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Towards a Climate Resilient Austin
The Health Implications of Climate Change on Vulnerable Communities in Austin

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Towards a Climate Resilient Austin
The Health Implications of Climate Change on Vulnerable Communities in Austin

by

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Abstract

Towards a Climate Resilient Austin
The Health Implications of Climate Change on Vulnerable Communities in Austin

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According to the recently released National Climate Assessment (NCA), climate change will disproportionally impact the health of the most vulnerable communities in Central Texas (Melillo, 2014). Exactly how climate change will impact these populations is unclear (Measham, 2011; Martens, 2014). Nationwide, there are few examples of cities looking at the impacts of climate change on existing public health issues and vulnerable communities. The NCA, Austin/Travis County Community Health Assessment (CHA) and Community Health Improvement Plan (CHIP), broadly identifies vulnerable communities as children, the elderly, the sick, the poor, and some communities of color (Melillo, 2014: Luber, 2009). The 2014 release of the NCA, in addition to the 2013 completion of the CHA and CHIP, provides an opportunity to compare current public health issues with projected changes in climate.

The deductive process starts with a review of the CHA and CHIP to identify issues that are directly impacted by hotter and longer heat waves including a lack of physical activity, a decrease in mobility, and greater social isolation. These issues are then compared to likely climate scenarios for Austin in the coming century. For Austin, climate scientists project longer and hotter heat waves and higher overnight average temperatures. The results of the process are a hypothetical framework and specific actions to incorporate increasing temperatures into short-term and long-term health improvement planning.

Comparing the NCA and CHA/CHIP reveals that an increase in intensity and duration of heat waves will make it especially dangerous for vulnerable communities who already struggle with health issues sensitive to heat such as obesity, respiratory ailments, and social isolation (Martens, 2014). Further analysis finds that the health implications of climate change come down to three broad topics: outdoor physical activities, lack of access to healthcare facilities, and isolation.

Austin's increasing temperatures and growing population means that more resources and efforts are needed to ensure the safety of all Austin residents. In this thesis, I put forth a hypothetical decision-making framework that prioritizes the allocation of resources to advance Austin's pathway to climate resiliency. In addition, tools and actions are proposed to increase the climate resilience of the most vulnerable community members in Austin.

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Introduction

As part of a larger health planning process, the City of Austin and Travis County Health & Human Services Department (ATCHHSD) recently banded with Veteran's Services, Central Health, St. David's Foundation, Seton Healthcare Family, the University of Texas Health Science Center at Houston School of Public Health Austin Regional Campus, Austin/Travis County Integral Care, and Capital Metro to identify community health issues in the Community Health Assessment (CHA) and suggested strategies to mitigate priority-identified impacts in the Community Health Improvement Plan (CHIP) (Community, 2013). Coincidentally, the Global Climate Change Impacts in the United States, a federal interagency organization, released a peer-reviewed report of climate projections for this region. Called the National Climate Assessment (NCA), the report discusses the predicted regional impacts that climate change might have on vulnerable communities (Melillo, 2014). When reading through the CHA and CHIP, I was struck by how similar the health issues that affected low-income communities in the region were to the issues that the NCA identified as most likely impacted by a climate change (Forsberg et al, 2012). The NCA identifies the same vulnerable populations that are discussed in the CHA and CHIP (such as the elderly, low-income, and non-native English speakers) as more susceptible to climate related health impacts (Community, 2013; Melillo, 2014). It is the overlap of these two documents that identify which Austin communities as most sensitive and least resilient to extreme weather events. This inspired me to graph the sections of the CHA and CHIP that were impacted by climate stressors. I found a link between community health and climate change. I also discovered that climate change might worsen current public health issues. This led me to question if, considering climate change, the actions outlined in the CHIP would do more harm than good for vulnerable populations in Austin. There was the chance that the actions in the CHIP would actually mal-adapt these communities to climate change creating hazardous situations.

In full disclosure, I am a full time employee of the City of Austin. My interest in climate change led me to pursue a master's degree to investigate a topic that, at the time, was relatively new to internal city discussions. I want to emphasize that this thesis is not a critique of the effort put forth by ATCHHSD and partners. The CHA and CHIP are valuable plans that get to the root of public health issues (Community, 2013). Rather, this thesis is an analysis of current findings in the context of climate change. During the creation of the CHA and CHIP, climate change was not overtly part of the internal dialog within local health organizations. It was not until after the CHA and CHIP was released that the Austin City Council formally addressed climate change.

I also want to preface that this thesis is not a climate vulnerability assessment of public health in the region. In addition to an increase in heat, a health based climate change vulnerability assessment would take into consideration all climate change impact to the region such as floods, water-, air-, and vector-borne diseases. This thesis is an analysis of the CHA and CHIP compared to an increase in heat projected by climate scientists. The climate change impacts addressed in this thesis also do not take into consideration the many facets of compounding hazards such as disease and power outages that sometimes occur after extreme events (Hess, 2008). Nor does this thesis touch on climate refugees and the capacity for the local municipalities to harbor an influx of populations. In this thesis, I look at the impacts that projected heat increases will have on the health issues identified in the CHA and CHIP documents.

The context in which extreme events occur is also significant. Cities are a "complex social system of integrated institutions that touch and interpenetrate in a variety of ways" (Klinenberg, 2002: 22). The diversity of social groups (stratified by age, economic status, ethnicity, race, sexual orientation, etc) that cohabitate in an area is what makes cities thrive (Glaeser, 2011). It is also the diversity and proximity of these social groups that can create inequality and tension (Hall, 1988). How government, for-profit and non-profit institutions engage with these populations adds another level of complexity to the delivery of health services (Scutchfield, 2006). For example, tension "can arise in communities when citizens and officials define the most important issues differently (Scutchfield, 2006: 82). This complexity requires that I define public health in the widest scope. The analysis in the thesis is based on the definition of health provided in CHA. "The CHA defines health in the broadest sense and recognizes numerous factors at multiple levels– from lifestyle behaviors (e.g., diet and exercise) to clinical care (e.g., access to medical services) to social and economic factors (e.g., employment opportunities) to the physical environment (e.g., air quality) – all have an impact on the community's health (Community, 2013: viii).

The term *climate resilience* if often used to explain a community's ability to weather a storm (Robertson, 2013). In this thesis, climate resiliency is defined as the anticipation of, response to, and ability to recover from an extreme weather event. A resilient community can typically recover from a major event with minimal damage to social, economic, and environmental systems (Robertson, 2013). *Vulnerable communities* are broadly described as children, the elderly, the sick, the poor, and some communities of color who are susceptible to climate exposure and climate variation (Melillo, 2014:221; Luber, 2009).

In this thesis, I evaluate the health strategies outlined by ATCHHSD and partners to an increase in heat in relation to the most vulnerable communities (Community, 2013; Melillo, 2014). I have also decided not to compare specific neighborhoods but to stay in line with the CHA/CHIP and discuss the population of Travis County and the City of Austin as one larger community. Discussing one or two low-income areas does not take into consideration the other neighborhoods and communities with vulnerable populations.

