Heat Watch Report

Boston, Massachusetts

CAPA
STRATEGIES

Climate | Adaptation | Planning | Analytics

The CAPA Heat Watch program, equipment, and all related procedures referenced herein are developed through a decade of research and testing with support from several universities and national agencies. These include, Portland State University, the National Oceanic and Atmospheric Administration, the National Integrated Heat Health Information System, the Climate Program Office, the Climate Resilience Fund, The U.S. Forest Service (USDA), and the National Science Foundation.

This report was prepared by CAPA Strategies, LLC
Summer 2019

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Purpose and Aims

Greetings Boston, Brookline and Cambridge!

First of all, **thank you to all of the participants, drivers, navigators, and organizers** of the Urban Heat Watch program in San Juan, Puerto Rico. After months of collaboration and coordination, local organizers and volunteers collected thousands of temperature and humidity data points in the morning, afternoon, and evening of a long, hot campaign day in July. Thanks to these efforts, analysts at CAPA Strategies were able to combine the data with satellite imagery to produce the urban heat maps being shared with you in this report. We are excited to present these data to you and your communities, and we look forward to learning about **your interpretations and implications of these patterns in the region.**

The purpose and aims of conducting this Heat Watch campaign are fourfold:

1. Recognize that communities face an **unprecedented challenge of locally** preparing for a dysfunctional global climate system. Needed are approaches that center communities and infrastructure that face the greatest threat from increasing intensity, duration, and frequency of climate-induced extreme weather events.

2. Understand the **distributional effects** of temperature and humidity (heat index) provide an immediate and compelling opportunity to engage communities.

3. Bridge the innovations in **sensor technology** and **spatial analytics** with community engagement efforts.

4. Engage communities in advancing local actions that can safeguard communities and infrastructure for an uncertain future.

To this end, the aim of the San Juan campaign is to engage researchers, municipal staff, and community members in the collection of hundreds of thousands of measurements of temperature and humidity throughout the region.

By conducting these campaigns throughout the day, the results provide an immediate means for participants and others to understand **how urban heat varies** across neighborhoods and how local landscape feature can affect temperatures.

CAPA Heat Watch aims to provide an accessible and simple process together with remote support for community groups to collect vast amount of primary temperature data in any metropolitan region. The results of the "campaigns" describe the distribution of heat, which are then used to identify potential actions for improving the health and well-being of local communities, infrastructure, and regional ecosystems. Our approach puts local organizers in a leadership position to engage community groups and advancing effective solutions.

**1.** Local organizers create polygons of the area of interest, and develop driving routes ("traverses") within each polygon.

2. By recruiting volunteers, and following CAPA-led trainings, local organizers set out to conduct their heat campaign, which consists of dozens of traverses in the area of interest.

3. Traverses are conducted by mounting sensor equipment on the car, and driving the designated routes at 6 a.m., 2 p.m., and 7 p.m. on a hot, clear day.

These sensors track GPS location, temperature, and humidity at one second intervals throughout each one-hour traverse. After completion, sensors are shipped back to the CAPA team for analysis.

4. The data are retrieved from each sensor and analysed using a machine learning algorithm that also incorporates local data and satellite imagery. The resulting maps show heat distribution for the entire city.
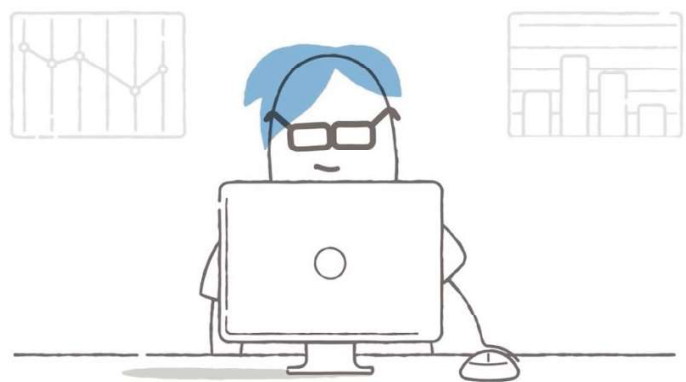
How to Use These Maps

The following sections include an overview of the results, which include a series of maps, overload on satellite imagery, that describe: (1) a combination of all the traverse data points, colored by temperature, for the morning, afternoon, and evening; and (2) a 'heat index' map that incorporates temperature and humidity to describes the area of interest, also in the morning, afternoon and evening ('Area Wide').

Warmer areas are depicted by red coloring, while relatively cooler areas are shown in blue. Details of the analytical process can be found in Shandas et al., 2019.

Note that the Heat Index map scale is classified by "natural breaks" in order to more explicitly depict warmer locations across each map. The temperature scales are different between the traverse and area-side maps because area wide includes the Heat Index.

