Version 1.0

Plan Integration for Resilience Scorecard™ (PIRS™) for Heat

Spatially evaluating networks of plans to mitigate heat

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This guidebook was developed as an extension of the original methodology developed by Matthew L. Malecha, Jaimie H. Masterson, Siyu Yu, and Philip Berke (2019) and available in the Plan Integration for Resilience Scorecard™ (PIRS™) Guidebook: *Spatially evaluating networks of plans to reduce hazard vulnerability*.

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Executive Summary

The combination of climate change and the urban heat island (UHI) effect is increasing the number of dangerously hot days and the need for all communities to plan for urban heat resilience equitably. Urban heat resilience requires an integrated planning approach that coordinates strategies across community plans and uses the best available heat risk information to prioritize heat mitigation strategies for the most vulnerable communities. The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat is an approach that communities can use to analyze how heat mitigation policies are integrated into different plans and to identify opportunities to better target heat mitigation policies in high heat risk areas. The PIRS™ for Heat was developed as an extension of the original Plan Integration for Resilience Scorecard™, a methodology, originally developed by Berke et al. (2015) and then further advanced and translated to planning practice by Malecha et al. (2019), for spatially evaluating networks of plans to reduce vulnerability to hazards. With support from the U.S. National Oceanic and Atmospheric Administration (NOAA) Climate Program Office's Extreme Heat Risk Initiative and in partnership with the American Planning Association, PIRS™ for Heat was piloted in five geographically diverse U.S. communities, including Baltimore, MD, Boston, MA, Fort Lauderdale, FL, Seattle, WA, and Houston, TX.

Adapting the process detailed in Malecha et al. (2019) to heat, the project team analyzed all policies in each community's network of plans, including their comprehensive plans, hazard mitigation plans, climate action plans, and climate change adaptation, resilience, or sustainability plans. Policies were only included if they had the potential to impact urban heat, were place-specific and contained a recognizable policy tool. Policies were then scored based on whether they would likely mitigate heat ("+1"), worsen heat ("-1"), or the impact was unclear from the description in the plan ("Unknown"). Scored policies were mapped to relevant census tracts across the communities to evaluate their spatial distribution and the net effect on urban heat. The resulting PIRS™ for Heat scorecard was then compared with physical and social vulnerability data to assess policy alignment with heat risks and to identify opportunities for improved urban heat resilience planning.

This guidebook explains the rationale for the PIRS™ for Heat, provides a step-by-step guide for any practitioner or researcher interested in applying the methodology, includes a detailed and ready-to-go worksheet, and summarizes key plan integration findings from five communities across the U.S.

Chapter 1: **Introduction**

The combination of climate change and the urban heat island (UHI) effect is increasing heat risk and the need for communities to plan equitably for urban heat resilience. While awareness about heat risk is growing, planners face many barriers in addressing heat, including a lack of research-based guidance for planning processes, underdeveloped regulatory structures, and siloed research, decision-making, and community plans. Urban heat resilience planning requires an integrated approach that coordinates strategies across community plans and uses the best available heat risk information to prioritize heat mitigation strategies for the most vulnerable communities.

The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat is a generalizable methodology that communities and researchers can use to assess how the development and policies proposed in different plans will collectively affect heat risk in different neighborhoods and to better target heat mitigation policies. The PIRS™ for Heat extends the PIRS™ methodology developed by a team of planning researchers and practitioners (Berke et al., 2015, 2019a, 2019b, 2021; Masterson et al., 2017; Malecha et al., 2018, 2019, 2021; Newman et al., 2019; Yu et al., 2020, 2021; Woodruff et al., 2021; Dong et al., 2021), which was originally designed for flood hazards (see pg. 6). This guidebook explains how communities and researchers can apply the PIRS™ for Heat to advance their urban heat resilience planning efforts.

The importance of planning for increasing heat risks

Extreme heat is the deadliest climate risk in the United States (U.S.), contributing to thousands of preventable deaths each year (Shindell et al., 2020). Heat risks are increasing, especially in urban areas, due to climate change and the UHI effect. Climate change, caused by greenhouse gas emissions, has already increased average global annual temperatures by 1.8°F (1°C) since 1900, and this shift in average temperatures has already led to a significant increase in the number of extremely hot days (USGCRP, 2018). The latest Intergovernmental Panel on Climate Change (IPCC) models project that the frequency, duration, intensity, and seasonality of heat waves will continue to increase (IPCC, 2021).

The UHI effect is the phenomenon where urban areas are warmer than surrounding rural or natural areas due to the built environment, including more impervious surfaces and heat-trapping materials, vegetation loss, and waste heat emissions (Figure 1). Daytime temperatures in urban areas can be 1–7°F (0.56–3.9°C) higher than in surrounding areas, while nighttime temperatures can be 2–5°F (1.1–2.8°C) higher (Hibbard, Hoffman, Huntzinger, & West, 2017). At the same time that cities are getting hotter due to the UHI effect, migration to urban areas continues across the world, increasing the number of people exposed to dangerous heat (Tuholske et al., 2021).

The severity of the UHI effect is influenced by the way the built environment is planned, designed, and operated (Oke, 1973; Stone & Rodgers, 2001). The loss of natural areas and vegetation that typically accompanies urbanization, the use of certain materials that absorb heat, like dark pavement, and waste heat emissions from automobiles, building cooling systems, and industrial processes all contribute to the UHI effect. Chapter 2 of *Planning for Urban Heat Resilience (PAS Report 600)* (Keith & Meerow, 2022) breaks down the different ways to measure and understand heat in urban areas in more detail and describes where communities can find additional resources on heat risk.

Communities in all regions of the U.S. face increasing chronic and acute heat risks. Communities in historically cooler regions can be particularly vulnerable if they lack experience with extreme heat events (Jones, Dunn, & Balk, 2021).

Plan Integration for Resilience Scorecard™ (PIRS™)

The Plan Integration for Resilience Scorecard™ (PIRS™) is a methodology for assessing how well a community's network of plans addresses a hazard. The PIRS™ analytical framework and an initial methodology were originally developed by Berke et al. (2015) and then further advanced and translated to planning practice by Masterson et al. (2017) and Malecha et al. (2019), with over a decade of support from the U.S. Department of Homeland Security's Coastal Resilience Center from 2013 to 2023. PIRS™ assesses how integrated a community's plans are in reducing vulnerability to flood hazards and whether policies are focused on vulnerable areas. The American Planning Association (APA) has adopted PIRS™ as their national standard and resource for building capacity to integrate resilience across planning sectors (DeAngelis et al., 2021). The APA is dedicated to promoting PIRS™ to advance resilience and equity considerations and encourage planners and local officials to take action in neighborhoods with overlapping social and physical vulnerabilities

We adopt and rely on the guidelines for PIRS™ developed in Version 2.0 of the PIRS™ Guidebook, written by Malecha and colleagues in 2019 (see Plan Integration for Resilience Scorecard™ (PIRS™) Guidebook: Spatially evaluating networks of plans to reduce hazard vulnerability). The guidelines help communities address the challenges of having multiple uncoordinated plans, limited collaborative planning processes, and a lack of spatial information about the effects of hazard mitigation policies. The 2019 PIRS™ Guidebook provides step-by-step guidance to help communities address these challenges through a three-phase process which includes 1) defining hazard zones and planning districts, 2)evaluating a community's network of plans and assigning scores to appropriate districts for relevant policies, and 3) assessing summed district policy scores and comparing them to physical and social vulnerability (Malecha et al., 2019). The PIRS™ process outlined in the guidebook can help improve a community's holistic understanding of its hazard vulnerability and planning efforts across traditionally siloed disciplines and serves to improve collaboration and planning outcomes (Berke et al., 2021; Malecha et al., 2019).

Researchers have used PIRS™ to reveal important insights about planning for flood hazards in a variety of communities. Berke et al. (2019a) applied the approach in Washington, NC, Asbury Park, NJ, League City, TX, Fort Lauderdale, FL, Tampa, FL, and Boston, MA. Yu et al. (2021) then looked at the relationship between planning capacity, contextual factors, and PIRS™ scores in these same six cities. Woodruff et al. (2021) revisited Boston and Fort Lauderdale, this time using longitudinal analysis of PIRS™ to explore if flood resilience planning was improving. Berke et al. (2021) used a participatory action research approach in collaboration with local planners to evaluate how the PIRS™ process improved planning in Nashua, NH, and Norfolk, VA.

The PIRS™ methodology has also been applied by Berke et al. (2019b) to evaluate planning for social equity and community resilience, by Newman et al. (2019) as a Geodesign tool for landscape performance, by Malecha et al. (2021) to evaluate the network of plans that were in place in Houston at the time Hurricane Harvey devastated the city in 2017, and by Dong et al. (2021) for the protection of networks of flood infrastructure. PIRS™ is also relevant for international contexts. Malecha et al. (2018) demonstrated the use of PIRS™ in Rotterdam, the Netherlands, a city with a planning and hazards context that differed markedly from the U.S. study locations. Yu et al. (2020) applied PIRS™ in Nijmegen, the Netherlands, to analyze how plans from different administrative scales shaped vulnerability to river flooding.

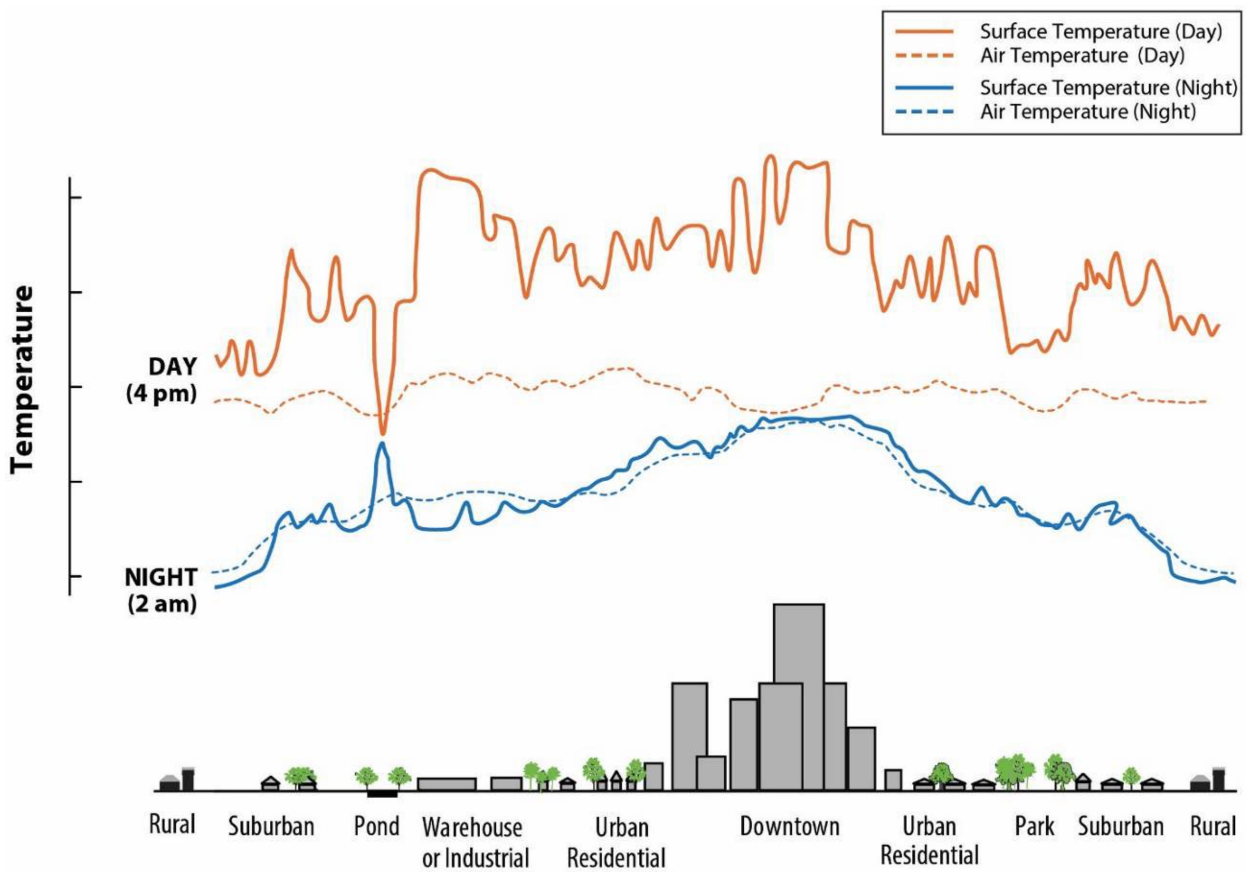

Figure 1. The UHI effect where land surface temperatures vary across built and natural environments (U.S. EPA).

Heat risk is also unevenly distributed within urban areas. Some neighborhoods, often those with lower-income, minority, and marginalized residents, are consistently hotter. Research shows that formerly redlined neighborhoods are an average of 5°F (2.8°C) hotter and have less tree canopy cover today (Hoffman, Shandas, & Pendleton, 2020). Certain community members are also at greater risk for heat-related Illnesses and deaths, including those who are young, old, have lower incomes, are experiencing homelessness, or who are institutionalized (Hondula et al., 2015).

Communities currently face many challenges in planning for extreme heat, including siloed disciplinary knowledge, many available heat mitigation approaches, and unclear guidance in measuring and mapping heat hazard-zones and vulnerabilities (Keith, Meerow, & Wagner, 2020; Meerow & Keith, 2021). A recent literature review (Keith et al., 2020) showed that, while a growing number of studies model and map urban heat islands, little research-based guidance is available to inform planning processes and assist practitioners with advancing heat planning. One survey of 3,500 climate change adaptation resources found that only 4 percent focused on heat, compared to 21 percent focused on sea-level rise and 14% on flooding (Nordgren, Stults, & Meerow, 2016). Planners are often not trained in urban climatology and either do not have access to heat hazard vulnerability information or do not know how to use that data to develop and target mitigation strategies. Climate information is often cited as a barrier to effective planning (Kim, Sun, & Irazábal, 2020), and previous evaluations of climate adaptation, resilience, sustainability, and hazard mitigation plans have found that the informational basis (e.g., vulnerability assessments, future risk projections) is often weak (Berke & Godschalk, 2009; Woodruff et al., 2022b).