Most cities in the United States that have incorporated climate change into their city's operations and future plans live on the coasts (Babcock, 2013). Sea-level rise is an easier rallying call to get city officials, businesses, and residents engaged in a climate resilience planning process. Cities that are not near the coast have a harder time convincing the local community to consider the dangers of climate change (Babcock, 2013). For example, heat waves do not have the same media attention as other natural disasters such as hurricanes. “Heat waves receive little public attention not only because they fail to generate the massive property damage and fantastic images produced other weather-related disasters, but also because their victims are primarily social outcast – the elderly, the poor, and the isolated – from whom we customarily turn away” (Klinenberg, 2002: 17). Although some cities have incorporated climate change into their emergency planning, few have incorporated climate change into the operations and long term planning (Babcock, 2013). In this thesis, I will provide the ATCHHSD and partners a framework to continue the discussion on potential health impacts of climate change and provide suggestions on how to augment future plans.

Frankly, more attention is needed on the impacts and dangers of climate change (Costello, 2009). “Heat-related morbidity and mortality are among the primary health concerns expected to increase as a function of climate change” (Johnson, 2008: 421). Climate change projections for Central Texas indicate an increase in potentially harmful heat waves (Melillo, 2014). Unless community leaders take steps to mitigate the impacts of an increase in heat, more people will suffer (Patz, 2000). Yet, more research is needed for local decision makers to incorporate climate resilience into community health planning initiatives (Bierbaum et al., 2013).

Chapter 1 Previous research

There is plenty of literature on global climate change trends and potential impacts to agriculture and geopolitical stability (Wang, 2012) but little of it is focused on the combination of climate change and public health (Künzli, 2012). Even less of the research on climate change and public health is focused on inland areas of the United States such as Central Texas (Babcock, 2013). Similarly, there is plenty of literature on public health but little of it is tied directly to climate change (Barrett, 2013). Although more and more research is focused on the impacts of climate change, “there has been little discussion of how public health organizations should implement and manage the process of planned adaptation” (Hess, 2012: 171)

Globally, nations and international non-governmental organizations have connected climate change to health for some time. The Secretary-General to the United Nations (UN) Ban Ki-moon states that climate change is “placing the foundations of our world and our global system under unprecedented stress” and made the impacts of climate change the top priority in his five-year action plan (Ki-moon, 2013: 1). The World Health Organization (WHO), tasked with analyzing and creating policies on issues of global health, has authored multiple policy documents and educational material on the impacts of climate change in third world counties (WHO, 2013). To incorporate the economic impacts of climate change on global health, the World Bank has started to calculate the financial ramifications of climate change and created programs to finance future climate adaptation projects (Posas, 2011). Even the International Monetary Fund (IMF), an organization typically known for its economically conservative views, has taken steps to create funding mechanisms for climate change related projects (Green, 2010). It is now acknowledged to most developed, undeveloped, and newly industrialized nations that climate change is going to have -and in some cases is already having- a negative impact on the health of their residents.

With a growing understanding of the global impacts of climate change comes more focus on the impacts to health (Costello, 2009). For nearly a decade, organizations such as the WHO and UN (WHO, 2013) (United, 2013) have published articles and journals on local health impact of air, water, and vector borne diseases that are augmented by climate change. This global discussion is vital for the health and wellbeing of those living in underdeveloped nations, especially those dealing with conflict (Costello, 2009). Yet, this dialogue is less helpful for regional and local organizations in the United States (Leiserowitz, 2005). Although large populations of the US are currently impacted by drought and flooding, the consequences of these events are far less lethal than in conflict-ridden areas found in places like sub-Saharan Africa (Hendrix, 2007). The global literature is less applicable to the conditions found in North American cities where economic, environmental and cultural systems experience very different impacts than those in less developed nations.

In North America, the literature is less defined. “Access to information pertaining to the vulnerability of municipalities to climate impacts has been reportedly scarce in both urban and rural locations” (Measham, 2011: 893). There are plenty of scientific papers across many disciplines that recognize climate change and current impacts (Hess, 2012). Yet, “the scientific and policy community were slow to recognize the potential importance and scope of human health impacts of global atmospheric changes, and only a small amount of scientific literature on the subject has been generated to date” (Martens, 2014: 147). In addition, many in the United States are still skeptical that climate change will have an impact on health (Leiserowitz, 2005). According to a recent survey, “one in five, however, say global warming will not cause any death (21%) or injury (20%), and a plurality of Americans – about four in ten (38% and 39% respectively) – say they “don’t know” (Leiserowitz, 2014:12). With the release of the movie *An Inconvenient Truth* in 2001, the narrator, former vice president and presidential candidate, Al Gore solidified the issue as a political battle cry on both sides (Jeffers, 2009). Overnight, the discussion was transformed into a liberal verses conservative debate stalling any major climate legislation on the federal level (Balogh, 2007). Although Congress failed to enact climate mitigation measures such as carbon cap & trade (Schuff, 2010), other legislation, such as CAFE Standards was successfully passed and is reducing national greenhouse gas emissions (National, 2002). On the climate adaptation front, President Barak Obama signed executive orders directing agencies to incorporate climate change projections into their long-term operation and asset plans (Gerrard, 2014). In addition, a core group of scientist and governmental agencies have come together to create the National Climate Assessment (NCA), a stakeholder led investigation into climate change projections and potential regional impacts (Melillo, 2014). But without clear and unified direction from congress, climate adaptation is difficult to plan and execute. True leadership has to come from local municipalities, institutions and nongovernmental organizations (Costello, 2009).

Even with the multitude of scientific papers, not enough attention is given to how climate change will impact public health at the local level (Künzli, 2012). The literature that connects climate change to health tends to focus on short-term extreme events rather than long-term planning. “This dearth of literature may be because innovative strategies have not yet materialized in many locations, perhaps because adaptation tends to occur in response to the stimulus of extreme events, or because such strategies have not yet made their way into the literature” (Hess, 2012: 172). This gap in literature and national dialog may explain why so few cities discuss public health in the context of climate change (Pinkerton, 2013).

Nationally, there are few examples of cities incorporating climate change into community health assessments or community health improvement plans (Bierbaum et al., 2013). The Center for Disease Control (CDC) has formed an internal group to look at the connection between climate and health (Kuehn, 2010) but municipalities and local health organizations are slow to incorporate this information into their planning process (Measham, 2011). This may be due to an uncertainty in climate change models and how to incorporate that uncertainty into the planning process. "There is currently a general lack of either legislative directive or community best practice for how to incorporate climate risk and its uncertainties into local decision-making" (Measham, 2011: 892). This leads health organizations to think of climate change as either a short-term emergency management issue or a future cost to worry about at a later date (Bierbaum et al., 2013).

In addition, the research on local health impacts of climate change is incomplete (Costello, 2009). There is plenty of information about how health is impacted by extreme heat but there is less research on impacts from a shift in climate (Martens, 2014). Although the research on climate change impact is currently not comprehensive, we are seeing more policy literature – especially from higher education and nonprofits. For example, the Georgetown University Climate Center and Columbia University Center for Climate Change Law review local and state climate change policies and provide tools and suggestions on how to increase climate resilience (Babcock, 2013). Larger organizations, such as The C40 Cities Climate Leadership Group (C40) and the Rockefeller Foundation, are funding cities to investigate these same issues (Rappaport, 2014). For example, C40's "$100 million investment will fund 100 chief resilience officers in selected cities, along with a suite of other services in an effort to build future-proof cities" (Rappaport, 2014: 1). But even with the contribution of these great institutions, more research is needed on the specific impacts and possible policy changes needed to embed climate resilience into their public health initiatives.

