Boston University School of Public Health
Department of Environmental Health

A BETTER CITY

The Boston Foundation

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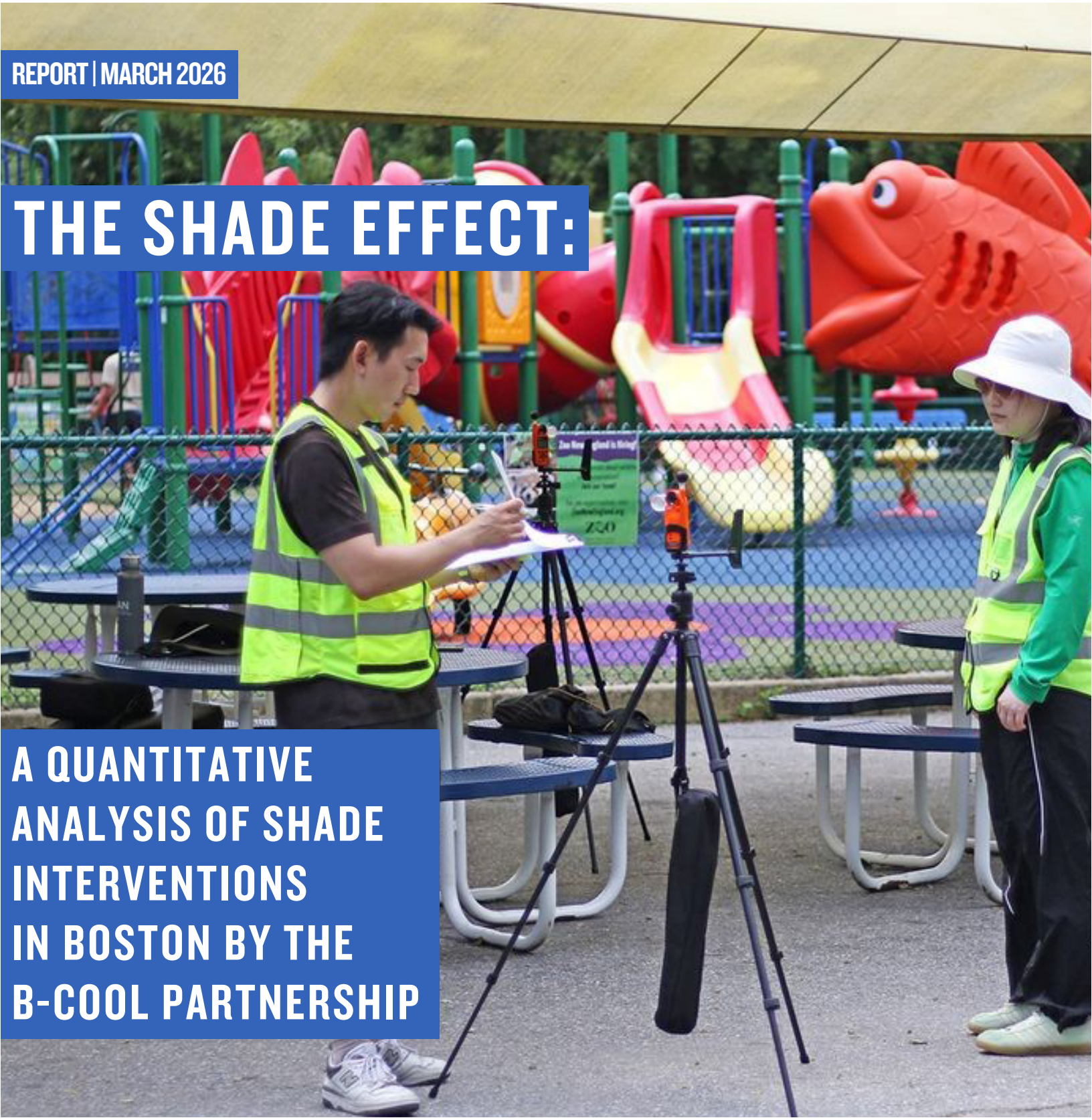
THE SHADE EFFECT:

A QUANTITATIVE ANALYSIS OF SHADE INTERVENTIONS IN BOSTON BY THE B-COOL PARTNERSHIP



Jonathan Lee and Yirong Yuan, BUSPH students and B-COOL sensor monitoring team members, measure the impact of a semi-permanent fabric shade structure over a family picnic area within Franklin Park Zoo.
Photo Credit: Megan Jones, Boston University School of Public Health, Sweating for Science

