

COOLING URBAN HEAT

Understanding and Addressing Extreme Heat in Cities

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Executive Summary

Extreme heat poses a significant threat to public health in the United States, causing more fatalities than all other weather-related incidents. Despite its deadly impact, people fear heat less than they do storms and tornadoes. Official statistics underestimate heat deaths due to delayed or indirect effects, earning heat the moniker of the "silent killer."

Urban areas, with their concentration of people, physical infrastructure, and activities, intensify heat, creating urban heat islands. These islands amplify heat, worsen air quality, and strain energy grids, impacting various demographics, including pregnant people and children, elders, outdoor workers, unhoused individuals, and low-income individuals. Mayors can mitigate the harmful effects of extreme heat with six actions:

1. Assign a Point Person: Designate a person responsible for extreme heat preparedness and response because cross-agency collaboration is essential to a proactive approach.
2. Develop a Heat Mitigation Strategy: Craft a comprehensive strategy tailored to the city's unique needs, drawing from models in Boston, Miami, New York City, and Phoenix.
3. Lead by Example: Mayors can set an example by making city buildings and public spaces heat responsive and by protecting outdoor city workers in extreme heat. Green roofs, shade structures, cool roofs, passive cooling technologies, and access to hydration can be incorporated into city buildings and public spaces to reduce heat impact.
4. Educate the Public: A mayor's messaging is important, because many people don't know the dangers of extreme heat or the warning signs of distress or basic mitigation strategies.
5. Deploy Stimulus Funds: Capital investments, like trees and shade structures and improving energy efficiency, as well as bold ideas, like thermal cooling systems or reconfiguring cities to increase greenspace can leverage federal stimulus funding while yielding long-term benefits.
6. Implement Incentives and Regulations: Provide incentives for homeowners, developers, and businesses to invest in cool roofs, shading, and energy-efficient upgrades.

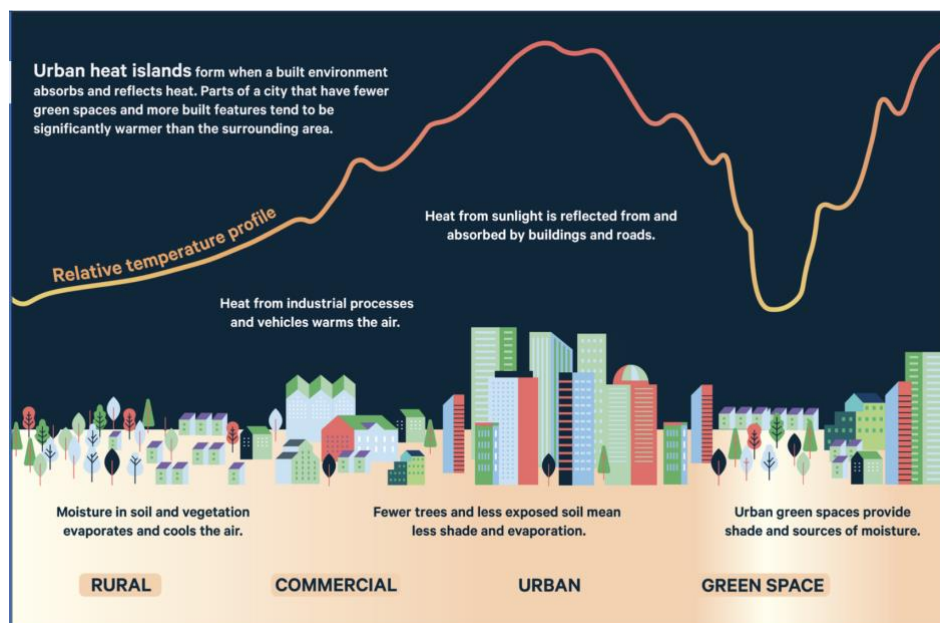
This paper describes mayoral actions to mitigate the impact of extreme heat on their communities.

Understanding the Problem

Extreme heat kills more people in the U.S. than any other weather-related disaster, including hurricanes, floods, or winter storms.¹ Yet, when researchers asked people which weather events they thought were dangerous, three times as many feared storms and tornadoes as did heat.²

Cities are concentrated centers of economic and social activity – and heat. The very things that make a city vibrant - population density; proximity to a variety of tightly connected hubs of culture, industry, and recreation, also concentrate energy use and heat. And the problem of urban heat is not new, with documentation of higher temperatures in London than in the surrounding areas as far back as 1807.³

Key elements of urban design amplify heat. Cities have less tree cover and fewer open spaces than suburban and rural areas, so heat has less opportunity to dissipate. Concrete, asphalt, steel, and tall buildings absorb and radiate heat, causing what is known as urban heat islands where temperatures are higher than in open and green spaces where airflow and shade are greater, as shown in the diagram below.



Source: Resources for the Future (rff.org), included in City of Chicago presentation to Harvard Community Data Health Initiative, May 9, 2024.

¹ Climate Central, "Heat and Hospitalizations." *Climate Matters*, July 2021, <https://www.climatecentral.org/climate-matters/heat-and-hospitalizations>.

² Alisa L. Hass, and Kelsey N. Ellis. 2019. "Motivation for Heat Adaption: How Perception and Exposure Affect Individual Behaviors During Hot Weather in Knoxville, Tennessee" *Atmosphere* 10, no. 10: 591. <https://doi.org/10.3390/atmos10100591>.

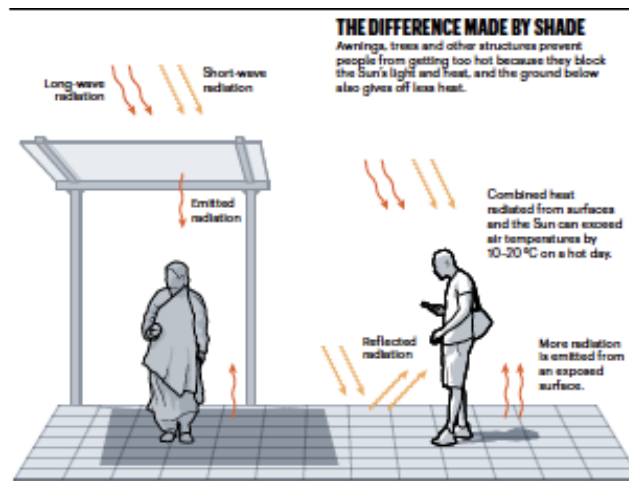
³ Luke Howard, *The Climate of London*, 1833. https://docs.ufpr.br/~feltrim/LIVROS/LukeHoward_Climate-of-London-V1.pdf.

Urban heat islands generate temperatures as much as 22 degrees F⁴ higher than in surrounding areas⁵ for a variety of reasons including but limited to:

- Paved surfaces retain higher temperatures than green spaces and vegetation.
- During extreme heat, urban density intensifies heat and makes it harder for surfaces to cool overnight, which can lead to more heat health impacts on the public.
- When tall buildings cluster together, they can create “canyons” that trap warm air.

Some impacts of heat are felt city-wide. For example, extreme heat events increase demand for energy use, which strains the electrical grid. Extreme heat can slow transit when rails need to be protected, and extreme heat can also exacerbate existing poor air quality.

Other impacts are directly felt by people. Exposure to extreme heat, especially for an extended period or when evening temperatures do not drop, puts people at risk of illness and death. Many people are impacted by extreme heat, from children who can’t play outdoors and isolated elders stuck indoors to outdoor workers and athletes who require hydration and shade or breaks to avoid heat illness. Low-income individuals are also at increased risk – researchers found that over half of people in one city were reluctant to use air conditioning due to the cost of the electricity.⁶ Urban dwellers exposed to sun without shading can suffer in extreme heat, as shown in the diagram below.



Source: Turner et al, Nature, 2023

⁴ Note that all temperatures are in Fahrenheit in this paper. Much of the academic literature uses Celsius measurements, and where necessary those values have been translated into Fahrenheit.

⁵ CalEPA, “Understanding the Urban Heat Island Index.” *California Environmental Protection Agency*, <https://calepa.ca.gov/climate/urban-heat-island-index-for-california/understanding-the-urban-heat-island-index/>.

⁶ Scott Sheridan et al., “A Survey of Public Perception and Response to Heat Warnings across Four North American Cities: An Evaluation of Municipal Effectiveness,” *ResearchGate*, 2007, https://www.researchgate.net/publication/6771452_A_Survey_of_Public_Perception_and_Response_to_Heat_Warnings_across_Four_North_American_Cities_An_Evaluation_of_Municipal_Effectiveness.

Official statistics underestimate heat deaths because they are not always accurately counted - the impact can be delayed or indirect, and seldom recorded on a death certificate. For example, a heart attack caused by exposure to excessive heat may well be recorded as a heart attack death without attribution to heat as an underlying cause. Hence heat is referred to as the “silent killer.” The NYC Health Department, in their analysis of heat-related mortality in New York City estimated the true impact of heat on health by calculating excess deaths on extreme heat days – the result: 50 times as many deaths on extreme heat days indirectly caused by heat.⁷

An EPA review of prior research found that the neighborhoods with highest temperatures are those where low-income individuals and people of color reside.⁸ Research has also shown that wealthier neighborhoods have the lowest temperatures during extreme heat events because they have more trees and vegetation, which have a cooling effect.⁹ A *New York Times* study using infrared cameras to measure surface temperatures captured a 31 degree F difference on a high heat day between two neighborhoods, one with and one without heat mitigating vegetation and shade.¹⁰ Susannah Burley, director of Sustaining Our Urban Landscape (SOUL), a New Orleans urban reforestation nonprofit reflecting on the city’s tree survey noted, “Anybody who works with trees knows that trees are barometers of health and wealth. This just proves what I think we’ve all known anecdotally for a long time.”¹¹

Every city has its own unique pattern of where heat is concentrated based on local building styles and materials, and the age and height of buildings as well as the amount of open and green space. Within cities, microclimates reflect neighborhood differences in the balance of impervious surfaces like pavement to trees and other vegetation, as well as the age and quality of the housing stock, and environmental factors such as vehicular traffic and idling patterns as well as proximity to industrial sites. For example, one neighborhood in Baltimore with an extreme heat problem is near a waste management site. According to Benjamin Zaitchik, PhD, professor of Earth and Planetary Sciences at Johns Hopkins, “The incinerators are a very big deal here in Baltimore, and so is traffic. Industrial activity directly contributes heat to the environment. These factors work in concert to create a bigger public health problem.”¹²

⁷ New York City Department of Health and Mental Hygiene, Health Data Portal, 2024 NYC Heat-Related Mortality Report, <https://a816-dohbep.nyc.gov/IndicatorPublic/data-features/heat-report/>.

⁸ U.S. Environmental Protection Agency (EPA), *Heat Islands and Equity*, <https://www.epa.gov/heatislands/heat-islands-and-equity>.

⁹ Sharon L. Harlan, Anthony J. Brazel et al., “Neighborhood microclimates and vulnerability to heat stress” *Social Science & Medicine*, Vol. 63, Issue 11, 2006, <https://www.sciencedirect.com/science/article/abs/pii/S027795360600373X>.