We invite you to find on the map your home, place of work, or favorite park and compare the temperatures throughout the day. **How does your own experience with heat in these areas align with the map?** What about the landscape (e.g. shade trees, concrete buildings, river-side walkway, etc.) do you think might be influencing the temperatures in this area?
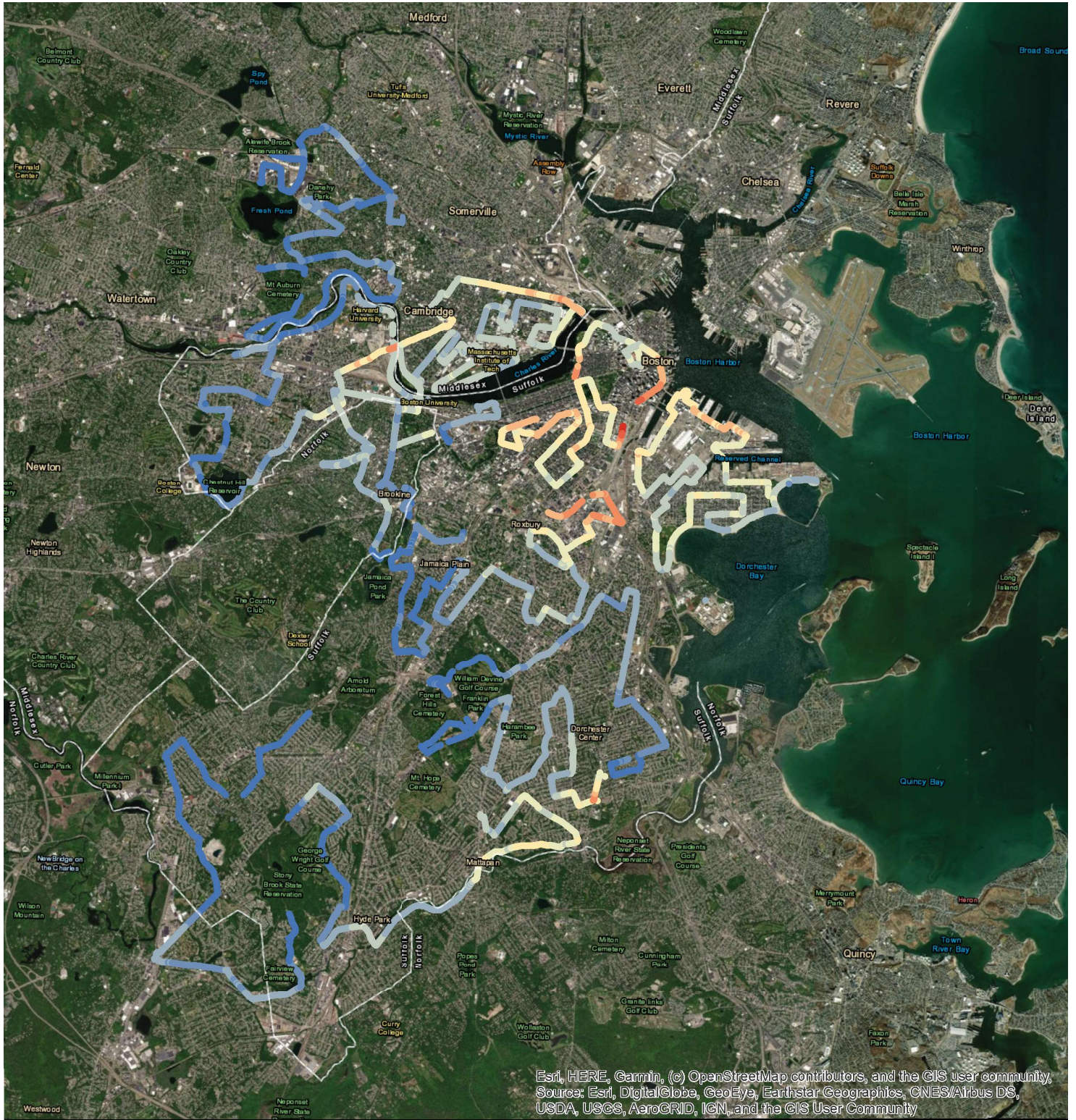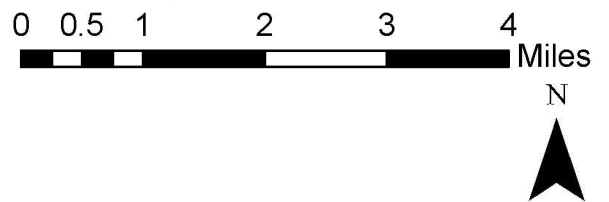
Morning Traverse (6 - 7 am)

Figure 1: Boston 6-7AM Traverse Point Temperature (°F)

● 72.7 - 73.8	● 75.7 - 76.1
● 73.8 - 74.3	● 76.1 - 76.5
● 74.3 - 74.8	● 76.5 - 76.8
● 74.8 - 75.2	● 76.8 - 77.4
● 75.2 - 75.7	● 77.4 - 84.4

