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Building community heat action plans story by story: A three neighborhood case study

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ABSTRACT

Increasing urban temperatures pose a public health threat and, in many cities, there is a disparity among neighborhoods with respect to access to cooling benefits. Residents may be unable to afford to operate cooling systems, and underserved communities are less likely and/or able to advocate for heat-reducing solutions. There is also a significant gap between adaptation theory and practice. This gap could be diminished by better understanding the barriers and limits to adaptation processes. This paper presents the Nature's Cooling Systems project's community engagement methodology, which aims to empower underserved communities to shift those dynamics. Through this process, we sought to learn about key urban heat adaptation barriers at the neighborhood scale.

The methodology was piloted in three neighborhoods in metropolitan Phoenix to provide better thermal comfort in the hottest and highest-need neighborhoods. Barriers to adaptation strategies that emerged from these workshops overlapped with those articulated in the literature, including detecting and defining the problem, increasing information use, and developing, assessing, and selecting options. This methodology can serve as a model for community-driven heat adaptation planning for other neighborhoods facing increasing heat. Attention to key barriers is critical for success of adaptation measures.

1. Introduction

Urban heat is a growing public health issue, especially for those with pre-existing health conditions, the poor, the elderly, young children, and those living in areas with little to no vegetation. These populations experience higher exposure, and have greater sensitivity, and lower adaptive capacity to heat (Harlan et al., 2006; Klinenberg, 2002). Annual average temperatures and the frequency of heat waves are projected to increase across the United States in all future scenarios (Wuebbles et al., 2017). In cities, which are already hotter than rural areas due to the urban heat island effect, future heat challenges will be all the more severe without a priori planning to reduce heat exposure, especially for vulnerable populations.

Extreme heat presents a resilience challenge for cities in managing urban development (Moser et al., 2019). There has been a shift in urban planning from focusing on sustainability to incorporating resilience efforts, thereby increasing the ability to respond to disturbances (Stumpp, 2013). Cities are resilient when they can persist, adapt, and transform in the face of stress and shocks, while maintaining their function and identity (Meerow & Newell, 2016). Resilient cities are concerned with, among other issues, protecting residents, especially the most vulnerable, from the effects of increasing temperatures, and more frequent and intense heat waves. The urban development literature now incorporates climate change adaptation, embracing this uncertainty and complexity (Stumpp, 2013).

Urban planners and policy makers are increasingly concerned about urban heat and its public health impacts and have made attempts to build urban heat resilience into city policies and plans. For example, the United States Environmental Protection Agency (EPA) provides guidance and tips to “reduce the heat island effect and improve your community's resilience to heat waves” (EPA, 2019). These include planting trees and other vegetation, installing green or cool roofs, using

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energy-efficient appliances, and checking in on others during high heat days. The EPA further recommends that the urban heat island be addressed through policy efforts such as tree and landscaping ordinances, comprehensive plans, zoning codes, green building programs and codes, and air quality requirements. The EPA has acknowledged the correlation between higher heat neighborhoods and the result of inequities in urban planning, development and maintenance and launched a "heat islands and equity" educational webpage to highlight heat equity solutions (EPA, 2020).

However, there is a significant gap between resilience theory and practice. The majority of adaptation actions are not plan implementation, but rather research and planning for adaptation The relative scarcity of implementation might be a result of myriad factors including lack of political will, institutional constraints, and misalliance between national policies and local action (Mortreux & Barnett, 2017). This gap could be diminished by better understanding the barriers and limits to adaptation, and how actors, the context, and the urban heat system contribute to these barriers (Moser, 2010). While poor and marginalized groups historically have suffered the most from climate impacts, they are often left out of the climate planning process, and some adaptation efforts may exacerbate existing inequalities (Jerneck & Olsson, 2008; Meerow & Mitchell, 2017; Webber, 2016). In general, climate adaptation discussions have involved government officials, universities, and environmental non-governmental organizations; however, vulnerable residents are rarely meaningfully engaged (Phadke et al., 2015).

Barriers, or obstacles to adaptation, occur during all phases of adaptation planning: understanding, planning, and managing (see Table 1). The adaptation process is hindered when there is limited understanding how the actors, the context (including governance and the human/biophysical environment), and systems interact and contribute to building (or eliminating) barriers (Moser and Ekstrom, 2010).

Encouraging transformative systems level change allows for a resilient city to transcend current unsustainable and inequitable system properties (Chelleri, 2015). Bouncing back to business as usual, in the context of urban heat, perpetuates social injustice and fosters the question of resilience for whom (Meerow & Newell, 2016). There is a disparity among urban neighborhoods with respect to access to cooling benefits in the urban landscape (Harlan et al., 2006). Historical legacies of discrimination and uneven development have resulted in communities that are highly vulnerable to heat (Harlan et al., 2019; Hoffman et al., 2020). Access to resources, such as central air conditioning, pools, and shade is deficient in these poor neighborhoods compared to more affluent communities. Further, locations for public cooling stations are not optimally sited in the highest need neighborhoods (Fraser et al., 2016).

Social capital—the shared social networks, and norms of reciprocity and trust among individuals—is comprised of bonding social capital, the links between homogeneous groups, and bridging social capital, the relationships of people with similar interests but differing social identities (Putnam, 2000). Because there is less trust and fewer networks among neighbors (bonding social capital) and less meaningful contact with decision makers (bridging social capital) in some neighborhoods, residents are unable to work collectively and advocate for heat mitigation and adaptation strategies (Harlan et al., 2015). Social capital enhances adaptation and ensures better recovery from disasters (Pelling & High, 2005) and low-income and immigrant neighborhoods have a well-connected network of family and friends, or strong bonding social capital (Hansen et al., 2014). Bridging and linking social capital allow for collective action in advocating for community improvements (Putnam, 2000). A community engagement methodology for combatting urban blight developed by Semenza et al. (2007) uses design workshops to build or reinforce social capital and increase problem-solving capacity of the project's low and middle-income participants. Bridging and linking social capital was strengthened through the permitting and municipal approval process and project construction/implementation was enhanced by collective action (Semenza et al., 2007).

Urban heat resilience is a growing issue as extreme heat kills more people in the United States than any other natural disaster (Berko et al., 2014). The World Health Organization has developed a guide for heat health action plans with an emphasis on identifying vulnerable populations, developing long-range urban planning that reduces heat exposure, and real-time surveillance and evaluation. These plans are developed at the national, regional, or state level. Heat health plans have been executed with varying degrees of success worldwide (Martinez et al., 2019); failure could be due to reduced risk perception of vulnerable populations, the inability to effectively connect with the groups that have the highest need and are hardest to reach, and limited local government involvement (Wolf et al., 2010). Despite this limited involvement, local governments are perceived to be the entities responsible for making heat health policies, are able to safeguard the interests of vulnerable populations, and are best suited to integrate heat health issues within current urban planning policies and existing health care practices (Mees et al., 2015). Local initiatives, developed by grassroots groups and the empowerment of identified vulnerable groups are keys to lessening social injustice and managing resilience transitions (Leach et al., 2012; Chelleri, 2015). Community resilience, the ability of a community to cope with external stresses and disturbances as a result of social, political, and environmental change (Adger, 2000, 347), can be either an outcome or a process and is dependent upon social resilience (Wilson, 2014). Community resilience can be enhanced by localized, nature-based solutions (NbS), which decrease vulnerability and mitigate climate change impacts (Kabisch et al., 2016). In fact, NbS can be a more effective solution than conventional approaches, such as air

Table 1
Common barriers in adaptation processes, abridged from Moser, 2010.