¹⁰ John Leland, “Why an East Harlem Street Is 31 Degrees Hotter Than Central Park West,” *The New York Times*, August 20, 2021, <https://www.nytimes.com/2021/08/20/nyregion/climate-inequality-nyc.html>.

¹¹ Philip Kiefer, “What’s Happening to the Trees in New Orleans?” *Bloomberg*, May 10, 2023, <https://www.bloomberg.com/news/articles/2023-05-10/new-orleans-tree-survey-shows-ongoing-effects-of-hurricane-katrina>.

¹² Aman Azhar, “From the Middle East to East Baltimore, a Johns Hopkins Professor Works to Make the City More Climate-Resilient,” *Inside Climate News*, June 8, 2022, <https://insideclimatenews.org/news/08062022/baltimore-professor-heat-trees-climate-resilient/>.

Extreme weather events are making headlines at an increasing rate, and mayors are under pressure to be ready for the next one. Mayors may not be able to control the weather, but they can control how their cities prepare for and respond to extreme heat events, and how the city reaches out to vulnerable populations who are most at risk of suffering health and economic impacts of extreme heat. Jeff Goodell, author of *The Heat Will Kill You First* puts the policy challenge of urban heat bluntly,

“Despite the fact that cities are full of people, urban heat has the perverse effect of creating islands of isolation and hardship for anyone without the means or the social connections to access cool spaces. It makes the hardship of poverty harder and turns even the simplest tasks of daily life into risky adventures.”¹³

The goal of this paper is to help mayors and their teams better understand the challenges of extreme heat in cities, and to generate ideas for their own unique plan to address it.

¹³ Jeff Goodell, *The Heat Will Kill You First: Life and Death on a Scorched Planet*, Little Brown and Company, 2023, p 68.

Understanding Public Impact

The impact of extreme heat on city residents spans a variety of policy areas, necessitating an all-of-government response. The impact is described for health and safety, social equity, economic viability and infrastructure strain.

Health and Safety

Sustained exposure to extreme high temperatures can cause dehydration, heat exhaustion, heat stroke, and death. Heat can destabilize those in precarious health and set off a downward spiral of heat-related ill health that can later lead to long term problems or death.

Health care visits and costs soar in an extreme heat event. Researchers at the Environmental Protection Agency's Office of Atmospheric Protection looked at emergency room visits across 47 children's hospitals in the US and found that children had a 17 percent greater likelihood of an emergency department (ED) visit on high heat days, and that each degree above 62 degrees F was associated with a 0.5 percent increase in daily incidence of ED visits.¹⁴ Based on higher ED visits, increased hospitalizations, and increased appointments for doctor's visits, one study estimated that health care costs for the US would be increased by \$1 billion each summer due to health impacts of extreme heat.¹⁵

Among the most vulnerable populations for heat risk include:

- **Pregnancy and infants.** Children suffer from extreme heat even before they are born with implications that can potentially span their entire life. During pregnancy, the body already produces extra heat, so extreme heat has a disproportionate impact on pregnant people and their unborn children.¹⁶ Extreme heat exposure in pregnancy is associated with a 25%¹⁷ increased risk of preterm birth, as well as increased risk for low birth weight, and stillbirth. Babies born during extreme heat waves are much more likely to have short-term (still births, premature births, birth defects) and long-term (developmental and cognitive issues, diabetes, asthma, congenital heart defects) adverse health outcomes.¹⁸

¹⁴ U.S. Environmental Protection Agency (EPA), "Climate Change and Children's Health and Well-Being in the United States," April 2023, https://www.epa.gov/system/files/documents/2023-04/CLiME_Final%20Report.pdf.

¹⁵ Steven Woolf et al, "The Health Care Costs of Extreme Heat," *Center for American Progress*, June 27, 2023, <https://www.americanprogress.org/article/the-health-care-costs-of-extreme-heat/>.

¹⁶ Early Childhood Scientific Council on Equity and the Environment. (2023). *Extreme Heat Affects Early Childhood Development and Health: Working Paper No. 1*. Retrieved from www.developingchild.harvard.edu.

¹⁷ Connor Y. H. Wu, Benjamin F. Zaitchik, Samarth Swarup & Julia M. Gohlke (2019) "Influence of the Spatial Resolution of the Exposure Estimate in Determining the Association between Heat Waves and Adverse Health Outcomes," *Annals of the American Association of Geographers*, 109:3, 875-886, DOI: 10.1080/24694452.2018.1511411.

¹⁸ Sandie Ha, "The Changing Climate and Pregnancy Health," *Curr Environ Health Rep*. 2022 Jun;9(2):263-275. doi: 10.1007/s40572-022-00345-9. Epub 2022 Feb 22. PMID: 35194749; PMCID: PMC9090695. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9090695/>.

- **Children.** Extreme heat makes it harder for children to safely play outdoors, undermining their physical and mental development and wellbeing. Babies do not perspire as much as adults, and children don't fully develop this capacity until their teens, so children are more likely than adults to overheat on high heat days, and they are frequently dependent on adults for protection and care and may not notice the signs of heat distress in themselves.¹⁹ As noted by Dr. Lindsey Burghardt Chief Science Officer at the Center on the Developing Child at Harvard University, "When it comes to young children, the ability to play, explore and move around your environment with both curiosity and comfort is so intangible and hard to measure. It's also critically important for healthy development, and as temperatures rise, we need to ensure we find ways to cool children's environments to support this kind of playful exploration and protect against the effects of extreme heat."²⁰
- **Students in schools.** A meta-analysis of published evidence, across countries and decades, on the effects of temperature in classrooms on children's performance in school found a consistent relationship between heat and decreased school performance and identified larger performance gaps for children who already were challenged. This research also found that the optimal temperature for learning for children is lower than the optimal temperature for adult cognitive performance in an office.²¹ The researchers who analyzed these studies predicted up to 20 percent improvement in cognitive gain for children in schools where optimal temperature can be achieved. A national study conducted by the American Economic Association found that for youth in schools without air conditioning, 1 degree of additional heat lowers learning by 1 percent, due to both teacher and student challenges in focus and attention. Further, this study found that 5 percent of the racial school achievement gap could be attributed to heat in schools without air conditioning.²² A study of students taking the NYC high school exit exam found that those who took the exam on a 90 degree day had a 12 percent greater chance of failing a subject and a 2.5 percent lower chance of on time high school graduation than those who took the exit exam on a 72 degree day.²³
- **People with underlying medical conditions.** Those with existing medical conditions including respiratory, cardiovascular, and kidney disease are more vulnerable to heat-related illness. The NYC Health Department's analysis of heat-related mortality found that 93 percent of those who died of heat had one or more underlying health

¹⁹ Presentation of Lindsey Burghardt, MD, MPH, FAAP to Harvard Community Data Health Initiative, May 9, 2024.

²⁰ Harvard Center on the Developing Child, The Brain Architects Podcast: Extreme Heat & Early Childhood Development: A Discussion on Rising Temperatures and Strategies for Supporting Development and Lifelong Health, April 2024. <https://developingchild.harvard.edu/resources/the-brain-architects-podcast-extreme-heat/#transcript>.

²¹ Pawel Wargocki, Jose Ali Porras-Salazar, Sergio Contreras-Espinoza, "The relationship between classroom temperature and children's performance in school," *Building and Environment*, Volume 157, 2019, Pages 197-204, ISSN 0360-1323, <https://doi.org/10.1016/j.buildenv.2019.04.046>.

²² Jisung R. Park, Joshua Goodman, Michael Hurwitz, and Jonathan Smith. 2020. "Heat and Learning." *American Economic Journal: Economic Policy*, 12 (2): 306–39. DOI: 10.1257/pol.20180612.

²³ Jisung Park, "Temperature, Test Scores, and Human Capital Production," *Harvard University*, February 26, 2017, https://scholar.harvard.edu/files/jisungpark/files/temperature_test_scores_and_human_capital_production_-_j_park_-_2-26-17.pdf.

conditions, most commonly cardiovascular disease.²⁴ Recent research shows that extreme heat, combined with pollution, can increase incidence of heart attack.²⁵

- **Elderly.** A study of NYC resident deaths and weather from 2000-2011 found that 73 percent of heat related deaths were for individuals 65 years of age or older.²⁶ Older adults are at greater risk of heat-related illness because they are more likely to have chronic conditions, or take medications, that affect how their bodies respond to heat. Even without a health condition, older bodies don't adjust as quickly to dramatic changes in temperature. Many seniors live on a fixed income, and research shows that low-wealth households may not be able to afford to adequately cool their living spaces. Elders may also be socially isolated or have limited mobility. For seniors who spend large amounts of time indoors, having and using air conditioning (AC) can make a big difference.

Social Equity

Some city residents may have little choice but to keep working through oppressive heat, whether in kitchens, near heat-generating machinery, or outdoors in the sun. One study described how low wage workers were unable to access cooling or take breaks for hydration in extreme heat.²⁷ Further, in some cities older housing stock puts residents at risk because of poor insulation, leading to leakage of cool air and/or higher costs when air conditioning is used. The cost burden of electricity for air conditioning is a barrier to use for some low-income individuals.

During extreme heat events, racial disparities are exacerbated. The NYC Health Department found a rate of heat mortality more than twice as high for Black New Yorkers compared to their white and Hispanic neighbors.²⁸ Research that examined 108 urban areas across the US showed that neighborhoods in historically redlined areas consistently had temperatures that were warmer than in non-redlined areas for a variety of reasons including less tree cover and more heat-trapping buildings and roads.²⁹ This study showed a nationwide average increase of 2.6

²⁴ New York City Department of Health and Mental Hygiene, Health Data Portal, 2024 NYC Heat-Related Mortality Report, <https://a816-dohbesp.nyc.gov/IndicatorPublic/data-features/heat-report/>.

²⁵ Ruijun Xu, MD, Suli Huang, MD, PhD, Chunxiang Shi, PhD, Rui Wang, MD, Tingting Liu, MS, Yingxin Li, MD, Yi Zheng, MD, Ziquan Lv, MD, PhD, Jing Wei, PhD, Hong Sun, MD, PhD, Yuewei Liu, MD, PhD, Extreme Temperature Events, Fine Particulate Matter, and Myocardial Infarction Mortality, *Circulation*, July 24, 2023, <https://www.ahajournals.org/doi/full/10.1161/CIRCULATIONAHA.122.063504>.

²⁶ Jamie Madrigano, Ito K, Johnson S, Kinney PL, Matte T. A Case-Only Study of Vulnerability to Heat Wave-Related Mortality in New York City (2000-2011). *Environ Health Perspect*. 2015 Jul;123(7):672-8. doi: 10.1289/ehp.1408178. Epub 2015 Mar 17. PMID: 25782056; PMCID: PMC4492264, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4492264/>.

²⁷ Chad Milando, Black-Ingersoll, F., Heidari, L. *et al.* Mixed methods assessment of personal heat exposure, sleep, physical activity, and heat adaptation strategies among urban residents in the Boston area, MA. *BMC Public Health* 22, 2314 (2022). <https://doi.org/10.1186/s12889-022-14692-7>.