0   0.5   1   2   3   4
Miles

N
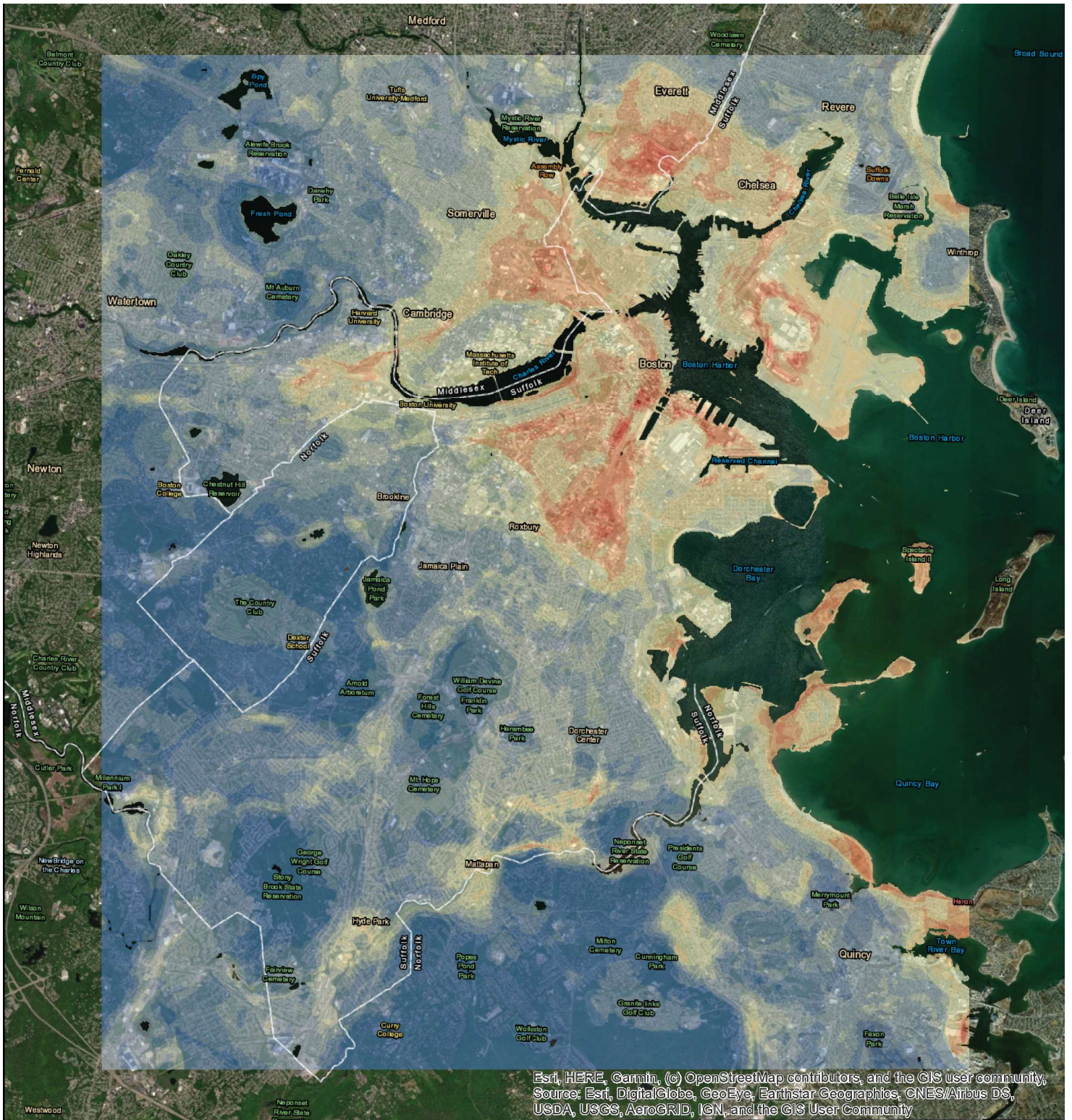
Figure 2: Boston 6-7AM Area-Wide Heat Index (°F)

73.0 - 74.4	77.4 - 77.9
74.4 - 75.2	78.0 - 78.6
75.2 - 76.0	78.6 - 79.6
76.0 - 76.7	79.6 - 81.7
76.7 - 77.4	81.7 - 87.7