A framework for urban heat resilience planning

While heat risks are growing, communities can deploy many planning strategies to address them (Keith & Meerow, 2022). These include efforts to *mitigate* heat in the built environment through land use planning, urban design, vegetation, and waste heat reduction, and to *manage* heat that cannot be mitigated through access to reliable energy and cooling, public health interventions, emergency management, and reducing exposure (Figure 2). Goals and policies that communities advance for other reasons besides heat are likely to shape heat risk. For example, green stormwater infrastructure and promoting walkability and non-automobile mobility can help to mitigate heat, while new industrial developments and road lanes could increase it.

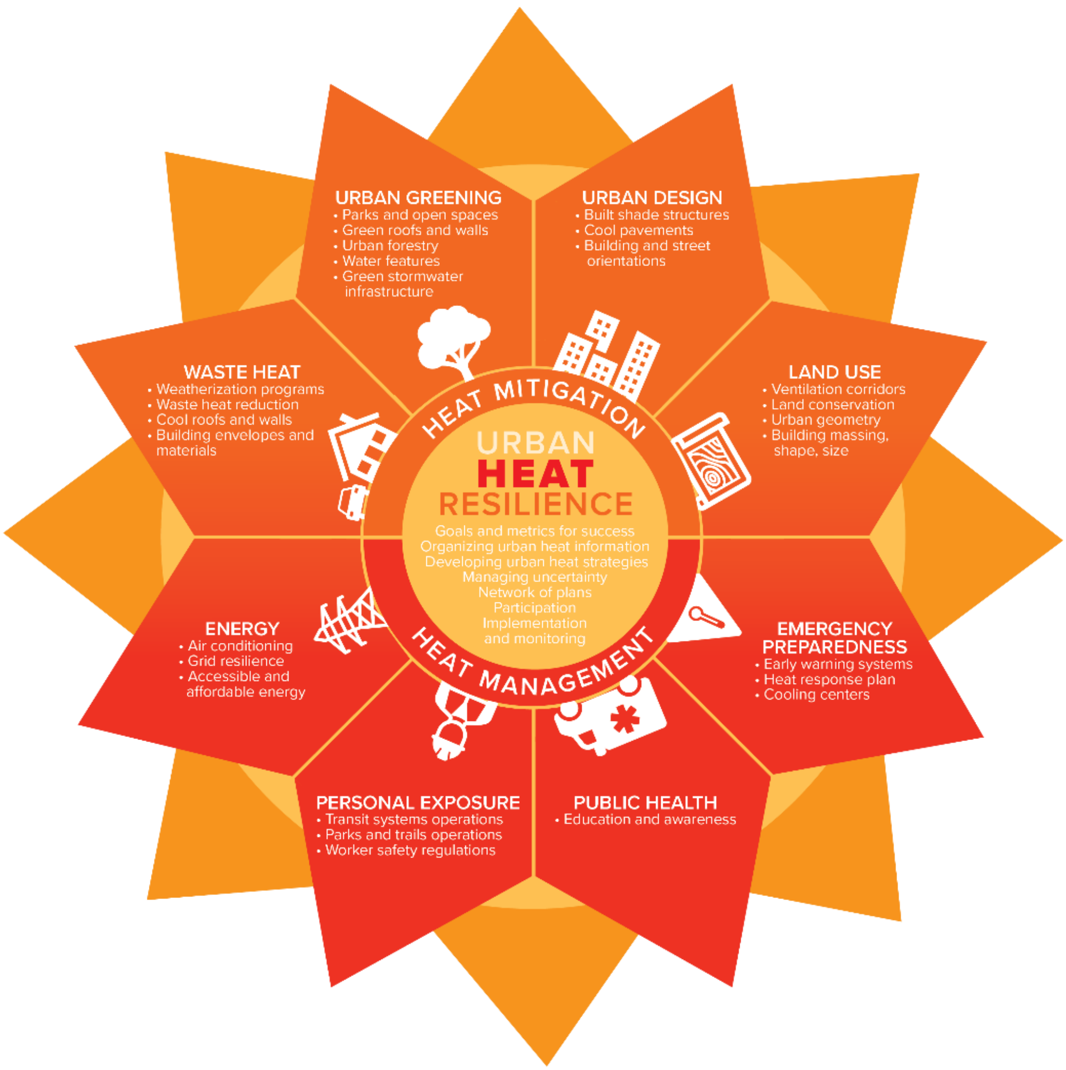

Figure 2. Urban heat resilience strategies (Keith & Meerow, 2022).

Effective heat planning should adhere to the broader principles of effective climate change planning (Meerow & Woodruff, 2019). Addressing heat holistically requires setting goals and associated metrics of success for both mitigation and management, gathering different kinds of heat-related information on the community, proposing a diverse portfolio of mitigation and adaptation strategies, managing uncertainty, coordinating various planning efforts, using inclusive and participatory planning processes, and implementing, monitoring, and evaluating the performance of heat strategies. More information on these planning principles and specific heat mitigation and heat management strategies can be found in Chapter 4 of *Planning for Urban Heat Resilience (PAS Report 600)* (Keith & Meerow, 2022).

Integrating heat mitigation across the network of plans

Communities develop many plans that shape land use, as well as infrastructure, buildings, and, ultimately, vulnerability to hazards. This collection of community plans that shape the built environment is called a "network of plans," (Berke et al., 2006). Comprehensive plans, hazard mitigation plans, and climate action plans all play key roles in either increasing or decreasing the UHI effect and urban heat risk (Meerow & Keith, 2021), but these plans are rarely coordinated, which can mean missed opportunities to reduce conflicting policies and increase synergies across the plans (Berke et al., 2019a; Woodruff et al., 2022a).

For example, a comprehensive plan might prioritize new development with accompanying large parking lots that increase land surface temperatures, a climate adaptation plan might call for new green infrastructure for cooling and stormwater management, and a hazard mitigation plan might acknowledge heat risk but not include any heat mitigation policies (Figure 3).

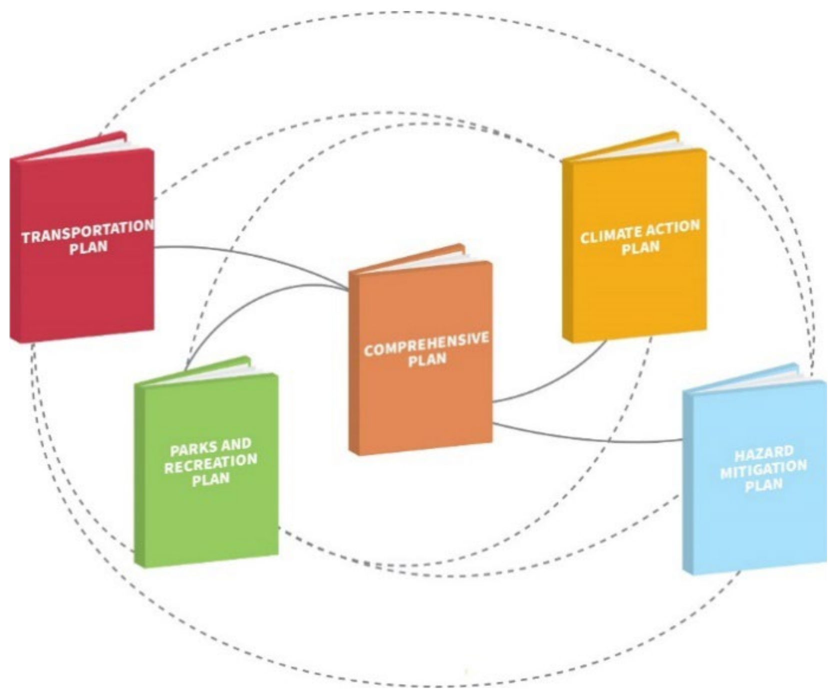

Figure 3. The network of plans (Keith & Meerow, 2022).

Meerow and Keith's (2021) survey of heat planning across the U.S. confirmed that heat is addressed in many different community plans. Most survey respondents said they addressed heat in at least one type of plan, but no single plan type addressed heat in the majority of the communities. These survey findings highlight the need to assess heat mitigation policies across a community's full plan network.

Effectively planning and governing heat risk requires a novel and holistic planning approach — coordinating strategies across community plans and developing scalable frameworks and tools (Berke et al., 2015; Malecha et al., 2019) to aid planners in equitably prioritizing heat mitigation strategies. Communities increasingly have access to high-resolution heat exposure and vulnerability information. However, communities may need additional guidance on how to integrate the data with existing planning efforts to generate targeted and equitable heat mitigation policies.

Advancing urban heat resilience with PIRS™ for Heat

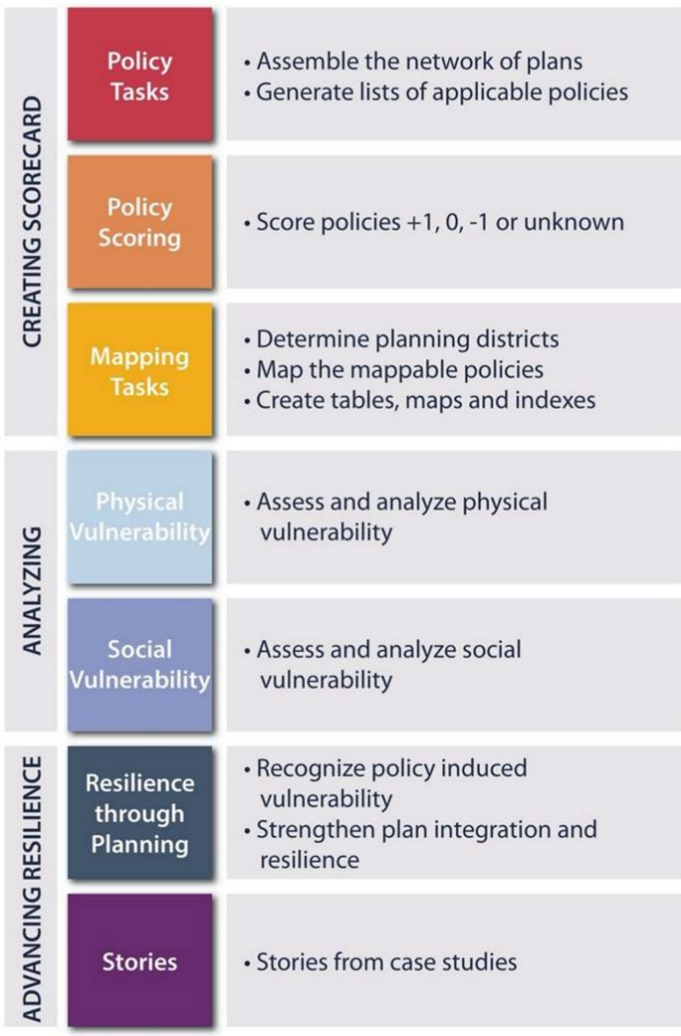

Figure 4. The PIRS™ for Heat process, adapted from Malecha et al. (2019).

The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat methodology in this guidebook adapts the PIRS™ approach (Malecha et al., 2019) to heat hazards so that communities can assess and advance their planning for urban heat resilience.

Following Malecha et al. (2019), the PIRS™ for Heat consists of three primary phases (Figure 4). The first phase is the creation of the scorecard, which includes policy tasks, namely selecting plans to evaluate and identify policies, policy scoring, and mapping tasks (Malecha et al. 2019). The second phase analyzes the scorecard results by comparing them with physical and social vulnerability data (Malecha et al., 2019). In the third phase, these results are used to advance urban heat resilience by addressing identified gaps in planning and sharing lessons learned through case studies (Malecha et al., 2019). The remainder of this guidebook discusses these steps in more detail.

Just as Malecha et al. (2019) documented for flooding, applying the PIRS™ for Heat can help a community 1) better understand spatial patterns in policy attention, or where planned development and policies are likely to exacerbate or mitigate the hazard—in this case, heat, and 2) compare those findings with physical and social vulnerability maps to understand where to prioritize future mitigation policies. The PIRS™ for Heat process can also bring together traditionally siloed disciplines and professionals within a community and help ensure that planning efforts align and work towards the same goals (Berke et al. 2021; Malecha et al., 2019).

For example, the PIRS™ for Heat conducted in Boston revealed that across the city's network of plans, there are over 106 policies that would likely impact the UHI effect. Impressively, only one was identified as likely to increase heat risks (Figure 5). In Boston, 66 policies were identified as likely to help mitigate heat, most commonly through urban greening or reducing waste heat by promoting alternative forms of transportation. As Figure 5 illustrates, though, the census tracts with the highest net scores, and thereby receiving the most heat mitigation policy attention, are not necessarily the hottest or most socially vulnerable areas.

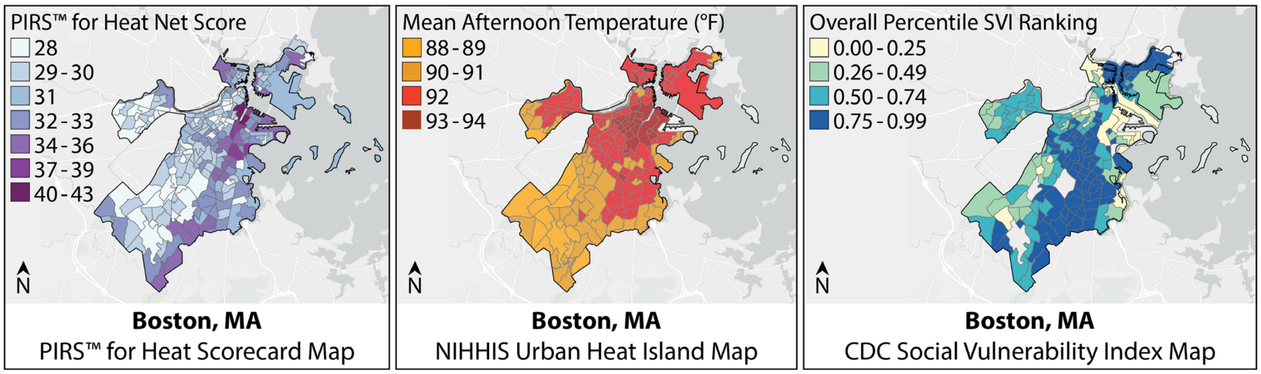

Figure 5. PIRS™ for Heat results for the City of Boston. The map on the left shows the net policy scorecard for all census tracts in the city. The middle shows the NIHHIS Urban Heat Island Map and the right shows the CDC Social Vulnerability Index Map.