Phase	Process	Abridged Barriers
Understanding	Detect problem	Existence, perception, detection of signal; Threshold of concern, response need and feasibility
	Gather/use of information	Interest, consensus, accessibility, relevance, credibility and trust, legitimacy, receptivity to information, willingness and ability to use
	(Re)define problem	Threshold of response need, feasibility, level of agreement or consensus
Planning	Develop options	Leadership, ability to identify and agree on goals, range of criteria, options, control issues
	Assess options	Availability, accessibility of data, methods, legitimacy of information, agreement on assessment approach, goals, criteria and options
	Select options	Agreement on selecting options, sphere of responsibility/influence/control/Threshold of concern over potential negative consequences, perception of option feasibility, clarity of authority and responsibility
Managing	Implement options	Threshold of intent, authorization, accountability, sufficient momentum to overcome institutional barriers, path dependency, behavioral obstacles
	Monitor outcomes & environment	Existence of a monitoring plan, agreement and clarity on monitoring targets and goals, availability of economic resources, technology, data management
	Evaluate effectiveness of option	Threshold of need and feasibility of evaluation, availability of expertise, data, willingness to learn, revisit previous decisions, legal limitations, social or political feasibility of revisiting previous decisions

conditioning (European Commission, 2015).

Extending resilience from a disaster mitigation perspective to include adaptive management expands community resilience (Stumpp, 2013). Barriers to adaptation "can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc. (Moser, 2010, p. 22027). Purposeful collaborations and the collective capacity of academic, health, and environmental leaders, along with the communities themselves, to respond to the threat of increasing urban heat entails developing a coordinated adaptation plan that transcends silo-based actions and limited landscape-level strategies. The aim of the transdisciplinary research reported in this paper was to develop a methodology to engage hard-to-reach vulnerable populations to co-create locally contextual and culturally appropriate urban heat interventions to increase community resilience. This paper explores the applicability of the Moser (2010) framework to illuminate barriers for climate change adaptation for one hazard at the neighborhood scale to discover which barriers emerge and how they are articulated by residents and other stakeholders. It also explores the role of key processes that can help overcome identified barriers, including capacity building, cross-sector collaboration, and participatory research. This work is grounded in a case study in three neighborhoods in metropolitan Phoenix, Arizona.

2. Methods

The Nature's Cooling Systems project was conceived as a collaborative community engagement process designed to identify barriers to urban heat adaptation at the neighborhood scale through a series of workshops and demonstration projects. The community engagement process for the Nature's Cooling Systems project was adapted from an urban blight amelioration methodology (Semenza et al., 2007) that enhances bonding, bridging, and linking social capital, thus facilitating collective action.

The Nature's Cooling Systems community engagement methodology was iterative and consisted of four steps, engage, design, plan, implement (see Fig. 1). First, community leaders were identified and welcomed to the process through a series of educational and planning meetings. Second, design workshops were conducted in each neighborhood. Next, based on the outcome of the workshops, a heat action plan was created. The final step will be the implementation of recommendations and then, through engagement with the community afterwards, the process will begin again with current and, perhaps, new participants. This paper reports only on steps 1–3, as implementation was in the nascent stages at the time of writing this manuscript. Throughout the engagement process, demonstration projects were implemented to keep enthusiasm high, identify potential barriers, create small wins, foster new relationships, and increase accountability to communities. Concurrently, the methodology builds social capital, a missing asset in high heat-vulnerable neighborhoods (Harlan et al., 2015). Initial participation allowed for new bonding social capital to develop and, with the increased involvement of other community decision makers and experts, allowed for increased bridging and linking social capital – necessary elements for overcoming adaptation barriers.

A key component for this approach is the community-based organizations that offered credibility for the boundary/core organizations and provided critical community knowledge (see Fig. 2). The community-based organizations, using their long-standing relationships within the community, were responsible for resident recruitment, educating the neighborhood on heat action possibilities, identifying municipal and community partners for participation in workshops, selecting locations for the workshops, providing input and approval for workshop agendas, and launching demonstration projects. They were contracted to lead and train facilitators and to draw in other organizations, and they were instrumental in ensuring that community engagement was conducted in a culturally sensitive and relevant manner. During this process, workshop participants were fully supported by a networked team of urban heat experts, decision makers, and experienced community organizers. Using a networked chain approach (Lemos et al., 2014) for boundary organizations, the knowledge exchanges between residents and other stakeholders was meant to encourage future collaborations and establish supportive relationships.

Workshop participant recruiters were trained in the science of urban heat and encouraged to collect residents' stories of urban heat, coping with heat, and how these might have changed over time. These stories were used during the workshops and in meetings with project partners. A 'zine, an informational brochure, was developed to explain the urban heat island effect, extreme heat, heat waves, and public health implications and was used as a recruitment tool in each neighborhood. This information was available in both Spanish and English, reflecting the dominant languages spoken in the target neighborhoods.

A rubric utilizing the Whole Measures framework, conceived by the Center for Whole Communities (http://wholecommunities.org/), was developed to provide a highly integrated, whole-systems approach to urban conservation. The Whole Measures framework assists people working in cities to plan for, measure and evaluate the social and economic impacts of urban conservation, resilience, and sustainability work. The Whole Measures rubric was adapted to evaluate the social and economic aspects of the Nature's Cooling Systems project. Using four broad areas — justice and fairness, community engagement, economic vitality, and community resilience —the Nature's Cooling Systems core team and community-based organizations co-developed several objectives for each area and identified evaluative metrics, culminating in the rubric, Whole Measures for Urban Heat Solutions.

The Nature's Cooling Systems project used storytelling wisdom and evidence-based research to understand the current and future urban heat challenges facing residents. Storytelling, a cornerstone of the project, was consciously chosen to honor different forms of expertise, facilitate understanding of complex ideas, and level the playing field between residents, organizations, and experts. Telling stories helped to nest multiple community goals together with urban heat mitigation and adaptation and allowed for decision makers to better understand the challenges underserved communities face in dealing with urban heat. Stories are also an effective way of overcoming communication barriers by getting people comfortable using their voice with experts in the room effectively communicating about their lived experience, and building trust among collaborators (Ebi and Semenza, 2008). All workshops were simultaneously conducted in English and Spanish, using whisper translation for the minority of speakers.