ACKNOWLEDGEMENTS

This work would not be possible without the cross-sector partnership of B-COOL core partners (Zoë Davis, City of Boston's Office of Climate Resilience; Dr. Patricia Fabián, BU School of Public Health; Julia Howard, The Boston Foundation; and Isabella Gambill, A Better City) and the generous partnership of B-COOL community partners and funders (thanks to our 2025 B-COOL partners: Boston Chinatown Neighborhood Center, Zoo New England/Franklin Park Zoo, Turner Construction Company, and the Office of Climate Resilience's green roof bus shelter team). The B-COOL 2025 temperature sensor work would also not have been possible without the help of many students and staff from the BU School of Public Health, including: Jonathan Lee, Beverly Ge, Yirong Yuan, Priam Vyas, Dr. Jinho Lee, Charlotte Robbins, Grace Betts, Julia Pearl-Schwartz, and others. The B-COOL project was funded by The Boston Foundation (TBF) and Dr. Fabián was funded by the National Oceanic and Atmospheric Administration RISA program. While primary funding for this work was provided by TBF, additional B-COOL staff time was funded by the Barr Foundation, the Wellcome Trust, and the Paul and Edith Babson Foundation. For more information on B-COOL work, A Better City's Heat Working Group, and how to get involved, please contact Isabella Gambill.

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EXECUTIVE SUMMARY

As Boston and other municipalities consider strategies to protect communities and critical infrastructure from extreme heat, the opportunity to increase public access to shade continues to gain momentum. Given the challenges associated with tree planting in the urban context, both temporary and permanent shade structures will become increasingly important heat relief strategies. While we know that shade creates pockets of cooler temperatures, Boston does not have quantitative data to explore how different types of shade impact both air temperature and the extreme heat lived experience.

To address this knowledge gap, on select heat advisory and heat emergency days in July and August 2025, the B-COOL team worked with the Boston Chinatown Neighborhood Center, Boston Office of Climate Resilience, Franklin Park Zoo, and Turner Construction Company to deploy kestrel sensors to measure the impact of different built shade structures on Wet Bulb Globe Temperature (WBGT), which combines solar radiation, wind, and other factors to more accurately reflect the physiological experience of heat outdoors. At each location, the team installed two sensors: one in the direct sunlight and one entirely beneath the shaded structure, on a tripod approximately 4 feet off the ground.

The B-COOL team confirmed the measurable impact of built shade on WBGT across permanent, semi-permanent, and pop-up shade structures, and found a range of an average of 6 degrees F cooling at Franklin Park Zoo's semi-permanent shaded picnic area, to an average of 8.9 degrees F cooling at Turner Construction's outdoor job site, measured underneath a pop-up shade tent for outdoor workers. While such results merely offer a snapshot of cooling effects across different high heat days and locations, the results suggest that all shade structure types have measurable benefits for heat-vulnerable populations. The B-COOL 2025 Shade Effect findings demonstrate that cost-effective built shade solutions have considerable impact on cooling and suggest that built shade should continue to be an extreme heat solution leveraged by public, private, non-profit, and community-based stakeholders to protect heat-vulnerable populations.

B-COOL: LEVERAGING PUBLIC-PRIVATE PARTNERSHIPS FOR SHADE EVALUATION

As most buildings and infrastructure in New England are designed to retain heat, and communities have differing access to air conditioning that is more ubiquitous in southern cities accustomed to high heat, both the City of Boston and Commonwealth of Massachusetts have identified extreme heat as an urgent and increasing threat for our communities, critical infrastructure, and regional economy. As the region seeks to implement heat solutions to help protect our communities, buildings, critical infrastructure, open spaces, ecosystems, and workforce from the heat, which heat solutions are most effective, particularly in urban environments where space for urban tree canopy may be limited, is an open question. While Boston businesses and residents have become increasingly comfortable leveraging "flood deployables" in advance of coastal flooding due to storm surge or king tides, there is less understanding of "heat deployables" or what businesses, residents, and institutions can deploy to provide heat relief in advance of and during heat emergencies and advisories.

