Title

Building Heat Resilience Communities: A Toolkit for Local Planning, Decision-Making, & Action

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Publication Date

2026-05-21

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A Toolkit for Local Planning, Decision-Making, & Action

The UCLA Luskin Center for Innovation acknowledges the Gabrielino/Tongva peoples as the traditional land caretakers of Tovaangar (the Los Angeles basin and So. Channel Islands). As a land grant institution, we pay our respects to the Honuukvetam (Ancestors), ‘Ahiihirom (Elders) and ‘Eyoohiinkem (our relatives/relations) past, present and emerging.

UCLA Luskin Center for Innovation

Informing effective and equitable environmental policy

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NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

NIHHIS

The Center for Heat Resilient Communities was established with funding from a grant provided by the National Oceanic and Atmospheric Administration (NOAA) and the National Integrated Heat Health Information System (NIHHIS) (OMB Control Number: 0648-0828, Expiration Date: 9/30/27). This in-progress report was partially completed before funding was terminated in May 2025. The UCLA Luskin Center for Innovation contributed additional funding and staff time to finalize the report for publication in its current form.

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Center for Heat Resilient Communities

Introduction

The Center for Heat Resilient Communities, founded as a National Oceanic and Atmospheric Administration (NOAA) & National Integrated Heat Health Information System (NIHHIS)-funded Center of Excellence, is dedicated to supporting local governments and communities in determining the best strategies to advance heat resilience. This first-of-its-kind effort brought together teams of experts and over 50 cross-sector partners to create a roadmap for community heat resilience.

The purpose of the Center for Heat Resilient Communities (the Center) was to provide technical assistance to communities seeking to advance heat resilience, pilot technical assistance tools for heat resilience, and ultimately make recommendations to the federal government on ways to support communities on their path to heat resilience. The Center aims to support practitioners, governments, agencies, Tribal Nations, and other groups or institutions that seek to advance heat resilience in their communities.

In this case, the term community refers to a social group with a common geographic base (Stebbins et al. 1987). Communities may be cities, counties, unincorporated regions, neighborhoods, school districts, Tribal communities, military bases, etc., with formal jurisdictional authority, as well as informal groups with the ability to make decisions that impact a particular territory.

The center developed three products to provide technical assistance to communities: The Guiding Framework[1], The Roadmap Workbook (the "Workbook"), and Interactive Technical Assistance and Support: workshops, peer-to-peer learning, and ongoing consultation[2].

The Guiding Framework (the "Framework") is a learning support document. The Framework provides an introduction to key concepts and terms, recommended readings, and a broad overview of the goals, objectives, and actions the Center recommends for communities seeking to improve heat resilience. The Framework offers grounding in the key concepts that will be applied in the Workbook.

[1] The 'Framework' reflects the Center activities completed prior to the early termination of funding on May 4th, 2025.
[2] The 'Interactive Technical Assistance and Support' products had to be modified due to the early termination of funding on May 4th, 2025.

The Roadmap Workbook (the "Workbook") is an interactive, virtual set of tools for communities to put the Framework concepts into action. The Workbook features activities organized around recommended guiding questions to support communities in advancing heat resilience planning and data-informed decision-making. Workbook offerings include downloadable tools, resources, and templates that can be used and tailored to collect key data points to support community heat resilience planning. Workbook activities are tiered to enable communities to engage at different levels of depth depending on their needs and capacities.

Building Heat Resilient Communities: A Toolkit for Local Action integrates these products into a comprehensive resource for practitioners to advance local heat resilience planning and action.

You are reading a companion report.

Download the toolkit here.

Key Terms

Heat resilience refers to the ability of a community and its constituent social, environmental, and technical systems to maintain or quickly return to desired functions, adapt to change, and transform when the status quo limits current or future capacity to mitigate and manage the causes and impacts of chronic and acute high temperature conditions across the many systems and sectors it affects (Meerow et al. 2016, Keith et al. 2020).

Heat management refers to preparation and response strategies for extreme heat events, often within the domains of emergency management or public health, whereas **heat mitigation** refers to design and planning strategies to reduce the built environment's contribution to urban heat (Keith, Meerow, and Wagner 2020).

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Private Sector

- ISeeChange
- America Adapts Podcast

Regional Networks

- Southeastern Sustainability Directors Network (SSDN)
- Climate Assessment for the Southwest (CLIMAS)
- Great Lakes Integrated Science and Assessment (GLISA)
- Great Lakes Partnership Network (GLPN)
- Los Angeles Regional Collaborative (LARC)

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Center-Wide Advisory Committee

The Center-Wide Advisory Committee included public officials in local, state, and federal government, non-profit organizations and advocacy groups, and private sector representatives who provided review of materials contained in the Framework and Workbook.

Guiding Framework

Introduction

The following core concepts form the basis of the Center for Heat Resilient Community's recommended approach to advancing heat resilience:

- Climate modeling and microclimate modeling
- Heat exposure settings
- Vulnerability
- Social, cultural, and equity considerations
- Stress testing, maturity modeling, and tabletop exercises
- Heat action planning
- Community engagement
- Indicators of heat resilience
- Benefit-cost analysis
- Policy analysis, and
- Public communication/alerts

This Guiding Framework (the Framework) introduces these core concepts and serves as a primer for the heat resilience planning activities in the Workbook. The Framework includes the following:

- Conceptual overview of core concepts
- Best and leading practices
- Examples of goals, objectives, and actions for each concept
- Tiered approach to recommended activities[3]
- Key terms
- Recommending readings and resources

[3] A key goal of the Center for Heat Resilient Communities is increased access to heat resilience for a variety of different communities. In recognition that not only priorities and contexts vary among communities but also capacity and resources, each part of the Workbook includes three tiers of recommended activities. The tiers are ranked in increasing order of the resources required for their execution.

Climate Modeling & Microscale Climate Modeling

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Conceptual Overview

A *climate model* is a research tool used to simulate future climate scenarios based on the current climate and past patterns of change. Climate models generate *projections* of future climate that are based on numerical representations of the physical, chemical, and biological properties of climatic systems, their interactions, and their *feedback processes*.

A *microscale climate model* is a highly detailed computer model that illustrates how climate affects very small areas within cities, such as individual buildings, streets, or neighborhoods. These models reveal how local features such as trees and tall buildings create unique weather patterns at very small scales, explaining why some parts of a city are hotter than others.

Climate and microclimate modeling are crucial to advancing heat resilience. These models empower communities with information needed to understand current heat exposure and plan for future heat burdens. Projections from global, regional, and locally downscaled models can be used to estimate future extreme heat conditions and develop adaptation and resilience strategies. County or city-scale climate information helps assess long-term trends in frequency, intensity, and duration of heat extremes (Wilhelmi and Boehnert 2019). These projections empower communities to reduce heat-related fatalities by proactively planning for heat management and mitigation.

For example, a *heat exposure* assessment studies how people feel heat in different city areas, focusing on air temperature, humidity, sunlight, wind, and surfaces like pavement. A heat exposure assessment can describe the amount of heat our bodies are absorbing, and how shade from trees or buildings can reduce it. This research helps understand how to make cities that experience chronic heat and extreme heat events safer and more resilient to heat. The resulting data allows communities to prioritize resources and identify locally relevant strategies for heat mitigation and risk management.

Challenges to Anticipate: Producing more specific information with greater accuracy & precision requires a greater investment of time, access to equipment, and alignment between goals & available resources.

Historic daily climate information helps communities establish associations between extreme heat and key community health and wellness outcomes. For example, a community can better understand the impact that heat has on public health by identifying locally relevant heat indicators, such as emergency room visits during chronic heat and extreme heat events.

Because describing a community's current and future heat exposure is a key part of understanding the need for heat resilience action, modeling will play a key role in Part 1 of the

Workbook: Make the Case. Communities can find guidance in accessing, interpreting, and collecting the modeling-based information they need to assess and respond to projected changes in extreme heat, including changes to warm season average temperatures; number of hot days and warm nights; frequency, intensity, and duration of locally defined extreme heat events; and other climatologically meaningful indicators of heat hazard and exposure.

Climate Modeling & Microscale Climate Modeling: Best and Leading Practices

1. Climate science is ever-evolving. Climate models are improving and we are using the best available science now, but this is an iterative process. As urban landscapes, societies, adaptations, and climate evolve, cities should use updated climate projections for planning and resilience building.
2. The Fifth National Climate Assessment (NCA5) is the most comprehensive and current report by the US government on climate change impacts, risks, and responses (USGCRP 2023). The report provides a big-picture view of the US, highlights changes in extreme heat across regions, and their implications for sectors and communities.
3. The Climate Resilience Information System (CRIS) includes data and interactive web portals such as the NCA5 Interactive Atlas and Climate Mapping for Resilience and Adaptation (CMRA). Communities can use this information to explore changes in extreme heat at the county or census tract scale.
4. Climate projections are not specific predictions or forecasts. They represent average climate and extreme heat events statistically. They cannot be used to predict the temperature for July 25, 2050, but they can provide information on the increased frequency of hot days and warm nights during summers around 2050. This information can help communities to plan for energy consumption, public health response, or economic activities that may be impacted by extreme heat.
5. Many DOs and DON'Ts for using climate information described in this recent article can be adapted for urban heat management and resilience planning (Vano et al. 2018).
6. Climate model outputs can be imported into a Geographic Information System (GIS) for visualization, integration with land-surface and socio-economic data, and analysis of exposure and heat risk (Wilhelmi et al. 2016, Wilhelmi et al. 2019).
7. County or city-scale climate information helps assess long-term trends and projected changes in frequency, intensity, and duration of heat extremes (Wilhelmi and Boehnert 2019). Neighborhood-scale climate information helps prioritize resources and identify locally relevant strategies for urban heat mitigation and risk management.
8. Multidisciplinary approaches from climatology, urban planning, public health, and environmental science are necessary to understand the multifaceted impacts of extreme heat.
9. The collaborative approach of co-producing or co-developing heat resilience data, strategies, and plans ensures that extreme heat is not only scientifically sound but also socially and economically viable (McNie et al., 2016). It fosters the development of actionable, context-specific solutions that are more likely to be effective and equitable in addressing extreme heat and its impacts (Schneider et al., 2024).

Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that can be addressed within the scope of climate modeling & microscale climate modeling, along with activities that could be undertaken to achieve them.

Climate Modeling & Microscale Climate Modeling: Goals, Objectives, and Actions

Goals	• Understand how extreme heat conditions vary geographically and over time, especially in the context of a changing climate. • Understand how observations, models, and scenarios can inform heat mitigation and adaptation planning. • Bridge the gap between scientific research and practical implementation, which is crucial for effective and sustainable action on urban climate governance and extreme heat (Keith et al., 2021; Schneider et al., 2024). • Understand associations between heat and health outcomes. • Understand the impacts of the urban heat island effect (which neighborhoods in a city are hotter than others). • Prioritize heat mitigation actions to cool neighborhoods and the city. • Estimate future extreme heat conditions and develop adaptation and resilience-building strategies.
Objectives	• Assess projected changes in extreme heat. • Assess changes to warm-season average temperatures. • Assess the number of hot days and warm nights. • Assess frequency, intensity, and duration of locally defined extreme heat events. • Assess other climatologically meaningful indicators of heat hazard and exposure.
Actions	• Determine which types of climate data are appropriate for a community's resilience goals. • Identify relevant heat indicators, how to use them in GIS, and how to interpret the findings • Identify relevant and usable climate data and information spanning scales from human and neighborhood to community and regional. • Identify locally-relevant heat indicators and thresholds. • Compile available climate data and information sources.

Climate Modeling & Microscale Climate Modeling: Tiered Approach

Tier 1	Tier 2	Tier 3

Understanding Heat Exposure	*Visualizing Heat Exposure*	*Modeling Local Microclimates*
Assess climate variability and change using interactive web-based tools that include common climate and heat indicators. Visualize maps, time-series graphs, and charts. Scale maps, time series graphs, and charts based on microclimate to regional climate needs.	Download available climate data and climate change projections in a GIS or CSV format. Visualize and interpret this information in the context of risk and resilience. Visualize and interpret this information in the context of risk and resilience.	Create locally relevant extreme heat and climate indicators at locally relevant time scales and spatial aggregations. Train ambassadors and communities on the use of microclimate modeling tools, such as EnviMet and SOLWEIG, and microclimate observations.

Climate Modeling & Microscale Climate Modeling: Key Terms

1. **Anomaly:** Difference between future climate and present-day climate.

2. **Climate**: Average (typically over more than thirty years) weather in a place.

3. **Climate Change:** Changes in average weather conditions that persist over multiple decades or longer. Climate change encompasses both increases and decreases in temperature, as well as shifts in precipitation, changes in frequency and location of severe weather events, and changes to other features of the climate system (cite). Climate change is increasing the likelihood of many extreme weather events, contributing to greater climate variability.

4. **Climate model:** A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes. Climate models can be used to study and simulate long-term (decadal or longer) climate projections and to produce shorter-term (seasonal, annual, interannual) projections. Related term: Earth system model.

5. **Climate projections**: The simulated response of the climate system to a scenario of future emissions or concentrations of greenhouse gases and aerosols, generally derived using climate models. Climate projections depend on the emissions, concentration, or radiative forcing scenario used, which, in turn, is

based on assumptions concerning, for example, future socioeconomic and technological developments.

6. **Climate variability:** The way aspects of climate (such as temperature and precipitation) differ from an average.

7. **Extreme heat**: In common usage, "Extreme heat" typically refers to temperatures much hotter and/or more humid than average. Because some places are hotter than others, this depends on what is considered average for a particular location at that time of year.42 Extreme heat is considered an invisible and silent threat, which is one of the factors that separates heat from other climate risks such as flooding or wildfires (Keith et al., 2019).

8. **Global climate:** A description of the climate of a planet as a whole, averaged across regions.

9. **Heat:** Refers to a transfer of energy.

10. **Heat exposure assessment**: Scientists study how people feel heat in different city areas, focusing on sunlight, wind, and surfaces like pavement. They measure how much heat our bodies absorb and how shade from trees or buildings can reduce it. This research helps understand how to make cities more comfortable and safer during hot weather.

11. **Microscale climate modeling**: Scientists use highly detailed computer models to study how climate affects very small areas within cities, such as individual buildings, streets, or neighborhoods. These models reveal how local features, such as trees or tall buildings, create unique weather patterns at very small scales, explaining why some parts of a city are hotter.

12. **Personal Heat Exposure:** Individual experience of heat is referred to as personal heat exposure. It encompasses environmental exposures such as climate and site conditions, demographic and health factors, activity level, and access to cooling.

13. **Regional climate:** The climate in a community's surrounding area is called its regional climate. Regional climate depends on factors such as the amount of sunlight it receives, its elevation, the land's shape, and its proximity to large bodies of water.

14. **Scenario**: A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Scenarios are neither projections nor forecasts but are used to provide a view of the implications of developments and actions.

15. **Urban climate**: Urban areas have a unique climate shaped by various processes within the city. This differs from rural climates due to factors such as buildings, human activities, and changes in natural landscapes, leading to effects such as the **urban heat island**, altered wind patterns, and altered precipitation (Oke et al., 2017).

16. **Weather**: The state of the atmosphere (temperature, humidity,

precipitation, cloudiness, visibility, wind) at a specific place and time.

Climate Modeling & Microscale Climate Modeling: Recommended Readings and Resources

1. Boehnert, J., & Wilhelmi, O. (2023, May 4). *The power of GIS*. ArcGIS StoryMaps. https://storymaps.arcgis.com/stories/ed58d3649a9642b7b645b561fc21dfc6
2. Climate Resilience Information System (CRIS) includes data and interactive web portals such as the NCA5 Interactive Atlas (U.S. Global Change Research Program 2023a) and Climate Mapping for Resilience and Adaptation (CMRA; U.S. Global Change Research Program 2023b). Communities can use this information to explore changes in extreme heat at the county or census tract scale.

   U.S. Global Change Research Program. (2023a). *Climate Mapping for Resilience and Adaptation (CMRA) assessment tool*. https://livingatlas.arcgis.com/assessment-tool/home/

   U.S. Global Change Research Program. (2023b). *NCA5 interactive atlas*. https://atlas.globalchange.gov

3. McNie, E., Parris, A., & Sarewitz, D. (2016). Improving the public value of science: A typology to inform discussion, design and implementation of research. *Research Policy, 45*(4), 884–895. https://doi.org/10.1016/j.respol.2016.01.004
4. Stebbins, J. F. (1987). Identification of multiple structural species in silicate glasses by 29Si NMR. *Nature, 330*, 465–467. https://doi.org/10.1038/330465a0
5. The Fifth National Climate Assessment (NCA5) is the most comprehensive and current report by the US government on climate change impacts, risks and responses (USGCRP 2023). The report highlights changes in extreme heat across U.S. regions and implications for sectors and communities.

   Crimmins, A. R., Avery, C. W., Easterling, D. R., Kunkel, K. E., Stewart, B. C., & Maycock, T. K. (Eds.). (2023). *Fifth National Climate Assessment*. U.S. Global Change Research Program. https://doi.org/10.7930/NCA5.2023
6. Vano, J. A., Arnold, J. R., Nijssen, B., Clark, M. P., Wood, A. W., Gutmann, E. D., Addor, N., Hamman, J., & Lehner, F. (2018). DOs and DON'Ts for using climate change information for water resource planning and management: Guidelines for study design. *Climate Services, 12*, 1–13.