²⁸ New York City Department of Health and Mental Hygiene, Health Data Portal, 2024 NYC Heat-Related Mortality Report, <https://a816-dohbesp.nyc.gov/IndicatorPublic/data-features/heat-report/>.

²⁹ Jeremy Hoffman & Shandas, Vivek & Pendleton, Nicholas. (2020). The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas. *Climate*. 8. 12. 10.3390/cli8010012.

degrees C and as much as 7 degrees C in the formerly redlined areas.³⁰ Another report that looked across multiple studies found consistent disparity in health outcomes for Black and Hispanic individuals, and in addition to physical health found that Blacks and Hispanics suffered more adverse mental health outcomes such as anxiety, psychosis, and substance use disorders during extreme heat, as compared to whites.³¹

In addition to low-wage workers and racial minorities, the following populations are some of the most at-risk groups:

- **Outdoor workers.** Those who work in construction, landscaping, utilities, public safety, and other outdoor environments may be exposed during their workday with no ability to prevent heat illness with rest, hydration, or shade. Further, heat stress is cumulative, so those who return to work again after a night of not fully cooling down at home increase their risk. While regulations prevent many unsafe working conditions, there is not yet a federal regulation protecting outdoor workers from exposure to extreme sun or heat; only five states have standards for occupational heat exposure.³²
- **Unhoused people.** Individuals without shelter have no home air conditioning to retreat to in a heat wave, which may result in additional exposure to heat and sun. They may have difficulty accessing water or cooling stations, especially if they do not have transportation. Further, their access to routine medical care and prescriptions may be strained, putting them at greater risk of a destabilizing health event. In Phoenix, AZ, unhoused individuals were at a heat illness risk level 300 percent higher than that of the general population in 2023.³³
- **Individuals with substance use disorder.** Those with substance use disorder are at increased risk as they may not recognize the signs of heat distress, or worse, may pass out in the sun and be unaware of the risk of burning their skin on hot asphalt. The city of Phoenix reports that 60 percent of its heat-related deaths in 2021 were associated with substance use.³⁴

Economic Viability

Extreme heat causes problems with sleep, as well as with energy levels and alertness, which can reduce productivity and can increase sick calls or rates of tardiness. In 2021, \$68 billion of

³⁰ Ibid

³¹ AG Berberian, Gonzalez DJX, Cushing LJ. Racial Disparities in Climate Change-Related Health Effects in the United States. *Curr Environ Health Rep.* 2022 Sep;9(3):451-464. doi: 10.1007/s40572-022-00360-w. Epub 2022 May 28. PMID: 35633370; PMCID: PMC9363288.

³² Occupational Safety and Health Administration (OSHA), "Heat Exposure Standards," <https://www.osha.gov/heat-exposure/standards>.

³³ Osha Davidson, "For Unhoused People in America's Hottest Large City, Heat Waves Are a Merciless Killer," *Yale Climate Connections*, July 24, 2023, <https://yaleclimateconnections.org/2023/07/for-unhoused-people-in-americas-hottest-large-city-heat-waves-are-a-merciless-killer/>.

³⁴ City of Phoenix, "Heat Response Plan 2023 – General Information Packet," April 19, 2023, <https://www.phoenix.gov/heatsite/Documents/Heat%20Response%20Plan%202023%20-%20For%20Gen%20Info%20Packet%20Apr19.pdf>.

potential income (or 0.3 percent of the US GDP) was lost from reduced labor because of extreme heat.³⁵ As reported in *The New York Times*, in auto factories, “a week of six days above 90 degrees F reduces production by 8 percent.”³⁶ By 2050, the World Bank estimates that 12 percent of work hours will be lost due to the impacts of extreme heat.³⁷

Infrastructure Strain

When it gets hot, the first instinct for many is to turn on the air conditioner. Yet, the use of air conditioning actually generates additional heat, as many cooling systems expel warm air outside the building. High air conditioning use also increases the load on the electrical grid which can drive up energy prices or cause brownouts or blackouts. This may be part of the reason cities take up just 2 percent of earth’s land but account for 60-80 percent of energy consumption.³⁸ While more energy-efficient air conditioning methods are developed, cities and their residents can adopt a wide range of strategies for cooling in addition to the use of air conditioning and should increase the efficiency of existing air conditioning through improved building weatherization.

Extreme heat can damage infrastructure such as roads and buildings, for example when asphalt buckles from the heat. This can be costly for both cities and their residents, not to mention dangerous and inconvenient when roads are in disrepair. In some cities, transit cars need to slow down during intense heat to protect rail lines. Transit impacts disproportionately affect low-wage workers who are more likely to be transit-dependent.

³⁵ Lancet Countdown on Health and Climate Change, “2022 Lancet Countdown U.S. Brief,” *Lancet Countdown*, accessed July 25, 2024, <https://www.lancetcountdownus.org/2022-lancet-countdown-u-s-brief/>.

³⁶ Nicholas Kristof, “Temperatures Rise, and We’re Cooked,” *The New York Times*, September 11, 2016, <https://www.nytimes.com/2016/09/11/opinion/sunday/temperatures-rise-and-were-cooked.html>.

³⁷ World Bank, “Four Things You Should Know About Sustainable Cooling,” *World Bank*, May 23, 2019, <https://www.worldbank.org/en/news/feature/2019/05/23/four-things-you-should-know-about-sustainable-cooling>.

³⁸ H. Akbari, Cartalis, C., Kolokotsa, D., Muscio, A., Pisello, A. L., Rossi, F., Zinzi, M. (2015). Local climate change and urban heat island mitigation techniques – the state of the art. *Journal of Civil Engineering and Management*, 22(1), 1–16. <https://doi.org/10.3846/13923730.2015.1111934>.

Taking Action: City Preparedness and Response

For many cities, extreme heat is a newly important problem, and one that is episodic, with most problems occurring in summer. As a result, many cities may need to create or update heat action plans and partnerships. As with most emergency situations, preparation can go a long way toward successful response; as reflected in the pages that follow, with more emphasis on preparedness actions. To help mayors and their staff consider the most locally-appropriate actions to prepare for and respond to extreme heat, the table in Appendix A lists examples of preparedness and response actions a mayor can take alone or with partners, and Appendix B provide references and links to other sources that may be helpful in generating additional locally appropriate ideas.

The pages the follow describe first some of the key preparedness actions, and then describe key response actions that a mayor can take, either directly or via partnerships with others inside and outside of government.

Preparedness: Key Mayoral Actions

Every city is unique and every mayor has a unique vision for achieving prosperity and wellbeing for their city. The pages that follow describe key actions a mayor should consider as part of their locally-relevant heat response strategy.

1: Put someone in charge. Without a point person responsible for extreme heat, the issue may get attention only once a crisis begins, rather than ahead of time when planning and preparation can help. In cities that do not have a heat manager, heat mitigation initiatives typically fall onto the emergency management department. This approach can be reactive rather than proactive. This paper is designed to help cities rethink how to tackle extreme heat as a chronic, not acute, issue, and assigning a staff person to lead the effort is a key first step. A good way to create a roadmap for the heat leader is to create a strategy. Several good examples exist, including from Boston,³⁹ Miami,⁴⁰ New York City,⁴¹ and Phoenix.⁴²

³⁹ City of Boston. "Boston Heat Resilience Plan." City of Boston, April 21, 2022. https://www.boston.gov/sites/default/files/file/2022/04/04212022_Boston%20Heat%20Resilience%20Plan_highres-with%20Appendix%20%281%29.pdf

⁴⁰ Miami-Dade County, Miami-Dade County Extreme Heat Action Plan. <https://storymaps.arcgis.com/stories/36c32f824ada442dac2d344263138bcc>

⁴¹New York City Mayor's Office. "Cool Neighborhoods NYC Report." New York City Mayor's Office. https://www.nyc.gov/assets/orr/pdf/Cool_Neighborhoods_NYC_Report.pdf

⁴²City of Phoenix. "Heat Response Plan 2023 – General Information Packet," April 19, 2023. <https://www.phoenix.gov/heatsite/Documents/Heat%20Response%20Plan%202023%20-%20For%20Gen%20Info%20Packet%20Apr19.pdf>

Combatting extreme heat is an interdepartmental challenge because no one organization or person is responsible for all heat-vulnerable populations across city agencies. A point person can keep all heat efforts aligned and can reduce duplicating efforts.

Further, a working group provides an easy way to coordinate efforts, such as who will take the lead when a new grant opportunity arises, as the NYC cross-agency staff-level heat working group does. Phoenix has 22 city agencies in its heat working group, including the expected participants such as the Heath, Water and Homeless Service departments, but also including others such as the Arts and Culture, Innovation and Library departments.⁴³ Further, responsibility may reach beyond city control across the region, such as with utility companies and county or state public health agencies. In Phoenix, for example, the heat working group includes 30 regional partners outside of city government including state and county parks, health, and economic development departments, local nonprofits, universities, and faith-based organizations.⁴⁴

Where the lead heat person is positioned organizationally is less important than having the authority to convene across government. For example, in Los Angeles the position is in the Public Works Department, in Phoenix it is in the City Manager's Office, in New York City, leadership on heat comes from the Public Health Department and in Baltimore it is in the Office of Sustainability.

2: Map the heat. To understand the areas most in need of heat mitigation, analyzing heat impact by neighborhood is a first step. Mapping software allows policymakers to identify literal hotspots within the city. Cities can map access to shade by neighborhood to pinpoint where there are "shade deserts,"⁴⁵ areas where there is not enough shade to keep people safe and healthy outdoors during extreme heat.

Mapping can identify priority areas most in need of greater tree canopy, additional cooling stations, or access to public water fountains. Cities should overlay maps of heat with maps of health outcomes, equity gaps, educational achievement, income, flood zones, pedestrian and biking safety, and public schools to identify priority areas. For example, the city of Austin mapped their tree canopy against measures of social equity and found that areas previously subjected to redlining had fewer trees and resulting higher temperatures.⁴⁶ And in the city of Los Angeles, the Cool Spots LA map allows residents to find cooling spots near them.⁴⁷

⁴³ City of Phoenix, "Heat Response Plan 2023 – General Information Packet," April 19, 2023, <https://www.phoenix.gov/heatsite/Documents/Heat%20Response%20Plan%202023%20-%20For%20Gen%20Info%20Packet%20Apr19.pdf>.

