Extreme Heat Intervention Guidebook

Prepared for City of Dallas
Office of Environmental Quality & Sustainability
by CAPA Strategies

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Guidebook Overview

As climate change transforms cities and regions across the United States, rising temperatures threaten urban infrastructure, human health, and liveability. In Dallas, heat has been identified as a local stressor in documents such as the Comprehensive Environmental and Climate Action Plan (CECAP), *ForwardDallas 2.0*, the *Dallas Urban Forest Master Plan*, and *Hazard Mitigation Action Plans* for both the City of Dallas and Dallas County.

In 2024, the City completed multiple assessments with the consultancy CAPA Strategies (CAPA) to better understand local conditions and context around extreme heat. These included a Heat Watch mapping campaign, showing citywide heat distribution; land cover, canopy cover, and impervious surface analyses; health and socio-demographic analyses; and a systematic review of heat-related content in local plans and codes, known as a *jurisdictional scan*. Concurrently, the City has coordinated with the group Smart Surfaces Coalition (SSC) to quantify the potential impacts of various cooling interventions. In 2025, CAPA engaged SSC, municipal staff, and partners in a series of interviews and a stakeholder workshop to identify (1) relevant content and details for this guidebook, and (2) potential roles and responsibilities for the implementation of interventions.

The *Extreme Heat Intervention Guidebook* presents solutions which are supported by existing literature, best practices, and local data and which are suitable for the humid subtropical climate of Dallas. It offers a suite of approaches, including both material and non-material interventions, that City staff and partners can draw on to advance heat resilience in Dallas. This is not a prescriptive implementation plan, but a menu of potential solutions to inspire and inform ongoing heat action.

The content is divided into three sections:

Foundations
This section offers an overview of the climate and environmental challenges in Dallas, including a recap of heat mapping, heat analyses, and jurisdictional scan results.

City Scale Strategies
This section covers high-level heat mitigation and adaptation strategies which are available to municipal managers and planners, non-profit or community based groups, academic institutions, commercial property owners, business owners, developers, utility companies, and other non-residential entities, as well as multi-family property owners or managers. These are classified within one of six categories: **trees, smart surfaces,**[1] **urban infrastructure, policy and legislation, social support,** and **emergency response**. The strategies in this section are relatively more expensive and time consuming than those offered as 'Household Scale' strategies, make an impact at a larger scale, and pertain to heat mitigation as well as adaptation.

Household Scale Strategies
This section covers household-level strategies for responding to heat and building resilience. These strategies, which are available to all individual residents and homeowners, are relatively inexpensive, can be implemented on a short timeline, and pertain to heat adaptation rather than mitigation.Tips and existing resources for Dallas residents are linked at the end of this section.

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[1]Items in this chapter are classified as Green, Permeable, or Reflective and refer directly to strategies and data points provided by SSC.

Overview of strategies included in the guidebook:

Type	Heat Mitigation or Adaptation Strategy	Details
City Scale	Trees	Planting, maintenance, and preservation
	Green roofs	Vegetated systems
	Vegetated open space (green space)	Native vegetation; Community gardens; Urban agriculture
	Green stormwater infrastructure	Vegetated bioswales; Rain gardens; Constructed wetlands
	Permeable surfaces	Porous pavements
	Reflective and/or light colored surfaces	High albedo (reflective) roofs, walls, and pavements
	Public and active transportation infrastructure	"Complete Streets;" Bike lanes; Pedestrian safety improvements
	Shading	Non-vegetative shade structures
	Energy microgrids	Backup power sources; Renewable energy generation
	Policy and legislation	Green building and infrastructure standards; Preservation; Public health
	Financial and technical assistance	Subsidies and rebates; Energy bill support; Home weatherization; Tree planting and maintenance help
	Community education and engagement	Heat mitigation measures; Heat safety and risk
	Job training and volunteer corps	Activating community stewards; Building wealth in all communities
	Resource giveaways	Cooling kits; Fans; Air conditioners; Air purifiers
	Emergency response	Planning; Deploying resources; Alerts; Cooling centers
Household Scale	Small-scale applications of City Scale strategies	Residential tree planting; Green/vegetated, light colored, and/or reflective residential roofs and building materials; Home weatherization; Energy efficiency upgrades and alternative home energy sources
	Maximizing air flow	Strategic use of fans and windows
	Air conditioning and dehumidification	Use of mechanical cooling equipment
	Insulation and weatherization	Air sealing; Insulation
	Shades, overhangs and window films	Strategic shading; Blocking sunlight

Table of Contents

Using this Guidebook

This guidebook is a resource for municipal staff, partners, and community members in Dallas who have a role in heat mitigation and adaptation. **Mitigation** measures are about minimizing the presence and intensity of heat, and reducing the urban heat island (UHI) effect. **Adaptation** measures are about avoiding and/or coping with extreme heat.

This guide offers a suite of interventions that are considered most appropriate for Dallas based on its specific climate and context. Many of these strategies (e.g., green roofs, weatherization) are tried and true and have been positively assessed in both academic and practical literature. Newer strategies (e.g., energy microgrids, "solar trees") show promise in the field of heat resilience and are growing in popularity. Select mitigation and adaptation options are described alongside tips for increasing their efficacy, sustainability, and appeal to local communities. **Municipal leaders, managers, planners and their professional partners are encouraged to use this information as a starting point, follow links and references, and dive deeper into the concepts that spark interest.**

Chapters 1 covers foundational information on the climate of Dallas, past heat assessments, and existing resources. This content may be of interest to municipal planners and partners, as well as city residents.

Chapter 2 is focused on trees (urban forestry) as a heat management strategy, including benefits, limitations, and tradeoffs. Recognized as a highly effective tool to reduce the UHI effect, trees offer myriad environmental, social, and economic benefits. Urban trees also bring particular challenges and limitations in practice.

Chapters 3-7 cover heat mitigation and adaptation approaches which could be initiated, funded and managed at the citywide scale. These 'City Scale' strategies are primarily intended for managers and planners, non-profit or community based groups, academic institutions, commercial property owners, business owners, developers, utility companies, district managers, and other non-residential entities, as well as multi-family property owners or managers. The strategies in this section require more time and money than 'Household Scale' strategies (Chapter 8) and make an impact at a larger scale.

Each city-scale strategy is presented with the following details:

- A brief overview of the strategy and how it works.
- Tips and special considerations for implementation, as applicable.
- Cross-references to existing plan goals, based on the results of the jurisdictional scan.
- Identification of departments or entities who might lead or support implementation.*

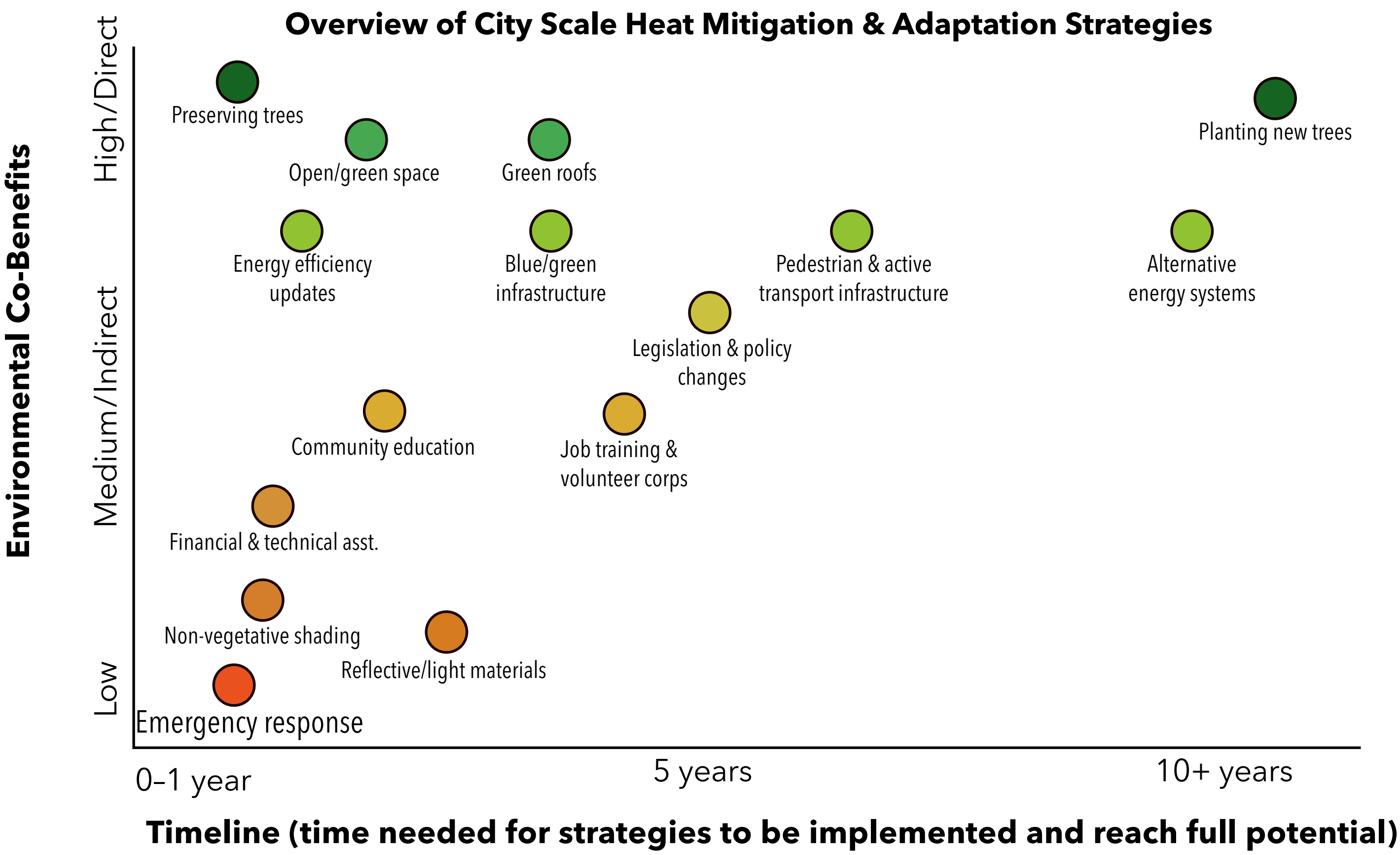
***Glossary of partner abbreviations:**

CCGI - Community Council of Greater Dallas	ECR - Emergency Management & Crisis Response	OHS - Office of Homeless Solutions
DART - Dallas Area Rapid Transit	EOD - Office of Economic Development	MDHA - Metro Dallas Homeless Alliance
DDI - Downtown Dallas, Inc.	FRM - Facilities & Real Estate Management	PDD - Planning & Development
DC HHS - Dallas County Health & Human Services	HCD - Housing & Community Development	PKR - Park & Recreation
DFR - Dallas Fire Rescue	LIB - Dallas Public Library	TPW - Transportation & Public Works
DWU - Dallas Water Utilities	OEQS - Office of Enviro. Quality & Sustainability	TTF - Texas Trees Foundation

Case studies are included throughout, demonstrating how select interventions have been implemented in peer cities.

The chart below offers a characterization of the City Scale strategies covered in this guidebook, including timeline (horizontal axis) and environmental co-benefits (vertical axis). Timeline refers to the approximate amount of time required to implement a heat mitigation or adaptation intervention, and when applicable, the time required for that intervention to reach its full potential. **Environmental co-benefits** reflect the ability for a strategy to address environmental stressors other than heat. Co-benefits considered here include those related to stormwater and flooding, air quality, carbon capture, and wildlife habitat, all of which could emerge directly as a result of specific heat-related interventions. Some measures do not have direct environmental benefits, but could contribute to them indirectly; for example, job training could lead to improved maintenance of trees, and trees produce co-benefits related to air quality, habitat, and stormwater management. Those measures are identified as having medium/indirect co-benefits.

This chart is intended as a conceptual aid. All representations are generalized estimates and relative to the other solutions presented here. The scale and particulars of any intervention in practice may increase or decrease its timeline and benefits.

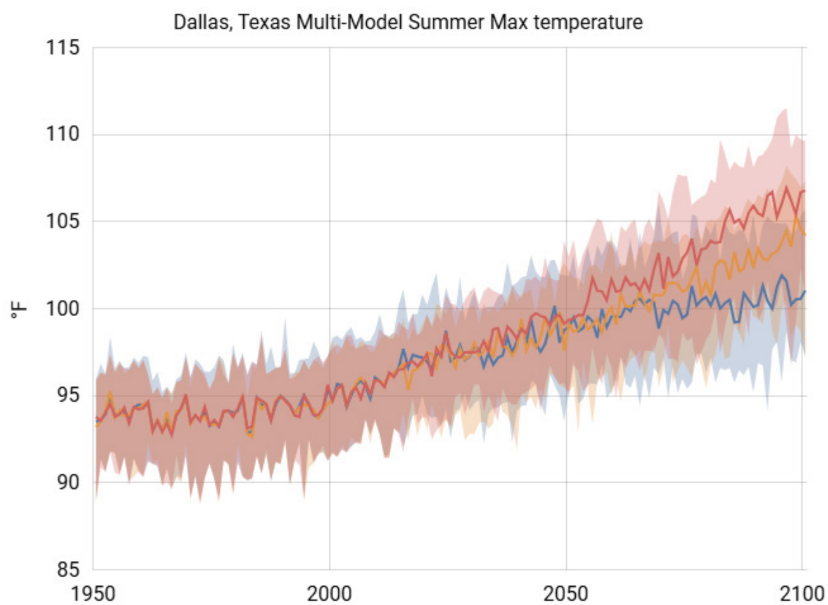


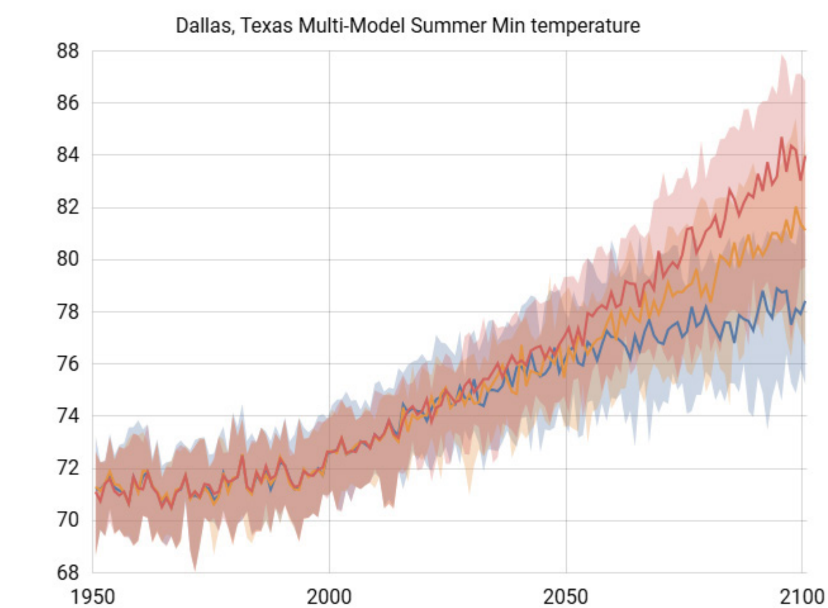
Chapter 8 is intended for use by city residents as it covers 'Household Scale' strategies, though the content may also be used by entities working at the City scale to frame outreach, education, and programming. This section covers individual, household-level strategies for coping with heat and building resilience. These are relatively inexpensive, can be implemented on a short timeline, and favor heat adaptation. The final section (8.5) directs readers to existing resources with tips for heat preparedness, safety, and coping mechanisms.