Heat Exposure Settings

Lead Author: Kelly Turner, Ph.D.

Conceptual Overview

Heat Exposure Settings are the places that people spend time and become vulnerable to heat. They are the everyday places where life is carried out, such as homes, workplaces, schools, transportation systems, public spaces, and other sites for routine activities. Each Heat Exposure Setting encompasses a unique combination of:

> (1) **Context-dependent heat exposure pathways and cooling requirements**, shaped by who uses the place, for what purposes, and during which times of day or year; and
>
> (2) **Institutions and actors that govern the setting,** jointly influencing how heat is mitigated and managed for the individuals, activities, and periods of use associated with that place.

Both components are necessary because effective heat governance requires alignment with how heat is experienced and how change can realistically be implemented.

Heat exposure and its health consequences are personal and context-dependent. An individual's heat-health risk is a function of "the three Ps": personal health, physical activity, and place-specific environmental conditions. Personal health factors that amplify risk, such as age, medical conditions, and medication use, limit your body's ability to cool itself. Physical activities that involve high exertion, long duration, occur in hot conditions, or involve equipment may increase the work your body has to do to cool down. Places that are fully exposed to weather elements, generate heat inside or outdoors through design or mechanical operations, or generally lack cooling, also put people at higher heat-health risk. By examining the specific mix of personal, activity, and place-specific environmental risk, communities can identify the dominant vectors of heat risk in a given Heat Exposure Setting and develop place-specific strategies that are both responsive and scalable.

The Heat Exposure Settings concept was initially developed by the UCLA Luskin Center for Innovation for a policy-gap analysis prepared for the State of California (De Shazo, Lim, & Pierce, 2021). That report argued that a place-based approach could improve the delivery of heat action by tailoring solutions to specific settings and aligning them with discrete areas under the regulatory authority and monitoring responsibilities of affiliated state agencies. The report used the American Time Use Survey and a literature review of heat-vulnerable populations to develop an initial list of settings: homes, workplaces, schools and childcare facilities, carceral facilities, parks and recreational facilities, and public transit stops. The authors then conducted policy analysis to audit the gap between heat-protection policy needs and existing California policies. Subsequent reports identified pathways to bridge policy gaps in homes and schools.

Taking a place-based approach is especially helpful for addressing heat because its governance is typically fragmented across institutions. Heat is not typically governed by a central statute that is carried out by one clear institutional authority. Instead, heat governance is carried out across a patchwork of policies operating across sectors and jurisdictions.

The most frequently occurring form of heat governance is emergency management of extreme heat events, sited in hazard and public health institutions, followed by urban heat mitigation, sited in land-use and environmental institutions. Most communities rightly engage public health, emergency services, land-use, natural resources, urban forestry, climate, sustainability, and resilience offices in heat-resilience planning. What these institutions do not fully address is the range of statutes, agencies, and officers that influence facilities, operations, personnel, and clients and partners that are responsible for the daily functioning of everyday life. Each setting entails distinct sets of institutions and actors that are frequently overlooked in heat resilience efforts because they are place-specific rather than heat-centric. Conversely, these institutions and actors may overlook their important role in heat resilience efforts because they are charged with delivering a range of services that may appear independent of heat. This gap in conceptualizing relevance to heat resilience can inadvertently prevent effective heat mitigation and management when rules conflict.

The Luskin Center for Innovation at UCLA used the Heat Exposure Framework to examine K-12 public schools in California (UCLA Luskin Center for Innovation 2023). School-aged children are a heat-vulnerable population. Key heat-impacted activities and hot facilities include outdoor recreation on sun-exposed playgrounds and indoor learning environments that lack mechanical cooling. Cooling school facilities entails engaging the Department of Education, which has authority to set standards for safe and educationally appropriate facilities; the Department of General Services; and the Division of the State Architect, which has authority to approve building designs and determine compliance with safety codes, among others. These entities, jointly with the Department of Justice and Office for Civil Rights, oversee compliance with the Americans with Disabilities Act (ADA). Federal and California ADA law requirements added a 40% funding match for any outdoor facilities upgrades, creating an additional fiscal burden for local school districts seeking to install shade structures on playgrounds; and frequently, the most resource-constrained schools were also the most heat-vulnerable. In response, legislation was introduced to limit ADA matches to 20% (SB515). This example highlights how an Exposure Settings Framework can reveal unintended conflicts by engaging institutions such as the ADA that fall outside conventional heat resilience framings.

Many heat exposure settings are universally important across communities, including homes, schools, workplaces, and transit. Others may be very specific to your community. For example, cultural heritage sites, military bases, and agricultural worksites.

Exposure Settings: Best and Leading Practices

1. **Start by identifying the dominant heat exposure pathways in a given setting to tailor intervention selection.** Avoid prescribing cooling interventions simply because they are preferred or conventional.
2. **Align cooling interventions with institutional authority.** Identify which institutions govern facilities, operations, personnel, funding, and other standards in the setting.
3. **Design solutions around existing rules-in-use.** Determine which rules facilitate, constrain, or could be amended to achieve cooling goals.

4. **Create a "menu" of options that provide multiple institutional pathways for implementing solutions in a given setting.** Draw from this menu when policy windows open. Avoid one-size-fits-all solutions across settings.
5. **Be mindful of ways existing rules entrench inequities.** Avoid doubling down on rules-in-use that historically have created disparities in heat exposure or its management.
6. **Track implementation and adapt over time.** Assess effectiveness, monitor rule changes, and identify innovations in site-specific implementation. Update rules as institutional or climate conditions change.

Heat Exposure Settings: Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that can be addressed within the scope of heat exposure setting assessment, along with activities that could be undertaken to achieve them.

Heat Exposure Settings: Goals, Objectives, and Actions

Goals	• Identify and prioritize action in the "settings" where people spend the most time exposed to hot conditions • Make connections between the sites, sectors, and stakeholders impacted and able to enact changes
Objectives	• Create an exhaustive list of heat exposure settings, including settings that are unique to the community • Determine what activities people engage in when they are in those settings • Assess heat vulnerability across the settings and sectors that are most affected • Determine what sectors (e.g., housing, education, transportation) and actors (e.g., Department of Transportation) influence facilities and operations in those settings
Actions	• Complete the Heat Exposure Settings Worksheet

Heat Exposure Settings: Tiered Approach to Workbook Activities

Tier 1	Tier 2	Tier 3
Heat Exposure Settings Identification	*Proposed; No Workbook Activity*	*Proposed; No Workbook Activity*

Identify and prioritize key exposure settings. Identify heat exposure pathways in each setting and the responsible institutional actors. Brainstorm potential interventions and discuss feasibility.	Identify which institutions govern facilities, operations, personnel, and funding. Review relevant statutes, requirements, and operational rules. Develop a menu of options for amending existing rules to facilitate cooling goals.	Engage relevant agencies and decision-makers to further understand institutional rules and potential changes. Develop a targeted plan to adjust rules, including appropriate vehicles of change (e.g., policy, plans, etc.). Create a monitoring and evaluation plan.

Heat Exposure Settings: Key Terms

1. **Exposure pathways:** The processes through which people experience heat. These pathways are conditioned by personal health, physical activity, and environmental conditions in particular places.

2. **Exposure settings**: The environments where people regularly spend time and are exposed to heat, including homes, workplaces, schools, transportation, and public spaces. Each setting features distinct heat exposure pathways, cooling needs, and governing institutions.

3. **Institutions:** The formal and informal rules-in-use that shape what is permitted, allowed, required, or forbidden (Ostrom, 2005).

4. **Institutional alignment:** The process of coordinating agencies, statutes, funding mechanisms, and operational practices to support effective heat mitigation and management in a setting.

5. **Place-based approach:** A planning strategy that organizes action around specific activity sites rather than abstract geographic zones or sectors.

6. **Setting-specific intervention:** A cooling strategy tailored to the populations, activities, facilities, and institutional context of a particular exposure setting.

Heat Exposure Settings: Recommended Readings and Resources

1. DeShazo, J. R., Lim, L., & Pierce, G. (2021). *Adapting to extreme heat in California: Assessing gaps in state-level policies and funding opportunities*. Luskin Center for Innovation, University of California Los Angeles. https://innovation.luskin.ucla.edu/wp-content/uploads/2021/10/Adapting-to-Extreme-Heat-in-California.pdf
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Heat Vulnerability

Lead Author: Sara Meerow, Ph.D.

Conceptual Overview

Heat risks are not evenly distributed. Heat vulnerability reflects the degree to which people, places, or systems are likely to be negatively affected by heat. Vulnerability is shaped by 1) heat exposure, the weather and climate conditions that together with the built environment determine a person, place, or system's thermal settings; 2) sensitivity, or the extent to which a person, place, or system is negatively affected by exposure to heat; and 3) adaptive capacity, or ability to respond to heat in order to minimize negative effects. These components vary by individual, household, neighborhood, and community, so it is important to understand the local context. This complexity makes it challenging to assess heat vulnerability, but doing so is important in order to efficiently and equitably target heat resilience efforts. There is likely no one-size-fits-all approach to measuring heat vulnerability. Most heat vulnerability assessments integrate a number of physical and social indicators, for example, in a spatial heat vulnerability index (HVI). Research suggests that heat-specific, localized indices may more accurately capture relative risks than generic ones.

Heat Vulnerability: Best and Leading Practices

1. **Develop a locally relevant definition of heat vulnerability** that considers the most important factors related to physical heat exposure, sociodemographic sensitivity, and adaptive capacity.

2. **Consider developing a community heat vulnerability index (HVI)** that integrates multiple spatial indicators of vulnerability, but make sure to carefully consider which indicators are most relevant to the community, the modeling approach, and the statistical and geospatial choices.

3. Use information on heat vulnerability, such as an HVI, to **identify priority areas** for resilience strategies.

Heat Vulnerability: Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that can be addressed within the scope of heat vulnerability assessment, along with activities that could be undertaken to achieve them.

Heat Vulnerability: Goals, Objectives, and Actions

Goals	• Set goals to reduce specific components of the community's heat vulnerability. Consider exposure, sensitivity, and adaptive capacity • Aim to prioritize heat resilience strategies in more vulnerable areas of the community
Objectives	• Plan to assess heat vulnerability across the community (e.g., develop a community-specific heat vulnerability index) • Set specific targets related to indicators of heat vulnerability that the community wants to improve in a particular timeframe
Actions	• Use existing indicators or a social vulnerability index to identify more socially vulnerable areas in the community • Develop a localized heat vulnerability index • Use the heat vulnerability assessment to identify priority areas for heat resilience strategies

Heat Vulnerability: Tiered Approach to Workbook Activities

Tier 1	Tier 2	Tier 3
Understanding Heat Vulnerability Use existing datasets to examine multiple dimensions of heat vulnerability in your community. Learn how to assess what a particular index or method for measuring vulnerability captures and does not capture.	*Building Your Own Social Vulnerability Viewer* Use online Geospatial Information System (GIS) tools to build a dynamic web map depicting social vulnerabilities to heat in your community.	*Creating a Social Vulnerability Index for Heat* Develop a unique social vulnerability index for your community using locally relevant indicators.

Heat Vulnerability: Key Terms

1. **Vulnerability**: "The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt." (IPCC 2022)

2. **Exposure**: “The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected [by heat]” (adapted from IPCC 2022).

3. **Sensitivity**: “The degree to which a system or species is affected, either adversely or beneficially [by heat]. The effect may be direct or indirect” (adapted from IPCC 2022).

4. **Adaptive capacity**: “The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences [of heat]” (adapted from IPCC 2022).

Heat Vulnerability: Recommended Readings and Resources

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Social, Cultural, and Equity Considerations for Heat Resilience

Lead Author: Trace Lane

Conceptual Overview

Social and cultural considerations of heat resilience describe the potential disruption, loss, or alteration of community events, cultural practices, and essential daily tasks that may result from increasing chronic and acute heat. Exploring the social and cultural, or *sociocultural*, impacts and risks of heat is important because it reveals how heat can pose a safety threat when communities engage in activities that maintain local lifeways and social cohesion within communities, tribes, and cultural groups. The disruption of these sociocultural activities matters because it can weaken the societal bonds that make communities more resilient to disasters, disconnect us from our cultural identities, make it dangerous to perform necessary daily tasks, and impose a barrier to heat-safe civic engagement. Understanding the sociocultural risks of heat can empower a community to proactively mitigate potential impacts through heat resilience planning, species monitoring and preservation plans, cooling intervention strategies, and other adaptation measures.

Sociocultural considerations can, and should, include a richly diverse range of interpretations. Ultimately, the conclusions about what is important to a community are determined by the community, even if the rationale does not fit an existing sociocultural model. Here, the goal is to provide a process for assessing the sociocultural risks posed by heat to a community. Conclusions derived from this process should be vetted by a diverse representation of community members. Planning efforts should address the risks deemed highest priority by the community.

We organize sociocultural considerations of heat into four areas of actionable practice:

1. Heat-Safe Community Events
2. Heat-Resilient Cultural Practices
3. Heat Resilience for Daily Life
4. Equity Considerations

Heat-Safe Community Events

Social connections, like those facilitated at community events, are a foundational element of community resilience (Tamasiga et al, 2024). Community events can include any gathering that takes place in your city, town, or neighborhood. Examples include food festivals, community bike rides, marathons, flea markets, art walks, concerts, and seasonal sports. Safe and enjoyable community events are an integral component of resilient communities because they offer the opportunity to build relationships, exchange knowledge, increase social cohesion, share resources, provide an outlet for local commerce, organize, and increase quality of life (among many other benefits) (Ludin et al, 2019).

However, as heat increases, so does the risk of heat exposure at outdoor events during the heat season, particularly for heat-sensitive attendees. In the Sociocultural worksheets, communities can identify events that may pose a health and safety risk to attendees - those which occur during heat season, are held outdoors, and lack a heat mitigation or management plan. Once events are identified, planning efforts can address these needs.

Heat-Resilient Cultural Practices

Plant and animal species that are irreplaceable, integral components of cultural practices are called cultural keystone species (Cristancho and Vining, 2004). Characteristics of cultural keystone species can include the generation of local, traditional, or indigenous knowledge; representation in cultural stories; use in traditional cuisine or medicine; and support of local economies by producing traditional products. In parallel with the concept of a keystone species in ecology, a cultural keystone species is a cornerstone of a culture (Mills et al., 1993). Just as the loss of an ecological keystone species can cause significant disruption or damage to an ecosystem, the loss of a cultural keystone species can disrupt or damage a culture.

Resources

- What is a Cultural Keystone Species?
- National Congress of American Indians (NCAI)
- Seventh Sovereign Tribal Engagement Tips
- NOAA Cultural Resources Toolkit
- NOAA Tribal Consultation Handbook

Learn About Cultural Keystone Species

- Sweet Grass
- Elderberry
- Totora Reed

Heat poses a risk to cultural practices when temperatures exceed the biological threshold for survival of cultural keystone species (Wahid et al., 2007). Cultural keystone species that are pushed beyond their temperature threshold for survival are at risk of extinction, species decline, migratory shifts, or other shifts in species assemblages (Seifert et al., 2015). If the cultural keystone species on which a cultural practice depends disappears or becomes inaccessible, so too will the cultural practice itself. This area of the sociocultural heat practice is made actionable in the worksheets. Communities can identify relevant cultural keystone species, their biological heat thresholds, and the potential for those thresholds to be exceeded.

Heat Resilience for Daily Life

As chronic and acute heat increase, new risks associated with heat are emerging in the necessary tasks of daily life. What might once have been a low-risk activity, such as waiting for the bus, may require an adapted approach to remain safe in the context of rising heat. Heat-sensitive pedestrians may need to shift to shaded routes to avoid sun exposure during the heat of the day. Caregivers for young children or elderly people may need to adjust activity

schedules, have a cooling strategy in case of emergencies, and learn to recognize the signs of heat-related illness. Pet owners may need to adjust outdoor schedules to avoid heat stroke or other heat-related injuries.

To respond to these emerging risks, communities must understand their lived experiences of heat exposure: when, where, and how people are exposed to heat while carrying out their daily tasks (also see Heat Exposure Settings). One way to understand the lived experiences of heat is through qualitative data collection that generates detailed, context–specific accounts of how heat is impacting the daily lives of community members. With this information, a community can better understand the heat challenges it is experiencing. These results can inform a community survey to determine the pervasiveness of the challenges and ultimately inform heat planning.

Qualitative data collection approaches can include:

- interviews
- multi-model storytelling opportunities (visual, oral, written)
- focus groups or group discussions
- other culturally appropriate ways of transferring community-held knowledge

For an example of qualitative data collection about lived experiences of heat, refer to the Resource Spotlight "Melting Metropolis".

Equity Considerations

Equity considerations of heat resilience address key questions: who bears the greatest burdens of heat, who benefits from cooling solutions, who has a voice in decision-making, and what information and perspectives are considered valid. These equity questions address the commonly referred to "pillars of equity". The pillars, or key categories, include recognitional, distributive, procedural, and epistemological equity. The definitions of these terms evolve as collective understanding shifts, and there can be overlap between the pillars. The utility of the pillars of equity lies in their offering a framework for thinking through crucial equity issues.

Recognitional equity is a key part of equitable heat resilience planning because it invites recognition of the social categories and structures that have historically increased burdens while decreasing access to benefits for some groups compared to others. For example, historical practices of redlining communities led to chronic disinvestment in some communities compared to others. This is illustrated by disparities in tree canopy coverage and freeway proximity, both of which affect the lived experience of heat in a community.