For more than a third of Boston's identified policies (37), it was impossible to determine whether the policy would increase or decrease urban heat based on the description provided in the plan, highlighting opportunities for the city to consider further how planned development will affect heat risk and add heat mitigation measures as needed. See Chapter 3 for the full PIRS™ for Heat results for Boston, as well as Baltimore, Fort Lauderdale, Houston, and Seattle.

The next chapter explains the steps of the PIRS™ for Heat methodology in detail so that practitioners and researchers can evaluate networks of plans for heat mitigation, compare PIRS™ for Heat scores against physical and social heat vulnerability, and advance urban heat resilience efforts.

Chapter 2: PIRS™ for Heat Methodology

Phase 1. Creating the Scorecard

In this chapter, we outline the PIRS™ for Heat process step-by-step for both practitioners and researchers. Applying the PIRS™ for Heat methodology requires a dedicated team, ideally at least two individuals, who can identify relevant city plans, categorize land use and development policies in those plans, score and map those policies, and conduct simple geospatial and statistical analyses of policy scores and physical and social vulnerability. Phase 1. Creating The Scorecard and all steps detailed below follow and complement the methodological approach described in Malecha et al. (2019) and available in the Plan Integration for Resilience Scorecard™ (PIRS™) Guidebook: *Spatially evaluating networks of plans to reduce hazard vulnerability*.

There are two approaches to applying the PIRS™ for Heat methodology. The first approach seeks feedback only at the beginning and the end of the process, while the second approach is more engaging and involves iterative feedback throughout the process (see sidebar below). Decide which one is right for your community or research based on available time, resources, and partnerships. The PIRS™ for Heat results can improve heat planning with both approaches.

Two approaches for conducting the PIRS™ for Heat

First Approach: Minimizing the community's time requirement
One approach is to have a small team conduct the PIRS™ for Heat, with short meetings with community staff at the beginning and end of the process and consultation as needed. This is the approach applied to the pilot case studies in this guidebook. It may be desirable to partner with a university or hire a consultant to conduct the PIRS™ for Heat in this way. Graduate students from an urban planning program may be able to conduct the PIRS™ for Heat for an applied project. At least one community staff member should still provide initial feedback on which plans the team should conduct the PIRS™ for Heat on, assist the team in locating available data sources to geospatially organize the policies, and participate in a final meeting to discuss results. This should not take more than five hours of the community staff member's time in total.

Second Approach: Maximizing the community's engagement
If the community can commit more time to the PIRS™ for Heat process, it could be conducted as a highly participatory process. In this approach, community staff and other stakeholders come together during each step of the PIRS™ for Heat process (Figure 4) to discuss and provide feedback. Community staff may even be the ones to code the plans, map the policies, and conduct the analysis. This helps to maximize learning, ensures that the results are carefully vetted by the most relevant stakeholders, and adds a deeper level of local knowledge and commitment to the results and following actions. This approach requires a much larger time commitment, particularly if staff code the plans themselves.

Step 1. Policy tasks

The first step of the PIRS™ for Heat process consists of the policy tasks, which include selecting relevant plans to evaluate and identify heat mitigation policies (Malecha et al., 2019). This is one of the most time-consuming steps.

Step 1.1 Assemble the network of plans

Begin by defining the community of focus for the PIRS™ for Heat and assemble the network of plans accordingly. The community is often a single municipality, but could also be an unincorporated town or village, county, or another jurisdiction that makes planning decisions.

After defining the community, assemble the network of plans most relevant to urban heat resilience. This requires selecting the community plans that are most important in shaping the built environment and that may have the potential to either increase or decrease the UHI effect. Different communities may select a variety of plans, but comprehensive and/or general plans, resilience and/or sustainability plans, climate action plans, and hazard mitigation plans are likely to be relevant for heat mitigation (see Table 1 for more guidance on plan types) (Keith & Meerow, 2022).

Table 1. Relevant community plans for heat mitigation

Plan types	Considerations
Comprehensive or general plan	Typically the leading plan guiding future land use and development in a community and is typically important to include.
Hazard mitigation plan	Because of FEMA requirements, most communities have a hazard mitigation plan to reduce the risk of disasters. Heat is one hazard that may be addressed.
Climate action plan	Developed by many communities to address climate change, can include heat mitigation strategies and policies with co-benefits (e.g., promoting alternative forms of transportation).
Climate change adaptation, resilience, or sustainability plan	Some communities have developed these plans which may address heat directly, and even when they do not, many may include policies with heat mitigation co-benefits (e.g., green infrastructure).
Functional plan (e.g., parks and recreation, transportation, green infrastructure)	Communities develop many other functional plans that may contain policies that increase or decrease urban heat. Review the categories of policies and consider which functional plans (if any) are most relevant.
Small area or neighborhood plans	Small area or neighborhood plans may contain spatially explicit policies that would affect heat risk and, therefore could be relevant, but including them may be too time-intensive.

Adapted from Keith & Meerow (2022).

Functional plans such as infrastructure plans, parks and recreation plans, and neighborhood or small area plans may also be included, but it is important to note that the more plans that are included, the more time-intensive the PIRS™ for Heat process will be. Focus on the community plans that most directly shape the built environment and development patterns. Exclude older community plans that are no longer actively referred to and that no longer guide development or policy. Community-scale (e.g., city or county) plans are likely more relevant than state-level plans.

Step 1.2 Generate lists of applicable policies

After assembling the network of plans, two individuals (referred to in this guidebook as the "coders") in the team should independently read the plans and create a list of all the policies in them that would influence land use and development of the built environment and affect urban heat. Use the PIRS™ for Heat Worksheet template to enter the policy information while reviewing each plan.

Only include policies in the PIRS™ for Heat Worksheet if they meet the following three criteria, which were also part of the original PIRS™ and termed the "Three-point Test" by Malecha et al. (2019):

1) The policy must potentially affect heat risk (i.e., either increase or decrease the UHI effect).
2) The policy must contain at least one mappable, place-specific term, although it can be applicable to the entire city.
3) The policy must have a recognizable policy tool, or a form of government intervention to achieve specific objectives and outcomes.

If a policy meets all three criteria, add it to the PIRS™ for Heat Worksheet. Many plans are developed with clearly delineated sections for goals and strategies/policies. Goals are usually broad statements of "future desired conditions" and are a reflection of the community's values, while strategies or policies lay out specific actions (e.g., regulations, programs, designs) that will achieve these goals (Berke & Godschalk, 2009, p. 231) to achieve goals. There are a diversity of ways that plans are developed though, so policies that meet the Three-point Test may not be explicitly labeled as policies or strategies. They can still be relevant and included as policies in the PIRS™ for Heat Worksheet.

Heat Management Policies

Coders may also want to document policies that do not meet the Three-point Test but are still relevant in the "Additional Policies" sheet of the PIRS™ for Heat Worksheet. For example, it may be of interest to document heat management policies such as the location of cooling centers or heat safety education programs.

Coders should categorize each policy by both policy tools and heat mitigation strategies. In addition to pasting in the policy language and categorizing the policy in the PIRS™ for Heat Worksheet, the following information should be included for each policy: the plan that the policy comes from, the page number of the plan where the policy starts, the geospatial indicator (based on the place-specific, mappable term in the policy) (Malecha et al.2019; Masterson et al. 2017), and a policy score (explained on page 22). Table 2 includes three example policies from the City of Boston's comprehensive plan, Imagine Boston, and the information that coders included for those policies in the PIRS™ for Heat Worksheet.

Table 2. Policy coding examples from the City of Boston

Plan	Imagine Boston	Imagine Boston	Imagine Boston
Policy	"Invest in streetscape, crosswalks, and wayfinding improvements along Dudley Street to improve pedestrian, bike, and bus connections to the Fairmount/Indigo Line station."	"New street grid in Sullivan Square, which will create developable parcels and ensuring a walkable job and housing center."	"Preservation and enhancement of industrial land to increase job density."
Policy tool category	Capital improvements	Land acquisition	Development regulations
Policy tool subcategory	Transportation infrastructure	Open space or easement purchase	Permitted land use
Heat mitigation category	Waste heat	Unknown	Land use
Heat mitigation subcategory	Transportation	Unknown	Urban development patterns
Plan page number	165	211	229
Geospatial indicator (i.e., location)	Along Dudley Street in Upham's Corner	Developable parcels and new street grid	Readville
Geospatial indicator notes	Map on page 164	Map on page 210	Map on page 231
Policy score	1	U	-1

Step 1.2.1 Categorizing policies by policy tool

When coders identify a policy that meets the Three-point Test, it should first be categorized by policy tool type in the PIRS™ for Heat Worksheet. Table 3 summarizes the categories and subcategories of land use policy tools most commonly used by local plans and defines how they can affect the UHI effect. The eight policy tool categories, adapted for heat from the PIRS™ Guidebook (Malecha et al., 2019), include the land use analysis and permitting process, capital improvements, development regulations, land acquisition, density transfer provisions, financial incentives and penalties, public facilities, and post-disaster reconstruction decisions.

If the policy does not fit into one of these policy categories or subcategories, but does have a clear policy tool, would affect the UHI effect, and is mappable, assign the "other" category or subcategory. There may also be instances where a single policy has multiple policy tool categories, in this case, simply select the one best aligned with the policy. Multiple subcategories can be selected.

Table 3. Policy tool categories and subcategories

Categories (bold) and subcategories	Definitions
Land use analysis and permitting process	
Land suitability	Heat, climate, or weather-related hazards are one of the criteria used in analyzing and determining the suitability of land for development.
Site review	Provision requiring addressing heat mitigation in process of reviewing site proposals for development.
Design construction guidelines	Guidelines or requirements relevant to heat mitigation that apply to the design or construction of developments.
Capital improvements	
Urban forestry	The planting, maintenance, care and protection of tree populations, such as shade trees, in urban settings. Urban forestry can be found in parks, gardens, landscaped boulevards, greenways, and street-side tree boxes.
Green stormwater infrastructure	Approaches designed to capture, infiltrate, or evapotranspirate stormwater close to where it falls, reducing the volume entering sewer systems or water bodies, often with permeable or vegetated elements (e.g., bioswales, rain gardens, cisterns, and basins).
Parks	Broadly, the network of planned and unplanned vegetated, natural, or open spaces within a city, spanning both the public and private realms, and managed as an integrated system to provide a range of benefits.
Transit infrastructure	Systems, structures, and facilities that support public transit, such as buses, trains, and streetcars.
Transportation infrastructure	Systems, structures and facilities that support pedestrian and bicycle uses.
Weatherization	Provision encouraging or requiring new development and/or existing buildings to improve structural resilience to heat through weatherization projects.
Shade structures	Manufactured shade structure designed for pedestrian use, which can be either attached to a building or freestanding.
Green roofs and walls	Elements of green infrastructure on buildings that utilize living vegetation to increase the cooling inside and outside and reduce stormwater runoff.
Cool roofs and walls	A roofing system that delivers higher reflectance and absorbs lower amounts of solar radiation, compared to conventional materials, in order to reduce surface temperature. Cool walls are exterior walls with high albedo, which helps to keep the inside cooler and decreases the urban heat island effect due to the exterior walls of the building.

Water features	Elements like pools, ponds, fountains, splash parks, natural water features, and artificial waterfalls, which can help to decrease the urban heat island effect.
Development regulations	
Permitted land use	Provision regulating the types of land use (e.g., residential, commercial, industrial, open space, etc.) permitted in areas of community; may be tied to zoning code.
Density of land use	Provision regulating density (e.g., units per acre); may be tied to zoning code.
Subdivision regulations	Provision controlling the subdivision of parcels into developable units and governing the design of new development (e.g., site stormwater management).
Zoning overlays	Provision to use zoning overlays that restrict permitted land use/density in hazardous areas; may be special overlay districts that address heat or sensitive open space protection zones.
Setbacks or buffer zones	Provision requiring buffers around hazardous areas (e.g., riparian buffers).
Cluster development	Provision requiring clustering of development away from hazardous areas, such as through conservation subdivisions.
Land acquisition	
Acquire land or property	Purchase of land or property (e.g., for protected open space).
Open space or easement purchase	Provision encouraging open space purchase by the community or open space easements as an element of development approval.
Density transfer provisions	
Transfer or purchase of development rights	Provision for transferring development rights to control density; may be transfer of development rights or purchase of development rights.
Financial incentives and penalties	
Density bonuses	Density bonuses such as ability to develop with greater density in return for dedication or donation of land.
Tax abatement	Tax breaks offered to property owners and developers who use heat mitigation methods for new development or retrofits.
Impact special study protection fees	Provision requiring impact fees, special study fees, or protection fees for development.
Public facilities (including public housing)	
Siting	Provision to site public facilities, such as municipal buildings and public housing.

Sizing capacity	Provision limiting capacity of public facilities, such as public housing, to cap the amount of development.
Post-disaster reconstruction decisions	
Development moratorium	Provision imposing a moratorium on development for a set period of time after a heat hazard event to allow for consideration of land use change.
Post-disaster land use change	Provision related to changing land use regulations following a heat hazard event; may include redefining allowable land uses after a heat hazard event.
Post-disaster capital improvements	Provision related to adjusting capital improvements to public facilities following a heat hazard event.

Adapted from Malecha et al (2019).

Step 1.2.2 Categorizing policies by heat mitigation strategy

In addition to assigning a policy tool, coders should also categorize each policy by the type of heat mitigation strategy in the PIRS™ for Heat Worksheet. While each policy should have a single distinct policy tool, it may include multiple heat mitigation strategies, so two heat mitigation categories and two subcategories are available on the PIRS™ for Heat Worksheet. For example, a policy calling for the development of a new linear park with shade sails built over benches would be categorized as a capital improvement (category)/park (subcategory) for the policy tool, but it could be categorized as both an urban greening (category)/urban forestry (subcategory) and urban design (category)/shade structure (subcategory). Table 4 summarizes the four heat mitigation categories (Keith & Meerow, 2022) used in the coding process.