Chapter 1: Background

1.1 Climate and environmental conditions in Dallas

Dallas, TX is located within the humid subtropical climate zone that spans most of the southeastern United States. This zone, also known as 'Cfa' in the Koeppen-Geiger classification system (Koeppen-Geiger, 2026), is characterized by warm to hot summers, mild winters, and year-round precipitation. It is typical for summer temperatures in the Cfa zone to exceed 80° Fahrenheit (°F), and maximum daily temperatures periodically reach triple digits (100°F+). Summer nights are also warm, as humid conditions prevent a rapid cooldown after sunset (Britannica, 2025).





Weather patterns in Dallas are consistent with a typical humid subtropical climate zone. However, as in many cities nationwide, annual weather in Dallas has been undergoing a shift. Long-range projections and historical trends in the region show both hotter days and hotter nights ahead. For example, under a "business as usual" emissions scenario, typical summertime maximum temperature will reach over 99°F by 2050 and over 106°F by 2100. These values reflect increases of nearly 5°F and 12°F, respectively, compared to the historical norm (1981-2010). Similar increases (+5°F in 2050 and +12°F in 2100) are projected for summertime minimum temperatures, meaning that nights will be warmer than in the past (Figure 1). This is concerning as high overnight temperatures make it difficult for the body to cool down and recover from daytime heat exposure.

Figure 1. Climate projects showing summertime maximum temperature (top) and summertime minimum temperature (bottom) over the period of 1950-2100. Projections for higher ("business as usual") and lower emissions scenarios are represented by red and blue lines, respectively (USGS National Climate Explorer, 2026).

Like all cities, Dallas is prone to the UHI effect. Impervious surfaces like roads and buildings absorb heat from the sun, while concentrated human activities such as driving add waste heat to the environment, leading to higher temperatures in heavily developed areas. With effects exacerbated by characteristically high humidity in the region, consistent summer temperatures in the upper 80s to 90s pose a significant risk to human health and quality of life.

Studies by the City and CAPA have shown that in Dallas, as in many US cities, heat is not evenly distributed (Figure 2). Lower-income areas of the city are more built out and less vegetated, and thus experience high temperatures (Figure 3). This means that residents with the fewest economic resources to cope with heat – for example, the ability to purchase or run an air conditioner – face the greatest exposure and risk. CAPA's findings are consistent with two studies from the Dallas area, showing higher rates of heat exposure and heat-related emergency department visits among populations in formerly redlined2 areas (Li et al., 2022; Dialesandro et al., 2021).

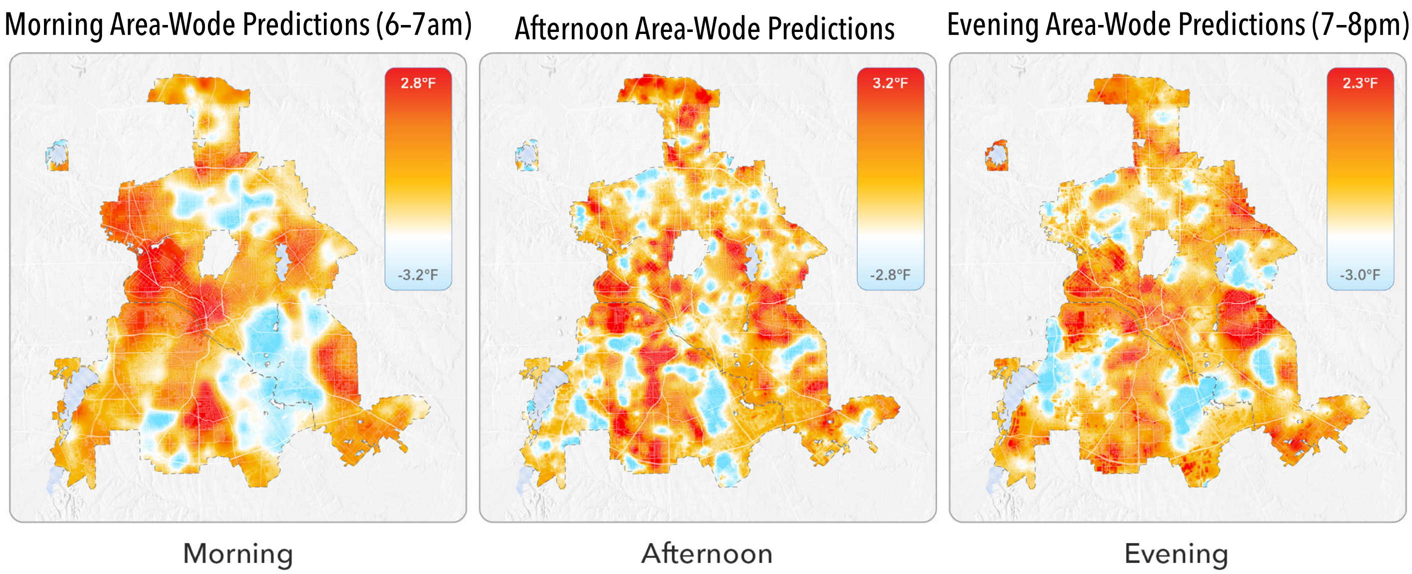


Figure 2. Morning, afternoon, and evening heat distribution maps based on composite 2023 & 2024 Dallas Heat Watch mapping data. Temperature legends show values (°F) above or below the mean (average) temperature for the city.

1.2 Health effects of extreme heat

Extreme heat can have economic and ecological impacts in the form of lost worker productivity, healthcare costs, damaged infrastructure, and degraded ecosystems. However, impacts to quality of life and public health are often cited as the strongest justification for heat action. Sustained, elevated internal body temperature can trigger major health events like heart attack or stroke for those with preexisting health conditions such as cardiovascular disease and diabetes (CDC, 2024a; Gronlund, 2014). Health impacts are exacerbated when outdoor air temperature remains high overnight, limiting opportunities for the human body to cool down. Even those in relatively good health can succumb to heat stress or heat stroke, the latter of which may be fatal if left untreated. This is particularly common among athletes and laborers who exert themselves in extreme heat (Alahmad et al., 2025; CDC, 2024b; Coris et al., 2004).

[2] Redlining is a historical practice of race-based discrimination in mortgage lending and in the provision of services to neighborhoods with significant minority populations.

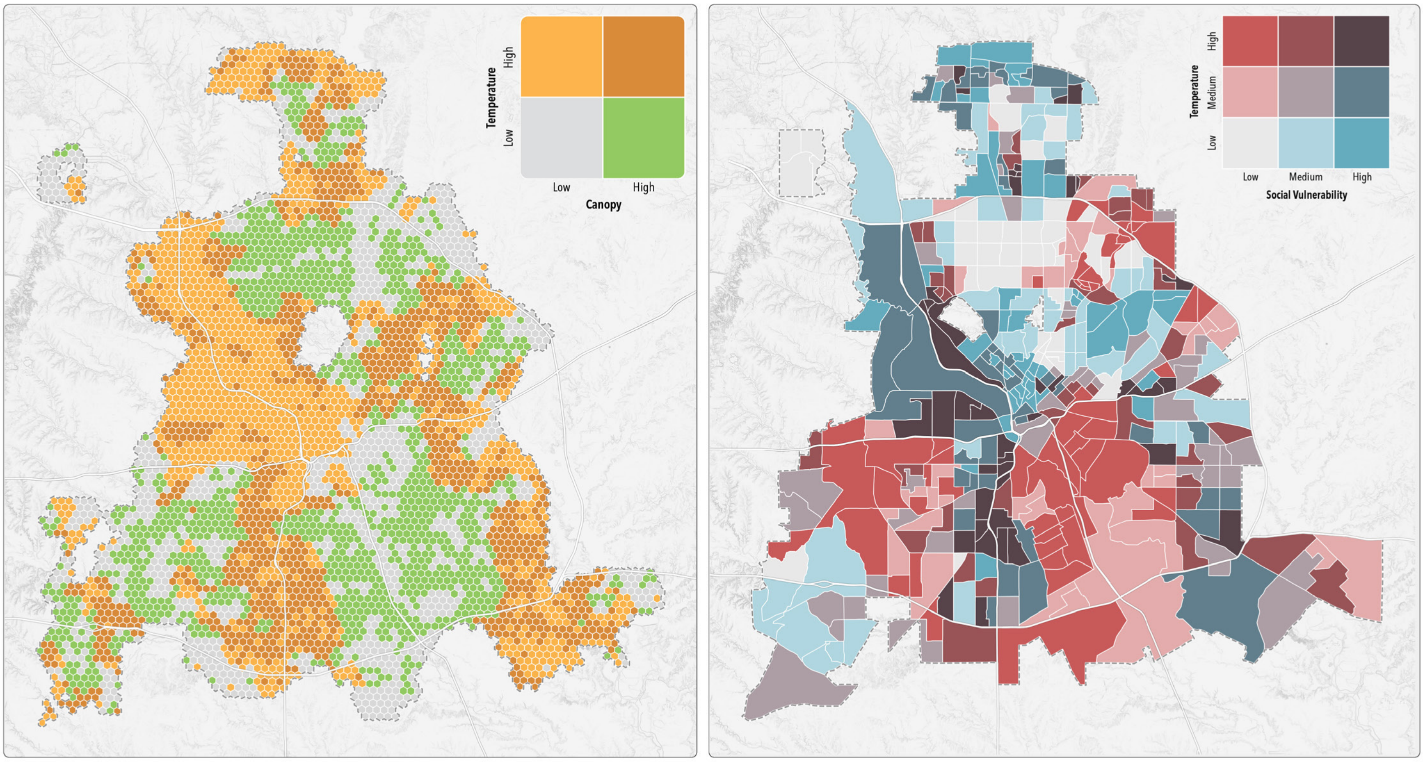


Figure 3. Results of the tree canopy and social vulnerability analyses conducted with local heat data.

Notable health effects of extreme heat exposure include:

- Increased heat-related illness, hospitalization, and mortality among high-risk populations including young children, older adults, and pregnant women (Jiao et al., 2023; Layton et al., 2020; Weinberger et al., 2021). *A local Dallas-area study found a 170% increase in heat-related emergency department visits among children from 2012 to 2023* (Merritt et al., 2025).
- Mental health effects including anxiety, depression, and aggressive behavior (Burke et al., 2018; Miles-Novelo & Anderson, 2019; Nori-Sarma et al., 2022).
- Heat-related occupational deaths, particularly in fields like construction, warehousing, and agriculture. *Since the nullification of local workplace safety ordinances in 2023 (via Texas House Bill 2127), the Occupational Safety & Health Association (OSHA) has documented ongoing heat-related deaths across Texas* (Pskowski & Gopal, 2025).
- Lasting disruptions to early childhood development and cognitive function (Clayton et al., 2021; Cuartas et al., 2025; Granés et al., 2024).
- Higher temperatures are associated with an increase in air pollution, especially ozone, which similarly affects the city's most economically and medically vulnerable residents, including children, older adults, and those with pre-existing health conditions (Heutel et al., 2021; Khatana & Groeneveld, 2023; Makri & Stilianakis, 2008).

1.3 Integrative heat mitigation and adaptation solutions

There are opportunities for heat-related interventions to address co-occurring social or environmental stressors. For example, transportation upgrades that reduce urban heat may also mitigate harmful emissions and air pollution (see section *4.1 Transportation*), while cooling trees and green spaces also help to control stormwater (see *Chapter 3 Smart Surfaces*). Public health strategies may address access to air conditioning (AC) as well as the energy cost burden that AC use may entail. Likewise, multiple 'smart surface' strategies may be combined for greater temperature reduction or cost savings.

Integrative solutions are recommended as a way to maximize the impact of each intervention, minimize redundant work and wasted resources, and tackle climate change as the complex challenge that it is (United Nations Environment Programme, 2021). From a municipal standpoint, heat-related interventions that serve a dual function may be easier to fund because they are a better value than standalone, single-stressor interventions; they may be covered under existing policies and programs pertinent to water management, urban forestry, or environmental health, perhaps reducing the need to pass new legislation; and they may more easily attain community buy-in as they appeal to multiple interest groups. The City and its partners will need to be intentional in framing heat-related interventions such that crosscutting benefits are well understood by funders, the public, and local decision makers.

1.4 Existing resources

This guidebook focuses specifically on options for heat mitigation and adaptation in Dallas. For additional background and information on related topics, please refer to the following resources (active as of February 2026):

City of Dallas Hazard Mitigation Action Plan (2024-2029) | City HMAP
Connect Dallas Strategic Mobility Plan (2021) | SMP
Dallas Comprehensive Environmental and Climate Action Plan (2020) | CECAP
Dallas County Community Health Needs Assessment (2022) | CHNA
Dallas County Hazard Mitigation Action Plan Update draft (2025) | County HMAP
Dallas Street Design Manual (2019) | SDM
Dallas Urban Forest Master Plan (2021) | UFMP
ForwardDallas 2.0 Comprehensive Land Use Plan (2024) | FD
Resilient Dallas Goals | RDG
The 360 Plan (2018) | 360P

The documents listed will be cross-referenced in Chapters 2-7 (as applicable) under the label "Supportive Plans" using the abbreviations shown above.