0   0.5   1   2   3   4
Miles

N
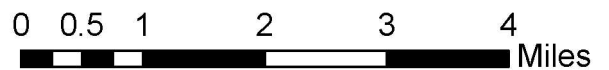
Afternoon Traverse (3-4 pm)
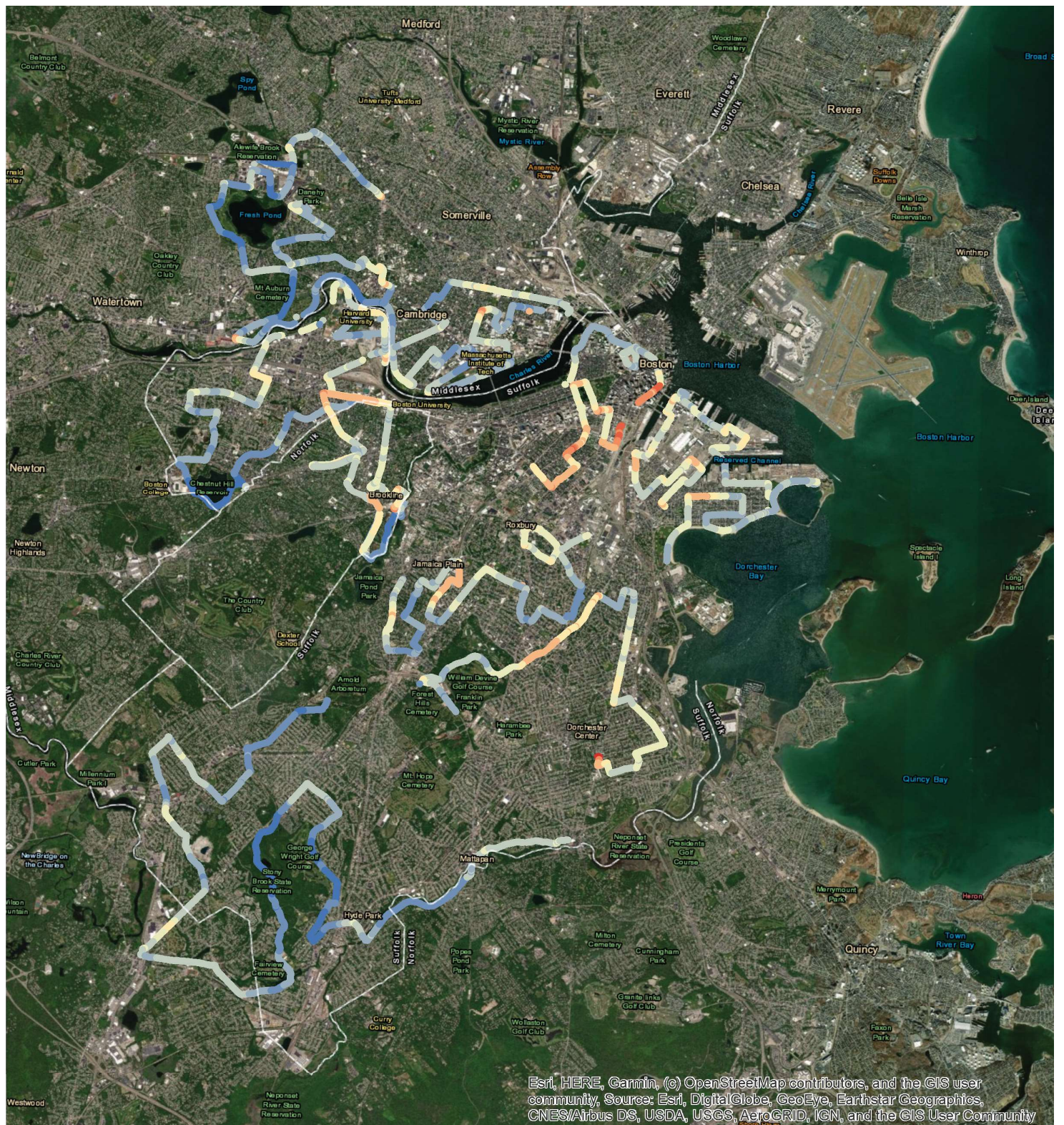
Figure 3: Boston 3-4PM Traverse Point Temperature (°F)

