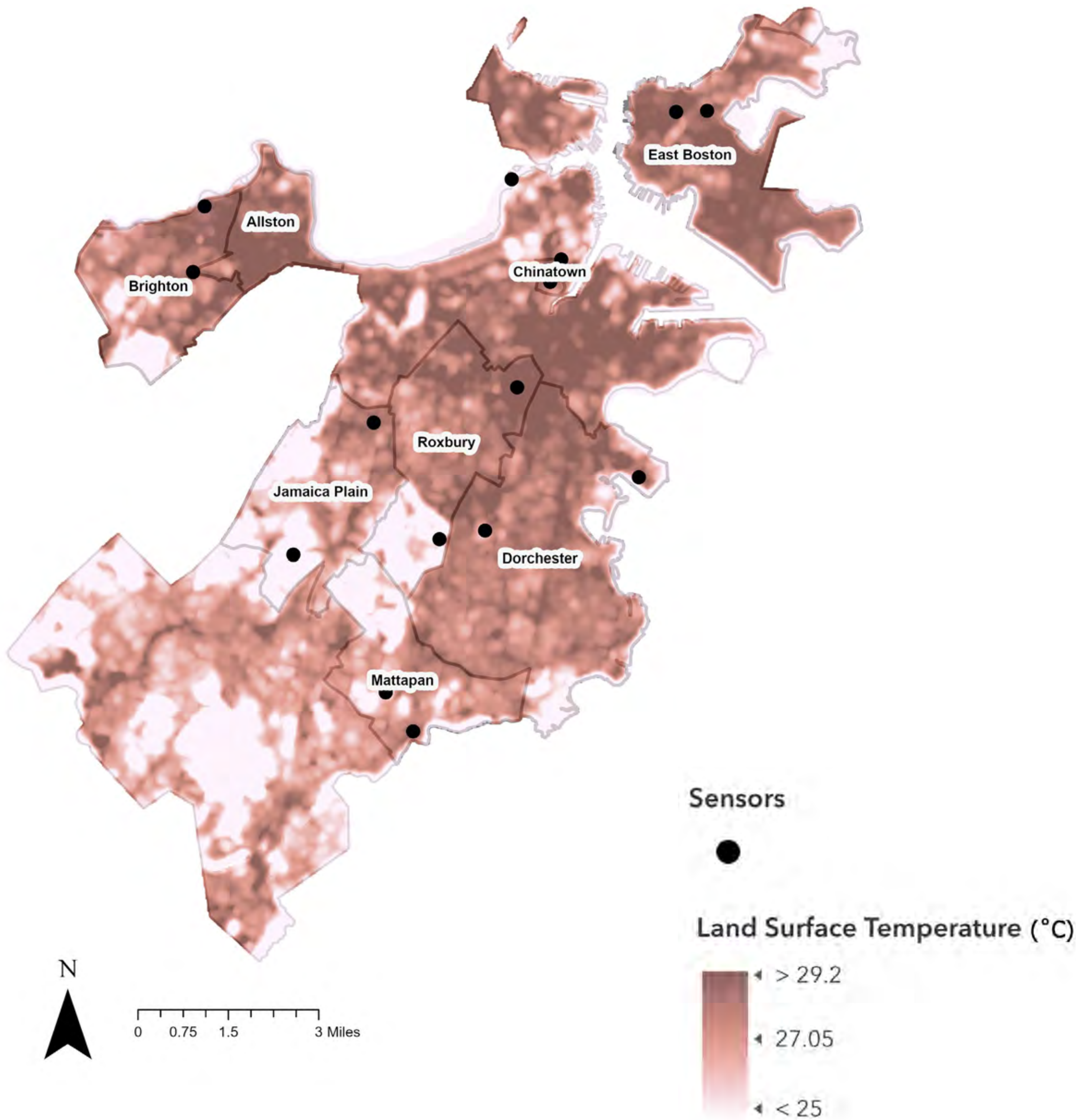
Sensors were installed in trees owned by the city or owned by community partners. Permission to use trees to install sensors was possible thanks to relationships with Boston's Urban Forestry Division and members of A Better City's Extreme Heat Working Group. Sensors were attached to trees using zip ties, about nine feet above ground, so that they would be close enough to capture exposure, as well as to minimize tampering. Each sensor was taken down at the end of the summer, so as not to damage host trees. The mapped sensor locations are included on the following page.