Table 4. Heat mitigation strategy categories and subcategories

Categories (bold) and subcategories	Definitions
Land use	
Urban development patterns	Urban development pattern is defined as a special pattern of human activity in a certain point and certain time. It includes two main categories of horizontal expansion or urban dispersion and the pattern of a compact city.
Roadways and parking lots	The use of manmade materials (asphalt, concrete used for parking lots and roadways) in urban areas are one of the main (if not the single largest) contributors to the urban heat island effect. Asphalt/concrete have low albedos and high heat capacities, meaning that solar radiation is mostly absorbed and reemitted as heat. There are ways to mitigate the impacts of roadways and parking lots, like using reflective surfaces, reducing, or eliminating parking lot requirements, "right-sizing" existing streets (e.g., road diets) and planning for new more narrow streets. (e.g., complete streets)
Ventilation corridors	An urban area that allows fresh air to flow through a city to mitigate the urban heat island effect, increase ventilation, or generally improve the climate. (e.g., wind corridors, urban canyon)
Land conservation	Protecting natural land and returning developed land to its natural form. This also includes the preservation of working agricultural land and natural open space outside of a city. (e.g., smart growth, infill development, urban growth boundaries)
Urban design	
Street and building orientation	Solar, wind, and drainage elements that are considered in the orientation of streets and buildings to alleviate reduce waste heat and mitigate urban heat.
Building shape and massing	Massing is the overall, basic shape of a building. The more compact a building is, the less amount of roof and wall exposure to the sun, making it easier to cool.
Shade structures	Built shade structure designed for pedestrian use and protection from direct sun, which can be either attached to a building or free-standing. (e.g., playground shade structures, ramadas, pergolas, awnings, canopies, arbors, and canvas)
Cool pavements	Reflective surface coating for streets or sidewalks that store less heat and may have a lower temperature. (e.g., cool sidewalks, reflective coating)
Urban greening	
Urban forestry	The planting, maintenance, care and protection of tree populations, such as shade trees, in urban settings. Urban forestry can be found in parks, gardens, landscaped boulevards, greenways, and street-side tree boxes.
Vegetated parks and open space	Broadly, the network of planned and unplanned green spaces within a city, spanning both the public and private realms, and managed as an integrated system to provide a range of benefits. (e.g., parks, greenways; passive, active, and/or natural recreation areas)

Green stormwater infrastructure	Approaches designed to capture, infiltrate, or evapotranspirate stormwater close to where it falls, reducing the volume entering sewer systems or water bodies, often with permeable or vegetated elements. (e.g., bioswales, rain gardens, cisterns, and basins)
Green walls and roofs	Elements of green infrastructure on buildings that utilize living vegetation to increase the cooling inside and outside and reduce stormwater runoff. (e.g., living roofs and walls)
Water features	Elements like pools, ponds, fountains, splash parks, natural water features, artificial waterfalls, and streams can help to decrease the urban heat island effects. Note: does not include green stormwater infrastructure.
Waste heat	
Building energy efficiency	A reduction in the unused energy required to operate a building that is released to the environment in the form of thermal energy. Waste heat can be recovered and used to decrease energy consumption. (e.g., LEED requirements, efficient HVAC systems, sustainable and/or green building requirements)
Cool roofs and walls	A roofing system that delivers higher reflectance and absorbs lower amounts of solar radiation, compared to conventional materials, to reduce surface temperature. Cool walls are exterior walls with high albedo, which helps to keep the inside cooler and decrease the urban heat island effect due to the exterior walls of the building. (e.g., white painted roofs and walls, reflective roofs and walls)
Transportation	Any approach that reduces waste heat from traditional fossil fuel-powered vehicles. This includes land use and infrastructure changes that support active transportation modes (e.g., walking and bicyling), transit use (e.g., bus, light rail, train, etc.), and the transition to hybrid and electric vehicles (EV) (e.g., EV charging stations, EV residential charging).

Adapted from Keith & Meerow (2022).

Step 1.2.3 Identifying geospatial indicators for policies

In addition to categorizing each policy, coders should include any information provided in the plan about where the policy will be applied spatially under the "geospatial indicator" in the PIRS™ for Heat Worksheet. There should always be some information to input here, because in order to pass the Three-point Test, a policy must contain at least one mappable, place-specific term (although it can be applicable to the entire city). The level of detail of the geospatial indicator will vary. For example, in the examples from Boston (Table 2), one policy is applied very specifically to "Along Dudley Street in Upham's Corner," while another applies to the entire neighborhood of "Readville." Because these policies will have to be mapped in Step 3, make a note of any maps in the plan that could be helpful in pinpointing the location(s) where the policy applies.

Step 2. Policy scoring for heat hazard

After identifying and categorizing all of the relevant policies in the assembled network of plans, coders should go back through and score the policies based on their likely impact on the hazard (Malecha et al., 2019), in other words, whether they will exacerbate or mitigate urban heat. Assign the policy a score of "+1" if it would help to mitigate heat, "-1" if it would likely worsen heat, and "0" if the policy would have a neutral effect (e.g., increases in heat risk would be counteracted through heat mitigation). There are likely few instances of "0" scoring. What may be more common are policies that would likely have an impact on urban heat, but the directionality of the impact is unclear. Assign these policies an unknown impact score, or "U". These "U" policies are critical to identify because they can reveal where development may take place that would shape future heat risk, but where the policy language leaves room for either a positive or negative effect on heat.

Below is an example policy from Boston's comprehensive plan to illustrate how a policy is categorized and scored:

> "The proposed greenway would preserve vehicle travel in both directions while consolidating the median, sidewalks, and wider areas into a **context-sensitive linear park** stretching from Franklin Park to Moakley Park. The allocation of roadway space will be determined in conjunction with local residents and **will include improved pedestrian paths and crossings, protected bike paths**, and **significantly more trees** to transform this former boulevard into a vibrant green corridor that is connected to the Blue Hill multiuse path to the south (p. 199), the Fairmount Greenway (p. 161), Dorchester Ave. Complete Street (p. 158), and the Carson Beach bike path, creating a continuous protected bicycling network into Downtown." - GoBoston 2030, p. 172

This policy would help to mitigate heat, is spatially specific, and falls under the policy tool category of capital improvements. The policy would receive a score of +1.

This policy contains many policy subcategories under the capital improvements category (e.g., urban forestry, parks, transportation infrastructure) and many heat mitigation strategy categories (e.g., urban greening, urban design) and sub-categories (e.g., urban forestry, vegetated parks and open spaces).

Policies can be scored at the same time as the policies are identified and categorized, or in a subsequent step. In either case, it is valuable to have two coders independently score and then reconcile those scores.

Step 2.1 Reconciling coding

The process of systematically reading through the plans is known in planning scholarship as content analysis and is an established approach for plan evaluation (Krippendorff, 2004). Research suggests that the accuracy of content analysis will increase if two coders independently analyze each plan and reconcile their findings, as having two coders reduces the likelihood of missing or incorrectly categorizing policies. This is why two coders are recommended for the PIRS™ for Heat method. Some subjectivity and differences in coders' results are inevitable, but these can be resolved through a reconciliation process. There are two different ways coding can be reconciled. In the first, the two coders compare their PIRS™ for Heat Worksheets directly, going through systematically and discussing differences, and then come to an agreement on whether a policy should be included, how it should be categorized, and its score. If they cannot immediately come to an agreement, it may be helpful to go back to the Three-point Test to make sure the policy is meeting the correct inclusion criteria and referencing the policy tool and heat mitigation category definitions (Tables 3 and 4). A second reconciliation approach, which can be useful if the two coders are struggling to reach a consensus, is to bring in a third team member to compare the two PIRS™ for Heat Worksheets and serve as a mediator, providing a decisive third vote if the two coders cannot agree. If the PIRS™ for Heat is being used for research purposes, it may be useful to calculate and report statistics on how much the two coders disagreed, what is known as inter-coder reliability (Krippendorff, 2004).

Completing step 2 will result in a single reconciled PIRS™ for Heat Worksheet that contains a vetted list of relevant heat mitigation policies from the community's network of plans, each of which is categorized by policy tool, heat mitigation strategy, scored, and contains a geospatial indicator that can be used to map where in the community it applies. Now it is time to map the policies and create the final PIRS™ for Heat scorecard.

Step 3. Mapping tasks

This step determines which community districts identified policies would apply to and assigns their score to those districts (Malecha et al., 2019). Scores are then added for each district to create the final PIRS™ for Heat scorecard, showing which areas in the community receive the most policy attention relevant to heat mitigation. Completing the mapping tasks requires spatial information about the community and can be done manually or with GIS software. This project used Esri ArcGIS software and refers to those tools, but similar tools exist in other geospatial software (e.g., QGIS).

Begin by subdividing the community into districts that will serve as the unit of analysis. Census tracts can be used as districts, with the benefit that most spatial and demographic data is already available at the census tract level. If a community has another meaningful geography that is used for decision-making (e.g., planning districts) those can also be used. Create both a map and a list of the community districts.

Look through the list of geospatial indicators in the PIRS™ for Heat Worksheet and prepare to map them. For example, if a policy refers to city-owned vacant parcels, look for a map or GIS file with these locations. Assign a policy label in the PIRS™ for Heat Worksheet for each policy included in the analysis. For example, the City of Boston's policies were labeled B1, B3, B3, etc.

Next, in the Scorecard sheet of the PIRS™ for Heat Worksheet, add IDs for all of the census tracts or districts that intersect with the community in column A, and the policy labels as rows. Make sure the district IDs match the IDs used in GIS files, as they will need to be matched and joined later. Create GIS maps with each community's boundary and the census tracts or smaller planning districts that intersect with it.

For each policy in the PIRS™ for Heat Worksheet, use the geospatial indicator and all available spatial data to determine which districts it would affect, and then apply the score to that district. In the Boston policy example above, the score of "1" would be applied to all districts (census tracts) that the proposed linear park from Franklin Park to Moakley Park passes through.

To save time, consider mapping only the policies that score a "-1" or "+1", skipping over those scored as "0" or "Unknown" since they will not affect the PIRS™ for Heat final net score. If time is not an issue, separately map the "Unknown" policies to helpfully point out areas where a lot of development is planned, but heat implications have not been explicitly addressed.

For policies that affect a large number of districts (or census tracts), consider using the ArcGIS "select" tool. In this example, the ArcGIS "select by location" tool can identify where the linear park intersects with census tracts and a table can be saved with a list of those tracts. This table can be exported as an excel file and added to the policy score sheet.

When this is complete, the Scorecard sheet will typically contain a table where each cell indicates the score for a particular policy and district. In districts where a policy is applicable, it will contain a "-1" or "1", when the policy does not apply to that district, it will be blank. Lastly, sum these scores for each district in the Net Scorecard sheet of the PIRS™ for Heat Worksheet. This final sheet should have the district IDs in the first column and the sum of all relevant policy scores for that district (termed the "net score") in the second column.

This Net Scorecard Sheet can then be imported into GIS and joined by the census tract or district IDs. Maps can be created showing the net scores for each district. To do this in ArcGIS, create a map with the districts (labeled with the district ID). Import the Net Scorecard sheet into ArcGIS. Use "add join" to join the net scores to the district layer. Use map symbology (e.g., different colors or shading) to visualize the variation in district scores (See Figure 5).

This concludes the first phase of the PIRS™ for Heat. At this point in the PIRS™ for Heat process, the community has a wealth of valuable information (Berke et al., 2019a, 2021; Malecha et al., 2019), including a detailed spreadsheet of heat mitigation policies. Since these policies have all been categorized, it is possible to analyze which policy tools and heat mitigation strategies are most prevalent and which ones could be expanded. The list of policies scored as "U" can be further examined through an urban heat resilience lens. The completed PIRS™ for Heat scorecard should clearly show which districts are the focus of heat mitigation policies and where more policy attention may be needed. The analyses outlined in the next phase provide even more information that communities can use to enhance heat resilience planning using scorecard results.

Phase 2. Analyzing Scorecard Results

After creating the PIRS™ for Heat scorecard, the next phase focuses on analyzing the results. In particular, district scores are compared with information on physical and social vulnerability. Adding these analyses, which draw on readily-available spatial data, can help to provide more valuable context for interpreting the scorecard results. Phase 2. Analyzing Scorecard Results and all steps detailed below follow and complement the original methodology developed by Malecha et al. (2019) and available in the Plan Integration for Resilience Scorecard™ (PIRS™) Guidebook: *Spatially evaluating networks of plans to reduce hazard vulnerability*.

It can be insightful to quantitatively evaluate citywide patterns in the relationship between district scores and heat vulnerability indicators. Consider using statistical analysis (e.g., a Pearson correlation coefficient) to determine whether policy scores are significantly higher in districts that are more vulnerable to heat. The Pearson correlation coefficient measures the strength of the linear relationship between two variables and ranges from -1 to 1. A larger positive coefficient (closer to 1) means higher values in one variable are associated with higher values in another, whereas a larger negative coefficient (closer to -1) means higher values in one variable tend to be associated with lower values in another.

Step 4. Assessing physical vulnerability

Determining whether policies in the network of plans are targeting the areas that are most vulnerable to heat requires spatial data on physical heat vulnerability. While there are numerous ways to assess which areas in a community are hottest, remotely sensed land surface temperature data is likely the most readily available (Keith & Meerow, 2022). The Trust for Public Land's Urban Heat Island Severity for U.S. Cities and the U.S. National Oceanic and Atmospheric Administration (NOAA) and National Integrated Heat Health Information Network (NIHHIS)'s Urban Heat Island Mapping Campaigns are reaching a growing number of communities. Communities may also have locally produced UHI maps that can be used.

This project used the NIHHIS UHI mapping campaign late afternoon temperature data as an indicator of physical vulnerability. For this data, use the Zonal Statistics tool in ArcGIS to determine the mean temperature for each district. These can be mapped, and the results compared visually with the scorecard map (Malecha et al., 2019). Alternatively, the results can be exported as a spreadsheet and any statistical software can be used to calculate the Pearson correlation coefficient between the mean temperature and net score across all districts in the community to quantitatively assess whether more mitigation policies are targeting hotter districts.

Step 5. Assessing social vulnerability

Because socially vulnerable communities may be at higher risk of heat hazard, consider also comparing scorecard results with sociodemographic indicators of social vulnerability (Berke et al. 2019b; Malecha et al., 2019; Yu et al., 2021). As with physical vulnerability, there are many different indices that could be used. Communities all have very different contexts and therefore different social indicators may be particularly relevant to map and compare with the scorecard results.