2.1. Design workshops

A series of three workshops was developed to identify adaptation barriers, map local assets, generate context-specific ideas for heat mitigation and adaptation, and create intervention designs. The Nature Cooling Systems workshops were held on Saturdays, within walking distance for most residents to reduce participation barriers. Each workshop began with a detailed explanation of the technical language used for mitigating and adapting to extreme urban heat to increase fluency for residents when they move forward with proposed solutions. In an effort to jumpstart emerging solutions and foster the momentum and relationships cultivated in the workshops, demonstration projects were co-developed, and participation was welcomed. These included tree planting, shade structure, and green infrastructure projects in sites identified by workshop participants and project partners.

2.1.1. Design workshop I

The first workshop was designed to provide a local context for the issue of extreme heat from a scientific standpoint and to combine that with how residents currently and historically cope with the heat. Community members, along with all others present, shared stories about living in the desert environment and how they manage heat, as local stories were seen as important in generating an understanding of

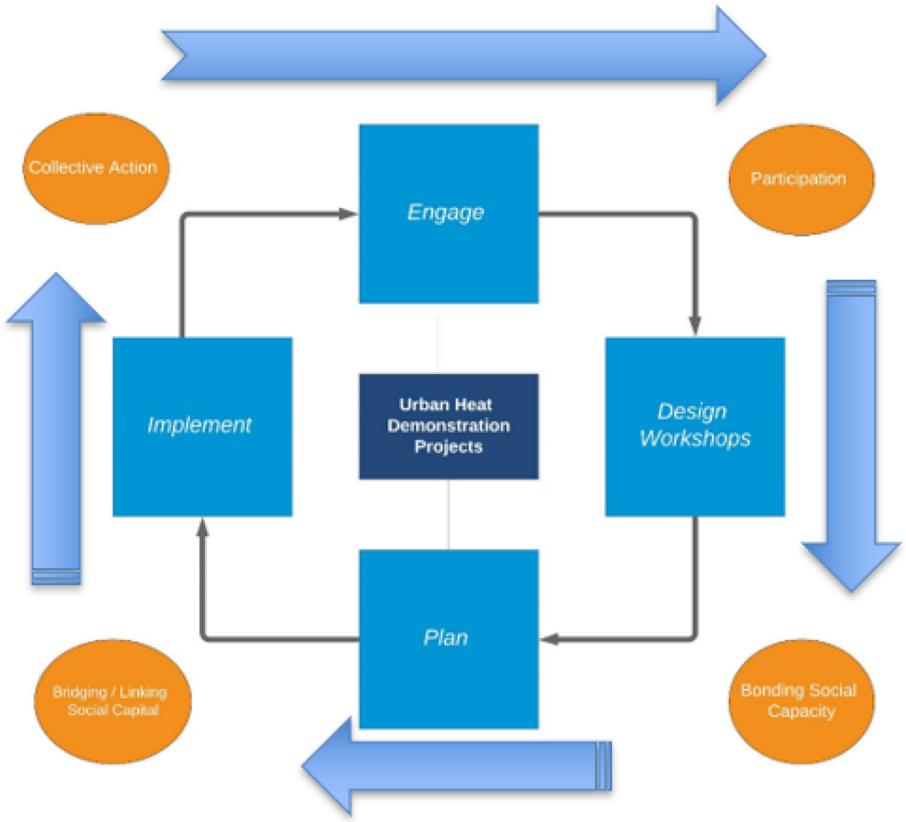

Fig. 1. Diagrammatic depiction of Nature's Cooling Systems community engagement process detailing the iterative flow and increasing social capital.

the possibilities for interventions in specific neighborhoods. Next, residents worked from large, printed neighborhood maps to highlight streets, buildings, and institutions involved in their urban heat stories. They developed asset maps of "cool spots" and exposure maps of "hot spots" to be used in later workshops. Finally, the workshop culminated with residents discussing concerns, intervention points in their neighborhood, and potential solutions. A final vote on priorities was then tallied and these became the starting point for the next workshop focused on potential solutions.

2.1.2. Design workshop II

The second workshop began with a review of project goals and collected heat stories, agreements, and an overview of the agenda for the day. The goal of this workshop was to expand upon some of the major concerns outlined by residents in the first, asset-mapping workshop. Advisors from the city streets, parks, neighborhood services, and transit departments, and the county public health department, told stories and showed pictures of their favorite cool places. After the opening exercise, experts, called advisors, sat in the center along with the facilitator and two empty chairs. This "fishbowl" format encouraged residents, some of whom have never interacted with city decision makers, to pose questions of advisors or ask for clarity on an issue. (See Fig. 3). Small group sessions followed, to further develop ideas using the cool and hot spots maps developed in the first workshop. The entire

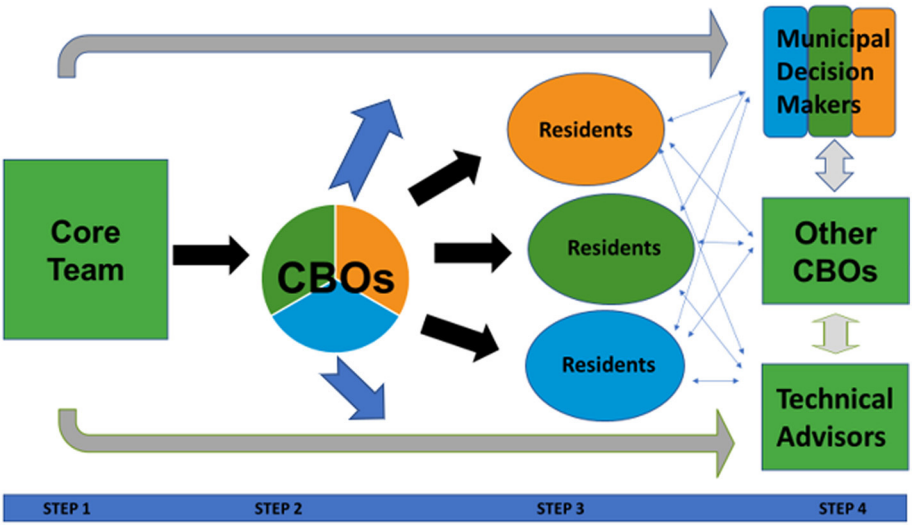

Fig. 2. Nature's Cooling Systems project stakeholder relationships in a four-step process. The core team selects community-based organizations in pilot neighborhoods who, in turn, recruit residents. Residents attend an initial workshop to develop baseline information. Subsequent workshops include a range of advisors who work directly with residents and are recruited by both the core team and the CBOs.

Fig. 3. Nature's Cooling Systems workshop in a fishbowl format with advisors in the center and residents listening to introduction. Empty chairs in the center are for residents to contribute to the discussion and pose questions.