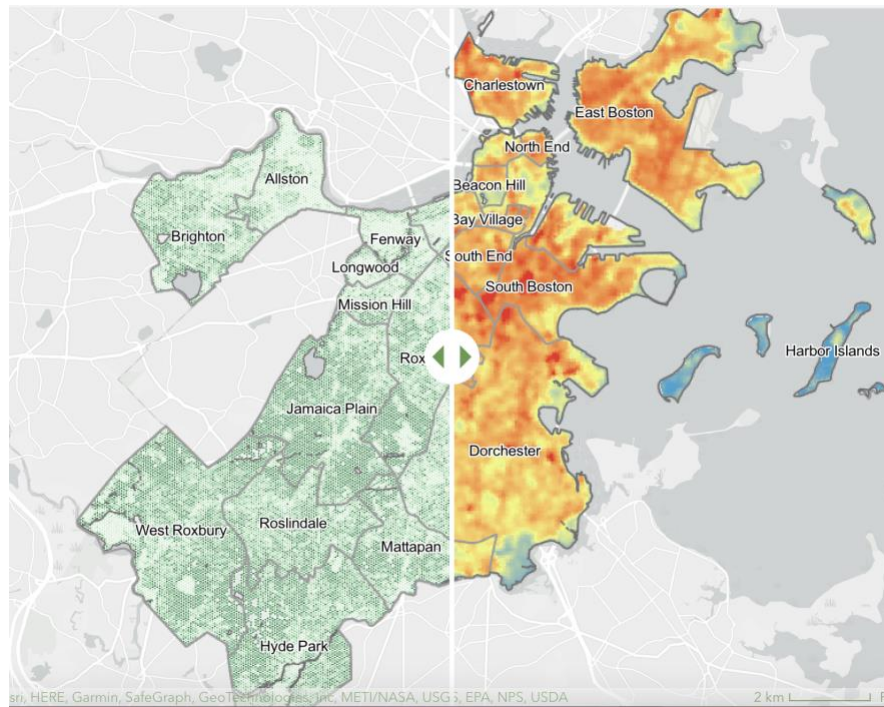
⁴⁴ Ibid.

⁴⁵ V. Kelly Turner, PhD presentation to Harvard Community Data Health Initiative May 9, 2024.

⁴⁶ ESRI, "Austin's Map of Tree Equity," *ESRI Newsroom Blog*, May, 2021, <https://www.esri.com/about/newsroom/blog/austins-map-of-tree-equity/>.

⁴⁷ Los Angeles Hub, "LA Hub Nearby Map Application," <https://lahub.maps.arcgis.com/apps/instant/nearby/index.html?appid=d3bea5218c3b4adca485a32c9e3fabee>.

As part of its heat strategy, the city of Boston mapped the areas exposed to extreme heat and without open space, as well as areas with high vulnerability to future flooding or with social vulnerabilities such as areas with significant numbers of elderly, children, individuals with disabilities, etc.⁴⁸ A local nonprofit, Speak for the Trees created an interactive map showing the visual connection between tree canopy and temperature, as can be seen in the screenshot below where the tree cover is shown in green on the left and heat is shown in red on the right.⁴⁹



3: Keep public buildings and employees from overheating. Mayors can lead by example in making city buildings and other public spaces as heat responsive as possible. City buildings can reduce their heat profile by adding greenery and shade structures around city buildings, creating more parks and parklets, creating cool roofs, using heat-reflective paving materials, or adopting passive cooling technologies. Boston now has a green roof on both its City Hall building and the public school headquarters building.⁵⁰ And the renovation of Boston’s City Hall

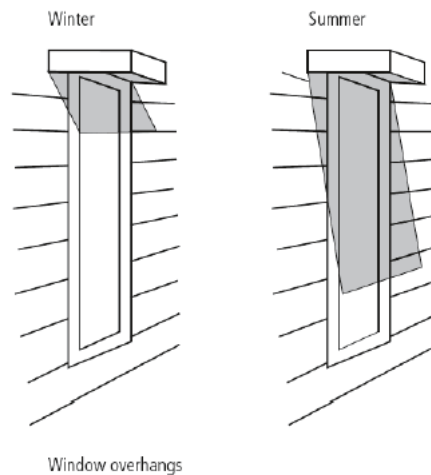
⁴⁸ City of Boston, “Boston Tree Canopy and Heat Island Map,” <https://boston.maps.arcgis.com/apps/View/index.html?appid=77e5ead45a664676b7d404d6df3d7f05&extent=-71.0996,42.3244,-70.9606,42.3940>.

⁴⁹ ESRI, “Mapping Urban Tree Canopy Equity: A Story of Boston,” *ArcGIS StoryMaps*, August, 2023, <https://storymaps.arcgis.com/stories/f06d420d9a2e4f979a6710117388b821>.

⁵⁰ Sasaki, “Bruce C. Bolling Municipal Building,” <https://www.sasaki.com/projects/bruce-c-bolling-municipal-building/>.

Plaza included the addition of 100 trees for shading and air quality improvement, as well as an innovative and fun water feature in the playground for cooling children on hot days.⁵¹

When renovating or designing public buildings, mayors can opt for design choices that use passive cooling and reduce energy use. Some of these approaches were used before the advent of air conditioning, such as creating basements or open courtyards, fountains for evaporative cooling, situating a building to capture more airflow and cross ventilation and less direct sunlight, and the use of shades. Other design choices like the orientation of windows can impact sunlight heat gain, with one study finding that east-facing windows consumed 41% more and west-facing windows consumed 35% more cooling energy during hot month of August, compared to north- and south-facing windows.⁵² Windows that have even minimal shade above them can significantly reduce heat gain due to sun, as shown in the diagram below.



Source: Akande, 2015

Other building design strategies include adopting standards such as LEED or passive house design. LEED building owners report lower operating costs, along with lower employee absenteeism and turnover.⁵³

City government can also make sure that outdoor employees have breaks for hydration, shade, and cooling on extreme heat days. As noted previously, very few states have regulations around workplace heat exposure, but cities and counties can develop their own occupational heat

⁵¹ City of Boston, "City Hall Plaza Renovation," <https://www.boston.gov/departments/public-facilities/city-hall-plaza-renovation>, and author direct observation.

⁵² Amin H. Almasri, 2024. "Smarter Window Selection for Smarter Energy Consumption: The Case of the United Arab Emirates" *Buildings* 14, no. 4: 876. <https://doi.org/10.3390/buildings14040876>.

⁵³ U.S. Green Building Council (USGBC), "About LEED," June 2023, <https://www.usgbc.org/sites/default/files/2023-06/1-leedabout-leed-deckv11-230331173158-475a9fd7.pdf>.

rules; Phoenix's Summer 2023 Heat Response Plan includes a section on the city's employee heat safety efforts.⁵⁴

4: Cool the city with shade, greenery, and cooler surfaces. Greening the city helps cool the air and improve air quality, both of which improve wellbeing. Scholars looking across over 200 studies found that urban trees decreased temperature more than other methods, and found that using multiple methods for cooling (trees, cool roofs, increased hydration) had far more impact than one strategy alone.⁵⁵ An important caveat is that urban trees do not provide maximum cooling until they reach maturity but rather literally grow into their full cooling capacity over time. Recent research shows that at higher temperatures, urban greenery is even more powerful in heat mitigation since at higher temperatures plants release more moisture into the air.

Trees provide shade and help to cool the air through the process of evapotranspiration, in which water evaporates from leaves and cools the surrounding air in the same way that the human body cools itself via perspiration. According to the EPA, trees not only mitigate urban heat but also reduce energy use, improve air quality, enhance stormwater management and water quality, provide wildlife habitat, and sequester carbon. Trees have been widely reported to have positive effects on mental health, and recent research even shows that increasing green space in cities can be associated with lower levels of violent crime.⁵⁶

NYC studied various neighborhoods around the city and compared a variety of factors including trees, building height, pavement, the orientation of the street, and proximity to water, and found that trees and shrubs were the most important factor in bringing temperature down.⁵⁷ Shade has been shown to reduce temperatures by 11-19 degrees F.⁵⁸ A study in Europe estimates that increased tree canopy in cities could reduce heat deaths by one third.⁵⁹ A research study in a midsized Midwestern city demonstrated a nonlinear relationship between tree canopy and cooling, with increased tree cover having an accelerated rate of cooling at the

⁵⁴ City of Phoenix, "Heat Response Plan 2023 – General Information Packet," April 19, 2023, <https://www.phoenix.gov/heatsite/Documents/Heat%20Response%20Plan%202023%20-%20For%20Gen%20Info%20Packet%20Apr19.pdf>.

⁵⁵ M. Santamouris, L. Ding, F. Fiorito, P. Oldfield, Paul Osmond, R. Paolini, D. Prasad, and A. Synnefa. 2017. "Passive and Active Cooling for the Outdoor Built Environment – Analysis and Assessment of the Cooling Potential of Mitigation Technologies Using Performance Data from 220 Large Scale Projects." *Solar Energy* 154: 14–33. <https://doi.org/10.1016/j.solener.2016.12.006>.

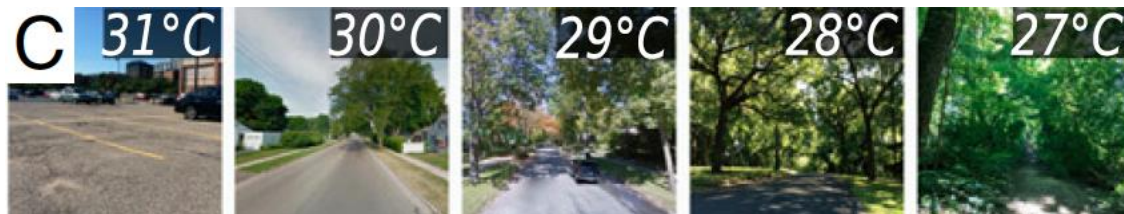
⁵⁶ Mardelle Shepley, Naomi Sachs, Hessam Sadatsafavi, Christine Fournier, and Kati Peditto. 2019. "The Impact of Green Space on Violent Crime in Urban Environments: An Evidence Synthesis" *International Journal of Environmental Research and Public Health* 16, no. 24: 5119. <https://doi.org/10.3390/ijerph16245119>.

⁵⁷ New York City Department of Health and Mental Hygiene (DOHMH), "Local Temperature Data Stories," <https://a816-dohbesp.nyc.gov/IndicatorPublic/data-stories/localtemp/>.

⁵⁸ Regan Hopper, Finding relief in the shade, US Forest Service, Urban and Community Forestry Program, July 24, 2023. <https://www.fs.usda.gov/about-agency/features/finding-relief-in-the-shade>.

⁵⁹ Tamara Lungman, Marta Cirach, Federica Marando, Evelise Pereira Barboza, Sasha Khomenko, Pierre Masselot, Marcos Quijal-Zamorano, et al. 2023. "Cooling Cities through Urban Green Infrastructure: a Health Impact Assessment of European Cities." *The Lancet (British Edition)* 401 (10376): 577–89. [https://doi.org/10.1016/S0140-6736\(22\)02585-5](https://doi.org/10.1016/S0140-6736(22)02585-5).

city block scale.⁶⁰ As shown in the photographs below, with no tree cover the temperature is 88 degrees F and with significant tree canopy the temperature is 81 degrees F. This study recommends both increasing tree canopy and decreasing paved surfaces because tree canopy is most helpful in mitigating heat during the day when the sun is out and reducing the amount of paved surfaces can help reduce heat retention at night.



Trees planted in clusters can be a more powerful tool for cooling, and mini-forests can grow ten times as fast as the typical sidewalk tree.⁶¹ The city of Brookline, MA planted such a mini-forest in the fall of 2023 at a cost of \$6,800 relying on community volunteers to help with planting.⁶²

Creating parks, community gardens, and other green spaces can provide shade and cooling. This can be a low-cost way to mitigate urban heat islands when repurposing vacant lots or other underutilized spaces. Converting empty, vacant, or abandoned locations into green space has the added benefit of beautification.

