Exploring the Relationship Between Social Capital and Vulnerability to Extreme Heat

by

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ABSTRACT

Urban heat is a growing problem that impacts public health, water and energy use, and the economy and affects population subgroups differently. Exposure and sensitivity, two key factors in determining vulnerability, have been widely researched. This dissertation focuses on the adaptive capacity component of heat vulnerability at the individual, household, and community scale. Using a mixed methods approach and metropolitan Phoenix as a test site, I explored how vulnerable communities understand and adapt to increasing extreme urban heat to uncover adaptive capacity that is not being operationalized well through current heat vulnerability frameworks. Twenty-three open-ended interviews were conducted where residents were encouraged to tell their stories about past and present extreme heat adaptive capacity behaviors. A community-based participatory research project consisting of three workshops and demonstration projects was piloted in three underserved neighborhoods to address urban heat on a local scale and collaboratively create community heat action plans. Last, a practitioner stakeholder meeting was held to discuss how the heat action plans will be integrated into other community efforts. Using data from the interviews, workshops, and stakeholder meeting, social capital was examined in the context of urban heat. Although social capital has been measured in a multitude of ways to gauge social relationships, trust, and reciprocity within a community, it is situational and reflects a position within the formal and informal aspects of any issue. Three narratives emerged from the interviews illuminating differentiated capacities to cope with urban heat: heat is an inconvenience, heat is a manageable problem, and heat is a catastrophe. For each of these narratives, generic adaptive capacity is impacted differently by specific heat adaptive capacity. The heat

action plan workshops generated hyper-local heat solutions that reflected the neighborhoods' different identities. Community-based organizations were instrumental in the success of this program. Social capital indicators were developed specific to urban heat that rely on heavily on family and personal relationships, attitudes and beliefs, perceived support, network size and community engagement. This research highlights how extreme heat vulnerability may need to be rethought to capture adaptive capacity nuances and the dynamic structure of who is vulnerable under what circumstances.

DEDICATION

This dissertation is dedicated to my husband, Ed, who makes all my dreams a reality.

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TABLE OF CONTENTS

Page

LIST OF TABLES viii

LIST OF FIGURES ix

CHAPTER

1 INTRODUCTION 1

Implications for Practice 4

Research Objectives 5

Research Questions 6

References 9

2 BUILDING COMMUNITY HEAT ACTION PLANS STORY BY STORY: A THREE NEIGHBORHOOD CASE STUDY 12

Introduction 13

Methods 16

Case Study 24

Results 28

Discussion 40

Conclusions 45

References 48

3 ADAPTIVE CAPACITY TO EXTREME URBAN HEAT: THE DYNAMICS OF DIFFERING NARRATIVES 51

Introduction 52

Methodology 56

CHAPTER Page

Results....60

Discussion....79

Conclusions....88

References....90

4 SOCIAL CAPITAL: IMPROVING COMMUNITY CAPACITY TO RESPOND TO URBAN HEAT....94

Introduction....94

Methodology....102

Results....106

Discussion....114

Conclusions....125

References....127

5 CONCLUSION....132

Intellectual Contribution....132

Summary of Key Findings....133

Implications for the Future....137

References....140

REFERENCES....141

APPENDIX Page

A. DEMOGRAPHIC DATA FOR ADAPTIVE CAPACITY TO EXTREME HEAT NARRATIVES……151

B. OECD ADAPTED EFFECTIVE SOCIAL CAPITAL INDICATOR CATEGORIES FOR URBAN HEAT..... 162

C. EFFECTIVE SOCIAL CAPITAL FOR URBAN HEAT (ESCUH) INDICATORS AND SUPPORTING SURVEY QUESTIONS 164

D. INSTITUTIONAL REVIEW BOARD APPROVAL 169

LIST OF TABLES

Table Page

1. Demographic Composition of Pilot Neighborhoods 25

2. Overview of Pilot Neighborhoods and Community Based Organizations (CBO)….

.....27

3. Resident Visions and Priorities for Cooling and Urban Heat Safety 34

4. Individual Adaptive Capacity in General and Specifically to Urban Heat.....55

5. Themes That Emerged in the Second Round of Coding 62

6. Overview of Differing Narratives Regarding Urban Heat by Category 68

7. Adaptive Capicity to Urban Heat Matrix by Narrative.....84

8. Indicators for Effective Social Capital for Urban Heat (ESCUH).....116

9. Strong and Weak Tie Measurements for Understanding Household

and Community Social Capital Strength 118

10. Framework for Effective Social Capital Indicators for Urban Heat.....125

LIST OF FIGURES

Figure Page

1. Diagrammatic Depiction of Nature's Cooling Systems Community Engagement Process....18
2. Nature's Cooling Systems Project Stakeholder Relationships in a Four-step Process....20
3. Nature's Cooling Systems Workshop in a Fishbowl Format 23
4. Neighborhood Maps with Specific Areas that Residents Highlighted as Especially Cool or Hot 32
5. Adaptive and Generic Capacity Feedbacks and Trade-offs by Narratives 83

CHAPTER 1

INTRODUCTION

Urban heat is a growing problem with implications for public health, water and energy use, and the economy, and affects population subgroups differently. Urban heat is a result of urbanization which contributes to urban heat islands, microclimates that are dependent on the urban form, shade, ground cover, wind patterns and materials (Oke, 2017). Increasing extreme heat, a result of climate change, exacerbates this problem. In the Southwest region, temperatures are expected to rise by 2.5-5.5º F by 2045 (National Climate Assessment, 2018).

Vulnerability to urban heat and extreme heat events is a complex interaction of *exposure* (weather conditions exacerbated by urban materials and vegetation), *sensitivity* (the extent to which a system can absorb impacts without suffering harm), and *adaptive capacity* (the ability to modify features or behaviors to cope with existing and anticipated stress (Wilhelmi, 2010)). Indices have been developed that map socio-economic factors against the urban landscape to spatially identify heat-vulnerable populations (Reid, 2009; Wilhelmi, 2010; Harlan, 2012; Hayden, 2011). These tools, while a step forward, do not identify how behavior is constrained by institutional factors, perception of heat risk, receptivity to adaptation and mitigation options, and the skills and resources available to cope with increasing temperatures. Sometimes conflicting maps are produced depending upon the weight and inclusion of certain variables. This can be confusing to practitioners and, as a result, these analyses have not had a substantial influence on policy making (Wolf, 2015).

Lower socioeconomic groups, those living in areas with limited access to cooling benefits, the elderly, ethnic minority groups and those with pre-existing medical conditions such as diabetes and cardiovascular disease, are especially vulnerable to urban heat (Harlan, 2006; Harlan, Declet-Barreto, Stefanov, & Petitti, 2013). Access to resources, such as central air conditioning, pools, and shade in these neighborhoods are deficient compared to more affluent communities. Due to less trust and networks among neighbors (bonding social capital) and less meaningful contact with decision makers (bridging social capital), residents are unable to work collectively and advocate for heat mitigation and adaptation strategies (Harlan, 2015).

Adaptive capacity and its relationship to vulnerability has not been fully explained (Sheridan, 2007; Hayden, 2011). Generic adaptive capacity indicators such as income, education, and health may be a less appropriate a gauge for urban heat, compared to specific adaptive capacity, the tools and skills needed to anticipate and respond to specific climate hazards (Eakin, Lemos & Nelson, 2014). There is a need to better understand vulnerable populations' specific urban heat adaptive capacity to urban heat and the subsequent trade-offs and impacts to their generic adaptive capacity.

Another component of adaptive capacity is social capital, the shared social networks, and norms of reciprocity and trust among individuals (Putnam, 2000). Social capital enhances adaptation and ensures better recovery from disasters (Pelling & High, 2005) and strong social ties are usually protective behaviors (Harlan, 2007). Neighborhoods with stronger ties had better social support and lower mortality during the 1995 Chicago heat wave (Klinenberg, 2002). Strong community networks indicate that residents cooperate, trust, and help each other (Harlan, 2006). Proxies for this in previous

research are residential housing tenure, the amount of vacant lots, and social relationships with neighbors (Chuang, 2015, Harlan, 2006). These questions, however, do not delve into the positional relationships of vulnerable populations to other groups, the strength of relationships within the wider community, and the trust in institutions that enhance household level adaptive capacity.

Social capital has two dimensions: the extent the community is capable of collective action and whether they have agency to choose to apply their abilities (de Souza Briggs, 2008). While social networks play a role in an individual's adaptive capacity to heatwaves, this does not always translate into a community-wide response (Zografos, 2016). Social capital in the United States has eroded overall but this erosion is most pronounced in low income neighborhoods where the majority of residents have a high school education or less, are blue collar or service sector workers, and are single parent households (Murray, 2012). Further, social capital is measured to be the lowest in the Southern states from Arizona to Florida, regions with highest and longest periods of high temperatures (Social Capital Project, 2018).

In general, climate adaptation discussions have involved government officials, universities, and environmental non-governmental organizations. Vulnerable residents, who have a sense that climate change is a distant problem, are rarely engaged in such conversations (Phadke, 2015). Climate change impacts are unevenly distributed, and urban planners and policy makers are increasingly concerned about urban heat and its public health impacts. Urban heat mitigation efforts have focused on landscape level interventions, the urban form, infrastructure, and materials usage; community generated solutions are not the norm. Despite urban heat being a highly contextual, local issue,

residents' local knowledge and wisdom remains largely untapped and community priorities for mitigation and adaptation are not fully explored.

Community resilience is strengthened by residents' ability to act collectively in the face of climate adversities (Moser and Boykoff, 2013, Phadke, 2015). Community involvement in urban blight and placemaking projects have stimulated both bonding and bridging social capital, bringing residents together with planners, architects, and developers, and, importantly, with each other (Semenza, 2007). Increasing agency and social capital in vulnerable communities will allow for the community to actively collaborate in climate planning and decision-making processes.

Given climate projections of increasing extreme temperature events, urban growth trends, and diminished social capital, especially in the hottest regions of the United States, heat-vulnerable populations face an adaptive capacity challenge. While exposure and sensitivity to extreme heat has been relatively fully explored, a more qualitative understanding of vulnerable populations' adaptive capacity could minimize poor public health outcomes, increase thermal comfort, and facilitate more effective community engagement. Better metrics for measuring social capital, understanding differing narratives regarding coping strategies, and discovering how best to engage vulnerable populations for climate planning could supplement existing vulnerability frameworks, indices, and maps to provide a more complete understanding of heat-related hazards and its differentiated effects on populations.

Implications for Practice

This dissertation makes three main contributions to understanding how heat-vulnerable communities understand and adapt to increasing urban heat. First, the

populations that are the hardest to reach and engage in climate planning are often those with the highest need and are the most impacted. There has been limited climate planning with these populations. The methodology developed from this research allows for a greater understanding of how to engage with and increase the capacity of populations living with impacts of inequalities. Second, during extended interviews, residents detailed underlying coping mechanisms and adaptive capacity not operationalized well through existing frameworks. Three narratives were developed that illuminate the differentiated capacities to cope with urban heat and provide direction for mitigation and adaptation efforts. Third, few have fully explored social capital and its relation to heat vulnerability. Effective urban heat social capital indicators were developed that provide a tool to increase adaptive capacity across differing populations.

Research Objectives

This dissertation research is based on urban climatology, vulnerability, political ecology, resilience, and hazards literature to develop an interdisciplinary, integrative understanding of the perceptions of urban heat, coping mechanisms, and adaptive capacity, especially social capital. The following chapters focus on three research questions and the final chapter includes a reflection of how each chapter is related, the strengths and weaknesses of this approach, and directions for future research.

This dissertation addresses the following research objectives:

1. Develop a community engagement methodology for localized climate planning that builds meaningful collaborations and enhances capacity.

2. Create a description of differing perceptions, coping, and capacity of populations that transcend the current understanding of vulnerability beyond exposure and sensitivity.

3. Identify effective social capital indicators for urban heat.

Research Questions

The following research questions address my research objectives to develop a more complete understanding of vulnerable populations and how to engage them to increase capacity at the individual, household, and community scales.

Chapter 2: Community Engagement Methodology for Localized Climate Planning

Q1. What is an appropriate method to engage vulnerable populations in developing neighborhood specific plans heat action plans and increasing capacity for implementation?

The framing of climate issues such as urban heat has been too large for neighborhoods to press for local, impactful solutions (Meerow, 2016). Further, the most vulnerable populations are often the hardest to engage in community outreach. In this chapter, I designed a community-based participatory engagement methodology that addresses urban heat issues at the neighborhood scale through a series of workshops and demonstration projects. The collaborative project combined storytelling wisdom with evidence-based research to create context-specific solutions for urban heat. Additionally, this iterative process increased social capital among residents, community-based organizations, stakeholders, and core team members to enable collective action for future plan implementation.

Chapter 3: Narratives for Urban Heat Adaptation and Mitigation

Q2. How do vulnerable populations understand and adapt to increasing urban heat? What are the coping strategies and tradeoffs between specific and generic capacity of differing populations?

Census information and other quantitative data paint a partial picture of urban heat vulnerability, especially when focusing solely on exposure and sensitivity and resulting mortality. How people who live in vulnerable situations change their behavior to cope with and manage extreme urban temperatures highlights different adaptive capacity within a city. Using open-ended interviews with residents from the metropolitan Phoenix area, distinctive narratives emerged that can be used to better understand motivations, perceptions, and diverse coping behaviors.

Chapter 4: Indicators to Measure Effective Social Capital for Urban Heat

Q3. What are the effective social capital indicators important for mitigating and adapting to urban heat?

Social capital is relative to different issues and indicators developed to measure development capacity or civic engagement do not necessarily apply to understanding the social capital necessary to cope with urban heat. Using data from the Nature's Cooling Systems workshops, extended interviews, and a stakeholder meeting, I developed indicators for effective social capital for urban heat (ESCUH). These indicators are measured by a combination of existing social capital questions from other frameworks and additional questions to clarify specific social capital capacity that can be used to develop appropriate adaptation pathways and identify trusted organizations and networks.

The community-based participatory research methodology in Chapter 2, the narratives developed in Chapter 3, and the effective social capital indicators described in Chapter 4 allow for a different approach to understanding urban heat vulnerability and create new pathways toward building community resilience.

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CHAPTER 2

BUILDING COMMUNITY HEAT ACTION PLANS STORY BY STORY: A THREE NEIGHBORHOOD CASE STUDY

Abstract

Increasing urban temperatures pose a public health threat, especially for the poor, those with pre-existing health conditions, and those living in areas with little to no vegetation. In many cities, there is a disparity among neighborhoods with respect to access to cooling benefits in the urban landscape. Municipal-wide spending for cooling interventions can be socially and geographically inequitable, 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. Here I present the Nature's Cooling Systems project's community engagement methodology, which aims to empower underserved communities, identify, and create community leaders, and build awareness about heat-reducing solutions to shift those dynamics.

The Nature's Cooling Systems project tackles heat at the neighborhood scale to collaboratively develop heat action plans that reflect local knowledge and community identity. The methodology was piloted in three neighborhoods in the metropolitan Phoenix area in partnership with community residents, The Nature Conservancy, Arizona State University, community-based organizations, city officials, and the county public health department. A series of workshops were developed, and demonstration projects undertaken to improve public health outcomes and provide better thermal comfort in the hottest and highest-need neighborhoods. Examples of solutions proposed by residents include creating cooler pedestrian routes, developing a community tree program, adding

shade stops at intervals throughout the community, and developing a heat safety training program. This participatory process will serve as a model for community-driven heat mitigation and adaptation planning for other neighborhoods and cities facing increasing heat and is applicable to municipal climate planning initiatives. The success of this project is in not just generating an outcome document, a regional heat action planning guide with neighborhood heat action plans, but also in the process that increases engagement and awareness over time.

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 rates, and have greater sensitivity, and lower adaptive capacity to heat (Klinenberg, 2002; Harlan, 2006). 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 owing 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. Located in the hot Sonoran Desert, the Phoenix Metropolitan Area experienced an average of 110 days over 100º F from 1981-2010 (National Weather Service, n.d.) and is home to one of the fastest growing urban heat islands (Stone, 2012). Extreme heat presents a resilience challenge for cities in managing urban development (Moser, 2019). Cities are resilient when they can persist, adapt, and transform in the face of stress and shocks, while maintaining their function and identity (Meerow, 2016). Resilient cities are concerned with protecting residents, especially the

most vulnerable, from the effects of increasing temperatures, and more frequent and intense heat waves.

There is a disparity among Phoenix neighborhoods with respect to access to cooling benefits in the urban landscape (Harlan, 2006). Historical legacies of discrimination and uneven development in metropolitan Phoenix have resulted in communities that are highly vulnerable to heat (Harlan, 2019). 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, 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, 2015).

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 and Olsson, 2008; Weber 2016; Meerow, 2017). In general, climate adaptation discussions have involved government officials, universities, and environmental non-governmental organizations; however, vulnerable residents are rarely engaged (Phadke, 2015).

Urban planners and policy makers are increasingly concerned about urban heat and its public health impacts. The United States Environmental Protection Agency (EPA) provides 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 energy-efficient appliances, and checking in on others during high heat days. Many of these recommendations, however, are inappropriate for the semi-arid climate of the American Southwest and do not assist renters or those with limited incomes who are unable to make capital improvements to their properties.

The EPA further recommends that the urban heat island can be addressed through policy efforts such as tree and landscaping ordinances, comprehensive plans, zoning codes, green building programs and codes, and air quality requirements. 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 but do not provide specific interventions in the highest need communities.

The framing of climate issues such as urban heat has been too large for neighborhoods to press for impactful solutions (Meerow, 2016). Urban heat mitigation efforts have focused on landscape-level interventions, the urban form, infrastructure, and materials usage; community generated solutions are not the norm. Yet, there is local knowledge that remains untapped by municipal decision makers and other planning participants.

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 core elements that include identifying a lead body organization,

alert systems, communication strategies, and organizational responsibilities. Emphasis is also placed 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, 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, 2010). There is a disconnect however, between residents and government agencies, as 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, 2015).

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 action 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.

Methods

Nature's Cooling Systems was conceived as a collaborative community engagement process designed to address urban heat mitigation and 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, 2007) that enhances bonding, bridging, and linking social capital, thus facilitating collective action. The Nature's Cooling Systems process strengthened relationships between and within neighborhoods, community-based organizations, decision makers, and the core team. The project combined storytelling wisdom and evidence-based research to understand the current and future urban heat challenges facing residents. Heat action plans were co-created that outlined neighborhood context-specific solutions to combat the effects of extreme urban heat and reflect local knowledge and community identity. This participatory process can become a model for a community-based approach to building heat resilience.

The community engagement process was iterative and consists of four steps (see Figure 1). First, in the "engage" stage, community leaders were identified and welcomed to the process through a series of 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 beyond the scope of this project. Throughout the engagement process, demonstration projects were implemented to keep enthusiasm high, create small wins, foster new relationships, and increase accountability to communities. 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 collective action.