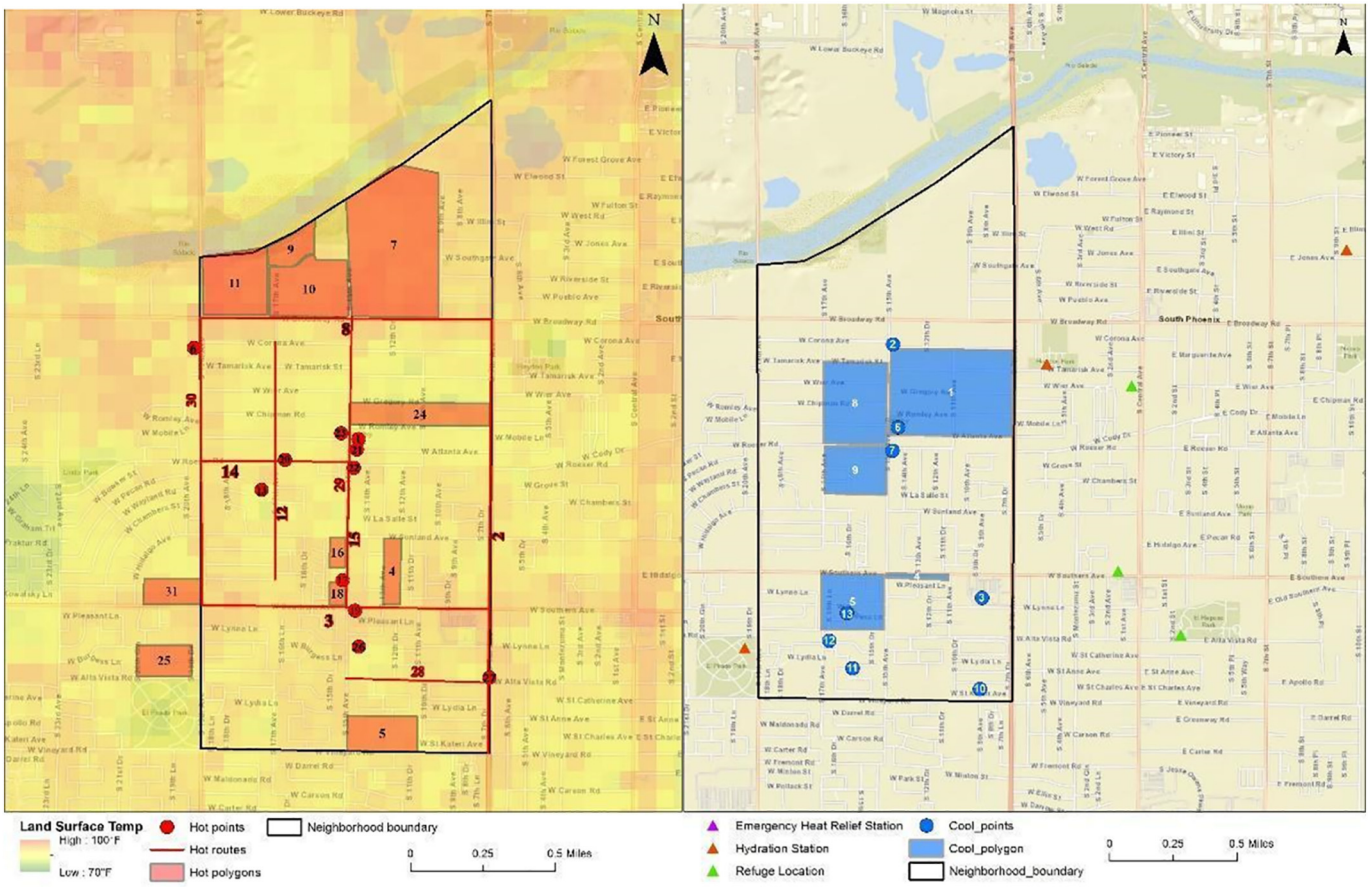

Fig. 4. Neighborhood maps with specific areas that residents highlighted as especially cool or hot (red). Major walking routes that have little to no shade were highlighted in red as well. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

group gathered for a debrief and final voting session on the appropriate next steps. (See Fig. 4:.)

2.1.3. Design workshop III

The final workshop also used the talking circle and fishbowl formats. Concepts introduced in the first two workshops were reviewed with a different set of advisors providing outside expert advice on technical issues and points of opportunity for residents to further refine ideas and feasibility. Residents were asked to consider their “concept of cool,” noting culturally significant practices, color palettes, and their "big" ideas. Designers simultaneously generated sketches to give the community a chance to provide additional feedback and an opportunity to share knowledge, concerns with proposed solutions, and skills.

2.2. Heat action plan compilation

Workshops were recorded, transcribed, and analyzed to draw out highlights and identify specific neighborhood needs and proposed

solutions. Using data collected during the workshops, heat action plans were developed for each community by community engagement leaders with input from experts, that outlined neighborhood context-specific solutions to combat the effects of extreme urban heat and reflect local knowledge and community identity. These plans were vetted by each community and will be used as the basis to advocate for providing cooling that improves public health outcomes and provides greater thermal comfort for residents. The plans were then rolled up into a regional heat action planning guide and disseminated via the project's many networks (Nature's Cooling Systems Heat Action Planning Guide https://repository.asu.edu/items/54600). A case study piloted in three neighborhoods highlighted the unique outcomes generated during the community engagement process.

2.3. Case study

Located in the hot Sonoran Desert, the Phoenix Metropolitan Area experienced an average of 110 days over 100^0 F from 1981 to 2010 (National Weath er Service, n.d.) and is home to one of the fastest growing urban heat islands (Stone et al., 2012).The Nature's Cooling Systems project was piloted in three metropolitan Phoenix neighborhoods and was led by the core team of The Nature Conservancy, Arizona State University, the Central Arizona Conservation Alliance, and the Maricopa County Department of Public Health. Workshops were held from May through September 2018.The research was approved through the Arizona State University Institutional Review Board (Study00006624). The pilot neighborhoods (see Table 2) were selected by consensus of the core team based upon an array of factors, including high urban heat exposure and sensitivity, presence of a strong community identity and entrenched community-based organizations (see Table 3), high heat mortality and morbidity, and planned or underway capital improvement projects. High heat-vulnerable communities were identified, in part, by a quantitative index and environmental variables demonstrated in the literature to be associated with higher risk (Harlan et al., 2013). Many portions of these test areas had higher surface temperatures compared to other communities, and little to no vegetation and shading.

Similar demographics can hide differences in strengths and weaknesses within an urban area, thus complicating the resilience landscape in an urban area (Chelleri et al., 2015). While these three neighborhoods are considered to be highly vulnerable to extreme heat compared to the greater Maricopa County, Arizona, differences between these communities transcend demographics and structural inequities, and reflect unique community identities and heritage.