The U.S. Centers for Disease Control and Prevention (CDC)'s Social Vulnerability Index (SVI) uses 15 census variables that provide information on socioeconomic status, household composition and disability, minority status and language, and housing type and transportation to identify areas of a community that are potentially more vulnerable to the negative impacts of hazardous events. The SVI produces overall scores for all census tracts in the U.S., ranging from 0 (lowest vulnerability) to 1 (highest vulnerability).

In addition to using the CDC SVI, communities can use the U.S. Environmental Protection Agency (EPA)'s Environmental Justice Screening and Mapping Tool (EJScreen) to explore health indicators that impact sensitivity to heat exposure at the census tract level. These include heart disease, asthma, and medically underserved communities. Other locally produced heat vulnerability maps and additional data sources may also be used. For example, some county or state health departments may have information on the areas where heat-related illnesses are treated or heat-related mortalities occur. Local data on indoor cooling prevalence and housing quality may also be useful if available.

To examine the relationship between district policy scores and social vulnerability, use statistical software to calculate the Pearson correlation coefficient between different social vulnerability indicators and the net score for all districts in the community. This will help show if the network of plans prioritizes the most socially vulnerable census tracts for heat mitigation policies.

Phase 3. Advancing Resilience

Having completed the PIRS™ for Heat scorecard and analyses, the final phase of the process focuses on using this information to advance urban heat resilience. As previously noted, the process produces valuable information on current plans and policies related to heat, so use this information to advance urban heat resilience in the community. Phase 3. Advancing Resilience and all steps detailed below follow and complement the methodological approach described in Malecha et al. (2019) and available in the Plan Integration for Resilience Scorecard™ (PIRS™) Guidebook: *Spatially evaluating networks of plans to reduce hazard vulnerability*.

Step 6. Resilience through planning

First, it is possible to use the categorizations of policies to identify if there are gaps in the policy tools or heat mitigation strategies being employed through the community's network of plans (Berke et al., 2015; Masterson et al., 2017). Communities should aim for a diverse portfolio of heat mitigation strategies, yet as the pilot city results show in Chapter 3, and consistent with research on U.S. cities more broadly (Meerow & Keith, 2021), some categories (e.g., urban greening) are more commonly used than others. Communities may also want to carefully consider whether the policy tools they are using are likely to be the most effective. Updates to the community's building codes, for example, would likely have a larger impact on urban heat than an individual urban greening project. The PIRS™ for Heat scorecard does not assess relative impact, but communities can make their own qualitative evaluations.

Additionally, communities can look at the types and scores for policies in different plans within the network of plans to see which plans are addressing heat, and which could be improved in future updates.

Results from our five pilot cases show that many policies likely affect heat risk, but the plans do not contain enough information to make this determination. The policies scored as "Unknown" are an opportunity for further investigation into the heat implications of policies that could impact the UHI effect either positively or negatively, depending on their implementation. For example, if a project could exacerbate the UHI effect, consider including heat mitigation elements through the development approval process or in the area as future capital improvement projects.

PIRS™ for Heat scorecards can help to identify spatial variation in policy attention, or in other words, scorecards can be used to examine whether some parts of the city are targeted by more planned heat mitigation policies than others. Communities can then work to address these disparities in future plans.

The scorecards should also be used to holistically assess how well the community is proactively planning for growing heat risks. Comparing district scores with indicators of physical and social vulnerability can show whether policies are targeting the areas of greatest need and pinpoint specific neighborhoods that future plan updates and policies should target for heat mitigation.

We recommend that the PIRS™ for Heat scorecard results be shared widely with community stakeholders and used to spark a broader conversation about urban heat resilience, including the need to break down siloes and improve plan integration (Malecha et al., 2019). Using the PIRS™ for Heat scorecard as a conversation-starting point has proven productive in communities that have applied the approach to flood planning (Berke et al., 2021). For instance, in Nashua, New Hampshire, a broad network of stakeholder groups was involved in the PIRS™ process for flood hazards, which resulted in a hazard mitigation plan amendment, new permitting process, and crowdsourcing to incentivize public participation (Berke et al., 2021). In another application of PIRS™ for flood risk in Norfolk, Virginia, elected officials and neighborhood groups were engaged in the process, which resulted in a comprehensive plan update, new funding to alleviate environmental injustices, and new standards for infrastructure (Berke et al., 2021).

We also recommend considering the first application of the PIRS™ for Heat as a baseline assessment and repeating the process in the future to document how planning for urban heat resilience has, hopefully, improved over time. Woodruff et al. (2021) found in a longitudinal analysis of flood resilience planning in Boston and Fort Lauderdale that the number of flood mitigation policies and the attention to climate change increased from 2015 to 2019.

Step 7. Stories

Sharing the lessons learned from applying PIRS™ for Heat with other communities is also important. Everyone can learn from the wealth of information the PIRS™ for Heat provides about heat planning, even without conducting one themselves. These community stories can collectively advance resilience in the face of growing heat risks. The next chapter of this guidebook summarizes PIRS™ for Heat results from the five pilot communities: Baltimore, Boston, Fort Lauderdale, Houston, and Seattle.

Chapter 3: **PIRS™ for Heat Pilot Cities**

PIRS™ for Heat Pilot: Baltimore

The City of Baltimore, Maryland, had a population of 609,032 in 2019. Located in the Middle Atlantic region of the U.S., Baltimore's average daily maximum temperature is currently 68°F (20°C), with an average of three days over 100°F (37.8°C). Under high emissions scenarios, the average daily maximum temperature would increase to 77°F (25°C) by 2100, with 40 days over 100°F (37.8°C).

Plans and policies

Table BA1 summarizes the four Baltimore plans assessed in the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat pilot project. Across the four Baltimore plans, we identified 77 heat-relevant policies that met the criteria for inclusion.

Table BA1. Plan detail summary

Plan Name	Year Adopted	Scale	Plan Category	Number of policies
City of Baltimore Comprehensive Master Plan	2006	City	Comprehensive	22
Baltimore Sustainability Plan	2019	City	Sustainability	27
Baltimore Climate Action Plan	2012	City	Climate	12
City of Baltimore Disaster Preparedness and Planning Project (DP3)	2018	City	Hazard	16

Table BA2. Land use policy tool categories

Policy Tool Category	Number of Policies
Land Use Analysis and Permitting Process	12
Capital Improvements	49
Development Regulations	10
Land Acquisition	3
Density Transfer Provisions	0
Financial Incentives and Penalties	3
Public Facilities	0
Post Disaster Reconstruction Decisions	0

We coded the 77 policies into five of the eight categories of land use policy tools (Table BA2). The majority of the policies were categorized as capital improvements (49 policies), followed by land use analysis and permitting process-related policies (12) and development regulations (10). No heat-related policies were identified that used density transfer provisions, public facilities, or post-disaster reconstruction decisions.

Table BA3. Heat mitigation strategy categories

Heat Mitigation Strategy Category	Number of Policies
Land use	21
Urban design	0
Urban greening	34
Waste heat	36

We also coded the 77 policies into three of the four heat mitigation strategy categories. The most common categories of heat mitigation strategies were waste heat reduction (33 policies) and urban greening (30 policies). Together these accounted for the majority of policies. In contrast, there were no policies focused on mitigating heat through urban design strategies. Note that some policies were associated with more than one heat mitigation strategy category/subcategory, so individual heat mitigation strategy category totals add up to more than the 77 policies identified.

Scorecard

Figure BA1 shows the PIRS™ for Heat net scores (the sum of all the applicable +1 and -1 policies) for each census tract, with higher scores indicating more policy attention to heat mitigation. Net scores ranged from 30 to 35 across the city. While there is limited spatial variation in scores, the highest scoring tracts tend to be in the downtown and in the west side of the city.

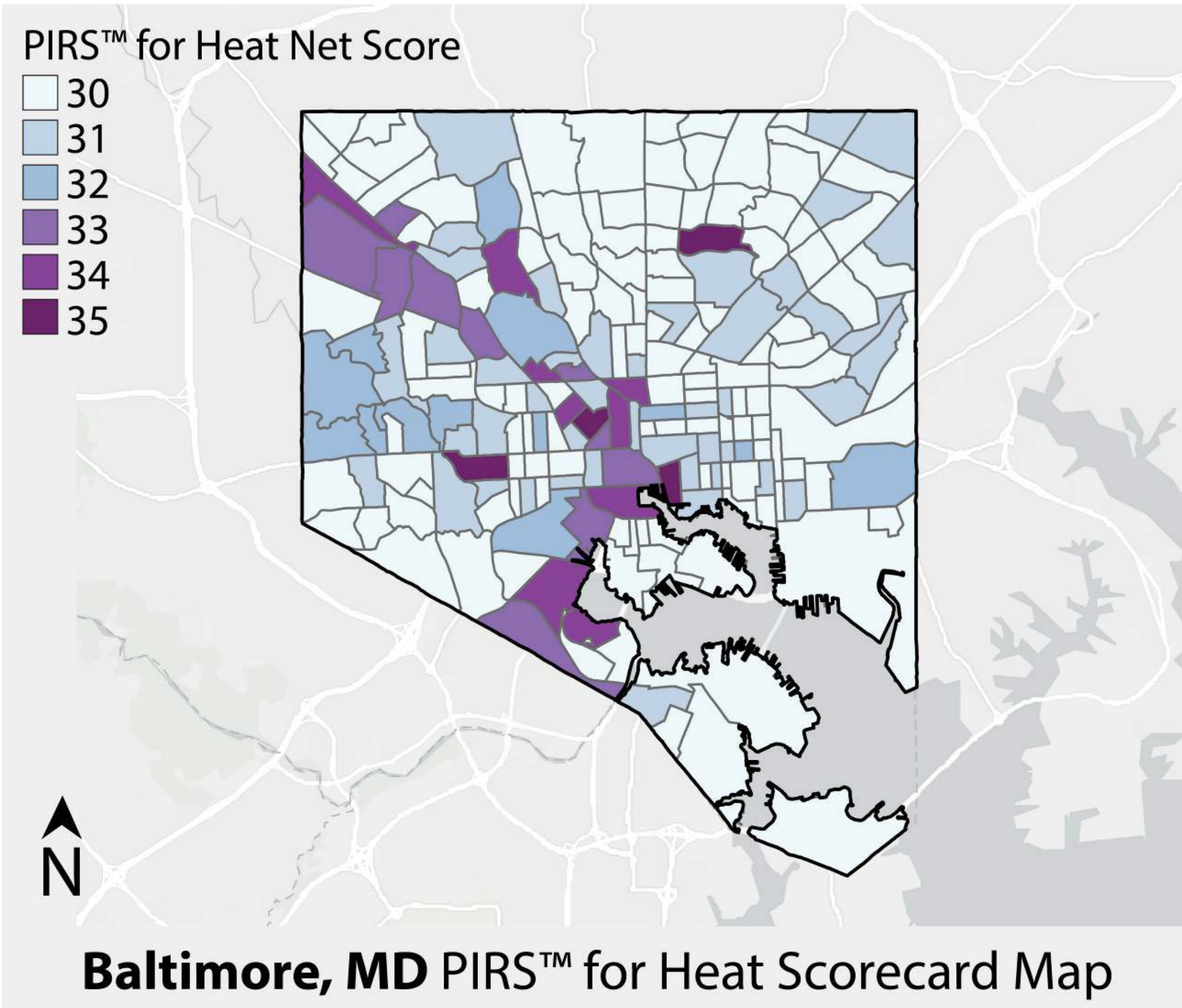

Figure BA1. Baltimore's PIRS™ for Heat net scores by 2020 census tract.

Out of the 77 policies we coded, 39 policies were found to decrease heat in the built environment, receiving a score of +1. Only one policy was found to increase heat in the built environment, receiving a score of –1. One policy received a score of zero, or was not found to impact heat, and 36 policies were classified as having an unknown impact on heat.

Only the policies that received a score of +1 or -1 were mapped; the policies with an unknown impact on heat were excluded from the scorecard map, and the policies with a score of 0 had no impact on the map.

Analysis

Figure BA2 shows Baltimore's PIRS™ for Heat net score, mean afternoon temperature from the U.S. National Integrated Heat Health Information Network (NIHHIS) Urban Heat Island (UHI) Map campaign, and the U.S. Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) ranking by census tract. Note that the scorecard is based on 2020 tract boundaries, while the temperatures and SVI are based on 2010 census tract boundaries. For the census tracts that are consistent across both datasets, the Pearson correlation coefficient analysis between the PIRS™ for Heat net score and mean afternoon temperature shows a small positive coefficient (0.011), but it is not statistically significant. The lack of statistical significance could be, in part, the result of the small sample size or the limited variation in net scores, but this finding also suggests that heat mitigation policies are not systematically targeting the hottest areas of the city.

The correlation coefficient (0.077) between PIRS™ for Heat net scores and social vulnerability is also positive but quite small and once again not statistically significant. This suggests that heat mitigation policies are not centered on the more socially vulnerable areas of the city. Importantly, we found a positive and statistically significant correlation (coefficient: 0.183, p-value: 0.010) between social vulnerability and mean afternoon temperature, indicating that more socially vulnerable areas are also hotter, compounding heat risks, and providing further motivation to target these areas with heat mitigation policies in the future.

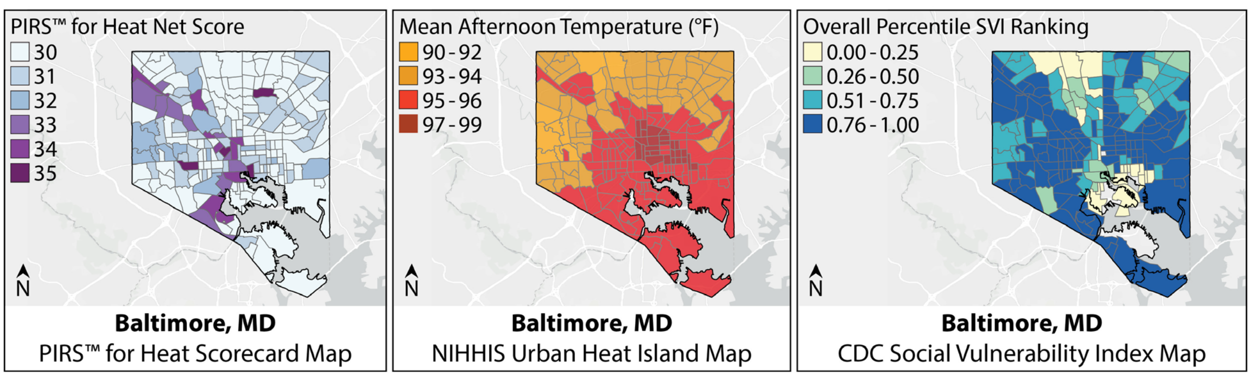

Figure BA2. Baltimore's PIRS™ for Heat net score by 2020 census tract (left), mean afternoon temperature by 2010 census tract (middle), and CDC SVI ranking by 2010 census tract (right).