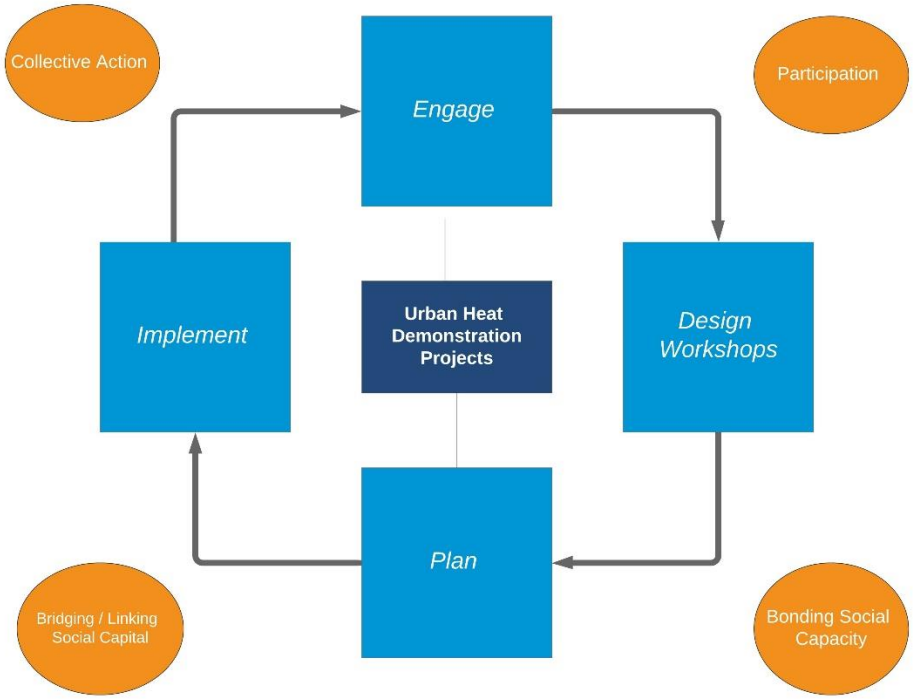

Figure 1. Diagrammatic depiction of Nature's Cooling Systems community engagement process detailing the iterative flow and increasing social capital.

The Nature Conservancy, Arizona State University, the Central Arizona Conservation Alliance, and the Maricopa County Department of Public Health operated as the core team for the Nature's Cooling Systems project, facilitating information and collaborations. Three pilot neighborhoods 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, 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, 2013). These test areas had higher surface temperatures compared to

other communities, and little to no vegetation and shading. The selected neighborhoods, while still high in need, were not the three hottest neighborhoods; other, hotter neighborhoods did not meet all the criteria set forth.

A key component for this approach is the community-based organization that offered credibility for the boundary/core organizations and provided critical community knowledge (see Figure 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, 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. 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, 2014) for boundary organizations, the knowledge exchanges between residents and other stakeholders was meant to encourage future collaborations and establish supportive relationships.

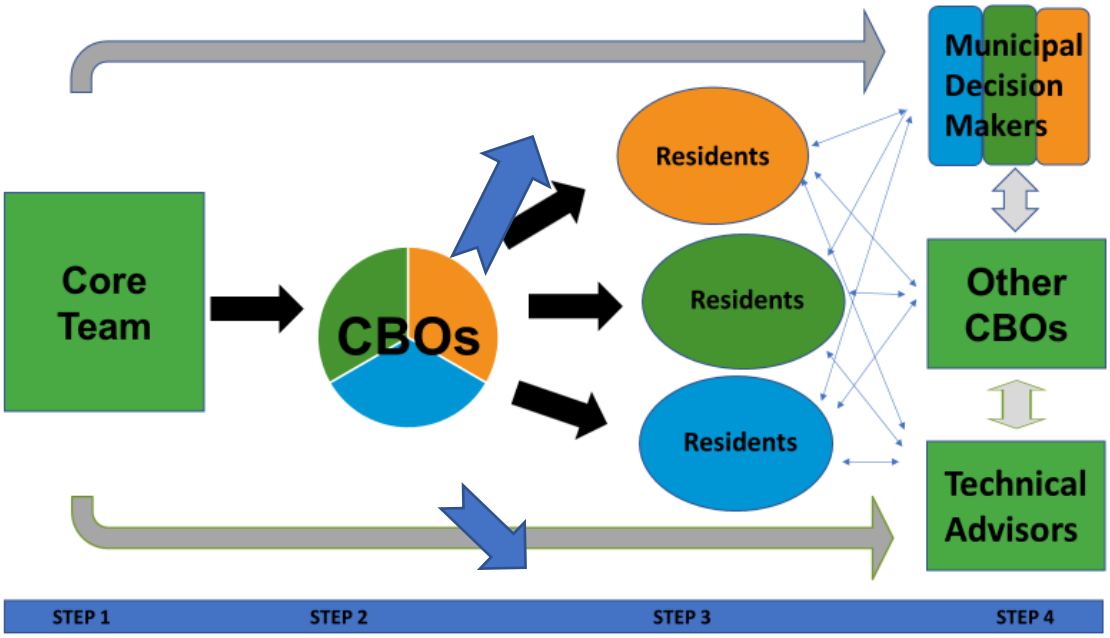

Figure 2. Nature's Cooling Systems project stakeholder relationships in a four-step process. The core team selects community-based organization in pilot neighborhoods who, in turn, recruit residents. Residents attend an initial workshop to develop baseline information. Subsequent workshops include a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

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 series of three workshops in each of the three neighborhoods (for a total of nine project workshops) was developed to map local assets, generate context-specific ideas for

heat mitigation and adaptation, and create intervention designs. Storytelling became a cornerstone of the workshops and was consciously chosen to honor different forms of expertise, facilitate understanding of complex ideas, and equal 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. All workshops were simultaneously conducted in English and Spanish, using whisper translation for the minority of speakers. The workshops were held from May through September 2018.

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 the possibilities for interventions in specific neighborhoods. Stories are also an effective way of getting people comfortable using their voice with experts in the room, a way for non-experts to communicate effectively about their lived experience, and a way to build trust among collaborators (Ebi, 2008).

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.

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 both within Phoenix and other locations.

For the second workshops, the participants sat in a circle around the room and introduced themselves and why they were here in the talking circle. All participants were given the opportunity to speak and tell their story; the dialogue was conducted simultaneously in Spanish and English. 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. Small group sessions followed, to further develop ideas using the cool and hot spots maps developed in the first workshop. The entire group gathered for a debrief and final voting session on the appropriate next steps.

Figure 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.

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 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. In an effort to jumpstart elements emerging from the heat action plans and foster the momentum and relationships cultivated in the workshops, demonstration projects were discussed, and participation was welcomed. These included tree planting, shade structure, and green infrastructure projects.

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. This framework assisted people working in cities to plan for, measure and evaluate the social and economic impacts of urban conservation, resilience, and sustainability work. To ensure social justice and fairness in this community engagement process, the Center for Whole Communities provided frequent input to the core team, especially in the early stages of the process, and 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 final document, Whole Measures for Urban Heat Solutions.

Using data collected during the workshops, heat action plans were developed for each community by the core team and community-based organizations with input from experts. Workshops were recorded, transcribed, and analyzed to draw out highlights and identify specific neighborhood needs and proposed solutions. 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.

Case Study

The project was piloted in three metropolitan Phoenix neighborhoods and was led by the core team previously mentioned. The research was approved through the Anonymized Institutional Review Board (Study00006624). Two neighborhoods within the City of

Phoenix (Edison Eastlake and Lindo Park-Roesley Park) and one in the City of Mesa (the Water Tower Improvement District) were selected by consensus among the core team. 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.

Table 1
Demographic composition of pilot neighborhoods

	Edison/Eastlake	Water Tower Improvement	Lindo/Roesley Park	Maricopa County
Households (HH)				
Number of HH	1,884	2,935	2,765	1,442,518
Median Income	$10,708	$29,870	$37,345	$53,596
Owner occupied	16%	35%	58%	63%
Residents				
Total Population	6,134	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%

Source: United States Census, 2010

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. There are three public housing sites, numerous vacant lots, one park at the northwest boundary and another just outside the neighborhood boundary. The legacy of redlining prevented

residents from getting mortgages to buy homes in this neighborhood in the 1930-1950s and manifests today in the low home-ownership rates. 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, 2015). Recently, 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. Phoenix Revitalization Corporation (PRC), http://phxrevitalization.org/, a community-based organization, has been instrumental in the HUD Choice Neighborhood process, and established and managed a resident leadership council within the Edison Eastlake community to ensure that residents have the capacity to advocate for their needs during the urban revitalization.

The next neighborhood, 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. Although the iconic Water Tower is gone, a history of municipal neglect and lack of investment is obvious in this community compared to the eastern portion of the city and the downtown district a few blocks away. 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.

> "There is a big difference between shade north of Main Street and south of Main Street. You go south and there's zero shade trees." Mesa resident

RAILMesa, http://www.railmesa.org/, a community-based organization focusing on retail, arts, industry, and the light rail within the city of Mesa, was selected to lead the Nature's Cooling System process in the Water Tower Improvement District. They have been at the forefront of ensuring that the light rail expansion considers current residents and business owners, and addresses end-of-line transit/quality of life issues, including increased homelessness.

Table 2
Overview of pilot neighborhoods and Community Based Organizations (CBO)

	Edison/Eastlake	Water Tower Improvement	Lindo/Roesley Park
Neighborhood Identity	Recipient of $30M 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

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. In the early part of the 20th century, Latinos and Blacks were required to live in certain areas within the City of Phoenix, this neighborhood being one of them, and the community still reflects this ethnic and racial composition. The neighborhood includes single-family homes, an elementary school, and two parks. The community has a rich farming cultural identity and history. Puente Movement, https://puenteaz.org/, an organization recognized for community leadership and grassroots collaboration on social justice issues, was contracted as the community-based organization for this neighborhood.

The Nature Cooling Systems workshops were all held on Saturdays, within walking distance for most residents. 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. The community-based organizations selected the workshop venues and were instrumental in ensuring that community engagement was conducted in a culturally sensitive manner and relevant manner.

Results

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 gaps 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. Community

organizing and advocacy by the residents and community-based organizations are crucial to success in creating a more thermally comfortable future in these neighborhoods.

From the inception, the goals for this community engagement process included creating urban heat awareness, agency, and social cohesion in the three pilot neighborhoods. The Nature's Cooling Systems methodology 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 have been distributed. Most importantly, relationships between stakeholders have been built and strengthened over the course of this process, enabling continuing collaboration on continuing the heat action work.

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 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 thirty minutes of the first workshop.

Community members knew that their neighborhoods are hotter than when they were children and shared vivid stories about how coping has changed over time.

> "We didn't wear shoes in the summer. Today it feels unbearable. I don't remember it being so intensely hot." Workshop participant

> "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 also parlayed their information in a storytelling format, setting the issue into a local context that non-experts can more easily access (Ebi, 2008). The 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 discussion by a university professor.

> "Now, instead of imaging 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 so that 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. 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.

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. Limiting exposure to the sun and heat throughout the sparsely vegetated communities is a challenge for residents who must walk to transit or their destinations. Long waits at street corners due to the traffic pattern prioritizing vehicular traffic over pedestrian crossings add to exposure. Traffic light timing, initiating an all-crossings "X" pattern for pedestrians, and shading corners were suggested interventions.

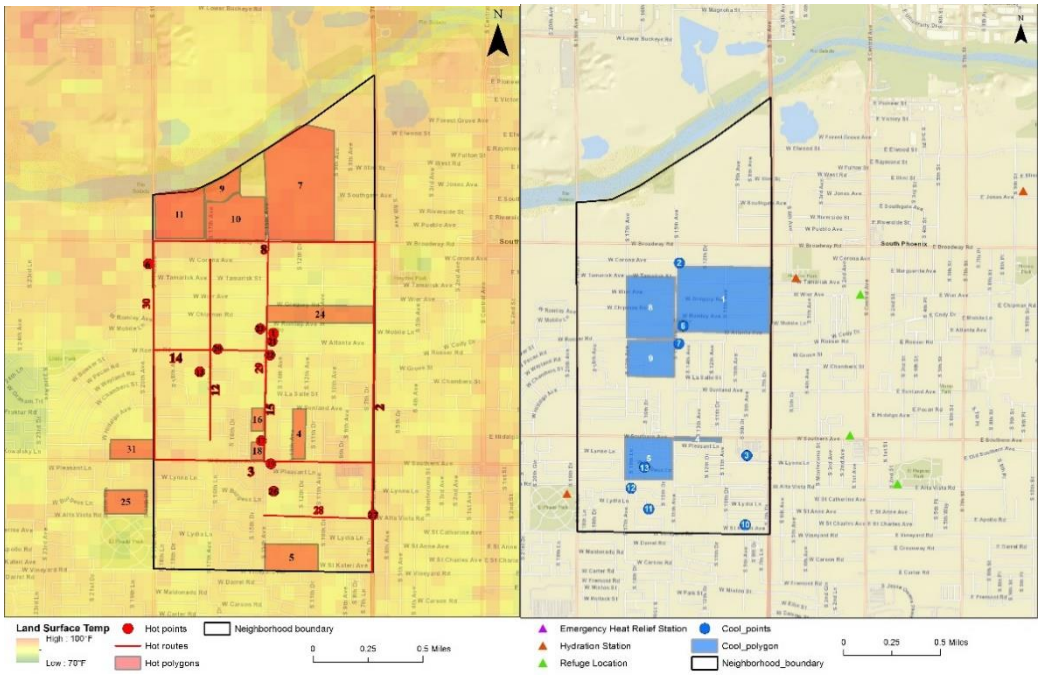

Figure 4. Neighborhood maps with specific areas that residents highlighted as especially cool or hot (red). Major walking routes that have little to no shade were highlighted in red as well.

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. Residents also wanted more public health training focusing on urban heat in their environments, and applicable to situations that they face every day, rather than the often-publicized precautions about hiking in extreme temperatures. They wanted to know the difference between heat stroke, which can be fatal, and heat exhaustion. This could be a First-Aid certification program specifically for extreme heat and could be administered through the current Community Emergency Response Team (CERT) program. A K-12 advocacy and heat education program that combined both of these issues was mentioned in one community.

Table 3

Resident Visions and Priorities for Cooling and Urban Heat Safety

Intervention	Edison/Eastlake	Water Tower Improvement	Lindo/Roesley Park
Provide more shade and reduce exposure	**Shade on public transit routes**	**Shade along school routes**	**Shade along school routes**
	Improvements along vacant lots	**Reduce pedestrian exposure at long traffic intersections; better connectivity to broader transportation 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 ½ mile intervals**	**Access to drinking water**	**Add shade rest stops that have drinking water and benches at ½ 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	**Preventative warning system for extreme heat**	**Reusable water bottle giveaway for all students and**	**Provide an air-conditioned Senior Center**

Programs		**ensure they don't leave school without it filled up**	
	Heat health emergency first aid training certification	**Emergency Summer Plan for K-12 students and adults in the community to raise awareness of cooling opportunities and heat safety actions**	
	"End of School" training for K-12 students to stay safe during summer heat		
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

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. 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.

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.

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. Information, available in both Spanish and English, is posted on the county website. However, most had never seen the heat health flyer or similar information distributed through other channels. 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

Upon further workshop discussion, residents decided that this first aid program on heat safety could be managed through the city first responders and a separate, urban appropriate heat module, could be added to the CERT program.

Barriers to cooling

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

The primary coping strategy is to not go outside in extremely hot weather, which may increase indoor heat exposure if air conditioning is not functioning, unaffordable, or set at a temperature that continues to risk health. Residents often set their thermostats above the average 78°F, with 85°F being the set point for those concerned about finances. Some participants did not have refrigerated air conditioning and used swamp coolers, which are ineffective under higher humidity conditions. Further, the implications of not going out in extremely hot periods include lack of exercise and limited social contact with others in the community. This is particularly worrisome for the elderly living alone and children.

> "When I moved to Phoenix 20 years ago, that's when I learned about the A/C. But also, how ... we didn't know in the morning when you leave home, if you wanna turn off the A/C, and then when you come back then you turn it on, and the house is gonna be too hot, and because of that the bill is bigger. We didn't know how to deal with A/C. And also, about some housing, they are not very friendly to the

> environment, or not friendly to the heat, right? Cheap apartments, cheap houses, cheap walls, and that makes everything worse." Community-based organizer

In the three communities, residents lamented the low quality of housing and inefficiency of air conditioning appliances which negatively affects electricity costs. Landlords and homeowners are slow to provide upgrades to air conditioning units and the lack of sufficient insulation in homes compounds the problem.

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.

Many residents expressed frustration about managing trees in their yards beyond issues about "dirty" trees that drop leaves and a cultural preference for cleanliness in outdoor spaces. 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 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.

Increasing social capital and trust

The Nature's Cooling System methodology generated agency and social cohesion. Residents feel 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 with different stakeholders stating their positions on 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.

Discussion

The workshops and creation of heat action plans were not without challenges. Differing styles of communication and understanding between groups had to be worked out before attempting to develop solution ideas. The core team and community-based organizations were intentionally open to adjusting this process based on new learning and neighborhood differences. This openness to an iterative process helped to ensure increasing participation and success. There was never enough time to accomplish the tasks set out by the group; this lack of time was compounded by differing expectations. Residents wanted to see change immediately, but municipal decision makers work on five-to-ten-year time scales. The community-based organizations help to bridge this gap and will be the driving force for future heat action plan implementation.

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 understood the unique history of the neighborhoods, who the key players were, past relationships, promises, and where opportunities exist. The community-based organizations 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 urban heat professionals echoed the feelings of intimidation, 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.

Ensuring meaningful communication

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.

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 big disconnect between residents and officials with many nuanced reasons for that disconnect 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 meetings, 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.

Slow process

Community heat awareness and active participation is a slow process. 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 community-based organizations testified that this was the first time they truly understood the 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 residents, CBOs, core team, and advisors came to understand that this workshop process 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.

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 and by increased community agency to advocate for potential solutions. The process, which included planning meetings, workshops, demonstration projects, and compilation of heat action plans, provided opportunities for the community to act more cohesively and collaboratively.

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. Just as these three highly heat-vulnerable communities revealed a range of characteristics, needs, and values, 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 workshops and community engagement helped to personalize solutions and develop consensus-based priorities for intervention areas. The Nature's Cooling Systems methodology may be of particular interest to practitioners interested in developing contextually appropriate climate plans as well as specifically targeted urban heat mitigation and adaptation plans.

The ultimate measures of success are uptake of the heat action plan recommendations including neighborhood actions, social network reinforcement, and 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.

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CHAPTER 3

ADAPTIVE CAPACITY TO EXTREME URBAN HEAT: THE DYNAMICS OF DIFFERING NARRATIVES

Abstract

How people who live in vulnerable situations change their behavior to cope with and manage extreme urban temperatures, and the resources necessary to prevent adverse health effects, highlights different adaptive capacity within a city. Heat does not affect all populations equally and there are disparities among various measurements of heat vulnerability. Census information and other quantitative data paint a partial picture as vulnerability is a combination of three factors: exposure, sensitivity, and adaptive capacity. This article explores how different city residents understand and adapt to increasing extreme urban heat, the tradeoffs different populations must make between generic and specific adaptive capacity, and the coping strategies that influence heat adaptive capacity at various scales. Using metropolitan Phoenix as a test site, open ended interviews were conducted where residents were encouraged to tell their stories about past and present extreme heat adaptive capacity and adaptive behaviors. Three narratives emerged: heat is an inconvenience, heat is a manageable problem, and heat is a catastrophe. Framing heat vulnerability using these differing narratives can help evaluate if standard recommended actions for coping with heat adequately represent solutions for the heat exposure levels and resources of more vulnerable groups. Learning how and under what circumstances vulnerable populations are motivated to make necessary changes to increase thermal comfort and safeguard public health will ensure that targeted heat mitigation and adaptation policies are widely adopted.