Adding shade structures to open spaces, parks and parklets makes them more appealing when the sun is hot, yet research shows that only 20% of US cities include shading in their heat mitigation strategies.⁶³ Some researchers suggest that using shade canopies with lattice-cut design can create both shade and ventilation.⁶⁴ As shown in the diagram below, shade can be created by any vertical object.⁶⁵

⁶⁰ Carly D. Ziter, Eric J. Pedersen, Christopher J. Kucharik, and Monica G. Turner. 2019. "Scale-Dependent Interactions Between Tree Canopy Cover and Impervious Surfaces Reduce Daytime Urban Heat During Summer." *Proceedings of the National Academy of Sciences - PNAS* 116 (15): 7575–80. <https://doi.org/10.1073/pnas.1817561116>.

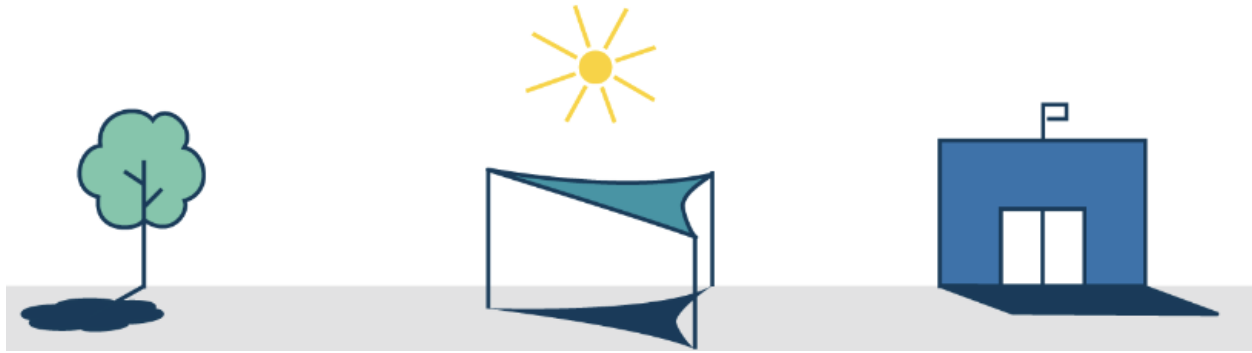
⁶¹ Cara Buckley, "Tiny Forests With Big Benefits," *The New York Times*, August 24, 2023, <https://www.nytimes.com/2023/08/24/climate/tiny-forests-climate-miyawaki.html>.

⁶² Email correspondence, Alexandra Vecchio, Parks and Open Space Division Director, Department of Public Works, Brookline, MA.

⁶³ V. Kelly Turner, Ariane Middel, and Jennifer K. Vanos. "Shade is an Essential Solution for Hotter Cities." *Nature*, July 26, 2023.

⁶⁴ Lucia Stein-Montalvo, Liuyang Ding, Marcus Hultmark, Sigrid Adriaenssens, and Elie Bou-Zeid, "Kirigami-inspired wind steering for natural ventilation," *Journal of Wind Engineering and Industrial Aerodynamics*, Volume 246, 2024, <https://doi.org/10.1016/j.jweia.2024.105667>

⁶⁵ V. Kelly Turner, PhD presentation to Community Data Health Initiative, Harvard University, May 9, 2024.



New forms of asphalt, concrete and permeable surfaces are enabling cities to create “cooler” infrastructure on their streets and sidewalks by applying reflective coatings to streets and parking lots or by choosing lighter colors that absorb less heat than the traditional black color. One research study confirms the significant heat-reducing power of retroreflective material, like that used in road signs, which cooled a building surface by 36 degrees F and the surrounding air by 5 degrees F.⁶⁶ This emerging set of technologies have yet to have long term studies of the costs and benefits. Given that compared to rooftops, pavement may be shaded for part of the day and may have varying levels of traffic, the return on investment for cool pavement is less easy to document than it is for cool roofs. While a handful of international studies show small improvements,⁶⁷ one study in Los Angeles found that the cool pavement reflected the heat back up, making pedestrians on the cool pavement warmer.⁶⁸

5: Educate the public about the dangers of extreme heat. A robust heat plan should include public education about the risks of extreme heat and should provide both the public and leaders of community service agencies with tips on mitigating heat, such as allowing the body to gradually acclimate to the heat as weather warms (for example by increasing blood volume, improving sweat efficiency etc.), and then on extreme heat days reducing exertion and time in the sun, hydration and seeking cool locations. One study of residents in an environmentally overburdened community found that a quarter of respondents didn’t know about basic heat mitigation strategies, like that window shades in a home reduce heat and that drinking water reduces their risk of heat illness.⁶⁹ Similar to how basic steps to prepare for other extreme weather events (i.e. boarding windows for hurricanes or staying inside and away from windows for tornadoes) are well-known in areas that typically experience these events, mayors can help develop and spread basic high-heat preparedness steps.

⁶⁶ Rachel Ramirez, “This simple solution could bring some chill to scorching summer heat,” CNN, March 11, 2024.

⁶⁷ Flannery Black-Ingersoll, Julie de Lange, Leila Heidari, Abgel Negassa, Pilar Botana, M. Patricia Fabian, and Madeleine K. Scammell. 2022. “A Literature Review of Cooling Center, Mistng Station, Cool Pavement, and Cool Roof Intervention Evaluations” *Atmosphere* 13, no. 7: 1103. <https://doi.org/10.3390/atmos13071103>.

⁶⁸ Akshat Rathi, “Reflective Pavement May Be Less Cool Than It Seems,” *Bloomberg*, October 3, 2019, <https://www.bloomberg.com/news/articles/2019-10-03/reflective-pavement-may-be-less-cool-than-it-seems>.

⁶⁹ Chad W. Milando, Flannery Black-Ingersoll, Leila Heidari, *et al*, “Mixed methods assessment of personal heat exposure, sleep, physical activity, and heat adaptation strategies among urban residents in the Boston area, MA.” *BMC Public Health* 22, 2314 (2022). <https://doi.org/10.1186/s12889-022-14692-7>.

Research on individual behaviors during extreme heat showed that simply increasing knowledge about heat-related dangers is an important driver influencing individuals to take action to mitigate heat impact,⁷⁰ making a mayor's role all the more important as a persuader. Reframing how residents view heat by relating heat preparation to preparations for hurricanes, blizzards, or tornadoes could help change how seriously residents take heat warnings.

Targeted messaging to vulnerable populations, such as seniors, children, outdoor workers, and pregnant women can be effective. Curriculum can be created to teach children about the dangers of heat, similar to the way that children learn about earthquake or fire safety. For example, Phoenix is developing an activity book for children in collaboration with its library and culture agencies that includes fun and age-appropriate educational activities to learn about heat risk and how to prepare. And Miami has a public service initiative to educate pregnant women about their specific risk in extreme heat.

6: Target carbon-producing behavior. Poor air quality exacerbates the negative health impact of extreme heat, so improving air quality will reduce the public health harm of extreme heat days. Cities are taking a wide variety of approaches to improving air quality from restricting idling of trucks to promoting private adoption of electric vehicles to using electric vehicles in city fleets. Los Angeles is implementing a zero-carbon loading zone program in their downtown area. The town of Arlington, MA has installed heat pumps in senior housing to reduce heating and cooling costs, while significantly lowering excess heat caused by air conditioning.⁷¹ Bold examples of improving air quality in cities through environmental policy choices include Copenhagen removing parking lots to discourage car usage in the city and congestion pricing as London has done to discourage car traffic in the central city and banning cars completely from certain areas as Barcelona has done.⁷²

7: Use stimulus funds for game-changing capital investments. Many heat mitigation strategies require capital investment such as planting new trees and greenery, building shade structures, adding cool roofs and pavements, or lowering the carbon footprint of city buildings. Bold ideas include removing parking lots to discourage car usage, or using lake water to create efficient thermal cooling as was done in downtown Toronto, which saves 80 percent over the cost of traditional air conditioning while saving water that would fill 350 Olympic size swimming pools annually.⁷³ Such investments are ideal for federal stimulus funds, which need to be spent in the coming years but can have benefits for years to come.

⁷⁰ Alisa L. Hass, and Kelsey N. Ellis. 2019. "Motivation for Heat Adaption: How Perception and Exposure Affect Individual Behaviors During Hot Weather in Knoxville, Tennessee" *Atmosphere* 10, no. 10: 591.

<https://www.mdpi.com/2073-4433/10/10/591>.

⁷¹ Trea Lavery, "Upgrades to Arlington Public Housing Could Cut Energy Use in Half This Winter," *MassLive*, December 20, 2023, <https://www.masslive.com/news/2023/12/upgrades-to-arlington-public-housing-could-cut-energy-use-in-half-this-winter.html>.

⁷² Gaia Pianigiani, "New Heat Wave Descends on Europe, as It Struggles to Adapt," *The New York Times*, July 14, 2023, <https://www.nytimes.com/2023/07/14/world/europe/europe-heat-wave-italy.html>.

⁷³ City of Toronto, "Deep Lake Water Cooling Expansion Study," <https://www.toronto.ca/community-people/get-involved/public-consultations/infrastructure-projects/deep-lake-water-cooling-expansion-study/>.

8: Tap into outside expertise. Mayors can create scientific or academic advisory committees to explore innovative ideas and to establish scientific approaches to heat. For example, the NYC Panel on Climate Change, a 20-member independent advisory body includes professors from many academic disciplines, ranging from public health to business to architecture, who produce a report every five years for the city council to provide a baseline of fact by summarizing research for city action, and provide expertise on how to prepare for extreme heat and flooding.⁷⁴

Preparedness: Key Partnerships

Several key partners outside of mayoral control may have enormous impact on mitigating the dangers of extreme heat on the public. Selected examples follow for how mayors can leverage these partnerships for the benefit of the public.

1: Provide financial support for residential cooling. Access to indoor cooling can significantly lower heat risk. Research conducted in Baltimore, MD, showed that indoor temperatures for those without AC can be as much as 18 degrees F higher than outdoor temperatures.⁷⁵ Experts note that indoor heat exposure overnight is important because while people sleep, they are at increased risk of suffering the most adverse health effects from heat.⁷⁶ For people who do not have functioning fans or air conditioning, repair or replacements can help; during extreme heat events, one Baltimore nonprofit gave out fans to those in need.⁷⁷ Data from the NYC Department of Health show that, of those whose death resulted from heat exposure at home, not one had working air conditioning in use at the time, with 80 percent having no air conditioning and the balance having AC that was either nonfunctioning or not in use.⁷⁸ Now, in NYC, any resident of the city's public housing agency, or anyone receiving a housing voucher, is automatically enrolled in the energy assistance program to help ease the cost burden of using air conditioning, and as of 2024 the city has a subsidy program to help eligible individuals purchase air conditioning. In 2023, officials in Maricopa County, AZ, used federal funds to allocate \$10 million to its air conditioner replacement and repair program.⁷⁹ In Chelsea, MA when new AC units were given out free, recipients also got gift cards to help pay the electric bill.

⁷⁴ New York City Mayor's Office of Climate and Environmental Justice, "NYC Panel on Climate Change (NPCC)," <https://climate.cityofnewyork.us/initiatives/nyc-panel-on-climate-change-npcc/>.