My research approach is relatively new to the Public Health field and can potentially set a framework for other cities and nonprofits to incorporate climate projections into the public health planning process. The first step to incorporating climate change projections into local policy is to understand the current health issues through an assessment**.** The following pages outline the most recent community health assessment process, key health themes and improvement strategies focused on prioritized health issues.

COMMUNITY HEALTH ASSESSMENT (CHA) AND COMMUNITY HEALTH IMPROVEMENT PLAN (CHIP)

As mentioned in the introduction, the City of Austin and Travis County Health & Human Services Department (ATCHHSD) recently banded with local health and transportation agencies to identify community health issues in the Community Health Assessment (CHA) and suggested strategies to mitigate priority-identified impacts in the Community Health Improvement Plan (CHIP) (Community, 2013).

The Community Health Assessment (CHA) and Community Health Improvement Plan (CHIP) is a multiagency assessment and implementation plan that identifies public health and social service issues that impact Austin's community today (Community, 2013). Published in July of 2013, the CHA and CHIP are the first of its kind for the region and provides an opportunity for other agencies and City of Austin departments to contribute to the health and wellbeing of City of Austin and Travis County residents. Other cities that have created a CHA and CHIP includes: Gallatin City-County Health Department, MT; Norwalk Health Department, CT; Barry-Eaton District Health Department, MI; East Central Kansas Public Health Coalition, KS; Alachua County Health Department, FL; Kittitas County Health Department, WA; New Orleans Health Department, LA; Central Valley Health District, ND; Plumas County Public Health Agency, CA; San Francisco Department of Public Health, CA; Thomas Jefferson Health District, VA (NACCHO, 2012). The local CHA and the CHIP are the result of a mandate established by the Affordable Care Act (Community, 2013). It states that hospital care institutions can partner with local governments to create a Community Health Needs Assessment ("CHNA") for the region. Spurred by the mandate for the local hospital systems and in preparation for public health department accreditation, A/TCHHSD coordinated the CHA and CHIP process to include Travis County HHS and Veteran's Services, Central Health, St. David's Foundation, University of Texas Health Science Center at Houston School of Public Health Austin Regional Campus, Austin/Travis County Integral Care, and Capital Metro. The three goals of the health plan were to conduct a public health assessment to compare both national and state standards, identify health concerns of community members within the Austin/Travis County community, and to delineate opportunities, constraints, and potential gaps in order to inform policy and funding decisions (Community, 2013).

The plan was created in two phases. The first phase was called the Community Health Assessment (CHA). This yearlong effort identified several key issues affecting health ranging from obesity to lack of adequate transportation options. The second phase was called the Community Health Improvement Plan (CHIP), which prioritizes four health issues, identify goals, and set a path forward for improving the Public's health issues in the Austin/Travis County community. The four priority issues are Chronic Disease – Focus on Obesity, Built Environment – Focus on Access to Healthy Foods, Built Environment – Focus on Transportation, and Access to Primary Care and Mental/Behavioral Health Services. The spatial boundary of the assessment area is based on the Travis County lines.

The stakeholder driven process included diverse group of experts, focus groups, forums and interviews with a wide variety of community members. Four community forums were held in schools, churches, and local businesses that included bilingual staff and free health screenings. 14 focus groups with key informants and 28 interviews of businesses and community leaders from priority populations were conducted. Priority groups included senior citizens, residents of public housing facilities, and immigrants.

There are some limitations to any publicly driven forums and this is articulated in the assessment. In any public survey, there is always a chance that some of the interviewees may under- or over-report issues in an attempt to drive an agenda. Plus, those who decide to participate in the public forums are not always representative of the greater community. Yet, even with these limitations, stakeholder feedback is still valuable. The CHA and CHIP was created understanding that the research method relies on a certain statistical margin of error to use these data (and that this margin of error is low) the information is still a useful in gauging the public health perception.

The following table (Table 1.1) is an adaptation of the Key Themes and Suggestions identified in the CHA (Community, 2013). The column on the right provides the Key Themes and Suggestions language found in the Executive Summary of the CHA. The corresponding titles in the left-hand column represent the author’s interpretation of the defining components of the Key Themes and Suggestions. The corresponding titles include Transportation, Vulnerable Communities, Mental Health, Physical Activity, Access to Primary Care, Prevention, and Resource & Recognition.

Table 1.1: Adaptation of CHA Key Themes (Community, 2013: 66).

Key Themes: Community Health Assessment	
Transportation	"There is wide variation within Travis County in population composition and socioeconomic levels. Lack of transportation services and living in a walkable community are two main concerns which have affected residents' perceived quality of life, stress level, and ease of accessing services."
Vulnerable Communities	"Latinos/Hispanics were identified as a vulnerable population in the community whose concerns stand to be exacerbated by the population growth in the region."
Mental Health	"Mental health was considered a growing, pressing concern by focus group and interview participants, and one in which the current services were considered inadequate to meet the current demand."
Physical Activity	"As with the rest of the country and state, issues around physical activity, healthy eating, and obesity are issues for Travis County residents, especially as chronic conditions are the leading causes of morbidity and mortality."
Access to Primary Care	"While strong health care services exist in the region, vulnerable populations such as the socially isolated elderly, non-English speaking residents, those living with disabilities, and the poor encounter continued difficulties in accessing primary care services."
Prevention	"Residents viewed prevention as critical, but they emphasized that the health care system focused more on clinical care and disease management than prevention."
Resource & Organizations	"Numerous services, resources, and organizations are currently working in Austin/Travis County to meet the population's health and social service needs."

The CHIP provides strategies to improve health conditions identified in the CHA. The strategies are organized into four Priority Areas. A Priority Area is defined as "broad issues that pose problems for the community" (Community, 2013: 52). Indentified through a stakeholder process, the following abbreviated Priority Areas help local health organizations, "…identify community strengths, resources, forces of change, and gaps in services to inform funding and programming priorities of Austin/Travis County" (Community, 2013: viii).

Table 1.2: CHIP Priority Areas and Goals (Community, 2013: 14-35).

Community Health Improvement Plan Priority Areas	
Priority Area 1	**Chronic Disease** – Focus on Obesity
	Goal 1: "Reduce burden of chronic diseases caused by obesity among Austin/Travis County residents.
Priority Area 2	**Built Environment** – Focus on Access to Healthy Foods
	Goal 2: "All in our community have reasonable access to affordable quality nutritious food."
Priority Area 3	**Built Environment** – Transportation
	Goal 3: "Local and regional stakeholders will collaboratively increase accessibility to community resources via safe, active transportation."
Priority Area 4	**Access to Primary Care and Mental/Behavioral Health Services** - Focus on Navigating the Healthcare System
	Goal 4: "Expand access to high-quality behaviorally integrated patient-centered medical homes for all persons."

While the CHA is a look at the current assessment of public health in the county, the CHIP identifies strategies to take place in a three-year period. Hence, there is a chance that strategies outlined in the CHIP may not be impacted by climate change. However, there is always the possibility of an extreme heat event occurring in the next few years and beyond. Identifying the climate projections for the Austin/Travis County region is an important step to understand how the CHIP might help, or even hurt, vulnerable communities as well as inform future health planning efforts.