Distributive equity considerations are an integral component of heat resilience planning. Understanding which community members are likely to be most impacted by extreme and chronic heat informs prioritization of cooling interventions (benefits). Exploring the distribution of cooling benefits in your community that are associated with the availability of shade structures, tree canopy, and other cooling infrastructure can further inform priorities.

Procedural equity refers to the fairness in a process, or equitable access to participation in the process of defining problems and adopting solutions (Schlosberg, 2007; Wenta et al., 2018; Van den Berg and Keenan, 2019). This is made actionable by considering who can participate in the planning process, if they are participating as an empowered decision maker or how their perspectives will be integrated into decision making (Wenta et al., 2018). Meaningful and ongoing participation of community members and trusted representatives can foster collaborative relationships and effective implementation of cooling solutions that work best for specific communities.

Epistemological equity refers to an equitable approach to the kinds of knowledge considered valid, in which perspectives from any one system of knowledge are not deemed more valuable than those from another. Epistemological equity is especially important in resilience planning. In practice, incorporating epistemological equity means that community-held knowledge, experiential knowledge, embodied knowledge, Traditional Ecological Knowledge, and other forms of knowledge are equally important to scientific knowledge. Related to procedural equity, this principle is made actionable by including and integrating community-held knowledge about priorities and preferences into decisions. For example, community-held knowledge can be a way to ground-truth scientific data about cooling priorities by informing planners about which pedestrian routes are preferred by the community and why, and therefore should be prioritized for cooling interventions.

Social, Cultural, and Equity Considerations: Best and Leading Practices

1. The definition of problems and appropriate solutions should be community-informed and community-led, informed by community-defined values.
2. Consider positionality, the history of relationships, and power dynamics when engaging with communities. Build trust slowly and authentically.
3. Before engaging with a tribe, indigenous organization, or front-line community, read historical accounts about that group that are written from their perspective(s). But remember that one person does not represent all perspectives for an entire group.
4. Understand and respect various forms of refusal to participate, including silence.
5. Ask yourself, “Who is this for, why are we doing this, and who will it benefit?”, and be transparent about the answer with all parties (Smith, 2019).
6. Utilize a trauma-informed approach when engaging with communities that have suffered injustice.

Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that

can be addressed within the scope of social, cultural, and equity considerations, along with activities that could be undertaken to achieve them.

Social, Cultural, and Equity Considerations: Goals, Objectives, and Actions

Goals	• Understand the potential risks that heat might pose to your community's social cohesion, community lifeways, cultural identity, and necessary daily tasks through an equity-centered lens. • Adopt heat resilience plans that include actions to address social, cultural, and equity risks.
Objectives	• Assess potential heat risks to community gatherings and events. • Assess potential heat risks to cultural keystone species. • Assess potential heat risk posed to the necessary daily tasks of community members. • Assess the process of defining problems and solutions through the key pillars of equity.
Actions	• Complete the community events worksheet. • Complete the cultural keystone species worksheet. • Consult the Melting Metropolis case study for guidance on qualitative assessment. • Utilize the equity scorecard resource. • Connect the results from these risk assessments to planning efforts.

Social, Cultural, and Equity Considerations: Tiered Approach

Tier 1	Tier 2	Tier 3
Sociocultural Events Heat Risk Assessment Utilizing the method developed by SOCIO, Tier 1 activities guide communities in the process of identifying events that take place during heat season and might pose a safety threat to heat-sensitive attendees. Planning efforts can address these needs through event-specific cooling interventions, reconsidering event timing	*Sociocultural Resource Identification* Utilizing the method developed by SOCIO, Tier 2 worksheets guide communities in the identification of sociocultural resources and keystone species that are relevant to the community and at risk of crossing their biological survival threshold for heat. Planning efforts can then address this need through	*Sociocultural Resource Risk Assessment* Utilizing the method developed by SOCIO, Tier 3 worksheets support communities in determining if sociocultural resources and cultural keystone plant species are at risk of crossing their biological survival threshold for heat. Planning efforts can then address this need through cultural keystone species monitoring

when appropriate, providing safety information for attendees, offering free hydration at events, deploying heat-informed medical response teams at events, or other solutions.	cultural keystone species monitoring and preservation plans, as deemed appropriate by the community, group, or tribe in a cultural relationship with the species.	and preservation plans, as deemed appropriate by the community, group, or tribe in a cultural relationship with the species.

Social, Cultural, and Equity Considerations: Key Terms

1. **Cultural keystone species:** Plant and animal species whose existence and symbolic value are essential to the stability of a cultural group, and perform functions that are so important for the culture that their withdrawal from the culture's context would cause significant cultural disruptions (Cristancho and Vining, 2004) .

2. **Epistemological equity:** Refers to an equitable approach to the kinds of knowledge that are considered valid, wherein perspectives from any one system of knowledge are not considered more valuable than perspectives from another.

3. **Keystone species:** Species that "exert influences on the associated assemblage, often including numerous indirect effects, out of proportion to the keystone's abundance or biomass" (Paine 1995, 962).

4. **Positionality:** Considerations of a researcher or practitioner's influence on the processes, outcomes, or people involved in a project that result from current or historical power dynamics, gender, age, culture and ethnicity, social class, and shared experiences (Manohar et al, 2017).

5. **Procedural equity:** Refers to the fairness in a process, or equitable access to participation in the process of defining problems and adopting solutions (Schlosberg, 2007; Wenta et al., 2018; van den Berg and Keenan, 2019).
6. **Recognitional equity:** The recognition of structural vulnerability and intergenerational disadvantaged positions of minority groups, in terms of their cultural, socioeconomic, and political rights or access to the political system. Meerow et al. (2019) assert that recognitional equity includes: (1) acknowledging community members' different intersecting identities (e.g., race, gender, social class, and age), (2) recognising that these identities are shaped by historical injustices that

can affect individual vulnerability to shocks and stresses, the ability to access re- sources, and the capacity to participate in decision-making, and (3) promoting respect for different groups.

7. **Distributive equity:** This concept addresses how burdens and benefits are distributed among groups in society.

8. **Restorative Justice:** Measures associated with restorative justice can be used to redress negative impacts of climate change, by first acknowledging harm that has occurred, the existence of an injustice, then identifying the offenders and victims, and finally considering the types of compensation and other repairs that can be made and sustained (Robinson and Carlson, 2021).

9. **Social and cultural considerations of heat**: The disruption, loss, or alteration of community events or spaces, social infrastructure, and cultural practices that maintain local lifeways and social cohesion of communities, tribes, and cultural groups in response to chronic or extreme heat.

Social, Cultural, and Equity Considerations: Recommended Readings and Resources

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Heat Governance, Maturity Assessment, Stress Testing, & Tabletop Exercises

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Conceptual Overview

Maturity describes a system's readiness to respond to a problem, such as extreme heat. We use the idea of assessing the *maturity* of a community's capacity to respond to heat to identify areas to prioritize for improvement. Capacities can be assessed in a Maturity Assessment for their level of sophistication in three overarching dimensions: (a) Institutions, including authority, funding, preparedness and response, and evaluation and accountability; (b) Partnerships and Networks, including coordination, inclusivity, and public communication, and (c) Assets of physical and natural infrastructure and application of technical knowledge (A Maturity Model for Heat Governance (June 2024), NOAA).

Stress testing is a method for assessing a system's readiness to respond to a problem, such as a community, government, institution, or agency. The problem is often posed as an emergency or extreme event, thereby stressing the system beyond its normal operating range. Stress testing can be a tool to identify capacity gaps and develop new, longer-term, equitable strategies to address them in the future. Stress testing for extreme heat involves working through the process of preparing for and responding to an extreme heat event in order to assess heat governance maturity. Stress testing is used to help partners evaluate their *capacities*, access to resources, funding, staff, partnerships, and other assets needed during an extreme heat event. Stress testing can involve conducting *tabletop exercises* in which participants, including individuals, organizations, and agencies, discuss how they would respond to an extreme heat event. Through this process, gaps in capacity can be identified and targeted for redress, thereby becoming better positioned to respond to actual extreme heat events.

Governance (contrasted with government) recognizes that response to heat within communities may involve not just formal state actors, but also nonprofit organizations, schools, healthcare systems and providers, and individual residents. Extreme heat preparedness and response require coordinating information and resources among diverse partners. Partners may include multiple government agencies and entities across jurisdictions and scales (e.g., municipal, rural, regional, and tribal agencies); community partners and non-governmental entities (e.g., schools, hospitals, and community- and faith-based organizations); and individual residents. Stress testing can help identify partners needed for extreme heat preparation and response.

It is crucial to tailor approaches to evaluating heat readiness to reflect communities' diverse needs. For example, an urban area may be data-rich and have well-defined government jurisdictions, readily accessible medical care to support increased needs during heat events, and

established cooling centers accessible by public transit, but lack accessible green space options and strong partnerships between government and non-governmental organizations. A rural or unincorporated area may have greater access to green spaces, but less clear jurisdictional boundaries, a lack of relevant heat data or monitoring equipment, and limited access to medical care or cooling centers.

Stress testing and maturity modeling will play a key role in assessing the capacity to respond to heat. Communities will assess their current capacities for responding to extreme heat and identify gaps. Based on the partners and specific needs identified by the maturity modeling and stress testing, communities will be directed to a tailored suite of recommended tools, resources, partnerships, and evaluation metrics.

Stress Testing: Best and Leading Practices

1. Organize a tabletop exercise with a diverse group of participants, even if there are limited heat adaptation plans or policies developed, as doing so can identify the most salient priorities for next steps (for example: Charleston)
2. Continue to engage stress testing activities to improve multi-sectoral and multi-jurisdictional response, even when initial heat adaptation plans have been completed, in recognition that building heat resilience is a continual process of improvement (for example: Phoenix)
3. Focus on specific subpopulations that may be particularly vulnerable to extreme heat, specifically engaging organizations that serve these populations (for example: Las Vegas)
4. Before the Stress Testing exercise, review and connect with local and regional heat governance plans, initiatives, heat-focused community organizations, and existing heat-related data and models, and consider conducting an initial Maturity Assessment.
5. After the Stress Testing exercise, immediately assign actions on the ideas generated, empower individuals and agencies to act upon them, and establish a timeline to re-evaluate progress.

Stress Testing: Key Decision Points

1. Communities must learn about tabletop exercises, including the range of objectives they can be designed to stress-test
2. Communities must decide the appropriate partners and assemble a planning committee to spearhead a tabletop exercise. This team will need to create objectives, prepare materials, design the scenario, and coordinate logistics of the event
3. Communities must decide how to integrate the findings of the tabletop exercise into the next steps to increase resilience for their communities (usually also included in the After Action Report)

Stress Testing: Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that can be addressed within the scope of stress testing and maturity assessment, along with activities that could be undertaken to achieve them.

Stress Testing: Goals, Objectives, and Actions

Goals	• Achieve an understanding of the governmental and non-governmental capacity needed to support heat resilience and planning. • Identify current capacities and gaps in existing heat resilience initiatives to respond to an extreme heat event. • Identify a suite of tools, resources, partnerships, and evaluation metrics that will support communities in further strengthening their heat-ready governance.
Objectives	• Evaluate "maturity" (i.e., self-identify the communities' existing capacities, funding, resources, etc., for heat resilience planning and governance). • Recommend the next resources/tools to move to the next level of readiness or a tabletop exercise.
Actions	• In conversation with key partners, review the 'Stress-Test A' checklist and indicate what capacities and resources the community currently has for heat resilience planning and governance.

Governance Capacity Assessment: Tiered Approach to Workbook Activities

Tier 1	Tier 2	Tier 3
Self Assessment (Stress Test A) Complete a comprehensive heat management resource assessment checklist and answer questions about local capacities and gaps.	*Maturity Model (Stress Test B)* Connect answers from Stress Test A to key capacity areas in the NOAA Maturity Model for Heat Governance. Form a list of relevant and willing stakeholders, existing planning documents, and key data points that will be useful for planning a future tabletop exercise.	*Proposed; No Workbook Activity. Tabletop Exercise* Use data collected in previous tiers and NOAA's Introduction to Heat Tabletop Planning and Coordination to develop a heat-specific tabletop exercise.

Stress Testing: Key Terms

1. **Adaptive capacity**: "The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences [of heat]" (adapted from IPCC 2022).

2. **Capacity**: A community's ability to provide services to residents, which is influenced by structural and cultural factors.

3. **Direct resident involvement**: The ability of residents and communities, including capacity to organize around shared needs and advocate for community benefits.

4. **Government capacity:** Public agencies' ability to provide services to residents. Factors influencing government capacity include: financial stresses, staff turnover, collaborative capacity, and procurement rules changes.

5. **Heat Governance:** The actors, institutions, strategies, and processes for managing/mitigating risks associated with heat (Keith et al 2021). *Governance* recognizes roles of formal state actors (government), as well as non-state actors (hospital systems, school districts, nonprofits, community-based organizations, businesses, etc.).

6. **Maturity:** A community's existing capacities, funding, resources, etc., for heat resilience planning and governance. Maturity can evolve as a community's capacities, resources, knowledge, and efforts change.

7. **Maturity model:** A tool to assess a community's current capacities, funding, and resources to successfully manage heat risk (i.e., the community 'maturity') and to identify the gaps and needs to improve heat resilience. For example, see the NOAA NIHHIS Maturity Model Planning Guide. (resource no longer available)

8. **Nongovernmental capacity:** The ability of non-governmental actors, including: hospital systems, school districts, nonprofits or community-based organizations, and businesses, to provide services to residents. Compared with government capacity, capacity from nongovernmental organizations can be more flexible, direct, leverage social networks and more/different material resources.

9. **Stress testing:** Methods to identify the needs and capacities of government and community entities to implement heat resilience governance and community-led initiatives (Miller & Muñoz-Erickson 2018).

2. **Table-top exercise:** A collaborative planning tool that simulates emergency situations in an informal environment. A facilitator guides exercise participants through a hypothetical emergency scenario to explore preparedness and response

strategies and build equitable long-term resilience. For example, see the NOAA NIHHIS Introduction to Heat TableTop Coordination and Planning Guide.

Stress Testing: Recommended Readings and Resources

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Heat Action Planning

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Conceptual Overview

New environmental challenges require systems to respond in new ways. Climate action, sustainability, adaptation, and resilience plans are comprehensive strategic documents that outline specific actions communities should undertake to address emerging environmental challenges. These types of plans offer a framework for identifying, measuring, and tracking progress towards goals designed to mitigate and manage the impacts of extreme weather events.

Heat action planning is the process by which a community outlines comprehensive goals, metrics, and actions to mitigate and manage heat. Heat action plans (HAPs) are the resulting "written documents that help manage actions across multiple organizations to reduce adverse health effects from extreme heat. HAPs broadly contain strategies such as performing surveillance, providing risk communication, supporting social and health care, establishing cooling centers, distributing water bottles and fans, and creating energy assistance programs." (Randazza et al. 2023). They can also outline strategies that cool communities, such as urban greening and designing buildings to maximize shade and ventilation. Heat action plans can thus include "a portfolio of assessments and actions to respond to and reduce heat-related impacts" (Arsht Rock).

Heat action planning encompasses two distinct areas: heat mitigation and heat management. *Heat mitigation* emphasizes design and planning strategies to reduce the contribution of the built environment to urban heat, such as green infrastructure, shade planning, or cool roofs (Keith & Meerow, 2022).

Heat management is focused on preparation and response strategies for extreme heat events, often within the domain of emergency management or public health (Keith & Meerow, 2022). Heat management strategies can include heat warning systems or free public transportation to cooling centers during extreme heat events.

Key Decision Point:
Communities must decide whether to integrate heat resilience into existing plans and/or develop a stand-alone heat action plan.

A foundational step in heat action planning is an initial evaluation of existing plans and policies, or the *network of plans*, that address extreme weather hazards, climate change, and sustainability. Evaluating the existing network of plans ensures awareness of current plans, how they are (or are not) connected to extreme heat, and potential co-benefits and conflicts among them. An evaluation of the existing network of plans provides communities with an opportunity to analyse

how heat mitigation policies are integrated across plans and to better target policies in high heat-risk areas.

A subsequent step in the heat action planning process is conducting a *plan quality evaluation*. This process assesses the quality of existing heat plans to ensure they include key elements such as goals, fact base, implementation and monitoring, coordination, public participation, and uncertainty. If a heat action plan already exists within a community, it can be improved or adjusted based on the results of the Plan Quality Evaluation for Heat Resilience. If communities want to go deeper to assess how planned land use changes and future developments could affect heat resilience, they may also conduct a Plan Integration for Resilience Scorecard™ (PIRS™) for Heat.

Heat action planning guidance will support communities by integrating heat goals, a fact base, strategies, and implementation measures across relevant local plans and within a dedicated heat action plan.

Heat Action Planning: Best and Leading Practices

1. Set clear goals and associated metrics for success.
2. Build a comprehensive "fact base" of information on heat risks.
3. Develop a diverse portfolio of heat mitigation and management strategies.
4. Develop a strategy for managing uncertainty.
5. Coordinate across planning efforts.
6. Ensure inclusive participation in planning processes.
7. Ensure effective implementation, monitoring, and evaluation.

"Planning for Urban Heat Resilience." PAS Report, Apr. 2022, planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/PAS-Report-600-r1.pdf.

Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that can be addressed within the scope of heat action planning, along with activities that could be undertaken to achieve them.