Chapter 2: Trees

2.1 Benefits of Trees

Supportive Plans	**UFMP** (general); **CECAP**: Goal 6, 7, 8; **FD**: Urban Design Elements + Strategies; **City HMAP**: Natural Resource Protection Actions
Potential Implementers	DWU, OEQS, PDD, PKR, TTF, TPW, Local non-profits

Trees are uniquely effective at mitigating the UHI effect and providing complementary social and ecological advantages. They reduce urban heat by reflecting, rather than absorbing, sunlight; protect people and surfaces from direct sunlight through shading; and release cooling water vapor into the air through the process of transpiration. Trees also shade buildings, which reduces the need for energy use to cool indoor spaces.

Heat mapping conducted in Dallas in 2024 showed that some parts of the city – those least vegetated and suffering the most severe impacts of the UHI effect – were up to 12°F hotter than the coolest parts. Mapping in comparable humid subtropical cities such as Charlotte (NC), Oklahoma City (OK), and Knoxville (TN) revealed comparable double-digit temperature variations largely consistent with variations in tree cover and other vegetation (CAPA Strategies, 2026).

Besides contributing directly to urban heat mitigation and adaptation, trees make urban environments more liveable and aesthetically pleasing, improve mental and physical health outcomes, increase property values, and reduce crime. They provide wildlife habitat and contribute to biodiversity, clean pollutants such as particulate matter and ozone from the air, filter water, and prevent erosion and flooding (National Wildlife Federation, 2026).

2.2 Limitations of a tree-based strategy

Despite their many benefits, trees are not appropriate or desired in every situation. Tree planting requires new irrigation systems and increased maintenance capacity, which may be prohibitive. In highly developed, UHI-prone areas, plantable space and healthy soil may be in short supply. Furthermore, trees alone are unable to satisfy all of a community's needs related to cooling. This means that planners will need to consider complementary solutions for heat management and apply them as needed. Generally speaking, major limitations of a tree-based strategy include:

- City residents may be reluctant to plant trees for a variety of reasons. Common concerns include the upfront costs associated with tree planting and maintenance, the cost of watering, and debris or property damage from fallen fruit, leaves, and limbs. While concerns could be overcome through outreach and education in some cases, not all property owners will welcome trees (Riedman et al., 2022).
- Trees require consistent maintenance for their first two to three years, and periodic watering and pruning after. Project plans and budgets often fail to account for the ongoing maintenance needs of trees. With no designated party responsible for upkeep, insufficient staff capacity, or no funds available to support them, new trees can die before reaching their full potential, or within just a few years of being planted (Pincetl et al., 2013; Widney et al., 2016).

- Heavily developed urban areas lack space for new trees. Making space requires major changes to the built environment such as de-pavement, or the re-purposing of land already serving another function, though many cities have found ways to integrate trees into new street designs and developments.
- Trees compete for land area with other uses such as residential and commercial development. Growth management planning may call for new homes and businesses to be built in closer proximity to each other (i.e., increasing density and limiting sprawl), leaving less open space for trees. [8]
- The presence of power lines and utility lines creates a conflict and limits the potential placement options for new trees.
- Trees cool the air and surfaces but do not alleviate humidity. Combined heat and humidity limits human thermoregulation via sweating (Raymond et al., 2020). In extreme conditions, trees will not negate the need for mechanically cooled and dehumidified indoor spaces.
- Trees have been shown to increase property values, which is usually framed as a benefit. However, studies have also shown that the uneven installation of green infrastructure (including trees) within cities can sometimes lead to a process called 'green gentrification' years later (Anguelovski et al., 2022; Gould & Lewis, 2016). In these cases, green amenities in areas previously lacking them can trigger an increase in property values, taxes and rents, attract new businesses and residents, and lead to the displacement of longtime residents. If not addressed intentionally by city planners and policymakers, this outcome could harm those communities who were meant to be served by greening.

2.3 Making the most of trees

The following recommendations can improve the sustainability and effectiveness of trees as a heat management strategy.

Aim for at least 30% coverage citywide, and 40% coverage or more in smaller geographic areas such as neighborhoods:

- Studies of humid subtropical climates have shown that the cooling benefits of trees level off when coverage reaches around 30% (Ng et al., 2013; Onishi et al., 2010); additional studies put this number as high as 40% (Ouyang et al., 2020) or 45% (Li et al., 2023). Higher threshold values are thought to be most appropriate for smaller geographic scales (i.e., block level or neighborhood) rather than the citywide scale. For example, the City of Dallas might aim to achieve 40% canopy coverage in residential areas while maintaining citywide coverage closer to 30%.
- According to the *Dallas Urban Forest Master Plan 2021*, the city has current coverage of 32%, though trees are threatened by pests, disease, and urban development. Total coverage may decrease without additional protections and/or an increase in tree planting.
- The citywide total does not reflect nuanced differences and disparities across census block groups and neighborhoods. Approximately 56% of census block groups in Dallas feature canopy coverage above 30%, and 31% of block groups have coverage above 40%. Approximately 23% of census block groups have canopy coverage under 20%.[3] These and other lower-canopy areas still require additional planting to reach the recommended minimum.
- Although cooling benefits may level off at 30-40%, denser canopy coverage could better address non-heat stressors such as stormwater runoff and air pollution.

Prioritize native and/or climate-adapted species:

- Native species complement other natural components of the urban ecosystem, and are adapted to historical norms of heat and precipitation.
- Due to climate change and encroaching pests, some native tree species may become less suitable over time. It is recommended that the City develop a climate adapted species list to guide future planting decisions.
- Deciduous trees provide the most effective shading and cooling in the summer, while allowing sunlight exposure in cooler months when leaves fall (Antoszewski, 2020; National Wildlife Federation, 2026).

[3] Tree canopy data points were generated by CAPA Strategies based on aggregated data from the US Geological Survey's National Land Cover Database.

This means that deciduous tree-shaded buildings can enjoy low cooling burdens in the summer without added heating burdens in the winter.

Plant strategically:

- A cluster of trees in a single location (e.g., a forest) offers greater benefits in terms of air purification, stormwater control, and localized heat mitigation. An example of this type of planting is Miyawaki Forests, or "pocket forests," in urban areas (Webber, 2026).
- The same number of trees spread equally over a large area (e.g. an entire city) will have less pronounced long-term ecological effects than clustered planting, but will positively impact a greater number of urban residents in the short term (Heynan, 2003). 10
- Placing trees within green space or near water features will maximize their cooling potential, and trees will have the greatest cooling effect in front of facades with a south-west exposure (Antoszewski, 2020; Yu et al., 2017).
- Local research from Texas Trees Foundation (TTF) has found that planting in clustered, diverse "tree groves" is the ideal configuration for cooling and ecological co-benefits (TTF, 2025).

Seek Community Buy-In

- Engaging with local communities, obtaining public buy-in, and considering anti-displacement measures from the start will ensure that tree planting projects respond to community interest and needs, that trees will be welcomed and cared for, and that greening does not cause unintended harm to vulnerable residents (deGuzman et al., 2018).
- Direct engagement and education with property owners may allow the City to leverage a cache of privately-owned planting space – including residential yards, parking lots, and commercial landscapes – which could be planted and maintained by those property owners.

Prioritize Mature Trees

- Create a plan for at least three to five years of monitoring and maintenance with new planting initiatives, including a regular watering schedule. Clearly designate the responsible entities and funding source to cover maintenance staff salaries, tools and equipment, water, and logistics. This will help ensure that new trees can reach maturity and thrive.
- Tree-based heat mitigation strategies should prioritize the preservation of mature canopy. Fully grown trees are up to 70 times more effective than saplings at capturing carbon, mitigating heat, and controlling stormwater (Stecker, 2014; Treekeepers of Washington County, 2026).

Chapter 3: Smart Surfaces

	3.1 Green surfaces	**3.2 Permeable surfaces**	**3.3 Reflective surfaces**
Supportive Plans	**FD:** Urban Design Elements + Strategies; **360P:** Ground Floor Articulation A4, Upper Floor Massing & Articulation A7, Parking Access & Design B2, Build Complete Neighborhoods Goal 2; **CECAP:** Goal 5, 6	**FD:** Urban Design Elements + Strategies, Environmental Justice & Sustainability Actions; **CECAP:** Goal 5, Goal 6	**360P:** Ground Floor Articulation A4, Parking Access & Design B2
Potential Implementers	DWU, OEQS, PDD, PKR, TPU, TTF	DWU, OEQS, PDD, PKR, TPW, TTF	DDI, OEQS, PDD, PKR, TPW

3.1 Green surfaces

Increasing the amount of vegetated or green space in Dallas has the potential to combat the UHI effect and provide co-benefits through cost savings, reduced energy demand, stormwater management, increased biodiversity, and reduced carbon dioxide (CO2) emissions. Notable vegetated surfaces include green roofs and walls, open spaces, and green stormwater infrastructure.

GREEN ROOFS

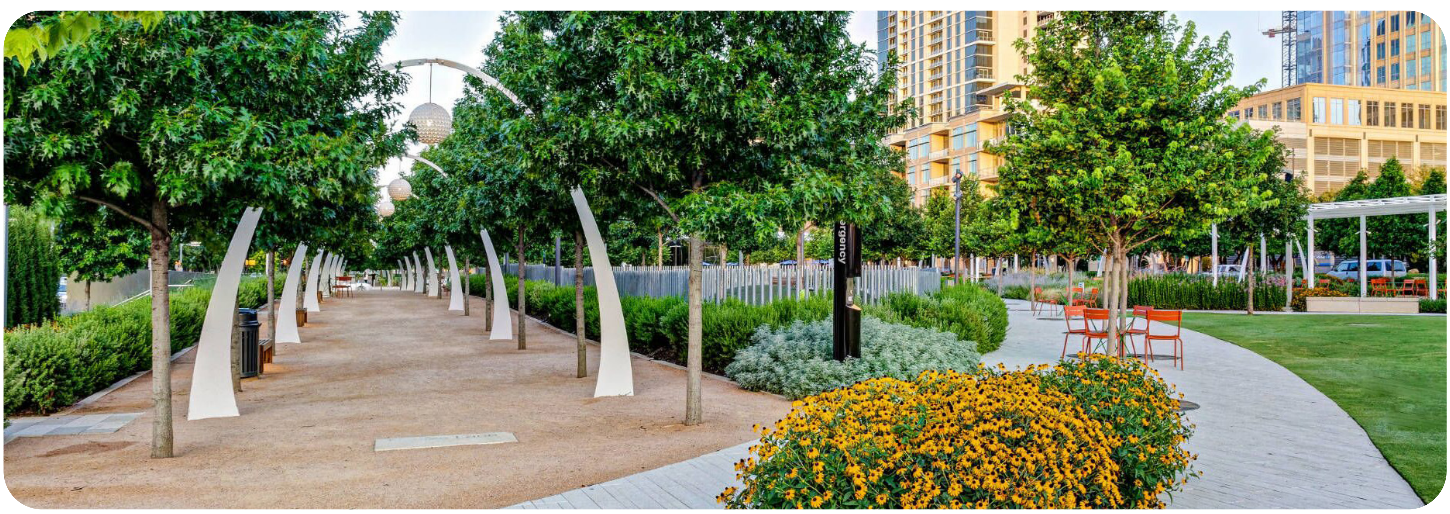
Impacts:

- Green roofs provide $36.33/ft2 in direct energy savings, drought risk reduction, and ecosystem services (SSC, 2026).
- Green roofs have a minimal impact on outdoor temperatures at the pedestrian (i.e., street) level, though can reduce localized air temperature by up to 5°F (EPA, 2026).
- Green roofs moderate indoor air temperature, reducing AC demand (Coma et al., 2016).
- Green roofs can capture and filter the first flush (1”) of stormwater.

Tips:

- For extensive green roofs (with 6 inches or less of growing medium), incorporate native, hardy, low-lying plants that can survive on rainwater precipitation for minimal maintenance.
- Prioritize species like sedum and succulents that can handle extensive direct sunlight, hold water, and reseed themselves (Getter, 2015).
- If a building can support the weight of heavier vegetation and if staff capacity allows, larger shrubs, grasses, and trees can be incorporated into green roofs to increase runoff capture and cooling capacity (Zheng et al., 2021).
- Prioritize green roofs on commercial buildings, multi-family residential buildings, or other large structures with dedicated maintenance staff. Small-scale residential green roofs are possible, though upkeep may prove challenging for homeowners. Vegetated roofs are permitted under the *International Green Construction Code* followed by the City of Dallas.

Vegetated green walls are a comparable strategy to reduce direct sun exposure and heat absorption by buildings. Green walls are expected to reduce AC demand up to 40-60% in temperate climates and also mitigate air pollution (Perini et al., 2011).



VEGETATED OPEN SPACE (GREEN SPACE)

Impacts:

- Vegetated open spaces such as parks, grassy yards, gardens, urban meadows, and greenways are less effective than trees but more effective than green roofs at reducing the UHI effect.

- While green roofs and walls are effective at localized heat reduction, parks and greenways provide thermal benefits on a larger scale (Lin and Li, 2025). 13
- In a Beijing study, a decrease in green space led to a significant rise in surrounding land surface temperature, while adding green space yielded only a minor reduction in temperature (Sun & Chen, 2017). This indicates that new vegetation does not immediately provide the same cooling benefits as established green space.
- Vegetated open spaces also support stormwater filtration and management.

Tips:

- Open, green spaces are most effective for cooling when they are built in compact and simple shapes, such as a circle or square (Li et al., 2012; Shih, 2017). For example, a square-shaped park will provide greater localized cooling than a long, thin strip of green space covering the same total area.
- Native grasses, forbes, and shrubs offer greater stormwater management, soil quality, wildlife habitat, and cooling benefits than turfgrass. The cooling function of grassy open spaces is improved when trees are distributed throughout (Yu et al., 2017), such as in parks. Rainwater flows 10 times slower through urban environments that mimic native habitat compared to lawn-style parks (Ossala et al., 2015).
- Urban meadows, which incorporate native grasses and flowering perennials, can accumulate particulate matter from air better than lawns (Przybysz, 2021), reflect 25-34% more sunlight than lawns (Marshall et al., 2023), and are on average 9°F cooler (Francoeur et al., 2021).
- Community gardens and urban agriculture sites can also serve as multipurpose cooling green spaces. These sites offer the added benefit of food production and community building for those who live in the area. Rainwater harvesting on-site offers a sustainable option for watering trees, crops, and other vegetation.