The Boston Cools, or B-COOL partnership, emerged in spring 2024, with an initial temperature sensor pilot that sought to evaluate the efficacy of Boston's heat emergency declaration protocols in reflecting the lived heat experiences of the 5 environmental justice heat island neighborhoods referenced in Boston's 2022 Heat Plan, as well as 2 additional neighborhoods for comparison (see the *Feeling the Heat* Report). As a cross-sector partnership between city government (Boston's Office of Climate Resilience), an academic partner with deep expertise in heat monitoring (BU School of Public Health), Boston's community foundation (The Boston Foundation), and non-profit/business stakeholders (A Better City), the B-COOL partnership's strength lies in ensuring that heat research is grounded in community needs, is aligned with the City's ongoing efforts for heat relief, and leverages the power of multi-sector community partners.

The *Feeling the Heat* Report was published in August 2025.

Thanks to the partnership of B-COOL community partners and A Better City's Heat Working Group[1] members, the team worked with Boston Chinatown Neighborhood Center, Franklin Park Zoo, Turner Construction Company, and the City of Boston's Office of Climate Resilience in July and August 2025 to monitor the impact of shade structures on heat exposure for heat-vulnerable populations, a critical step in providing effective and community-driven heat relief. Shade structures were selected based on interests from the city and partner community organizations, and included structures at playgrounds, cultural institutions' outdoor picnic and family areas, outdoor construction sites, and green roof bus shelters along the fare-free Route #28. All structures serve key heat-vulnerable populations: transit-dependent commuters, outdoor workers, and children and families.

The team recorded measurements under and adjacent to shade structures during declared heat emergencies and advisories in Boston using Kestrel sensors, which measure wet bulb globe temperature (WBGT). WBGT combines solar radiation, wind, and other factors that more accurately reflect the physiological experience of heat outdoors, akin to a "feels like" temperature reading (see Images 1 and 2, below).

1 A Better City's Extreme Heat Working Group was initially formed in 2022, in response to the publication of Boston's Heat Plan and 20-Year Urban Forest Plan. Since then, the A Better City Heat Working Group serves as an informal multi-sector coalition that continues to partner with the City, State, and A Better City members and community-based organizations to help implement equitable heat resilience interventions.

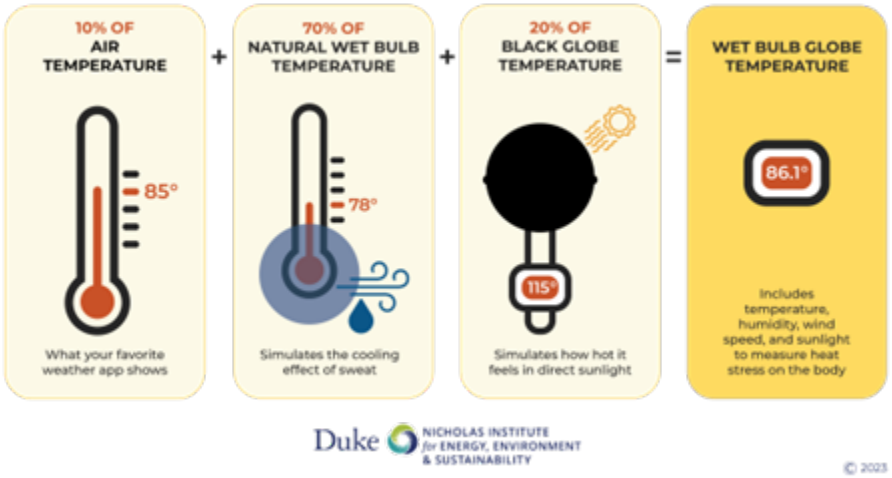

Image 1. Wet Bulb Globe Temperature (WBGT) Definition (source: Duke University's Nicolas Institute for Energy, Environment, & Sustainability).

Suggested Actions and Impact Prevention		
WBGT(F)	**Effects**	**Precautionary Actions**
< 80		
80-85	Working or exercising in direct sunlight will stress your body after 45 minutes.	Take at least 15 minutes of breaks each hour if working or exercising in direct sunlight
85-88	Working or exercising in direct sunlight will stress your body after 30 minutes.	Take at least 30 minutes of breaks each hour if working or exercising in direct sunlight
88-90	Working or exercising in direct sunlight will stress your body after 20 minutes.	Take at least 40 minutes of breaks each hour if working or exercising in direct sunlight
>90	Working or exercising in direct sunlight will stress your body after 15 minutes.	Take at least 45 minutes of breaks each hour if working or exercising in direct sunlight

Image 2. Wet Bulb Globe Temperature (WBGT) Thresholds Relative to Recommended Precautionary Actions (Source: National Weather Service).