●	87.3 - 88.7	
●	88.8 - 90.0	
●	90.1 - 90.9	
●	91.0 - 91.8	
●	91.9 - 92.7	

●	92.8 - 93.6
●	93.7 - 95.0
●	95.1 - 96.6
●	96.7 - 99.0
●	99.1 - 102.6

0   0.5   1   2   3   4

Miles

N
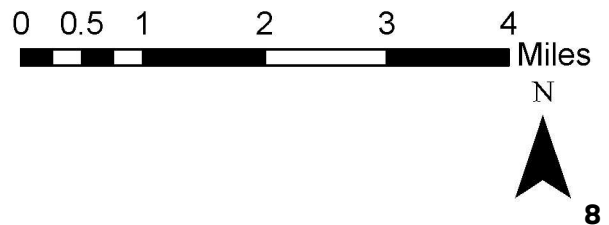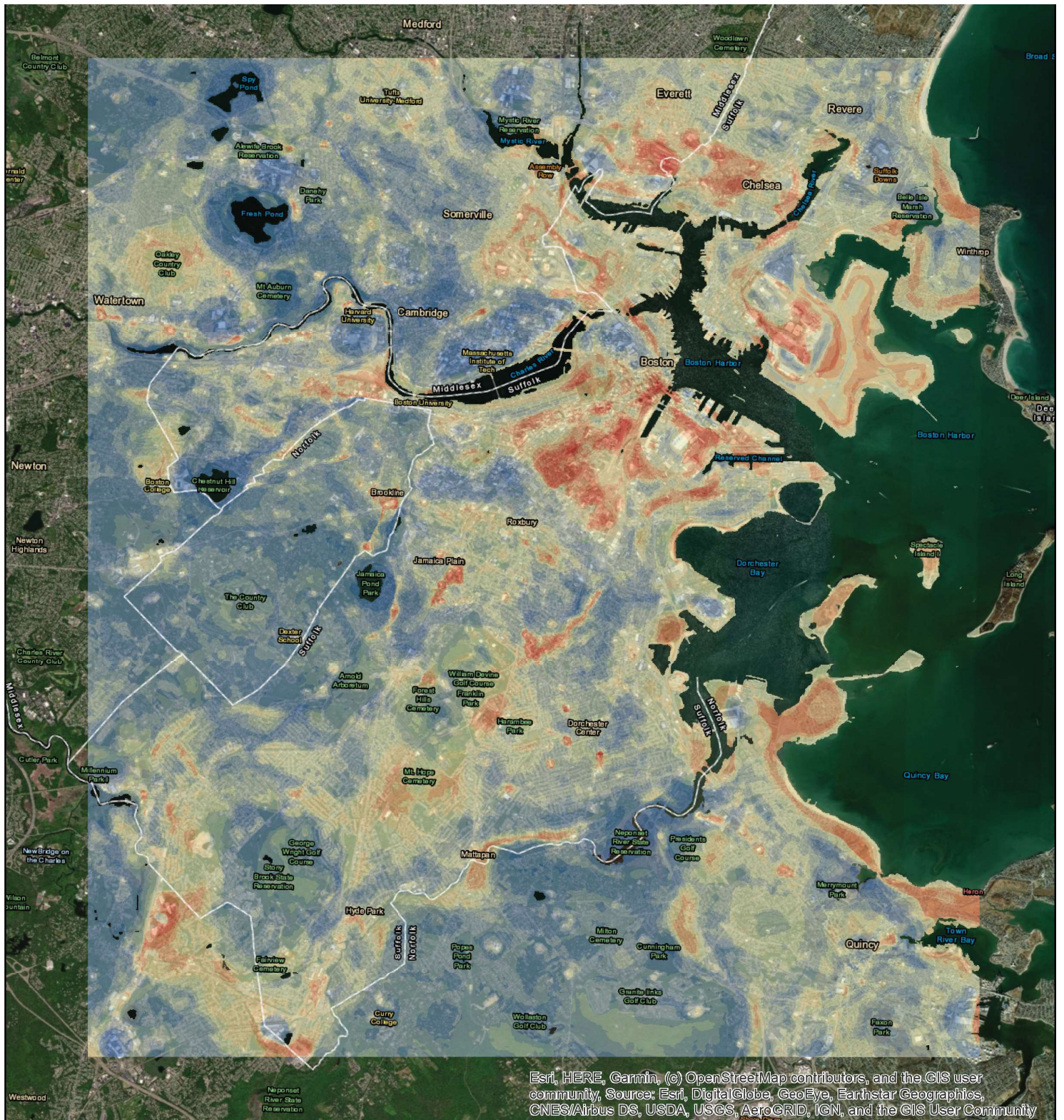
Figure 4: Boston 3-4PM Area-Wide Heat Index (°F)

91.0 - 94.1	97.1 - 97.6
94.2 - 95.0	97.7 - 98.4
95.1 - 95.7	98.5 - 99.5
95.8 - 96.4	99.6 - 101.4
96.5 - 97.0	101.5 - 108.9