GREEN STORMWATER INFRASTRUCTURE

Rain gardens, bioswales, and constructed wetlands—or green stormwater infrastructure (GSI)—capture and treat stormwater by mimicking natural systems. These strategies are lower-cost alternatives to gray infrastructure that manage stormwater and cool neighborhoods by increasing vegetated land cover. While these features are typically recommended to address stormwater and urban flooding, they are also notable for their potential impact on ambient air temperatures.

Considerations:
Green installations and open spaces require ongoing maintenance. These needs should be considered and budgeted for prior to the expansion of vegetated space or installation of green infrastructure.

Seek opportunities to capture and reuse stormwater to reduce the City's dependence on irrigation and meet water conservation goals in the CECAP.

For more information on green stormwater infrastructure and policy recommendations that cities can apply to increase GSI adoption, consult the Smart Surfaces Coalition Green Stormwater Infrastructure Policy Guide, found on the SSC Best Practices page.

3.2 Permeable surfaces

In addition to the permeable green spaces noted in section 3.1, the City may implement permeable pavements to decrease surface temperatures and control stormwater runoff. Permeable pavements are an alternative to impervious surfaces, like concrete and asphalt, that allow rainfall to infiltrate through pavement to subsurface soils or into a combination of soil and underdrain systems.

Impacts:

- Concrete permeable pavement absorbs less heat than asphalt, reducing the UHI effect.
- Through evaporative cooling, water retained in permeable pavement systems keeps surface and near-surface temperatures lower than impermeable pavements (Ossala et al., 2013). One study found that water-retaining paver blocks can stay 2-10°C cooler than impervious blocks (Chin et al., 2018).
- In a study of paved areas in Taipei, a year of monitoring showed that the surface temperature of permeable light gray brick pavers was on average 2.7°C lower than impervious pavement and 3.9°C lower than asphalt pavement (Chen at al., 2024).

- By storing surface runoff before it enters waterbodies, permeable pavements can also lower the temperature of the stormwater runoff itself, protecting fish and other aquatic life from temperature shocks (Upper Midwest Science Center, 2019).
- Researchers in North Carolina found that permeable pavement can reduce heavy metal, nutrient, and sediment pollution in runoff by 70% (Braswell et al., 2018).

Tips:

- Replace large swaths of asphalt or standard concrete with permeable pavement in parking lots, plazas, driveways, bike lanes, and sidewalks. .
- Install permeable pavement on multi-use paths (e.g., in City parks) to improve the comfort of pedestrians, cyclists, and pets.
- When sidewalks, service lanes, or parking areas are scheduled for replacement or maintenance, they can be evaluated to incorporate permeable paving materials. Permeable and interlocking concrete block systems make utility maintenance easier, because they can be removed and replaced as needed.
- Consider permeable options such as articulating concrete blocks, pavers, and panels, pour-in-place pervious concrete, and permeable resin bound paving.
- Permeable pavement systems require periodic maintenance such as vacuuming to ensure large particles do not clog void space.

Considerations:
The City's *Drainage Design Manual* contains inconsistent guidance regarding where permeable pavement can be implemented. Minor clarifications in the *Drainage Design Manual* may accelerate permeable paver adoption and crucially mitigate extreme heat and stormwater flooding.
For more information on permeable pavement systems and policy recommendations that cities can apply to increase permeable pavement adoption, consult the Smart Surfaces Coalition Permeable Pavement Policy Guide, found on the SSC Best Practices page.

3.3 Reflective surfaces

Reflective roads, roofs, and walls reduce the extent to which hard surfaces absorb heat. Reflective and/or light colored roofing materials are an alternative to green roofs as they provide similar indoor cooling benefits, require less regular maintenance, and may be suitable for older buildings or those that cannot support the weight of a green roof. However, reflective and light surfaces do not contribute directly to stormwater management or air quality improvement and must be periodically replaced.

Impacts:

- One study from Arizona found that reflective roads reduced daytime surface temperatures by 9-16°F and reduced evening air temperatures by 0.5°F (Middel et al., 2021).
- A community-wide cool pavement installation in Pacoima, CA measured average daytime air temperature reductions of 2.1°F and up to 3.5°F during an extreme heat event (Taha, 2024).
- Like green roofs and walls, reflective building surfaces help keep indoor temperatures low and reduce the need for mechanical cooling.

- Cool or reflective walls provide annual energy savings, peak power demand reduction, emissions reductions, and heat island mitigation benefits comparable to cool roofs (Levinson et al., 2019).

Tips:

- The noted Arizona study (Middel et al., 2021) found that humans' heat exposure ('mean radiant temperature') increased 5.5°F, on average, when walking on reflective surfaces in afternoon sun, while the Pacoima study (Taha, 2024) found no negative thermal impacts on average. Given the potential for unintended discomfort, consider limiting reflective materials in locations with high-intensity pedestrian activity.
- Consider reflective pavement options such as polymer modified cement composite, photocatalytic pavement rejuvenators, epoxy-fortified acrylic seals, reflective asphalt sealcoat, and alternative mixes with polymer-based binder and light-colored aggregates.
- Cool or reflective roof materials are available across most product lines, including single-ply membranes, liquid-applied coatings, asphalt shingles, clay & concrete tiles, or metal roofs.
- Light-colored or infrared-reflective exterior wall coatings increase solar reflectance and reduce energy demand.

3.4 Data highlights

The following data points are derived from SSC's Benefit-Cost Analysis Tool. These summaries reflect expected savings in five categories: (1) energy savings, (2) public health benefits, (3) reduced infrastructure costs (installation and maintenance), (4) environmental benefits (drought mitigation and ecosystem services), and (5) climate change mitigation (applying the social cost of carbon to greenhouse gas and CO2equivalent [CO2e] reductions). All projections assume a "moderate" uptake of smart surface interventions citywide, implemented over 15 years (2026-2041), and consider a benefits timeline of 25 years (2026-2051). For details about this tool and methods visit https://bca.smartsurfacescoalition.org/methods.

While specific interventions have variable impacts across categories listed above, a combination of smart surfaces may yield maximum benefits and address both extreme heat and stormwater management.

DALLAS SMART SURFACES DATA HIGHLIGHTS

COOL (REFLECTIVE) ROOFS

Moderate target = +80% of eligible roof area converted

$459M
Energy Savings

$333M
Public Health Benefits

$1.03B
Climate change mitigation

PERMEABLE PAVERS

Moderate target = +10% of stormwater runoff from roads, parking lots, and other paved survaces managed

$3.2M
Public Health Benefits

$1.27B
Reduced infrastructure cost

$219M
Environmental benefits

$6.7M
Climate change mitigation

TREES

Moderate target = +3% canopy coverage across all land area

$1.4M
Energy Savings

$122M
Public Health Benefits

$954M
Reduced infrastructure cost

$146M
Environmental benefits

$188M
Climate change mitigation

COMBINED STRATEGIES

+80% cool roofs, +15% cool pavements, +3% solar photovoltaics, +10% permeable pavement, +10% bioswales, +40% rain gardens, +3% trees

$2.1B
Energy Savings

$780M
Public Health Benefits

$6.28B
Reduced infrastructure cost

$1.21B
Environmental benefits

$2.76B
Climate change mitigation

Managed stormwater = 34.76 billion gallons/year
CO2e reductions = 19.1 million metric tons

Chapter 4: Urban Infrastructure

	4.1 Transportation	**2.2 Shading**	**4.3 Energy Micrograds**
Supportive Plans	**360P:** Advance Urban Mobility Goal 5; **CECAP:** Goal 3, 8; **SDM** (general); **SMP** (general); **FD:** Transit Oriented Development & Connectivity	**CECAP:** Goal 1, 3; **360P:** Ground Floor Articulation A4, Upper Floor Massing & Articulation A6	**360P:** Upper Floor Massing & Articulation A6, Parking Access & Design B2; **CECAP:** Goal 1, 2; **County HMAP:** Countywide Action #2
Potential Implementers	DART, DDI, OEQS, PDD, PKR, TPW, TTF	DDI, OEQS, PDD, PKR, TPW	ECR, FRM, OEQS, PDD, PKR, TPW, Utilities

4.1 Transportation

Automobile use exacerbates the UHI effect and harmful air pollution locally, while contributing to emissions and warming at a broader scale. Prioritizing public and multi-modal transportation in Dallas is a way to simultaneously mitigate heat, reduce emissions and air pollutants, and promote community health via active transportation (Glazener & Khreis, 2019).

Strategies:

- Add new bike lanes to larger thoroughfares.
- Designate select small roads as bike-only thoroughfares closed to non-resident traffic.
- Create safe, comfortable walking paths and pedestrian spaces.
- Increase the reach of DART bus routes and frequency of trips.

Use of active and multi-modal transportation options could mean that commuters spend more time traveling and/or exerting themselves outdoors. Upgrades to pedestrian and commuter heat safety infrastructure will also be needed (Karner et al., 2019). Public and multi-modal transportation projects can provide extreme heat relief for pedestrians and commuters by incorporating green infrastructure, permeable paved surfaces, solar reflective coatings, and shade canopies.

Strategies:

- Provide shade at bus stops. Incorporate green roofs, solar reflective materials, and/or solar panels for extra benefits.
- Place public water fountains or misting stations along popular commuter routes.
- Locate new bike or walking paths close to existing tall buildings or trees, which provide shade.
- Utilize permeable and/or solar reflective pavements along pedestrian and bike paths and bus lanes to cool the path surface and assist with stormwater capture (Lanza & Durand, 2021; United Nations Environment Programme, 2021).
- Line pedestrian and bike paths and public rights-of-way with trees and green stormwater infrastructure to provide buffers from automobile traffic, manage stormwater runoff, and reduce temperatures.

"Complete Streets" design policies guide the integration of pedestrian and multi-modal infrastructure into urban development and were adopted by the City of Dallas in 2016. Since then, the City has formalized guidance that supports increased access to safe, environmentally-friendly transportation options. The *Streets Design Manual* and *Strategic Mobility Plan* do not make specific references to urban heat, though call for relevant improvements and may be leveraged for heat mitigation alongside priority topics such as air pollution mitigation, traffic calming, and stormwater management. Furthermore, any move toward "Complete Streets" should include green elements (trees and other vegetation).

Tip: Explore opportunities to increase connectivity between heat-vulnerable people/places and resources. For example, ensure that cooling centers, medical facilities, and air conditioned public places (e.g., libraries) are directly accessible by bus from neighborhoods facing the highest temperatures.

Considerations:
Any expected increases in the frequency of active transportation (walking, biking, skating, etc.), should be coupled with appropriate public health messaging and safety warnings during high heat events, particularly when air pollutant concentrations are also high.

4.2 Shading

Limiting direct sun exposure is an effective way to reduce heat stress and the UHI effect. Large trees create shade while offering environmental co-benefits, though trees require ongoing maintenance and may not work in all areas, such as narrow sidewalks or other paved spaces, and areas without proper soil, drainage, or irrigation. Non-vegetated shade structures serve a similar heat mitigation function but require less upkeep compared to trees and have an immediate cooling impact.

One study of artificial (i.e., non-tree) shade structures in a humid subtropical climate found that areas shaded by a pergola with some overhead vegetation, or shaded by a building, could feel nearly 30°F cooler than those receiving direct sunlight (Watanabe et al., 2014). Another found that shading, whether by natural or artificial means, reduced thermal stress by more than half and that the effects of artificial shading closely resembled those of tree shade (Ouyang et al., 2023).

Strategies:

- Permanent shade pavilions, shelters, and pergolas.
- Retractable shade canopies. [20]
- Temporary/removable shade sails and tents.

Tips:

- Deploy temporary shade structures to the highest-risk areas (e.g., playgrounds, schoolyards, sports fields, transit stops) during a heat wave.
- Deploy shade structures to neighborhoods lacking natural shade as a stopgap while pursuing long-term green infrastructure improvements.
- Equip permanent structures with a green roof, solar reflective coating, or solar panels to provide co-benefits.
- Identify locations for large, high-impact shade installations such as parking lots or campuses.
- Prioritize busy commuter routes, areas where people congregate, and areas where individuals will be resting or waiting (e.g., benches, bus stops) for shading.
- Aim for at least 30% shade coverage along transit paths, and consider how shade structures will behave at different times of day and with different sun angles.
- Note that sites with east-west exposure will require more shading than those with north-south exposure (Jay et al., 2021; United Nations Environment Programme, 2021).

CASE STUDY:

SOLAR PHOTOVOLTAIC (PV) TREES IN SAN DIEGO, CA

In 2008, the University of California San Diego (UCSD) installed solar arrays, with individual structures called "solar trees," in two campus parking lots. Solar trees provide shade to parked vehicles and can be equipped with electric vehicle charging infrastructure. Surface temperatures under these installations measure 20°F cooler than a typical, uncovered parking lot. Each solar tree is capable of generating 17,000 kilowatt hours of solar electricity per year, which can be used on the campus (Nagel, 2008). Supplemental energy sources like this allow the University to reduce its demand during peak usage times and reduce stress on the city's power grid. The successful solar installations at UCSD remain in place after 15+ years.

Considerations:
The City of Dallas has installed some "canvas and pole" shade structures in parks and play areas. Challenges include maintenance costs, preventing graffiti, keeping visitors from climbing on the structures, and positioning structures to protect against low sun. Budget increases for installation and maintenance will likely be needed to support major expansion of park shade structures.

Local non-governmental organizations ("Friends" groups) sometimes donate shade structures for trails. However, these groups should coordinate with Dallas Park & Recreation early on to ensure that structures are appropriately designed and will not create unintended problems for the City.

4.3 Energy microgrids

Building- or community-scale energy systems and storage ("microgrids4") promote heat resilience in multiple ways. Heat wave power outages are becoming increasingly common nationwide as centralized energy grids are strained by increased demand for air conditioning (Stone et al., 2021). Power outages during extreme heat are a top concern of emergency managers in Dallas given local reliance on mechanical cooling. Community-scale energy systems and storage provide a backup to the main grid, potentially protecting high-risk individuals who would be impacted by loss of access to air conditioning, refrigeration, and life-saving medical devices. Backups also allow for continued operations at government, medical, and other essential facilities in the event of a power outage.

When microgrids rely on renewable energy sources, such as on-site solar and wind installations, this provides an added environmental and social benefits. Localized, renewable systems may offer low-income households the opportunity to generate energy and save on electric bills. This is important for heat resilience as low-income households often cannot afford to run air conditioning as needed.

Strategies for municipal and large private/commercial structures:

- Install solar panels atop buildings that can support them, and ensure backup power is available at essential facilities.
- Expand on existing efforts to provide backup power at City-owned recreation centers.
- Couple energy system upgrades with pre-planned building renovations for older buildings.