RESULTS

Chinatown Shade: Average Heat Index of 95 degrees F, shade cooling average of 7 degrees F (WBGT)

Boston Chinatown Neighborhood Center (BCNC) sits in the middle of Chinatown, one of Boston's hottest neighborhoods, and often uses a ground-level playground for children attending daycare at BCNC. The ground-level playground has semi-permanent, slightly translucent, dark green, high-density polyethylene (HDPE) fabric shade structure flying above the playground equipment that helps to provide heat relief to children during recess. The shade structure fabric, ShadePlay Canopy, is knitted monofilament and tape construction comprised of HPDE with Ultra-Violent Stabilizers. It allows for air flow and can be taken down due to inclement weather or other factors. BCNC is also in the process of renovating a rooftop playground, with interest in additional shade structures to provide further heat relief.

On July 3, 2025, from 11 AM-2 PM the B-COOL team deployed two sensors at the BCNC ground-level playground—one in the direct sunlight and one entirely in the shade—to evaluate the impact of the semi-permanent shade structure (see Image 3, below). With an average heat index of 95 degrees F and full sun on the sampling day, the semi-permanent shade structure at BCNC was found to deliver on average 7 degrees F cooling relief for children playing within the shade, compared to children playing in direct sunlight.

Image 3. Boston Chinatown Neighborhood Center's Ground-Level Playground Shade Structure.

Franklin Park Zoo Shade Structure: Average Heat Index of 97 Degrees F, Shade Cooling Average of 6 Degrees F (WBGT)

The Franklin Park Zoo is one of the B-COOL partner locations that was consistently found to be a "cool spot" in the 2024 temperature sensor pilot, likely due to its extensive surrounding greenspace and limited impervious structures. In 2025, the Zoo wanted to assess the impact of a semi-permanent, opaque yellow, high-density polyethylene (HDPE) fabric shade structure above a family picnic area (adjacent to a playground), to better understand how heat-vulnerable visitors, including children, were benefitting from shaded heat relief. These learnings could also inform efforts to better understand how additional shade might benefit animals at the Zoo.

On June 25, 2025, from 11 AM-2 PM, the B-COOL team deployed two kestrel sensors at the Franklin Park Zoo— one in the direct sunlight and one entirely in the shade—to evaluate the impact of the semi-permanent shade structure (see Image 4, below). With an average heat index of 97 degrees F, and a mix of full sun and partly cloudy conditions, the team found that the Zoo's semi-permanent, opaque yellow, HDPE fabric shade structure protecting an outdoor lunch and seating area next to a playground, provided an average of 6 degrees F cooling to children, the elderly, and families seeking heat relief in full sun, and an average of 4 degrees F heat relief in partial sun/overcast weather.

Image 4. Franklin Park Zoo Shade Structure, Picnic Table and Playground Area.

Turner Construction Company's Outdoor Construction Site: Heat Index of 94 Degrees F, Shade Cooling Average of 8.9 Degrees F (WBGT)

The Turner Construction Company (Turner) is a national leader in providing worker protections during extreme heat and continues to be on the leading edge of voluntary heat worker protections in Boston. Given the A Better City Heat Working Group's interest in how to protect outdoor workers in the heat, the B-COOL team worked with a Turner jobsite team to evaluate the impact of a pop-up, opaque white, polyester fabric shade tent on outdoor workers. The pop-up tailgate canopy is constructed of polyester fabric with a silver-coated interior complete with air vents, providing UPF 50+ and UV protection. In addition to evaluating the temporary pop-up shade tent, the B-COOL team also had the opportunity to learn from Turner's heat safety interventions, which include providing ample breaks, water, and other heat-relieving resources; creating underground "cooling shacks" in neighboring parking garages, with air conditioning for workers to cool down as needed; and hiring a full-time medic to keep an eye on workers for signs of heat stress.