0   0.5   1   2   3   4
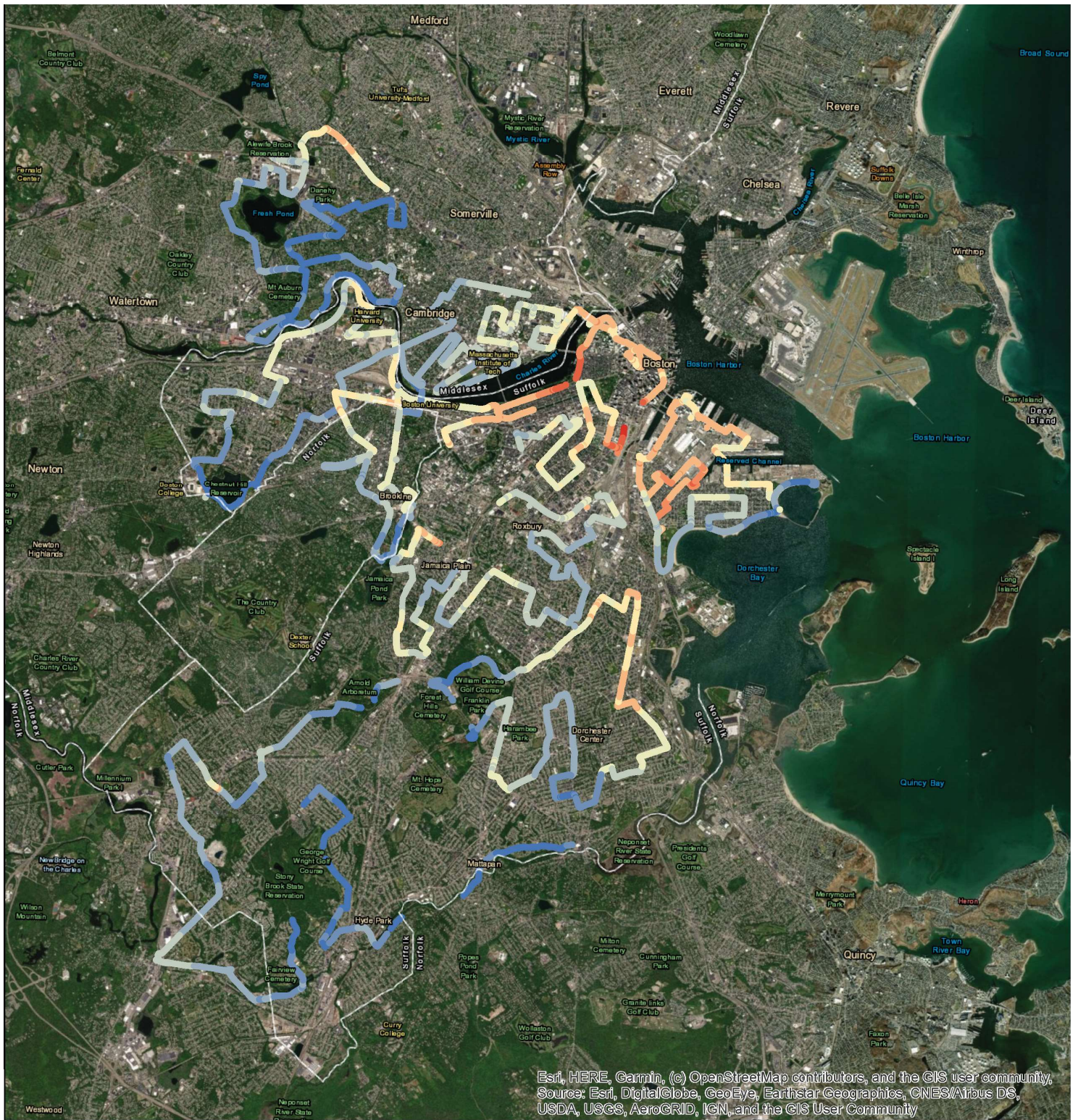
Miles

N
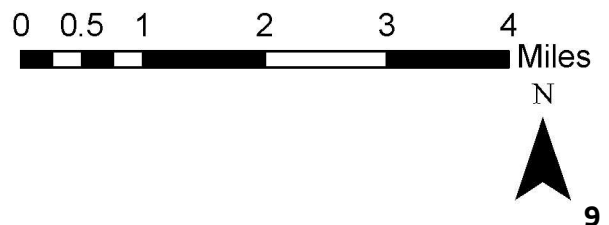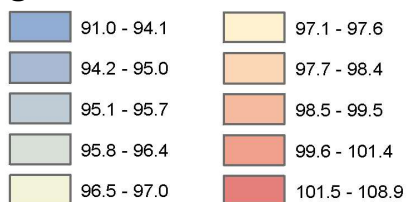
Evening Traverse (7 - 8 pm)

Figure 5: Boston 7-8PM Traverse Point Temperature (°F)