The Edison Eastlake neighborhood located in Central Phoenix, is a largely Latino community with an elementary school, the St. Luke's Medical Center, some private homes, and the largest concentration of public housing in the City of Phoenix. Common to the other Nature's Cooling Systems neighborhoods, a history of discrimination against Latinos and other minority groups resulted in a vast disparity of investments in infrastructure and amenities compared to non-minority communities. For example, tree coverage in Edison Eastlake is 5.3%, compared to a county average of 8.8% and Phoenix Metropolitan Area tree coverage of 13% (Middel et al., 2015). In 2019, this neighborhood was the recipient of a $30 million United States Housing and Urban Development (HUD) Choice Neighborhood grant. As a result, residents have been engaged in a transformation process, which will bring much needed upgrades to the public housing sites, improved public spaces, added trees and vegetation, and public transit options.

The Water Tower Improvement District is located in west Mesa and is a historically Latino, working-class neighborhood where residents worked in the citrus groves and were laborers during the agricultural days of Mesa. The light rail has been extended into the downtown Main Street area and transit-oriented development is flourishing, attracting a more affluent base, but potentially uprooting residents through gentrification.

The Lindo-Roesley neighborhood in South Phoenix is near to, but not in, a planned light rail expansion along Central Avenue. This community has a history of environmental injustice as a consequence of local manufacturing sited within the residential area owing to lax (or no) zoning (York et al., 2014), with brownfields and contaminated sites dotting the community.

Table 2
Demographic composition of pilot neighborhoods.
Source: United States Census, 2010.

	Edison/ Eastlake	Water Tower Improvement District	Lindo/ Roesley Park	Maricopa County
Households (HH)				
Number of HH	1884	2935	2765	1,442,518
Median Income	$10,708	$29,870	$37,345	$53,596
Owner occupied	16%	35%	58%	63%
Residents				
Total Population	6134	10,439	11,440	4,018,143
Aged 65 +	5%	5%	7%	13%
White	51%	75%	62%	80%
Black	7%	1%	18%	5%
Hispanic	76%	70%	71%	30%
Foreign born	29%	35%	28%	15%
Use public transportation	7%	3%	3%	2%

3. Results

3.1. Overview

The final heat action plans reflected the unique community priorities for each of the three pilot neighborhoods with culturally appropriate pathways. These plans went beyond typical heat mitigation recommendations of adding more shade, installing cool or green roofs, and using 'cooler' materials. The Nature's Cooling Systems process revealed deep inequities and communication/relational barriers that transcend specific urban heat issues and show how any suggested urban heat mitigation must also address issues of poverty, distribution of city services, and access to public infrastructure. Barriers during the "understanding" phase included threshold of the response needed, detection and perception of a signal, initial framing as a problem, accessibility of information, and establishing credibility and trust.

Overall, the process engaged more than 200 participants in the nine workshops and seven demonstration projects, and it also attracted supporting partners. To date, more than 3000 flyers, 600 community notices, and 300 brochures were distributed. Most importantly, relationships between stakeholders have been built and strengthened over the course of this process, enabling continuing collaboration on the heat action work.

Initially, dialogue at the workshops revealed that residents detected a problem yet were unaware of the threshold of response and threshold of feasibility. Community members knew that their neighborhoods are hotter than when they were children and shared vivid stories about how coping has changed over time.

> "I'm a native Phoenician. I've been here all my life. It is much hotter today, than it was when I was a kid. …Literally, we would run around barefooted all the time when I was a kid. We would go to the recreation department and we would just run from shadow to shadow underneath trees, running from grass patch to grass patch to get to the park. I don't see that happening nowadays, that kind of youthful experience I had."
>
> Workshop participant

Scientists and experts followed resident cues related to problem detection and parlayed their information in a storytelling format,

Table 3
Overview of pilot neighborhoods and Community Based Organizations (CBO).

	Edison/Eastlake	Water Tower Improvement District	Lindo/Roesley Park
Neighborhood Identity	Recipient of $30 M HUD grant, largest concentration of public housing in Phoenix	Burgeoning city adjacent to Phoenix. Light rail extension along Main Street bringing urban development and end-of-line transit/quality of life issues	Light rail extension threatens rich Hispanic and farming cultural identity and encourages gentrification
CBO	Phoenix Revitalization Corporation (PRC)	RAILMesa	Puente Movement
CBO Identity	Empowering a Resident Leadership Council to ensure transition has resident input	Residents, artists, local business owners leading grassroots efforts	Grassroots collaborator and community leader on social justice issues

setting the issue into a local context that non-experts can more easily access (Ebi & Semenza, 2008). Climate science was stripped of its jargon and put into a standard format — a story — that people generally relate to better. Below is an excerpt of the climate story by a university professor.

> "Now, instead of imagining that you are a person going for a barefoot walk on a hot day – imagine that you are a giant trying to make your way across the city. You as a giant would do the same thing, trying to find the surfaces that were a little bit cooler or hotter than others as you make your way across the city. You'd find some neighborhoods to step in that were a bit cooler, and the reason that some neighborhoods are hotter or cooler than others is because they have different materials. You as a giant would probably try to step on neighborhoods that had more trees and shade and less roads and parking lots."
>
> Academic partner/core team presenter at the workshops

This personalized the issue, overcoming the barriers of accessibility of information, salience/relevance, and increased community members' receptivity and willingness to use the information presented. Community members understood the local implications of increasing urban temperatures and could see from a surface temperature map that their neighborhood was so much hotter compared to surrounding communities. By tailoring a larger discussion about urban heat and its drivers to the local context, residents could see how they could tackle urban heat in their community. Information, once presented in an understandable format, produced a threshold of concern and a level of consensus to act collectively, an important step in the process to overcome barriers to change (Moser, 2010). During the workshops, residents shared their belief that experts should have the answers and yet experts shared that they need help to better understand the problem and to learn how larger ideas can be executed locally. Wisdom was equally exchanged.

3.2. Developing/assessing options: making urban heat solutions hyper-local

The Nature's Cooling Systems workshops developed two maps for each neighborhood that will assist policymakers in understanding locations that residents perceive are the hottest and coolest areas within their communities. These hot spots and cool spots maps became the foundation for developing appropriate interventions and will assist in the execution of existing strategies, such as the City of Phoenix Tree and Shade Master plan. For example, while all communities wanted more trees and shade within their neighborhoods, some prioritized walking paths to public transportation nodes and others prioritized routes where children are walking to school.

Access to drinking water was an issue for participants even though local urban legend often quotes an Arizona law requiring businesses to provide the public with free water. No such law exists.

> "My children have disabilities and we go to their appointments and it takes me two hours and a half to get to their appointments, two hours and half to come back from their appointments, and I bring ten water bottles. We finish the water, but there are no places to drink water. What can the city do for people like us that are out on the street and we need to drink water?"
>
> Workshop participant

Drinking water, especially bottle refilling stations, were requested at transit stops, in parks, and along highly trafficked pedestrian routes. Bus stops, sometimes a signpost in the ground in these neighborhoods, could be transformed into cooling/shade stops that provide relief for walkers as well as transit riders.