Heat Action Planning: Goals, Objectives, and Actions

Goals	• Develop or update a dedicated Heat Action Plan, or • Integrate a heat action component into an existing plan.
Objectives	• Evaluate existing plans and policies across urban planning, hazard mitigation planning, public health, and emergency management to support communities in equitably addressing heat mitigation and management.
Actions	• Complete the Plan Quality Evaluation for Heat Resilience or PIRS™ for

	Heat. • Cohort participants will be trained to conduct plan assessments in their communities. • Utilize the 7 Principles of Strong Climate Change Planning to develop or update a dedicated Heat Action Plan.

Heat Action Planning: Tiered Approach to Workbook Activities

Tier 1	Tier 2	Tier 3
Planning Capacity Assessment Workshop Conduct a workshop to select a network of plans, qualitative assessment of focus across plans on heat (e.g., fact base, goals, strategies, implementation)	*Plan Quality Evaluation for Heat Resilience* Complete Tier 1 plus conduct Plan Quality Evaluation for Heat Resilience	*Plan Integration for Resilience Scorecard (PIRS) for Heat* Complete Tier 1 and 2, plus conduct PIRS™ for Heat

Heat Action Planning: Key Terms

1. **Heat action planning:** The process by which a community outlines comprehensive goals, metrics, and actions for mitigating and managing heat. Heat action plans (HAPs) are "written documents that help manage actions across multiple organizations to reduce adverse health effects from extreme heat. HAPs broadly contain strategies such as performing surveillance, providing risk communication, supporting social and health care, establishing cooling centers, distributing water bottles and fans, and creating energy assistance programs." (Randazza et al. 2023). Heat action plans include "a portfolio of assessments and actions to respond to and reduce heat-related impacts" (Arsht Rock).
2. **Urban Heat mitigation:** "Design and planning strategies to reduce the contribution of the built environment to urban heat" (Keith & Meerow 2022).
3. **Heat management**: "Preparation and response strategies for extreme heat events, often within the domain of emergency management or public health" (Keith & Meerow, 2022).
4. **Heat resilience:** "Proactively managing and mitigating heat across the many systems and sectors it affects." (Meerow & Keith 2022)
5. **Heat equity:** "The development of practices and policies to mitigate and

manage heat with a focus on reducing the inequitable distribution of risk across different groups within the same community" (Keith & Meerow, 2022).

6. **Heat governance:** "The actors, strategies, processes, and institutions that can mitigate and manage this hazard" (Keith et al. 2021, Nature).

7. **Network of plans**: "Collection of community plans that shape the built environment" including comprehensive plans, hazard mitigation plans, and climate action (Keith et al. 2023).

8. **Plan quality evaluation:** "An established method for evaluating the content of plans to see whether they contain elements that are widely believed to be critical to the plan's effectiveness in achieving community goals" (Meerow et al. 2024).

9. **Plan Integration for Resilience Scorecard™ for Heat**: A methodology for analyzing the land use policies, or action items, across community plans that would affect urban heat and comparing spatial patterns in policy attention with indicators of vulnerability (Keith et al. 2023).

Heat Action Planning: Recommended Readings and Resources

Readings on current state of heat planning research and practice:

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5. Gabbe, C. J., Pierce, G., Petermann, E., & Marecek, A. (2024). Why and How Do Cities Plan for Extreme Heat? *Journal of Planning Education and Research*, *44*(3), 1316-1330. https://doi.org/10.1177/0739456X211053654

Readings on evaluating heat planning

1. Meerow, S., Keith, L., Roy, M., & Trego, S. (2024). Plan evaluation for heat resilience: Complementary methods to comprehensively assess heat planning in Tempe and Tucson, Arizona. *Environmental Research Letters.* https://doi.org/10.1088/1748-9326/ad5d05
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Readings on heat action planning

1. Keith, L., & Meerow, S. (2022). *PAS Report 600: Planning for urban heat resilience*. American Planning Association. https://www.planning.org/publications/report/9245695/
2. Guardaro, M. (2023). Strengthening heat action plans in the United States. *American Journal of Public Health, 113*, 465–467. https://doi.org/10.2105/AJPH.2023.307260
3. Randazza, J. M., Hess, J. J., Bostrom, A., Hartwell, C., Adams, Q. H., Nori-Sarma, A., Spangler, K. R., Sun, Y., Weinberger, K. R., Wellenius, G. A., & Errett, N. A. (2023). Planning to reduce the health impacts of extreme heat: A content analysis of heat action plans in local United States jurisdictions. *American Journal of Public Health, 113*, 559–567. https://doi.org/10.2105/AJPH.2022.307217
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8. McGregor, G. R., Bessemoulin, P., Ebi, K., & Menne, B. (Eds.). (2015). *Heatwaves and health: Guidance on warning-system development.* World Meteorological Organization & World Health Organization. https://climate-adapt.eea.europa.eu/en/metadata/guidances/heatwaves-and-health-guidance-on-warning-system-development
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Stakeholder Engagement

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Conceptual Overview

Engagement refers to processes through which stakeholders become involved in heat resilience preparations in order to shape and enhance outcomes. This core concept focuses on approaches that enable three overarching engagement activities: meaningful engagement with impacted communities, strategic engagement with decision-makers, and media outreach to the public at large.

Engagement is a crucial component for understanding the impacts of heat in a community, identifying which heat intervention strategies are a good fit, and implementing the adopted strategies effectively. Heat resilience strategies are more robust when they include the voices of impacted communities and decision-makers' expertise; more effective when they include buy-in from key stakeholder groups; and more durable when they are supported by stakeholders, rules, and resources.

Thoughtful, meaningful, and strategic engagement for heat resilience planning can ensure community interests and concerns inform heat actions; increase the likelihood that heat actions can be implemented effectively through supportive legislation, regulation, funding, and guidelines; and create greater awareness of heat issues and actions among the public-at-large, indirectly influencing policy through community concern. Early, ongoing, and iterative interactions are a precursor to meaningful engagement that is relationship-based, built on trust, and willing to acknowledge a range of stakeholder priorities. This is a key component of heat resilience planning because heat is a cross-cutting problem that necessitates collaboration among communities, organizations, Tribal Nations, and city departments.

Engagement occurs on a spectrum ranging from one-way communication (least robust) to collaborative partnerships (more robust). At a minimum, engagement entails one-way communication between community leaders and an audience. This level of engagement could include posting National Weather Service heat alerts on social media, running a heat education campaign through community communication channels, or developing communications and media to illustrate disproportionate urban heat exposure.

Key Decision Point:
Identifying communities affected by urban heat-related inequities requires community engagement.

Recommendation:
Engage with community leaders to learn about the resident experience of heat-related inequities and associated health disparities.

Most heat resilience action goals will benefit from a more robust engagement strategy. A more robust engagement approach includes two-way communication, wherein a community or stakeholder group provides insight and feedback that is integrated into plans and decisions. This type of engagement must happen early in a project so that the feedback can be integrated at crucial planning junctures, rather than after plans are finalized.

A more robust approach to engagement will include longer-term initiatives that support an authentic relationship among the community(ies) of impact, other stakeholders, and the project team. Goals of this level of in-depth engagement can include empowering community leaders through existing community channels and organizations to lead community outreach or engaging decision-makers during multiple phases of the policy cycle to develop relationships and align agendas.

Some forms of engagement will include working with city or Tribal agencies, departments, or bureaus to gather information and operate within administrative protocols. For example, to conduct a benefit-cost analysis of tree canopy expansion as a cooling intervention strategy, one city department might engage another to obtain cost data. To ensure the project's success, it will be important to consider how expanding tree canopy might affect operations across other city departments (such as tree maintenance) and which administrative protocols are relevant when seeking information.

Key Decision Point:
Introducing resources within a community, particularly those that are policy-based, often necessitates support from decision makers.

Recommendation:
Engage residents and allies in power mapping to identify spheres of influence and how they can be leveraged to reach resident goals.

Other forms of engagement will be focused on communities of impact - residents, community organizations, and other community stakeholders. Engaging with community leaders and trusted messengers is a key part of understanding how heat impacts community members' lives and which proposed intervention strategies would have community support. Without community support, it is much less likely that an intervention strategy will succeed in addressing the intended problem. This is because the data available to researchers about heat in a given location is not intended to provide contextual details. These contextualizing details can only be learned through engagement with community members and relevant city departments. Absent meaningful engagement at impactful junctures in the planning process, interventions might be off-target or pose additional problems for the community.

Stakeholder Engagement: Best and Leading Practices

1. Identify communities affected by urban heat
2. Create an engagement strategy, map, and tracker to stay organized.
3. Ask community leaders for advice on when, where, who, and how to engage.
4. Demonstrate respect for diverse priorities, approaches, languages, cultures, and knowledge.
5. Ensure appropriate access to urban heat-related resources and information.
6. Meet community residents where they are (e.g., door-to-door, house meetings).
7. When appropriate, compensate community members for their time (e.g., for participation in door-knocking and data collection).
8. Offer childcare for in-person events.
9. Research the work of the person/s with whom you are engaging prior to meeting.
10. Invest time in listening to the people you are engaging with.
11. Prioritize communities that have been historically underrepresented in decisions, planning, and distribution of benefits.
12. Follow up and report back: demonstrate how you integrated the feedback you received.

Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that can be addressed within the scope of engagement, along with activities that could be undertaken to achieve them.

Stakeholder Engagement: Goals, Objectives, and Actions

Goals	**Community** • meaningful engagement with impacted communities **Decision-Makers** • strategic engagement with decision-makers **Media** • media outreach to the public at large

Objectives	**Community**
	• Identify resident interests in heat resilience.
	  ▪ Identify community heat-related challenges and needs.
	  ▪ Identify community assets concerning heat adaptation, mitigation, and management.
	  ▪ Identify community-specific policy and governing challenges.
	• Identify community heat-related adaptation, mitigation, and adaptation goals.
	  ▪ Identify effective mechanisms for circulating heat/health alerts.
	
	Decision-Makers
	• Identify the policy and governing challenges.
	• What are the policy levers and legislative vehicles available to make changes?
	• Take the current policy temperature. What type of rules are open for change in the current policy cycle?
	• Create specific action goals.
	
	Media
	• Determine the intention of engaging the media.
	• Determine the vehicle best suited for that type of engagement (e.g., OpEds, news, social media).
	• Create media content and a dissemination strategy.

Actions	**Community** • Build community leaders • Expand the community base • Build community coalitions • Voter education and mobilization • Communications and media • Engage decision-makers **Decision-Makers** • Review existing rules and proposed new rules being considered that pertain to extreme heat at the appropriate jurisdictional scale. • Develop a full policy brief on specific key issues that are priority areas for the community and are aligned with stakeholder goals/well-positioned to move forward. • Develop relationships with key decision-makers such as legislative staff of bill authors, agencies and departments, advocates, etc., to better understand their heat-related concerns and goals, and to provide review

	of policy brief materials prior to the start of the new bill deadline if possible.

Stakeholder Engagement: Tiered Approach to Workbook Activities

Tier 1	Tier 2	Tier 3
Community: *Build Community Leaders* Train leaders to hold community workshops with community groups. **Policy:** *Policy Landscape Analysis* Create an issue statement, map key stakeholders, locate your issue in the policy cycle, and identify policy pathways toward change. **Media:** *The Media Quadrant* Prepare to respond to media inquiries.	**Community:** *Build Community Coalitions* Build community coalitions to support community advocacy. **Policy:** *Tracking Policy* Building on the policy landscape analysis, track policy vehicles relevant to your issue statement to inform response. Develop policy-facing materials and deliver them at key convenings and through one-on-one meetings. **Media:** *Proposed; No Workbook Activity.* Develop a message and proactively reach out to the media, drafting OpEds, etc.	**Community:** *Co-Develop Heat Action Goals* Co-develop heat action goals, strategies, tactics, etc., with communities through collaborative partnerships with community groups. **Policy:** *Proposed; No Workbook Activity.* Co-design and guide policies through one-on-one relationships with decision-makers and their staff. **Media:** *Proposed; No Workbook Activity.* Develop media campaigns, complete with toolkits and partners to deploy.

Stakeholder Engagement: Key Terms

1. **Impacted communities:** Communities experiencing urban heat impacts.
2. **Environmental justice communities**: Underserved, low-income communities and communities of color experiencing disproportionate environmental exposures, such as urban heat impacts.

3. **Community leaders**: Central actors in environmental change initiatives, formally or informally recognized as environmental justice, public health, or community organizing experts.

4. **Decision-makers**: Individuals with legal authority to enact and enforce rules, or individuals informally recognized as authorities via large influence over particular groups.

5. **Policy cycle:** Stages in the process of the policy development stream, including agenda setting, formation, implementation, and review, to which engagement should be tailored.

6. **Policy landscape analysis:** Map of the key players, institutions, and leaders that impact a policy or research issue.

7. **Media**: Means of mass communication encompassing traditional formats such as print, radio, television, and online publications, as well as new media such as social media, podcasts, and blogs.

8. **Heat alerts:** Tools used to communicate heat risk and encourage protective actions, such as advisories, watches, and warnings used by the National Weather Service (Hondula et al. 2022).

9. **Heat risk management system**: The suite of tactics and tools, and supporting institutions and infrastructure, used to evaluate and reduce harm to groups and individuals that may become exposed to high temperatures that affect community health and well-being.

10. **Heat actions**: An action involving heat-related community organizing, outreach, education, adaptation and mitigation strategies, policy analysis and development, etc.

Stakeholder Engagement: Recommended Readings and Resources

2. Callahan, C., Coffee, D., DeShazo, J.R., & González, S.R. (2021). *Justice40 and climate equity: Final report.* Luskin Center for Innovation, University of California Los Angeles. https://innovation.luskin.ucla.edu/wp-content/uploads/2021/10/luskin-justice40-final-web-1.pdf
3. Mohnot, S., Bishop, J., & Sanchez, A. (2019). *Making equity real in climate adaptation and community resilience: Policies and programs—A guidebook.* Greenlining Institute. https://greenlining.org/wp-content/uploads/2019/08/Making-Equity-Real-in-Climate-Adaption-and-Community-Resilience-Policies-and-Programs-A-Guidebook-1.pdf
4. Douglas, J.A. (2024). Empowering communities of color for environmental health and justice: The stand together against neighborhood drilling in Los Angeles case. *Preventing Chronic Disease, 21*, 230248.. https://www.cdc.gov/pcd/issues/2024/23_0248.htm

5. UNICEF Eastern and Southern Europe and Central Asia. (2024). *Beat the heat: Child health amid heatwaves in Europe and Central Asia.* https://www.unicef.org/eca/reports/beat-heat-2024
6. Movement Strategy Center. (n.d.). *MB101 full packet.* https://www.scribd.com/document/44610753/MB101-Full-Packet-2-1
7. Movement Strategy Center. (2021). *The practices of transformative movement building.* https://movementstrategy.org/wp-content/uploads/2021/11/The-Practices-of-Transformative-Movement-Building-1.pdf
8. Building Leadership Organizing Communities. (n.d.). *Rep Ya Bloc! Transitions training—Facilitator guide.* https://www.scribd.com/document/44610770/Rep-Ya-Bloc
9. California Coalition for Health Equity. (n.d.). *Coalition building.* http://ccheonline.org/sites/default/files/Coalition_Building_2.pdf
10. California Coalition for Health Equity. (n.d.). *Introduction to popular education and reflection guide for CCHE.* https://www.scribd.com/document/44610728/Intro-to-Popular-Education-and-Reflection-Guide-for-CCHE
11. California Coalition for Health Equity. (n.d.). *Power analysis process.* http://ccheonline.org/sites/default/files/Power_Analysis_Process.pdf
12. Simple Power Map. (n.d.). *Simple power map.* https://www.scribd.com/document/44610669/Simple-Power-Map
13. Berkeley Media Studies Group and The Praxis Project. (2005). *Meta messaging framing your case and reinforcing your allies.* https://www.scribd.com/document/44610754/Meta-Messaging-FINAL3
14. The Praxis Project. (n.d.). *Planning for media advocacy.* https://www.scribd.com/document/44610766/PraxisMedia
15. National Democratic Institute. (n.d.). *Developing a decision maker engagement plan (English).* https://www.ndi.org/sites/default/files/Developing%20A%20Decision%20Maker%20Engagement%20Plan%20%28English%29.pdf

Indicators of Heat Resilience

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Conceptual Overview

An indicator is a value that can be observed and measured to communicate the presence or absence of a phenomenon. When an indicator is tracked over time, the measurements can communicate increases or decreases in the phenomenon of interest. This type of observation and measurement can be used to identify the presence of a problem, gauge likely resilience to it, track progress towards goals, and evaluate the impact of solutions.

Challenges to Anticipate:

1. Key data sources may be missing or difficult to access.

2. Collecting data for indicators often requires collaboration across multiple agencies and sectors.

Identifying appropriate indicators at the community scale will play a key role in advancing heat resilience. Accessible, reliable, and valid indicators can empower communities to communicate the extent of extreme heat exposure and its impact on their communities.

Understanding a community's exposure to extreme heat is a critical step toward making the case to address the associated challenges. Indicators that describe the historical and current *heat burden*, or the amount of heat a community is exposed to, offer insight into the scale and severity of the extreme heat people in a particular place experience.