Introduction

This article explores how different socio-economic groups respond to the challenge of urban heat, both for short-term emergency situations and for long-term adaptation planning. Despite increasing temperatures, people from a range of demographic groups are surviving under extreme heat conditions which points to underlying coping mechanisms and adaptive capacity that have not been well operationalized through existing frameworks in the sustainability, resilience, and public health literature. Whereas much of the previous literature related to heat vulnerability and adaptive capacity involves or draws from analysis of mortality and morbidity records, this study instead focuses on how residents ensure their thermal comfort and well-being during hot weather as determined from in-depth interviews.

Extreme heat is a leading cause of weather-related deaths in the United States (CDC, 2019) and extreme heat events are predicted to become longer, more frequent, and more intense (National Climate Assessment (NCA4), 2018). Residents of certain parts of cities face higher heat exposure than rural populations due to the urban heat island effect, which develops when heat is absorbed into the built environment and released slowly at night, making some neighborhoods substantially hotter than others within the same city (Stone, 2001). Most importantly, heat related deaths and illnesses are preventable (CDC, 2019).

Urban vulnerability research is largely derived from three domains: hazards, political economy or political ecology, and resilience literature. The hazards literature views vulnerability as an impact or endpoint in a linear process and is based upon

exposure to climate hazards, sensitivity of infrastructures, populations or activities and results in specific impacts, usually mortality or morbidity. This literature typically does not delve into *why* different sectors within cities are disproportionately affected, whether stakeholders are open to adaptation strategies, or whether they are capable and motivated to make necessary changes (Romero-Lankao, 2011).

The 'inherent urban vulnerability' context has roots in livelihoods, political economy, and political ecology literature (Eakin & Luers, 2006). Of importance to researchers in this domain is how or why subgroups are more vulnerable, and why some are more able to cope and adapt than others. In this literature, urban vulnerability is viewed as a dynamic process that the result of decreasing ability within a city to cope with stressors. Adaptive capacity, in this context, is a combination of demographic and socioeconomic factors, the capacity to predict, react, and recover and cope with hazards, and the governance and policy influence on adaptive capacity.

Resilience literature reflects the complexity within a city to respond to and recover from impacts. Most of the literature regards resilience as a positive adaptation in the face of shocks or adversity. Harlan (2006), Ruddell (2010), and Uejio (2011) approach heat vulnerability as a function of interdependence between the socioeconomic, environmental, and technical (SETS) subsystems.

There have been attempts to combine these three lineages through the development of integrated frameworks. However, published approaches to date, such as vulnerability mapping, results in sometimes produce conflicting results depending on the variables used or analysis technique (Reid, 2009; Harlan, 2013). The majority of urban heat vulnerability research is dominated by quantifications of the relationship between

all-cause or cause-specific mortality or morbidity and temperature, including stratified analysis focusing on variables such as age and gender. This literature revealed, in some cases, contrasts in mortality and morbidity risks associated with heat for different urban sub-populations (Romero-Lankao, 2012). I contend that qualitative analysis of the nuanced coping strategies, risk perceptions, and attitudes about heat may add to and help explain quantitative findings and enhance understanding of adaptive capacity (Wilhelmi, 2010).

Taking actions to mitigate and adapt to urban heat is a complex issue for vulnerable populations and those who want to assist them. Implemented heat health action plans have increased awareness of potential heat illnesses but have not stimulated appropriate actions, contributing to "last mile" failures of these policies (Martinez, 2019). Failures stem from a suite of issues including low risk perception of vulnerable populations and related health practitioners, low local government involvement, and difficulties targeting the most vulnerable groups (Wolf, 2010). A review of the urban heat vulnerability mapping and visualizing literature found that these tools have had little impact on policymaking or in inspiring protective actions (Wolf, 2015).

Some scholars have argued that there are different types of adaptive capacity that contribute to individuals' abilities to cope with hazards. One framing separates adaptive capacity into *specific* adaptive capacity and *generic* adaptive capacity. Specific adaptive capacity is the ability to respond to a specific threat, in this case urban heat. Generic capacity is broader and is the ability to respond to social, political, and economic stressors (see Table 4). Income, education, and physical assets are components of generic capacity (Lemos, 2016). The interaction between generic adaptive capacity and specific

adaptive capacity to urban heat is not well understood. This knowledge gap is problematic because generic capacity and specific capacity interactions can lead to negative feedback loops, reinforcing poverty traps and prioritizing short term coping at the expense of long-range adaptation (Lemos, 2013). In order to attain climate change adaptation, both generic and specific capacity need to be addressed "explicitly, simultaneously, and iteratively" (Eakin, 2014, p.1).

Table 4
Individual adaptive capacity in general and specifically to urban heat. Adapted from Eakin, 2014 and Belanger, 2015.

Generic	Income Education Health Material assets Participation in organizations
Specific	Access to air conditioning at a thermally comfortable level Ability to leave the hot city for reprieve Adopting preventative outdoor behaviors; limiting exposure especially during high heat events Keeping hydrated Decreasing indoor sources of heat Insurance for potential exposure mitigation during high heat includes home warranty, roadside assistance

We contend that adaptive capacity has not been well operationalized or measured in much of the heat vulnerability literature to date. The quantitative orientation of much of the literature is inherently problematic and limiting in attempting to understand some of the specific behaviors and iterations that contribute to both generic and specific adaptive capacity. Concepts and themes that are important to measure related to urban heat adaptive capacity include how behavior is constrained by institutional factors, receptivity to adaptation and mitigation options, perception of heat risk, decision making

processes employed, and the skills and resources available to cope with increasing temperatures. These factors contribute to differentiated levels of adaptive capacity within identified "vulnerable" population subgroups. The norms, values, rules, and relationships that structure decision making by key stakeholders are can be as important as hard infrastructure and environmental management to urban vulnerability dynamics (Eakin, 2017). The failure to capture these formal and informal influences and dynamics in vulnerability analysis has consequences and can direct municipal and private infrastructure investments away from where and how they could be most beneficial.

This article explores how different city residents understand and adapt to increasing extreme urban heat using qualitative analysis of in-depth interviews. I investigated the tradeoffs different populations must make between generic and specific adaptive capacity when facing increasing urban temperatures and the coping strategies that influence heat adaptive capacity at various scales are investigated. Perceptions and motivation for adaptive behaviors will inform recommended actions under extreme heat situations. In doing so, I aim to build a more thorough understanding of the dynamics of adaptive capacity for urban heat so that equitable urban heat solutions can be successfully designed and implemented, especially for the most vulnerable.

Methodology

This research explores urban heat adaptive capacity at the individual, household, and neighborhood scale. Semi-structured interviews of 23 residents were conducted to understand their lived experience in greater depth. Respondents were encouraged to tell their stories about their methods, capacity, and ability to make changes to how they

respond to increasing urban heat. Past practices for heat mitigation and adaptation as well as attitudes, beliefs, and norms were examined.

The three-part, semi-structured interviews were designed to gather information on heat-health decision making, risk perceptions, motivation to alleviate risks, trust in others, and community relationships. The respondents were asked to "tell me about the issue of urban heat and say anything that comes to mind" following grounded theory (Charmaz, 2012a) interviewing methods that balance general questions which envelope a wide range of responses with narrow questions that stimulate responses about specific experiences. The first part was open-ended for the respondent to provide unsolicited conceptualizations of heat adaptation strategies, beliefs, social relationships, and risk perceptions. Respondents were encouraged to tell stories about urban heat, being indoors and outdoors, through all phases of their lives. The second portion contained probing, open-ended questions about challenges or the most important things they have to deal with on a regular basis that may or may not have to do with heat, adjustments, or trade-offs from managing heat, risk perceptions, and heat-emergencies encountered. General questions about social and organizational relationships, and how those might change when it is extremely hot, were asked along with which organizations might provide help for coping with heat-related emergency episodes. The final portion of the interview probed into the respondent's interpersonal relationships and support network, as well as their opinions of community cohesion.

Participants were selected using the snowball sampling method developed by Charles Kadushin (1968) and included participants from different groups, including the most vulnerable. Snowball sampling is when research participants recruit other

participants for the study from among their acquaintances. During the previous two years, we have been part of a community engagement process in highly heat vulnerable neighborhoods in metropolitan Phoenix during which time we have built trust and rapport with key community members. The initial set of participants were recruited from this community engagement process. These key informants helped to expand the list of potential contacts and interviewees to ensure that a broad sample from these vulnerable communities, along with other, more affluent respondents were included in the interviews. The resultant nonprobability sample allows us to understand processes and decision-making rationales for heat mitigation and adaptation. Using the data saturation technique, the cumulative number of new concepts after each additional interview determined the final number of interviews necessary. A total of 23 interviews were conducted and this sample size was large "enough to uncover and understand core themes" (Bernard, 2016, p.41).

All interviews were recorded, transcribed, and edited to provide participant anonymity. Interviews were conducted in English or Spanish, whichever was preferred by the respondent. A native Spanish language speaker assisted in conducting and translating interviews where necessary. The interviews lasted approximately one hour.[1]

The transcripts were analyzed using grounded theory by employing comparative analysis, moving from specific concrete realities to developing conceptual understanding of the data. Grounded theory, used to analyze narratives, treats these stories as data, which are analyzed to develop themes common across storylines. This process was

[1] Respondents were compensated $25 for their time. This project was approved by the Institutional Review Board of Arizona State University (Study #00006624).

"inductive, comparative, iterative, and interactive" and provided an interpretation of the participants' worldview by learning the implicit meaning of their experiences (Charmaz, 2012b).

Two cycles of coding methods, descriptive and pattern coding, were used to examine and re-examine the data (Saldana, 2016). Coding was conducted in an iterative fashion using grounded theory practice (Glaser and Strauss, 1967). In the first round of analysis, descriptive coding consisted of cataloguing the topics interviewees spoke about, providing the groundwork for further interpretation (Wolcott, 1994). These descriptive codes were used to develop recurring patterns.

Another round of analysis moved from descriptive to pattern coding. Recurring patterns emerged from the data reflecting adaptive capacity theories at the household or individual level. These patterns were used to describe major themes in the interviews. Borrowing from Hayden's (2011) definition of adaptive capacity to urban heat, the components of household level knowledge, attitudes, and practices, household resources, social capital as well as community resources and risk reduction programs were used as a starting framework for developing themes for further examination. The transcripts were coded by pattern codes which applied to multiple, rather than exact words. The transcribed text was analyzed using QSR International Nvivo 12, a qualitative analysis software package, to identify theme categories within the data from these pattern codes. Different narratives were emerged that told a collective story about extreme heat.

This research attempts to capture a contrasting portrait of how differing socio-economic groups respond to the challenges of urban heat and uncovers differing coping mechanisms to provide thermal comfort and prevent heat-related illnesses. The use of

semi-structured interviews allowed respondents to speak freely, identify concepts most important to them, and to provide a range of unsolicited coping mechanisms. The small sample size may limit empirical generalizability but allows for inferring, suggesting and identification of general patterns. By allowing residents to provide unsolicited answers concerning urban heat coping and risk perceptions, we provide different insights on how groups conceptualize and cope with the issue of urban heat than is possible with a close-ended survey with uniform questions and response options.

Results

This section will detail the demographic characteristics of the sample and subcategories, results from rounds of coding, and an overview of the distinct narratives that emerged from the data to understand the attitudes and perceptions of different socio-economic groups in coping and responding to the challenge of extreme urban heat. Short-term emergency responses as well as long-term adaptation measures for urban heat were considered.

The interviews revealed that, in general, there was an acceptance of urban heat, its intensity, and the resulting issues as part of life in a desert environment. Complaining about the heat was common; thinking of constructive solutions to mitigate heat and ensuing problems was not. In fact, apathy and pessimism initially made recruiting for interviews a challenge as potential participants often stated that they did not have much to say about heat. This claim ultimately proved to be untrue. Residents we interviewed ultimately had a lot to say about how they cope with extreme heat, the planning required to go about their daily activities in the high temperatures, and, for some, how heat is an emotionally charged issue.

Demographics

Twenty-three residents of metropolitan Phoenix were interviewed between January and May 2019. Most respondents were in the 25-44 and 45-64 age groups (see Appendix A). Three quarters of the interviewees were women. More than 40% of those interviewed were in the $30,000- $75,000 income groups but there was representation from higher and lower earning groups as well. (As a benchmark, the median household income in Maricopa County, Arizona, where metropolitan Phoenix is located, is $58,580 (U.S. Census Bureau, n.d.). 87% of participants had a high school degree or higher and over 40% attained a college degree or higher. The research sample was largely White and roughly a third of the respondents identified as Hispanic or Latino; however, close to 10% did not respond to this question. Due to the snowball recruiting method, this sample is not reflective of the general population in Metropolitan Phoenix but, nonetheless, provides direction and furthers understanding of how many of the population segments cope with extreme heat.

Coding

Five major themes revealing residents' perceptions and behaviors for adaptive capacity emerged from the data. The final round of coding made note of the shared and different ways respondents spoke about each theme and revealed "implicit shared orientations that organize people's perceptions and actions" (Daiute, 2014, p. 142). These themes provided insight into larger discussions about urban heat; the themes are coping, emotions, structural inequality, social capital, and decision-making (see Table 5).

Table 5
Themes that emerged in the second round of coding*

Theme	Description	Exemplar	Indicators
Coping	Actions individuals take to adjust to the heat both inside and outside of their homes. Includes adjustments to routines, household decisions, behaviors. Does not include actions taken to reduce vulnerabilities outside of exposure to heat.	"Almost all of us lock ourselves in, if you look around, you'll see that there is no one around right now…. No one knows if you're dead or alive, we go outside quickly to throw the trash out and then inside again."	Leaving the Phoenix area, doing chores earlier or later in the day, air conditioner usage, staying indoors, seeking water/pools/splash pads, financial/spending adjustments
Emotions	Expressed feelings towards having to deal with or being exposed to the heat.	"Summer makes me sad, overwhelmed, so tired from heat."	Angry, cabin fever, unbearable, fun, horrible, overwhelming, brutal

Structural Inequity	Perceptions about community assets and access to cooling features. Does not reflect individual assets but assets of the community as a whole.	"In the neighborhood I live in now there's very little shade, not a lot of trees, not a lot of much of anything, and so, going for a walk in the summer, it's not even possible or not enjoyable. One of the things that stands out to me is the big difference between shade north of Main Street and south of Main Street. If you go into the neighborhoods that are just one block to the north, you have big mature trees, there are huge shade trees. You go to the south there's zero shade trees."	Lack of shade, trees, pools, splash pads, lower quality housing stock, substandard public spaces
Social Capital	Includes family, friends, and informal networks. Describes the social resources they have to deal with heat and their lives in general.	"I can tell you that I can count on all of my brothers to help me."	Trust, rely on, community, support systems, interaction (phone, social media, face-to-face), belonging, helping
Decision-making	Decisions, planning, and trade-offs participants associate exclusively with extreme heat.	"And now I have to be more economical with my energy use, since when the heat increases those of us who have asthma can suffocate because we don't have the money to pay."	Financial decisions, decisions about family activities, planning for protection from heat

There were commonalities in responses for several of the themes and general agreement on certain topics. Respondents had a romantic view of their summertime

childhood and how they were not affected or concerned about the heat at that time. They recalled spending all day outdoors, returning home only in the evening, and playing in pools, irrigation ditches, water parks, and any other water source. It was as if they were immune to the heat. Going barefoot, unheard of today, was common in these stories.

Another point respondents agreed upon was that the metropolitan Phoenix area weather is sublime for the majority of the year and the summer weather was a hurdle similar to northern United States winters. Just like Northerners that stay indoors during the cold, icy, snowy months, Phoenicians hide in their homes to avoid the summer heat. Staying indoors emerged as a primary coping strategy, with the resulting isolation and cabin fever a common complaint.

> "I would say that the first thing that comes to mind is people who come from out of town, and they always say, "you get used to the heat, right?" And I always tell them, no. You get used to being inside. Because nobody gets used to being outside in that heat."

As a consequence, most interviewees discussed the need to leave the area for a reprieve. This was true for all income levels. All of the interviewees discussed how they changed their behaviors in extremely hot weather. Air conditioning was an effective adaptation tool; most used it but not all used it the same way. The majority of the interviewees relied on their own social networks and extended family to assist them if, for example, their car broke down, or their air conditioning failed during the year and especially if there was a concern during high heat days. There was a general feeling that the city and city agencies would not help out. The oft mentioned advice of checking on neighbors (e.g. Ready.gov) was not followed, primarily because most respondents did not know their neighbors beyond a handwave and a brief chat.

The perception of extreme heat depended upon past experiences and present conditions related to housing, economic, health, and available coping assistance from others, if necessary. Divergent viewpoints became apparent.

> "But other than that, I don't think too much about (heat as a) danger, per se, more, maybe inconvenience."
>
> "No, I guess at this point I'm adapted, so it doesn't bother me. Yeah, it gets super-hot at times, but we I think we learn to adapt and manage."
>
> "It's almost like sometimes I personify the Summer or the heat or the sun, and it's like my enemy, and I don't want to have the nature or the environment around me be my enemy, but I do feel that way.."

Categories

The interviews revealed a range of attitudes, perceptions, and behaviors in dealing with extreme heat. We have grouped the interviews and the analysis into three broad categories that emerged in my analysis and reflect differing narratives in mitigating and adapting to urban heat.

- **Heat is an inconvenience**
- **Heat is a manageable problem**
- **Heat is a catastrophe**

Heat is an inconvenience. The interviewees in this group live a largely air-conditioned existence and are rarely exposed to extreme heat for any period of time. They restructure their day compared to winter months so that they can accomplish all the same tasks. The summer months equate to minimal trade-offs and more excursions to cooler venues. They have devices that maximize thermal comfort and efficiency such as programmable thermostats, new air conditioning units, thermal pane windows, and have installed added insulation and vents. Major home improvements have been paid in full at the time of

installation from family assets. They cannot imagine living in Arizona without air conditioning. They are *sure* that there are programs in place to assist vulnerable people but are mostly fuzzy on the details.

Heat is a manageable problem. This group feels that they have taken pains to adapt to the heat so that when they are outside, they are safe. Indoors, they keep their thermostat set in the 78-82F range. There are some spending adjustments due to increased electricity costs in the summer, but these do not impact the basics of food, shelter, and transportation. Residents in this group are aware of assistance programs for utility bills but feel they mostly do not qualify for these benefits. Many retain budget billing, which evens out payments over the year, as a planning strategy. For major system upgrades they have used home equity loans or financing provided by the installer.

Heat is a catastrophe. The respondents in this group endured the most amount of outdoor exposure and highest indoor temperatures. Their lives are greatly impacted by extreme heat and they cannot or will not do tasks because of the heat and subsequent danger. Many rely on public transportation and have less efficient air conditioning units and/or more poorly insulated homes, causing higher energy costs for air conditioning. Some knew of assistance programs available but felt they were difficult to access. They stay indoors during high heat periods mostly because public indoor alternatives require spending money. Many use a pay-as-you-go card for electricity.