On August 11, 2025, from 11 AM-2 PM, the B-COOL team deployed two kestrel sensors at the Turner outdoor construction site in the Seaport—one in the direct sunlight and one entirely in the shade—to evaluate the impact of the pop-up shade structure (see Images 5 and 6). With an average heat index of 94 degrees F and partly cloudy skies, the team measured a shade cooling difference of an average of 8.9 degrees F underneath the pop-up, opaque white, polyester fabric shade tent. Interestingly, even though the monitoring day was partly cloudy, and the jobsite was directly on the water with a coastal breeze in one of Boston's least hot neighborhoods, the pop-up shade tent still provided significant relief to outdoor workers.


Images 5 and 6. Turner Outdoor Construction Site Location.

Route #28 Green Roof Bus Shelters: Heat Index of 100 Degrees F, Shade Cooling Average of 7.6 Degrees F (WBGT) at Green Roof Bus Shelter Location vs. 1.6 Degrees F (WBGT) Cooling at Clear Bus Shelter

In 2025, the City of Boston installed the largest deployment of green roof bus shelters in the nation, with 30 green roof bus shelters along the fare-free Route 28 across the environmental justice and highly transit-dependent neighborhoods of Dorchester, Mattapan, and Roxbury. As highlighted in the City's press release, the green roofs, "feature drought-resistant plantings that will help provide shade, improve air quality, increase stormwater retention, and add new green space along the bus route." Alongside anticipated heat relief provided by the 30 green roof bus shelters, the City of Boston also launched this pilot to provide stormwater retention co-benefits. Combined, they have the estimated potential to absorb up to 1,500 gallons during a 1-inch rainfall, significantly reducing runoff and preventing localized flooding. Given the high heat vulnerability of transit-dependent riders, and the increased risks of waiting outside for a bus during the summertime heat and potential bus delays, both the City of Boston and A Better City's Heat Working Group were very interested in understanding how these green roof bus shelters and their shade impact lived heat experiences of riders.

On June 24, 2025, from 11 AM-2 PM, the B-COOL team deployed two kestrel sensors—one in direct sunlight and one in entirely in the shade—at two Route #28 bus shelter locations: one with a newly retrofitted green roof and one with its original clear plexiglass roof, serving as a control (see Images 7-10, below). With an average heat index of 100 Degrees F (considered a record-breaking heat day for Boston) and full sun, the team found that permanent shaded green roof bus shelters provided an average of 7.6 degrees F heat relief to riders. On the other hand, the plexiglass clear roof only provided an average of 1.6 degrees F reduction.

The sizeable heat reduction benefits from green roofs could make the case for why green roof bus shelters should be expanded to other bus routes throughout the City to help broaden heat relief for transit-dependent riders. Additionally, it is important to note that for green roof bus shelters and many horizontal shade structures, maximum shade benefits are provided when the sun is directly overhead the bus shelter roof (closest to midday/noontime).

Images 7 and 8. Green Roof Bus Shelter Location in Grove Hall with B-COOL Kestrel Sensors (left) and Aerial View of a Route #28 Green Roof Bus Shelter (right, courtesy of City of Boston).

Images 9 and 10. Clear Roof Bus Shelter Location in Grove Hall with B-COOL Kestrel Sensors

Summary of B-COOL Shade Monitoring Results

A summary comparison chart of measured shade impact by location and shade type is included in Table 1 below.

Table 1. Summary chart of B-COOL shade monitoring results.

Shade Monitoring Location	**Shade Type**	**Measured Cooling Average Temperature Reduction (Wet Bulb Globe Temperature)**	**Relevant Heat Vulnerable Populations**
Boston Chinatown Neighborhood Center Ground-Level Playground	Semi-Permanent (slightly translucent, dark green, high-density polyethylene fabric shade structure)	7 Degrees F*	Children
Franklin Park Zoo Family Picnic Area	Semi-Permanent (opaque yellow, high-density polyethylene opaque fabric shade structure)	6 Degrees F*	Children and Families
Turner Construction Company Outdoor Construction Site	Pop-Up (opaque white, polyester fabric pop-up tent)	8.9 Degrees F*	Outdoor Workers
Green Roof Bus Shelter Route #28 bus stop	Permanent (green roof)	7.6 Degrees F*	Transit-dependent riders
Clear Roof Bus Shelter (control) Route #28 Bus Stop	Permanent (clear plexiglass roof)	1.6 Degrees F*	Transit-dependent riders

Note: measured cooling averages were taken on different monitoring days, across different locations in the city, indicating a snapshot of cooling rather than a direct comparison across shade typologies

KEY TAKEAWAYS

There are several key takeaways from the 2025 B-COOL Shade Effect Pilot that could help to inform future work in Boston's heat resilience and similar work in other jurisdictions. Key takeaways include:

- **2025 B-COOL shade structure evaluation data convey significant heat-relieving benefits** to heat-vulnerable populations and suggest that permanent (green roof bus shelters), semi-permanent (shade fabric above playgrounds and picnic areas), and pop-up (pop-up shade tent) shade solutions all contribute significantly to reducing extreme heat exposure.