NATIONAL CLIMATE ASSESSMENT (NCA)

The second step to incorporating climate change projections into city policy discussions is to identify the specific extreme weather events to which the city must adapt. To do this, local decision makers and staff must better understand the climate science and climate models (Tillett, 2011). The National Climate Assessment (Melillo, 2014) is a stakeholder driven process that provides climate projections and potential impacts for different regions in the United States. The assessment is periodically updated and the most recent report is available to the public. Authors are made up of experts on specific topics and a draft is made available prior to the final release for public comment. The assessment makes the case that the climate is changing and that human activity is one of the main drivers for this change (Melillo, 2014). It also goes into detail on the impacts climate change will have on vulnerable communities, transportation, and health.

Most of the climate science provided in the NCA is not new. Climate scientists have known for some time that the global temperatures are warming (Todd, 2007). Analysis of historic concentrations of greenhouse gas in the atmosphere has been correlated with an increase in global temperatures. In turn, climate scientists are able to predict future change in climate based on predicted greenhouse gas emission levels in the atmosphere. This is not an exact science. Various computer models predict future climate but only within a range of certainty (Pierce, 2009). Rather than give specific temperature and rain amount for any given day or month, climate models will determine the likelihood that an event will occur. For example, it is very likely that temperatures in Central Texas will increase, yet changes in precipitation are less certain.

The National Climate Assessment provides both broad projections of climate scenarios and potential impacts of these scenarios for Texas. The assessment divides the United States into 6 different regions. The region that encompasses Texas is the 'Great Plains' that traverses the central United States from Montana to Texas. To make the projections more relevant to local constituents, the expansive region is broken into Northern and Southern sections, the latter of which contains Texas – as well as Kansas and Oklahoma. The experts that authored the assessment use the Intergovernmental Panel on Climate Change (Tonn, 2007) global data to downscale climate models for specific regions.

> Work for the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report (AR4) has produced global climate model data from groups around the world. These data have been collected in the CMIP3 dataset (1), which is archived at the Program for Climate Model Diagnosis and Intercomparison at Lawrence Livermore National Laboratory (LLNL). The CMIP3 data are increasingly being downscaled and used to address regional and local issues in water management, agriculture, wildfire mitigation, and ecosystem change (Pierce, 2009: 8441)

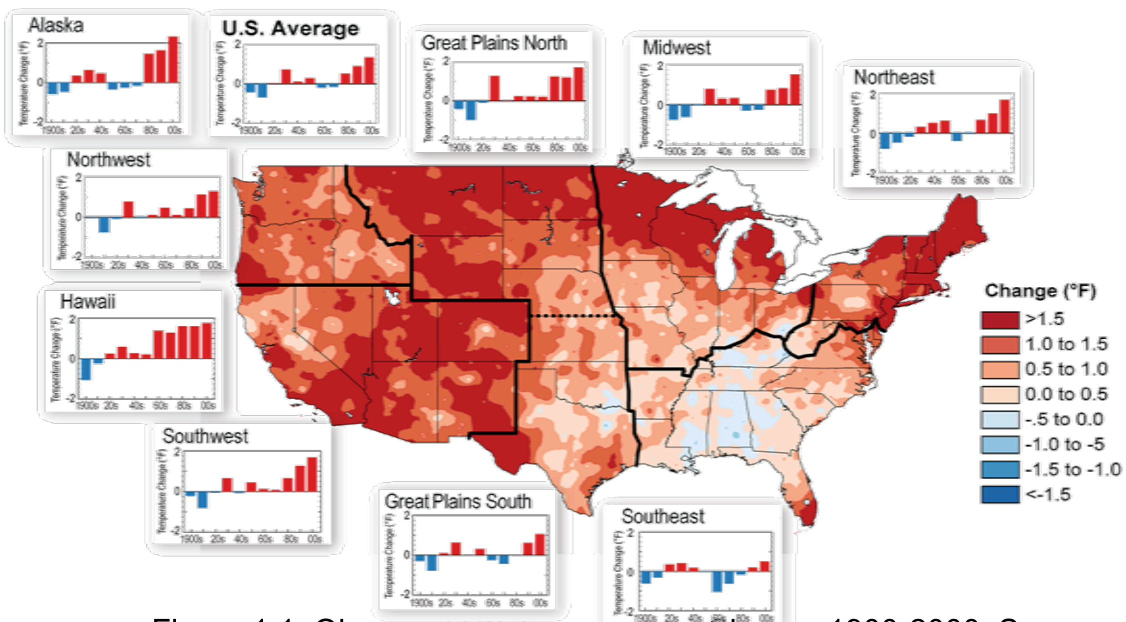

Figure 1.1: Observed US Temperature Change 1900-2000, Source: 2014 U.S. National Climate Assessment (2014)

Scientists are already measuring an increase in heat (Figure 1.1) and expecting it to rise over time. According to the NCA, days over 100ºF are expected to quadruple in the next 30 years in Texas. This trend is also true for the number of days with minimum temperatures higher than 80ºF. Similarly; projected annual precipitation levels are projected to decrease in the summer with larger stretches of time with no precipitation at all. There is a trend for a slight increase in heavy precipitation the Fall and Winter seasons. More detailed projections are identified later in this chapter.

What is new in the NCA is the description of regional and local impact from climate change. These descriptions are not uplifting. Even if humans were to stabilize or reduce their global greenhouse gas emissions immediately, periods of higher temperatures are still expected to occur much more often. In the interest of this thesis, I have focused on the NCA sections that discuss regional impacts (chapter 19), transportation impacts (chapter 5) and health impacts (chapter 9).

The regional impacts (chapter 19) are broken out into 5 key findings. The first finding connects an increase in temperature to a rising demand for water and energy. In return, the rising demand adds pressure on natural resources making it more difficult for vulnerable communities (such as the elderly, low-income, and non-native English speakers) to afford water and energy. The second finding discusses potential stresses to agriculture and new farming and livestock techniques that are needed to adapt to a changing climate. The third finding discusses landscape fragmentation, a greater concern for the northern Great Plains with the added pressures from energy development activities. The fourth finding states that past weather events are no longer an adequate measure of future climate scenarios and that current efforts are not sufficient to mitigate harm to vulnerable communities. The fifth and final finding is the most relevant to this thesis. It discusses the impacts of climate change on vulnerable communities, especially low-income, elderly and non-native speakers.

It is the fifth finding, on climate vulnerable communities, that best mirrors the issues outlined in the CHA. The NCA states that low-income, elderly, and non-native speakers are more sensitive to climate change. This climate sensitivity is partly due to physical, economic, and political isolation and their lack of access to public health facilities and appropriate housing. For example, “elderly people are more vulnerable to extreme heat, especially in warmer cities and communities with minimal air conditioning or sub-standard housing. “Language barriers may impede Hispanics from plan for, adapt to, and respond to climate-related risks” (Melillo, 2014:451). Effective communication is also a major factor in climate vulnerability as the elderly and Hispanic communities are isolated from the general public. A recent concurrent study shows that, amongst Latino women in the United States, “…limited access to transportation, working in remote areas, and a physical environment not being conducive to meet neighbors have been previously reported as obstacles to forging social relationships and increased feelings of isolation” (Hurtado-de-Mendoza, 2014:79). Isolation makes it harder for public health organizations to inform residents on how to protect themselves from extreme weather events.