⁷⁵D.W. Waugh, He, Z., Zaitchik, B. *et al.* Indoor heat exposure in Baltimore: does outdoor temperature matter?. *Int J Biometeorol* 65, 479–488 (2021). <https://doi.org/10.1007/s00484-020-02036-2>.

⁷⁶ S. E. McMillan, R. M. Norris, and L. T. Jones, "The Impact of Extreme Heat on Public Health: A Review of Current Knowledge and Future Directions," *The Lancet Public Health* 7, no. 4 (2022): e299–e308, [https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196\(22\)00139-5/fulltext](https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(22)00139-5/fulltext).

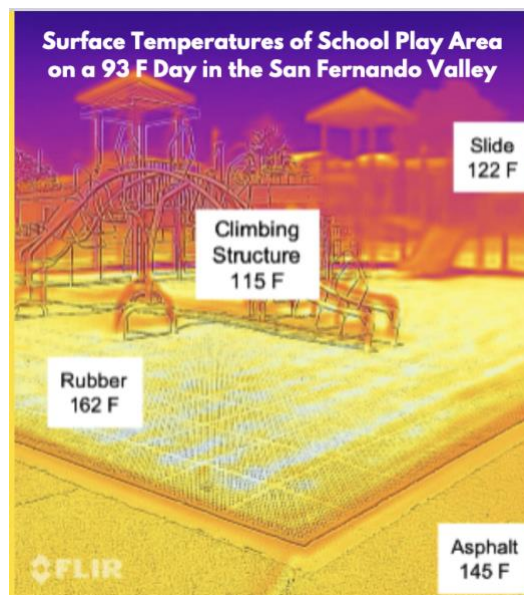
⁷⁷ Alan Greenblatt, "Baltimore Prepares for More Periods of Extreme Heat," *Governing*, July 15, 2023, <https://www.governing.com/next/baltimore-prepares-for-more-periods-of-extreme-heat>.

⁷⁸ New York City Department of Health and Mental Hygiene, "Heat-Related Mortality Report," December 12, 2022, <https://www.nyc.gov/site/doh/about/press/pr2022/heat-related-mortality-report.page>.

⁷⁹ Maricopa County, "Maricopa County Increases HVAC Fund by \$10 Million to Help Homeowners Ahead of Summer," *Maricopa.gov*, April 17, 2023, <https://www.maricopa.gov/CivicAlerts.aspx?AID=2696>.

2: Minimize heat exposure for children. Keeping children cool at school, on playgrounds, and in other recreational spaces is important for their wellbeing and for their learning. As many mayors do not have direct control over their school systems, these strategies will require collaboration and partnership.

- **School heat mitigation.** Children can't focus on their studies if their classrooms gets too hot. School buildings should be a priority when cities plan for cooling, whether by increasing tree canopy and green infrastructure or installing cool roofs, cool pavement, or increased permeable surfaces, as well as adding air conditioning and fans where they are not already in place. In September 2023, several Massachusetts school districts cancelled school on a high heat day due to lack of air conditioning in school buildings. Cities with older infrastructure may have challenges; for example, more than a dozen Boston Public Schools buildings are so old they will not physically support window unit air conditioners. When school buildings are constructed or renovated, adopting passive cooling strategies and energy efficiency measures can improve temperature resilience and comfort, and can improve cognitive gain for children as described earlier.
- **Cool the school play space.** Play areas may attract and retain heat on a sunny day. As shown in the photo below, on a 93-degree F day, some surfaces on a playground can be as hot as 162 degrees F, enough to produce third degree burns.⁸⁰



Reducing the amount of metal and asphalt in a school playground and increasing the use of natural surfaces will reduce heat as well as improve stormwater runoff. NYC's Department of Environmental Protection partnered with the Trust for Public Land to create

⁸⁰ UCLA Luskin School of Public Affairs, "Urban Heat and Cool Design Facts," *UCLA Luskin Innovation*, October 2022, <https://innovation.luskin.ucla.edu/wp-content/uploads/2022/10/Urban-Heat-and-Cool-Design-Facts.pdf>.

environmentally friendly school playgrounds that are community spaces for all ages after school hours, with colorful active spaces and increased shade and greenery.⁸¹

- **Improve cooling features of recreational areas.** Cooling features, such as misting stations, fountains, shade structures, splash parks, and other water features at schoolgrounds and city parks can be included in a heat mitigation strategy. Coupled with tree canopy, water features in public parks can create a pleasant way to cool off for all ages. Further, increased number of and access to public water fountains with water bottle refill capacity can decrease risk of heat related illness while helping reduce the use of single use plastic bottles.

3: Use incentives and regulations to nudge heat mitigation in private buildings. Some cities provide incentives to developers when permitting new buildings if there are heat mitigation or climate-friendly plans in place. For example, Washington, DC has added 6 million square feet of green roof via business incentives, along with many trees and other green spaces.⁸² Cities can also provide incentives to existing businesses to make modifications such as energy efficiency upgrades, adding shade to their buildings, or converting to green infrastructure such as cool roofs and cool or more permeable paving.

Roofs and pavements typically comprise over 60 percent of urban surfaces.⁸³ On a hot and sunny summer afternoon, these surfaces are heated by the sun and create additional heat via reflection off their surface. Cool roofs use reflective materials that reduce absorption of heat from the sun and lower temperatures, as shown in the photos below. The impact is greatest in the rooms directly below the roof, which in residential settings often means the bedrooms.

Cool Roof Example



Traditional Roof Example



⁸¹ Trust for Public Land (TPL), “New York City Playgrounds,” <https://www.tpl.org/our-work/new-york-city-playgrounds>.

⁸² District of Columbia Department of Energy and Environment (DOEE), “Inventory of Green Roofs, January, 2019,” <https://doee.dc.gov/publication/inventory-green-roofs>.

⁸³ C40 Knowledge Hub, “A Practical Guide to Cool Roofs and Cool Pavements,” January, 2012, https://www.c40knowledgehub.org/s/article/A-Practical-Guide-to-Cool-Roofs-and-Cool-Pavements?language=en_US.

Green roofs are those with trees, shrubs and other greenery planted on them. Green roofs can be on buildings, or on bus shelters as is done in the city of Boston. Some research has found that both cool roofs and green roofs are equally effective at lowering temperature, but that cool roofs can do so at a lower cost.⁸⁴ They are also less expensive and complex. As newer cool roof materials are developed, researchers are experimenting to determine which are the most successful at bringing down summer temperature without losing heat in the winter.⁸⁵

For residential home builders and renovators, incentives can improve weatherization, reducing homeowner energy costs while softening the impact of extreme weather. An extreme heat day can be less likely to overheat a house if the attic is insulated. One example is shown in the diagram below of a hypothetical high heat day.⁸⁶



Buildings upgraded to be more resilient to heat can increase the number of hours that residents can remain comfortable with their windows open, which results in both indoor air quality and health benefits.⁸⁷ Many utility companies already provide energy efficiency audits, and expanding these can help city residents find ways to moderate fluctuations in indoor temperature or lower costs while keeping residences cool. Insulation for energy efficiency can make a big difference; a building completed in Boston in 2023 uses 65 percent less energy than similar buildings due to the tight building envelope⁸⁸ and research has found that residential

⁸⁴ Dan Li et al, “The effectiveness of cool and green roofs as urban heat island mitigation strategies,” 2014 Environ. Res. Lett. 9 055002.

⁸⁵ Chiara Chiatti, Claudia Fabiani, Xinjie Huang, Elie Bou-Zeid, Anna Laura Pisello, “Exploring the potential of phosphorescence for mitigating urban overheating: First time representation in an Urban Canopy Model,” *Applied Energy*, Volume 362, 2024, <https://doi.org/10.1016/j.apenergy.2024.122984>.

⁸⁶ Holly Samuelson, DDes, presentation to Harvard Community Data Health Initiative, May 9, 2024.

⁸⁷A Baniassadi, Heusinger, Gonzalez, Weber, H Samuelson, “Co-benefits of energy efficiency in residential buildings.” *Energy*, 2022; and A Baniassadi, Heusinger, Meili, Gonzalez, H Samuelson, “Urban heat mitigation through improved building energy efficiency.” *Energy and Climate Change*, 2022.

⁸⁸Paula Moura, “Boston’s Largest Skyscraper to Become the World’s Largest Passive House,” *WBUR*, October 5, 2023, <https://www.wbur.org/news/2023/10/05/skyscraper-boston-largest-passive-house-the-world>.

energy efficiency produces \$.43 in climate and health benefit for every \$1 in utility cost savings.⁸⁹

Cities can also require energy efficiency and reporting from large building owners. Boston, the first city in the nation to deploy a green building standard through municipal zoning requirements, now requires that all large building owners report annually to the city on their energy use and become carbon neutral by 2050.⁹⁰

4: Engage researchers and community members in documenting heat challenges and suggesting solutions. Several cities are finding ways to involve local universities and the public in heat data collection and idea generation efforts. The city of Baltimore has a longstanding and robust partnership with Johns Hopkins University to develop climate solutions, including heat response. Recently, heat officials in Baltimore engaged community groups in a series of outreach and idea gathering sessions about urban air quality and heat with its research partner Johns Hopkins University. The city of Chicago has partnered with Northwestern University on an intergovernmental research and practice working group to build resilience to extreme weather events.⁹¹ In recent years, this interdisciplinary heat team in Chicago has trained citizen scientists to collect heat data across the city with mobile sensors.⁹²

New York City worked with Columbia University and a citywide Urban Heat Island Working Group to develop its heat vulnerability index (HVI) which helps target heat mitigation programming to those in greatest need.⁹³ The HVI is a sophisticated statistical model that includes neighborhood level data on individual demographics, surface temperature, amount of green space, and access to home air conditioning.

The city of Chelsea, MA has a partnership with Boston University that has produced both scholarly research and actionable policy insights. In 2021, the city and researchers helped raise awareness about heat vulnerability with individual resident voices and perspectives through a project to document heat experiences via photography and writing. The final product, Photovoice/Fotovoz, visually describes neighborhood level heat challenges as shown in the graphic that follows.⁹⁴

⁸⁹Williams, Baniassadi, Izaga Gonzalez, Buonocore, Cedeno Laurent, Samuelson, "Health and Climate Benefits of Heat Adaptation Strategies in Single-Family Residential Buildings," *Frontiers in Sustainable Cities*, 2020.

⁹⁰ City of Boston, "Final Amended Docket 0775: Building Energy Reporting and Disclosure Ordinance (BERDO) 2.0," December 2021, <https://www.boston.gov/sites/default/files/file/2021/12/Final%20Amended%20Docket%200775%20BERDO%2020.pdf>.

⁹¹ Buffett Institute for Global Affairs, "Defusing Disasters: A Global Working Group on Disaster Risk Reduction," <https://buffett.northwestern.edu/research/global-working-groups/defusing-disasters.html>.

⁹² City of Chicago, "Heat Watch 2023," *Chicago Department of Public Health*, https://www.chicago.gov/city/en/depts/cdph/provdrs/environmental_health/supp_info/heat-watch-2023.html.