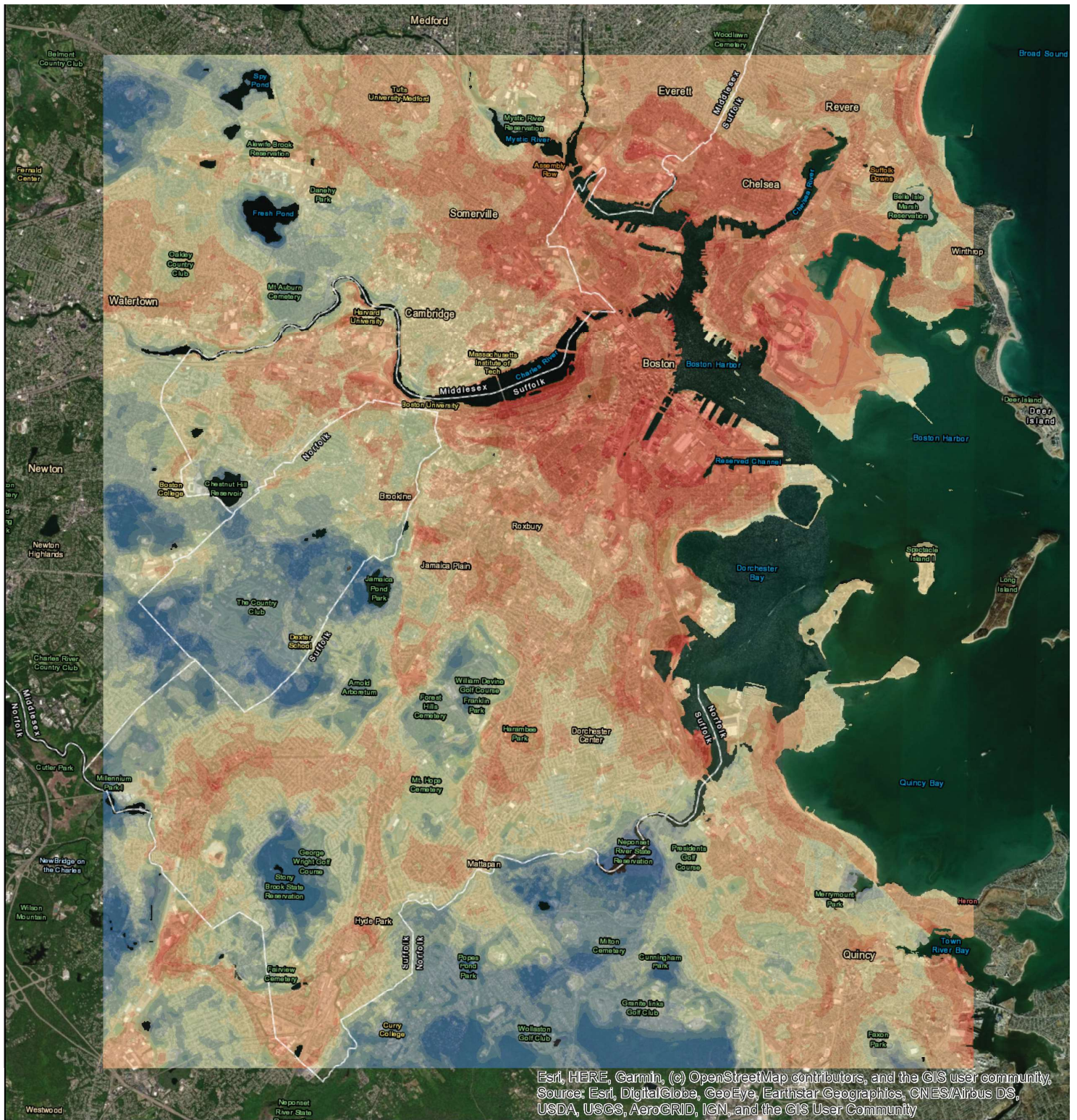|	
● 81.9 - 82.8	● 86.0 - 86.5
● 82.8 - 83.7	● 86.5 - 87.3
● 83.7 - 84.6	● 87.3 - 88.0
● 84.6 - 85.3	● 88.0 - 89.2
● 85.3 - 86.0	● 89.2 - 91.6

0 0.5 1   2   3   4
Miles

N

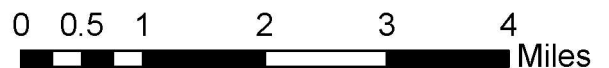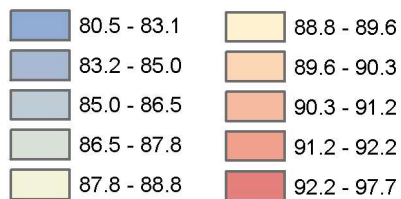**Figure 6: Boston 7-8PM Area- Wide Heat Index (°F)**

Legend:
- 80.5 - 83.1
- 83.2 - 85.0
- 85.0 - 86.5
- 86.5 - 87.8
- 87.8 - 88.8
- 88.8 - 89.6
- 89.6 - 90.3
- 90.3 - 91.2
- 91.2 - 92.2
- 92.2 - 97.7

0 0.5 1 2 3 4 Miles

N

Summary of Findings

Temperature Statistics

Traverse	Temperature (°F)			Heat Index (°F)		
	MIN	MAX	MEAN	MIN	MAX	MEAN
6 - 7 am	71.8	82.7	74.5	73.0	87.7	75.8
3 - 4 pm	87.3	102.2	90.8	90.9	108.6	96.2
7 - 8 pm	78.7	91.1	84.0	80.5	97.7	88.9

Number of Data Points Used

Traverse	Numer of Points
6 - 7 am	20,185
3 - 4 pm	17,129
7 - 8 pm	20,270

Accuracy Assessment* - Adjusted R Square

Traverse	Temperature	Heat Index
6 - 7 am	0.98	0.98
3 - 4 pm	0.96	0.95
7 - 8 pm	0.98	0.97

On July 29th and 30th, 2019, volunteers traversed ten study areas across Boston, Cambridge, and Brookline. The maximum heat measured during the traverses was 102.3 degrees Fahrenheit (near Boston Harbor), with a highest concurrent heat differential of 15 degrees.