Another section of the National Climate Assessment connected to public health is related to how transportation will be impacted (Chapter 5). Although most of the transportation section is focused on road material choices and design, it does acknowledge the role that transportation has on health. Road construction crews that work outdoors during a heat wave are at risk of heat exhaustion (Forsberg et al, 2012). Similarly, heat waves are likely to impact public transit ridership and alternate forms of transportation like walking and bicycling. Isolation, as discussed in the previous paragraph, is connected to mobility. For example, “…older adult mobility may be more limited and impede seeking a cooler environment or obtaining assistance. Older adults are one of the most important extreme heat risk groups and have higher mortality and hospital admission rates than the general population” (Uejio, 2011: 501).

The chapter on health (chapter 9) establishes the relationship between climate change and direct impacts to human health. The first key finding is that climate change poses a threat to human health and that we can already see the impacts. The second key finding is that climate change will exacerbate existing public health stressors and that the most vulnerable communities (poor, minorities, and elderly) are most at risk. The good news, according to the third finding, is that preparing for climate change can greatly reduce the negative impacts. And lastly, the fourth finding states that climate change provides an opportunity to work with many other sectors of the community that are not typically thought of as being related to health. For example, the Austin/Travis County Health & Human Service department can expand their partnership with organizations in the energy and transportation sector to mitigate public health issues. Examples could include expanding weatherization programs and organizing air conditioning drives to provide to community members unable to afford such items.

To better understand the climate projections at the scale of a metropolitan region, the City of Austin hired Dr. Katherine Hayhoe, from Texas Tech University and Atmos Research & Consulting, in early 2014 to analyze statistical downscaled models. These models provide likely future climate scenarios by downscaling large global climate models down to scale of a local weather station. In the case of Austin, Dr. Hayhoe used the weather data from Camp Mabry just west of downtown Austin. Her research found that the climate is starting to change earlier than expected and that these changes are happening locally.

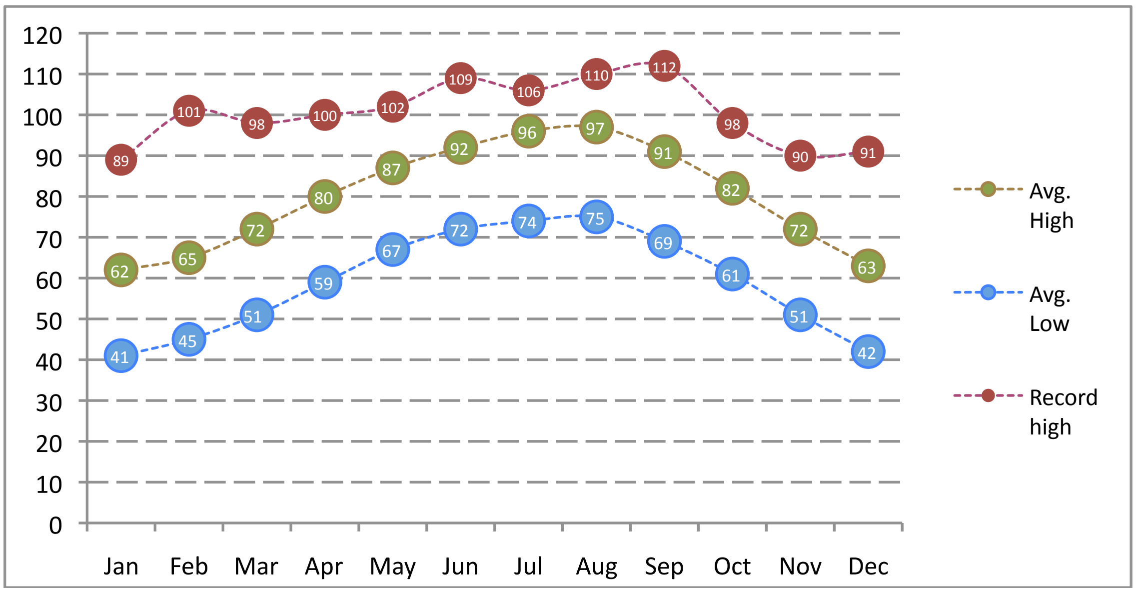

Figure 1.2: Average tempartures for Austin Texas from 1889-2013, Source: Weather.com

According to Dr. Hayhoe's research, Austin can expect an increase in temperature both annually and seasonally from its current baseline climate (Figure 1.2). This will include more days with extremely hot days (over 110^0F) and more drought conditions in the summertime. Although the annual precipitation amounts are not expected to change drastically, there is a high likelihood that extreme precipitation events will increase outside of the summer months. Lastly, these projected climate conditions may happen sooner than expected. There is the chance that the 2011 drought and heat wave may turn into the norm for Austin in as little as twenty years (Figure 1.3, Figure 1.4).

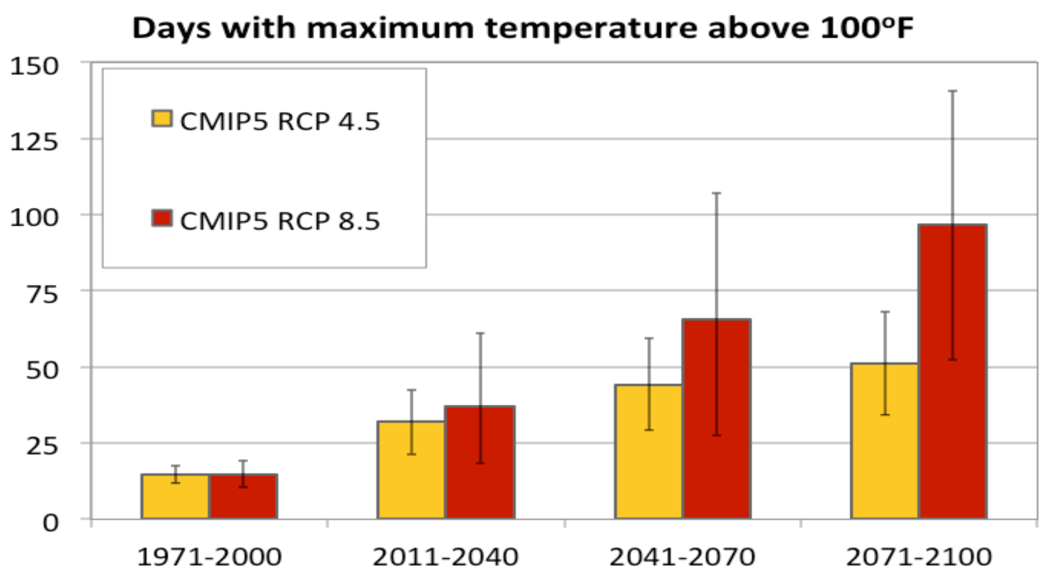

Figure 1.3: Days with maximum temperature above 100^{0}F, Source: K. Hayhoe for 2014 U.S. National Climate Assessment

As mentioned before, determining the variability of climate change is not an exact science. A climatologist will never predict the exact temperature of a particular day twenty years in advance. Climate models are used to make estimations based on existing weather data, the amount of greenhouse gasses emitted into the atmosphere, and the degree to which the gasses will alter the global climate. Imbedded in these projections are many assumptions and uncertainties. The climate projections provided by the National Climate

Assessment and Dr. Hayhoe are the culmination of many data sets that produce a climate projection that, with some confidence, is likely to happen. It is understood, for the sake of this thesis, that the projections used may not represent exactly what will happen in the future but, instead, what is most likely to happen.