A description for each of the three groups follows that details their perception of urban heat, overall challenges to living in a hot city, how they cope with the heat, emotions associated with extreme heat and Summer, structural inequities, social capital,

and decision-making issues (Table 6). A general overview of their support systems, perceptions of city assistance, and electricity usage patterns is also included.

Table 6
Overview of differing narratives regarding urban heat by category

	Heat is an inconvenience	Heat is a manageable problem	Heat is a catastrophe
Coping	Minimal outdoor exposure, paid for thermal comfort alternatives, such as going to movies, consistent AC usage in home, work, car	Some outdoor exposure but managed carefully to avoid health issues, carefully monitor energy use during high heat months	Unavoidable outdoor exposure especially for those who use public transportation, stay indoors at other times to avoid the heat, can't afford to be thermally comfortable, set thermostats high
Emotions	View dealing with the heat as a game	Not a feeling of panic about upcoming extreme heat period because they have planned for it but frustrations about larger problems such as sprawl, work/life balance, fear relating to undocumented residents, affordability in the future due to gentrification.	A feeling of desperation, being overwhelmed, sad about the heat.
Structural Inequity	Aware of struggles of others in heat but confident city is managing programs for the vulnerable	Live in older sections of the city and know that newer, wealthier neighborhoods have better infrastructure and amenities	High exposure rates due to compounding issues of underspending for infrastructure that creates a cooler environment and limits exposure
Social Capital	Not reliant on networks in times of emergencies, would stay at hotel if AC failed	Reliance on networks and extended family during emergency situations. Personal access to AC installers and mechanical helpers to ensure functioning AC.	Reliant on networks and extended family to assist with coping with extreme heat due to mistrust of police and city

Decision making	No difficult life altering choices due to extreme heat. Can chose between two or more good options to maintain thermal comfort and purchased outright.	Due to past poor experiences, they are proactive for large purchases such as new air conditioning units. These will be financed, not purchased outright	Due to lack of credit or down payment, many use pay-as-you go energy services.

Heat is an inconvenience.

The "heat is an inconvenience" group did not face the challenges of the other two groups due to personal resources and community assets. Residents in this group have an array of options to keep comfortable and socially active during the summer months. To some extent, they have adapted to the high heat by creating a world where they have extremely limited heat exposure.

> "You know, pretty much when you live in a place like this, especially in warmer times in the year, you go from your air conditioned house to air conditioner car to air conditioned work back to ... so actually sometimes it's a relief to walk out of the air conditioning into the boiling heat, just to warm your skin back up. But then you jump back into something. So, air conditioning is really the only way to survive here. It doesn't work any other way."

The respondents in this group, in general, perceive heat to be an inconvenience that requires some adjustments in your daily scheduling to work around. They use their financial assets to ensure adaptive capacity to urban heat and are aware that they are fortunate compared to other, more vulnerable residents. The interview question "What are your biggest challenges in living in Arizona and it does not have to be about heat?" stumped many of the interviewees and they often felt that heat was not a big challenge for them. Their concerns are "first world problems."

> "Well the very first thing you're wondering is, what am I going to wear today? So, what is the temperature going to be? What am I doing today? So, what do I need

> to be prepared for? If you continue the day, say you drive to work, do you put the window screen thing up?"
>
> "I think honestly the wear and tear on the tires."

Although many with children expressed a feeling of cabin fever during the summer months, they did intersperse the summer with excursions to malls, stores, museums, water parks, resorts that offer "staycations" to residents, and indoor play areas – most of which require spending money. Even in their more affluent neighborhoods, parks and outdoor play venues are perceived to be unusable during the high heat months. Despite their air-conditioned existence, they leave the area multiple times during the summer. Many have family members with vacation homes elsewhere and spend extended time there during the hottest summer months.

This group spends the most amount of money on their energy bills but felt that the expense was "not that bad" even when the increase in summer electricity bills compared to winter bills was above $300 per month. There was a sense that coping with heat and planning around heat exposure was more like a game than something to be dreaded.

> "We were actually, it's been kind of fun to open the bill and be like, look how much different it is (due to the new unit). 'Cause it's really been a year, and we're comparing the months. It's been pretty fun."

Since most had financial cushions, protections, insurance, and newer assets in place, they were not reliant on a network of family or friends to assist them if they needed help during the summer months. If their home air conditioning failed, they would stay at a hotel or "implement an emergency staycation" at a local resort. The participants in this group were *sure* that the city offers programs to people in need during the summer months. They did not know exactly how assistance was accessed and what the

qualifications were but were confident that safeguards were in place. They were grateful for never being in the position where they had to find out more.

> "Well, I know that on the bill you can mark the little thing and give a dollar through that program, and I have done that. It's voluntary. The City of Tempe bill that comes has a place where you can mark it and pay a dollar more than the bill is, and it will go into a fund that helps people that can't afford their bill. But I don't know what their criteria is for using that, or how they disperse it. So, I'm *sure* that they are doing something, I just don't know what it is. I'm one of those lucky ones that has never been in a position where I had to worry about that."

Difficult choices when having to deal with heat and its effects for this group were nonexistent. They can afford to be thermally comfortable despite the extreme heat and their decision making revolved around ensuring that air conditioning was available throughout their day. No one discussed having to forgo necessities to cope with the heat.

> "Like whether to stop at the grocery store first or last. First world choices. No, we can't have ice cream 'cause we have to stop at the post office. I mean, you could say that you didn't do something else because you had to have that air conditioning."

> "While I don't think it's precluding us from doing a lot of large things, it's still something that if we didn't have that big of a bill, it would be ... Yeah, we may, who knows, go out to dinner or see a movie more often than we do. I mean, we do. We probably go out to dinner about every 10 days or so, I would guess. Movies, once or twice a month, all of us."

Demographic snapshot

The "heat as an inconvenience" group was largely female, White, older (45-64), affluent, and more educated compared to all of the interviewees together in the sample. Half lived in two person households; the other half lived in 5-6 person households. All of the households had two or more adults.

Heat is a manageable problem.

The extreme heat for the "heat is a manageable problem" group is not a catastrophe but, rather, a situation that must be planned and budgeted for to avoid trouble. Should they

encounter difficulties, most had nearby family and a strong network of friends to assist. Their lives are mildly disrupted due to the heat and they pride themselves on being adapted and acclimated to high temperatures.

Residents in this group mentioned being careful in many aspects of their lives: finances, hot weather activities, and daily decision-making. They have actively managed their lives so that they are safe both indoors and outdoors. Their homes are managed to maximize comfort and minimize spending; this group is frugal. Their home thermostat is usually set at a moderate 78-82ºF range and can go higher when they are not at home. Urban heat is not a hazard to be avoided at all costs (like those in the Inconvenience group) but a part of life to become adapted to, to work with. Residents in the "heat is a manageable problem" group spoke about spending some time outdoors during the summer, albeit a managed exposure with precautions taken. Changing the timing for errands and shopping, drinking more water, and taking rest breaks while outside doing chores (like gardening) or participating in sports were cited as a means to maintain thermal comfort and health. Eating out often was not perceived as a viable option, so many cook at home but limit the use of the oven. They make some sacrifices in the summer months when increased electricity usage produces higher bills but, again, they are not in danger of forgoing the basics of housing, food, or transportation. Meal planning and conserving on non-essential purchases are common strategies for maintaining thermal comfort. Their daily routines will change in terms of timing and mode, but they will still be able to accomplish the same tasks as during the winter months and thermal comfort is not comprised.

> "I mean every Saturday morning, we get up, walk down to Pioneer Park and kind of hang out, get a few things, walk back. That's in our routine over the past month, month and a half since that market opened. And it's great, and we're trying to take advantage of it as much as we can right now because come June, I doubt that we'll make that walk. We'll probably still go to the market, but it's probably going to be a drive even though it's a quarter mile."

Since heat is perceived as a manageable problem, there is not a feeling of panic about the upcoming Summer months and increase in household expenses. The residents in this group became emotionally charged over larger, systemic issues. Challenges to living in Arizona for this group included not having legal documentation and the ensuing fear of being discovered, the stress of trying to maintain life/work balance, managing small businesses, and staying within a fixed income, and concern for whether their children will be able to live in this community.

Residents in this group are managing their finances despite structural hurdles such as living in older neighborhoods with limited (or no) shade and inferior infrastructure compared to the newer parts of the city. There is an understanding that their neighborhoods do not have the same amenities compared to more affluent communities and that utility payments comprised a larger proportion of their income, especially compared to the "heat is an inconvenience" group.

> "My assumption is that we're probably using a lot more water in the older homes in west Mesa than the newer in east Mesa which means that, we, again, are paying a larger portion of our income into our water utilities partially because of the infrastructure and because of the age of homes, the toilets, all the stuff that comes with these older homes. And so, our city is financially-structured in a way that disproportionately harms the older and lower income parts of the city."

When asked who they would contact if their car broke down on an extremely hot day, the interviewees in the "heat is a manageable problem" group had a network of

people who could help, most often extended family members and friends, rather than a pay-for service such as the American Automobile Association (AAA).

> "First person that I would call is my husband. I have him in case of an emergency on my cellphone. He's the first one that I call. Then, I have my brothers lined up of who's next to help me if my husband's not answering. I can tell you that I can count on all of my brothers to help me."

As with the "inconvenience" group, the residents in this group do not use city assistance for extreme heat issues. They, however, have a more realistic understanding of assistance available and the difficulty in accessing these services. When asked whether the city would help them in times of extreme heat, many were grateful that they did not need assistance in their situation.

> "I wouldn't expect the (city) to, especially not any kind of emergency help. I could be completely misled in that, my understanding is that any kind of help you got from them would be minimal and weeks, if not months, away from happening. Accessing some resources is almost a full-time job for people if they need to make that happen in the amount of hours it takes on hold and processing and driving to a place and coming back. It takes hours and hours."

A few of the people in the heat is a manageable problem group have attempted to get extreme heat utility or related assistance for others and have experienced first-hand how difficult that can be. The income levels in the "heat is a manageable problem" group tend to be just above the threshold levels for assistance, but some have experienced help from outside sources in the past. A few spoke about living in Arizona without having family members nearby and how their friends have become their de facto family.

> "So, the challenges that you find in Arizona that …none of our family …lives here. Our families are all people that we've chosen out here or become connected with. I find that that's a lot of people's story out here. I've come across a lot of people who have no phone numbers that are in Arizona in their phone."

Interestingly, not everyone is in the metropolitan Phoenix area without family. Some interviewees had extended family living in their household or multiple adult siblings living nearby. The majority of these families are Latino or have had family members marry into Latino families and then have become part of that extended family network.

> “That's quite common. I've heard other people, they have not only your family but your extended family living with you and then dealing with household stuff. That's a very Latino thing I think, as far as I've seen.”

Of the homeowners in this group, many made additional improvements while installing new air conditioner units. There was some surprise at how much more efficient the new units were and the amount of money they saved by adding other upgrades at the same time. What differs in this group compared to the “Inconvenience” group is that these purchases were financed through home equity loans and installation providers. They often “knew someone” who gave them a substantial break in the new air conditioner unit and installation price.

> "I had to refinance my house and take some money out to do that. The reason I had to get it was because mine was already giving out. And the person who would come and do the maintenance in it, he's my ex-husband's brother, so he would come and check it and charge it. But sometimes it would make this noise like, "mmmmmmm." And I would be like, "Oh, please just this one more summer, one more summer please. I don't have the money.” And so, I didn't wait until it broke because it would have been disastrous. I already went through it once and I didn't want to do that again. So, we just exchanged it. Took the money out from the loan and did that. It was $5,000. Yeah, he gave me a good deal. Family discount.”

Demographic snapshot.

This group was predominantly younger than the Inconvenience group with half being 44 or younger. Half had children under 17 living in the household. This group included a range of educational attainment and had household income between $30,000-$75,000. Roughly

one third were Hispanic or Latino. Household size was larger than the Inconvenience group, with half having more than 4 people in the household.

Heat is a catastrophe.

The respondents in this group endured the most amount of outdoor exposure and highest indoor temperatures. They have an accepted view of being thermally uncomfortable in their homes and community. Assistance programs and services, like utility bill vouchers, cooling centers and water giveaways do not address the underlying structural issues and perceptions of the residents in the "heat is a catastrophe" group. However, residents in the "heat is a catastrophe group" do possess adaptive capacity to extreme heat unrecognized in the other groups due to their acclimation to the outdoors and abrupt changes in scheduling, forgoing regular activities of the winter months. Their rich social networks provide a safety net that public services do not provide or are perceived to not provide for those in need.

The interviewees in this group are more than inconvenienced by extreme urban heat due to many factors such as not having ample resources to absorb the increase in electricity costs, reliance on public transportation, the condition of their homes, and challenges due to previous life circumstances. They, or people they know, have had poor health outcomes due to the heat but know that there are few options to avoid exposure in their life. The respondents in this group spend more time outdoors during the summer compared to the other groups. Unlike the "inconvenience" and "manageable" groups, this group feels it is "possible to engage and be outside in Summer," it just is not pleasant.

> "I do remember being like, "This heat is awful." I also remember realizing how different it was here, that you walk in this weird zig-zag pattern to try and walk in the shade, and how different the shade makes the temperature."

Access to free sources of indoor cooling are important to the residents in the "heat is a catastrophe" group, especially since their air conditioning thermostat is set high, they have more people living in smaller spaces, and /or are living in rental units with inefficient air conditioning units. Those with children try to frequent free indoor alternatives for their kids. The same is true for adults. Respondents in the "heat is a catastrophe group" leave town as well to spend time by the water or at higher elevation to avoid the heat, although not as frequently or for as long as other groups.

Summertime brings on intense emotions for the respondents in this group. They are fearful of the summer for the potential for dangerous health conditions and discomfort surviving day-to-day in extreme heat. They know they are at risk. They feel tired from the heat, similar to all of the other respondents, but there is also a sense of being overwhelmed and sad as a result.

> "The heat makes me fearful."

> "I think this heat will be the death of some people in all honesty, and that's what scares me."

Structural inequities in these neighborhoods compound the issue of exposure. Many live in areas without shade on their walking routes and need to rely on public transportation because they either do not have a car or do not have the money for car repairs or gas. Without laundry facilities in the home or building, having to walk in the heat with laundry is an added burden for some residents in this group.

> "The distance you would have to walk… is not far, but with the heat it's like an eternity to get there, and even though you have some shade, it's hot. You feel the

> heat coming from the pavement and when the cars pass by you feel the hot air that they make. You feel that desperation when you arrive at the doctor's office, you're going in for one thing and they end up checking you for another thing,"

When asked about challenges residents in the "heat is a catastrophe" group face, responses highlighted a legacy of discrimination, poverty, outsized debt, or drug/alcohol abuse. They were concerned about police abuse, the impact of minimum wage, and homelessness. Many felt that the police were not there to help, but to harass them, and the government systems were not set up to help them in their current circumstances.

> "Nobody's really trying to help that problem. You can call the city all day long and tell them about the heat exhaustion and how the heat is affecting anybody, they'll just be like, "Okay, we'll take it into consideration." What's your consideration? Just looking the other way?"

The assistance needed for this group is supplied by their rich personal network of friends and family. They do not rely on the city for assistance and feel that the city is not helping where it is most needed. Most people do not know their neighbors beyond a quick hello; the exception being those that work specifically in neighborhood organizing capacities.

> "I have no problem calling (friends) and them coming to my rescue at any given time. And if they can't, then of course they call out to others, and it's like a chain reaction literally."

To pay for increased utility costs, basics such as food and gas are curtailed, or extra shifts are added to supplement wages. Their thermostat is set at 85F in some cases, barely maintaining a level of thermal comfort. Some even forgo using air conditioning, not only because it is unaffordable, but also because it is ineffective in their home.

> "I don't have air conditioning; I don't turn it on at all. So, I don't turn the air conditioning on because to me, there's no point… If you have the air conditioning on, you're still gonna feel the heat from outside... So, I've learned, you can keep your air conditioning… your house is still gonna be hot."

Demographic snapshot.

The heat is catastrophic group was predominantly female between the ages of 25-45, with the majority earning less than $20,000 per year. More than half had a High School degree or less. Of the five respondents in this group, one respondent identified as Native American and two identified as Hispanic/Latino.

Discussion

The three narratives (inconvenience, manageable, and catastrophe) highlight different adaptive capacities for urban heat. Existing frameworks can be adapted to incorporate this expand view of urban heat risk and vulnerability. The narratives explain how generic and specific capacity are differently affected, and how providing assistance specifically for urban heat issues may be misguided.

Enhanced Extreme Heat Vulnerability Frameworks

The three urban heat coping narratives presented allow for a rich understanding of the impacts of urban heat beyond existing frameworks, indices, and maps which do not account for the dynamic nature of vulnerability (Eakin & Luers, 2006). Further, due to challenges in obtaining the appropriate data, there have been limited attempts to add ethnographic knowledge of behavioral norms, social networks, and risk perceptions that are equally relevant to understanding urban vulnerability (Wolf, 2015). Past attempts to operationalize vulnerability include the Social Vulnerability Index (SoVI), dependent on social and economic indicators (Cutter, 2003), an outdoor thermal comfort index which included relationships with neighbors (Harlan, 2006), and a heat vulnerability index (HVI) that included public health data, air conditioning prevalence, and social isolation

(Reid, 2009). Few have fully explored adaptive capacity and its relationship to urban heat vulnerability.

Wilhelmi (2010) presented an Extreme Heat Vulnerability Framework that measures exposure, sensitivity, and adaptive capacity as well as external drivers and adaptation or responses to represent a population's adaptive capacity. Adaptive capacity, in this framework, is a combination of household level knowledge, attitudes and practices (KAP), household resources, social capital, risk reduction programs and community resources. Hayden (2011) tested this framework in metropolitan Phoenix using open ended questions about heat health issues, risk perceptions, behavioral modifications, and community cooling resources. It relied on using neighbor relationships as a proxy for social capital; 44% spoke daily or often to them and 84% felt comfortable asking for assistance. Our current research contradicts those findings. With the exception of two interviewees, most barely knew their neighbors and did not socialize with them. Rather, a close network of family and friends were those who they could count on. Many belonged to faith-based organizations and were involved with members beyond attending services. Additionally, many had extended family or other adults living in the household: more adults could mean more adaptive capacity.

Coping strategies such as staying indoors, staying hydrated, and adjusting schedules to early morning or late in the day for outdoor activities were common in both Hayden (2011) and this study. However, many of the respondents of this study left the area for a reprieve from the heat, an option not explored in the Hayden framework. While the Hayden study reported that many participants felt too hot inside their homes, actual

thermostat settings were not queried to determine if this is due to an unhealthy setpoint or other factors. An enhanced adaptive capacity framework could include:

> **Household level KAP** -knowledge, attitudes, and practices around extreme heat:
> How many adults are living in your household, unrelated or related?
> Do you have extended family living in the area?
> How many people can you rely on for assistance and how many people rely on you?
> Are you able to leave the metropolitan area for a break from the heat?
> At what temperature do you set your home thermostat during the summer months?
>
> **Social Capital**:
> How many people are in your local face-to-face network?
> Do you have family or friends that could provide financial support in case of an emergency?
>
> **Community resources and risk reduction programs:**
> Are there faith-based organizations in your community? Do they offer community assistance?
> Do you belong to a faith-based organization?
> Do you belong to a community-based organization?