Figure 3. B-COOL Temperature Sensor Locations Relative to Environmental Justice Neighborhoods



Source: Jonathan Lee, Boston University School of Public Health

Figure 4. B-COOL Temperature Sensor Locations Relative to Land Surface Temperature



Source: Jonathan Lee, Boston University School of Public Health

For this pilot study, B-COOL used HOBO temperature and relative humidity sensors (manufactured by Onset, Bourne, MA) paired with solar radiation shields. The solar radiation shields are important to include since they help to diffuse solar radiation and prevent inaccurately high temperature readings in direct sunlight. With solar radiation shields, the same ambient temperature is recorded regardless of whether the sensor is in direct sunlight or in the shade. On the bottom of each temperature sensor, a QR code was included that linked to a one-pager description of the project, which was translated into five of the most commonly spoken languages in Boston other than English (Spanish, Haitian Creole, Vietnamese, Simplified Chinese, and Traditional Chinese). The one-pagers also included a contact email address for the team.

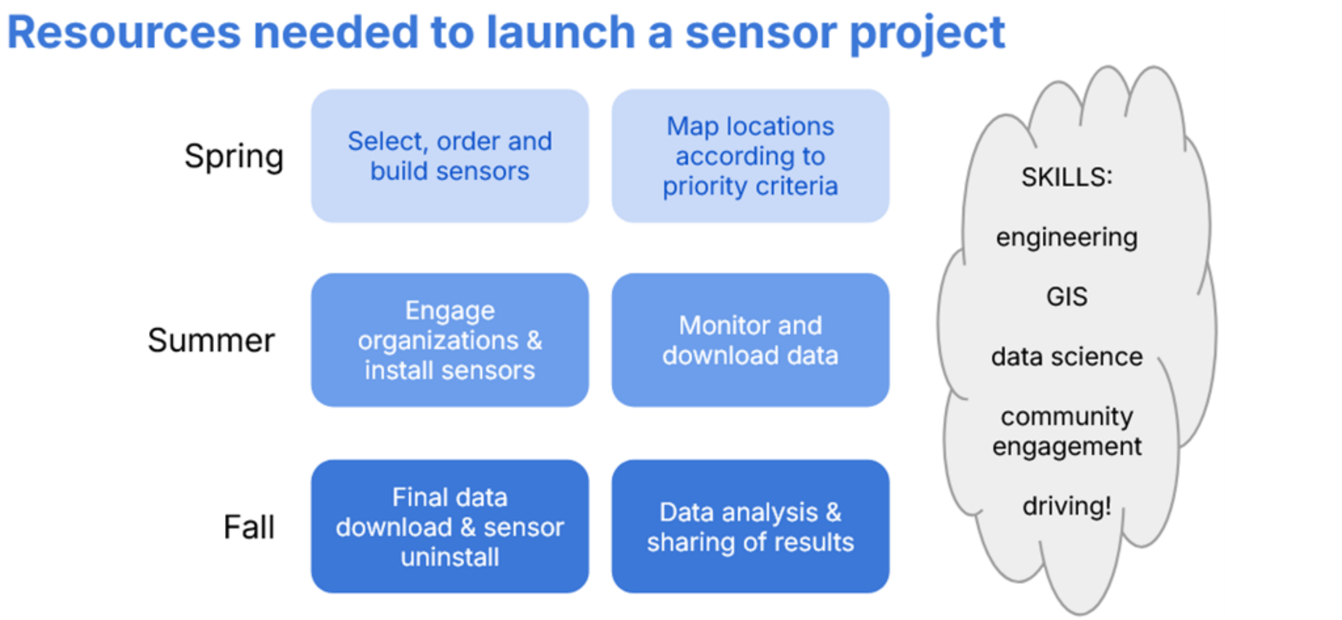
Figure 5. Photos of B-COOL Team Members Building and Installing HOBO Temperature and Relative Humidity Sensors in Boston

Source: Megan Jones and Patricia Fabián, Boston University School of Public Health, Isabella Gamill, A Better City

The sensor installation and deployment team installed temperature sensors across all host sites, follwed by the research and data collection team driving to each of the 15 sensors every two weeks, to download sensor data via bluetooth, and perform any needed sensor maintenance.