⁹³ New York City Department of Health and Mental Hygiene, "Climate Health Indicators (HVI)," <https://a816-dohbsp.nyc.gov/IndicatorPublic/key-topics/climatehealth/hvi/>.

⁹⁴ C-Heat (2022). Photovoice / Fotovoz: Chelsea and East Boston, Massachusetts. <https://www.c-heatproject.org/reports>.



CONTRASTS



Here is the view of Chestnut Street standing at Beacon Street. **The lack of trees and vegetation is notable, particularly given the proximity to the loud and dirty Tobin Bridge.** - Susana



This street, and the rest of Admiral's Hill, has **an abundance of trees and vegetation that offer protection from the heat as well as the air and noise pollution of the Tobin Bridge.** I am hopeful that when city officials see these photos, they'll see how much inequity is present throughout the City. - Susana

Study participants shared their perspectives on living with extreme heat and their ideas to mitigate it. Suggestions included many of the expected ideas like planting trees, but also included other new ideas, such as longer hours for libraries as cool spaces during heat waves, accountability for private landowners for tree maintenance, more shade near food pantries, more marketing and promotion for hydration stations, and Spanish language outreach and notification of heat waves.

Another example of engaging community residents in finding solutions to their local heat problems is the Harlem Heat Project, a collaboration among academic, community, and media organizations.⁹⁵ This project brought together citizen scientists who measured indoor temperatures and developed ideas to mitigate heat impacts, including making cooling centers convenient by putting them in the lobby of public housing buildings, or creating cool cooking spaces outdoors for grilling to offer an alternative to heating up the kitchen.

⁹⁵B. Vant-Hull, and Coauthors, 2018: The Harlem Heat Project: A Unique Media–Community Collaboration to Study Indoor Heat Waves. *Bull. Amer. Meteor. Soc.*, 99, 2491–2506, <https://doi.org/10.1175/BAMS-D-16-0280.1>.

Response: Key Mayoral Actions

Many cities take short-term heat mitigation actions such as creating cooling centers in public buildings like senior centers public libraries and auditoriums, letting fire hydrants provide cooling and recreation for children, and the like. Cities such as Phoenix and Philadelphia hand out free water in public places during heat waves. New York City created outdoor misting stations to allow residents to cool off when pandemic restrictions decreased the appeal of cooling centers. Additional strategies worth considering include those described below.

1: Announce the heat emergency early to maximize preparation time. Announcing a heat emergency early helps the public, and the government, prepare for a more effective and timely response. This can allow individuals to prepare themselves to alter plans in a way that mitigates their exposure to the heat.

2: Extend hours for cooling centers and public pools, and create temporary or mobile cooling and stations. Heat does not end when the typical government building closes for the day, or stop on weekends, so cooling centers should be open during the hours they are most needed by the public. One study showed that only half of a city's cooling centers were open Saturdays and 83 percent were closed on Sundays.⁹⁶ Pools and misting stations can also extend their hours on the days with greatest heat risk. While most cities have cooling center options in existing locations, some cities are also employing temporary or mobile cooling centers for the summer season. Boston has portable misting stations for use at outdoor events in summer. Phoenix erected enclosed tents with cooling and water distribution that are open during peak heat season. The goal was to provide heat respite for individuals experiencing homelessness.

3: Provide free public transit during extreme heat events. Cooling centers are a staple of heat response strategies. Yet they are often underutilized because residents are unable to get there without walking in the heat or paying for transportation. Providing free public transit in a heat emergency allows those who would otherwise be walking to be cooler while in an air-conditioned bus or train, and it reduces the chance that people are unable to access cooling services provided by the city. The city of Philadelphia offers free public transit to residents during extreme heat events.

4: Provide wellbeing checks on vulnerable populations. Many cities have found ways to reach out to vulnerable populations during heat events, such as elders, individuals living alone or those who are unhoused. Some cities, such as Portland, OR have leveraged their Meals on Wheels program to provide fans and cooling information to elders.⁹⁷ Other cities have created buddy programs to have volunteers perform wellness checks, either in person or via phone with

⁹⁶ New York City Comptroller, "Overheated and Underserved: The Disproportionate Impact of Extreme Heat on NYC's Most Vulnerable," August 2, 2022, <https://comptroller.nyc.gov/reports/overheated-underserved/>.

⁹⁷ Danielle Renwick, "Meals on Wheels as a Climate Relief Model," *The Lund Report*, April 27, 2023, <https://www.thelundreport.org/content/meals-wheels-climate-relief-model>.

elders and other vulnerable individuals during a heat emergency, such as is being done by the Phoenix Heat Relief Network and NYC's Be a Buddy campaign⁹⁸

Response: Key Partnerships

Once a mayor has declared a heat emergency, all regional partners have a role to play. Selected examples are described below.

1: Prohibit power shutoffs during a heat emergency. Requiring that utilities not shut off service during heat waves will ensure that residents are not cut off from hydration or energy for cooling at a time when it is dangerous to their health. The state of Arizona now bans electricity cutoffs for nonpayment during the hottest months and in NYC utilities may not shut off electricity during a declared heat emergency.⁹⁹

2: Require landlords to provide cooling. In some cities, having air conditioning or a fan in a heat wave is a matter of life and death, and yet most cities do not require landlords or public housing agencies to provide this amenity. Unlike the requirement in many cities that landlords provide heat, cities have been slower to regulate access to air conditioning. In Chicago, during an unseasonably warm spell with temperatures in the 90s in May 2021, three African-American women in their 60s and 70s died when the centrally controlled heat in their housing complex remained on and the air conditioning off.¹⁰⁰ Now, residential buildings for older people in Chicago must provide air conditioning in common areas and the Illinois State Senate passed legislation requiring that affordable housing complexes have air conditioning operable by residents and available once the temperature reaches 80 degrees F.^{101,102}

3: Support health care capacity during heat events. Mayors can provide an important support by being a vocal advocate for their local public health agencies, health care providers, clinics and hospitals as well as emergency response services, and by engaging in ongoing dialog on emerging best practices.

⁹⁸ City of Phoenix, "Human Services Department Fact Sheet 2016," <https://www.phoenix.gov/humanservicessite/Documents/HRN%202016%20fact%20sheet.pdf>.

⁹⁹ Arizona Corporation Commission, "Arizona Corporation Commission Reminds Ratepayers of Disconnection Prohibition," July 12, 2022, <https://www.azcc.gov/news/2022/07/12/arizona-corporation-commission-wants-to-remind-ratepayers-of-disconnection-prohibition>. Interview w Lauren Smalls-Mantey, MS, PhD, Senior Environmental Systems Scientist, Bureau of Environmental Surveillance and Policy, New York City Department of Health and Mental Hygiene, June 29, 2023.

¹⁰⁰ Don Babwin, "Deaths of 3 women in early heat wave raise questions, fears," *Associated Press*, May 28, 2022, <https://apnews.com/article/politics-chicago-heat-waves-climate-and-environment-a654df09a9598220bd5978e4f6dce4cb>.

¹⁰¹ Don Babwin, "May heat wave deaths prompt new cooling rules in Chicago" *Associated Press*, June 2, 2022, <https://apnews.com/article/chicago-heat-waves-c5f92fd402b05554cd3aec6fa4481605>.

¹⁰² Senator Mike Simmons, "Simmons' Initiative to Require Air Conditioning in Affordable Housing Passes Senate," *Illinois Senate Democrats*, May 1, 2023, <https://www.illinoisenatedemocrats.com/caucus-news/74-senator-mike-simmons-news/4622-simmons-initiative-to-require-air-conditioning-in-affordable-housing-passes-senate>.

Conclusion

Mayors have no control over the weather, and limited authority over the levers to alleviate the poverty and isolation that make extreme urban heat worse for some residents. But a mayor can develop strategies that identify those most vulnerable to harm, and attempt to address inequities. Most heat deaths are preventable with adequate warning to reduce exertion and with access to cooling, hydration and shade. A mayor can lead in this increasingly important area for making city life more enjoyable and vibrant.

Long-term solutions to the harmful health impacts of extreme heat must include big ideas such as lower cost energy so that low income individuals and families can afford sufficient cooling, new technologies to make cooling less likely to produce heat as a byproduct, urban design that minimizes concentration of heat in tall buildings and paved surfaces, improved air circulation via varied building heights, capping the amount of paved surface, requiring shade in public and private spaces, and greater levels of routine intergovernmental collaboration.

For now, with some cities increasingly facing extreme weather events, mayors can take immediate and near-term action to prepare for and mitigate the impacts on their residents of exposure to excessive heat in a variety of ways described in this paper and the resources included. Mayors are often the ones on the front lines of innovation for emerging issues. The impact of extreme heat on city residents is an opportunity for mayors to collaborate across silos and sectors and to mine best practices to bring out the best in their city, regardless of the weather.

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Appendix A: Mayoral Heat Mitigation Strategies and Tools

No one approach is appropriate in all cities or regions – for example, hospitals in Texas won’t see a spike in heat related illness until temperatures reach 105 degrees F, while in Massachusetts the threshold is 86 degrees F. Age of infrastructure and materials used, relative humidity, and many other factors impact how hot a city will get and how able its residents are to handle the heat. The intensity and duration of extreme heat events and the local climate and bidding types necessitate that each mayor craft a unique solution for dealing with extreme heat.

The chart below lists selected actions and strategies a mayor can take or can encourage others to undertake via partnerships both to prepare in advance for extreme heat events and to mitigate the health impacts on the public once an extreme heat event occurs. Actions are divided into those that are taken in advance of an extreme heat event and those that can be taken once an extreme heat event is under way.

Phase and Type of Action	Mayoral Actions	Partnership-dependent Actions
Preparedness: Heat mitigation planning	<ul style="list-style-type: none"> • Appoint a single point of contact in city government for heat mitigation to coordinate efforts across departments • Develop a cross-agency team to coordinate heat response efforts in an all-of-government approach, under the direction of a heat response leader. • Create a heat response strategy that identifies specific locations in need of relief and vulnerable populations. • Develop a public awareness campaign and use mayoral influence to engage other community influencers. • Develop partnerships with local research, advocacy and community-based groups to identify, co-create and implement locally-tailored solutions. • Train all city workers in heat awareness, especially those who work outdoors or in hot conditions (police, fire, food service, parks and recreation, sanitation, etc.) 	<ul style="list-style-type: none"> • Engage with school leadership to assure that children can learn comfortably in schools that are adequately cooled on extreme heat days • Work with school leadership to cool the places children play outside of school • Engage with day care providers, camps and other organizations responsible for supervision and wellbeing of children to encourage shade and cooling on extreme heat days • Encourage health care providers to reach out to their patients to educate them about the warning signs of heat illness and mitigation strategies such as taking a cool shower or bath or sponging off, hydrating and keeping alert to the weather. • Work with transit agencies to incorporate cooling into both transit and waiting areas, including green roofs on bus shelters and misting stations as locally appropriate.