To gauge how communities are likely to be impacted by their exposure to extreme heat, indicators in key areas of community well-being that are known to contribute to **heat resilience**, or the ability to withstand and recover from extreme heat experiences, can be identified for measurement. Key indicators should acknowledge past and current heat burden, the surrounding natural and built environment, overall health and economic levels, social and demographic connections, local grid security, and social factors that might influence heat risk or resilience.

Key Decision Points:

1. Communities must determine which indicators they would like to prioritize in the short and long-term.

2. Communities must decide to either use existing data/databases or begin collecting their own data.

Indicators are crucial for describing a community's heat burden, tracking progress towards heat resilience goals, and assessing the impact of heat resilience strategies. Indicators provide evidence to support reducing exposure to heat hazards, reducing overall vulnerability (such as enhancing emergency response capacity, increasing access to cooling centers, or expanding green infrastructure), and increasing communities' ability to respond to heat hazards. As communities determine their heat resilience goals, indicators allow them to track progress towards these goals in ways that are meaningful, measurable, specific, time-based, and applicable to their unique community context.

Indicators of Heat Resilience: Best and Leading Practices

1. Indicators must be observable, measurable over time, and actionable.
2. Community needs and priorities, informed by historical experiences and vulnerabilities, should inform the indicators of heat burden and heat resilience.
3. Ensure indicators are quantifiable with available data; if data are not available, ensure it can be collected or provided by the community or team.
4. Provide flexibility in the wording and application of the indicator to meet community needs.
5. Indicators are useful for both identifying heat risk and tracking progress to lessen that risk (or increase resilience) over time.
6. Indicators will have different themes depending on the goal. For example, health goals need health indicators, economic goals need economic indicators, and so on.
7. Effective indicators must be both evidence-based and accepted by the community as relevant in their given context.
8. Include community members in the process of defining indicators and deciding which indicators are meaningful.
9. Choose your indicators with awareness that members of impacted communities may not be visible in the same ways as members of more affluent communities, and might not be accurately represented in counts or frequencies.
10. Ensure that your indicators can track whether communities that have historically shouldered a disproportionately high share of the heat burden have access to the benefits of heat resilience solutions.
11. The indicators should be iteratively and adaptively updated to reflect learning from the design, implementation, and evaluation of heat adaptations.
12. When possible, indicators should align with existing urban planning, public health, climate adaptation, and emergency management frameworks.

Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that can be addressed within the scope of resilience indicators, along with activities that could be undertaken to achieve them.

Indicators of Heat Resilience: Goals, Objectives, and Actions

Goals	Understand the change in heat impacts and progress towards heat resilience.
Objectives	Track indicators of heat impacts and heat resilience over time.
Actions	Identify appropriate indicators through which to track heat impacts and heat resilience.

Indicators of Heat Resilience: Tiered Approach to Workbook Activities

Tier 1	Tier 2	Tier 3
Develop Resilience Indicators Decide which heat burdens you want to track to describe and monitor the problem. Decide which type of heat resilience you want to track to monitor progress towards it. Identify and compile a list of potential indicators of heat burden and heat resilience for your community based on research.	*Proposed; No Workbook Activity* Prioritize the potential indicators list based on community importance and feasibility, determined through community and stakeholder engagement. Refine and prioritize the list of indicators for short and long-term goals based on assessed capacity. Identify sources of data needed to track your chosen indicators, and engage with knowledge holders as needed to develop a plan for data sharing.	*Proposed; No Workbook Activity* Start to track indicators of implementation or success. Monitor the indicators over time. Report changes/no changes for each indicator on a regular schedule to monitor heat burden and progress towards heat resilience. Communicate changes/no changes in indicators to stakeholders.

Indicators of Heat Resilience: Key Terms

1. **Community:** FEMA defines community as: 1. A group of people living in the same locality and under the same government, or a political subdivision of a state or other authority that has zoning and building code jurisdiction over a particular area. 2. A political entity that has the authority to adopt and enforce floodplain ordinances for the area under its jurisdiction. 3. A network of individuals and families, businesses, governmental and nongovernmental organizations, and other civic organizations that reside or operate within a shared geographical boundary and may be represented by a common political leadership at a regional, county, municipal, or neighborhood level. 4. Any State, or area or political subdivision thereof, or any Indian tribe or authorized Tribal organization or Alaska Native village or authorized native organization, which has authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

2. **Heat-caused death:** A loss of life where heat exposure is listed as a direct cause of death on the death certificate (Maricopa County Dept of Public Health).

3. **Heat risk:** The danger to health or infrastructure due to heat as a function of exposure, sensitivity, and the ability to adapt.

4. **Heat-related health data:** Health outcomes data that describe illness, injury, disability, or death that is either directly caused by heat or deaths where heat was a contributing factor.

5. **Heat-contributed death**: A loss of life where heat exposure is listed as a contributing factor on the death certificate (Maricopa County Dept of Public Health).

6. **Indicator**: A measurement or value that can be tracked over time to communicate the state of heat risk (or heat resilience) in a given area over a period of time.

Indicators of Heat Resilience: Recommended Readings and Resources

1. Keith, L. & Meerow, S. (2022). *Planning for urban heat resilience (PAS Report 600).* American Planning Association. https://www.planning.org/publications/report/9245695/
2. National Oceanic and Atmospheric Administration. (2024). *A maturity model for heat governance*. https://cpo.noaa.gov/wp-content/uploads/2025/02/Heat-Governance-Maturity-Model_V1.pdf
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    a. Shortridge, A., Walker VI, W., White, D. D., Guardaro, M. M., Hondula, D. M., & Vanos, J. K. (2022). HeatReady schools: A novel approach to enhance adaptive capacity to heat through school community experiences, risks, and perceptions. *Climate Risk Management, 36*, 100437. https://doi.org/10.1016/j.crm.2022.100437
    b. Arizona State University. (n.d.). *HeatReady schools.* https://globalfutures.asu.edu/heatready/schools/about/
4. HeatReady Neighborhoods
    a. Guardaro, M., Gastelum, A., Winkle, R., Munoz Encinas, M., Vanos, J., Bassett, S., & Hondula, D. (2025). HeatReady Neighborhoods: A Planning Rubric for Extreme Heat. Journal of the American Planning Association, 91(2), 177–191. https://doi.org/10.1080/01944363.2024.2396923
    b. Arizona State University. (n.d.). *HeatReady neighborhoods.* https://globalfutures.asu.edu/heatready/neighborhoods/about/
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6. New York State. (2024). *Extreme heat in New York State. Summary of impacts and vulnerabilities.* https://dec.ny.gov/sites/default/files/2024-06/extremeheatsummaryimpactsreport.pdf
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8. San Francisco Department of Public Health. (2003). *Heat and air quality resilience plan.* https://media.api.sf.gov/documents/HAQR-2305221_0.pdf
9. City of Phoenix. (n.d.). *City of Phoenix heat response plan.* https://www.phoenix.gov/administration/departments/heat/heat-response-programs/heat-response-plan.html
10. State of Arizona. (2024). *Arizona extreme heat response plan.* https://resilient.az.gov/sites/default/files/2024-07/extreme-heat-preparedness-plan-2024-03-1.pdf
11. Murage, P., Hajat, S., Macintyre, H. L., Leonardi, G. S., Ratwatte, P., Wehling, H., ... Kovats, S. (2023). Indicators to support local public health to reduce the impacts of heat on health. *Environment International*, *183*, 108391. https://doi.org/10.1016/j.envint.2023.108391

Benefit-Cost Analysis

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Conceptual Overview

Benefit-cost analysis is the process of identifying, quantifying, and monetizing expected benefits and costs of investments, actions, or policies to determine which alternative yields the highest net benefits, and deciding which solutions are the most appropriate economic fit for your community (for a primer on the general use of benefit-cost analysis in a policy context, see OMB Circular A-4).

Key Decision Point:
Communities must decide which cooling intervention(s) to analyze.

Recommendation:
Choose an existing intervention that the community is considering expanding or a new intervention that is likely to have co-benefits beyond heat.

Benefit-cost analysis is a useful tool for selecting among possible actions a community might take to improve heat resilience. These assessments empower communities to identify and, where possible, quantify benefits (e.g., reduced mortality, reduced emergency room visits, improved worker productivity, improved student test scores, increased property values, improved stormwater management). To the extent that the benefits of a specific action can be assigned a monetary value, they can be compared to the action's costs to calculate net benefits. Communities can then compare the net benefits of alternative policy actions. Importantly, however, while useful, a simple comparison of net benefits should not be the only factor determining the suitability of a given heat resilience action.

Benefit-cost analysis is a key part of understanding and describing the economic impacts of extreme heat across various aspects of human welfare, such as health, education, worker productivity, infrastructure, and government operations.

Analyzing Benefits of Extreme Heat Intervention Strategies

The benefits of heat interventions can potentially span economic, social, and environmental benefit categories, each with different kinds of data. For example, expanding tree canopy not only provides economic benefits (avoided labor costs, reduced governance operations, lower healthcare costs associated with higher temperatures, and lower energy costs) but also ecosystem benefits, such as increased biodiversity, improved stormwater management, and carbon sequestration. In addition, trees provide social benefits that are not always appropriate to monetize but should still be included, such as the ability to gather in cool spaces during extreme heat, a sense of place, identity, and psychological well-being. Adding to the nuance, trees provide different benefits at different points in their lifespan, so benefit timescales must be informed by the tree's growth cycles (a one-year-old tree provides less benefit than a ten-year-old

tree). However, in order for the benefits of a tree to be realized, the analysis must assume appropriate maintenance, including its associated costs.

Analyzing Costs of Extreme Heat Interventions

Economic analyses, including benefit-cost analysis, empower communities to identify and, where possible, monetize resource costs and the costs of financing them. The costs of an intervention strategy are analyzed by quantifying labor, materials, land, maintenance, and other relevant costs associated with procuring, implementing, and maintaining the intervention. For example, costs for a shade structure might include the labor of architects and engineers to design the structure, the procurement of materials, construction, any electrical work needed to comply with lighting codes, and ongoing maintenance.

Comparing Different Alternatives

Benefit-cost analysis empowers communities to compare interventions with each other and with a "business as usual" scenario. Business-as-usual may mean continuing on the existing trajectory across a range of future climate scenarios. Alternatives analysis is a key component of analyzing the benefits and costs of potential heat interventions, selecting the most advantageous interventions, and making compelling arguments to decision-makers and potential funders.

Benefit-Cost Analysis: Best and Leading Practices

1. BCAs are widely used to evaluate whether resources should be allocated to environmental improvements in general, and increasingly to climate adaptation.
2. Heat resilience is a relatively new context for applying BCA.
3. The most valuable part of conducting a BCA is the systematic thinking process it can inform, rather than the "final number" itself.
4. Incorporate equity in the analysis through an inclusive community engagement process and by incorporating perspectives of historically marginalized groups into the analysis, including BCA results disaggregated by socio-demographic groups.
5. BCA should be viewed as an opportunity to engage the public at different points, including in defining the problem, prioritizing interventions to analyze, and assessing results.
6. Use locally calibrated data when available. The question of how much local data to collect is important because, in some circumstances, local data collection would be feasible and practical, while in others it could be extremely time-consuming and yield small benefits relative to using regional or national data.
7. For heat-related interventions, consider broader co-benefits (urban ecosystem benefits, social benefits, SCOPE emissions costs).
8. For interventions that don't directly relate to heat, consider if there are any heat-related benefits and costs.
9. Costs represent the foregone value of the alternative use of resources committed to the project; thus, labor (or jobs) are typically a cost, not a benefit, in a BCA.
10. Analysis monetizes a stream of expected future benefits and costs for projects and identifies which additional benefits and costs could be quantified but not monetized, and which could be identified but not quantified.

11. Include benefits and costs for communities that have been historically marginalized and excluded from past analyses, including communities of color, low-income communities, unhoused residents, and others.
12. Check whether historically marginalized groups receive a proportional share of net benefits.
13. Ensure that members of impacted communities have a voice in identifying benefits and costs and in shaping decisions and planning processes. Planning processes should be accessible to diverse linguistic preferences, cultural approaches, schedules, and abilities.
14. Consider benefits and costs beyond those that can be quantified or monetized and hold other kinds of value for community members.

Goals, Objectives, and Actions

The specific goals, objectives, and actions a community chooses to prioritize should be tailored to the local context. The following offer broad examples of the kinds of goals and objectives that can be addressed within the scope of benefit-cost analysis, along with activities that could be undertaken to achieve them.

Benefit-Cost Analysis: Goals, Objectives, and Actions

Goals	• Gain an understanding of the benefits and costs associated with heat resilience interventions to support the selection of strategies that will advance heat resilience goals. • Help public agencies and community organizations select among possible heat interventions and make compelling arguments to decision-makers and potential funders. • Build capacity to conduct BCAs using peer-reviewed evidence, publicly available datasets, and established analytical frameworks. • Facilitate effective community engagement around BCA. • Provide frameworks for different types of analyses, tailored to community needs and capacity. • Increase the likelihood of project financing.
Objectives	• Conduct a benefits-cost analysis of heat-resilience interventions, including urban forestry, green infrastructure, cool roofs, and cooling centers.
Actions	• Define the scope of the analysis in collaboration with community stakeholders and decision-makers. • Choose intervention(s) of interest for analysis from a limited menu of options (e.g., urban forestry, green infrastructure, cool roofs, cooling centers) • Identify key outcomes to be measured.

	• Develop a detailed project timeline, including phases for community engagement, data collection, tool application, analysis, and reporting. • Define baseline and potential alternatives. • Collect local data from public agencies, community-based organizations, and other sources. Use national datasets when local data are unavailable or not feasible to collect. • Apply tools and models to estimate the benefits and costs of selected intervention(s). • Summarize potential benefits and costs of intervention(s). The summary could be presented as a slide deck or a policy brief. • Present summary to decision makers in public meetings (e.g., Planning Commission, City Council) and post online for the broader community.

Benefit-Cost Analysis: Tiered Approach to Workbook Activities

Tier 1	Tier 2	Tier 3
Apply the Heat Action Platform Assessment is qualitative and descriptive. No quantitative analysis, but does identify potential benefits and costs based on existing national/international evidence. *Proposed; No Workbook Activity.* One-way community engagement only (agency or organization provides the public with information but does not solicit feedback). Share a summary presentation of the evidence base.	*Apply the C40 Heat Resilient Cities Tool* Quantification of some direct project outcomes. Monetization of benefits and costs using at least one potential intervention using external publicly available data (e.g., from academic or gray literature). *Proposed; No Workbook Activity.* Some community outreach prior to BCA and/or following initial analysis.	*Proposed; No Workbook Activity.* Robust community engagement prior to and following the BCA analysis. Identify local cost, implementation, and maintenance data from the relevant department or organization. Conduct a complete BCA associated with at least one heat-related intervention, using community-specific data.

Benefit-Cost Analysis: Key Terms

1. **Benefit-cost analysis**: identifying, quantifying, and monetizing expected benefits and costs of investments, actions, or policies to determine which alternative yields the highest net benefits. (OMB Circular A-4)

2. **Willingness to pay**: estimate of the monetary value to a representative individual of a beneficial outcome that does not have a market price (such as a reduction in mortality risk). (EPA Guidelines for Preparing Economic Analyses)

3. **Opportunity cost:** monetary benefit foregone to society by using a resource for an investment, action, or policy rather than for its highest valued alternative use (such as real estate being used for commercial activity rather than green space). (EPA Guidelines for Preparing Economic Analyses)

Benefit-Cost Analysis: Recommended Readings and Resources

BCA examples from local governments

2. Autocase. (2021). *Cost-benefit analysis of key climate ready strategies: Executive summary* (City of San Antonio). https://www.sanantonio.gov/Portals/0/Files/Sustainability/News/Cost-Benefit-Analysis-of-Key-Climate-Ready-Strategies.pdf
3. AECOM, & The Nature Conservancy. (2021). *Economic assessment of heat in the Phoenix metro area.* The Nature Conservancy. https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_EcoHeatAssement_AZ_Report.pdf
4. Autocase. (2018). *Triple bottom line cost-benefit analysis of green infrastructure/low impact development (GI/LID) in Phoenix, AZ.* Prepared by Autocase, Stantec, and Watershed Management Group. https://www.phoenix.gov/content/dam/phoenix/pddsite/documents/pz/tbl-cba%20autocase%20features%20and%20projects%20evaluation.pdf

BCA and community engagement resources from government agencies and NGOs

5. Federal Emergency Management Agency. (n.d.). *Benefit-cost analysis toolkit.* U.S. Department of Homeland Security.
6. https://www.fema.gov/grants/tools/benefit-cost-analysis
7. U.S. Environmental Protection Agency. (n.d.). *Green infrastructure cost-benefit resources. https://19january2021snapshot.epa.gov/green-infrastructure/green-infrastructure-cost-benefit-resources_.html*
8. U.S. Environmental Protection Agency. (2024). *Guidelines for preparing economic analyses.* U.S. Environmental Protection Agency.

https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses-3rd-edition
9. Office of Management and Budget. (2003). *Circular No. A-4: Regulatory analysis.* Executive Office of the President. https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4
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11. European Commission. (2014). *Guide to cost-benefit analysis of investment projects: Economic appraisal tool for cohesion policy 2014–2020.* European Commission Directorate-General for Regional and Urban Policy. https://ec.europa.eu/regional_policy/en/information/publications/guides/2014/guide-to-cost-benefit-analysis-of-investment-projects-for-cohesion-policy-2014-2020#:~:text=The%20Commission%20with%20help%20of,case%20studies%20for%20the%20Guide.
12. National Oceanic and Atmospheric Administration. (2025). *A checklist for writing grant proposals that encourage meaningful community engagement.* https://coast.noaa.gov/data/digitalcoast/pdf/grant-proposal-checklist-community-engagement.pdf

Key scholarship about the health benefits of heat interventions

13. Hondula, D. M., Balling, R. C., Vanos, J. K., & Georgescu, M. (2015). Rising temperatures, human health, and the role of adaptation. *Current Climate Change Reports, 1*(3), 144–154. https://doi.org/10.1007/s40641-015-0016-4
14. Kovats, R. S., & Hajat, S. (2008). Heat stress and public health: A critical review. *Annual Review of Public Health, 29*, 41–55. https://doi.org/10.1146/annurev.publhealth.29.020907.090843

Key scholarship related to the economic analysis of heat interventions

15. Johnson, D., See, L., Oswald, S. M., Prokop, G., & Krisztin, T. (2021). A cost–benefit analysis of implementing urban heat island adaptation measures in small- and medium-sized cities in Austria. *Environment and Planning B: Urban Analytics and City Science, 48*(8), 2326–2345. https://doi.org/10.1177/2399808320974689
16. Teotónio, I., Silva, C. M., & Cruz, C. O. (2018). Eco-solutions for urban environments regeneration: The economic value of green roofs. *Journal of Cleaner Production, 199*, 121–135. https://doi.org/10.1016/j.jclepro.2018.07.084

Roadmap Workbook

Introduction

You are reading a companion report.