Along with drinking water, residents expressed a need for splash pads, sprinklers, and fountains in public spaces to provide relief from the heat. Public pools, none of which are available in the project neighborhoods, are closed in the evening and could stay open later as it is still hot well into the evening hours.

> "But the one thing I can tell you, is I was at CityScape one day, and it was blazing hot that day, and I remember that I was looking at those water features going up and down in the middle of the park there, and just looking at those things made me feel cooler. That was one thought I had. I remember, how can I feel cooler when I'm just looking at it, but it felt like that. I think part of it was an emotional feeling."
>
> Community-based organizer

Residents requested advocacy training to help them better understand how to navigate the existing system to ensure that their neighborhoods get resources similar to those of other communities to battle the extreme heat. Table 4 details the strategic priorities for neighborhood participants for providing greater thermal comfort during high heat periods.

4. Discussion

The workshops and creation of heat action plans were not without challenges. Similar to Moser's (2010) common barriers in the "understanding" phase, there were signals for urban heat adaptation that needed to be addressed before being able to develop a science-based, community-inspired heat action plan. Residents did not see a solution pathway, or the threshold of response need and feasibility, and, therefore, heat was not a top-of-mind concern. At the beginning of the engagement process, residents from the three pilot communities commonly believed that the extreme heat was "just the way it was" and that there was little that they could do to change their situations, despite their neighborhoods being the hottest in metropolitan Phoenix. There was a limited understanding of the science and drivers for increasing urban heat and evidence-based urban heat solutions. They did not make the connection as to how increased urban heat was impacting their health, quality of life, and personal economic situation.

> With conversations with neighbors in South Phoenix, what is very interesting to me is that they say, "Oh it's hot, that's normal. And I think that's the interesting part of the conversation. It is hot, but it's not normal. There is something that we can do."
>
> Community-based organizer

This fatalist and normative approach made initial recruitment for the workshop a challenge but also became an educational opportunity

Table 4
Resident visions and priorities for cooling and urban heat safety.

Intervention	Edison/Eastlake	Water Tower Improvement District	Lindo/Roesley Park
Provide more shade and reduce exposure	Shade on public transit routes Improvements along vacant lots	Shade along school routes Reduce pedestrian exposure at long traffic intersections; better connectivity to broader transportation routes	Shade along school routes Reduce vacant lots and their dust Tackle stormwater and shading in a systems manner by installing green infrastructure on streets that flood
Provide drinking water	Drinking water available at 1/2 mile intervals	Access to drinking water	Add shade rest stops that have drinking water and benches at 1/2 mile intervals
Provide cooling opportunities	Providing sprinklers or longer hours at the nearby public pool	A public water feature within a 10-minute walk including splash pads, pools, sprinklers for kids, fountains in public spaces	Add more cool spots and public places to cool down such as shaded parks, splash pads, or community centers
Advocacy training		Advocacy training for urban heat solutions	Advocacy training for urban heat solutions
Target priorities	Emphasis on the elderly and those with disabilities	Emphasis on children and elderly, especially those living alone	Emphasis on children and elderly
Preventative measures/ information programs	Preventative warning system for extreme heat Heat health emergency first aid training certification "End of School" training for K-12 students to stay safe during summer heat	Reusable water bottle giveaway for all students and ensure they don't leave school without it filled up Emergency Summer Plan for K-12 students and adults in the community to raise awareness of cooling opportunities and heat safety actions	Provide an air-conditioned Senior Center
Funding assistance	Assistance in managing the high cost of indoor cooling	Community fund for tree maintenance and planting	Community fund for tree maintenance and planting Install better insulation to poor quality housing to reduce electricity bills

and an organizing principle. After the community-based organizations explained how there are solutions available to increase thermal comfort, improve public health outcomes, and decrease expenditures for cooling and related expenses, residents were intrigued to learn more and try to help their community. The residents' understanding of the complexity of urban heat and solutions available changed over time, most noticeably within the first 30 min of the first workshop. It was important to have the residents shift their level of concern about urban heat and the need to act to address this growing problem, a first step in Moser's "understanding" phase of the adaptation process.

Throughout the engagement process, barriers emerged that required the team to address before moving on to the next step. The core team and community-based organizations were intentionally open to adjusting this process based on newly identified barriers, new learning, and neighborhood differences. This openness to an iterative process helped to ensure increasing participation and success.

4.1. Developing options: the impact of inequities over time

Once residents learned how high the surface temperatures were in their neighborhoods due to limited vegetation, engineered shade, or other cooling features, they were surprised to find out just how much hotter their neighborhoods were compared to others, reflecting historical discrimination patterns (Harlan et al., 2006, 2019).They were aware that neighboring communities had shade trees, parks with splash pads, and drinking water, even for dogs, but the impact of not having these features was greater than a lack of thermal comfort; residents are enduring a more intense heat in their environment. Having access to cooling features that provide greater thermal comfort and lessen the surface temperature of their neighborhoods became an advocacy priority to ensure that grassroots voices are incorporated into future urban planning (Phadke et al., 2015).

These revelations led to heat-health safety discussions and revealed that current heat intervention programs are not fully serving these neighborhoods. Residents and the core team discovered that there are no official cooling centers within walking distance in these three highly vulnerable neighborhoods. Residents used de facto cooling centers by visiting the library and by going to the movies and malls. Most of these options required spending money to obtain a respite from the heat, whether it was admission fees or transportation costs to get there. Further, as previously stated, drinking water is not available along pedestrian routes compounding exposure and heat health safety issues.

Residents wanted more public health training focusing on urban heat in their environments similar to a First-Aid certification and applicable to situations that they face every day, rather than the often-publicized precautions about hiking in extreme temperatures. One resident suggested educating each other to be able to respond quickly to a heat-related health crisis.

> "What I mean by that is something similar to how you can be certified and take classes on CPR or first aid. I think they should also have training where you can be certified in heat, you become a heat expert or maybe there's a better terminology for that but, heat responder? Something, you know not necessarily fire but more heat, and understanding how you can care for someone or take care of someone when they're dehydrated, when they have heat exhaustion, and that's completely relevant to every day."
>
> Workshop participant

Public health information is not reaching these residents despite Maricopa County Department of Public Health and other organizations making copious materials available on preventing heat stroke and heat exhaustion, another instance where the "signal" was not reaching stakeholders (Moser, 2010). However, most had never seen the heat health flyer or similar information distributed through the county website and other channels, reflecting the current disconnect between heat-vulnerable resident needs and government efforts (Mees et al., 2015).

4.2. Lessons learned

4.2.1. Credibility and trust: the essential component – community-based organizations

Community-based organizations were the key to connecting residents with the core team and other stakeholders in this engagement process. They understand the unique history of the neighborhoods, who the key players were, past relationships, promises kept and broken, and where opportunities exist. The community-based organizations (CBO)

in this project were as different as the neighborhoods they served. One CBO was a corporation serving municipalities in other states with many employees, another was a "ragtag group of volunteers" with no employees at the beginning of this process. CBO work styles also differed and, as a result, the core team needed to be flexible and the process adapted accordingly.