Phase and Type of Action	Mayoral Actions	Partnership-dependent Actions
	<ul style="list-style-type: none"> • Create an advisory board to provide expertise on health, emerging technology, public engagement, sustainable design, cultural institutions, and other topics relevant to heat mitigation 	<ul style="list-style-type: none"> • Support air conditioning and fan installation, repair and replacement programs.
Preparedness: Urban design for reduced heat	<ul style="list-style-type: none"> • Create cool roofs in public buildings • Design new public buildings and renovate existing with heat mitigation in mind, such as by adding courtyards and cross ventilation, installing windows that minimize sun heat, shade for windows and outdoor spaces, etc. • Use cool pavements where appropriate • Install solar panels in areas where they can also provide shade • Add water features on the exterior of public buildings for evaporative cooling or for recreation (e.g. splash pads) 	<ul style="list-style-type: none"> • Provide incentives to commercial developers and to multi-family property owners to either build new cool roofs or to add cool roofs to existing buildings • Consider requiring large building owners to engage in energy efficient actions and to report on energy consumption annually. • Require common areas of multi-family residences have adequate cooling. • Require shading in green areas around commercial and residential buildings.
Response: Awareness	<ul style="list-style-type: none"> • Announce a heat emergency as early as possible so that the public has adequate time to prepare • Provide messaging in the format most easily consumed by the public, allowing the public to self-select the format and language for their alerts (text, email or phone) and share announcements via both social and traditional media in all relevant languages. 	<ul style="list-style-type: none"> • Engage with private sector large building owners to broadcast alerts on message boards in lobbies and elevators
Response: Cooling	<ul style="list-style-type: none"> • City cooling centers open at hours convenient and necessary for the public, including temporary cooling centers in locations that are easy to access • Free public transit to cooling centers during a heat event 	<ul style="list-style-type: none"> • Weatherization programs to help seal in cool air when residential AC is used • Compel landlords to provide cooling when temperatures reach a certain level • Incentivize shading and other passive cooling elements in

Phase and Type of Action	Mayoral Actions	Partnership-dependent Actions
	<ul style="list-style-type: none"> • Mistig centers in locations that are easy to access • Improved weatherization and energy-efficient cooling in all public buildings, especially public housing, public schools and senior housing and community centers. • Create mobile pop-up cooling centers that can be activated for large events in summer. 	<ul style="list-style-type: none"> • commercial and residential buildings • Incentivize cool roofs in new construction as well as on existing commercial and residential buildings • Prevent electric utilities from disconnecting residential power during an extreme heat event • Consider requiring that pop up cooling stations, shade and hydration be provided in order to grant permits for outdoor gatherings in summer.
Response: Shade	<ul style="list-style-type: none"> • More trees, shade structures, awnings and the like at city buildings • Increase shade at locations the public gathers or has to wait, such as parks and bus stops • Create more parks and parklets that include shade • Increase shade at existing city parks and community centers • Increase shade on well-traveled pathways and sidewalks, with particular attention to support for vulnerable populations, such as shading routes children take to school or locations and routes frequented by seniors. 	<ul style="list-style-type: none"> • Mandate shade breaks for outdoor workers on city contracts • Incentivize shade structures and trees in new buildings and in renovations, including awnings and overhangs • Consider changing building code to require more shade structures for new buildings • Consider requiring that pop up cooling stations, shade and hydration be provided in order to grant permits for outdoor gatherings in summer.
Response: Hydration	<ul style="list-style-type: none"> • Provide hydration stations in all public buildings. • Create new hydration stations, with specific focus on densely populated areas and areas shown by maps to be resource-poor and subject to higher temperatures due to lack of shade. • Include reminders about hydration in messaging to vulnerable populations. 	<ul style="list-style-type: none"> • Incentivize hydration stations in new public buildings, or when buildings are renovated. • Incentivize multi-family building owners to provide hydration stations in lobbies and common areas. • Require that water utilities not shut off service during a heat emergency.

Appendix B: Resources for Heat Mitigation Planning

The resources described here may be helpful to cities as they plan their heat mitigation strategies and plans and represent a select few of the rapidly growing number of resources to identify solutions to respond to extreme heat.

Government resources:

Heat.gov is the web portal for the National Integrated Heat Health Information System (NIHHIS). [Heat.gov](#) serves as the premier source of heat and health information for the nation to reduce the health, economic, and infrastructural impacts of extreme heat and includes funding opportunities as well as a wealth of resources for planning for heat mitigation. This site is updated frequently.

The Environmental Protection Agency (EPA) [Heat Island guidebook](#) provides a good overview of Urban Heat Islands and the steps that some communities are taking to address them.

The EPA maintains a community actions [database](#) of strategies used by local communities in mitigating urban heat islands.

The UN report [Beat the Heat](#), offers 80 ideas and case studies from across the globe in a handbook that offers practical tips on not only how to create a strategy to mitigate heat but also on implementation steps.

Academic resources:

Harvard's Center on the Developing Child has produced the toolkit, [Place Matters: Action Guide for Policy](#), which helps a policymaker understand how environment shapes the health and wellbeing of children, including ways to mitigate urban heat impacts.

Researchers at Johns Hopkins University have created a tool that they [deployed in Baltimore](#) to assist in making tradeoffs among various heat mitigation strategies called City-Heat Equity Adaptation Tool (City-HEAT). This tool enables tradeoffs across time and cost and to meet the needs of various vulnerable groups. The scholars [shared the source code](#) for their tool so that other cities could use the tool as well. Unlike other planning tools in the literature, City-HEAT can optimize multiple adaptation objectives, consider numerous future scenarios and adaptation actions, and generate adaptive plans at fine temporal (annual) and spatial (sub-city) resolutions.

Doctors and researchers, including from Harvard School of Public Health, worked with AmeriCares to create a [toolkit](#) for health facilities to prepare for extreme heat. Resources are available for doctors, patients and administrators in English and Spanish and cover both the basics of heat preparedness and how to address special issues such as dementia, COPD, asthma, and pregnancy during extreme heat.

MIT Sensable City created [Treepedia](#), which measures the canopy cover in cities. Per the website, “Rather than count the individual number of trees, we’ve developed a scalable and universally applicable method by analyzing the amount of green perceived while walking down the street. The visualization maps street-level perception only, so your favorite parks aren't included! Presented here is preliminary selection of global cities.”

Advocacy and other resources:

The Adrienne Arsht Rockefeller Foundation Resilience Center is focused on heat and other aspects of resilience across the globe, and funded heat officers in cities around the world, including one in Miami. Their [Extreme Heat Resilience Alliance](#), has a website that brings together a variety of resources for international best practices on heat planning and resilience. Their [Heat Action Platform](#) is an online tool for city officials, practitioners, and financial institutions to find existing resources for on reducing the impact of extreme heat at the regional or municipal level.

The Trust for Public Land has created a tool to help the 100 most populous cities see how they stack up against others for equitable access to parks and green spaces. The ParkScore tool compares equity, investment, acreage and amenities and can be [found here](#).

The World Health Organization has on its [Heat Waves](#) page a lot of information on the global impact of heat on health, as well as infographics that may be a helpful starting point on communicating key messages to the public on how to stay safe in the heat.

The Union of Concerned Scientists created [a tool](#) that shows the rapid increases in extreme heat projected to occur in locations across the US due to climate change. Results show the average number of days per year above a selected heat index, or “feels like” temperature, for three different time periods: historical, midcentury, and late century.

GIS technology company Esri has created multiple tools to help cities understand their heat problems and plan accordingly, including:

- Future heat predictions tool, accessible [here](#), and providing an interactive map that shows the rapid, widespread increases in extreme heat projected to occur across the United States due to climate change. Information is presented by county and includes all 3,109 counties in the contiguous US.
- A [tree planting map tool](#) uses land surface temperature, lack of tree canopy, and population density data to identify areas where tree planting campaigns could help build community resilience to extreme heat events.
- A [cooling centers interactive map](#) tool enables cities to examine which areas have greatest need for a cooling center. This map uses land surface temperature, population aged 65+, and population with no vehicle access to identify areas where improving access to cooling centers could help build community resilience to extreme heat event
- A [buddy program map tool](#) helps cities decide which neighborhoods are in most need of creating buddy programs to support elders who may suffer from social isolation. This

map uses land surface temperature, population aged 65+, and population living alone to identify areas where developing a "be a heat buddy program" for health checks could help build community resilience to extreme heat events.

- This [interactive map](#) created by the Science Museum of Virginia and Esri shows formerly redlined neighborhoods in 108 cities and their exposure to urban heat.

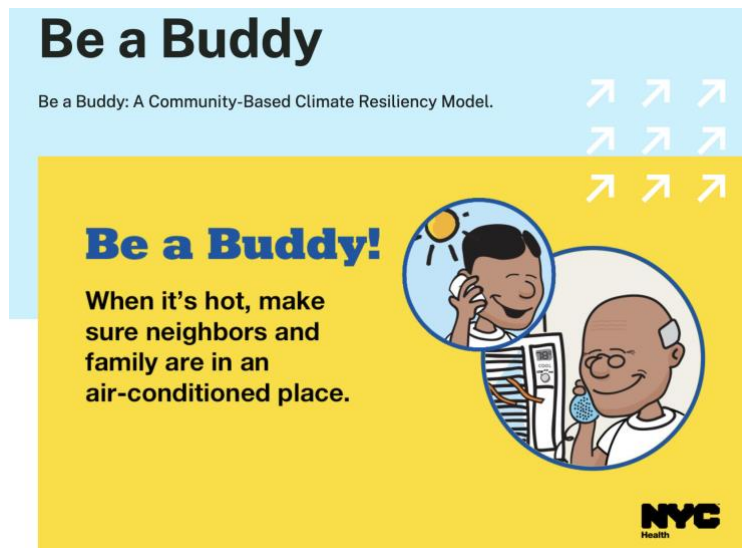
National Geographic Education has an online learning tool for school-aged children to teach them about urban heat islands. The content is well written and could be used as a resource when creating public information campaigns because of how clear and un-technical they have made the science. It is [found here](#).

The Washington Post in its [story](#) on extreme heat in India included a 3-dimensional model of an interior of a home which describes how heat is intensified indoors in a typical scenario in a poor neighborhood.

The [Smart Surfaces Coalition](#) provides tools to help cities understand the benefits of cool roofs and pavements, porous pavements, green roofs.

A good resource on community engagement and co-creation of greenspaces is the [11th Street Bridge Park's Equitable Development Plan](#). Met with community resistance in the Anacostia neighborhood of DC, the city engaged in a collaborative plan with neighborhood residents to assure that greening the park created along the bridge did not displace longtime residents due to green gentrification.

Another resource on city outreach and education is NYC's "Be a Buddy" campaign includes education for participants on heat mitigation strategies, such as turning the air conditioning on at a comfortable temperature such as 75 degrees F, rather than 65 degrees F which may stress the power grid. This program encourages residents to reach out to their neighbors, as demonstrated in the graphic below.



The city has also created a fun, online five question heat awareness quiz. NYC releases an annual heat mortality report to document the death toll from extreme heat.¹⁰³ The city also uses visuals to convey messages, such as in the example below.



Targeted messaging to vulnerable populations, such as seniors, outdoor workers and pregnant women can be effective. Miami has an initiative to educate pregnant women about their specific risk in extreme heat as shown below.