To access the complete Workbook, download the toolkit here.

The Roadmap Workbook (the Workbook) is a suite of guided activities that empower communities to put the Framework into action. It includes downloadable worksheets, templates, and other resources to help communities collect key data points for local planning processes. These include new, tailored resources created by the Center's team of experts to support action in each content area introduced in the Framework. The Workbook also offers a curated collection of existing resources recommended by the Center for Heat Resilient Communities team.

The Workbook is a supplement to the local planning process

Each community will have their own decision making processes. These resources are intended to support these processes with data relevant to evaluating the merits of heat action strategies.

Recognizing that each community will have its own decision-making process, the Workbook is not a prescription for how to conduct planning and decision-making. Rather, the Workbook activities will guide users in identifying, collecting, and organizing the data needed to inform planning and decision-making.

Each part of the Workbook is centered around addressing the foundational considerations introduced in the Framework, articulated as "Guiding Questions".

Taken together, the answers to these questions provide a basis for local, data-informed decision-making. The activities can also serve as documentation for potential funding applications.

- Part 1: *Make the Case* guides users in collecting and organizing relevant data to define the problem of heat in their local context.
- Part 2: *Assess Capacity to Respond* supports communities in identifying existing capacities to address the problems defined in Part 1.
- Part 3: *Prioritizing Action* asks users to generate a list of exposure setting-specific strategies and qualitatively evaluate them using data collected in Parts 1 and 2.
- Part 4: *Make Goals and Strategies Actionable* builds on the identified strategies and guides users in collecting and organizing data to evaluate the effectiveness and feasibility of potential heat action strategies.
- Part 5: *Putting it all Together* supports users in prioritizing strategies identified in Part 3, using the evidence base developed across all Workbook activities.

The five 'parts' of the Workbook are designed to be engaged linearly, though you may choose to complete activities according to your community's needs and where you are in the decision-making process. Each part contains 'steps'. Each step represents a specific type of data or action useful to the heat action planning process. Each step may contain up to three different activities, organized into three 'tiers'. Tier 1 activities require the least lift, while Tier 3 activities require the most time and resources.

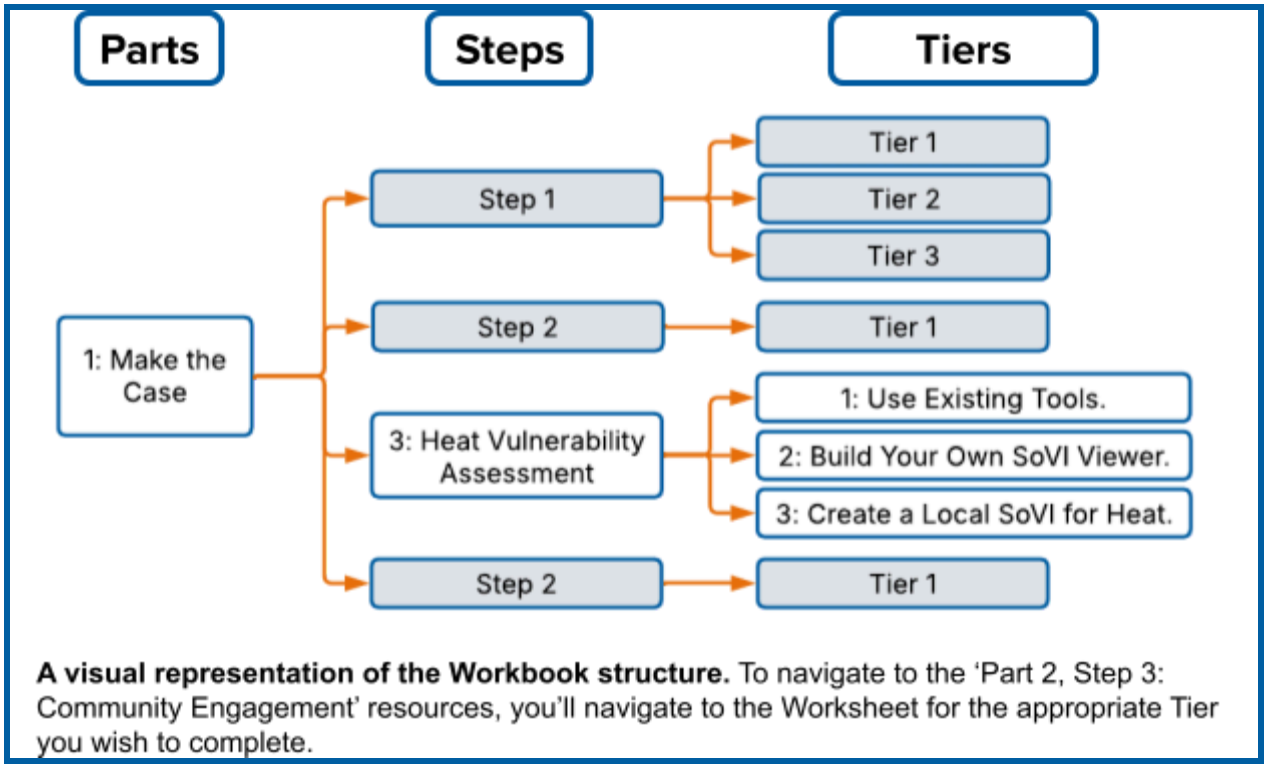
Each tiered activity within a step contains a "worksheet" with instructions and guidance on how to use each embedded resource. Embedded resources may include input data, shapefiles (geospatial boundaries for analysis), additional readings, and interactive tables to organize data collected during the activity. Additional resources, such as case studies and examples, are also offered.

Using the Workbook

The Workbook is available as an interactive toolkit for download here. The toolkit contains all of the activity worksheets and supplement resources needed to complete the workbook. These are organized linearly according to the part-step-tier structure outlined above. Each activity worksheet contains links to all necessary external resources to complete the activity. Some also contain discussion questions to help users make sense of collected data and other activity outputs.

Within the toolkit, you will also find the "Data Sheet". This document is designed to help organize data from activities in one location. Tabs within the Data Sheet contain local links to other parts of the Data Sheet to provide an integrated experience and create a one-stop-shop location for heat planning data.

Where relevant, activity worksheets will indicate where to input information in the Data Sheet. In Parts 3 and 5 of the Workbook, you will look back at the data you have collected in the Data Sheet (and other external sources) to produce your priority list of heat action strategies.



A visual representation of the Workbook structure. To navigate to the 'Part 2, Step 3: Community Engagement' resources, you'll navigate to the Worksheet for the appropriate Tier you wish to complete.

Part 1: Make the Case for Action

The guidance in Part 1, Make the Case for Action, is focused on understanding the impacts of extreme heat on communities and the health, well-being, and livelihoods of community members. Completion of Part 1 will empower communities with the information needed to make the case for heat resilience action to decision makers, residents, and potential funders in the local heat action planning process. Part 1 will also provide data to aid decision-making, set priorities, and allocate resources. It supports community understanding of current and future extreme heat impacts in the absence of heat resilience action. Part 1 is organized into 4 steps and draws from the following sections of the Framework: Climate Modeling & Microscale Climate Modeling; Exposure Settings; and Social, Cultural, & Participation Considerations.

Part 1, Step 1

Guiding Question: What is my community's current and future heat exposure?

Heat Exposure Assessment will provide guidance on accessing, interpreting, and collecting the modeling-based information that communities need to assess and respond to projected changes in extreme heat, including changes to warm-season average temperatures; number of hot days and warm nights; frequency, intensity, and duration of locally defined extreme heat events; and other climatologically meaningful indicators of heat hazard and exposure.

Part 1, Step 2

Guiding Question: Where in my community are people commonly exposed to heat?

Heat Exposure Settings will provide guidance on employing the heat exposure settings framework. This framework is based on the idea that each location, or setting, where people are exposed to heat encompasses a universe of institutions that jointly determine the physical design of spaces and rules about ownership, access, and use - all of which impact the selection of appropriate heat mitigation strategies. To make effective changes, the full universe of institutions should be audited in each setting to fully understand the context of heat exposure and feasible intervention pathways.

Part 1, Step 3

Guiding Question: Who in my community is most vulnerable to heat?

Social Vulnerability Assessment will provide guidance on accessing, interpreting, and visualizing spatialized information that communities need to assess and respond to uneven susceptibility to heat-related harm. Understanding how social vulnerability informs overall heat vulnerability, how it is measured, and how to interpret this data will help communities make data-informed heat action and policy decisions that recognize inequitable distribution of heat burdens.

Part 1, Step 4

Guiding Question: Which social and cultural assets in my community are at risk due to heat?

Social, Cultural, and Equity Considerations will provide guidance on assessing and managing heat-induced disruption, loss, or alteration of community events or spaces, social infrastructure, and community practices, and cultural heritage practices that maintain local lifeways and social cohesion of communities, tribes, and other groups. These considerations make visible how the day-to-day lives of community members may become unsafe as heat becomes more extreme.

The table below provides an overview of the worksheet activities and additional resources provided to complete Part 1 of the Workbook.

Workbook Part 1: Make the Case for Action

	Step		Worksheets	Resources
Part 1: Make the Case for Action	Step 1: Heat Exposure Assessment	1	Understanding Heat Exposure using Existing Tools	
		2	Visualizing Heat Exposure Data	
		3	Modeling Local Microclimates with ENVI-met	Case Study: Evaluating Local Micro-Climates (MaRTy)
	Step 2: Heat Exposure Settings	1	Identifying Heat Exposure Settings	
	Step 3: Heat Vulnerability Assessment	1	Understanding Heat Vulnerability Data using Existing Tools	
		2	Building Your Own Social Vulnerability Viewer	Case Study: Creating Decision Support Tools for Heat Health
		3	Creating a Local Social Vulnerability Index for Heat	
	Step 4: Social, Cultural, & Equity Considerations	1	Sociocultural Heat Risk Assessment	Case Study: Melting Metropolis Art Walk
				Resource Spotlight: iSeeChange

Part 2: Assess Capacity to Respond

The guidance in Part 2, Assess Capacity to Respond, supports communities in identifying key resources, assessing capacity gaps, and engaging them in responding to the challenges identified in Part 1. Completion of Part 2 will empower communities to design appropriately scaled approaches to heat resilience that are aligned with current capacities and community-identified needs. It will also help them communicate capacity and resource needs to decision makers, residents, and potential funders in local planning and decision-making processes. Part 2 is organized into 3 steps and draws on the following sections of the Framework: Heat Governance, Maturity Assessment, Stress Testing & Tabletop Exercises, Heat Action Planning, and Engagement.

Part 2, Step 1

Guiding Question: Are our government and civic institutions prepared to respond to acute and chronic heat?

Governance Capacity Assessment will help you assess your community's capacity to respond to heat events. Provided resources will help you i) survey and synthesize your existing capacities to respond to acute events into priority action areas and ii) apply this information to a Maturity Model for Heat Governance. The outcomes from these activities will prepare you for a future tabletop exercise. This includes identifying key documents, stakeholders, and policies to consider as you plan to increase your heat action capacity.

Part 2, Step 2

Guiding Question: Do our existing planning activities support heat resilience?

Community Plan Assessment will provide guidance on assessing the breadth, quality, and spatial distribution of policies and strategies in existing community plans. Provided resources will also help you identify opportunities to improve plan integration with heat resilience and policy goals. **The guidance provided in this Step may be useful in completing 'Part 2, Step 1: Governance Capacity Assessment'.

Part 2, Step 3

Guiding Question: How can we engage relevant stakeholders to improve heat resilience?

Build Community Engagement Capacity provides direction and guidance on completing exercises with community leaders and stakeholders to build trust and support knowledge co-production. These resources are intended to help you co-develop heat action goals with stakeholders from impacted communities, leading to more durable and effective solutions.

The table below provides an overview of the worksheet activities and additional resources provided to complete Part 2 of the Workbook.

Workbook Part 2: Assess Capacity to Respond

	Step		Worksheets	Resources
Part 2: Assess Capacity to Respond	Step 1: Governance Capacity Assessment	1	Performing a Simple Stress Test	
		2	Applying the Maturity Model for Heat Governance	Resource Spotlight: NOAA Maturity Model
				Resource Spotlight: NOAA Tabletop Exercises
	Step 2: Community Plan Assessment	1	Planning Capacity Assessment Workshop	
		2	Plan Quality for Heat Resilience Assessment	
		3	Plan Integration for Resilience Scorecard (PIRS) for Heat	
	Step 3: Build Community Engagement Capacity	1	Building Community Leaders Workshop	
		2	Building Community Coalitions Workshop	
		3	Co-Developing Heat Action Goals Workshop	

Part 3: Prioritizing Action

In Part 3, communities will use the information they've collected thus far on baseline heat impacts and governance capacity to generate a preliminary list of goals and strategies to address various dimensions of each goal. These goals may come from existing plans or community initiatives or represent new opportunities identified through previous Workbook activities. Using the Exposure Settings framework, users will then qualitatively assess how well each strategy addresses known heat impacts and whether existing capacities are sufficient for implementation. Provided resources guide users in comparing strategies based on their relevance to known heat impacts in high-impact exposure settings and their feasibility, leading to a priority list of strategies for further examination.

Workbook Part 3: Prioritizing Action

Part 2:	Step	Worksheets		Resources
Assess Capacity to Respond	Step 1: Governance Capacity Assessment	1	Listing and Ranking Goals and Strategies	

Part 4: Make Goals and Strategies Actionable

The guidance in Part 4 focuses on developing pathways to implement the goals and strategies identified in the local planning process. Completion of Part 4 will empower communities with the information needed to prioritize and evaluate the effectiveness of potential heat action strategies and communicate these data points to potential funders and stakeholders engaged in local planning processes. Workbook activities support communities in tracking and communicating progress toward heat resilience, evaluating the benefits of heat resilience action, and addressing policy needs. Part 4 is organized into 5 steps and draws from the following sections of the Framework: Benefit-Cost Analysis, Engagement, and Indicators of Heat Resilience.

Part 4, Step 1
Guiding Question: How can we articulate the economic benefits of reducing heat impacts?
Benefit-Cost Analysis provides a primer to conducting benefit-cost analysis for heat, including key steps and considerations. Included resources will introduce available tools for conducting heat-specific benefit-cost analysis of common interventions.

Part 4, Step 2
Guiding Question: Which policies support local heat action priorities?
Policy Analysis will provide a suite of exercises and tools to analyze the policy landscape, putting your community in a position to gain local and extra-local support for heat action. This includes guidance on conducting desk research and directly engaging policymakers to advocate for and design effective local heat action strategies that are more likely to be actionable in your specific policy environment.

Part 4, Step 3
Guiding Question: How can we communicate effectively with the public to support heat goals?
Media Communication will provide guidance on creating and delivering compelling messaging when communicating across media platforms. Provided resources will help you prepare talking points to deliver strategic messaging to local media who can use their coverage of extreme heat to further local goals and generate support for heat action.

Part 4, Step 4: Proposed; not completed before funding termination.

Part 4, Step 5
Guiding Question: How can we track heat impacts and progress toward goals?
Resilience Indicator Selection will help communities identify and collect data on locally relevant, evidence-based heat risk indicators. This information can be used to determine past and present heat risk and evaluate progress towards enhancing heat resilience moving forward. These data

will strengthen your ability to make the case for the provision of resources and for funding applications.

The table below provides an overview of the worksheet activities and resources provided to complete Part 4 of the Workbook.