Additionally, while only one policy was identified that would increase vulnerability to heat in Baltimore, 36 relevant policies were coded as having an unknown impact on heat. It would be beneficial for the city to review these policies and add additional information so that they mitigate heat, as well as continually consider the impact of policies on heat in the development of future plans.

Going forward, Baltimore can utilize the results from the PIRS™ for Heat analysis, as well as documented heat risk and social vulnerability data to prioritize the most vulnerable areas of the city for policies that increase resilience to the impacts of heat and decrease heat in the built environment.

PIRS™ for Heat Pilot: Boston

The City of Boston, Massachusetts, had a population of 684,379 in 2019. Located in the Northeast region of the U.S., Boston's average daily maximum temperature is currently 62°F (16.7°C), with no days over 100°F (37.8°C). Under high emissions scenarios, the average daily maximum temperature would increase to 70°F (21.1°C) by 2100, with 19 days over 100°F (37.8°C).

Plans and policies

Table BO1 summarizes the four Boston plans assessed in the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat pilot project. Across the four Boston plans, we identified 106 policies to include in our analysis.

Table BO1. Plan detail summary

Plan Name	Year Adopted	Scale	Plan Category	Number of policies
Imagine Boston 2030	2017	City	Comprehensive	60
Resilient Boston	2017	City	Resilience	8
Climate Action Plan 2019 Update	2019	City	Climate	22
2021 Natural Hazard Mitigation Plan Update	2021	City	Hazard	16

Table BO2. Land use policy tool categories

Policy Tool Category	Number of Policies
Capital Improvements	74
Land Use Analysis and Permitting Process	16
Development Regulations	14
Land Acquisition	2
Density Transfer Provisions	0
Financial Incentives and Penalties	0
Public Facilities	0
Post Disaster Reconstruction Decisions	0

We coded the 106 policies into four of the eight categories of land use policy tools (Table BO2). The majority of the policies fell under the policy tool category of capital improvements (74 policies), followed by policies related to land use analysis and permitting processes (16) and development regulations (14). There were several policies categorized as land acquisition, but none as density transfer provisions, financial incentives and penalties, public facilities, or post-disaster reconstruction decisions.

Table BO3. Heat mitigation strategy categories

Heat Mitigation Strategy Category	Number of Policies
Land use	35
Urban design	2
Urban greening	44
Waste heat	55

We also coded the 106 policies into all four heat mitigation strategy categories (Table BO3). The most common categories of heat mitigation strategies utilized by Boston's policies were waste heat reduction (48 policies), primarily through promoting alternative forms of transportation and improving the energy efficiency of buildings. Urban greening (44 policies) was also common, including policies related to parks and open spaces with vegetation, green stormwater infrastructure, and urban forestry. Policies related to land use were the third most common (35) category, and included policies that would change urban development patterns primarily. Note that policies may be associated with more than one heat mitigation strategy category/subcategory, so individual heat mitigation strategy category totals add up to more than the 106 policies identified.

Scorecard

Figure BO1 shows the PIRS™ for Heat net score by census tract. Net scores ranged from 28 to 43 across the city, with higher scores indicating more policy attention to heat mitigation. The highest-scoring census tracts in Boston are located near the downtown area, while the majority of the lowest-scoring census tracts are located in the more suburban neighborhoods in the western part of the city.

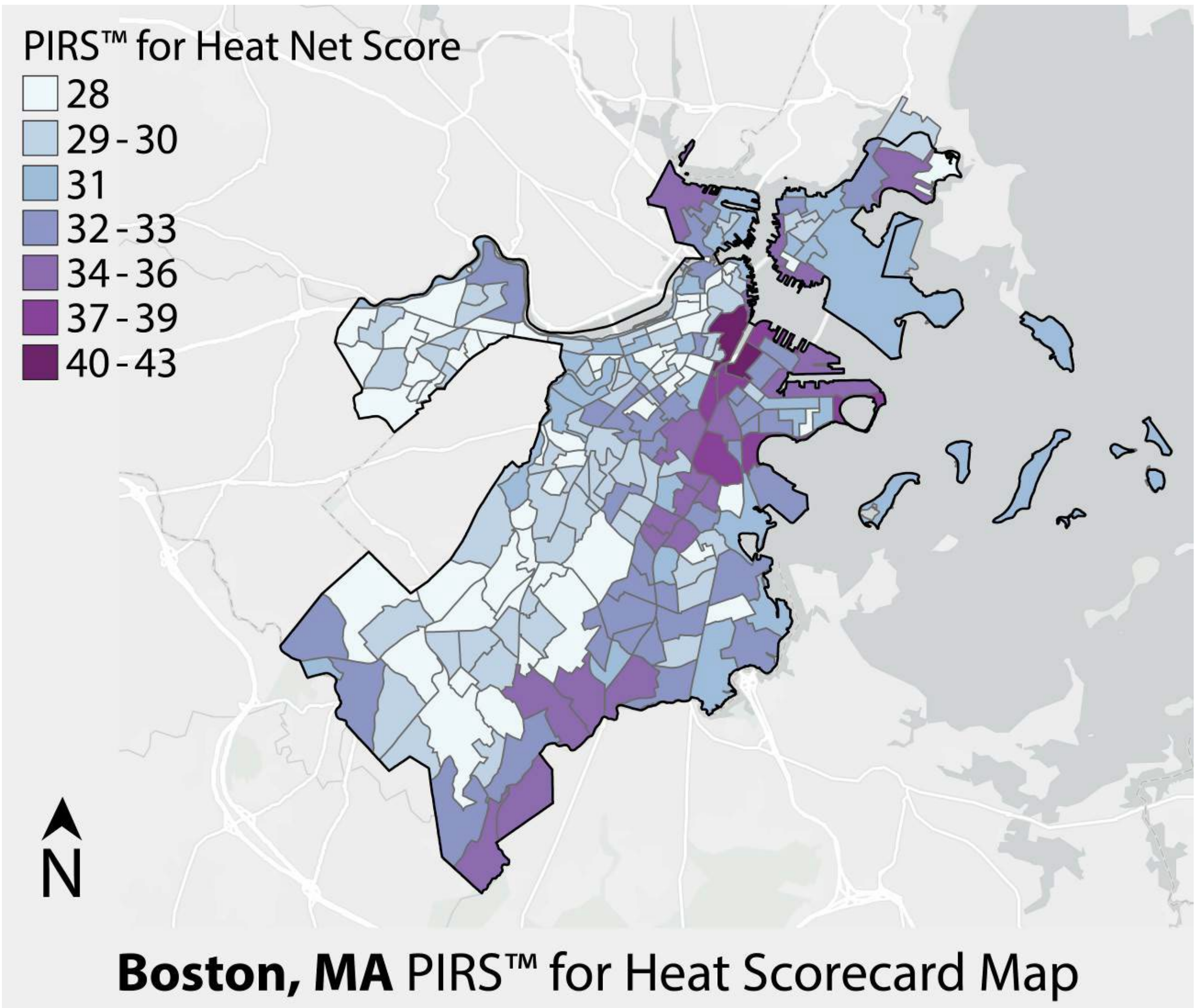

Figure BO1. Boston's PIRS™ for Heat net scores by 2020 census tract.

Out of the 106 policies, 66 policies were found to decrease heat in the built environment, receiving a score of +1. Only one policy was found to increase heat in the built environment, receiving a score of –1. Six policies received a score of zero, or were not found to impact heat, and 37 policies were classified as having an unknown impact on heat.

Only the policies that received a score of +1 or -1 were mapped; the policies with an unknown impact on heat were excluded from the scorecard map, and the policies with a score of 0 had no impact on the map.

Analysis

Figure BO2 shows Boston's PIRS™ for Heat net score, mean afternoon temperature from the National Integrated Heat Health Information Network (NIHHIS) urban heat island (UHI) map campaign, and CDC Social Vulnerability Index (SVI) ranking by census tract. Note that the scorecard is based on 2020 tract boundaries, while the temperatures and SVI are based on 2010 census tract boundaries. For the census tracts that are consistent across both datasets, the Pearson correlation coefficient analysis between the net score and mean afternoon temperature shows a marginally significant positive coefficient (Coefficient: 0.150; p-value: 0.061). This suggests that more heat mitigation policies target the hotter areas of the city, although the small size of the coefficient indicates that there is still room for improvement.

The correlation coefficient (Coefficient: 0.360; p-value: 0.000) between PIRS™ for Heat net scores and social vulnerability is also positive and statistically significant. This suggests that more heat mitigation policies target the more socially vulnerable areas of the city. There is not a clear relationship between socially vulnerable areas and the hotter areas of Boston, the correlation coefficient (0.0551) is extremely small and not statistically significant.

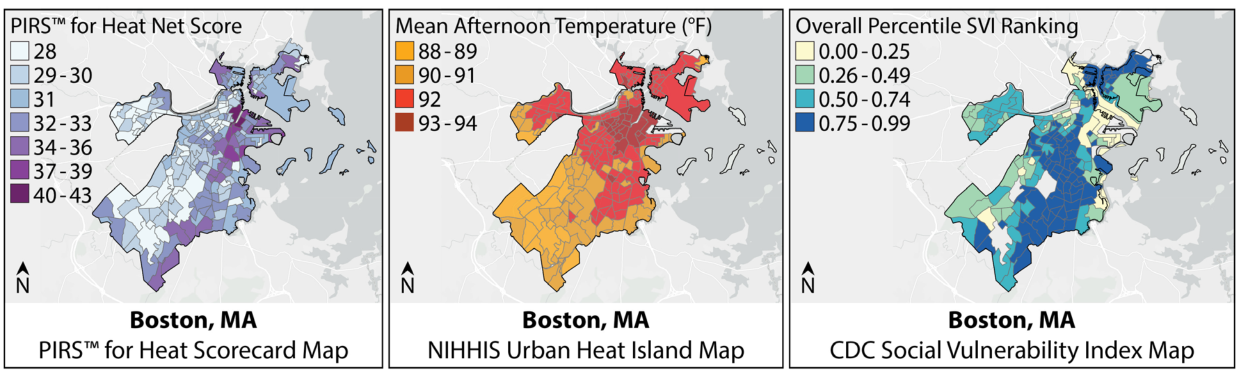

Figure BO2. Boston's PIRS™ for Heat net score by 2020 census tract (left), mean afternoon temperature by 2010 census tract (middle), and CDC SVI ranking by 2010 census tract (right).

These results indicate that Boston's policies are targeting hotter areas and more socially vulnerable communities for heat mitigation. These two areas are not necessarily co-located. Additionally, while only one policy increased vulnerability to heat in Boston, 37 policies were coded as having an unknown impact on heat. It would be beneficial for the city to review these policies and add additional information so that they decrease vulnerability to heat, as well as continually consider the impact of policies on heat in the development of future plans.

Going forward, Boston can utilize the results from the PIRS™ for Heat analysis, as well as documented heat risk and social vulnerability data to prioritize the most vulnerable areas of the city for policies that increase resilience to the impacts of heat and decrease heat in the built environment.

PIRS™ for Heat Pilot: Fort Lauderdale

The City of Fort Lauderdale, Florida, had a population of 180,124 in 2019. Located in the Southeast region of the U.S., Fort Lauderdale's average daily maximum temperature is currently 86°F (30°C), typically with no days over 100°F (37.8°C). Under high emissions scenarios, the average daily maximum temperature would increase to 92°F (33.3°C) by 2100, with 40 days over 100°F (37.8°C).

Plans and policies

Table FT1 summarizes the three Fort Lauderdale plans assessed in the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat pilot project. Across the three Fort Lauderdale plans, we identified 185 heat-relevant policies that met the criteria for inclusion, the majority of which were in the comprehensive plan.

Table FT1. Plan detail summary

Plan Name	Year Adopted	Scale	Plan Category	Number of policies
Advance Fort Lauderdale	2020	City	Comprehensive	158
Sustainability Action Plan	2011	City	Climate	16
Broward County Emergency Management Enhanced Local Mitigation Strategy (ELMS)	2017	County	Hazard	11

Table FT2. Land use policy tool categories

Policy Tool Category	Number of Policies
Land Use Analysis and Permitting Process	50
Capital Improvements	90
Development Regulations	38
Land Acquisition	1
Density Transfer Provisions	0
Financial Incentives and Penalties	6
Public Facilities	0
Post Disaster Reconstruction Decisions	0

We coded the 185 policies into five of the eight categories of land use policy tools (Table FT2). The majority of the policies were categorized as capital improvements (90 policies), followed by land use analysis and permitting process-related policies (50) and development regulations (38). No heat-related policies were identified that used density transfer provisions, public facilities, or post-disaster reconstruction decisions.

Table FT3. Heat mitigation strategy categories

Heat Mitigation Strategy Category	Number of Policies
Land use	71
Urban design	16
Urban greening	62
Waste heat	102

We also coded the 185 policies into all four heat mitigation strategy categories (Table FT3). The most common categories of heat mitigation strategies were waste heat reduction (79 policies) and urban greening (49 policies). Together, these accounted for the majority of policies. In contrast, there were no policies focused on mitigating heat through urban design strategies. Note that some policies were associated with more than one heat mitigation strategy category/subcategory, so individual heat mitigation strategy category totals add up to more than the 185 policies identified.

Scorecard

Figure FT1 shows the PIRS™ for Heat net scores (the sum of all the applicable +1 and -1 policies) for each census tract. Net scores ranged from 24 to 30 across the city, with higher scores indicating more policy attention to heat mitigation. The highest scoring census tracts tend to be on the east side of the city.