- **B-COOL shade evaluation data demonstrate differences in cooling averages by shade type**, **suggesting differences across shade materials** (e.g., fabric vs. green roof) and shade type (e.g., opaque vs. semi-translucent vs. clear). Since B-COOL shade interventions were monitored on different days and at different sites, future work may consider monitoring different shade materials and types at the same location, on the same day and timeframe, for more direct comparison. Additional analysis may further consider material color and composition.

- **These data also suggest that effective shade interventions can be made accessible to a variety of stakeholders**, from more permanent green roof bus shelters that also provide stormwater retention, air quality, and green infrastructure co-benefits, to semi-permanent fabric shade structures, and even pop-up shade tents or deployables, which are considerably more affordable, flexible, and accessible.

- **B-COOL data from the outdoor construction monitoring site suggest that even in partly cloudy conditions, like when the team went to a coastal construction site on a partly cloudy day in August, pop-up shade deployables can provide significant cooling benefits**.

- **Beyond outdoor workers, pop-up shade heat deployables could be a significant tool in helping to protect heat-vulnerable populations like the unhoused, transit dependent commuters, and even sporting event athletes and spectators**. Pop-up shade structures could be deployed citywide and especially in heat island hot spot locations, ranging from pop-up shade at Boston neighborhood block parties to protecting visitors for the 2026 FIFA World Cup, to expanding pop up shade medical tents for heightened bed capacity in hospital parking lots for triage during heat emergency-related surges in the Emergency Department.

• **With the anticipated release of Boston's 2030 Climate Action Plan in spring 2026, there are several climate action strategies relevant to heat relief, including the intent for heat-relieving deployables** in public parks and publicly accessible open spaces, which could be informed by B-COOL shade structure evaluation data.

• A critical takeaway from both the 2025 B-COOL Shade Effect Pilot as well as the 2024 B-COOL Temperature Sensor Pilot is the **outsized impact that a strong network of partners and collaborators, in this case building off A Better City's Heat Working Group, can have on informing and piloting equitable heat resilience solutions.** Through this multi-year and multi-sector partnership, the B-COOL team's work has been presented to local, regional, state, and national audiences, and can be a replicable model for cross-sector partnerships in extreme heat resilience.

• In addition to these key takeaways, building on the collaborative spirit of the B-COOL project, **the City of Boston will release a "heat research agenda" this spring that outlines exploratory questions across a range of heat resilience topics** to guide future collaboration and implementation.

ADDITIONAL STATEMENTS FROM 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

"Our work in the last years has demonstrated the utility of local temperature monitoring to inform local decisions that improve heat health for residents, and the tremendous value of researcher-city-local organization partnerships in advancing climate resilience."

Chris Osgood, Director of Climate Resilience, City of Boston

"Last summer, Boston faced record-breaking temperatures that triggered multiple heat emergencies, underscoring the growing climate risks facing our residents and infrastructure. The findings from the B-COOL Pilot will be instrumental as we implement the right tools to protect our most heat-vulnerable neighbors."

Julia Howard, Senior Program Officer of Climate, The Boston Foundation

"This summer's study further demonstrates the potential value of localized temperature sensing to inform solutions that can improve the health and safety of every Boston resident. Building community resilience against the effects of extreme heat will take an all hands on deck effort, which is why we are grateful to be part of the B-COOL team, bringing the private and public sectors to collaborate and develop innovative, data-driven solutions."

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

"A Better City was thrilled to partner on the B-COOL 2025 Shade Effect Pilot to better understand how shade structures—whether permanent, semi-permanent, or pop-up—can be a powerful tool for bringing heat relief to vulnerable populations in in Greater Boston. As the region prepares to host a triumvirate of national and global events this summer, A Better City remains committed to working with member and partners alike to develop new strategies for measuring and combatting the impact of extreme heat on our communities, our infrastructure, and our economy."

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