Workbook Part 4: Make Goals & Strategies Actionable

	Step		Worksheets	Resources
Part 4: Make Goals & Strategies Actionable	Step 1: Benefit-Cost Analysis	1	Apply the Arsht-Rockefeller Heat Action Platform Policy Tool	Resource Spotlight: Arsht-Rock Heat Action Platform
		2	Apply the C40 Heat Resilient Cities Tool	Resource Spotlight: FEMA's Benefit-Cost Analysis Tool
	Step 2: Policy Analysis	1	Policy Landscape Analysis	
		2	Tracking Policy Activity	
	Step 3: Media Communication	1	Apply the Media Quadrant to Your Issue	
	Step 4: Heat Alert Development	1	Proposed; not completed before funding termination.	Resource Spotlight: LARC Heat Campaign
	Step 5: Resilience Indicator Selection	1	Develop Resilience Indicators	Resource Spotlight: Heat Ready Schools

Part 5: Putting It All Together

In Part 5, users will return to their priority strategies identified in Part 3 and attach evaluation metrics, simple cost-benefit information, policy levers, and communications considerations. Considering relevance to high-impact exposure settings, feasibility, and implementation complexity, users will have an evidence-based list of priority strategies to use as appropriate in local decision-making. A template is provided to transfer priority strategies into a Heat Action Blueprint to orient local coordination and to communicate with impacted community members and decision-makers.

Workbook Part 5: Putting It All Together

Part 5:	Step	Worksheets		Resources
Putting it All Together	Step 1: Refine and Present Your Priority Strategies	1	Listing and Ranking Goals and Strategies	

Appendices

Center Staff and Contributors' Expanded Biographies

Kelly Turner, Ph.D.
Co-Principal Investigator
Dr. Kelly Turner (she/her) is the Director of the Center for Heat Resilient Communities, Co-Principal Investigator, and a lead author for the Engagement section of the Framework and Workbook. Dr. Turner is an Associate Professor of Urban Planning and Geography and serves as Associate Director of the Luskin Center for Innovation at the University of California, Los Angeles. She leads Luskin Center for Innovations research on heat, which provides evidence-based approaches to protect people where they live and work. Dr. Turner's current research encompasses heat governance and policy, planning for climate-resilient communities, and producing actionable data for heat-health. Her work has been published in *Nature*, *Environmental Research Letters*, and the *Journal of the American Planning Association* and funded by the National Science Foundation, the Robert Wood Johnson Foundation, and the Strategic Growth Council of California. She has served as a panelist for the National Academy of Sciences and as a Science Advisor to the Arsht-Rockefeller Extreme Heat Resilience Alliance.

Ladd Keith, Ph.D.
Co-Principal Investigator
Dr. Ladd Keith is a Co-Principal Investigator for the Center for Heat Resilient Communities and a lead author for the Heat Action Planning section of the Framework and Workbook. Dr. Keith is an assistant professor in the School of Landscape Architecture and Planning and a faculty research associate at the Udall Center for Studies in Public Policy at the University of Arizona. An urban planner by training, he has over a decade of experience planning for climate change with diverse stakeholders in cities across the U.S. His research explores heat planning, policy, and governance to help communities increase their heat resilience. He is the UA lead of the DOE-funded Southwest Urban Corridor Integrated Field Laboratory (SW-IFL), the heat research lead of the NOAA-funded Climate Assessment for the Southwest (CLIMAS), co-investigator of the CDC-funded Building Resilience Against Climate Effects (BRACE), and co-investigator of the NIH-funded Southwest Center on Resilience for Climate Change and Health (SCORCH). He also serves on the WHO and WMO's Global Heat Health Information Network (GHHIN)'s Management Committee.

Sara Meerow, Ph.D.
Co-Principal Investigator
Dr. Sara Meerow is a Co-Principal Investigator for the Center for Heat Resilient Communities and a lead author for the Heat Action Planning section of the Framework and Workbook. Dr. Meerow is an Associate Professor in the School of Geographical Sciences and Urban Planning at Arizona

State University. She is an interdisciplinary scholar working at the intersection of urban planning and geography to make cities more resilient in the face of climate change and other hazards, while at the same time more sustainable. Her research focuses on climate change adaptation planning with a focus on heat and flood hazards, green infrastructure, and conceptualizations of urban resilience. Her work on heat resilience planning has been published in *Nature*, *Journal of the American Planning Association*, *Journal of Planning Education and Research*, and by the American Planning Association. Some of her recently funded projects include a National Science Foundation grant on flood resilience planning, Department of Energy-funded work on urban climate resilience, a National Oceanic and Atmospheric Administration-funded project on extreme heat resilience, the National Center for Atmospheric Research's early career fellowship, and a Humboldt Research Fellowship in Germany.

Trace Lane
Senior Project Manager & Researcher

Trace Lane (she / her / hers) is the Senior Project Manager for the Center for Heat Resilient Communities and lead author for the Social, Cultural, and Equity Considerations of Heat section of the Framework. Trace is the Senior Project Manager at the UCLA Luskin Center for Innovation's Heat Research Team. Trained as an interdisciplinary hydro-social climate scientist, Trace completed a B.S. in Organizational Psychology and an M.P.A. in Political Science and Public Affairs from the University of Alabama, and an M.S.W. - A.M. in International Social Welfare and Human Rights from the University of Chicago. Her interdisciplinary doctoral studies in human rights and governance and coastal resilience management focused on strategies for designing epistemologically diverse climate resilience solutions. Trace's climate resilience work includes designing benefit-cost analysis tools for the Los Angeles Bureau of Street Serves, conducting community-based action research on barriers to wildfire evacuation with the Santa Barbara County Fire Safe Council, conducting socio-legal water rights research for the Human Rights Commission of Maharashtra, India; serving as a senior sustainability consultant to the Environmental Protection Agency; and is the founder of SOCIO, a method that bridges story with science to describe environmental change and identify sociocultural climate risks.

Zach Wampler
Program Coordinator

Zach Wampler (he/him) is the Project Coordinator for the Center for Heat Resilient Communities. He holds a B.S. in Human & Organizational Development from Vanderbilt University, where he researched how geospatial vulnerability assessment approaches affect environmental managers' responses to climate hazards and worked with the Mayor's Office of Metro Nashville and Davidson County to engage the public and build capacity to address heat risk. Prior to joining the Luskin Center for Innovation, he completed an AmeriCorps term with the Sacramento Metro Air Quality Management District, focused on heat mitigation policy and human-scale heat monitoring to inform land-use projects. Zach's professional interests include urban climate metrics and policy, science translation and education to improve decision-making and build community power, and the use of participatory methods to address sustainability and community resilience.

Anne-Lise Boyer, Ph.D.
Postdoctoral Research Associate

Anne-Lise Boyer is a postdoctoral research associate with Climate Assessment for the Southwest (CLIMAS) at the University of Arizona. CLIMAS is a Climate Adaptation Partnership (CAP), funded by the U.S. National Oceanic and Atmospheric Administration that includes experts from social, physical, and natural sciences who collaborate with partners across the Southwest to develop sustainable solutions for regional climate challenges. Under the guidance of Associate Professor of Planning and Sustainable Built Environments Ladd Keith, Anne-Lise's work aims to bridge climate science and decision-making to advance heat resilience in rural, tribal, and border communities in the U.S. Southwest.

Before joining CAPLA, Anne-Lise was a Postdoctoral Fellow at the International Research Lab Iglobes (CNRS-UA), at Biosphere 2. There, she worked on drought resilience and climate change adaptation, contributing to an interdisciplinary research project on intermittent bodies of water. Her focus was on the relationship of local communities to heavily disturbed and changing waterscapes. Anne-Lise earned her Ph.D. in Geography and Planning from the Ecole Normale Supérieure de Lyon in France, where she examined drought resilience and water conservation strategies implemented by desert metropolises. Originally from France, Anne-Lise developed a keen interest in the socioecological challenges faced by the Southwestern U.S. since her first visit to Tucson as an exchange student in 2015.

Kathrine Wall
Graduate Student Researcher

Kathrine Wall (she/her) is the Graduate Student Researcher supporting the Center for Heat Resilient Communities. She is currently pursuing a Master's of Urban and Regional Planning at the UCLA Luskin School of Public Affairs with a concentration in Climate, Environment, and Society with Urban Design. Her professional background includes data analysis for local, state, and federal projects supporting urban resilience, cultural conservation, and community-focused climate adaptations. Her professional and academic interests include urban climate analytics, local natural disaster resilience planning, and equitable access to public resources. She completed a B.A. in Geography/Environmental Science and Political Science with a minor in Geospatial Information Sciences from UCLA, where she researched inequitable environmental health outcomes as a result of discriminatory housing policies. Her current research focuses on wildfire resilience in hillside communities throughout Los Angeles, CA as well as public access to urban heat resources in Los Angeles, CA and Paris, FR.

Ariane Middel, Ph.D.

Core Lead: Climate Modeling & Microscale Climate Modeling

Dr. Ariane Middel (she/her) is a lead author for the Climate Modeling & Microscale Climate Modeling section of the Framework and Workbook. Dr. Middel is an Associate Professor in the School of Arts, Media & Engineering and the School of Computing & Augmented Intelligence at Arizona State University. Her research interests lie in the interdisciplinary field of urban climate with a focus on extreme heat. Dr. Middel's applied and solutions-oriented research uses unconventional field methods such as MaRTy (a mobile weather station), microclimate simulations, and human-centric heat exposure modeling. Dr. Middel is the President of the International Association for Urban Climate (IAUC), serves on the Board of the American Meteorological Society (AMS) Built Environment, and directs the SHaDE Lab at ASU. She received an NSF CAREER award on "Human Thermal Exposure in Cities" and has published over 100 peer-reviewed articles in journals such as Nature Communications, BAMS, Sustainable Cities and Society, and Landscape and Urban Planning. Her work has been featured by Good Morning America, CNN, National Geographic, and the New York Times.

Olga Wilhelmi, Ph.D.

Core Lead: Climate Modeling & Microscale Climate Modeling

Dr. Olga Wilhelmi (she/her) is a lead author for the Climate Modeling & Microscale Climate Modeling section of the Framework and Workbook. Dr. Wilhelmi is a Project Scientist in the Research Applications Laboratory at the NSF National Center for Atmospheric Research (NCAR). Dr. Wilhelmi founded NSF NCAR's GIS Program, where she leads actionable and convergent research on societal risks and resilience to extreme weather and climate change. Dr. Wilhelmi brings 20 years of experience in extreme heat research and applications working with communities and decision-makers from local to national levels. Her work has been funded by the National Science Foundation, Environmental Protection Agency and National Aeronautics and Space Administration, and National Oceanic and Atmospheric Administration. Dr. Wilhelmi has recently served as an author on the Human Health Chapter of the Fifth National Climate Assessment. Her current research focuses on responses to heat risks across the U.S.

Florian Schneider, Ph.D.

Core Lead: Climate Modeling & Microscale Climate Modeling

Dr. Florian A. Schneider (he/him) is a lead author for the Climate Modeling & Microscale Climate Modeling section of the Framework and Workbook. Dr. Schneider is Senior Research Advisor at Third Way's Climate and Energy Program, where he combines rigorous policy analysis with international collaboration to advance evidence-based strategies for clean energy deployment, industrial decarbonisation, and climate resilience in Europe and the United States. His background bridges climate science, sustainability, and urban heat research, with a focus on equitable and transdisciplinary approaches to climate adaptation. Dr. Schneider earned his Ph.D. in Sustainability from Arizona State University, where his research focused on sustainable urban heat mitigation and co-producing usable, policy-relevant science with city practitioners and communities. He has led major decarbonisation modelling efforts in Poland and Romania, directed the EU-wide Annual Decarbonisation Perspective, and produced policy briefs that inform EU and Member State energy strategies. He also holds BS and MS degrees in Atmospheric Science from Universität Leipzig and previously contributed to the European Space Agency's EarthCARE mission as a scientific programmer at TROPOS Leipzig, developing satellite data processing algorithms for global climate monitoring

Elizabeth M Cook, Ph.D.

Core Lead: Stress Testing, Maturity Modeling, & Tabletop Exercises

Dr. Elizabeth Cook (she/her) is a lead author for the Stress Testing, Maturity Modeling, & Tabletop Exercises section of the Framework and Workbook. Dr. Cook is an Assistant Professor in Environmental Science, Sustainability at Barnard College-Columbia University. Elizabeth is an urban ecosystem scientist. Her work uses mixed methods and participatory approaches to explore cities as complex social-ecological-technological systems. She co-leads a National Science Foundation Growing Convergence project that applies transdisciplinary approaches to explore future sustainability and resilience of North American and Latin American cities to changing climate and extreme events. She works collaboratively with interdisciplinary scientists and local practitioners through participatory methods to envision positive futures and the transformative capacities needed to achieve future climate resilience. She also co-leads the global NATURA network studying and implementing nature-based solutions to improve urban resilience. Her other current projects explore human-environment interactions and people's perceptions of nature and ecosystem services under changing environmental conditions.

Theo Lim, Ph.D.

Core Lead: Stress Testing, Maturity Modeling, & Tabletop Exercises

Dr. Theo Lim (he/him) is a lead author for the Stress Testing, Maturity Modeling, & Tabletop Exercises section of the Framework and Workbook. Dr. Lim is an Associate Professor in the School of Community and Regional Planning at the University of British Columbia. He specializes in research and teaching in urban environmental and climate adaptation planning, environmental science-policy interfaces, and community engagement. He has led two projects that use

participatory action research methods to address governance gaps in planning for rising temperatures in Roanoke, Virginia: the H.O.P.E. for Heat Resilience project, funded through the National Science Foundation's CIVIC Innovation Challenge, and Heat Ready Roanoke, funded through NOAA's Environmental Literacy Program. His work has been published in the *Journal of the American Planning Association*, *Landscape and Urban Planning*, and *Sustainable Cities and Society*. Theo also serves on the Editorial Team of the journal *Planning Theory & Practice*.

Jason A. Douglas, Ph.D.
Core Lead: Stakeholder Engagement

Dr. Jason A. Douglas is a lead author for the Engagement section of the Framework and Workbook. Dr. Douglas is a community-engaged environmental health disparities researcher in the Department of Health, Society, and Behavior and the Center for Environmental Health Disparities Research at UC Irvine. Leveraging community-based participatory action research, Douglas works with community-based organizations and residents in Black and historically marginalized communities to investigate and redress environmental health disparities. His work ranges from structured observation of neighborhood-level assets and challenges that may encourage or encumber health-promoting behaviors to large-scale geospatial examinations of health and place. His current research examines air pollution- and urban heat-related health disparities, legal drug retail (e.g., tobacco shops, liquor stores), access to recreational spaces and physical activity opportunities, and community organizing practices for advancing health and wellbeing. Supported by state and federal funding, Douglas has developed and adapted innovative participatory methodologies—e.g., structured observation and neighborhood mapping—for examining novel public health challenges.

Ronnen Levinson, Ph.D.

Core Lead: Indicators of Heat Resilience

Dr. Ronnen Levinson is a lead author for the Indicators of Heat Resilience section of the Framework and Workbook. Dr. Levinson is a Staff Scientist and Leader of the Heat Island Group at Lawrence Berkeley National Laboratory (LBNL) in Berkeley, California, where he develops cool roof, wall, and pavement materials; improves methods for the measurement of solar reflectance; quantifies the energy and environmental benefits of cool surfaces; and promotes resilient cooling of people, buildings, cities, and the planet. He serves on the boards and technical committees of the Cool Roof Rating Council and the Global Cool Cities Alliance, and advises policymakers, code officials, utilities, and building rating programs about cool surfaces. He holds a B.S. in engineering physics from Cornell University and an M.S. and a Ph.D. in mechanical engineering from the University of California at Berkeley. He has authored or co-authored over 140 publications, serves as an Associate Editor for *Energy & Buildings* and a Guest Editor for *Nature Scientific Reports*, and sits on the editorial boards of *Energy & Buildings*, *Solar Energy Advances*, and *Nature Scientific Reports*. He received the 2016 Marty Hastings Award for outstanding contributions to the Cool Roof Rating Council, and a 2016 R&D 100 Award for the invention of the Cool Roof Time Machine.

Chris Uejio, Ph.D.

Core Lead: Indicators of Heat Resilience

Dr. Chris Uejio (he/him) is a lead author for the Indicators of Heat Resilience section of the Framework and Workbook. Dr. Uejio is a Professor of Geography and Public Health. Earlier in his career, he worked with public health departments to develop evidence-based extreme heat maps. He partnered with Emergency Medical Services to build the evidence base for indoor heat exposure levels that are harmful to human health. As a member of NASA's Health and Air Quality Applied Science Team (2020-2024), his team is creating reproducible workflows to map air temperature and the urban heat island effect. Finally, he is a member of a team that evaluates the process and outcomes of extreme heat interventions. This work has been funded by multiple U.S. federal (NASA, NIH, CDC, EPA, NSF, NOAA), state, and non-profit institutions (e.g., Wellcome Trust).

Jennifer Vanos, Ph.D.

Core Lead: Indicators of Heat Resilience

Dr. Jennifer Vanos is a lead author for the Indicators of Heat Resilience section of the Framework and Workbook. Dr. Vanos is an Associate Professor in the School of Sustainability at Arizona State University. As a human biometeorologist, she works to strengthen the understanding and practice surrounding how we protect people from extreme heat and air pollution in a changing climate. Her work on extreme heat addresses risks and challenges within heat-sensitive and heat-exposed groups, including children, athletes, and outdoor workers. She also runs the HeatReady™ Schools program at ASU. Dr. Vanos was awarded an NSF Early Career research grant in 2021, and is co-authoring new WHO Heat & Health guidance. She is PI of the Human Biometeorology lab at ASU, a scientific advisor for the Korey Stringer Institute, and Outgoing

Chair of the American Meteorological Society's Board on Environment & Health. Dr. Vanos previously worked at UC San Diego, Texas Tech, and Health Canada, and received her Ph.D. and bachelor's degrees from the University of Guelph in Canada.