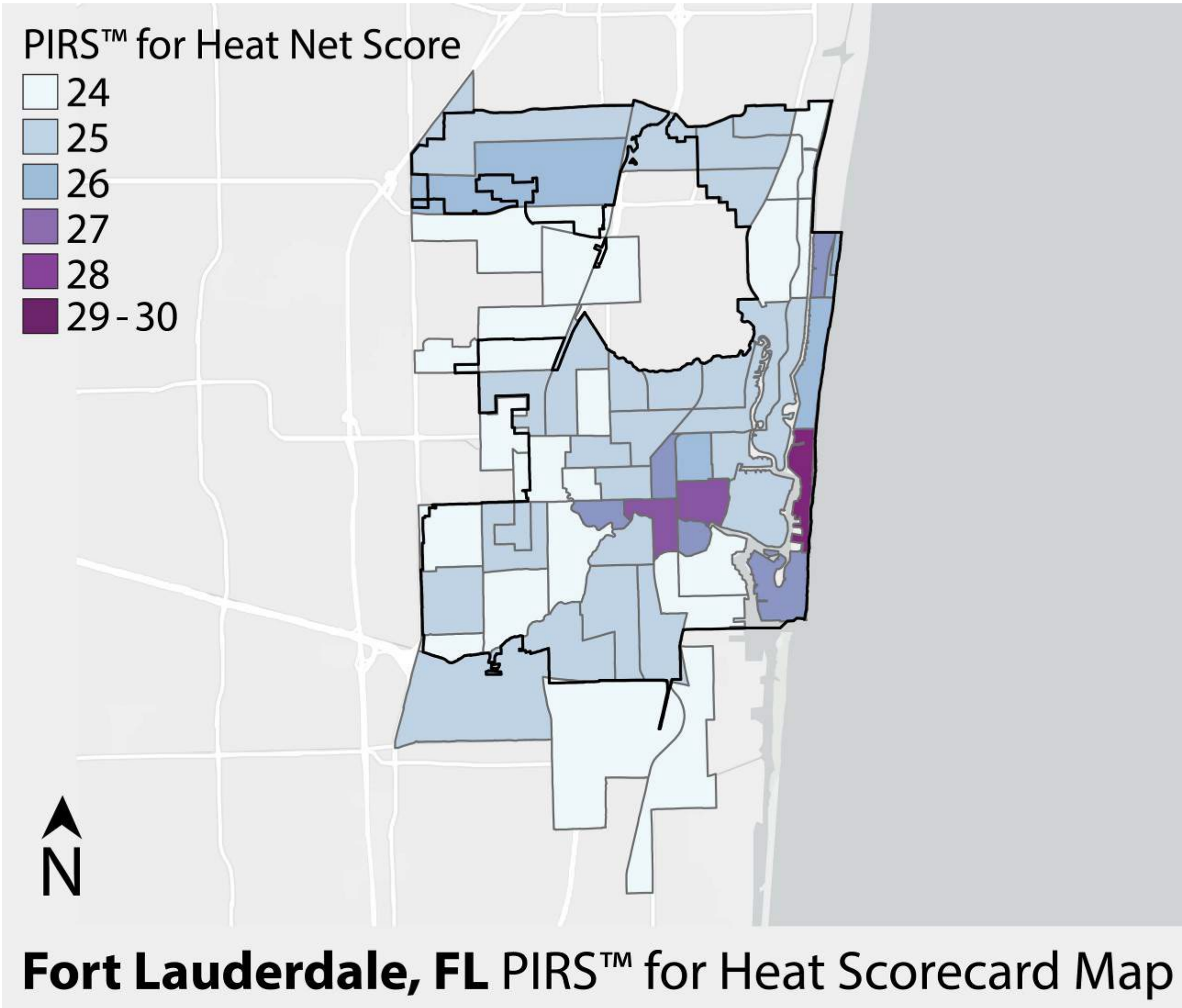

Figure FT1. Fort Lauderdale's PIRS™ for Heat net scores by 2020 census tract.

Out of the 185 policies we coded, 33 policies were found to decrease heat in the built environment, receiving a score of +1. Only two policies were found to increase heat in the built environment, receiving a score of -1. Four policies received a score of zero, or were not found to impact heat, and 146 policies were classified as having an unknown impact on heat.

Only the policies that received a score of +1 or -1 were mapped; the policies with an unknown impact on heat were excluded from the scorecard map, and the policies with a score of 0 had no impact on the map.

Analysis

Figure FT2 shows Fort Lauderdale's PIRS™ for Heat net score, mean afternoon temperature from the U.S. National Integrated Heat Health Information Network (NIHHIS) Urban Heat Island (UHI) Map campaign, and the U.S. Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) ranking by census tract. Note that the scorecard is based on 2020 tract boundaries, while the temperatures and SVI are based on 2010 census tract boundaries. For the census tracts that are consistent across both datasets, the Pearson correlation coefficient analysis between the PIRS™ for Heat net score and mean afternoon temperature shows a small negative coefficient (-0.180), but it is not statistically significant. The lack of statistical significance could be, in part, the result of the small sample size (N=42), but this finding suggests that heat mitigation policies are not systematically targeting the hottest areas of the city.

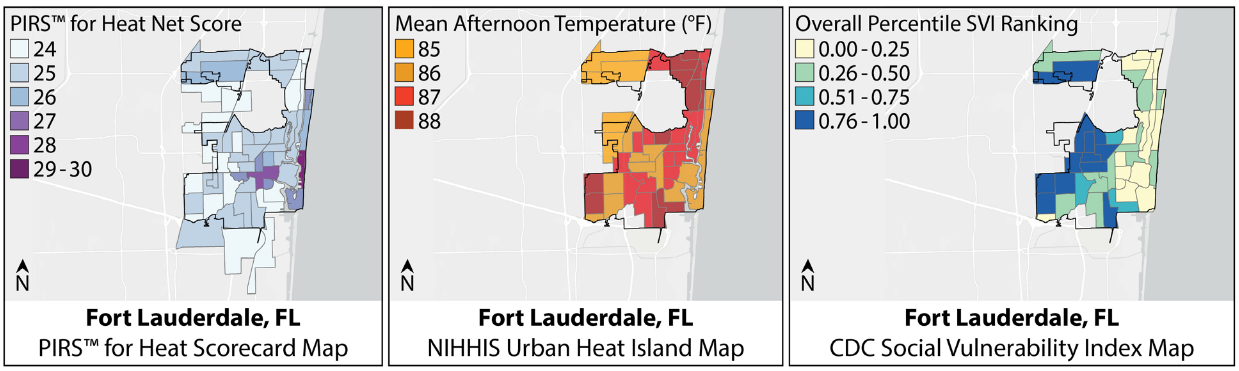

Figure FT2. Fort Lauderdale's PIRS™ for Heat net score by 2020 census tract (left), mean afternoon temperature by 2010 census tract (middle), and CDC SVI ranking by 2010 census tract (right).

The correlation coefficient (-0.251) between net scores and social vulnerability is also negative and not statistically significant. This suggests that heat mitigation policies are not centered on the more socially vulnerable areas of the city. There is not a clear relationship between socially vulnerable areas and the hotter areas of Fort Lauderdale, the correlation coefficient (-0.176) is small, negative, and not statistically significant. The fact that socially vulnerable and heat risk areas are not necessarily co-located means that the city should carefully consider which areas are most important to focus on for heat mitigation efforts.

These results indicate that Fort Lauderdale's policies are not targeting hotter or more socially vulnerable areas for heat mitigation. One challenge may be that these areas are not necessarily the same areas. Additionally, while only two policies increased vulnerability to heat in Fort Lauderdale, nearly 80 percent of policies (146) had an unknown impact on heat. It would be beneficial for the city to review these policies and add additional information so that they decrease vulnerability to heat, as well as continually consider the impact of policies on heat in the development of future plans.

Going forward, Fort Lauderdale can utilize the results from the PIRS™ for Heat analysis, as well as documented heat risk and social vulnerability data to prioritize the most vulnerable areas of the city for policies that increase resilience to the impacts of heat and decrease heat in the built environment.

PIRS™ for Heat Pilot: Houston

The City of Houston, Texas, had a population of 2.3 million in 2019. Located in the Southern Great Plains region of the U.S., Houston's average daily maximum temperature is currently 81°F (27.2°C), with an average of six days over 100°F (37.8°C). Under high emissions scenarios, the average daily maximum temperature would increase to 88°F (31.1°C) by 2100, with 70 days over 100°F (37.8°C).

Plans and policies

Table HO1 summarizes the four Houston plans assessed in the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat pilot project. Across the four Houston plans, we identified 60 heat-relevant policies that met the criteria for inclusion.

Table HO1. Plan detail summary

Plan Name	Year Adopted	Scale	Plan Category	Number of policies
Plan Houston	2015	City	Comprehensive	9
Resilient Houston	2020	City	Resilience	13
Houston Climate Action Plan	2020	City	Climate	35
City of Houston Hazard Mitigation Plan Update	2018	City	Hazard	3

Table HO2. Land use policy tool categories

Policy Tool Category	Number of Policies
Land Use Analysis and Permitting Process	9
Capital Improvements	41
Development Regulations	7
Land Acquisition	1
Density Transfer Provisions	0
Financial Incentives and Penalties	2
Public Facilities	0
Post Disaster Reconstruction Decisions	0

We coded the 60 policies into five of the eight categories of land use policy tools (Table HO2). The majority of the policies were categorized as capital improvements (41 policies), followed by land use analysis and permitting process-related policies (9) and development regulations (7). No heat-related policies were identified that used density transfer provisions, public facilities, or post-disaster reconstruction decisions.

Table HO3. Heat mitigation strategy categories

Heat Mitigation Strategy Category	Number of Policies
Land use	22
Urban design	2
Urban greening	21
Waste heat	27

We also coded the 60 policies into all four heat mitigation strategy categories (Table HO3). The most common categories of heat mitigation strategies were waste heat reduction (27 policies) and urban greening (21 policies). Together these accounted for the majority of policies. In contrast, there were no policies focused on mitigating heat through urban design strategies. Note that some policies were associated with more than one heat mitigation strategy category/subcategory, so individual heat mitigation strategy category totals add up to more than the 60 policies identified.

Scorecard

Figure HO1 shows the PIRS™ for Heat net scores (the sum of all the applicable +1 and -1 policies) for each census tract. Net scores ranged from 21 to 27 across the city, with higher scores indicating more policy attention to heat mitigation. While there is limited spatial variation in scores, the highest scoring tracts tend to be in the downtown area and on the southeast side of the city.

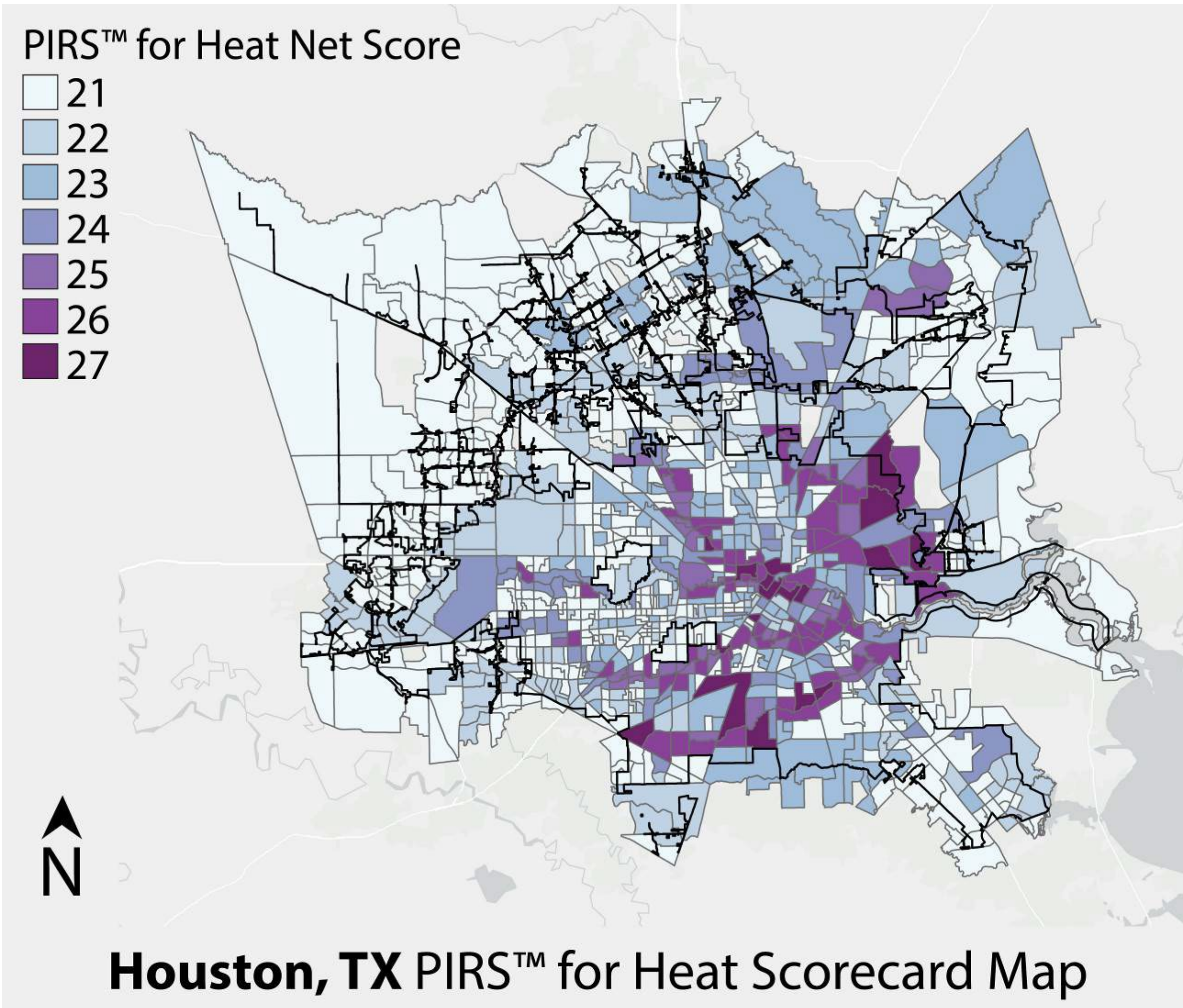

Figure HO1. Houston's PIRS™ for Heat net scores by 2020 census tract.

Out of the 60 policies we coded, 30 policies were found to decrease heat in the built environment, receiving a score of +1. No policies were found to increase heat in the built environment, which would have received a score of -1. One policy received a score of zero, or was not found to impact heat, and 29 policies were classified as having an unknown impact on heat.