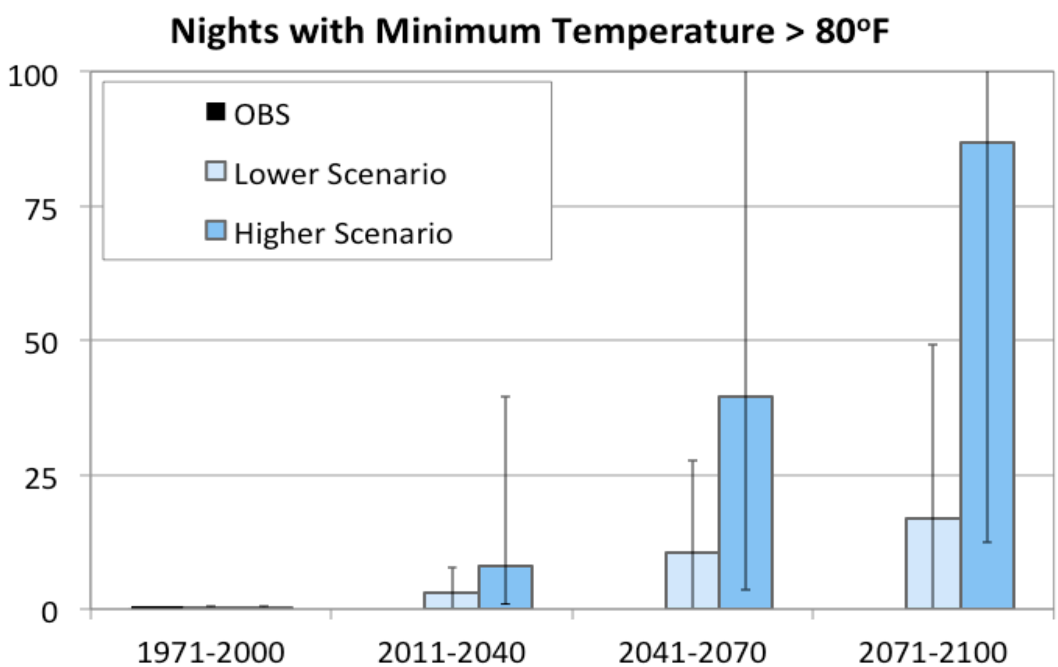

Figure 1.4: Nights with Minimum Temperatures over 80^{0}FSource: K. Hayhoe for 2014 U.S. National Climate Assessment

The City of Austin has taken measures to ensure that the residents are safe during a heat wave. Revised in May 2013, the Office of Homeland Security and Emergency Management released the Special Operation Plan on Heat Emergencies. The plan outlines actions that will take place when certain weather thresholds occur (Mashhood, 2011). The National Weather Service in New Braunfels determines these thresholds, called triggers, by issuing a Heat Advisory or Excessive Heat Warning when temperatures reach a certain height and humidity levels. Heat Advisory and Excessive Heat Warnings are based on how the outside temperature feels. Temperature alone does not account for the whole story. Humidity plays a key role in making seemingly normal temperatures become dangerous. The Heat Index Chart, found in the City of Austin Heat Emergency Plan, calculates the apparent temperature, given in degrees Fahrenheit (^{0}F), by combining temperature and relative humidity to determine what the temperature 'feels' like (Table 3). For example, the outside temperature may reach 90^0 F but with 95% humidity, it may feel like 127^{0}F. Over the last decade, overall summer temperatures have remained around 90^{0}F to 100^{0}F. Yet during this time, humidity has consistently stayed above 80% (Figure 1.5). That means that, during the summer months, daytime apparent temperatures have ranged from 106^{0}F to 130^{0}F for more than 3 months in a row.

The National Weather Service in New Braunfels issues heat advisories based on the Heat Index Chart. A Heat Advisory is issued when the heat index is between 105°F and 115°F and an Excessive Heat Warning is issued when the heat index is above 115°F for a set amount of time. When the heat plan is 'triggered', relevant governmental and nonprofit organizations coordinate to mitigate heat impacts on the community. These 'triggers' activate one of two phases. Phase one is triggered for a Heat Advisory and includes an increase in monitoring of at-risk populations through the coordination of faith-based organizations and low-income shelters (Mashhood, 2011). In addition, hospitals will track heat related emergency room visits (Figure 2.1). Phase two is triggered during an Excessive Heat Warning and includes more direct actions. For a Phase Two trigger, the Health & Human Services Department may do door-to-door needs assessments in ‘at-risk’ neighborhoods to make sure people are safe.. The city will open cooling stations throughout the city and CapMetro will use their buses to create temporary cooling stations in neighborhoods and at larger events. In additional, a public education campaign is designed to inform residents of the dangers of extreme heat. Although extremely important, the Emergency plan is a short-term strategy and does not take longer-term public health issues into consideration. There still exists a gap between short-term emergency efforts longer-term climate and health planning (Künzli, 2010).

NOAA's National Weather Service

Heat Index

Temperature (^oF)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

Table 1.3: Heat Index (NOAA)

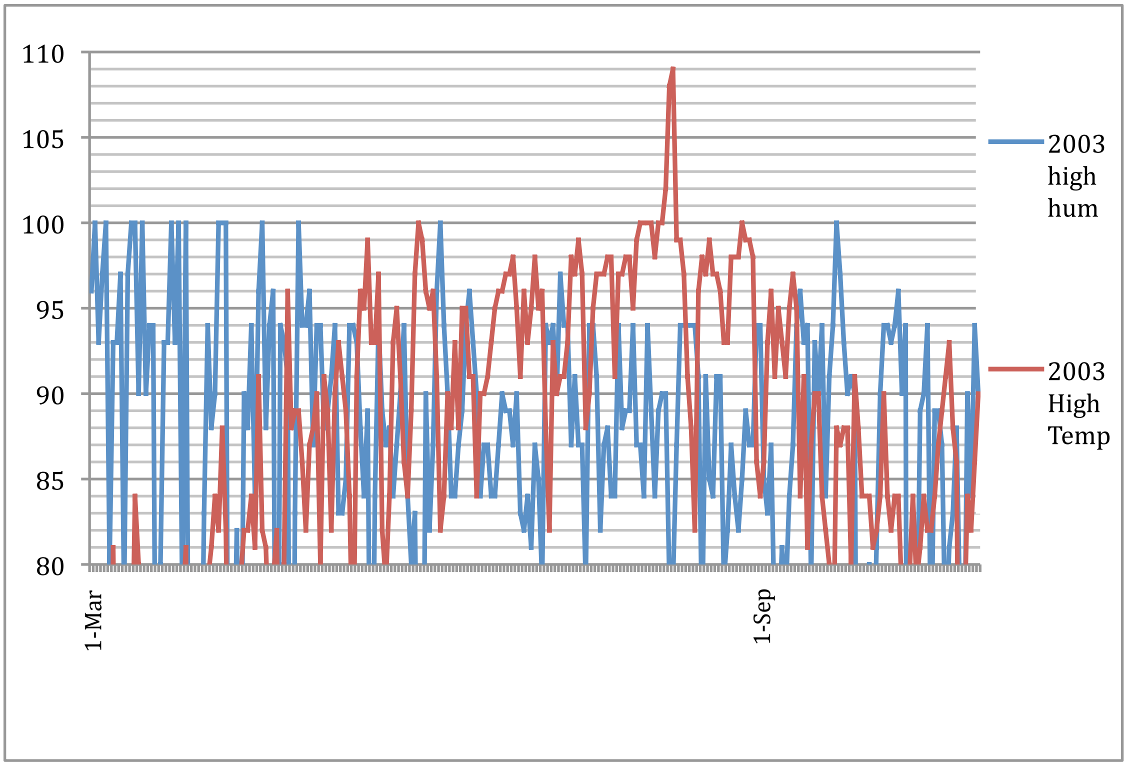

Figure 1.5: 2003 daily-recorded temperatures (red) and humidity levels (blue) between March 1st and October 31st, Source: Weather Underground