These questions could be added to municipal surveys, such as the National Community Survey administered through the National Research Center, to better understand differentiated needs in the context of coping with increasing urban heat.

Belanger et al (2015) surveyed residents in nine disadvantaged neighborhoods in Quebec, Canada to develop a heat adaptation index. Heat reducing strategies identified were common to other studies such as limiting oven or dryer usage. An adaptation index was built on these heat reducing behaviors and quantitative data for age, presence of air conditioning, health impacts, and climate trends to describe these vulnerable populations. Adding social capital (trust and reciprocity, and personal relationships), motivation for

certain behaviors, or past perceptions of heat would also enhance this study. may be more important than the behaviors themselves may be why you perform these behaviors.

Motivation for heat adaptive behavior was examined through a mixed methods survey and included a question about why behavior was not changed on hot days. Results showed three main themes: they spend little time outdoors and are not exposed to extreme temperatures, they were acclimatized to or well prepared for heat, or they cannot change their schedule because of work or other factors (Hass, 2019). These results mirror the three narratives developed in this paper.

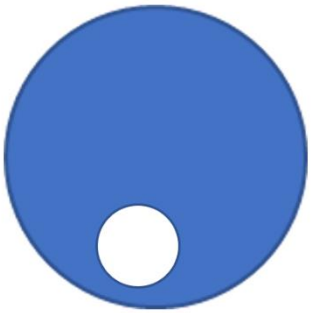
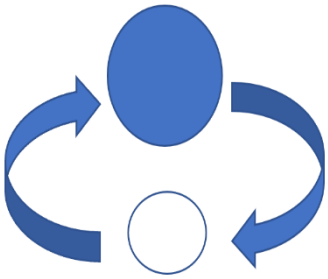
The three urban heat narratives reflect past perceptions, beliefs, and practices, and could predict future behavior. Narratives regarding urban heat could enhance vulnerability and adaptive capacity measurement tools and provide an in-depth understanding of motivations and limitations for different groups in how they approach urban heat. While the recollections may not be factually accurate representations of lived experience, they illuminate how different groups interpret the past and make meaning of urban heat within the context of their lives. For marginalized groups, especially, these narratives could lead to a re-examination of the "master" narrative surrounding preconceived notions of how different groups think about, respond, and behave proactively to urban heat (Riessman 2017).

Heat is part of the poverty trap

Two pathways emerged in explaining heat-specific adaptive capacity: one pathway consists of being able to pay for adaptation and mitigation strategies with redundancies built in to ensure thermal comfort is preserved, the other path is often non-monetary based and consists of strong social networks.

The residents in the "Heat as an inconvenience" group have abundant generic capacity and specific capacity to deal with heat is a small portion of their overall capability. (See Figure 5). There are no sacrifices in housing, education, food, or health. The residents in the "heat is a manageable problem" group manage heat-specific adaptive capacity carefully and it has minimal impact on generic capacity. Extras normally obtained through disposable income and savings cover unexpected specific capacity issues.

Figure 5. Adaptive and Generic Capacity feedbacks and trade-offs by narratives. Blue circles indicate generic capacity; white circles represent specific adaptive capacity for urban heat. The amount of adaptive capacity and impacts on specific capacity differ by narrative.

		
Heat is an inconvenience	**Heat is a manageable problem**	**Heat is a catastrophe**
"No Loss"	"Trade-offs"	"Zero-sum"

However, for the "heat is a catastrophe" group, generic capacity is greatly impacted by specific capacity to extreme heat. Urban heat becomes a poverty trap the way it is currently institutionalized. A poverty trap is when a system exists in a state of bare existence and is unable to accumulate enough assets to escape this situation and move toward a wealthier system dynamic, a sustainable yet maladaptive condition (Holling, 2001). These stable states are self-reinforcing through internal feedbacks and external effects (Barrett & Swallow, 2006). For the "heat is a catastrophe" group, this is evidenced

by the greater proportion of income spent on energy costs and cooling levels maintained in the house that compromise health since they are often hot indoors (Hayden, 2011). Spending to provide thermal comfort comes at the expense of generic capacity: it is zero sum situation for the residents in the "heat is catastrophic" group.

Borrowing from Eakin (2014), the capacity matrix for adaptive capacity to urban heat illustrates how providing resources to deal with urban heat without also addressing generic capacity may not be adequate for residents in the "Heat is a catastrophe" group (Table 7). According to Lemos (2013), specific adaptive capacity benefits depend on achieving minimum generic adaptive capacity levels. For the residents in the "heat is a catastrophe" group, short term survival takes priority over long-range planning for increasing generic capacity, thus reinforcing the poverty trap.

Table 7
Adaptive Capacity to urban heat matrix by narrative

		Specific Capacity : Urban Heat	**Specific Capacity : Urban Heat**
		Low	**High**
Generic Capacity	**High**		Heat is an inconvenience (Sustainable Adaptation)
	Low	Heat is a catastrophe (Poverty trap)	Heat is a manageable problem (Safety-first)

The residents in the "heat is an inconvenience" group are capable of long-term planning for adaptation and mitigation for urban heat as well as providing for increases to generic capacity through personal investments. This group has the potential to implement transformative adaptation strategies to address urban heat in the long-term. The residents in the "heat is a manageable problem" group have low generic capacity but also have developed high specific capacity through their individual and household management

behaviors. They rely on a social network of family and friends to assist them in heat-related emergencies resulting in minimal generic capacity impacts in times of need. While they may be asset-poor compared to the "Heat is an inconvenience" group, they have prioritized maintaining thermal comfort over investments in generic capacity that might increase their adaptive capacity compared to the "heat is an inconvenience" group level. Adaptive capacity to urban heat, therefore, needs to be addressed within a wider context with an understanding of the drivers of poverty and vulnerability.

Implications of differing narratives

There are positives and negatives associated with each of these urban heat narratives. These narratives have an impact on each other and, especially for the "heat is a manageable problem" group, life circumstances can result in a shift in capabilities and, as a consequence, change narrative group affiliation.

Heat is an inconvenience

While the "inconvenience" group has the assets and connections to cope with extreme heat with little impact on their lives, the reliance on air conditioning as a coping strategy could be troublesome in the event of a power outage. This group has minimal exposure to the outdoors and, therefore, are likely not acclimated to high heat. Further, air conditioning usage is maladaptive as it creates waste heat, requiring more air conditioning usage, which, in turn, creates more waste heat. Urban green infrastructure along with cooler construction materials and methods, such as passive cooling, may be a better long-term alternative to reduce energy usage and provide thermal comfort (Martinez et al., 2019).

> "This would be the worst place in the world to live, 'cause no one would know how to function here, and without air conditioning people would ... Our system, like our houses and our everything, ... There's not good cross breezes. There's not good shade. We deal with heat through air conditioning, and if that was not in place it'd be a crazy place to live, and I think people would go crazy."

There may be a lack of awareness in the 'inconvenience" group in understanding the travails and intersectionality of the urban heat issue for those in the "catastrophe" group. While some in this group had empathy for those less fortunate than themselves, there is a risk that some are "pretend(ing) that this is your desert island, private desert island, personal desert island and everything goes well." This group was *sure* that utility assistance services are offered but have no concept how hard it is to access them, especially in times of dire need. Utility assistance is available in metropolitan Phoenix area through location-specific city services, non-profits, and faith-based organizations that operate as a Utility Assistance Network. The 80 organizations operate under different rules, but most follow the guidelines for the Low-Income Home Energy Assistance Program (LIHEAP) which provides federal funds to assist families with energy costs. This is limited to a $250-$300 once per year payment. In 2017, LIHEAP funding reached only 6% of the eligible Arizona population statewide (Zwik, n.d.).

The danger of not understanding the challenges of life in the "manageable" and "catastrophe" groups is that the "inconvenience" group runs the risk of not supporting mitigation and adaptation policies, heat emergency programs, and public cooling spaces, among other interventions because they do not perceive urban heat as a serious problem that requires collaboration across many sectors to differentially assist those impacted by increasing urban heat.

> "Maybe that's why people don't really talk about it. Because if they're not around people for whom (heat) is a problem, or if you don't experience it as one, then you're probably not going to speak of it like one."

Heat is a manageable problem

While this group is frugal and maintains a managed life in many aspects beyond finances, some may be in a precarious position in a financial turndown, change in employment status, or if they experience enduring health issues. Their generic adaptive capacity could be threatened, and short-term solutions made more difficult. The residents in the "heat is a manageable problem" group understood the difficulty of accessing utility assistance services and believe that careful budgeting and long-term management of finances is an important safeguard. For some residents in this group, family and friends are able and willing to provide a safety net. The "heat is a manageable problem" group also relies on air conditioning as a coping strategy and are subject to the same risk of exposure, although less than the "inconvenience" group, as they have acclimated somewhat to outdoor temperatures.

Heat is a catastrophe

Urban heat, for the "catastrophic" group impacts their generic capacity and contributes to the poverty trap. This group pays a greater portion of their monthly income on energy costs and often has to make the decision between two bad choices, for example, to not pay rent or to not use air conditioning. While they are more acclimated to higher temperatures than other groups, this does not guarantee a positive health outcome when strictly limiting air conditioning use. The availability of emergency assistance, even if you qualify, is strikingly low. While a one-time payment will provide a very short-term solution, it will not assist with providing opportunities to increase their generic capacity,

thus ending this heat-related poverty trap. For these residents, programs that address chronic poverty issues may be better to solve heat-related public health problems.

There is also a concern as to who is offering the assistance, since the residents in the "heat is catastrophic" group mistrust police and largely believed that the city was not there to help them. Further, there is a mistrust among undocumented residents for outside/official interveners, who could expose a family member to potential immigration issues. There is a need to broker services through non-municipal providers, such as through faith-based organizations, community-based organizations, and non-profits, as a potential better conduit for assistance.

Future directions for expanding research on the differing narratives of urban heat adaptive capacity could focus on confirming these shared narratives on a larger scale and to specifically target the elderly, those living alone, those with young/school age children, and those experiencing homelessness. Understanding the social capital indicators and which relationships are most important for maintaining thermal comfort during extreme heat would reveal additional pathways for ensuring an equitable approach to assistance. More developed and expanded narratives will help target policies more effectively and efficiently and create a better understanding of the differing effects of urban heat on people's daily lives.

Conclusion

Current urban heat vulnerability research is improved by understanding differing narratives and points to a better way to think about populations within a city beyond vulnerability maps and demographic data. The "heat is an inconvenience," "heat is a manageable problem," and "heat is a catastrophe" groups each have distinctive

perceptions of urban heat, the coping behaviors necessary to maintain thermal comfort, and degree of impact on their generic capacity. This is necessary to understand to determine if standard recommended actions for coping with heat adequately represent solutions for the heat exposure levels and resources of more vulnerable groups. Learning how and under what circumstances vulnerable populations are motivated to make necessary changes to increase thermal comfort and safeguard public health will ensure that targeted heat mitigation and adaptation policies are widely adopted.

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CHAPTER 4

SOCIAL CAPITAL: IMPROVING COMMUNITY CAPACITY TO RESPOND TO URBAN HEAT

Abstract

Urban heat is a growing problem, especially for vulnerable populations who are disproportionately exposed to higher temperatures. Adaptive capacity and, especially, social capital increases recovery from disasters and enhances adaptation. Social capital is declining nationwide and the Sunbelt States, with highest national temperatures, have the lowest levels of social capital. Social capital is situational and reflects and reflects a position within the formal and informal aspects of any issue and frameworks developed for some purposes may not be relevant for others. Few have fully explored social capital and its relation to heat vulnerability. This research explores indicators and related questions for specific social capital for urban heat. There is a need to better understand social capital in the context of urban heat to determine if it is present, is used, is enhanced or is a latent capacity. Better metrics for urban-heat social capital can inform policies that deepen networks and increase trust, minimize poor public health outcomes, and facilitate more effective community engagement.

Introduction

Extreme urban heat is a leading cause of weather-related illness in the United States and, given projections of increasing urban heat intensity, expected to be a growing problem (CDC, 2019, National Climate Assessment, 2018). Not all populations are affected equally by heat. Vulnerable populations have been identified using various

combinations of measures for sensitivity, exposure, and adaptive capacity at the household level (Cutter, 2003; Harlan, 2006; Reid, 2009; Chuang, 2015) and its influence on urban heat morbidity and mortality. Lower socioeconomic groups, those with pre-existing health conditions, minorities, the elderly, and those with limited access to cooling benefits are especially vulnerable to urban heat (Harlan, 2006). This paper explores the specific elements of one form of adaptive capacity, social capital, and how it is used in adapting to or mitigating urban heat and offers a framework for measuring specific social capital for urban heat.

Vulnerability Measurements for Urban Heat

Few have fully explored social capital and its relation to heat vulnerability. Social capital is derived from three schools of thought: Bourdieu, Coleman, and Putnam. Social capital is defined by Bourdieu (1984) as the actual or potential resources of a network of relationships of mutual acquaintance or recognition and is a theory based on social stratification. Social capital is one of four types of capital, the others being economic, cultural, and symbolic. Coleman (1990) considers social capital an outcome of social processes and interactions whose social structures of relationships could develop into resources for individual uses. Putnam (1993) defines social capital as the features of social life, the networks, norms, and trust, that allow participants to act together more effectively to pursue common goals. Social capital generates benefits at the neighborhood scale as networks of civic engagement reinforce and encourage reciprocity and trust, facilitate communication and dissemination of information, amplify reputations, and assist in collective action resolutions. Social capital can be used to research adaptive

capacity and actions within communities of place (residents) and communities of practice (organizations)(Pelling, 2005).

Previous research has attempted to quantify social capital in relation to heat vulnerability. Harlan (2006) developed an outdoor human thermal comfort index which found positive correlations between heat stress exposure and low income/minority communities. Harlan (2006) assessed the strength of neighborhood social ties through four questions pertaining to relationships with neighbors: how well you know your neighbors, visit informally, invite them over, help your neighbors. Due to less trust and networks among neighbors (bonding social capital) and less meaningful contact with decision makers (bridging social capital), residents are unable to work collectively and advocate for heat mitigation and adaptation strategies (Harlan, 2015). Reid (2009) included public health data, air conditioning prevalence, and social isolation, along with the social/environmental components of the SoVi index (Cutter, 2003) to create a heat vulnerability index (HVI).

Wilhelmi (2010) included social capital as an aspect of heat adaptive capacity. Adaptive capacity in this framework consisted of household level knowledge, attitudes, and practices (KAP), household resources, social capital, and community resources and risk reduction programs. Proxies for strong social capital were knowing neighbors, talking with neighbors often or daily, feeling comfortable asking for assistance from neighbors, and calling a neighbor or someone in the neighborhood in emergency situations. The respondents in this research did not join formal organizations and were unaware of community heat-related programs (Hayden, 2011).

Existing social capital indicators developed for other purposes

Social capital, however, is more than knowing and relying on neighbors and belonging to organizations. Political science literature details robust frameworks for measuring social capital. This section details relevant social capital theory, highlighting three frameworks, and describes measurement challenges.

Concern for weakening civic engagement has spurred a growing body of political science literature on general aspects of social capital to determine the strengths of associational life. While there are many definitions in the literature, this paper defines social capital as the norms of reciprocity and trust among individuals as well as shared social networks (Putnam, 2000). Under this definition, social capital is measured on two different scales – the household or individual level which includes individual relationships as well as associational life, and community social capital comprised of the total of all members' relationships.

There are two components to social capital theory: the types of interpersonal relationships, and trust and reciprocity. Bonding social capital occurs within homogeneous groups such as religious or ethnic groups. Higher levels of bonding capital generate higher levels of trust and shared norms. Bridging social capital describes relationships of exchange between people with shared interests but different social identities. These individuals are loosely connected through involvement in civic, political, education, sports, and special interest organizations. These ties display greater demographic diversity than bonding social capital and can provide new information and resources to assist individuals in advancing in society. Linking social capital includes

vertical relationships across boundaries (such as community groups and social classes) and connects everyday citizens with those in positions of power (Putnam, 2000).

Previous research highlights that urban communities have strong bridging capital and less bonding capital than rural areas, and that men have more bridging and linking social capital whereas women have stronger bonding social capital (Woolcock, 2000(Woolcock & Narayan, 2000)). According to Putnam (1993), social capital makes life easier in communities. The networks of engagement reinforce and encourage reciprocity and trust, facilitate communication and dissemination of information, amplify reputations, and assist in collective actions. Households use individual mitigation strategies in situations where there is a weak civil society and centralized decision-making (Pelling, 1998).While increasing collective social capacity would be in the public interest and long-term individual advantage, individuals are not always motivated to participate in collective action (Pelling, 2005).

Social capital can explain how individuals and communities can shape hazard mitigation and adaptation strategies (Pelling, 2005). Social capital enhances adaptation and ensures better recovery from disasters (Pelling & High, 2005) and strong social ties are usually protective behaviors (Harlan, 2006). Bonding social capital facilitates the flow of disaster information and preparation, and immediate aid and recovery assistance and, thus, reduces requests for formal assistance. During disasters, individuals withdraw from the larger society and turn to close knit groups, strengthening bonding capital. Social capital networks provide access to resources in disaster situations such as childcare, emotional, and psychological support, relevant information, and financial resources (Aldrich & Meyer, 2014). Low-income and immigrant networks have a well-

connected network of family and friends (Hanson, 2014) and the community grapevine is invaluable for spreading information especially for those whom English is not their first language. In the context of urban heat, Klinenberg's (2002) assessment of the 1995 Chicago heat wave found that isolated, elderly residents were more likely to die. Further, those that died resided in a poor, African American community with less social capital than an equally poor, neighboring Hispanic community.

Social capital still is declining overall in the United States especially as the highly engaged, "Greatest Generation" of those born before 1930, have died off. What has emerged is a divide in community engagement by social class (Sander & Putnam, 2010). Youth community engagement among white, upper middle-class families have strengthened while youth engagement among working class or lower-class backgrounds have declined. Related to this, trust in other people remained steady among more affluent youth but declined among those less privileged. This class divide is noted by other social capital studies and extends beyond youth engagement. Polarization has escalated to demonizing those who do not think similarly, which further erodes social capital (Murry, 2012, Dunkleman, 2014). This culminates in an upper middle class that has much influence on "the course of the nation," but little exposure to the lives of ordinary Americans. They make decisions about what is good or appropriate for other people based on their experiences and atypical lives (Murray, 2012,p. 100-101).

Social scientists have not agreed upon how to accurately measure social capital (Aldrich & Meyer, 2014). One technique is derived from attitudinal and cognitive aspects of social capital such as trust. Here, survey questions delve into general measurements of trust such as "most people can be trusted" or "most people are honest" and is measured

relationally to other groups (Putnam, 2000). Another method is through behavioral manifestations of social capital in daily life and explores memberships in homeowner, volunteer, or other local organizations, or whether doors are locked.

The largest and most commonly used survey of social capital is the Harvard University National Social Capital Benchmark Community Survey (2000, 2006). It measured participation in community/organizational life, engagement in public affairs, community volunteerism, informal sociability, and social trust. This study was developed to better understand social change in America and declining civic participation. The decline in institutional trust, less volunteering for large, national organizations, and women entering the workforce, according to this study, contributed to a decline in social capital. Survey questions included voting behavior, parade attendance, political involvement, donating blood frequency, and trust for different ethnic groups, factors which may not have an impact on adaptive capacity for urban heat.