*To assess the strength of our predictive temperature models, we used a 70:30 "holdout cross-validation method," which consists of predicting 30% of the data with the remaining 70%, selected randomly. An 'Adjusted R-Squared value of 1.0 is perfect predictability, and 0 is total lack of prediction. Additional information on this technique can be found at the following reference: *Voelkel, J., and V Shandas, 2017. Towards Systematic Prediction of Urban Heat Islands: Grounding measurements, assessing modeling techniques. Climate 5(2): 41.*

Please note that since raw files were used to create a predictive model for these maps, the extent of each map will extend beyond the areas where the data were collected. As such, we suggest interpreting the Heat Index values that extend beyond the traversed areas with caution.
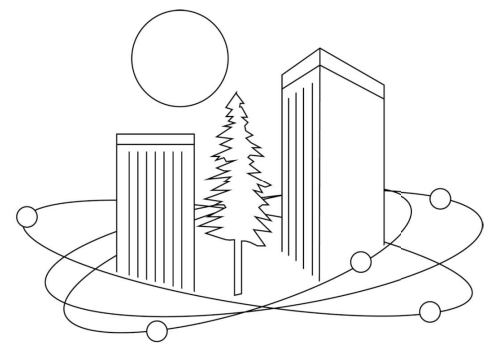

Media Links

New England Cable Network (NECN), "Volunteers Seek to Find Hottest Parts of Boston" July 2019.
https://www.necn.com/news/new-england/Volunteers-Seek-to-Find-Hottest-Parts-of-Boston-513299081.html

NBC 10 Boston, "'Wicked Hot Boston' Study to Find Warmest Spots in City"
https://www.nbcboston.com/news/local/Wicked-Hot-Boston-Study-to-Find-Warmest-Spots-in-City-Museum-of-Science-513418571.html

What's Next?

To further explore how your community's heat distribution affects local populations and infrastructure, we have created a suite of tools that help to organize these variables in user-friendly interfaces.
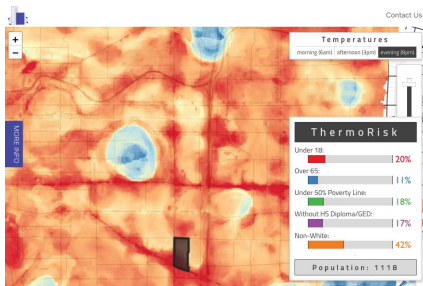

Social Vulnerability

Use Heat Watch data and publicly available demographic information to explore the intersection of urban heat and social vulnerability to better understand the needs of local communities facing the most acute impacts of a warming planet.
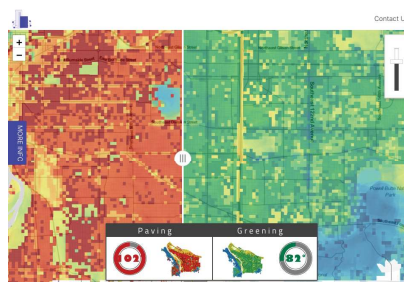
Scenarios of Changing the Built Environment

Using computer models and municipal infrastructure data, this tool shows the effect on heat of changing the built environment. We explore scenarios of increased paving versus greening on heat at the scale of a city-block up to an entire city.
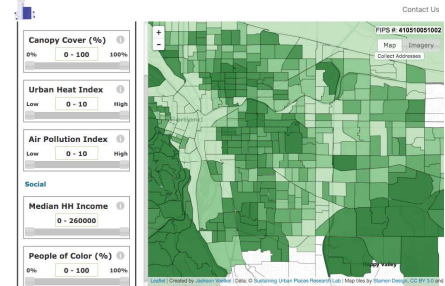
Branch Out

This tool serves as a planting map to identify areas where expanding tree canopy will have direct benefit to social and environmental conditions. By using publicly available data along with socio-demographics, land use, and other datasets, each neighborhood is described in terms of the potential plantable locations.

Growing Capacity

Moving beyond data acquisition and decision support tools, CAPA offers resources and services to build and implement climate preparedness strategies. At CAPA we aim to make climate planning as accessible as possible by offering multiple scales of resources to fit your needs and capacity. Explore openly available tools, request place-specific analyses, or engage our team in facilitating outreach and planning processes. More information available at https://capastrategies.com/growing-capacity.

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