Strategies for residences and smaller facilities:

- Permit renewable-powered, behind-the-meter (BTM) microgrids across Dallas, including
  - Household scale: serves individual homes
  - Campus scale: serves buildings on a large property such as a college or medical campus
  - Community scale: serves critical facilities, homes, businesses, other community buildings
- Work with residents, community groups, schools, and others to encourage adoption of solar panels, small-scale wind power installations, and other renewables; backup storage; and community- or building-scale energy systems.

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[4] Microgrids are small-scale energy systems that support the use of alternative energy (solar, geothermal), promote energy independence for all communities, and offer a safety net in a heat emergency. Typically, sustainable energy sources charge batteries for use in a power outage and may also power homes or businesses within the microgrid on a regular basis (Gastelum, 2022).

Considerations:
The implementation of microgrids or individual BTM energy systems, including subsidies for low-income residents to access alternative energy infrastructure (e.g., solar panels), would require significant upfront investment by the City or other funding partner.

The municipal code does refer to solar panels, implying that solar installations are permissible, though it is not clear what size, capacity, and types of alternative energy systems are permitted. Code language could be more straightforward about what is allowed and what is not for different types of structures and zones.

MULTIPLE MICROGRID CASE STUDIES

A report released by the California Energy Commission (2018) provides detailed information about nine (9) microgrid projects in the State of California, 10 from elsewhere in North America, and seven (7) from international locations, including characteristics, costs, value-adds, and lessons learned from each. This resource offers a wealth of information from case studies in diverse climates and socio-political environments. Common motivations for implementation of a microgrid system included a desire to integrate renewable energy with conventional utilities; reduce energy bills; reduce carbon footprint; and increase resilience, particularly when the electrical grid is disrupted by extreme weather events.

Chapter 5: Policy & Legislation

	5.1 Green Building	5.2 Preservation	5.3 Public Health
Supportive Plans	**FD:** Environmental Justice + Sustainability Actions, Urban Design Elements + Strategies; **City HMAP:** Protective Activities Actions	**UFMP** (general)	**CHNA** (general); **RDG:** Goal 5A, 7A
Potential Implementers	PDD, OEQS, TPW, TTF	OEQS, PDD, PKR, TTF, Non-profits	DC HHS, ECR, Academic institutions, Local health providers, Non-profits

5.1 Green building

Large buildings (e.g., commercial or residential high rises, office parks, university facilities, shopping centers) are ubiquitous in urban areas and contribute significantly to the UHI effect. The City of Dallas currently enforces standards in the *2015 International Green Construction Code* and *2015 International Energy Conservation Code* with the express intention of mitigating urban heat through building codes. These codes notably include requirements for roofing (such as Energy Star certification, reflectivity, and vegetation) and hardscaping (such as inclusion of trees or permeable pavements). While effective in new developments and additions, the rules do not apply to existing structures, and only cover large, primarily commercial buildings.

Strategies:

- The Green Building Task Force brings together a diverse group of stakeholders, including design professionals, contractors, owners, developers, building organizations, property managers, realtors, third-party providers, and City staff. Reconvene the Task Force when adopting a newer version of green building codes.
- In the meantime, consider ways to incentivize rather than mandate stronger green building practices that are not required by the 2015 code. For example, offering a density bonus for large buildings that take extra steps toward efficiency, use of cooling materials, or vegetative landscaping; or incentivizing energy efficiency upgrades in existing properties.

- Offer stormwater fee reductions for installation of green infrastructure and permeable paved surfaces.
- Establish a green building fund to help the owners of existing buildings pay for retrofits and sustainable upgrades (may include residential and commercial owners). 24

Considerations:
Local developers opt for reflective surfaces more often than vegetated ones to comply with code requirements. Consider ways to encourage the use of vegetation which could mitigate urban heat and provide additional co-benefits such as stormwater capture and site beautification.

While even future codes may apply only to larger, non-residential developments, there is an opportunity for the City to explore incentive- and/or education-based approaches that address residential green construction and efficiency.

5.2 Preservation

Many cities articulate planning policies and goals that appear to benefit urban trees but are not legally binding. For example, the 2006 *ForwardDallas* comprehensive plan includes a goal to "preserve and increase canopy cover" as well as corresponding action items. According to the *Dallas Urban Forest Master Plan 2021*, additional guidance from the *State of Dallas Urban Forest Report* (2015) and *Urban Heat Island Management Study* (2017) has scarcely been implemented.

Dallas might consider a robust municipal "tree code" to achieve stated goals related to mature tree preservation and care, including rules for both public/street and private property trees. Legislation that establishes clear tree protections, makes unnecessary tree removal more difficult, and/or commits funding and staff time to the maintenance of trees are all options to improve outcomes in the urban forest.

For more information on strategies and policies that cities can use to increase urban tree canopy, see the Smart Surfaces Coalition's policy guide on urban trees.

CASE STUDY EXAMPLES:
PORTLAND, LOS ANGELES, SEATTLE & ATLANTA TREE CODES

The City of Portland, OR's Title 11, known colloquially as the "tree code," sets standards for tree preservation during development. In cases when a mature tree cannot be protected from removal, developers pay a fee which goes toward planting new trees elsewhere in the city. This code also sets enforceable standards for tree density around new developments. Likewise, the City of Los Angeles' "Protected Trees and Shrubs Ordinance" identifies protected trees according to size and species, and requires developers who must remove protected trees to apply for a permit and pay a fee. While such requirements do not fully prevent the removal of trees, they create an additional barrier for developers and generate revenue that can be used to support other aspects of urban forestry. Additional peer cities with relatively strong, codified tree protections include Seattle, WA and Atlanta, GA.

Urban trees are a frontline defense against the UHI effect and can have a significant, day-to-day impact on those who live or work in the city. While vegetated open spaces and natural areas do not provide the same amount of cooling as trees (see chapter 3.1 *Green Surfaces*) and are less common in populated urban areas, preservation of natural, open space is another strategy for keeping temperatures down. Maintaining natural areas like riparian corridors and prairies means that naturally cool surfaces are not replaced by concrete, buildings, and roads. Preservation of natural areas and open space also promotes favorable conditions for plants and animals, both of which can be negatively affected by rising temperatures. Preservation of open space can be achieved through strong zoning laws and dense urban development standards which limit urban sprawl.

5.3 Public health

Heat is sometimes considered less of a priority than other environmental hazards because, except in the most extreme cases, it does not cause highly visible physical damage. In the latest *Dallas County Community Health Needs Assessment* (2022), extreme heat is not mentioned. However, heat kills more people in the US annually than any other environmental hazard, and efforts to mitigate heat have gained support as it is increasingly framed as a public health threat (Henderson et al., 2021).

Strategies:

- Build on existing coordination between the City and Dallas County Health & Human Services to gather heat-health data, track heat-related illness, and develop data-informed heat-health standards of practice for the region. Standards may cover topics such as:

- integrating health considerations into local planning decisions;
- staffing cooling centers with healthcare providers;
- training healthcare professionals to discuss, code, and/or better treat heat-related illness, including both physical and mental symptoms. 26
- developing specific heat-health care guidelines for medically sensitive populations, such as pregnant women;
- adding standard questions about summertime heat and air pollution exposure to future iterations of the *Dallas County Community Health Needs Assessment*.

- Leverage research and data to advocate for protective legislation at the local or State level. Examples include required in-home cooling for renters or energy shut-off prevention in a heat wave, both with the aim of reducing heat-related illness and mortality.
- Where legislation is infeasible, consider policy directions that facilitate community engagement, outreach, and voluntary compliance with heat resilience measures. For example, although local workplace safety rules were recently overridden by Texas House Bill 2127, the City may still implement its own workplace safety policy for City staff, and conduct outreach to local businesses encouraging them to do the same.

CASE STUDY:
OREGON TEMPORARY HEAT SAFETY RULES

In 2025, the Oregon Public Utility Commission implemented temporary rules to protect residents from extreme heat during summer months. Specifically, power utilities were limited in their ability to disconnect service due to nonpayment. From June through October, the following rules were in place:

Not disconnect service during peak heat – Utilities are prohibited from disconnecting electric or natural gas service for 48-hours following a qualifying heat event, such as a heat advisory from the National Weather Service.

Reconnect service required during heat event – Customers whose utility services were disconnected up to 7 days before a heat event can request to be reconnected without delay once the heat event begins.

Waive reconnection fees – Although previous rules approved by the Commission waive select reconnection fees for any low-income customer, these temporary rules expand to waive all reconnection fees for medical certificate account holders or discount program participants.

Improve outreach and communication – The new rules require utilities to improve customer notifications to help ensure eligible customers are informed of their rights and can quickly access reconnection when needed.

Chapter 6: Social Support

	6.1 Financial & technical assistance	6.2 Education & engagement	6.3 Job training & volunteer corps	6.4 Resource giveaways
Supportive Plans	**County HMAP:** Dallas County Action #2; **UFMP (general)**	**RDG:** Goal 5B; **City HMAP:** Public Information Actions; **County HMAP:** Countywide Action #1	**RDG:** Goal 3A, 3B; **UFMP** (general)	N/A
Potential Implementers	DC HHS, HCD, OEQS, TTF, Non-profits	DC HHS, ECR, OEQS, PDD, PKR, TTF, Non-profits	EOD, CCGD	DC HHS, OEQS, TTF, Non-profits

6.1 Financial and technical assistance

The City, non-profit groups, and other partners can support residents and businesses in taking proactive measures which allow them to adapt to heat and advance local greening initiatives. Two key areas for financial and technical assistance include:

(1) Home energy and weatherization: Upfront costs are a common barrier to individuals taking heat-adaptive action, and financially supportive services may encourage individuals to invest in efficient appliances, new insulation, and building weatherization. While a significant portion of homes in Dallas have access to an air conditioner (AC), local research and anecdotal evidence suggest that access to AC does not guarantee cooling. Rather, lower-income residents limit or avoid AC use to save money on energy bills.

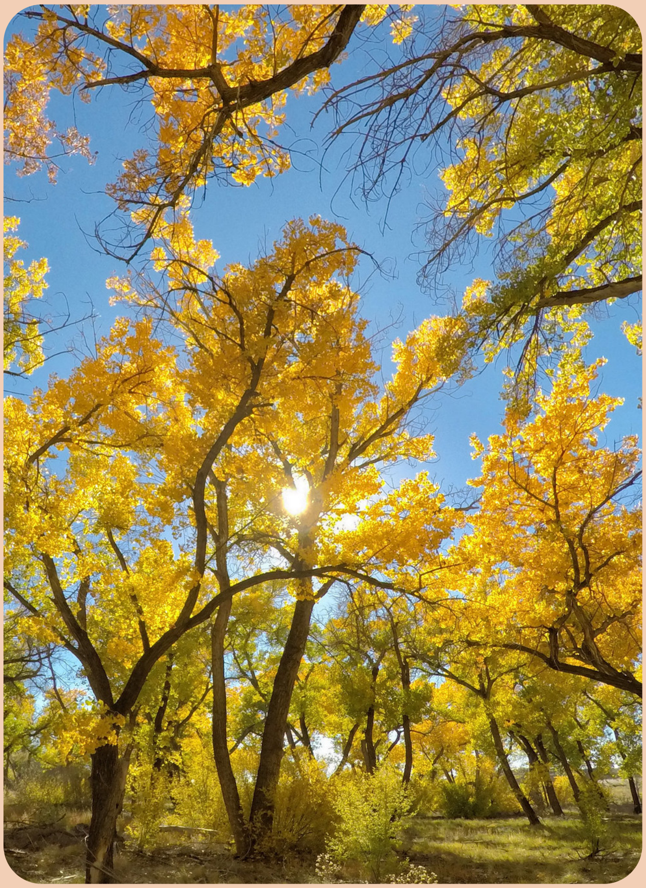
(2) Tree planting and maintenance: City resources may boost public acceptance of canopy and green space expansion, and engage private property owners in planting and stewardship.

Strategies:

- Offer subsidies or rebates for weatherization, energy upgrades, or installation of green infrastructure to offset prohibitive implementation costs (Cousins & Hill, 2021).

- This strategy will only work for those who have sufficient disposable income to pay upfront and await a rebate.

- Provide assistance with home energy bills, especially during high-heat summer months.
  - Low-income residents can apply for the Low Income Home Energy Assistance Program (LIHEAP), though funds often fall short of demand and this program does not prioritize energy use for cooling (Ruben Gallego, 2025).
  - Other options like the Texas Comprehensive Energy Assistance Program (CEAP) and TXU Energy Aid may be unknown or difficult to navigate. 28
  - City staff can work with non-profit partners to increase public awareness of supportive programs and guide their clients through the application process.
- Offer free tree giveaways and planting support to homeowners and business owners.
- Offer free training for those who wish to plant and steward trees or other green infrastructure on their properties or in their communities.
  - Training may come from a certified arborist, master gardener, or other appropriate advisor contracted by the City.



CASE STUDY:

TREE NEW MEXICO

Tree New Mexico (TNM) is a statewide nonprofit group based in Albuquerque, which focuses solely on tree planting and tree-based education. The organization uses a mix of community planting events, free tree giveaways, and educating residents about the value of trees to get plants in the ground. Technical education is also provided to ensure long-term sustainability of newly planted trees. To this end, TNM offers training on topics such as tree and site selection, tree planting and care, proper tree pruning, trees and beneficial insects, and identifying and addressing tree problems. Education is supported by state and local experts in urban forestry and arborists, and TNM has been growing the state's urban forest for over 30 years.

CASE STUDY:

ENERGY OUTREACH COLORADO (EOC)

EOC is a non-profit that was created by the State of Colorado to improve coverage in low-income energy assistance. The agency provides "a one-stop shop for low-income energy services in the state," including emergency financial assistance, tips to lower energy bills, grants to other nonprofits and multi-family affordable housing properties, and affordable energy advocacy. EOC relies on a variety of funding streams and partnerships and serves as an example of government facilitating energy assistance outside of conventional channels.

6.2 Education and engagement

Education and awareness are important components of an effective heat mitigation and adaptation strategy. On one hand, the City and its partners must convey to the public the challenges posed by heat, the importance of heat mitigation, and the economic, social, and ecological co-benefits associated with heat mitigation interventions (Wang et al., 2021). Without such an understanding, it is less likely that residents will respond positively to cooling measures and new expenses, or that residents will take personal initiative to mitigate heat (e.g., opt to plant and maintain a tree on one's own property).