Key components of the B-COOL team that helped to enable success included a transdisciplinary team—research academic partner, the city, a nonprofit business organization, and a community-oriented funder. In addition to having interested and collaborative community partners beyond the core team, the research team also had technical expertise across building and sensor installation, data collection, GIS mapping and data analysis, statistics and data science. Figure 6 shows a schematic of time and technical resources needed to launch a temperature sensor campaign.

Figure 6. Schematic Of Resources, Technical Skills And Timeline To Plan And Launch A Temperature Monitoring Campaign.

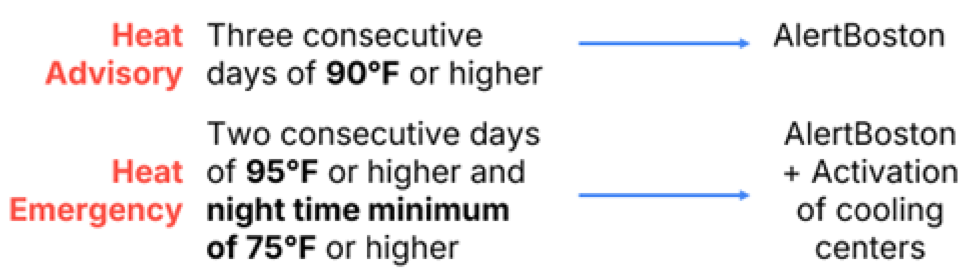


Source: Boston University School of Public Health

RESULTS

The City of Boston's emergency protocols used to declare heat advisories or emergencies are informed by NWS data, based on heat index (temperature + relative humidity) taken at the NWS station at Logan Airport. A heat advisory is declared when a heat event is forecast for three consecutive days of 90 degrees F or higher when the nighttime temperature does not fall below 75 degrees F. Heat advisory declarations trigger the distribution of heat safety communications via AlertBoston, the City's opt-in communications tool across all emergencies and climate hazards. A heat emergency is declared with two or more consecutive days of 95 degrees F or higher, where the nighttime temperature doesn't fall below 75 degrees F. In addition to launching AlertBoston heat safety communications, heat emergencies in Boston also trigger activation of cooling centers, and the deployment of cooling resources.