Working collaboratively was a learning process for many involved in this project. It is one thing to say community voice matters, but another to set up the process so that everyone can contribute effectively. CBOs pointed out that residents would be attending workshops to learn from experts and may have had the opinion that experts have the answers. The workshops were planned to include experts, consciously called 'advisors' during the workshops. Advisors parlayed information which, when combined with resident experience, produced proposed solutions. As a result, residents felt that they were listened to and heard.

One CBO discussed how this represented a shift from how the organization normally operates and required some adjustments.

> "This is a very new process, from my perspective, because in South Phoenix and the community I mostly work with, it is confrontational. Talking about heat is not very romantic but super necessary. People were able to ask the city and county about this. I think this was something different and amazing."
>
> Community-based organizer

The CBOs agreed that residents felt heard during this process and overcame the initial feelings of being intimidated by experts in the room. The feelings of intimidation were echoed by the urban heat professionals, too. It is one thing to understand how the urban heat science works but to be in a room with people who are experiencing heat, often in catastrophic ways, was humbling and powerful. This process helped to build trust between the groups quickly. The leadership of the CBOs, combined with skilled facilitators, and active participation by a range of decision makers, provided the forum to produce contextually appropriate urban heat solutions and minimized barriers in the planning stage. Community organizing and advocacy by the residents and community-based organizations will be crucial to success in creating a more thermally comfortable future in these neighborhoods.

4.2.2. Assessing options: ensuring meaningful interaction

Building community resilience by improving adaptive capacity is dependent upon the community having the scientific and process knowledge and motivation to advocate for change (Wilson, 2014). Workshop participants, beyond the community-based organization personnel, had extremely limited interactions with city decision makers regarding urban heat interventions prior to this project, or any topic for that matter. The "fishbowl" offered the first time to ask questions of city managers for many workshop participants. The lack of involvement on the part of residents may reflect lack of knowledge about pathways for participation rather than lack of interest or ability to get involved in government affairs. The actors in this process and the dominant governance structures needed to change to build urban heat mitigation and adaptation plans that reflect both community needs and feasible municipal options.

In the second and third workshops, where subject experts and city officials were invited to be involved in the community process, it became apparent that there was a sense of frustration from both residents and decision makers regarding community engagement on public projects that were taking place in or near these communities. In all of the neighborhoods the city officials had reached out through established channels for community input for an array of projects: community redevelopment, park improvements, and a redesign of the community center property. While residents from the Edison Eastlake neighborhood were involved in some of the outreach, none of the residents participating in the Nature's Cooling Systems project from the other two communities were involved in the outreach or, in some cases, even aware that community input had been solicited. There was a barrier between residents and officials with many nuanced reasons that rise above the claims that "we held the event, and very, very few people came."

> "I think that there's a really large, cultural and language barrier in this area, and I think that people don't engage with us because they don't think we speak their language. So they think that we don't understand what's going on, but we do. (That) affects us, and I think that there needs to be education, like they mentioned earlier, on both sides. That they need to understand us, and we need to understand them. There needs to be some sort of communication and engagement with the community here, 'cause it seems like there's been a lack of it."
>
> Workshop participant

Residents stated that they want to be involved but have limited knowledge of the process, timelines, options for contributing and access points to have their voices heard and acknowledged. City officials explained how to be involved in the various city council, zoning, and planning board meetings, and how to meet with city department heads to have their concerns understood. Residents explained that they do not feel comfortable meeting in government offices and formal venues, and that if the city wanted to better serve them, they needed to meet in their neighborhoods, in their language, and at appropriate (working class) times.

The difference between lengthy time frames required for city planning and resident needs for immediate change creates another point of friction. Residents want changes implemented within a very short time frame, one to three years. Yet planning and funding cycles for projects necessitate a much longer time frame of five or more years. What seems like inaction sometimes reflects the longer planning horizon. The continuous integration of differing needs, acknowledging the complexity of addressing urban heat in a systems manner, addressing uneven climate impacts and incorporating grassroots wisdom into the planning processes will help shift risk/disaster management to resilience management (Stumpp, 2013).This may not be easy, but will be necessary to ensure social justice and systems level change.

4.2.3. Selecting options: increasing agency

The Nature's Cooling System methodology helped to generate agency and social cohesion. Residents felt a strong sense of community identity yet involvement in formal advocacy projects is low. Storytelling helped to establish trust and social cohesion among groups that were not known to each other prior to the workshop. It also helped to motivate each resident to do something about the dire situation in their community, especially when solutions are apparent in nearby neighborhoods or when, with a few tweaks, they could piggyback on existing projects underway.

> "And what we had said earlier about the bench but no shade on it, made me kind of wonder, I'm going to go back and take a look at those plans, and I'd be happy to bring them to the next meeting … tell me where you want the trees and we can actually view that. Whether it's on the walking path or on the benches, … but you guys will have an opportunity to actually be involved in what that looks like. So next meeting, I will definitely bring the plans down and take a look at where the trees are going to be put, and if you want to change it, we're going to change it."
>
> Municipal employee

This quote from a city official was the beginning of a shift in the workshops from different stakeholders stating their positions to working collaboratively together to find equitable solutions. After the formulation of the heat action plans, management and executive responsibility and generating momentum for this project shifted from the core team of The Nature Conservancy, Arizona State University, and the Maricopa County Department of Health to the community-based organizations, residents, and municipal decision makers, albeit with

differing intensity and buy-in.

4.2.4. Barriers to cooling for residents

Residents of the three neighborhoods have limited resources to develop heat solutions at the individual and household level. They are often in a difficult situation, having to choose between negative options. Staying indoors is an effective strategy to avoid high outdoor temperatures but exposure may still be high if air conditioning is unaffordable. Although adding trees and shade features is desirable, again, that can be too high of an expense or, as in the case of renters, out of their control. Quality of life is negatively impacted, and subsequent emotional stress lessens the ability to cope appropriately.

> "I think also, working with residents all over the city, one of the things that it was interesting, the residents told us when they said, quote 'no meetings in the summer' end quote. They also said, "if we come to a meeting in the summer, we're just going to be irritable and non-productive."
>
> Community-based organizer

To escape the intense heat, many leave town. Those that can take a day trip or spend the weekend in the surrounding mountain communities during extreme heat periods. Taking trips requires having disposable income to spend, access to transportation, a place to stay, and time off from work and other responsibilities– luxuries that are not available to all residents. While temporary escapes provide relief from the heat, they do not address the core issue of compromised thermal comfort in neighborhoods and homes.