On the other hand, education is a pathway to personal heat safety awareness and adaptation. Many individuals do not understand the threat posed by heat, do not imagine that they could be susceptible to heat-related illness or mortality, and do not know the signs of serious illness (Howe et al., 2019). In Dallas, public health authorities and community-based organizations can make a concerted effort to educate residents about the risks posed by heat.

Strategies

- Articulate risks for medically sensitive as well as seemingly healthy groups.
- Provide advice on activities to avoid, symptoms to look for, and measures to take when exposed to high temperatures.
- Provide information on staying safe outdoors, indoors, and over prolonged periods of exposure to high temperatures.
- Disseminate information through multiple channels such as local news and television stations, printed materials, radio announcements, and social media.
- Share information in multiple languages for accessibility.

Engagement can inform the City's understanding of heat impacts, help identify appropriate intervention strategies, and cultivate community buy-in. For heat mitigation and adaptation efforts to be successful, residents must understand what the City is doing and why; must be able to connect heat-related work and challenges to their own lives, interests, and well-being; and must take some responsibility for advancing those efforts (Campbell-Arvai & Lindquist, 2021; Thorne et al., 2018). Community-based efforts can have an enormous impact on the overall heat resilience of a city, and the participation of private property owners (single family, rentals, businesses, schools) builds upon efforts made by the City.

Considerations:
While recognizing the need for more public education on heat safety, risk, and resources, the City has limited information on the types of messages that are most effective. A review of relevant case study literature, ideally combined with a local social-behavioral study, may shed light on the most impactful ways to share information with the public. This includes details like wording, tone, and delivery media.

Non-profit and community-based organizations offer unique access to the most heat-vulnerable populations and can expand City capacity for community engagement.However,these organizations often have limited funding and internal capacity. While some may be open to providing volunteer assistance, the City should seek opportunities to formally contract with non-profit and community-based organizations and compensate them for their time and labor.

6.3 Job training and volunteer corps

Getting residents involved in large numbers may bolster local efforts to mitigate and adapt to extreme heat (Jerome et al., 2017). Time, labor, and resources provided by residents offer a supplement to City services which may be overstretched, particularly when it comes to the maintenance of new heat-mitigating infrastructure.

Strategies:

- Organize a volunteer program which can serve a variety of functions with regard to heat mitigation and adaptation. Volunteer groups may emerge organically, though coordination by the City, a nonprofit group, or other managing entity can greatly improve their efficacy and capacity.
  - Neighborhood Emergency Teams consist of volunteers who help to deploy services and perform wellness checks during a heat emergency.
  - Youth conservation corps help cities expand tree canopy and care for green space.
  - Neighborhood coalitions support ongoing maintenance of trees and green infrastructure facilities when funding is scarce.

- Support job training programs that allow residents to get involved in heat mitigation and benefit. This approach is valuable where residents face dual stress of low incomes and high environmental exposure (heat, air pollution, flooding). Job training, combined with the creation of more 'green jobs,' is a step toward building a robust network of practitioners who can take action. This also advances environmental goals by connecting residents with paid jobs (Gould & Lewis, 2016).

CASE STUDY:

GROUNDWORK GREEN TEAM (DENVER)

Groundwork is a national non-profit organization dedicated to sustainably managing and improving the natural environment through empowering, socially just, community-based partnerships. The Denver, CO chapter works closely with young adults through its Green Team program. This workforce development program imparts valuable training and experience in a range of green jobs and offers paid work opportunities. Green Team members' work includes building community gardens, improving parks, and educating the community about environmental issues.

CASE STUDY:

VOLUNTEER HEAT RESPONSE IN PHOENIX, AZ & PORTLAND, OR

The City of Phoenix operates a 'Heat Relief Network' that utilizes volunteer assistance to provide information, relief, and wellness checks. The network is a partnership of the Maricopa Association of Governments (MAG), municipalities, nonprofit organizations, the faith-based community, and businesses. Partners can list their property as a hydration/water donation station and/or a cool refuge to aid vulnerable populations (Maricopa Association of Governments, 2024b). Other volunteer roles are open to the general public. 'We're Cool' volunteers engage with Phoenix residents and visitors, especially in the downtown area, to "provide maps to cooling and hydration stations, offer health-related summer safety information, and promote enjoyable and safe activities in Phoenix during the summer months."

The City of Portland Bureau of Emergency Management, in partnership with Portland Fire & Rescue, operates a Neighborhood Emergency Teams (NET) program. Although the program was originally designed for earthquake emergencies, NETs have been increasingly deployed during heat emergencies. NET volunteers provide rides to cooling shelters, pass out water and snacks to unhoused residents, and direct people toward resources. Some see a future opportunity to deploy NETs for home wellness checks to neighbors in need, though that system is not currently in place (Garcia, 2022).

6.4 Resource giveaways

Distributing simple resources can make a significant impact on Dallas residents' heat health and safety at a relatively low cost.

- For those who live, work, or recreate outdoors, cooling kits including ice packs, ice water, cooling towels, sun hats, sunscreen, or handheld fans can provide short-term relief.
- In-home solutions such as blackout curtains, do-it-yourself insulation supplies (sealing tape, under-door draft stoppers), and window or portable air conditioning units can improve indoor environmental conditions.
- Air purifiers may help those who suffer from the combined effects of heat and air pollution, and encourage residents to open windows at night to let cooler air circulate indoors (assuming poor air quality is a cause for keeping windows closed).

Chapter 7: Emergency Response

Supportive Plans	**City HMAP:** Public Information Actions; **County HMAP:** Countywide Action #1, #2, #4
Potential Implementers	DC HHS, DFR, ECR, HCD, LIB, MDHA, OHS, OEQS, PKR, TPW, Non-profits, Community groups

Working proactively toward heat adaptation and mitigation, addressing potential problems 'upstream,' is critical to building long-term resilience. However, even in the most prepared cities, extreme heat events and emergencies do occur. The City government can be ready with a robust heat response protocol which directs resources and attention to high-risk areas and communities. Preparation for heat emergencies can improve coordination between departments, clarify roles and responsibilities, and improve health outcomes for heat-vulnerable residents.

Strategies:

- Continue to open public cooling centers during daytime hours (i.e., during peak afternoon heat); aim to expand the number of centers and geographic coverage.
- Offer free rides or free bus fare to help low-income or mobility-challenged residents access cool spaces such as cooling centers, libraries, medical facilities, or public parks.
- Extend hours for air-conditioned public spaces such as libraries and community centers.
- Provide citywide emergency alerts in multiple languages and formats (by email, text message, phone call, on local news, online) when a heat wave is expected. Alerts should be coordinated with the National Weather Service and Dallas County Health & Human Services.
- Activate wellness checks and resources (e.g., bottled water and cooling kits, mobile cooling/misting stations) to high-risk areas such as homeless camps, mobile home parks, and affordable housing facilities. In-home wellness checks can be performed via phone calls to member listservs from low-income health plans, veterans and disability services, or other social programs. The City of Dallas may also consider contracting with non-profit partners or volunteer networks to reach out to specific populations.
- Publicly share the locations of cooling amenities and resources, such as libraries, community cooling stations and spraygrounds.

CASE STUDY:

NEW HAMPSHIRE HEAT EMERGENCY RESPONSE PLAN

New Hampshire is one of few jurisdictions with a comprehensive Heat Emergency Response Plan. The plan includes guidelines for how to respond to heat-related illness, details of public messaging, and steps that can be taken to reduce heat stress on the local population. Strategies include opening and promoting cooling centers, extending hours for pools and beaches, offering wellness checks to those living alone, and providing safety tips for the general population as well as specific high-risk subsets.

Considerations:

In order to receive City services or resource giveaways (even bottled water), residents must agree to be registered in a government management system. This could make it more challenging for City officials to offer assistance, particularly in an emergency when there is not time for trust and relationship building.

Funding for emergency response and sheltering is currently limited. There is a need for local data on heat-related hospitalizations and deaths, particularly among the unhoused population, to make emergency response a priority.

Populations that are at highest risk during a heat emergency are often the most difficult to access, such as isolated adults who are not enrolled in any social services, and unhoused residents living outdoors.

Non-profit partners often have specialized access that can extend the City governments' reach. Potential partner organizations should be identified early and involved in development of the response plan.

Given the potential for extreme heat and hazardous air pollution (ozone,wildfire smoke) to co-occur in Dallas, consider emergency response options that address both hazards. One such strategy is to use public school buildings as summertime community refuges that provide air filtration and cooling during emergencies. The comparable idea of multi-hazard "resilience hubs" is relatively novel but growing in popularity as new applications are explored nationwide.[5]

CASE STUDY:

SCHOOLS AS COMMUNITY CLEANER AIR AND COOLING CENTERS

The US Environmental Protection Agency (EPA) recognizes the dual threat posed by extreme heat and poor air quality, both of which are becoming more severe as the climate changes, and both of which disproportionately affect vulnerable populations. A grant program launched in 2021 funded four jurisdictions to develop 'cleaner air and cooling centers' within public school facilities. This includes projects in California, Oregon, Arizona, and Washington to transform schools into resilience hubs where high-risk community members can seek refuge from heat and polluted air. Projects are intended to improve indoor environmental conditions for children who attend the schools, while establishing safe spaces for others in the neighborhood. These projects target low-income communities lacking access to opportunity, which typically feature higher heat and air pollution, and are done in collaboration with community-based organizations.

[5] Urban Sustainability Directors Network (2024). Resilience Hubs. http://resilience-hub.org/

Chapter 8: Household & Personal Adaptations

This section is dedicated to adaptive actions that individuals can take to keep themselves safe and comfortable, and their homes cool. Individuals can apply many of the City Scale heat mitigation strategies described in the previous chapters at a personalized scale. For example, homeowners can plant trees and gardens around their properties, weatherize their homes, or install their own shade structures, solar panels or green roofs. Non-homeowners can take part in public tree planting events, start or support a community garden, or volunteer to steward trees and other green infrastructure assets in their neighborhoods. The accumulation of personal actions like these can have a real impact on outdoor urban temperatures beyond a single residence. Residents can also access household-specific solutions including airflow maximization, air conditioning and dehumidification, insulation and venting, indoor shading, and self cooling which will improve personal comfort on hot days.

8.1 Airflow maximization: strategic use of fans and windows

Maximizing airflow is one of the most effective ways to keep your home cool and does not require the use of energy-intensive air conditioners. It can often be achieved passively by opening windows and doors when there is a breeze or wind outside. During the hottest part of the day, it is better to open windows near shaded spots with cooler outdoor air, and avoid opening windows that receive high sun exposure (US Department of Energy, 2001). You can enhance airflow by adding fans in combination with open windows or air conditioning. Click here for more information and visuals.

- Open windows overnight and in the early morning hours when air is coolest. You can also set up fans at your windows, pointing inwards, during these times. This will allow the fans to pull cool air from outside and circulate it in your home.
- Close windows during the day and early evening when outdoor temperatures are highest. This will trap cool air inside and prevent warm air from entering. Avoid using window fans to blow air into your home when outdoor temperatures are higher than indoor temperatures.
- Once outdoor temperatures cool down, you can create cross ventilation to pull cool air in and push hot air out. Do this by placing a window fan at one side of your house, pointing inwards – this fan will pull in cooler air from outside. At the same time, set up a second fan at the other side of your house, pointing outwards – this fan will remove hot air that is already in your home (US Department of Energy, 2001).
- Ceiling and floor fans are highly effective at cooling indoor spaces, especially when combined with air conditioning. Ceiling fans should be run counterclockwise in the summer to prevent warm air being pushed down. If running a ceiling fan in combination with an air conditioner, you can set the thermostat around 4 degrees higher without experiencing a decrease in comfort (US Department of Energy, 2026).

Whole-house fans are costlier to install than ceiling or portable fans, but can efficiently remove hot air from your home. Other options to promote targeted hot air removal and dehumidification include exhaust fans in the kitchen and bathroom (US Department of Energy, 2001).

8.2 Air conditioning and dehumidification

Electrical air conditioners (AC) are the most commonly-used cooling strategy worldwide, but are not a sustainable solution to extreme heat. While cooling indoor environments, they actually contribute heat to the outdoor environment, and widespread use of AC can overload local power grids resulting in blackouts. However, in the short term, air conditioners are a critical tool. They improve indoor thermal comfort and safety by reducing air temperature and humidity (Jay et al., 2021). It is recommended that residents have at least one cool room in their home which remains under 80°F (Jay et al., 2021; Oregon State Legislature, 2022). Heat pumps are an alternative to conventional ACs which are more sustainable and energy efficient, and are growing in popularity. Heat pumps, which come in both centralized and portable forms, should be prioritized over conventional AC when possible.

For residents with a mechanical cooling system: In the absence of a central AC or heat pump, cooling and dehumidification can be achieved by using a portable or window AC unit. Close doors and other windows in the room with the portable unit to keep cold air inside, and ensure that the AC unit or exhaust pipe fits snugly in your window to prevent the loss of cooled air.

For residents without a mechanical cooling system: Without an AC or heat pump, you can increase your comfort and safety by focusing on dehumidification. Portable dehumidifiers are typically less expensive to purchase and operate than air conditioners. By removing moisture from the air, you can increase your body's ability to cool itself naturally through sweating, even in higher temperatures. Running fans and maximizing airflow (see section 8.1) can also help you reduce humidity and cool your space.

Note: "Swamp coolers" (also known as evaporative air coolers) are a type of do-it-yourself air cooler that relies on the evaporation of chilled water. These are not recommended for use in humid climates because they add moisture to the air (Sustainable Energy for All, 2026).

8.3 Insulation and venting

A well-insulated house is more able to keep cool air in and hot air out when you use the cooling strategies described above (windows, fans, air conditioning). Permanent upgrades to your home can be expensive initially, but save you money in the long run by reducing your energy use for both cooling and heating. For income-qualifying households (renters and homeowners), funding is available through the State's Weatherization Assistance Program for weatherization and utility assistance.

Options for improving insulation:

- Install new insulation in your attic and/or under your roof. The roof is an entry point for a lot of solar radiation and heat into your home.
- Install new insulation in walls, particularly those which receive the most sun exposure during the day.
- Replace windows and doors to ensure a snug fit and reduce draftiness.

The effects of good insulation are magnified by good ventilation. This can be achieved through some actions already described, including the use of open windows and doors, exhaust fans, window fans, and central air conditioning. The idea with all ventilation is to keep air moving through your home and prevent hot air from becoming trapped inside.