The World Bank provides a social capital assessment tool (SOCAT) to measure structural social capital, cognitive social capital, and collective actions. It is used to assess development opportunities and includes community profiling and asset mapping, measurements of collective action and solidarity, community governance and decision making, relationships between organizations and the community, and institutional networks and organizational density (Grootaert et al, 2004).

The Joint Economic Committee of the United States embarked on a three-year research effort to illuminate the quality, importance, and changing nature of social relationships called the Social Capital Project. It measures “associational life” at the state and county scale. The family unit figures prominently in this framework and includes

family unity, family interaction, social support, community and institutional health, collective efficacy, and philanthropic health. The Joint Economic Committee reported that social capital was measured to be the lowest in Southern states – the regions with the highest and longest periods of extreme temperatures. (New York State, also with a low score, was the geographic outlier.) This study noted that less time is spent with coworkers outside the job and with neighbors, there is less racial segregation but more class segregation, and lower membership and confidence in organized religion. The time spent with friends, time volunteering, and trust in friends and local government remained the same from the 1970s to the 2010s.

Specific Social Capital for Urban Heat

Social capital is situational and reflects a position within the formal and informal aspects of any issue (Pelling & High, 2005). Since social capital will change depending on the issue, it becomes difficult to make comparative evaluations using social capital frameworks developed for other purposes. Urban heat is a contextual, local issue, and county, state, or national aggregated indicators for social capital may provide a general direction but a social capital indicator tool for urban heat must be tied to very local and time specific settings to be meaningful. Understanding how social capital is utilized under the issue of urban heat can augment vulnerability indices and vulnerability mapping on an individual, household, and neighborhood basis can inform public policies, minimize poor public health outcomes, enhance adaptive capacity, and provide avenues for greater thermal comfort for the most vulnerable populations living with the effects of inequalities. There have been limited attempts to add to vulnerability frameworks ethnographic knowledge of "behavioral norms, social networks, and risk perceptions that

are equally relevant to understanding urban vulnerability" due to lack of data (Wolf, 2015).

Therefore, I ask what are the social capital indicators that are important in coping with extreme heat at the individual, household, and community scales? And second, how could this be measured? There is a need to better understand the indicators for social capital in the context of increasing urban heat to determine if it is present, is used, is enhanced or is a latent capacity. Practitioners have underutilized social networks in community outreach, maybe due to "few agreed upon metrics" (Aldrich and Meyer, 2015). Better metrics for urban-heat social capital can inform policies that deepen networks and increase trust, minimize poor public health outcomes, and facilitate more effective community engagement.

Methodology

My approach to develop a specific social capital instrument for adapting to and mitigating heat used different methods and data sources. Data were derived from urban heat-specific interviews, community engagement workshops and a stakeholder meeting to better understand the social capital deployed when coping with urban heat. Included in this three-part research were different population groups involved in and affected by urban heat: communities of place (residents) as well as communities of practice (organizations). The urban heat social capital indicators resulting from this analysis were compared to existing frameworks to uncover similarities and new questions for further exploration.

Coping with increasing urban heat has two dimensions: the short-term emergency management of extreme heat events and the long-term mitigation and adaptation in urban neighborhoods. In the highest need communities, there is often limited shading along streets, few “third places” with cooling infrastructure such as parks and water features such as pools or splash pads, and housing with inadequate insulation and older air conditioning units. Long-term mitigation and adaptation strategies for urban heat would correct some of those inequities. Strong ties and close-knit social networks have proven helpful in emergency situations, yet the weak ties of bridging and bonding relationships are instrumental in working towards transformations in a community. A community needs both strong and weak ties to holistically tackle urban heat.

The Organization for Economic Cooperation and Development (OECD) compiled metrics for measuring social capital and the OECD Social Question Databank, assembled from 50 international and national surveys, allows users to compare different question types and response formulations. Questions are organized by “social capital theme” (Grooteart, 2004) including trust and cooperative norms (social norms and shared values), personal relationships (the structure of personal networks and how they are established and maintained), social network support (resources available to individuals through personal social networks), civic engagement (activities that contribute to community and civic life).

For specific social capital indicators for urban heat, I tested the OECD framework to validate if these state and county level frameworks apply to the neighborhood scale and whether general social capital surveys can be adapted to specific climate related issues such as urban heat. Of the 39 categories listed by the OECD, I determined that 19

categories were relevant to urban heat (see Appendix B).The remaining categories, such as news readership, have little bearing on coping with or mitigating or adapting to extreme heat.

Extended interviews

Extended interviews were conducted with 23 residents of metropolitan Phoenix to better understand adaptive capacity at the individual, household, and community scale. These three-part interviews consisted of a broad, open ended question - "tell me about the issue of urban heat" – to provide unsolicited perceptions of risks, beliefs, social relationships, and coping behaviors. The second portion contained open-ended questions about challenges currently faced (which may or may not have to do with urban heat), financial or behavioral changes made when it is extremely hot, and social relationships and organizations that might help in heat-related situations. The last part took a deep dive into the interviewees' social relationships, informal and formal networks, and perception of community cohesion and used questions from the OECD database.

Community engagement workshops

The Nature's Cooling Systems project consisted of a series of nine community workshops held during the summer and fall of 2018 to collaboratively develop community-specific heat action plans in three underserved metropolitan Phoenix neighborhoods (Guardaro, n.d. (a)). Led by The Nature Conservancy along with the core team of Arizona State University, the Maricopa County Department of Health, and the Arizona Conservation Alliance, the community engagement methodology adapted from Semenza (2007), was designed to enhance bridging, bonding, and linking social capital during the workshop process, demonstration projects, and production of the heat action

planning guide containing three neighborhood heat action plans. Community-based organizations played a key role in bringing residents and other relevant organizations into the process. The workshops also included city management, other community-based organizations, not-for-profits, landscape architects, designers, and regional transit officials. The initial workshops allowed for the building of bonding social capital, and, with the escalating participation of experts and decision makers in the second and third workshops, developed bridging and linking social capital.

Stakeholder meeting

A stakeholder meeting among the community of practitioners was held eight months after the last workshop to reflect on the Nature's Cooling Systems process and to discuss how the heat action plans will be integrated into other community and municipal efforts. During this session, social capital was explored to understand how relationships were made and strengthened across communities. The communities of practice groups played a vital role in serving as connectors for residents and leaders in the three neighborhoods and were instrumental in explaining various processes for effective community engagement. They were the key to building bridging and linking social capital.

Triangulation across data sources (interviews, workshop proceedings, and a stakeholder meeting) were utilized to reduce biases and increase reliability and validity of this research. This validity procedure is used by researchers to uncover agreement and alignment from different sources of information to develop themes from the research data (Creswell & Miller, 2000). Triangulation increases the breadth of the research and allows for a more complete understanding of the data (Jonson, 2009).

The interviews, workshops, and stakeholder meeting were recorded and transcribed. Notes from those transcriptions provided an overview of the aspects of social capital as it relates to urban heat. Using deductive coding methods, where a codebook is used as a reference throughout the coding process, the transcriptions were coded for broad social capital themes used by the OECD (Fereday, 2006). Common descriptions emerged from across these data and were used to develop parameters for specific social capital for urban heat including indicators and related survey questions.

Using different social capital frameworks, these urban heat social capital indicators were compared to existing questions and categories. Where possible, existing indicators and questions from tested assessments, such as the Harvard Community Benchmark Social Capital Survey, the World Bank Social Capital Assessment Tool (SOCAT), and the Social Capital Project were used to provide an opportunity for future comparisons.

Results

The following sections detail the evidence of social capital used by study participants to cope with and adapt to urban heat. Effective social capital for urban heat includes a combination of trust and reciprocity, personal relationships, and community engagement in both formal and informal organizations. Strong ties, in the form of bonding relationships, were tapped for assistance in reducing exposure, especially during emergency situations. The bridging and linking relationships, weak ties, were developed during the engagement process, both for organizers and for the residents.

Evidence of effective social capital for urban heat

Three narratives emerged from the extended interview data: heat is an inconvenience, heat is a manageable problem, and heat is catastrophic (Guardaro, n.d. (b)). Those in the "heat is an inconvenience" group, live a largely air-conditioned existence, are rarely exposed to extreme heat for extended periods of time and have the ability to pay for any urgent or long-term needs in adapting to urban heat. Those in the "heat is a manageable problem" group have exposure to the extreme heat but manage it in a way to ensure thermal comfort and health. High exposure levels and high indoor temperatures are part of living with extreme heat for those in the "heat is a catastrophe" group. Their lives are greatly impacted by extreme heat and their schedules and activities are changed compared to cooler months. The effective social capital for urban heat focuses on the social capital necessary specifically for the latter two groups. (The workshop participants, communities of place, were considered to be in the heat is a manageable problem or heat is a catastrophe group.)

Trust & Reciprocity

Trust and reciprocity include attitudes and beliefs about the values and expectations of family, friends, and the larger society, feelings of belonging or discrimination, cooperative behavior norms, and trust in different institutions such as the government or police. Interview data highlights the deep bonds and reciprocity thriving in neighborhoods.

> "I have no problem calling them, and them coming to my rescue at any given time. And if they can't, then of course they call out to others, and it's like a chain reaction literally. I learned that, that I can really count on them… I contacted one person, they contacted another to help me get there. And I was like, wow. I know

> these people will move mountains for my family and for any family, to get where they need to go. I've seen it happen."
>
> "More for people we know who don't have (the) luxury of a car, so to get places, there will be people who check in to ask if they need rides. If someone is absent or unavailable through calls and text messages, then there will probably be a string of people trying to figure out where is so and so is if it's been a while. If we have any of our planned gatherings and meetings and someone doesn't show, typically someone will check in through text or whatever."

Attitudes and beliefs

Trust in government and police, in the context of urban heat issues, was found to be important for long-term adaption. During the Nature's Cooling Systems workshop process, participants discussed their reluctance to become involved in city projects because they did not want to go to Town Hall and instead wanted municipal leaders to come to their neighborhoods, using their language, during appropriate hours for the working residents, to better understand their culture and needs. Further, workshop participants revealed that they were reluctant to contact the police about illegal activity in their neighborhoods for fear that they would be accused of the crime. There was a general sentiment that "people who look like me" get harassed; this was also true for interviewees from minority populations and also the formerly homeless. They did not want the police in their homes. Instead, informal community networks provide assistance instead of relying on institutions.

Interviewees reported that friends and family connections are important in coping with urban heat. When it is very hot, those with a strong network went to someone else's cooler house or swam in their pool. Trips outside of the urban area with friends and family were common. For those that must use public transit, friends and family provided rides in the extremely hot weather.

Cooperative Norms

There was a strong sense of community identity and attachment to neighborhoods during the workshops and stakeholder meeting. Some interviewees expressed the importance of working with what you have to make their community a better place, rather than wishing they lived in another place. People in the "heat is a manageable problem" and "heat is a catastrophe" groups believed that people like them can make a difference. Many discussed how it just takes one motivated resident to initiate change where others can assist. Those people who serve as "connecters" to others, provide help in emergency situations or with other less-pressing issues and are highly important to the survival of the community. They bridged relationships between different groups and services. Respondents in the interviews and the workshops felt that understanding who was a connector resulted in fast-tracking solutions as they have knowledge of how to get things done effectively. One connector boasted "almost all of our calls get attended to."

When speaking about home projects to improve thermal comfort such as installing new air conditioning, repairing older units, or installing more thermally efficient windows, the interviewees spoke of their network of friends and family that helped by providing a "family discount," or, more importantly during high heat days, immediate assistance. Unlike the "heat is an inconvenience group" that would call AAA if their car broke down on a highway, the cooperative norms among the interview study group revolve around assistance from family or friends.

Experience of Discrimination

Workshop residents of underserved communities understood that other areas within the city have more amenities and that, to some extent, the rules are not equally

applied and/or are not enforced in their communities. Vacant lots produce dust in the desert environment and during the workshops one of the not-for-profit members pointed out that there are regulations where construction sites must spray water on the lot to reduce dust. The workshop respondents' response was "not in this neighborhood you don't." Low-income, minority neighborhoods in metropolitan Phoenix are the result of a history of discrimination against Latinos and other minority groups that have resulted in a vast disparity of infrastructure investments and amenities compared to non-minority neighborhoods (Harlan, 2006).

Identity and belonging

Among the Latino interview participants, family was very important in coping with extreme heat. They watched out for their extended families and helped when needed. One workshop participant stated the first thing he bought when he got his first job was an air conditioner for his parents. Extended families gather together often whether it is to celebrate or in times of crisis. This face-to-face frequent interaction strengthened their bonds and reinforced their obligations to each other. A white, elderly interviewee whose daughter married into a Mexican family, felt that he could turn to this very large extended family if he needed anything.

Personal Relationships

Based on interview, workshop, and stakeholder meeting data, the foundation for effective social capital for urban heat rests on personal relationships. The size of social networks and the perceived support from those contacts, along with regular social contact provides additional coping capabilities in extreme heat conditions. Personal relationships include both face-to-face and non-face-to-face social contact, contact with people from

different socioeconomic groups, network size, places or activities where personal relationships are established and number of people to count on. The interviews revealed relationships and networks that have frequent contact.

> "So we have, as a whole we spend time with a lot of people, but then we also have a smaller community within that community, I guess you could think of it like as a small group, or we call it a missional community that we get together on a regular basis and really just try to live life with. So, we have a lot of shared experiences together. So that community essentially kind of functions like a family. So, we share meals together, if we have birthdays or other celebrations, we share that, we watch each other's kids, we have each other over for different events or just to have play dates during the day. I mean, we help out. There's kind of a general sense that we're going to be there for each other."

> "There are six siblings here in Mesa. The other six are in Mexico. All families have issues, some problems. When it comes to a family time, crisis, or just to celebrate, we're always there. We're always in touch over the phone. Also, I'm attached to one of them with two of my nieces, they're always at my house. We try to see each other at least once a month even though we live close. I think we see them more than that."

The sources for personal relationships varied as some respondents had extended family living nearby, some lived with extended family, and others made close networks that are similar to family. The members of these groups have a "shared life" with deep connections and can rely on these deep, personal relationships, especially during emergency situations. Faith-based organizations provided an opportunity to build community outside of the family unit, especially those religious institutions that met once a week beyond worship services. Some interviewees remarked that they do not have many friends "outside of my house and people I hang out with at church meetings."

Surprisingly, interview respondents who had a high number of relationships relied on face-to-face social contact rather than social media. More than half of the interviewees had face-to-face social contact with 25 or more people over the course of a month, outside of school or work contacts. This was important for effective social capital for

urban heat as it because it became an early warning system if someone fails to show up or an extra safety measure if someone appeared to be ill from the heat. Text messaging groups that kept distant relatives and school chums connected and were not perceived to be necessarily helpful in building effective social capital for urban heat.

A handful of interviewees and workshop participants knew their neighbors well and the vast majority of those who knew their neighbors lived in their current house for a long period. The rest knew their neighbor well enough to wave and nod, but never mentioned a neighbor as someone they could rely on or who relied on them.

Social isolation

The antithesis of strong support, social isolation, has been posited as an important determinant of extreme heat vulnerability (Klinenberg, 2002). The vast majority of participants in the Nature's Cooling Systems workshops and interviewees lived with other people, so the issue of social isolation arose only in speaking about others in their community, usually the elderly. Respondents differentiated between living alone, being reclusive, and being socially isolated. Interviewees that experienced homelessness felt they were socially isolated.

Civic Engagement

Trust and reciprocity, along with personal relationships, build strong ties and bonding social capital. In order to extend these assets beyond the household level, community actions are necessary to provide for a cooler, safer environment. Effective social capital for urban heat includes different aspects of civic engagement from participation in community activities to being actively involved in groups or clubs of any

type along with religious participation. The interviews revealed the presence and participation in more informal groups rather than large, established national institutions.

> "I guess there's a lot of people that I rely on when it comes to my community life because we help each other out a lot of on little projects that we're working on or little, I don't know. I always have little side community projects that I ask someone for help to research something. Yeah. So, I'm always like, "Hey, can figure this thing out because I've been working on this thing over here." And that, I don't know. There's probably a group of 10 to 15 people that kind of fallen to that category of relying on for community stuff."

Civic Action and Community Engagement

Interviewees reported that support within communities occurred through individual, small group, and community-based organizations. The workshop participants had some interactions with larger non-profits and local chapters of national organizations. Organic, special interest groups formed to tackle "little side community projects." through both formal and informal channels. The structure of community involvement was fluid; rather than organized committees, community members worked on an issue and then reformulated the group for the next issue.

Engagement in the form of advocating at City Hall or with municipal authorities was low for both the interviewees and participants in the Nature's Cooling Systems workshops for a range of reasons, the most important being that they did not feel welcomed. During the workshops, municipal leaders explained the participation process and opportunities for engagement with officials who can implement change.

Associational involvement

The Nature's Cooling Systems process brought together people who might not have otherwise interacted. The workshop "community of practice" acknowledged that engaging the community required a lot of effort, but it was worth it when urban heat

solutions were collaboratively developed. The stakeholder meeting highlighted how outside organizations offered subject matter expertise, but residents provided the local context and wisdom. Community-based organizations provided knowledge about past efforts, broken promises, and future plans. Other, small, local organizations within the community became involved as the process developed.

Religious Participation

Some interviewees spoke about having a strong faith-based community where they not only went to weekly services but also were involved in smaller subgroups on a weekly basis. Prayer groups, missional communities, and mission-based work allowed for a widening of the social circle beyond friends and family. Because they see each other on a regular basis, they know what is happening in each other's lives and know when someone needs help, which is important during extreme heat periods. This formed a sense of community that became a substitute family, complete with the benefits and trials of extended family life. There was a sense of being committed to each other, not just because they liked each other, but because there was "something more." There was general agreement, though, that these relationships took a long time to build.

Discussion

I found that effective social capital for urban heat (ESCUH) reflects two requirements for increasing thermal comfort. First, during extreme heat emergency days, social networks can provide a needed safety net, especially in neighborhoods that are impacted by inequalities resulting in hotter environments compared to surrounding, wealthier neighborhoods. Second, to shift that dynamic, collective action is needed for

upgrades and installation of cooling features that increase long-term mitigation and adaptation**.**

Effective social capital for urban heat (ESCUH) indicators

Since social capital cannot be measured directly, it must be inferred from contributing factors or manifestations and indicators linked to social capital theory. There are factors that impact social interactions and facilitate increasing social capital, for example, having a large extended family. The other measurement, manifestations, are outcomes of social capital, such as cooperative community actions undertaken.

Understanding the mechanisms through which social capital is used can refine existing measures or lead to the discovery of new, more appropriate measures (Carrillo-Alvarez, 2017). At the household or individual level, my analysis indicated that social capital may influence coping with extreme heat by:

- Ensuring minimal thermal comfort is achieved and health is not compromised by frequent face-to-face frequent contact. Non-face-to-face contact allows for assistance from a wider network of social contacts.
- The strength of bonds between contacts and sense of obligation that serve as a safety net and opportunity for reciprocal care for extreme urban heat.
- Pooling of resources to assist in providing for thermal comfort and increased capacity to find heat relief outside the urban area.
- Social engagement and social participation in organizations that increase access to local services

At the community level, mechanisms contribute to long-term adaptation and mitigation, and require some level of social cohesion for collective efficacy. They include the:

- Presence of local, embedded organizations and efficacy of past civic actions that indicate social capital capacity and high levels of social capital inherent in the community.
- Feeling of belonging and identity with the community and the belief that change can happen, which serve as motivation for positive change for those most affected.