C.J. Gabbe, Ph.D.
Core Lead: Benefit-Cost Analysis
Dr. C.J. Gabbe (he/him) is a lead author for the Benefit-Cost Analysis section of the Framework and Workbook. Dr. Gabbe is an Associate Professor in Santa Clara University's Department of Environmental Studies and Sciences. His research focuses on identifying and mitigating the impacts of climate hazards in the United States, particularly through land use planning and housing policy interventions. He collaborates with local governments and community-based organizations, and serves as co-chair of Santa Clara County's Heat and Air Quality Resilience Working Group. C.J. has a Ph.D. in Urban Planning from UCLA and a Master of Urban Planning degree from the University of Washington.

Glenn Sheriff, Ph.D.
Core Lead: Benefit-Cost Analysis
Dr. Glenn Sheriff is a lead author for the Benefit-Cost Analysis section of the Framework and Workbook. Dr. Sheriff is an associate professor in Arizona State University's School of Politics and Global Studies, with a research focus on the distribution of benefits and costs of environmental, natural resource, and climate policy. He received his master's and doctorate in agricultural and resource economics at the University of Maryland. Before joining ASU, he taught at Columbia University and served as an economist at several federal agencies, including the U.S. State Department, White House Council on Environmental Quality, Environmental Protection Agency, and Department of Agriculture. His work has been published in outlets such as the *Journal of the Association of Environmental and Resource Economists*, *Nature Communications*, *Environmental Research Letters*, and *Demography*, and funded by grants from the National Science Foundation, NASA, the U.S. Environmental Protection Agency, and the U.S. Department of Agriculture.

David Eisenman, Ph.D.
Content Contributor: Heat Alert Development
David Eisenman, MD, MSHS, is a professor at the David Geffen School of Medicine at UCLA and has a joint appointment at the UCLA Fielding School of Public Health, where he directs the Center for Public Health and Disasters. Dr. Eisenman is also an Associate Natural Scientist at RAND.

Erin Coutts
Content Contributor: Heat Alert Development
Erin Coutts is the Executive Director of the Los Angeles Regional Collaborative for Climate Action and Sustainability (LARC). Housed at UCLA, LARC is a membership organization that works to facilitate a sustainable and resilient Los Angeles. Erin is focused on convening local and regional

decision-makers who perform climate mitigation and adaptation work. She completed a master's degree in Urban and Environmental Policy and Planning at Tufts University.

Kara Schlighting, Ph.D.
Content Contributor: Social, Cultural, & Equity Considerations Case Study
Kara Murphy Schlichting is an Associate Professor of History at Queens College, CUNY. She earned her Ph.D. from Rutgers, the State University of New Jersey. Schlichting's current research explores climatological aspects of environmental history. She is also a co-investigator on the Wellcome Discovery Award project "Melting Metropolis: Everyday Histories of Health and Heat in London, New York, and Paris since 1945," which explores the impact of climate change and rising temperatures on urban life.

Morgan Rogers, Ph.D.
Content Contributor: Climate Modeling & Microscale Climate Modeling
Morgan (she/her) was a doctoral student in Urban Planning, a graduate student researcher at the UCLA Luskin Center for Innovation, and a National Science Foundation Research Trainee (NSF NRT). She uses remote sensing, GIS, spatial statistics, and 3D modeling methods to study urban environments with the goal of translating this research into actionable insights for environmental planning. At the Luskin Center for Innovation, Morgan applied 3D modeling, shaped by community feedback, to explore and propose effective, low-cost outdoor cooling interventions for communities most impacted by extreme heat.

Sahar Derakhshan, Ph.D.
Content Contributor: Heat Vulnerability Assessment
Dr. Derakhshan received her doctorate in Geography from the University of South Carolina, her Master of Public Policy (MPP) from the University of California, Berkeley, and holds a Bachelor of Science in Civil Engineering from the University of Science and Culture, Iran. Dr. Derakhshan employs geospatial analytics in her interdisciplinary research to study and assess the effect of inequalities, institutions, and social and economic status, in taking action to foster change in mitigation planning and disaster recovery, for a safer and more resilient community.

Glossary of Key Terms

1. **Adaptive capacity**: "The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences [of heat]" (adapted from IPCC 2022).

2. **Anomaly:** The difference between the future climate and the present-day climate.

3. **Benefit-cost analysis**: The process of identifying, quantifying, and monetizing expected benefits and costs of investments, actions, or policies to determine which alternative yields the highest net benefits. (OMB Circular A-4)

4. **Built shade**: Manufactured shade structure designed for pedestrian use, which can be either attached to a building or freestanding.

5. **Capacity**: Ability to provide services to residents, which is influenced by structural and cultural factors

6. **Climate**: Average weather in a place, typically over more than thirty years.

7. **Climate change:** Changes in average weather conditions that persist over multiple decades or longer. Climate change encompasses both increases and decreases in temperature, as well as shifts in precipitation, changes in frequency and location of severe weather events, and changes to other features of the climate system. Climate variability is often natural, however climate change is causing an increase in the probability of many extreme weather events, and those events contribute to climate variability.

8. **Climate model:** A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes and accounting for some of its known properties. Climate models are applied as a research tool to study and simulate long-term climate projections (decadal or longer) and operationally used to create shorter climate predictions (seasonal, annual, interannual) (Fifth National Climate Assessment, 2023). Related term: Earth system model.

9. **Climate projections**: The simulated response of the climate system to a scenario of future emissions or concentrations of greenhouse gases and aerosols, generally derived using climate models. Climate projections depend on the emissions, concentration, or radiative forcing scenario used, which, in turn, is based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized.

10. **Climate variability:** The way aspects of climate (such as temperature and precipitation) differ from an average.

11. **Community leaders**: Central actors in environmental change initiatives formally or informally recognized as environmental justice, public health, or community organizing experts.

12. **Cooling centers**: Publicly available air-conditioned or otherwise mechanically cooled facilities that provide spaces for residents to cool off and find protection from heat on very hot days.

13. **Decision-makers**: Individuals with legally instantiated authority to enact and enforce rules, or individuals informally recognized as authorities via large influence over particular groups.

14. **Direct resident involvement**: the ability of residents and communities, including capacity to organize around shared needs and advocate for community benefit

15. **Environmental justice communities**: Underserved, low-income communities and communities of color experiencing disproportionate environmental exposures, such as urban heat impacts.

16. **Exposure**: "The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected [by heat]" (adapted from IPCC 2022).

17. **Exposure pathways:** The processes through which people experience heat. These pathways are conditioned by personal health, physical activity, and environmental conditions in particular places.

18. **Exposure settings**: The environments where people regularly spend time and are exposed to heat, including homes, workplaces, schools, transportation, and public spaces. Each setting features distinct heat exposure pathways, cooling needs, and governing institutions.

19. **Extreme heat**: Temperatures that are much hotter and/or more humid than average. Because some places are hotter than others, this depends on what is considered average for a particular location at that time of year.

20. **Global climate:** A description of the climate of a planet as a whole, with all the regional differences averaged.

21. **Governance:** The actors, institutions, strategies, and processes for managing/mitigating risks associated with heat (Keith et al 2021). *Governance* recognizes roles of formal state actors (government), as well as non-state actors (hospital systems, school districts, nonprofits, community-based organizations, businesses, etc.).

22. **Government capacity:** Public agencies' ability to provide services to residents. Factors influencing government capacity include: financial stresses, staff turnover, collaborative capacity, and procurement rules changes.

23. **Heat actions**: An action involving heat-related community organizing, outreach, education, adaptation and mitigation strategies, policy analysis and development, etc.

24. **Heat action plans (HAPs)**: “Written documents that help manage actions across multiple organizations to reduce adverse health effects from extreme heat. HAPs broadly contain strategies such as performing surveillance, providing risk communication, supporting social and health care, establishing cooling centers, distributing water bottles and fans, and creating energy assistance programs.” (Randazza et al. 2023). Heat action plans include “a portfolio of assessments and actions to respond to and reduce heat-related impacts” (Arsht Rock)

25. **Heat action planning:** The process by which a community outlines comprehensive goals, metrics, and actions for mitigating and managing heat.

26. **Heat alerts:** Tools used to communicate heat risk and encourage protective actions such as advisories, watches, and warnings used by the National Weather Service (Hondula et al. 2022).

27. **Heat-caused death:** A loss of life where heat exposure is listed as a direct cause of death on the death certificate (Maricopa County Dept of Public Health).

28. **Heat-contributed death**: A loss of life where heat exposure is listed as a contributing factor on the death certificate (Maricopa County Dept of Public Health).

29. **Heat equity:** “The development of practices and policies to mitigate and manage heat with a focus on reducing the inequitable distribution of risk across different groups within the same community” (Keith & Meerow 2022).

30. **Heat exposure assessment**: Scientists study how people feel heat in different city areas, focusing on sunlight, wind, and surfaces like pavement. They measure how much heat our bodies absorb and how shade from trees or buildings can reduce it. This research helps understand how to make cities more comfortable and safer during hot weather.

31. **Heat governance:** “The actors, strategies, processes, and institutions that can mitigate and manage this hazard” (Keith et al. 2021, Nature).

32. **Heat management**: “Preparation and response strategies for extreme heat events, often within the domain of emergency management or public health” (Keith, Meerow, and Wagner 2020)

33. **Heat mitigation:** “Design and planning strategies to reduce the contribution of the built environment to urban heat” (Keith, Meerow, and Wagner 2020).

34. **Heat resilience:** “Proactively managing and mitigating heat across the many systems and sectors it affects” (Meerow et al. 2016, Keith et al. 2020).

35. **Heat-related health data:** Health outcomes data that describe illness or death that is either caused by heat or attributed to heat.

36. **Heat-resilient building codes**: The use of building codes to codify the above strategies and others into new construction and remodeling subject to local land use policies.

37. **Heat risk:** The danger to health or infrastructure due to heat as a function of vulnerability and total exposure.

38. **Heat risk management system**: The suite of tactics and tools, and supporting institutions and infrastructure, used to evaluate and reduce harm to groups and individuals who may become too exposed to high surface temperatures that affect community health and well-being.

39. **Home retrofits / weatherization**: Provision encouraging or requiring new development and/or existing buildings to improve structural resilience to heat through weatherization projects.

40. **Impacted communities:** Communities experiencing urban heat impacts.

41. **Indicator**: A measurement or value that can be tracked over time to communicate the state of heat risk (or heat resilience) in a given area over a period of time.

42. **Indoor cooling subsidies**: Financial incentives to help residents and businesses acquire, maintain, or operate mechanical cooling systems such as air conditioning, heat pumps, or other technologies.

43. **Institutional alignment:** The process of coordinating agencies, statutes, funding mechanisms, and operational practices to support effective heat mitigation and management in a setting.

44. **Maturity:** Describes the level of readiness of the system to respond to a problem, such as extreme heat.

45. **Maturity model:** A tool to assess a community's current capacities, funding, and resources to successfully manage heat risk (i.e., the community 'maturity') and to identify the gaps and needs to improve heat resilience.

46. **Microscale climate modeling**: Scientists use highly detailed computer models to study how climate affects very small areas within cities, such as individual buildings, streets, or neighborhoods. These models reveal how local features like trees or tall buildings create unique weather patterns on a very small scale, explaining why some parts of a city are

hotter, known as the "urban heat island" effect.

47. **Media**: Means of mass communication encompassing traditional formats such as print, radio, television, and online publications, as well as new media such as social media, podcasts, and blogs.

48. **Nongovernmental capacity:** The ability of non-governmental actors, including: hospital systems, school districts, nonprofits or community based organizations, and businesses, to provide services to residents. Compared with government capacity, capacity from nongovernmental organizations can be more flexible, direct, leverage social networks and more/different material resources.

49. **Network of plans**: A “collection of community plans that shape the built environment” including comprehensive plans, hazard mitigation plans, and climate action (Keith et al. 2023).

50. **Opportunity cost:** Monetary benefit foregone to society by using a resource for an investment, action, or policy rather than for its highest valued alternative use (such as real estate being used for commercial activity rather than green space). (EPA Guidelines for Preparing Economic Analyses).

51. **Place-based approach:** A planning strategy that organizes action around specific activity sites rather than abstract geographic zones or sectors.

52. **Plan Integration for Resilience Scorecard™ for Heat**: A methodology for analyzing the land use policies, or action items, across community plans that would affect urban heat and comparing spatial patterns in policy attention with indicators of vulnerability (Keith et al. 2023).

53. **Plan quality evaluation:** “An established method for evaluating the content of plans to see whether they contain elements that are widely believed to be critical to the plan’s effectiveness in achieving community goals” (Meerow et al. 2024).

54. **Policy cycle:** Stages in the process of the policy development stream, including agenda setting, formation, implementation, and review, to which engagement should be tailored.

55. **Policy landscape analysis:** A map of the key players, institutions, and leaders that impact a policy or research issue.

56. **Procedural equity:** Refers to the fairness in a process, or equitable access to participation in the process of defining problems and adopting solutions (Schlosberg, 2007; Wenta et al., 2018; van den Berg and Keenan, 2019).

57. **Public communication campaigns**: Information campaigns intended to inform the public of extreme heat events and protective actions for both chronic heat and extreme heat events.

58. **Reflective (Cool) surfaces**: Horizontal and vertical surfaces that deliver higher reflectance and absorb lower amounts of solar radiation compared to conventional materials to reduce surface, air, and radiant temperatures i.e. high albedo surfaces.

59. **Regional climate:** The climate of where your community is located is called a regional climate. Regional climate can be described by the temperatures over the seasons, how windy it is, and how much rain or snow falls. The climate of a region depends on many factors including the amount of sunlight it receives, its height above sea level, the shape of the land, and how close it is to oceans.

60. **Scenario**: A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts but are used to provide a view of the implications of developments and actions (Fifth National Climate Assessment, 2023).

61. **Sensitivity**: "The degree to which a system or species is affected, either adversely or beneficially [by heat]. The effect may be direct or indirect" (adapted from IPCC 2022).

62. **Setting-specific intervention:** A cooling strategy tailored to the populations, activities, facilities and institutional context of a particular exposure setting.

63. **Stress testing:** A group of methods to explore and identify the needs and capacities of government and community entities to implement heat resilience governance and community-led initiatives (Miller & Muñoz-Erickson 2018).

64. **Urban climate**: Urban areas have a unique climate shaped by various processes within the city. This differs from rural climates due to factors like buildings, human activities, and changes in natural landscapes, leading to effects like the urban heat island, altered wind patterns, and modified precipitation (Oke et al., 2017).

65. **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.

66. **Vegetative infrastructure**: Using vegetation and green space to reduce outdoor and indoor temperatures. Examples include green walls and roofs, provision of outdoor green spaces, and reduction of impervious surfaces (e.g., depaving).

67. **Vulnerability**: “The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.” (IPCC 2022)

68. **Willingness to pay**: An estimate of the monetary value to a representative individual of a beneficial outcome that does not have a market price (such as a reduction in mortality risk). (EPA Guidelines for Preparing Economic Analyses)

69. **Weather**: The state of the atmosphere at a particular place and point in time with respect to temperature, humidity, precipitation, cloudiness, visibility, and wind.

Recommended Readings & Resources

Climate Modeling & Microscale Climate Modeling

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Center for Heat Resilient Communities Workbook Activities

Part 1: Make the Case for Action		
Step 1: Heat Exposure Assessment	T1	Understanding Heat Exposure Data using Existing Tools
	T2	Visualizing Heat Exposure Data
	T3	Modeling Local Micro-Climates with ENVI-Met
Step 2: Exposure Settings Identification	T1	Identifying Heat Exposure Settings
Step 3: Heat Vulnerability Assessment	T1	Understanding Heat Vulnerability Data using Existing Tools
	T2	Building Your Own Social Vulnerability Viewer
	T3	Creating a Local Social Vulnerability Index for Heat
Step 4: Sociocultural Impacts Assessment	T1	Sociocultural Impacts Assessment: Keystone Species & Events
Part 2: Assess Capacity to Respond		
Step 1: Governance Capacity Assessment	T1	Performing a Simple Stress Test
	T2	Applying the Maturity Model for Heat Governance
Step 2: Community Plan Assessment	T1	Planning Capacity Assessment Workshop
	T2	Plan Quality for Heat Resilience Assessment
	T3	Plan Integration for Resilience Scorecard (PIRS) for Heat
Step 3: Build Community Engagement Capacity	T1	Building Community Leaders Workshop
	T2	Building Community Coalitions Workshop
	T3	Co-Developing Heat Action Goals Workshop
Part 3: Prioritizing Action		
Organize Your Data into Priority Strategies		Listing and Ranking Goals and Strategies
Part 4: Make Goals and Strategies Actionable		
Step 1: Benefit-Cost Analysis	T1	Apply the Arsht-Rockefeller Heat Action Platform Policy Tool
	T2	Apply the C40 Heat Resilient Cities Tool
Step 2: Policy Analysis	T1	Policy Landscape Analysis
	T2	Tracking Policy Activity

Step 3: Media Communication	T1	Apply the Media Quadrant to Your Issue
Step 4: Heat Alert Development	T1	{Proposed. Not completed before funding termination}
Step 5: Resilience Indicator Selection	T1	Develop Resilience Indicators
Part 5: Develop a Heat Action Blueprint		
Refine and Present Your Priority Strategies		Putting it all Together Activity