Figure 7. Heat Emergency and Advisory Declaration Thresholds for Boston

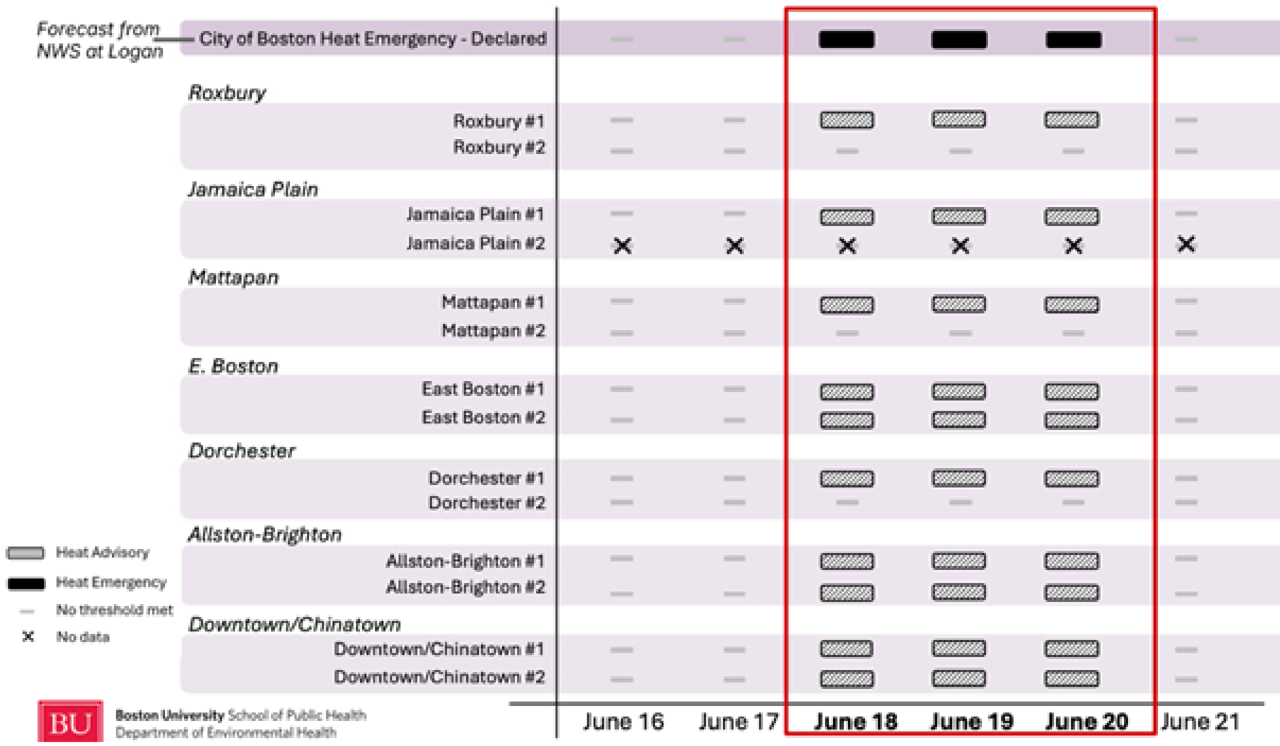


Source: Boston University School of Public Health

During the summer of 2024, there were two heat emergencies and two heat advisories declared. For each of the events, the data analysis team compared official declarations based on forecasts from the NWS, and the temperatures taken at each temperature sensor site.

For the first official heat emergency declared from June 18-20, 2024, temperatures at the B-COOL sensors did not reach heat emergency thresholds, and some did not even reach heat advisory thresholds (See Figure 8, following page).

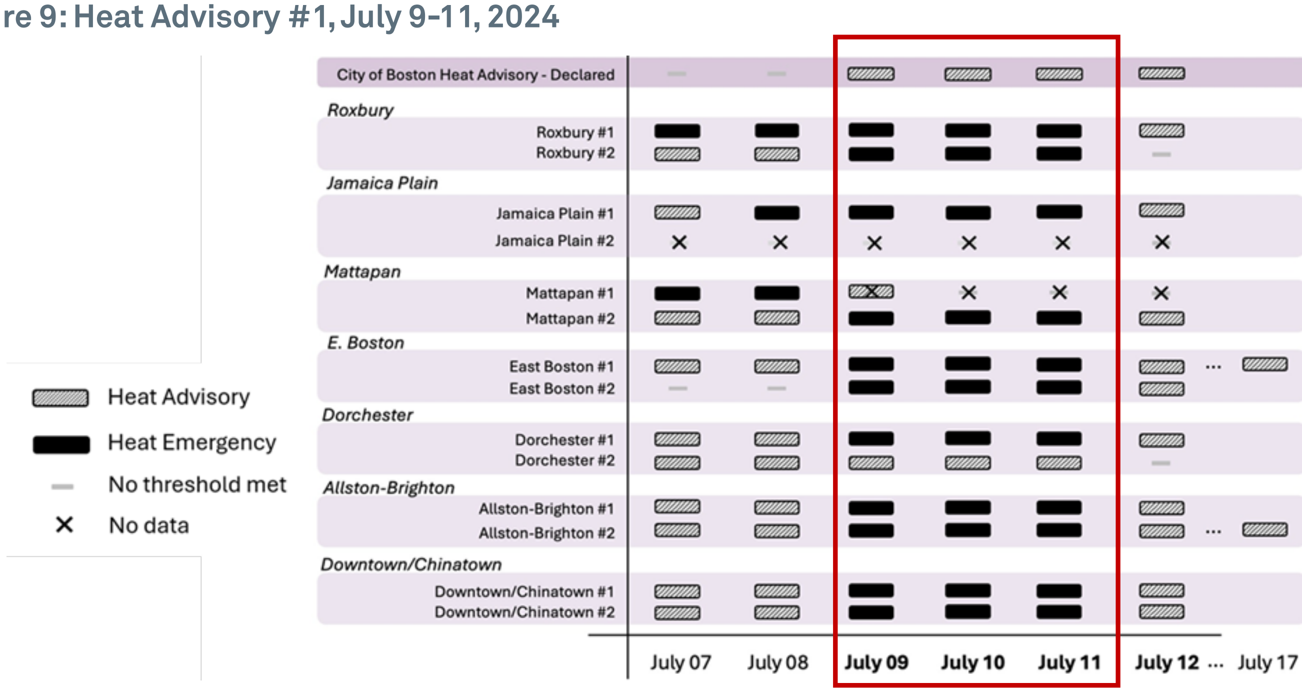
Figure 8: Heat Emergency #1, June 18-20, 2024



Despite the discrepancy, it can be effective and important to overprepare early in the summer, and to be overly cautious when people are less accustomed to high heat. In other words, it is better to err on the side of caution.