- Installing a ventilation system in your attic or under-roof crawl space can help to keep hot air from entering your living space. However, it is better to prevent hot air from entering through the roof in the first place, which can be achieved with proper insulation, a reflective roof, or a green roof.
- Whole-house fan systems are a type of in-built, mechanical ventilation which are highly effective and energy efficient, and may alleviate the need to use electrical air conditioners for much of the summer (US Department of Energy, 2001; Zhang et al., 2021).

8.4 Shades, overhangs, and window films

Preventing solar radiation from hitting your home is a simple way to reduce indoor temperatures. This can be achieved by increasing the amount of shading on your property, whether through trees, tall shrubs, or manmade shade structures such as awnings, eaves, cantilevers, and similar overhangs. Installing overhangs or other shade structures around your home will keep your indoor space cooler, and provide cooler outdoor air that you can ventilate inside as needed (see section 8.1). Overhangs and shading on the south side of your building will have the greatest potential impact as this is the side that typically receives the most sun exposure. Detached shade structures will not cool your home but can make it more pleasant to spend time outdoors in the heat.

You can keep indoor spaces cool by having blinds down and curtains closed; this is especially important when your windows are receiving direct sunlight, such as east facing windows in the morning and west facing windows at sunset. South and southwest facing windows should be covered throughout the day (Jay et al., 2021). Blackout curtains are particularly effective at reducing indoor temperatures as they allow little to no sunlight to pass through. Thinner fabrics and slatted blinds are less effective for this purpose. Heat resistant window films are an affordable option that can be installed by residents, though these are not as easily removed as curtains and blinds when not in use.

8.5 Resources: heat related illness and safety

About Health & Your Health (CDC)

People at Increased Risk for Heat-Related Illness (CDC)

Heat-Related Illness and First Aid (CDC)

General Overview: Heat Vulnerability and Illness (Cleveland Clinic)

Occupational Safety: Working in Indoor and Outdoor Heat Environments (OSHA)

Summary of Strategies

	Intervention	Details
City Scale Strategies	Trees	Distribute trees throughout urban areas, targeting those with low canopy coverage and high urban heat.
		Aim for canopy coverage of at least 30-40%.
		Leafy, broad canopy trees are most effective for shading.
		Prioritize native species.
		Promote mature tree preservation as well as new tree planting.
	Green Roofs	Incorporate native plants and species that can handle direct sunlight and hold water.
		Prioritize green roofs on commercial buildings, multi-family residential buildings, or other large structures.
	Vegetated open space (green space)	Compact, simple shapes have the greatest cooling benefits.
		Permeable, vegetated spaces provide cooling and stormwater management benefits.
	Green stormwater infrastructure	Improve stormwater management and provide cooling by reducing the amount of impervious surfaces in the city.
	Permeable surfaces	Includes natural materials (e.g., soil) and pavements.
		Prioritize where large swaths of pavement exist, such as parking lots and walkways.
	Reflective and/or light colored surfaces	Reduce outdoor temperature with reflective streets, parking lots, and other horizontal surfaces.
		Reduce indoor temperature with reflective walls and roofs.
		Limit in areas with high pedestrian activity (e.g., sidewalks).
	Public and active transportation infrastructure	Increase opportunities for active/public transportation to decrease air pollution and heat.
		Increase shade, water fountains, and other cooling amenities near bus stops and along active commuter routes.
	Shading	Aim for at least 30% shade coverage along transportation paths; focus on resting or waiting points such as bus stops and benches.
		Increase shade in high-risk locations such as playgrounds, schoolyards, and sports fields.
		Non-vegetative shade coverings can provide relief from the heat comparable to tree shade, though do not come with the environmental co-benefits of trees.

Summary of Strategies

	Intervention	Details
City Scale Strategies	Energy microgrids	Install solar panels and backup energy systems at City-owned facilities.
		Permit household-scale or community-scale microgrids and educate the public about their options.
	Policy and legislation	Consider a mix of incentives and code updates to encourage green building and tree preservation.
		Leverage research, data, and existing partnerships to advance heat management as a public health strategy.
	Financial and technical assistance	Offer subsidies or rebates for energy efficiency upgrades and home or building weatherization.
		Assist homeowners with energy bills related to cooling; expand upon programs like LIHEAP.
		Provide free training to homeowners on tree planting and care.
	Community education and engagement	Educate residents about heat risk, who is at risk, what symptoms to look out for, and how to stay safe.
	Job training and volunteer corps	Organize volunteers to assist with tree planting, tree and natural area maintenance, and similar functions when City staff capacity is limited.
		Job training gets locals involved in green jobs and builds economic resilience.
	Resource giveaways	Cooling kits, bottled water, fans, and ice packs provide short-term relief while giveaways of shade curtains, portable AC units or heat pumps, and dehumidifiers could help with indoor heat long term.
	Emergency response	Continue to operate and expand coverage of public cooling centers; offer free transportation during extreme heat; provide citywide heat emergency alerts in multiple formats and languages; active wellness checks and resource distribution to high-risk populations; and publicly share locations of cooling spaces and amenities.
Household Scale Strategies	Maximizing air flow	Open windows overnight and close them during the day; use fans to move cool outside air and/or air conditioned indoor air around the home.
	Air conditioning and dehumidification	Prioritize energy efficient heat pumps over portable or central AC; in the absence of mechanical cooling, improve indoor comfort with a dehumidifier; avoid swamp coolers/evaporative coolers in a humid environment.
	Insulation and weatherization	Upgrade insulation in roofs and walls; install a whole house fan or ventilation system in the attic; replace windows and doors for a better seal.
	Shades, overhangs and window films	Add shade outside to reduce solar radiation using tall vegetation or manmade shade structures; focus shade on the south side of a building; cover windows with blackout curtains, especially south/southwest-facing windows.

References

Alahmad, B., Kessler, W., Alwadi, Y., Schwartz, J., Wagner, G. R., & Michaels, D. (2025). A nationwide analysis of heat and workplace injuries in the United States. Environmental Health, 24(1), 65. https://doi.org/10.1186/s12940-025-01231-1

Anguelovski, I., Connolly, J. J. T., Cole, H., Garcia-Lamarca, M., Triguero-Mas, M., Baró, F., … Minaya, J. M. (2022). Green gentrifica-tion in European and North American cities. Nature Communications, 13(1), 3816. https://doi.org/10.1038/s41467-022-31572-1

Antoszewski, P., Świerk, D., & Krzyżaniak, M. (2020). Statistical Review of Quality Parameters of Blue-Green Infrastructure Elements Important in Mitigating the Effect of the Urban Heat Island in the Temperate Climate (C) Zone. International Journal of Environmental Research and Public Health, 17(19), 7093. https://doi.org/10.3390/ijerph17197093

Braswell, A. S., Winston, R. J., & Hunt, W. F. (2018). Hydrologic and water quality performance of permeable pavement with inter-nal water storage over a clay soil in Durham, North Carolina. Journal of Environmental Management, 224, 277–287. https://doi. org/10.1016/j.jenvman.2018.07.040

Britannica (2026). Humid subtropical climate climatology. Earth Sciences. https://www.britannica.com/science/humid-subtropical-cli-mate

Burke, M., González, F., Baylis, P., Heft-Neal, S., Baysan, C., Basu, S., & Hsiang, S. (2018). Higher temperatures increase suicide rates in the United States and Mexico. Nature Climate Change, 8(8), 723–729. https://doi.org/10.1038/s41558-018-0222-x

Campbell-Arvai, V., & Lindquist, M. (2021). From the ground up: Using structured community engagement to identify objectives for urban green infrastructure planning. Urban Forestry & Urban Greening, 59, 127013. https://doi.org/10.1016/j.ufug.2021.127013

CAPA Strategies (2024). Open Science Framework. Heat Watch Mapping Results Database. https://osf.io/user/9neka?tab=2

CDC (2024a). Heat and People with Chronic Conditions. Extreme Heat. https://www.cdc.gov/heat-health/risk-factors/heat-and-chron-ic-conditions.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fextreme-heat%2Frisk-factors%2Fextreme-heat-and-chron-ic-conditions.html

CDC (2024b). People at Increased Risk for Heat-Related Illness. Extreme Heat. https://www.cdc.gov/extreme-heat/risk-factors/?CDC_AAref_Val=https://www.cdc.gov/disasters/extremeheat/specificgroups.html

Chen, J., Chu, R., Wang, H., Zhang, L., Chen, X., & Du, Y. (2019). Alleviating urban heat island effect using high-conductivity perme-able concrete pavement. Journal of Cleaner Production, 237, 117722. https://doi.org/10.1016/j.jclepro.2019.117722

Clayton, S., Manning, C.M., Speiser, M., & Hill, A. N. (2021). Mental Health and Our Changing Climate: Impacts, Inequities, Respons-es. Washington, D.C.: American Psychological Association, and ecoAmerica. https://www.apa.org/news/press/releases/mental-health-climate-change.pdf

Coma, J., Pérez, G., Solé, C., Castell, A., & Cabeza, L. F. (2016). Thermal assessment of extensive green roofs as passive tool for ener-gy savings in buildings. Renewable Energy, 85, 1106–1115. https://doi.org/10.1016/j.renene.2015.07.074

Coris, E. E., Ramirez, A. M., & Van Durme, D. J. (2004). Heat Illness in Athletes: The Dangerous Combination of Heat, Humidity and Exercise. Sports Medicine, 34(1), 9–16. https://doi.org/10.2165/00007256-200434010-00002

Cousins, J. J., & Hill, D. T. (2021). Green infrastructure, stormwater, and the financialization of municipal environmental governance. Journal of Environmental Policy & Planning, 23(5), 581–598. https://doi.org/10.1080/1523908X.2021.1893164

References

Cuartas, J., Balza, L. H., Camacho, A., & Gómez–Parra, N. (2025). Ambient heat and early childhood development: A cross–national analysis. Journal of Child Psychology and Psychiatry, jcpp.70081. https://doi.org/10.1111/jcpp.70081

deGuzman, E., Malarich, R., Large, L., & Danoff-Burg, S. (2018). Inspiring Resident Engagement: Identifying Street Tree Stewardship Participation Strategies In Environmental Justice Communities Using A Community-Based Social Marketing Approach. Arboriculture & Urban Forestry, 44(6), 291–306. https://www.ioes.ucla.edu/wp-content/uploads/291_306_AUFNov2018.pdf

Daemei, A. B., Shafiee, E., Chitgar, A. A., & Asadi, S. (2021). Investigating the thermal performance of green wall: Experimental analysis, deep learning model, and simulation studies in a humid climate. Building and Environment, 205, 108201. https://doi. org/10.1016/j.buildenv.2021.108201

Dialesandro, J., Brazil, N., Wheeler, S., & Abunnasr, Y. (2021). Dimensions of Thermal Inequity: Neighborhood Social Demographics and Urban Heat in the Southwestern U.S. International Journal of Environmental Research and Public Health, 18(3), 941. https://doi. org/10.3390/ijerph18030941

Environmental Protection Agency (EPA) (2026). Using Green Roofs to Reduce Heat Islands. Heat Islands. https://www.epa.gov/heatis-lands/using-green-roofs-reduce-heat-islands

Francoeur, X. W., Dagenais, D., Paquette, A., Dupras, J., & Messier, C. (2021). Complexifying the urban lawn improves heat mitigation and arthropod biodiversity. Urban Forestry & Urban Greening, 60, 127007. https://doi.org/10.1016/j.ufug.2021.127007

Garcia, I. (2022). Know Your Neighbors. Portland Mercury. https://www.portlandmercury.com/news/2022/08/02/44589908/know-your-neighbors

Gastelum, D. (2022). The Role of Microgrids in Building Climate Resilience in Boston's Frontline Communities. ClimateXChange. https://climate-xchange.org/2022/01/07/the-role-of-microgrids-in-building-climate-resilience-in-bostons-frontline-communities/

Getter, K.L. (2015). Selecting Plants for Extensive Green Roofs in the United States. Michigan State University Extension. https://www. canr.msu.edu/resources/selecting_plants_for_extensive_green_roofs_in_the_united_states_e3047

Glazener, A., & Khreis, H. (2019). Transforming Our Cities: Best Practices Towards Clean Air and Active Transportation. Current Environmental Health Reports, 6(1), 22–37. https://doi.org/10.1007/s40572-019-0228-1

Gould, K., & Lewis, T. (2016). Green Gentrification. Routledge. https://doi.org/10.4324/9781315687322

Granés, L., Essers, E., Ballester, J. et al. (2024) Early life cold and heat exposure impacts white matter development in children. Nature Climate Change, 14, 760–766. https://doi.org/10.1038/s41558-024-02027-w

Gronlund, C. J. (2014). Racial and Socioeconomic Disparities in Heat-Related Health Effects and Their Mechanisms: A Review. Current Epidemiology Reports, 1(3), 165–173. https://doi.org/10.1007/s40471-014-0014-4

Henderson, S. B., McLean, K. E., Lee, M., & Kosatsky, T. (2021). Extreme heat events are public health emergencies. BJ Medical Journal, 63(9), 366–367. https://bcmj.org/bccdc/extreme-heat-events-are-public-health-emergencies

Heutel, G., Miller, N. H., & Molitor, D. (2021). Adaptation and the Mortality Effects of Temperature Across U.S. Climate Regions. The Review of Economics and Statistics, 1–14. https://doi.org/10.1162/rest_a_00936

References

Heynen, N. C. (2003). The Scalar Production of Injustice within the Urban Forest. Antipode, 35(5), 980–998. https://doi.org/10.1111/ j.1467-8330.2003.00367.x

Howe, P. D., Marlon, J. R., Wang, X., & Leiserowitz, A. (2019). Public perceptions of the health risks of extreme heat across US states, counties, and neighborhoods. Proceedings of the National Academy of Sciences, 116(14), 6743–6748. https://doi.org/10.1073/ pnas.1813145116

Jay, O., Capon, A., Berry, P., Broderick, C., de Dear, R., Havenith, G., … Ebi, K. L. (2021). Reducing the health effects of hot weather and heat extremes: From personal cooling strategies to green cities. The Lancet, 398(10301), 709–724. https://doi.org/10.1016/ S0140-6736(21)01209-5

Jerome, G., Mell, I., & Shaw, D. (2017). Re-defining the characteristics of environmental volunteering: Creating a typology of community-scale green infrastructure. Environmental Research, 158, 399–408. https://doi.org/10.1016/j.envres.2017.05.037