Policy recommendations by the EPA to address urban health through tree and landscaping programs have not been implemented in these neighborhoods, despite the approval of local plans. These efforts, such as the City of Phoenix Tree and Shade Master Plan, tend to have broad unfunded or underfunded goals such as achieving at 25% shade cover by 2030 and they do not provide specific interventions in the highest need communities. Landlords have no incentive to maintain trees, and renters, even while knowing that trees could help lower electricity bills, are unwilling to take on this added expense. Those who do own homes and, thus, control decision making about outdoor landscaping, also cited obstacles. While the local utility provides free trees for homeowners, the tree itself is a small portion of the costs of providing shade on residents' property. Residents are unable to afford the added expenses of watering and maintaining trees. In parts of the neighborhoods with older trees, many are dying from lack of maintenance and residents do not have funds to remove dead trees, compounding an already hazardous condition. New trees are not desired until the old, dead trees can be removed.

Residents would like to see a community tree fund developed that would help to maintain these large shade trees, assist with the financial burden of removing the dead trees, and encourage the planting of new trees. This fund can also be used for people who own land but do not have the resources to install shade features such as trees, benches, and engineered shade structures on heavily trafficked pedestrian routes. Landowners could agree to install a rest stop on their property to encourage neighbors to cool down and stay safe before continuing on their way. In the Roesley/Lindo Park neighborhood, residents wanted to use traditional practices to maintain trees in an arid environment such as using ollas, large ceramic pots planted near trees that slowly release water. This community tree fund could also include providing a community watering truck to ensure that trees are properly maintained. These are examples of nature-based solutions, found to build community and urban resilience through the provision of ecosystem services - provisioning, regulating, cultural, and supporting (Gómez-Baggethun et al., 2013). Residents spoke of trees not only as a provisioning resource (shade) or regulating resource (temperature), but as importantly as a cultural resource, providing connections to neighbors, land, even ancestors. While city officials had previously identified trees as an important urban heat solution, here residents identified more feasible and culturally-appropriate ways of applying nature-based solutions in their neighborhoods.

4.2.5. Additional barriers: slow process

Moser (2010) points to the importance of not skipping over steps in the framework as that will have unintended consequences further along the adaptation process. It is important to note that community heat awareness and active participation is a slow process, yet we consciously did not shortchange any methodological steps. In the beginning of the project, the community canvassers struggled with talking about extreme urban heat in an actionable way and that required extra time to educate the team on the science driving increasing urban heat and evidence-based solutions. Further, technical team members made a conscious effort to communicate in a manner that is easily understood by residents and each other, which required extra time as well. The extra time investment was worthwhile because leaders of community-based organizations testified that this was the first time they had truly understood climate science and its local effects.

Participation levels were also a slow build and it was a challenge to reach the right people interested in participating in the workshops and in advocating for the implementation of the heat action plans. It takes time to involve residents and other community-based organizations working in these neighborhoods. It was more fruitful, in some cases, to target people who were active in other projects and draw them into the Nature's Cooling Systems project to increase community participation and this method could have been used more strategically from the project's initiation. Another consideration would have been to connect with more than one community-based organization to co-lead the process in each neighborhood, thus increasing the potential participation pool.

It was important to establish a sense of trust by allowing everyone present to introduce themselves and speak about their urban heat story before embarking on the planned agenda. Even though each speaker had a time limit, working in two languages simultaneously required waiting for translation. This became an added time challenge because, due to cultural norms, workshops never began on time. The workshops were conducted at the speed of trust (Covey, 2008), which takes time.

The Moser framework for diagnosing barriers to climate change adaptation was applicable to the methodology used for the Nature's Cooling Systems process. In the "understanding" phase, detecting signals, raising the level of concern, establishing trust, and presenting concepts in a storytelling format, made the subsequent planning workshops more productive. The planning phase was a collaborative learning process to balance competing options for urban heat adaptation, while also sharing in decision-making and control of the process. Working through barriers, especially those that arose during the demonstration projects, allowed for better planning engagement. Accordingly, we would adapt Moser's phases and subprocesses diagram to add demonstration projects as a check in for each phase (understanding, planning, managing) of the adaptation process. We would also add barriers to participation, especially for the most vulnerable population, to be considered prior to adaptation engagement.

The residents, CBOs, core team, and advisors came to understand that this methodology is another, different, way of approaching community engagement and advocating for solutions.

> "The practitioners, the researchers, the community organizers, the residents, the city decision people got out of some established patterns and comfort zones they usually work through and produced something really unique."
>
> Core team member

Engaging in a collaborative manner takes extra time, requires extra effort to better understand other stakeholders, and helps to produce new, emerging leaders for adaptation and other relevant issues in each community.

5. Conclusions

The success of the Nature's Cooling Systems project is not measured solely by the production of a co-created community heat action planning document but also by increased awareness of extreme heat issues, leadership development, the ability to effectively communicate complex climate science issues and its impacts, and by increased community agency to advocate for potential solutions. The methodology, which included planning meetings, workshops, demonstration projects, and compilation of heat action plans, provided opportunities for the community to act more cohesively and collaboratively. The deliberate steps outlined in the methodology allow for addressing barriers and working through them, especially during the implementation of demonstration projects during this engagement period. Barriers emerged at the understanding and planning phases, but with demonstration projects, open communication, trust and the willingness to adapt our process, they were addressed and overcome.

Just as there is not a one-size -fits-all way to overcome adaptation barriers (Moser, 2010), it is important that decision makers not treat the final heat action plans as a one-size-fits-all plan that can be used in other communities. The three highly heat-vulnerable communities in the case study revealed a range of characteristics, needs, and values, and other heat-vulnerable communities will also have unique features, history, and cultural identities. The *process*, however, will be applicable to other neighborhoods.

> "The neighborhoods that need the most help are often the most difficult to reach. This creates a cycle of not getting the help they need. What we can do is to try to continue to strengthen and empower them to be the voice to do greater things for the neighborhood. That sense of empowerment can make the difference, instead of being at the mercy of just living our existence and hoping it's going to turn out okay."
>
> Community-based organizer

The ultimate measures of success are the uptake of the heat action plan recommendations including neighborhood actions, reinforcement of social networks, and the implementation of policies that will advance adaptation in practice by city decision makers, funders, and additional communities. The next five years will be an opportunity to measure whether the community-based organizations have embraced a leadership role in heat mitigation and adaptation, the impact on heat-related public health in these communities, and whether desired interventions have been successfully implemented.

CRediT authorship contribution statement

Building community heat action plans.

Melissa Guardaro: conceptualization, methodology, investigation, formal analysis, resources, data curation, writing-original draft, writing-review and editing, project administration.

Maggie Messerschmidt - conceptualization, methodology, investigation, resources, writing-original draft, supervision, project administration, funding acquisition.

David Hondula - conceptualization, investigation, resources, writing-original draft, writing- review and editing, supervision, project administration.

Nancy Grimm – conceptualization, writing- original draft, supervision, funding acquisition.

Charles Redman – writing – original draft, supervision, funding acquisition.

Declaration of competing interest

None.

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