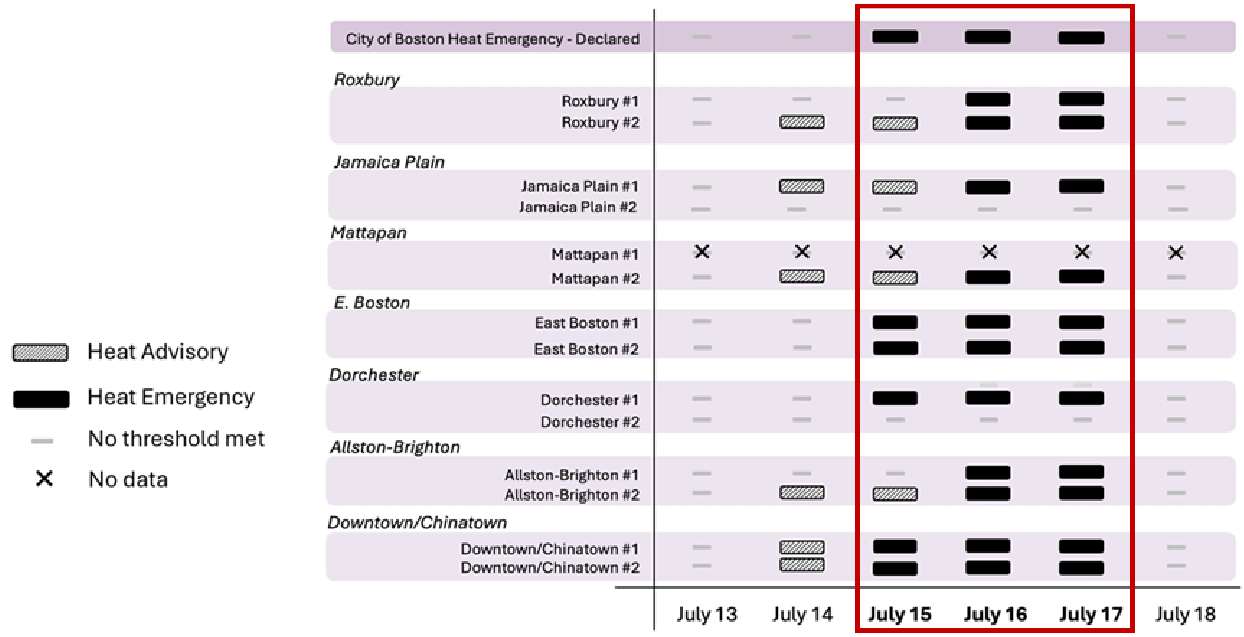
For the first official declared heat advisory of the summer from July 9-11, 2024, the B-COOL sensor results demonstrate that most of the B-COOL sensors measured temperatures that were hot-enough to qualify for a heat emergency one to two days prior to the official declaration. Sensors in Roxbury, Jamaica Plain, and Mattapan, for example, all registered heat emergency conditions one to two days prior. All B-COOL sensors measured high heat on either end of the official declaration, with sensors measuring heat advisory qualifying temperatures as many as two days prior and two days after the official declaration (See Figure 9, below).