- Levels of exclusion and discrimination which result in feelings of alienation and further drive actions to the household level at the expense of collective action.

The indicators for effective social capital for urban heat are detailed in Table 8 and a comprehensive list of survey questions to support these indicators is in Appendix C.

Table 8
Indicators for effective social capital for urban heat (ESCUH**)**

Variable category	**Description**	**Indicator**
Trust & Cooperative Norms	Attitudes and Beliefs	Importance of family and friends Support from local government
	Cooperative Norms	Collective action within the community
	Experience of Discrimination	Experience of discrimination and exclusion
	Identity and Belonging	Commitment to community
	Trust in Institutions	Trust in local government Trust in local police Willingness to attend public meetings
Personal Relationships	Family	Presence and size of nearby extended family
	Social Contact	Daily contact face-to-face plus non-face-to-face Contact with others outside the home
	Sources of Personal Relationships	Overlapping networks
Social Network Support	Network size	Size of social network
	Perceived support	Support from family Support from friends Support offered to others
Civic Engagement	Community engagement	Engagement for community issues
	Associational involvement	Presence of organizations in community Active involvement in local organizations
	Religious Participation	Presence of faith-based organizations

		Small-group faith-based involvement

These indicators are influenced by both weak and strong ties and the intense obligations between certain groups. ESCUH survey questions were developed using questions derived from existing social capital surveys and, where there were gaps, new questions based upon the results from this study were added.

Weak and strong ties

Strong and weak ties are complementary components of urban heat social capital (see Table 9). Strong bonding ties within families can come at the expense of linking and bonding social capital at the community level. Social networks increase an individual's ability to adapt to increasing heatwaves; they do not translate into community-level actions (Zografos, 2016). ESCUH indicators for urban heat would measure both.

Attitudes and beliefs about friends and family as well as cooperative norms within the family unit explain the strength and depth of the relationships; personal relationships and social network support indicators highlight the breadth of an individual's network. These indicators will illuminate strong ties within tightknit family and social networks that enable recovery during disaster events and build/maintain resilience at the household scale. At the neighborhood/community scale, attitudes and beliefs about the local area and government and society, as well as community engagement display the potential to develop mitigation and adaptation plans within a community.

Table 9
Strong and weak tie measurements for understanding household and community social capital strength

	Strong Ties	Weak Ties
Trust & Cooperation	Importance of family & friends Commitment to community	Support from local government Collective action within community Experience of discrimination & exclusion Trust in local government Trust in local police Willingness to attend public meetings
Personal Relationships	Presence and size of nearby family Daily contact face-to-face & non-face-to-face	Contact with others outside the home Overlapping networks Support offered to others
Social Network Support	Support from family Support from friends	Size of social network
Civic Engagement	Active involvement in organizations Small-group faith-based involvement	Engagement for community issues Presence of organizations in community Presence of faith-based organizations

Intense obligations

All strong ties are not equal which has been overlooked in previous urban heat vulnerability research. Cultural obligation norms and shared religious commitment revealed relationships that are "something more." This may explain why Latino neighborhoods fared better in the Chicago heat wave compared to similar socioeconomic communities (Klinenberg, 2002). These deep commitments, especially to elder members, may also explain why the elderly in these communities were not as vulnerable.

In the Latino community, family is defined not just as a nuclear family living together with blood or marriage relations, it is defined along the line of relationships. These "fictive kin" are equally important as marital or biological family (Gill-Hopple, 2012) which allows for inclusion of new members as kin and reinforces reciprocal

interdependence. Familism, where the needs of the family are more important than any one family member, a Latino value, results in more frequent contact compared to Anglo families (Lopez, 1999, Grebler, Moore & Guzman, 1970, Keefe 1979). Because of these multigenerational kin, second generation Latino families have broader social networks (Vega, 1990, Lopez, 1999).

Cultural differences in the level and intensity of obligations between family members became apparent among study participants. During the interviews, some spoke of making family from a collection of nearby friends, others had extended family networks with intricate family bonds emanating from the Latin American concept of compadrazgo, or co-parenting. Usually part of a Catholic baptism, the child and parents of the child become linked with a sponsor for the child. The biological family is the first linkage, the sponsor and child the second linkage, and the third link is between the sponsor and the parents. In Latin American culture, the compadre-comadre become the "fictive kin" and co-parents of the child (Mintz & Wolf, 1950). The American Catholic godparent relationship is a smaller form with obligations focusing on the religious upbringing of the child, however the compadre-comadre relationship is much larger and more encompassing. This practice has increased vertical or bridging relationships between different classes of people, as the compadre or comadre is a person with prestige who is financially responsible, has "influence," and is the social link between different socio-economic groups.

The compadre or comadre functions to broaden and increase the social and economic resources of the child and his parents. It solidifies relationships horizontally within the extended family group. The community where compadrazgo is practiced is

more interdependent and secure (Mintz & Wolf, 1950). Insecurity and scarcity of available resources are moderated by the extended kin system (Lopez, 1999). The social, emotional, and financial support from these complex family relationships may explain why Latinos use fewer formal services compared to others in similar socioeconomic positions (Lopez, 1999). This mechanism of compadrazgo may be influential in limiting exposure and securing thermal comfort for more vulnerable family/ritual kin members.

Measurement questions for the indicators

The effective social capital indicators for urban heat in Appendix II reflect essential social capital components, which can be measured a variety of ways. Survey questions for effective social capital for urban heat were derived from the Social Capital Project, the Social Capital Benchmark Survey, and other surveys compiled by the OECD. Based upon the data from my research, I used existing survey questions when they accurately represented qualities respondents deemed valuable, but that left gaps or supporting questions that were not previously used in social capital frameworks. Therefore, we developed additional questions as a consequence of this research.

Trust & Cooperative Norms Questions

Social capital generated without economic gains are important for coping with extreme climate events (Adger, 2003). This section contains questions about importance of family and friends, and attitudes and beliefs about assistance from local government. Questions about past collective actions indicate capacity levels for community-wide adaptation and mitigation for urban heat. Study participants indicated that they believed people like them have the influence to make changes in the neighborhood, and, in fact, sometimes it takes just one person to make a change. Past experiences of discrimination

and exclusion have tempered formal civic involvement and eroded trust in local government and police. Measurements about public meeting attendance, the standard, do not delve into an important reason for this illuminated during the Nature's Cooling Systems workshop – residents do not feel comfortable meeting in Town Hall or other official government venues. Feelings of belonging to the community and length of residence may be closely correlated.

Personal Relationships Questions

The Social Capital Project focused on family unity as a major support provider and measured single parent households and marriage statistics with the assumption that a traditional nuclear family had more resources and time to participate outside the household. The effective social capital indicators for urban heat expands the concept of family and measures the number of adults living in the household (married or not) and strength of these relationships.

The 2000 and 2006 Social Capital Benchmark Study contained many questions about network diversity and attitudes toward different socio-economic groups. Neighborhood composition has shifted to a stratification by economic groups, resulting in a "new kind of segregation" (Murray, 2012). The likelihood that of working with dissimilar neighbors are decreasing, therefore, indicators and categories about diversity were not included. The focus for effective social capital personal relationship indicators is on the number of face-to-face relationships and the intensity and frequency of these relationships. Non-face-to-face contact may reflect impersonal relationships formed from shared interests, a new sense of belonging, but may be without a sense of obligation (Dunkelman, 2014).

Social Network Support

Living alone and social isolation increase urban heat vulnerability (Harlan, 2006; Klinenberg,2002). However, living alone does not equal social isolation and, therefore, a "living alone" metric may misrepresent social ties. An epidemiological study of the 1995 Chicago heat wave found that people who lived alone or *did not leave home each day* had a higher risk of mortality (Semenza, 1996). The effective social capital for urban heat queries frequency of interactions with others and whether participants leave home each day to better understand social isolation issues. A large network of friends, along with support from a range of sources for general issues as well as urban heat related challenges, can reduce vulnerability.

Civic Engagement

Civic engagement and associational involvement have eroded over time, especially for large, non-profits. Americans now consider themselves "members" of organizations but stopped attending meetings and serving as officers (Putnam, 2000). Prior urban heat vulnerability research highlighted the low levels of memberships in formal organizations (Wilhelmi, 2010), yet the study participants involved in this paper spoke of organic, small, local, less formalized groups in their community. The questions in this section seek to measure the number of organizations regardless of size, and active involvement inside and outside of an organizational structure. The Social Capital Project measured these same variables using US Census survey data from the Volunteer Supplement to the September 15th Current Population Survey, US Religion Census: Religious Congregations and Membership Study, County Business Patterns, and the American Community Survey.

Summary

Measuring effective social capital for urban heat will help to further explain adaptive capacity and isolation issues in coping with heat. It will also allow for a transfer to other resilience issues, and provide an effective pathway for community engagement, especially in under-served neighborhoods.

While belonging to a strong social network can reduce vulnerability to urban heat (Harlan, 2007; Klinenberg 2001), the composition of that network and obligations, trust, and reciprocity have largely been unexplored in the context of urban heat, especially among minority, low-income marginalized groups (Zografos, 2016). Vulnerability indices that are measured relative to mortality and morbidity do not focus on positive adaptation factors: absence of mortality does not necessarily equate with high levels of coping or adaptation. Further, the 14 urban heat coping behaviors detailed by Belanger (2015) could be enhanced to include behaviors that contribute to (or diminish) effective social capital for urban heat.

Social isolation is particularly dangerous and is highly correlated with extreme heat vulnerability and could be viewed as the absence of social capital (Klinenberg, 2002). Social insulation, the social networks, systems, and behaviors, provide protective factors for extreme heat (Chakalian, 2019). Definitions of social isolation, however, differ between disciplines, sometimes far from the literal meaning of being disconnected from other individuals, used by epidemiologists. Isolation, for sociologists, describes the relationships between rather than among communities. The motivation for isolation matters, too. Fear of crime and perceived neighborhood dangers cause some to isolate themselves from neighbors, which is different from a conscious lack of contact with

friends, families, and other institutions. Therefore, the question often seen in social capital surveys of "Do you live alone?" needs to be qualified with other social capital measures.

In general, climate adaptation discussions have involved government officials, universities, and environmental non-governmental organizations. Vulnerable residents are rarely engaged in this process (Phadke, 2015). The neighborhoods that need the most help are often the most difficult to reach and this reinforces a cycle where they do not get the help they need. Community resilience is strengthened by residents' ability to act collectively in the face of climate adversities (Moser and Boykoff, 2013; Phadke, 2015). Adaptation can be enhanced by the presence of social capital and social networks (Adger, 2003).

In order to implement urban heat interventions, understanding the social capital within a community will help facilitate appropriate pathways and identify relevant, trusted organizations (see Table 10). Individuals with high social capital act as connectors and can be tapped to develop community social capital and enhance other residents' adaptive capacity. During the Nature's Cooling System project, it was important to piggyback off of existing relationships within the community. Effective social capital for urban heat, comprised of both household and community social capital, is a necessary component for building resilience and self-defining resilience for whom, what, when, where, and why (Meerow, 2016).

Table 10
Framework for Effective Social Capital Indicators for Urban Heat

	High Personal /Household Social Capital	**Low Personal /Household Social Capital**
High Community engagement + Social Capital	Transfer knowledge to other communities	Increase individual resilience through community-based organizations
Low Community engagement + Social Capital	Increase capacity of neighborhood-based networks through organizing and leadership training	Outside intervention to build capacity

Depending upon the levels of household/individual and community social capital, a range of heat adaptation and mitigation pathways can be deployed using outside agencies, community-based organizations, and residents with high social capital.

Conclusion

Social capital measured for other uses, such as the decline of community life, can be refined to illuminate the social capital necessary to cope with, and mitigate and adapt to urban heat. Interview data revealed networks based on extended family, faith-based organizations, and organic, special interest groups that were helpful for short term, emergency management and coping with urban heat and displayed capacity that can possibly be harnessed for long-term heat community mitigation and adaption strategies. The indicators developed for specific social capital for urban heat can better inform existing heat-vulnerability frameworks and expanding on the social capital component of adaptive capacity may explain gaps in current vulnerability knowledge. Social isolation can be understood beyond a "living alone" metric; relationships can be enlarged from knowing one's neighbors. The opportunity to build specific social capital capacity to

urban heat transforms the discussion from identifying vulnerabilities to increasing residents' abilities to address extreme heat at the community scale.

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CHAPTER 5

CONCLUSION

Intellectual contribution

This dissertation advances thinking regarding vulnerability to better understand coping mechanisms that are often hard to measure and are limited in current hazards, political ecology, and livelihoods frameworks. The community engagement methodology advances opportunities for respectfully engaging vulnerable populations, often left out of the decision-making process, and advances community-based participatory research knowledge. My research focuses on *processes* for a different understanding of adaptive capacity and allows for the dynamic nature of vulnerability to be considered alongside demographic, landscape level, public health, and urban form data. Urban heat can be addressed beyond the "technical and palliative" by understanding the trade-offs between generic and specific capacity for urban heat and how that can contribute to poverty traps (Lemos, 2013).

The adaptation deficit, the difference between potential capacity and adaptation action, may be explained by narratives, social capital not previously identified, and lack of knowledge about advocacy pathways or evidence based solutions (Sarzynski, 2014). Capacity for adapting to increasing heat does not mean adaption strategies are executed (Romero-Lankao, Qin, & Dickinson, 2012). Further, a "last mile" policy failure currently exists due to low risk perceptions, low local government involvement, and difficulties engaging those most affected by climate impacts (Martinez et al., 2019). The community engagement methodology positions urban heat as a compelling local concern and allows residents to develop strategies most appropriate for their neighborhoods, thereby thinking

locally, and acting locally (Betsill & Betsill, 2001). Developing community adaptive capacity can facilitate long-term adaptation, transformation, and transitions to a more resilient future (Lemos, 2013).

My qualitative research focused on the social processes inherent in coping with urban heat, individually and collectively, rather than quantifiable, often aggregated, assets. This allowed for a better comprehension of the "complex, non-linear challenges facing everyday life"(Toole, Klocker, & Head, 2016). It also uncovered adaptive strategies deployed that, at first glance, may not be identified as a protection from the effects of extreme heat. The "heat is a manageable problem" group's budgeting focus serves as an example.

Urban heat is a growing public health and social justice issue, compounding historical inequities and disproportionately affecting lower socio-economic groups living in the urban core and resulting in preventable deaths. Given climate projections and increasing urbanization, this problem will become magnified in the future. Understanding socio-political infrastructure and, especially, differentiated adaptive capacity and effective community engagement with vulnerable residents, is as important as hard infrastructure investments (Eakin et al., 2017).

Summary of Key Findings

In Chapter 2, I highlight that the disparity in neighborhoods with regard to cooling benefits such as landscaping and shade are a result of historical discrimination and that residents have not been involved in climate planning due to less trust, minimal contact with decision makers, and few networks for collective action. The dominant framing of climate change and extreme heat makes urban heat a regional issue resulting in a lack of

understanding how neighborhoods could change or mitigate the trajectory of increasing temperatures. In this chapter, I argue that given the proper information, tools, and access, residents are capable of providing grassroots insights, creative solutions, and building collective action teams. Through the community-based participatory research methodology, climate science, landscape architecture, and city management were presented in a format easily understandable – a story. Storytelling helped to quickly build trust and honored different forms of knowledge, including residents' coping strategies and wisdom. The hyper-local solutions generated by this process reflected their strong community identity. However, strong feelings about each community did not translate into collective action in the past, primarily because residents had limited knowledge of municipal processes, had differing expectations for project timelines, and were unclear about how to have their voices heard and acknowledged. To this point, two of the neighborhoods requested advocacy training (the third had a training program in place). Low social capital may be a contributing factor to the lack of involvement for community action but understanding the advocacy process and knowledge of evidence-based solutions may be a larger reason.

The key to the heat action plan community engagement was the leadership of the community-based organizations. Their local knowledge, embeddedness in the community, trust, and understanding of where opportunities exist, were invaluable to recruiting residents and other community-based organizations into the workshops and demonstration projects. The lead community-based organizations learned from each other and expanded their networks, enabling them to be more effective for the implementation of the heat action plans and other projects. Community-based

organizations provided valuable feedback and acted as a bridge between different project stakeholders. The future success for implementing the heat action plans will be due to the persistence and tenacity of these locally based groups.

The three narratives regarding urban heat I formulated in Chapter 3 revealed a range of attitudes, risk perceptions, and coping strategies and uncovered adaptive capacity not being measured by existing vulnerability frameworks. Each of the three narrative groups are vulnerable to heat, but in vastly different ways and for different reasons. The people who live a largely air-conditioned existence, the "heat is an inconvenience group," may be at a higher risk for heat illness if the power fails than other groups due to the lack of comparative acclimation. The "heat is a manageable problem" group becomes vulnerable should their safety net and planning fail due to a shock or disruption such as job loss, climate event, or illness. Those in the "heat is a catastrophe" group have been acclimatized to extreme heat but, due to increased unavoidable daily exposure compared to other groups, extreme heat events pose a larger challenge.

Differing motivation levels for addressing urban heat in the long term can be explained by the three narratives. If urban heat is not perceived as a problem due to high personal coping levels, the impact on others may not be well understood or explored. Urban heat becomes "uncomfortable knowledge" and is either denied, dismissed, diverted to another topic, or displaced (Raynor, 2012). The assurance from the people in the "heat is an inconvenience" group that utility assistance was available to those in need, despite the difficulty of obtaining such aid, is an example of dismissal – the problem is taken care of by others. Relying on and prioritizing family and friends' needs, such as those in the "heat is a manageable problem" group can come at the expense of actions

outside the intimate circle. Engaging within these networks for collective action, such as through faith-based organizations, may be more effective than a city-led climate action program directed towards communities in need. Until generic, basic needs are met, it is unrealistic to expect those in the "heat is a catastrophe" group to be involved in community actions.

In Chapter 4, effective social capital for urban heat (ESCUH) indicators were developed from urban heat focused interviews, community engagement, and from urban heat practitioners and community leaders. Low levels of social capital have been blamed for decreasing civic engagement and can explain how individuals and communities shape hazard mitigation and adaptation strategies (Pelling, 2005). Social capital is situational and will change depending upon the issue. Urban heat is also situational; its impacts are highly localized depending on the urban form, materials used, wind patterns and, therefore, unique, localized heat solutions based upon the surrounding conditions are necessary.

Friends and family from the "heat is a manageable problem" and "heat is a catastrophe" groups assist each other during extreme heat by offering rides, cool gathering spots, or trips out of town. The strong bonds allow for keeping each other safe. Identifying the cultural norms that reinforce the importance of these helping networks, especially among the Latino population, may explain the gap in knowledge why Latino populations fare better than other minority groups with the same demographic characteristics in extreme heat events (Klinenberg, 2002). It is not just having large family nearby; it is the sense of intense obligation. The ESCUH indicators probe not only

presence of family and friends, but intensity, frequency, and importance of these relationships.