Jiao, A., Sun, Y., Avila, C., Chiu, V., Slezak, J., Sacks, D. A., Abatzoglou, J. T., Molitor, J., Chen, J.-C., Benmarhnia, T., Getahun, D., & Wu, J. (2023). Analysis of Heat Exposure During Pregnancy and Severe Maternal Morbidity. JAMA Network Open, 6(9), e2332780. https://doi.org/10.1001/jamanetworkopen.2023.32780

Khatana, S. A. M., & Groeneveld, P. W. (2023). Extreme Heat and Poor Air Quality: Dual Threats to Cardiovascular Health. Circulation, 148(4), 324–326. https://doi.org/10.1161/CIRCULATIONAHA.123.065572

Koeppen-Geiger (2026). World Map Of The Köppen-Geiger Climate Classification Updated. http://koeppen-geiger.vu-wien.ac.at/ present.htm

Lanza, K., & Durand, C. P. (2021). Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership. International Journal of Environmental Research and Public Health, 18(2), 463. https://doi.org/10.3390/ijerph18020463

Layton, J. B., Li, W., Yuan, J., Gilman, J. P., Horton, D. B., & Setoguchi, S. (2020). Heatwaves, medications, and heat-related hospi-talization in older Medicare beneficiaries with chronic conditions. PLOS ONE, 15(12), e0243665. https://doi.org/10.1371/journal. pone.0243665

Levinson, R., Ban-Weiss, G., Berdahl, P., Chen, S.,...Nazarian, N. (2019. Solar-Reflective “Cool” Walls: Benefits, Technologies, and Implementation. California Energy Commission, Publication Number CEC-500-2019-040. https://www.energy.ca.gov/sites/default/ files/2021-06/CEC-500-2019-040.pdf

Li, D., Newman, G. D., Wilson, B., Zhang, Y., & Brown, R. D. (2022). Modeling the relationships between historical redlining, urban heat, and heat-related emergency department visits: An examination of 11 Texas cities. Environment and Planning B: Urban Analytics and City Science, 49(3), 933–952. https://doi.org/10.1177/23998083211039854

Li, Y., Lin, D., Zhang, Y., Song, Z., Sha, X., Zhou, S., Chen, C., & Yu, Z. (2023). Quantifying tree canopy coverage threshold of typical residential quarters considering human thermal comfort and heat dynamics under extreme heat. Building and Environment, 233, 110100. https://doi.org/10.1016/j.buildenv.2023.110100

Li, X., Zhou, W., Ouyang, Z., Xu, W., & Zheng, H. (2012). Spatial pattern of greenspace affects land surface temperature: Evidence from the heavily urbanized Beijing metropolitan area, China. Landscape Ecology, 27(6), 887–898. https://doi.org/10.1007/s10980-012-9731-6

Lin, H., & Li, X. (2025). The role of urban green spaces in mitigating the Urban Heat Island Effect: A systematic review from the per-spective of types and mechanisms. Sustainability, 17(13), 6132. https://doi.org/10.3390/su17136132

References

Makri, A., & Stilianakis, N. I. (2008). Vulnerability to air pollution health effects. International Journal of Hygiene and Environmental Health, 211(3–4), 326–336. https://doi.org/10.1016/j.ijheh.2007.06.005

Marshall, C. A., Wilkinson, M. T., Hadfield, P. M., … Eves–van den Akker, S. (2023). Urban wildflower meadow planting for bio-diversity, climate and Society: An Evaluation at king's college, Cambridge. Ecological Solutions and Evidence, 4(2). https://doi. org/10.1002/2688-8319.12243

Merritt, T. A., Bhatia, S., Solomon, C., & Yu, A. (2025). Heat-Related Illness Trends at a Pediatric Health Care System, 2012 to 2023. Academic Pediatrics, 25(6), 102855. https://doi.org/10.1016/j.acap.2025.102855

Middel, A., Hondula, D., Sailor, D., Schneider, F, … Ortiz, J. C. (2021). Cool Pavement Pilot Program. Arizona State University Urban Climate Research Center. https://globalfutures.asu.edu/sustainabilitysolutions/wp-content/uploads/sites/37/2025/03/COPE-Report_FULLFINAL.pdf

Miles-Novelo, A., & Anderson, C. A. (2019). Climate Change and Psychology: Effects of Rapid Global Warming on Violence and Aggression. Current Climate Change Reports, 5(1), 36–46. https://doi.org/10.1007/s40641-019-00121-2

Nagel, D. (2008). UCSD Plants Solar Trees on Parking Structures. Campus Technology, Green Initiatives. https://campustechnology. com/Articles/2008/09/UCSD-Plants-Solar-Trees-on-Parking-Structures.aspx

National Environmental Mapping and Applications Center (2026). Climate Explorer: Dallas County. https://crt-climate-explorer. nemac.org/

National Park Service (2022). Green Roofs on Historic Buildings: Plants for Green Roofs. https://www.nps.gov/articles/000/green-roofs-on-historic-buildings-plants-for-green-roofs.htm#:~:text=Plants%20for%20extensive%20green%20roofs%20should%20have%20low%20growth%20height,conditions%20and%20minimize%20water%20loss.

National Wildlife Federation (2024). How trees make a difference. https://www.nwf.org/Trees-for-Wildlife/About/Trees-Make-a-Differ-ence#:~:text=Trees%20lower%20air%20temperatures%20and,transpiration%2C%20has%20a%20cooling%20effect.

Ng, E., Chen, L., Wang, Y., & Yuan, C. (2012). A study on the cooling effects of greening in a high-density city: An experience from Hong Kong. Building and Environment, 47, 256–271. https://doi.org/10.1016/j.buildenv.2011.07.014

Nori-Sarma, A., Sun, S., Sun, Y., Spangler, K. R., Oblath, R., Galea, S., Gradus, J. L., & Wellenius, G. A. (2022). Association Between Ambient Heat and Risk of Emergency Department Visits for Mental Health Among US Adults, 2010 to 2019. JAMA Psychiatry, 79(4), 341. https://doi.org/10.1001/jamapsychiatry.2021.4369

Onishi, A., Cao, X., Ito, T., Shi, F., & Imura, H. (2010). Evaluating the potential for urban heat-island mitigation by greening parking lots. Urban Forestry & Urban Greening, 9(4), 323–332. https://doi.org/10.1016/j.ufug.2010.06.002

Oregon State Legislature (2022). Senate Bill 1536. https://olis.oregonlegislature.gov/liz/2022R1/Downloads/MeasureDocument/ SB1536/Enrolled

Ouyang, W., Morakinyo, T. E., Ren, C., & Ng, E. (2020). The cooling efficiency of variable greenery coverage ratios in different urban densities: A study in a subtropical climate. Building and Environment, 174, 106772. https://doi.org/10.1016/j.buildenv.2020.106772

References

Ouyang, W., Ren, G., Tan, Z, Li, Y., & Ren, C. (2023). Natural Shading vs. Artificial Shading: A Comparative Analysis on Their Cooling Efficacy in Subtropical Outdoor Environments. SSRN. http://dx.doi.org/10.2139/ssrn.4669730

Perini, K., Ottelé, M., Haas, E. M., & Raiteri, R. (2011). Greening the building envelope, facade greening and Living Wall Systems. Open Journal of Ecology, 01(01), 1–8. https://doi.org/10.4236/oje.2011.11001

Pincetl, S., Gillespie, T., Pataki, D. E., Saatchi, S., & Saphores, J.-D. (2013). Urban tree planting programs, function or fashion? Los Angeles and urban tree planting campaigns. GeoJournal, 78(3), 475–493. https://doi.org/10.1007/s10708-012-9446-x

Przybysz, A., Popek, R., Stankiewicz-Kosyl, M., Zhu, Ch. Y., Małecka-Przybysz, M.,... Wińska-Krysiak, M. (2021). Where trees cannot grow – particulate matter accumulation by Urban Meadows. Science of The Total Environment, 785, 147310. https://doi.org/10.1016/j. scitotenv.2021.147310

Psokowski, M. & Gopal, K. (2025). Texas Workers Keep Dying in the Heat. Public Health Watch. https://publichealthwatch. org/2025/11/25/texas-workers-keep-dying-in-the-heat/

Ran, J., & Tang, M. (2018). Passive cooling of the green roofs combined with night-time ventilation and walls insulation in hot and humid regions. Sustainable Cities and Society, 38, 466–475. https://doi.org/10.1016/j.scs.2018.01.027

Raymond, C., Matthews, T., & Horton, R. M. (2020). The emergence of heat and humidity too severe for human tolerance. Science Advances, 6(19), eaaw1838. https://doi.org/10.1126/sciadv.aaw1838

Riedman, E., Roman, L. A., Pearsall, H., Maslin, M., Ifill, T., & Dentice, D. (2022). Why don't people plant trees? Uncovering bar-riers to participation in urban tree planting initiatives. Urban Forestry & Urban Greening, 73, 127597. https://doi.org/10.1016/j. ufug.2022.127597

Ruben Gallego (2025). Gallego, Kelly Introduce Legislation to Ensure Fair Share of Energy Assistance, Lowers Costs in Hot Weather States. Press Releases. https://www.gallego.senate.gov/news/press-releases/gallego-kelly-introduce-legislation-to-ensure-fair-share-of-energy-assistance-lowers-costs-in-hot-weather-states/

Saber, H. H. (2022). Hygrothermal performance of cool roofs with reflective coating material subjected to hot, humid and dusty climate. Journal of Building Physics, 45(4), 457–481. https://doi.org/10.1177/17442591211001408

Shih, W. (2017). The cooling effect of green infrastructure on surrounding built environments in a sub-tropical climate: A case study in Taipei metropolis. Landscape Research, 42(5), 558–573. https://doi.org/10.1080/01426397.2016.1235684

Stecker, S. (2014). E&E: Old trees store more carbon, more quickly, than younger trees. Pacific Forest Trust. https://www.pacificforest. org/ee-old-trees-store-more-carbon-more-quickly-than-younger-trees/

Stone, B., Mallen, E., Rajput, M., Gronlund, C. J., Broadbent, A. M., Krayenhoff, E. S., … Georgescu, M. (2021). Compound Climate and Infrastructure Events: How Electrical Grid Failure Alters Heat Wave Risk. Environmental Science & Technology, 55(10), 6957–6964. https://doi.org/10.1021/acs.est.1c00024

Sun, R., & Chen, L. (2017). Effects of green space dynamics on urban heat islands: Mitigation and diversification. Ecosystem Services, 23, 38-46. https://doi.org/10.1016/j.ecoser.2016.11.011

Sustainable Energy for All (2026). Sustainable Cooling Solutions. https://thisiscool.seforall.org/solutions#solutions

References

Taha, H. (2024). Micrometeorological effects and thermal-environmental benefits of cool pavements: Findings from a detailed ob-servational field study in Pacoima, California. Environmental Research Communications, 6(3), 035016. https://doi.org/10.1088/2515-7620/ad2a8e

Texas Trees Foundation (2025). How Evidence-Based Design Fights Urban Heat. https://texastrees.org/how-evidence-based-design-fights-urban-heat/

Thorne, C. R., Lawson, E. C., Ozawa, C., Hamlin, S. L., & Smith, L. A. (2018). Overcoming uncertainty and barriers to adoption of Blue– Green Infrastructure for urban flood risk management. Journal of Flood Risk Management, 11(S2). https://doi.org/10.1111/jfr3.12218

Treekeepers of Washington County (2026). Benefits of trees. https://www.treekeeperswc.org/tree-benefits-information

United Nations Environment Programme (2021). Beating the Heat: A Sustainable Cooling Handbook for Cities. https://www.unep. org/resources/report/beating-heat-sustainable-cooling-handbook-cities

Upper Midwest Water Science Center. (2019). Evaluating the potential benefits of permeable pavement on the quantity and quality of stormwater runoff. USGS. https://www.usgs.gov/centers/upper-midwest-water-science-center/science/evaluating-potential-bene-fits-permeable-pavement

US Department of Energy (2001). Cooling your home with fans and ventilation. Energy Efficiency and Renewable Energy Clearinghouse. https://www.nrel.gov/docs/fy01osti/29513.pdf

US Department of Energy (2026). Fans for cooling. Energy Saver. https://www.energy.gov/energysaver/fans-cooling

Wang, C., Wang, Z.-H., Kaloush, K. E., & Shacat, J. (2021). Perceptions of urban heat island mitigation and implementation strategies: Survey and gap analysis. Sustainable Cities and Society, 66, 102687. https://doi.org/10.1016/j.scs.2020.102687

Watanabe, S., Nagano, K., Ishii, J., & Horikoshi, T. (2014). Evaluation of outdoor thermal comfort in sunlight, building shade, and pergola shade during summer in a humid subtropical region. Building and Environment, 82, 556-565. https://doi.org/10.1016/j. buildenv.2014.10.002

Webber, S. (2026). The Miyawaki Method for Creating Forests. Creating Tomorrow's Forests. https://www.creatingtomorrowsforests. co.uk/blog/the-miyawaki-method-for-creating-forests.

Weinberger, K. R., Wu, X., Sun, S., Spangler, K. R., Nori-Sarma, A., Schwartz, J., Requia, W., Sabath, B. M., Braun, D., Zanobetti, A., Dominici, F., & Wellenius, G. A. (2021). Heat warnings, mortality, and hospital admissions among older adults in the United States. Environment International, 157, 106834. https://doi.org/10.1016/j.envint.2021.106834

Widney, S., Fischer, B., & Vogt, J. (2016). Tree Mortality Undercuts Ability of Tree-Planting Programs to Provide Benefits: Results of a Three-City Study. Forests, 7(12), 65. https://doi.org/10.3390/f7030065

Yu, Z., Guo, X., Jørgensen, G., & Vejre, H. (2017). How can urban green spaces be planned for climate adaptation in subtropical cit-ies? Ecological Indicators, 82, 152–162. https://doi.org/10.1016/j.ecolind.2017.07.002

Zhang, C., Kazanci, O. B., Levinson, R., Heiselberg, P., Olesen, B. W., Chiesa, G., … Zhang, G. (2021). Resilient cooling strategies – A critical review and qualitative assessment. Energy and Buildings, 251, 111312. https://doi.org/10.1016/j.enbuild.2021.111312

Zheng, X., Zou, Y., Lounsbury, A. W., Wang, C., & Wang, R. (2021). Green roofs for stormwater runoff retention: A global quantitative synthesis of the performance. Resources, Conservation and Recycling, 170, 105577. https://doi.org/10.1016/j.resconrec.2021.105577

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