Figure 9: Heat Advisory #1, July 9-11, 2024



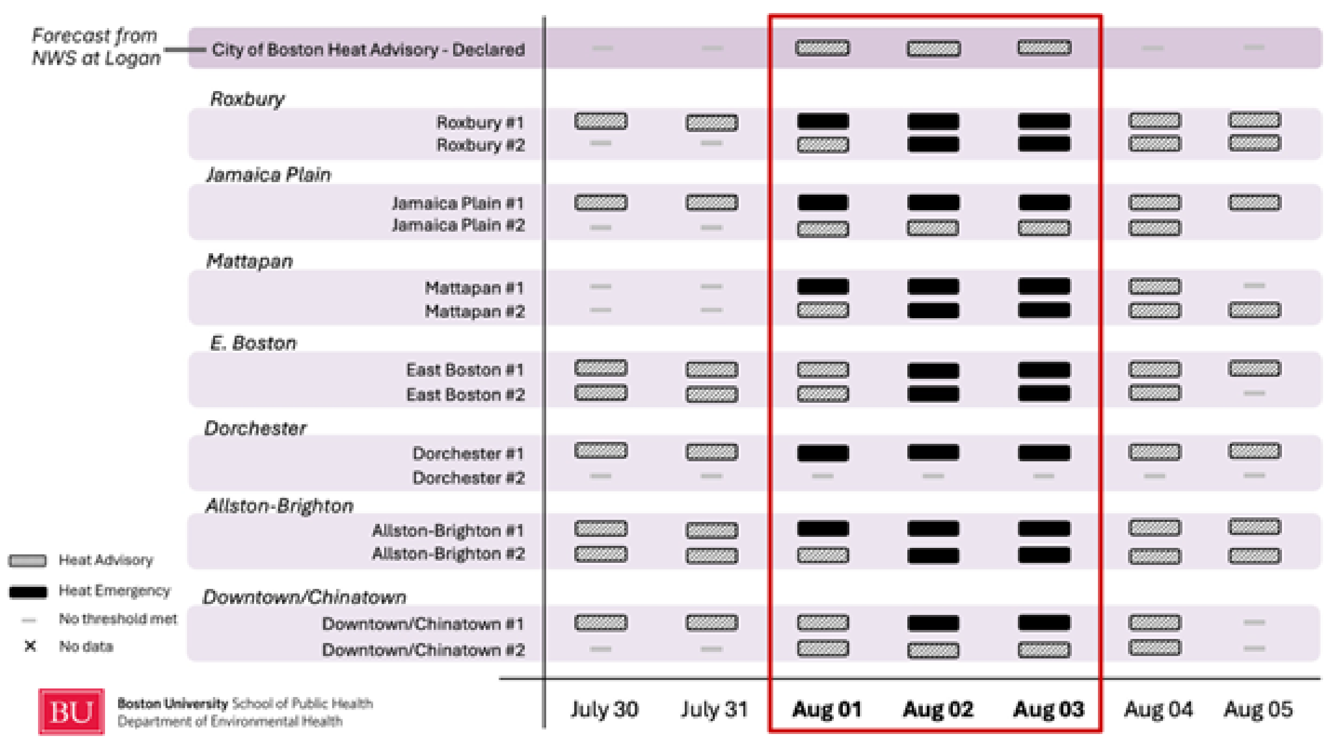
For the heat emergency declared from July 15-17, 2024, about one third of the sensors reflected heat emergency conditions for the full three days as predicted, while others only reached heat emergency thresholds for two of the three days. Interestingly, a sensor in Jamaica Plain and a sensor in Dorchester did not register heat advisory or emergency conditions for any of the declaration period (see Figure 10, below).

Figure 10: Heat Emergency #2, July 15-17, 2024



For the heat advisory declared from August 1-3, 2024, even starker differences in heat index were documented by B-COOL sensors. Compared to the heat advisory forecast declared by the City of Boston, many B-COOL sensors measured temperatures hot enough to breach heat emergency conditions (see Figure 11, below).

Figure 11. Heat Advisory #2, August 1-3, 2024



While B-COOL sensors highlight significant differences between NWS forecast declarations and hotspot neighborhoods, this pilot also demonstrates contrasts across hotspot neighborhoods, and within hotspot neighborhoods. Temperature sensors in hotspot neighborhoods on average measured hotter temperatures than were forecast by National Weather Service-informed data and experienced longer high heat duration than official heat declarations for Boston suggested. Additionally, the B-COOL sensors demonstrate differences in duration of cumulative heat exposure, with sensors picking up heat advisory and emergency conditions both before and after official declarations occur, meaning that heat-vulnerable neighborhoods are exposed to heat for longer than official declarations are able to provide heat-relieving resources (like cooling centers, for example). Such differences carry implications for future heat protocol declarations and response, as detailed below:

Figure 12. B-COOL Sensor Installation in Chinatown

Photo credit: Isabella Gambill, A Better City

KEY TAKEAWAYS & LESSONS LEARNED

There were several key takeaways and lessons learned from the B-COOL temperature sensor pilot, including:

Emergency Declaration Protocols

- On hot days, temperatures in neighborhoods across the city can be significantly higher than at the NWS station. B-COOL sensor data show that heat advisory and emergency conditions were sometimes reached in hotspot neighborhoods that were not reflected in the NWS declarations for Boston. Some of the 2024 heat advisories and emergencies in hotspot neighborhoods started up to two days before and as long as six days after official declaration durations, highlighting significant differences in exposure to high heat by neighborhood. Although this study did not investigate why such differences across and within neighborhoods occur, the B-COOL team results are reflective of urban heat island hotspots as indicated in Boston's Heat Plan and Wicked Hot Boston, in which low income neighborhoods and formerly redlined communities of color are placed on the frontlines of heat hazards, due to less urban tree canopy, more heat-retaining materials like steel, concrete, and surrounding highways, and other factors. In comparison, the NWS sensor at Logan Airport likely benefits from being on the coast with a cooling coastal breeze.
- Where to locate heat sensor networks to measure and predict heat index is key for effective heat resilience and emergency response planning. Including hotspot neighborhood data from environmental justice communities also helps to prioritize Boston's most vulnerable residents and to ensure an equitable approach to heat solutions.
- In addition to the extent of high heat temperatures reached during heat events in Boston (how hot), it is important to consider differences in duration of heat exposure for vulnerable populations (how long). Difference in duration and cumulative exposure to high heat can be particularly damaging for outdoor workers, transit dependent commuters, unhoused populations, and athletes/students, and heat-relieving resources should be prioritized for heat-vulnerable populations with the longest heat exposure.
- In addition to significant differences across neighborhoods, B-COOL data also highlighted differences within neighborhoods, with heat advisory and emergency conditions being felt in specific locations, only a mile or so away from neighborhoods that never reached any high heat threshold for advisory nor emergency.

Considering How Temperature Discrepancies Impact Heat-Vulnerable Populations

- For heat vulnerable populations, differences within and between neighborhoods can translate into differences in time exposed to higher temperatures. For example, a hypothetical outdoor worker working from July 30-August 5, 2024 (with the official heat advisory declaration from August 1-3, 2024) would have been exposed to 28 working hours above 90 degrees F in a cooler neighborhood, compared to 52 hours in a hotter neighborhood.
- For other vulnerable populations like children, older adults, unhoused communities, and other heat-vulnerable patients, access to cooling at night while resting and sleeping can be vital in enhancing heat resilience. For a hypothetical resident trying to sleep during the heat event from July 30-August 5, 2024, someone living in a cooler neighborhood may be able to access up to 21 hours of nighttime below 75 degrees F, whereas a resident living in a hotter neighborhood may only be able to access 14 hours below 75 degrees F.

Leveraging Temperature Sensors for Community Engagement and Resource Allocation

- Key components of a successful sensor network campaign included: a transdisciplinary team, interested and collaborative community partners, and interdisciplinary technical expertise (across engineering, GIS, data science, community engagement, and driving through Boston traffic).
- The B-COOL team used the spring to order and build sensors and to map their locations according to priority criteria, the summer to engage organizations and install sensors, and monitor and download the data, and the fall to finalize data downloads, uninstall sensors, and perform data analysis and begin sharing results.
- Temperature sensors can be an extremely effective community engagement tool and can provide an opportunity to gain experience from community leaders and partners regarding how temperature data may support the communities that they serve. From using temperature sensors for climate education at Boston Green Academy, to thinking about how Franklin Park Zoo can keep both its human staff and visitors and animals safe in the heat, sensors can be a catalytic tool in asking questions grounded in how data science can serve local communities.
- Sensor network data can be powerful in demonstrating differences in lived heat experiences, both by geography and by heat-vulnerable stakeholder groups. Such data grounded in community needs can be transformational in helping to prioritize the allocation of resources for heat relief, especially as budgets for climate resilience are limited.
- Neighborhood-specific temperature sensor data can help to prioritize resource allocation for areas of hotspot neighborhoods that are experiencing longer duration extreme heat. Boston may want to consider ways to augment NWS data with neighborhood-specific temperature sensor networks, as suggested by the Heat Plan.