Civic engagement is often measured by attendance at public meetings, involvement in community activities, and memberships in groups. The findings in Chapter 4 suggest participants engage in organic, localized, issue-based involvement in community affairs that are not measured by standard social capital frameworks. For many respondents in my research, attending a meeting at a municipal building was not a possibility because they did not feel comfortable or welcome in that setting. Understanding social capital within different narratives illuminates why marginalized voices are perceived to be not heard in public spaces and why attendance is limited. The indicators I developed poll these attitudes about attending meetings to better understand the drivers for community engagement.

Implications for the Future

This dissertation puts forward significant implications for how we approach vulnerability to heat. Heat vulnerable populations, identified through demographic, public health and landscape characteristics, are not the same. Differing beliefs, attitudes, and social capital contribute to distinctive narratives that alter coping behaviors and motivation for collective action. Nontangible assets and processes provide capacity and pathways for adaptation that are underutilized.

The current framing of heat vulnerability may need to be rethought given the results of this dissertation research. Vulnerability assessments that weigh heavily on sensitivity and exposure miss adaptive capacity components that may explain current gaps in coping with extreme heat. Social capital, similar to urban heat, is a localized issue

and therefore, context is key. The dynamic structure of social capital, risk perceptions, and attitudes, may be as important to understanding thermal comfort behaviors as demographic and landscape characteristics. Accordingly, the long-term solution may also lie in enhancing these relationships for better household and collective action. Using effective social capital indicators for urban heat, along with narratives of differing capabilities and attitudes can allow for a better grasp of who is vulnerable under what circumstances.

In Maricopa County, Arizona, heat mortality is a gender issue – men died at twice the rate of women from heat during 2006-2015 (Maricopa County Department of Public Health, 2016). Women have more strong bonds than men (Putnam, 2000) and strong bonds are known to be a safeguard in emergency situations. The difference in effective social capital for urban heat along gender lines warrants further research.

Another topic for future research would be how to transform clan behavior to localized, civic, collaborative actions. Urban heat adaptive capacity is complicated with many linkages, nuances, and moving parts. A holistic viewpoint of adaptive capacity is necessary to ensure positive public health outcomes during extreme heat events and to address long-term planning for mitigation and adaptation. Implementing solutions for a heat resilient community may lie in invisible attributes like trust and reciprocity, relationships, frugality, collective action, and resourcefulness. Strong family bonds increase rebounds from disasters, but the pathway is unclear for expanding these bonds for community action.

The community based participatory research outlined in Chapter 2, along with the narratives described in Chapter 3, and the ESCUH indicators detailed in Chapter 4, create

new resources for communities, researchers, and adaptation professionals to build community resilience. The starting point for communities wishing to replicate this work would be conducting open ended interviews first to confirm the presence of differing narratives, attitudes about institutions, and trust in local government and local organizations. Organizations identified through interviews could be tapped to lead community engagement. A pre and post measurement of social capital would measure effectiveness of the methodology and capacity for execution of collaboratively developed climate plans. This iterative process provides a pathway for respectfully engaging with populations that are currently not part of governance processes and embraces the needs and abilities of a range of citizens to increase resilience for the projected increasing urban heat and other climate hazards.

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APPENDIX A

DEMOGRAPHIC DATA FOR ADAPTIVE CAPACITY TO EXTREME HEAT NARRATIVES

I. Demographic composition of the total interview sample

Category	Subcategory	Number of Participants	Percentage+
Gender	Male	5	12%
	Female	17	74%
	No Response	1	4%
Age	18-24	1	4%
	25-44	9	39%
	45-64	9	39%
	65+	3	13%
	No response	1	4%
Income	<$20,000	3	13%
	$20,000-30,000	2	9%
	$30,000-$50,000	5	22%
	$50,000-$75,000	5	22%
	$75,000-$100,000	2	9%
	$100,000+	3	13%
	No response	3	13%
Household Size	1	1	4%
	2	6	26%
	3	0	0%
	4	2	9%
	5	4	17%
	6	5	22%
	10	1	4%
	No response	4	17%
Children 17 and younger	0	7	30%
	1	1	4%
	2	5	22%
	3	5	22%
	4	1	4%
	5	1	4%
	No response	3	13%

Education	Less than High School	2	9%
	High School including GED	6	26%
	Some College	2	9%
	Associate Degree	2	9%
	Bachelor's Degree	3	13%
	Some Graduate Training	3	13%
	Graduate or Professional Degree	4	17%
	No response	1	4%
Race/Ethnicity ^	White	15	65%
	Black	0	0%
	Hispanic/Latino	7	30%
	Native American	1	4%
	Asian or Pacific Islander	0	0%
	No response	2	9%

+Totals do not add up to 100% due to rounding

^Respondents can pick more than one

II. Heat is an Inconvenience Demographics

Category	Subcategory	Number of Participants	Percentage +	Number of Participants	Percentage
		Total Interview Sample		Heat is an inconvenience group	Heat is an inconvenience group
Gender	Male	5	12%	1	17
	Female	17	74%	5	83
	No Response	1	4%	0	0
Age	18-24	1	4%	0	0
	25-44	9	39%	1	17
	45-64	9	39%	5	83
	65+	3	13%	0	0
	No response	1	4%	0	0
Income	<$20,000	3	13%	0	0
	$20,000-30,000	2	9%	0	0
	$30,000-$50,000	5	22%	0	0
	$50,000-$75,000	5	22%	1	17
	$75,000-$100,000	2	9%	2	33
	$100,000+	3	13%	3	50
	No response	3	13%	0	0
Household Size	1	1	4%	0	0
	2	6	26%	3	50
	3	0	0%	0	0
	4	2	9%	0	0
	5	4	17%	2	33
	6	5	22%	1	17
	10	1	4%	0	0

	No response	4	17%	0	0
Children 17 and younger	0	7	30%	3	50
	1	1	4%	1	17
	2	5	22%	1	17
	3	5	22%	0	0
	4	1	4%	1	17
	5	1	4%	0	0
	No response	3	13%	0	0
Education	Less than High School	2	9%	0	0
	High School including GED	6	26%	1	17
	Some College	2	9%	0	0
	Associate Degree	2	9%	1	17
	Bachelor's Degree	3	13%	0	0
	Some Graduate Training	3	13%	1	17
	Graduate or Professional Degree	4	17%	2	33
	No response	1	4%	0	0
Race/Ethnicity ^	White	15	65%	6	100
	Black	0	0%	0	0
	Hispanic/Latino	7	30%	1	17
	Native American	1	4%	0	0

	Asian or Pacific Islander	0	0%	0	0
	No response	2	9%	0	0

III. Heat is a Manageable Problem Demographics

Category	Subcategory	Number of Participants	Percentage +	Number of Participants	Percentage
		Total Interview Sample		Heat is manageable group	Heat is manageable group
Gender	Male	5	12%	4	33
	Female	17	74%	7	58
	No Response	1	4%	1	8
Age	18-24	1	4%	1	8
	25-44	9	39%	5	42
	45-64	9	39%	2	17
	65+	3	13%	3	25
	No response	1	4%	1	8
Income	<$20,000	3	13%	0	0
	$20,000-30,000	2	9%	1	8
	$30,000-$50,000	5	22%	4	33
	$50,000-$75,000	5	22%	3	25
	$75,000-$100,000	2	9%	0	0
	$100,000+	3	13%	0	0
	No response	3	13%	3	25

Household Size	1	1	4%	1	8
	2	6	26%	2	17
	3	0	0%	0	0
	4	2	9%	1	8
	5	4	17%	2	17
	6	5	22%	3	25
	10	1	4%	1	8
	No response	4	17%	2	17
Children 17 and younger	0	7	30%	3	25
	1	1	4%	0	0
	2	5	22%	2	17
	3	5	22%	4	33
	4	1	4%	0	0
	5	1	4%	1	8
	No response	3	13%	2	17
Education	Less than High School	2	9%	1	8
	High School including GED	6	26%	2	17
	Some College	2	9%	1	8
	Associate Degree	2	9%	1	8
	Bachelor's Degree	3	13%	3	25
	Some Graduate Training	3	13%	1	8
	Graduate or Professional Degree	4	17%	2	17
	No response	1	4%	1	0

Race/Ethnicity ^	White	15	65%	7	58
	Black	0	0%	0	0
	Hispanic/Latino	7	30%	4	33
	Native American	1	4%	0	0
	Asian or Pacific Islander	0	0%	0	0
	No response	2	9%	2	17

IV. Heat is a Catastrophe Demographics

Category	Subcategory	Number of Participants	Percentage +	Number of Participants	Percentage
		Total Interview Sample		Heat is a catastrophe group	Heat is a catastrophe group
Gender	Male	5	12%	1	20
	Female	17	74%	4	80
	No Response	1	4%	0	0
Age	18-24	1	4%	0	0
	25-44	9	39%	3	60
	45-64	9	39%	2	40
	65+	3	13%	0	0
	No response	1	4%	0	0
Income	<$20,000	3	13%	3	60
	$20,000-30,000	2	9%	1	20
	$30,000-$50,000	5	22%	1	20
	$50,000-$75,000	5	22%	0	0
	$75,000-$100,000	2	9%	0	0
	$100,000+	3	13%	0	0
	No response	3	13%	0	0
Household Size	1	1	4%	0	0
	2	6	26%	1	20
	3	0	0%	0	0
	4	2	9%	1	20
	5	4	17%	0	0
	6	5	22%	1	20
	10	1	4%	0	0

	No response	4	17%	2	40
Children 17 and younger	0	7	30%	1	20
	1	1	4%	0	0
	2	5	22%	2	40
	3	5	22%	1	20
	4	1	4%	0	0
	5	1	4%	0	0
	No response	3	13%	1	20
Education	Less than High School	2	9%	1	20
	High School including GED	6	26%	2	40
	Some College	2	9%	1	20
	Associate Degree	2	9%	0	0
	Bachelor's Degree	3	13%	0	0
	Some Graduate Training	3	13%	1	20
	Graduate or Professional Degree	4	17%	0	0
	No response	1	4%	0	0
Race/Ethnicity ^	White	15	65%	5	100
	Black	0	0%	0	0
	Hispanic/Latino	7	30%	2	40
	Native American	1	4%	1	20

	Asian or Pacific Islander	0	0%	0	0
	No response	2	9%	0	0

APPENDIX B

OECD ADAPTED EFFECTIVE SOCIAL CAPITAL INDICATOR CATEGORIES FOR URBAN HEAT

I. Trust & Cooperative Norms

Attitudes and Beliefs:

Community/Local – feelings about community or local area (will you want to stay?)

Friends/Family - values & expectations related to friends and family

Government/Society - values & expectations related to friends and family

Cooperative Norms- values & expectations related to cooperative behavior

Experience of Discrimination – experience of discrimination or social exclusion

Identity and Belonging- feeling of belonging or pride in certain group, location, or nationality

Trust in Institutions – trust in different institutions such as govt, media, police

II. Personal Relationships

Network diversity – contact with people from different social groups (ethnicity, income)

Social contact

All – face-to-face plus non face-to-face

Face-to-face

Non-face-to-face

Sources of personal relationships – places/activities where personal relationships are established

III. Social Network Support

Network Size – number of friends

Perceived support/sources of support- someone to count on

Social isolation- feelings of isolation and loneliness

IV. Civic Engagement

Community Engagement – participation in community activities, events or decision making, not necessarily within the context of an association or organized group

Associational Involvement – active involvement in associations, groups, or clubs of any type

Religious Participation – participation in group religious activities

Voluntary work – respondents' participation in voluntary work in the context of organized groups

APPENDIX C

EFFECTIVE SOCIAL CAPITAL FOR URBAN HEAT (ESCUH) INDICATORS AND SUPPORTING SURVEY QUESTIONS

OECD =Organization for Economic Cooperation and Development framework questions;
SOCAT= World Bank Social Capital Assessment Tool questions;
SCP= Social Capital Project survey questions;
Social Capital Community Benchmark Survey= private survey;
No source = new questions.

Variable category	Description	Indicator	Survey Questions
Trust & Cooperative Norms	**Attitudes and Beliefs**	**Importance of family and friends Support from local government**	• How important is each of these things in your life: Family? 0-10, where 0 means Extremely unimportant and 10 means Extremely important; Don't Know. (OECD) • How important is each of these things in your life: Friends? 0-10, where 0 means Extremely unimportant and 10 means Extremely important; Don't Know. (OECD) • Will the city help you during extreme heat periods or heat waves?
	Cooperative Norms	**Collective action within the community**	• If there was a problem in this community, which people in the neighborhood would get together to take some action about it? No one/neighbors among themselves/Local government/neighborhood association/all community leaders acting together/entire community/other specify (SOCAT) • In the last three years, has the community organized to address a need or problem? Yes/No/Describe (SOCAT) • How often in the past year have you joined with others in your community to address a common issue? Never/once/couple of times/frequency (SOCAT)
	Experience of Discrimination	**Experience of discrimination and exclusion**	• Would you describe yourself as being a member of a group that is discriminated against in this country? Yes/no/don't know (OECD) • On what grounds is your group discriminated against? Color or race; Nationality; Religion; Language; Ethnic Group; Age; Gender; Sexuality; Disability; Other (write in); Don't Know (OECD)

	Identity and Belonging	**Commitment to community**	• Do you feel a sense of belonging to your community? • How long have you lived in this community? __Years (SOCAT) • How much influence do you think people like yourself can have in making your community a better place to live? A lot/some/not very much (SOCAT)
	Trust in Institutions	**Trust in local government** **Trust in local police** **Willingness to attend public meetings**	• How much of the time do you think you can trust your local government to do what is right? Just about always/Most of the time/Some of the time/Hardly ever/Don't know/refused (Social Capital Community Benchmark survey 2006) • Please tell me on a score of 0-10 how much you personally trust the police? (OECD) • Would you feel comfortable attending a meeting at City Hall?
Personal Relationships	**Family**	**Presence and size of nearby extended family**	• Presence of family within 50 miles – total # of adults • Presence of multi-generational family living in one household – yes/no • Number of adults (related or unrelated) living in household • Share of one person households (SCP)
	Social Contact	**Daily contact face-to-face and non-face-to-face** **Contact with others outside the home**	• Share of adults who were in contact with family and friends "basically every day" past year (SCP) • Share who communicated with family/friends via email/internet "basically every day" (SCP) • How often do you meet socially with friends, relatives, or work colleagues? (OECD) • Do you leave home each day?
	Sources of Personal	**Overlapping networks**	• For each type of organization with which you are involved (member, participated, donated money or voluntary work), do you have personal friends within this organization: *multitude of

	Relationships		organizational types here*Yes; No; Don't Know (OECD)
Social Network Support	**Network size**	**Size of social network**	• Average number of close friends reported by adults (SCP) • Total number of friends and acquaintances interacted with in the last month
	Perceived support	**Support from family** **Support from friends** **Support offered to others**	*Share who report family demonstrates four ways of being resilient "all or most of the time" when having a problem (SCP) *Share who report having someone to turn to for emotional support re children/parenting (SCP) Do you have anyone with whom you can discuss intimate and personal matters? (OECD) *Get emotional support they need only sometimes, rarely, never (SCP) *Who provides this emotional support: family, friends, neighbors, work/school colleagues *Share of adults reporting they and their friends do favors for each other at least 1X month (modified SCP) *Do you provide any of the following types of support during extreme heat days: provide transportation, water drives, utility donation. Yes, No, Don't know *Do you leave the urban area during high heat days with friends/family? *Please say to what extent you agree with the following statement: There are people in my life who really care about me. Agree strongly; strongly agree; Neither agree nor disagree; Disagree; Disagree strongly; Don't Know. (OECD) *Apart from your own children, how often, if at all, do you give unpaid help to a family member or relative outside your household with childcare, other care, housework, or home maintenance? Never; less than once a month; once a month; several times a month; once a week; several times a week; every day; Don't Know(OECD) *If you needed help, is there anyone outside your household you can count on to give you unpaid help with childcare, other care, housework, or home maintenance? Yes; No; Don't Know (OECD)

Civic Engagement	**Community engagement**	**Engagement for community issues**	• Share of adults that have volunteered for a group in the past year (SCP) • How many times in the past year have you worked on a community project? Range/don't know/refused (soc cap com bench survey) • Share who report having attended a public meeting regarding community affairs in the last year (SCP) • Share who have contacted/visited a public official in the past year (SCP) • Share who worked with neighbors to fix/improve something in the past year (SCP)
	Associational involvement	**Presence of organizations in community** **Active involvement in local organizations**	• Membership in organizations per 1,000 (SCP) • Registered non-religious non-profits per 1000 (modified SCP) • Associations per 1,000 (SCP) • Share of adults who served on a committee as an officer of a group (SCP) • Which groups play the most active role in helping the well-being of community members? (SOCAT)
	Religious Participation	**Presence of faith-based organizations** **Small-group faith-based involvement**	• Registered religious congregations per 1,000 (SCP) • Religious adherents per 1,000 (SCP) • Share saying, they attend religious services at least once per week (SCP) • Share saying, they participate in prayer, scripture study or religious education groups at least 1x/week (SCP)

APPENDIX D

INSTITUTIONAL REVIEW BOARD APPROVAL

EXEMPTION GRANTED

Charles Redman
Sustainability, School of
480/965-2975
CHARLES.REDMAN@asu.edu

Dear Charles Redman:

On 1/15/2019 the ASU IRB reviewed the following protocol:

Type of Review:	Modification
Title:	Cooler Phoenix: How to collaboratively build a cooler city
Investigator:	Charles Redman
IRB ID:	STUDY00006624
Funding:	Name: Bloomberg Philanthropies, Grant Office ID: FP00015322 , Funding Source ID: NA
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Adaptive Capacity consent form dec 4, Category: Consent Form; • Phoenix/Bloomberg IGA, Category: Sponsor Attachment; • AZ APA Workshop Agenda, Category: Other (to reflect anything not captured above); • NCS Workshop Evaluation Mesa, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • IRB Consent NCS Neighborhood workshop, Category: Consent Form; • AZAPA_Workshop_Survey_II.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • AzAPA Natures Cooling Email Announcement (1).pdf, Category: Recruitment Materials; • Adaptive Capacity Interview Protocol, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • IRB Cooler Phoenix, Category: IRB Protocol; • IRB Cooler Phoenix Verbal Announcement for Consent, Category: Consent Form; • Rough Draft 'Zine, Category: Recruitment Materials; • NCS Workshop Evaluation South Phoenix, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Phoenix/Bloomberg Statement of Work, Category: Sponsor Attachment; • American Planning Association - Arizona Chapter - About Us.pdf, Category: Recruitment Materials; • NCS Community Asset Mapping Workshop Agenda, Category: Other (to reflect anything not captured above); • NCS Workshop Evaluation Edison Eastlake, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

	• Adaptive Capacity Post Interview Survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • IRB AZ APA Consent Form (4).pdf, Category: Consent Form; • Adaptive Capacity Recruitment Email Template, Category: Recruitment Materials;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 1/15/2019.

In conducting this protocol, you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Melissa Guardaro
Melissa Guardaro
Yuliya Dzyuban
Jessica Ortiz
David Hondula
Nicholas Weller
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