As I mention at the beginning of this chapter, there are few methods that exist to incorporate climate resilience into the public health process (Hess, 2012). The Community Health Assessment (CHA) and Community Health Improvement Plan (CHIP) accomplishes the task of identifying the most pressing public health issues in the area while providing a framework to ameliorate the situation. Similarly, the National Climate Assessment discusses the impact of climate on health but does not dive down to the regional or municipal level. This thesis attempts to bridge the gap between the two assessments and create a framework for other cities to use.

The process to incorporate climate resiliency measures into the political and government process is not straightforward (Hess, 2012). In this thesis, climate resiliency is defined as the anticipation of, response to, and ability to recover from an extreme weather event. A resilient community can typically recover from a major event with minimal damage to social, economic, and environmental systems (Robertson, 2013). To address potential climate change impacts, governing agencies will have to create or adopt new ways of developing long-term plans in embedding climate resiliency. The management of climate change "threats is likely to require innovative strategies acknowledging that the systems protecting public health have limited resources and are dynamic, incompletely understood, and subject to multiple stakeholders" (Hess, 2012: 176). It is not enough for Public Health institutions to obtain climate projections and expect decision makers to know how to incorporate the information into municipal operations and planning. Most cities will use some type of policy framework to incorporate climate resiliency into the planning process. These frameworks typically help public health institutions identify vulnerable communities, and, if needed, priorities efforts, and suggest options to allocate funding (Flax, 2002).

"Despite the surge in interest and the plethora of new resources available for local governments, there is a paucity of comprehensive and binding adaptation plans for communities" (Picketts, 2014:985) In recent years, several nonprofits and federal agencies have tested methods to assess sector-based climate vulnerability**.** Reviewing some of these frameworks and creating a simplified method for this thesis may answer the question of climate change impacts on public health.

As cities grapple with an increase in extreme weather events, they scramble to identify a process to make their operations and assets more resilient to climate change (Turner, 2013). Depending on the most prevalent climate stressors, each municipality will gauge how to best establish actions to mitigate the impact of such stressors. For example, a city on the ocean might determine that sea level rise is the greatest threat to city operations and assets. In the case of Austin, heat, drought and intense rainfall are the most likely extreme weather events to occur (Melillo, 2014). Government and nongovernmental organizations such as ICLEI - Local Governments for Sustainability (ICLEI), Center for Disease Control (CDC), and the Federal Highway Administration (FHWA), have created tools to help cities and metropolitan regions understand and implement climate resilient strategies. Yet, most of these processes are specific to one or two sectors, such as transportation or sea level rise, and might not transfer well to other sectors.

The international group called the International Council for Local Environmental Initiatives - Local Governments for Sustainability (ICLEI) created the most recognized framework. ICLEI is a nonprofit membership organization that helps local governments achieve sustainability and climate resilient goals (Krause, 2012). Their tool, called ADAPT, is based on 5 milestones consisting of a vulnerability assessment, resiliency goal setting, plan development, plan implementation, and measuring progress (O'Neil et al, 2009). Although the tool has helped many cities implement adaptation strategies, the organization does not easily allow nonmembers access to the tool, making it unattainable to graduate students. The key challenge with the ICLEI process is the act of identifying the climate change projections before identifying the climate thresholds. This impacts-oriented approach creates confusion and uncertainty when applied to specific real-life situations. As described in the book Climate Change,

> Although it is now becoming common to consider impacts, adaptation and vulnerability together (the so-called "IAV community"), there are actually significant differences between an impacts-oriented approach to coping with climate change and an adaptation-vulnerability approach. The former normally begins with a climate scenario that then drives a number of potential biophysical impacts, which, in turn, prompt responses from individuals and societies. The cascading uncertainties associated with this approach, however – especially those associated with downscaling global climate model information to short time and small spatial scales – render the approach of limited value to on-the-ground adaptation.
>
> Starting with vulnerability, on the other hand, emphasizes the socio-economic context in which adaptation must occur. In particular, it emphasizes the nature of institutional, cultural, equity, economic, social and governance contexts that help to define vulnerability, as well as the range of external factors that affect people's livelihoods and well-being. (Richardson, 2011: 390-391)

To counter the uncertainty of the impacts-oriented approach, staff at the Federal Highway Administration (FHWA) created a tool that identifies climate thresholds before identifying local climate projections. Called the Climate Change & Extreme Weather Vulnerability Assessment Framework**,** this framework takes an adaptation-vulnerability approach. The process is fairly straightforward. The user, typically a Metropolitan Planning Organization (MPO), first identifies all transportation assets within the region. The user then identifies which assets are most critical to the greater transportation system. For example, large freeway interchanges or freight rail trunks are considered critical transportation assets. If such assets were interrupted by an extreme weather event, it would impede emergency operations or cause major economic losses. Once the critical assets are identified, local stakeholders will determine the temperature and precipitation thresholds at which transportation infrastructure would be negatively impacted. These thresholds are based on historic events. For example, Mobile, Alabama has piloted this framework and found that railroad tracks start to warp at 90^0F, and at 100^0F; tracks warp to the point that can cause freight trains to derail. Identifying the threshold to temperature extremes, drought, heavy precipitation, and wind allows municipalities to know exactly what climate condition will impact, and potentially compromise, their operations or assets. It is at this point in the process that climate projections are introduced.

For MPOs that are using the FHWA method, climate projections are attained either through a federal agency like the United States Geological Survey (USGS), state climatologist, experts at a college or university, or through a consultant. Locally, Capital Area Metropolitan Planning Organization (CAMPO) and the City of Austin Office of Sustainability are partnering to pilot the FHWA framework in an attempt to better understand the vulnerability of the regional transportation system to extreme weather events. The framework includes stakeholder led criticality assessments and sensitivity thresholds workshops followed by climate projection analysis and risk assessment. In relation to the FHWA framework, future climate predictions are compared to climate thresholds of critical transportation systems. This process allows the stakeholders to determine which assets and operations are most vulnerable to climate change and the likelihood that the event will happen.

It is worth mentioning that the CDC does have a framework to incorporate climate change in the public health assessment and planning process. Called Building Resilience Against Climate Effects (BRACE), the framework is a 5-step process starting with 1) forecasting climate impacts and assessing vulnerabilities (Marinucci, 2014). The next step is to 2) project the disease burden followed by 3) assessing possible public health interventions. The municipality would then 4) create a health adaptation plan followed by 5) an evaluation mechanism to ensure actions are working. Although this method seems simple enough, the impacts-oriented approach identifies the climate change projections first and then determines the impacts of the findings. “The cascading uncertainties associated with this approach, however – especially those associated with downscaling global climate model information to short time and small spatial scales – render the approach of limited value to on-the-ground adaptation (Richardson, 2011: 390-391). This particular framework is not transferable to this graduate thesis and this is not considered for the methodology.