Only the policies that received a score of +1 or -1 were mapped; the policies with an unknown impact on heat were excluded from the scorecard map, and the policies with a score of 0 had no impact on the map.

Analysis

Figure HO2 shows Houston's PIRS™ for Heat net score, mean afternoon temperature from the U.S. National Integrated Heat Health Information Network (NIHHIS) Urban Heat Island (UHI) Map campaign, and the U.S. Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) ranking by census tract. Note that the scorecard is based on 2020 tract boundaries, while the temperatures and SVI are based on 2010 census tract boundaries. For the census tracts that are consistent and have data across both datasets, the Pearson correlation coefficient analysis between the PIRS™ for Heat net score and mean afternoon temperature shows a small negative coefficient (-0.649) that is not statistically significant. It should be noted that the urban heat island map does not cover the full extent of the city, so only those tracts that were included in the mapping campaign are included in those analyses. This finding does nevertheless suggest that heat mitigation policies are not systematically targeting the hottest areas of the city.

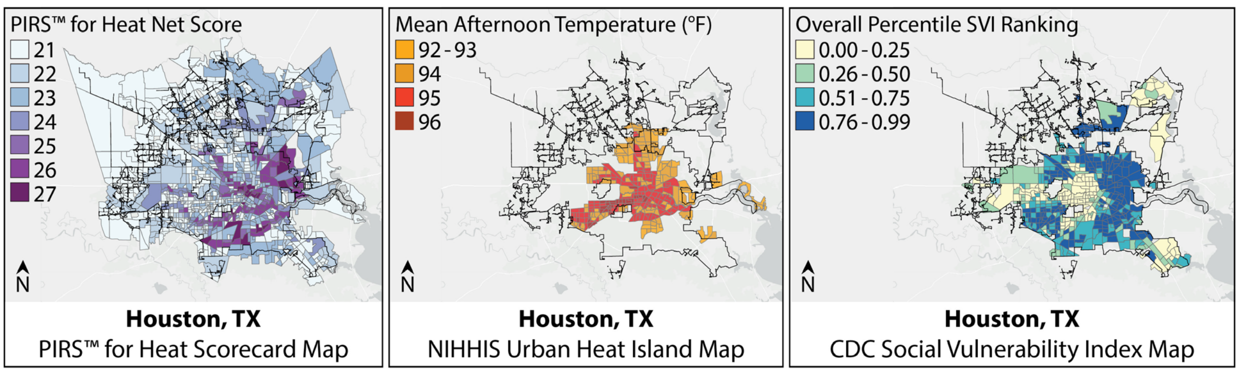

Figure HO2. Houston's PIRS™ for Heat net score by 2020 census tract (left), mean afternoon temperature by 2010 census tract (middle), and CDC SVI ranking by 2010 census tract (right).

The correlation coefficient (0.188) between PIRS™ for Heat net scores and social vulnerability is small, positive, but not statistically significant (Coefficient: 0.073; p-value: 0.213). This suggests that more socially vulnerable areas of the city are also not necessarily the focus of more heat mitigation policies. There does not appear to be a strong relationship between socially vulnerable areas and the hotter areas of Houston, at least where temperatures have been assessed; the correlation coefficient (-0.225) is fairly small, negative, and statistically significant (p-value: 0.000). The fact that hotter areas and socially vulnerable communities are not always co-located means that the city may need to carefully consider where is most important to focus heat mitigation efforts.

These results indicate that Houston's heat mitigation policies are not necessarily targeting more socially vulnerable or hotter areas. One challenge may be that these areas are not necessarily co-located. Additionally, while no identified policies increased vulnerability to heat in Houston, around half the policies (29) had an unknown impact on heat. It would be beneficial for the city to review these policies and add additional information so that they decrease vulnerability to heat, as well as continually consider the impact of policies on heat in the development of future plans.

Going forward, Houston can utilize the results from the PIRS™ for Heat analysis, as well as documented heat risk and social vulnerability data to prioritize the most vulnerable areas of the city for policies that increase resilience to the impacts of heat and decrease heat in the built environment.

PIRS™ for Heat Pilot: Seattle

The City of Seattle, Washington, had a population of 724,305 in 2019. Located in the Northwest region of the U.S., Seattle's average daily maximum temperature is currently 56°F (13.3°C), with, on average, no days over 100°F (37.8°C). In June 2021, the city experienced a record-breaking heatwave, with temperatures reaching 108°F (42.2°C). Under high emissions scenarios, such extreme heat waves would become more likely, with the average daily maximum temperature increasing to 64°F (17.8°C) by 2100 and an average of three days occurring each year where the high reached 100°F (37.8°C).

Plans and policies

Table SE1 summarizes the four Seattle plans assessed in the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat pilot project. Across the four Seattle plans, we identified 150 heat-relevant policies that met the criteria for inclusion.

Table SE1. Plan detail summary

Plan Name	Year Adopted	Scale	Plan Category	Number of policies
Seattle 2035	2020	City	Comprehensive	124
Preparing for Climate Change	2017	City	Adaptation	11
Seattle Climate Action	2018	City	Climate	14
City of Seattle 2015-2021 All-Hazards Mitigation Plan	2015	City	Hazard	1

Table SE2. Land use policy tool categories

Policy Tool Category	Number of Policies
Land Use Analysis and Permitting Process	40
Capital Improvements	70
Development Regulations	34
Land Acquisition	0
Density Transfer Provisions	2
Financial Incentives and Penalties	3
Public Facilities	1
Post Disaster Reconstruction Decisions	0

Table SE3. Heat mitigation strategy categories

Heat Mitigation Strategy Category	Number of Policies
Land use	63
Urban design	11
Urban greening	47
Waste heat	72

We coded the 150 policies into six of the eight categories of land use policy tools (Table SE2). The majority of the policies were categorized as capital improvements (70 policies), followed by land use analysis and permitting process-related policies (40) and development regulations (34). No heat-related policies were identified that used land acquisition or post-disaster reconstruction decisions.

We also coded the 150 policies into all four heat mitigation strategy categories (Table SE3). The most common categories of heat mitigation strategies were waste heat reduction (64 policies), land use (45), and urban greening (30). Together these accounted for the vast majority of policies. In contrast, there were only 11 categorized as urban design. Note that some policies were associated with more than one heat mitigation strategy category/subcategory, so individual heat mitigation strategy totals add up to more than the 150 policies identified.

Scorecard

Figure SE1 shows the PIRS™ for Heat net scores (the sum of all the applicable +1 and -1 policies) for each census tract. Net scores ranged from 27 to 37 across the city, with higher scores indicating more policy attention to heat mitigation.

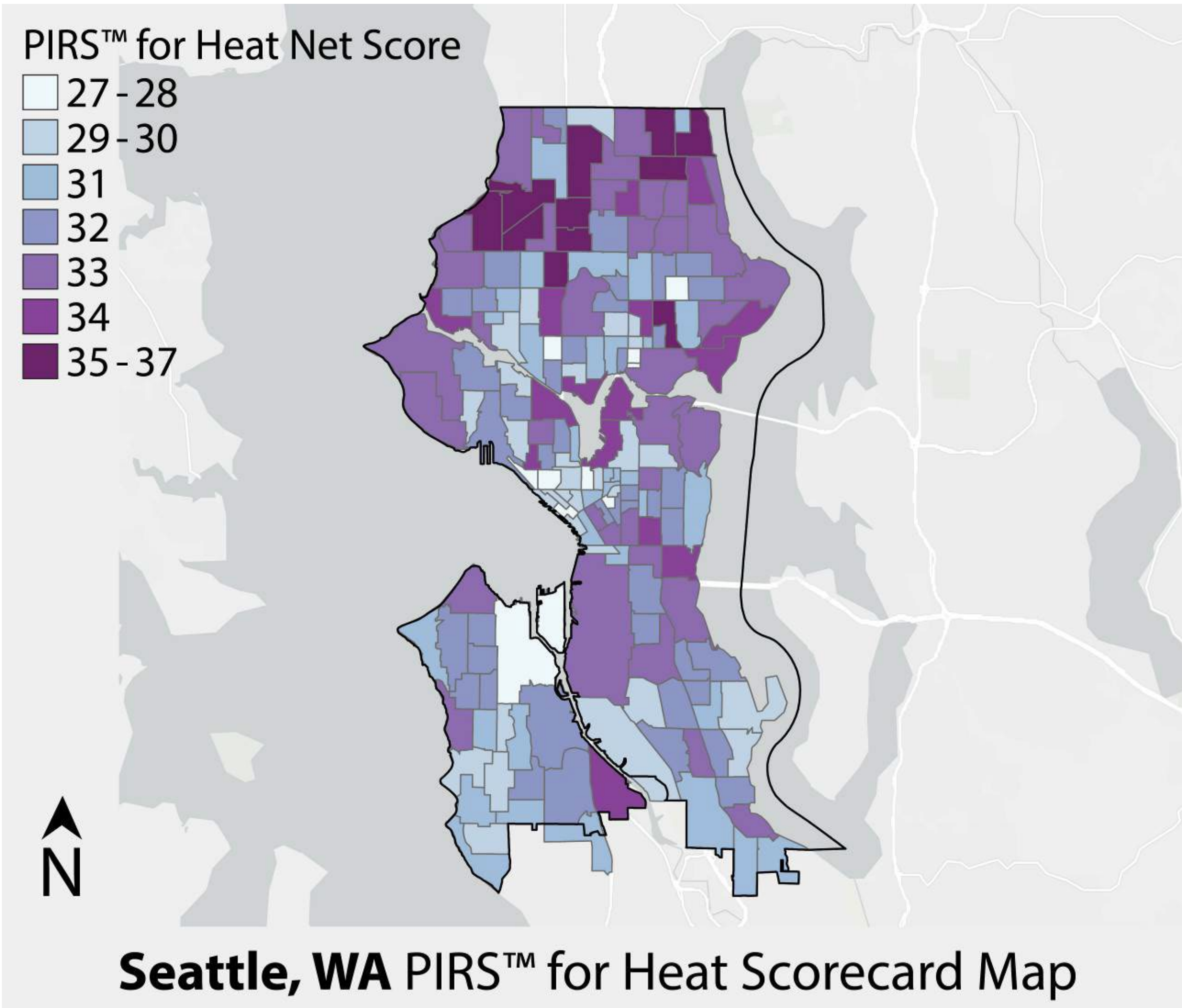

Figure SE1. Seattle's PIRS™ for Heat net scores by 2020 census tract.

Out of the 150 policies we coded, 41 policies were found to decrease heat in the built environment, receiving a score of +1. Only two policies were found to increase heat in the built environment, receiving a score of –1. Six policies received a score of zero, or were not found to impact heat, and 106 policies were classified as having an unknown impact on heat. Only the policies that received a score of +1 or -1 were mapped; the policies with an unknown impact on heat were excluded from the scorecard map, and the policies with a score of 0 had no impact on the map.

Analysis

Figure SE2 shows Seattle's PIRS™ for Heat net score, mean afternoon temperature from the U.S. National Integrated Heat Health Information Network (NIHHIS) Urban Heat Island (UHI) Map campaign, and the U.S. Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) by census tract. Note that the scorecard is based on 2020 tract boundaries, while the temperatures and SVI are based on 2010 census tract boundaries. For the census tracts that are consistent across both datasets, the Pearson correlation coefficient analysis between the PIRS™ for Heat net score and mean afternoon temperature shows a small positive coefficient (-0.131), which is not statistically significant. This suggests that heat mitigation policies are not systematically targeting the hotter areas of the city.

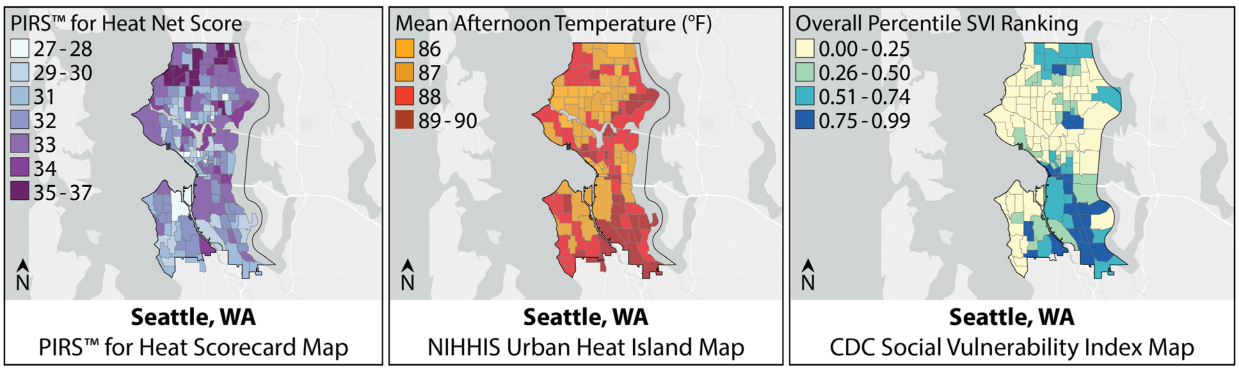

Figure SE2. Seattle's PIRS™ for Heat net score by 2020 census tract (left), mean afternoon temperature by 2010 census tract (middle), and CDC SVI ranking by 2010 census tract (right).

The correlation coefficient (-0.003) between net scores and social vulnerability is also very small, negative, and not statistically significant. This again suggests that heat mitigation policies are not centered on the more socially vulnerable areas of the city. There is a positive, statistically significant correlation (Coefficient: 0.344; p-value: 0.000) between socially vulnerable areas and the hotter areas of Seattle, compounding heat risks, and providing further motivation to target these areas with heat mitigation policies in the future.

These results indicate that Seattle's policies are not systematically targeting the hottest or most socially vulnerable areas of the city. This is a missed opportunity since, in general, areas that are hotter are also more socially vulnerable. Additionally, while only two policies were identified that would increase vulnerability to heat in Seattle, over 70 percent of the policies (106) had an unknown impact on heat. It would be beneficial for the city to review these policies and add additional information so that they decrease vulnerability to heat, as well as continually consider the impact of policies on heat in the development of future plans.

Going forward, Seattle can utilize the results from the PIRS™ for Heat analysis, as well as documented heat risk and social vulnerability data to prioritize the most vulnerable areas of the city for policies that increase resilience to the impacts of heat and decrease heat in the built environment.

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