NEXT STEPS & FUTURE WORK

Upon conclusion of the 2024 summer temperature sensor pilot, the B-COOL team continues to share the results of this study with community partners and beyond, including presentations to the state Resilient Mass Action Team (RMAT), Boston's Climate Resilience Team, the National Weather Service, and others. In addition to considering neighborhood-specific temperature for emergency and advisory declarations and related resource allocation, future heat interventions could also consider prioritizing heat-vulnerable populations like workers, transit-dependent commuters, students and children, and at-risk patients whenever possible.

Thanks to the generous support of The Boston Foundation, B-COOL summer 2025 sensing will build upon the 2024 pilot to begin to evaluate the impact of shade interventions on the heat stress of heat-vulnerable populations and surrounding critical infrastructure. By evaluating the impact of shade structures like bus stops with green roof shelters along MBTA Route 28 playgrounds with shade at Boston Chinatown Neighborhood Center and the Franklin Park Zoo, the B-COOL team will begin to gather evidence for which shade interventions are most effective for cooling vulnerable people and critical infrastructure. The hope is that such data can be helpful in future heat-relieving resource allocations.

A longer-term vision for this work includes a public-private cross-jurisdictional partnership that could help share extreme heat data across institutions, mobilize shared resources in advance of and during extreme heat emergencies, identify locations for potential community resilience hubs, and develop equitable extreme heat policy priorities to inform city- and state-level advocacy.

ADDITIONAL STATEMENTS FROM PILOT PROJECT TEAM PARTNERS

Dr. M. Patricia Fabián, Associate Professor of Environmental Health and Associate Director of the Institute of Global Sustainability, Boston University School of Public Health

> “Cross-sector collaborations like this Boston extreme heat project are the future for advancing climate resilience efforts in cities, and we hope to generate actionable information for different stakeholders, including the city, businesses, community partners and researchers. As a public health researcher, ultimately my goal is to see improved population health and reduced health inequities through collaborative climate projects like this one.”

Brian Swett, Chief Climate Officer, City of Boston

> “To enhance Boston’s resilience against climate change impacts, addressing extreme heat remains a primary focus. This heat sensor pilot project is a crucial step towards understanding and mitigating the disparities in heat exposure across our neighborhoods. By filling critical data gaps, we can develop more equitable heat resilience strategies and better protect our residents. I am thankful to our partners including A Better City, Boston University, and The Boston Foundation, as well as Zoë Davis from the City who has been crucial to Boston’s work to equitably respond to extreme heat.”

Julia Howard, Senior Program Officer, The Boston Foundation

> “We are proud to partner on this pilot program that not only highlights a need to update our current heat sensor system, but it offers a path towards equitable solutions supported by data and driven by community voice.”

Isabella Gambill, Assistant Director of Climate Energy & Resilience, A Better City

> “Extreme heat is the number one killer of all weather-related climate impacts—yet almost all deaths from extreme heat are preventable, as survival in the heat is entirely dependent upon someone’s access to cooling resources. A Better City is grateful to partner on this project in the hopes that it may help the city, our members, and our community-based partners to better allocate heat relief resources to the vulnerable neighborhoods that need them most.”

About the Project Team

The team on this project consists of Isabella Gambill from A Better City, Dr. M. Patricia Fabián, Jonathan Lee, Ameera Saba, Yirong Yuan from Boston University School of Public Health, Zoë Davis from the City of Boston Office of Climate Resilience (in partnership with the Mayor’s Office of New Urban Mechanics and the Green New Deal Office), and Julia Howard from The Boston Foundation. This pilot project, as well as subsequent summer 2025 B-COOL research, is generously funded by The Boston Foundation. Additional funding for extreme heat work of B-COOL team members was provided by the Barr Foundation the Paul & Edith Babson Foundation and the National Oceanic and Atmospheric Administration (NOAA).

B-COOL team, left to right: Zoë Davis (City of Boston), Isabella Gambill (A Better City), Jonathan Lee (Boston University), Ben Hires (Boston Chinatown Neighborhood Center, B-COOL Community Partner), Ameera Saba (Boston University), Julia Howard (The Boston Foundation), and Dr. Patricia Fabián (Boston University)