Chapter 2 Methodology

The methodology for this thesis starts with the FWHA Climate Change and Extreme Weather events framework and simplifies it to work within the perimeters and timeline of the graduate program structure. By identifying the health issues and climate thresholds before identifying local climate projections, the anticipated findings will better represent the potential impact to socially and economically vulnerable communities as well as other external factors (Richardson, 2011: 391). The methodology breaks down into 4 steps:

Step 1: Review CHA and CHIP for climate impacts.

The deductive process started by reviewing the Community Health Assessment (CHA) for health issues that are directly impacted by weather. For example, the CHA identifies obesity and lack of outdoor activity as a Priority One health issue. Understanding that outdoor activities are impacted by weather, this is one of the issues analyzed by this thesis. The CHA is followed, in the Health Department's assessment, with the Community Health Improvement Plan (CHIP), which together provides possible actions the Health Department and community members can take to ameliorate the identified health issue. The CHIP is also incorporated into the climate analysis process. Issues outlined in the CHA and the CHIP that are impacted by climate change, in this case heat, are the only issues that are viewed through the lens of climate change.

Step 2: Retrieve climate projections from NCA and other sources.

In this step, I use the future climate scenarios provided by the National Climate Assessment and Dr. Hayoe. From the literature review, it is understood that an increase in heat is the most likely, and most dangerous, scenario.

Step 3: Analyze possible impacts of climate change on issues outlined in the CHA and CHIP.

Once the climate sensitive public health issues are identified and climate projections are identified, I compared the two to determine which public health issues are most likely to experience a negative impact from an increase in heat.

Step 4: Determine if/what other actions are need to mitigate the identified potential harm.

Understanding the potential impacts of heat on public health, I determined if new changes were needed to ensure that the CHA and CHIP achieve its directive. When mitigation strategies were needed, I suggested policy changes to add to the current CHA and CHIP or incorporate those suggestions into the next iteration.

It is important to reiterate that this is not a climate change vulnerability assessment, but simply a review of Public Health system documents (CHA and CHIP) in light of increased heat (NCA). This thesis does not take into consideration any increase or decrease in precipitation or any increase in vector, air, or water borne diseases. In essence, I look at the overlap between the CHA and CHIP and the NCA.

There are assumptions associated with the method and findings. It is assumed that the Travis County community is sensitive to certain climate exposures, in this case heat. Other regions, such as Phoenix, Arizona, often see summer temperatures reach 110^0F. Assuming that residents of a desert climate might expect such high temperature, it is assumed that they would prepare themselves and less people would get hurt. It is also assumed that longer and hotter heat waves would happen sooner and more often than expected and that vulnerable communities could not, hence would not, prepare themselves for dangerously high temperature.

Lastly, the methodology is only as good as the quality of the data. My research analysis is limited by the availability of data. To make this thesis more robust and accurate, more data are needed. Yet, the results should represent actual impacts and solutions for the Travis County region. With the methodology, assessments, and projections available to the general public, it is assumed that someone could reproduce this project and come to the same findings.

Chapter 3 Findings

From the literature review, it is evident that many of the key themes identified in the CHA (Transportation, Vulnerable Communities, Mental Health, Physical Activity, Access to Primary Care, Prevention, and Resource & Recognition) and priorities identified in the CHIP (Chronic Disease – Focus on Obesity, Built Environment – Focus on Access to Healthy Foods, Built Environment – Transportation, and Access to Primary Care and Mental/Behavioral Health Services - Focus on Navigating the Healthcare System) are impacted by climate. Although not all of these are directly impacted, most could have severe consequences if policies do not change. Comparing these to climate projections from The National Climate Assessment (NCA) and work completed by Dr. Kathy Hayhoe will provide a clearer view of which public heath issues are impacted by climate change and possible strategies to mitigate these impacts.

Of the seven 'Key Themes' identified in the CHA (Transportation, Vulnerable Communities, Mental Health, Physical Activity, Access to Primary Care, Prevention, and Resource & Recognition), only one is not directly impacted by climate change. The Key Theme *Resource & Organizations* recognizes that, "Numerous services, resources, and organizations are currently working in Austin/Travis County to meet the population's health and social service needs"

(Community, 2013: 66) While the other six themes discuss specific asset and population based health issues, the seventh Key Theme refers to the existence of multiple organizations providing public health services in the region. Although current literature does connect climate change and health (Marinucci, 2014), the author did not find any literature that connects climate change and the ability for groups to self-organize or manage their accounts. A prolonged heat wave might cause an organization to deplete their resources providing services but little is written or known about the impacts of climate change on the numbers of organizations in a region. It is assumed that climate change will have an indirectly impact on public opinion and policy makers but this is outside the scope of this thesis. The other themes are impacted by a change in climate. Of the remaining 6 themes, the common thread comes down lack of physical activity, lack of access to healthcare facilities, and isolation. All of these are impacted by an increased intensity and duration of heat.

As the literature review describes, the CHIP outlines four “Priority Areas” that the Austin/Travis County Health & Human Services Department focuses on. They are: (1) Chronic Disease – Focus on Obesity, (2) Built Environment – Focus on Access to Healthy Foods, (3) Built Environment – Transportation, (4) Access to Primary Care and Mental/Behavioral Health Services – Focus on Navigating the Healthcare System. I consider that all of these are impacted by a change in climate. For simplicity, the Priority Areas are organized into two major themes: (1) lack of physical activity (focusing on obesity and access to health foods) and

(2) social isolation (focusing on transportation and access to heath care services).

Both the NCA and Dr. Hayoe clearly state that an increase in heat is the most likely climate change factor for our region. Heat is particularly dangerous to public health (Anderson, 2010). “Death from extreme heat is the number one weather-related killer in North America and likely the world” (Johnson, 2009: 419). With an increase in temperature, it is important to understand how heat impacts community members and how to keep them safe. Possible strategies to keep community members safe could include, “a plan to improve weather forecasting, alert those at risk, provide readily accessible air-conditioned shelters, and reduce energy costs during extreme weather so that air conditioning is affordable may decrease morbidity and mortality during heat waves” (Bouchama, 2002: 1986). Some of these actions are covered in chapter 4: Discussion.

The impacts of heat waves are not continuous and do not correlate evenly with a rise in temperature. *When* a heat wave starts and ends has the greatest impact on those participating in outdoor activity (Klinenberg, 2002). Locally, this is evident in hospital visit logs that document when patients come into the emergency room for heat and dehydration related aliments (Figure 2.1). The chart highlights that heat, alone, does not increase the number hospital visit over a prolonged period of time. Rather, it shows that hospital visits are tied directly to sharp increases in heat. For example, the chart shows a sharp increase in temperature in the beginning of April and a corresponding rise in incidents connected to heat and dehydration. The incidents then decline drastically through the middle of April although the heat stays consistently high for a few more weeks. This pattern is seen again in May, June, and July. Even a small amount of outdoor physical activity during a rapid increase in temperature is dangerous.

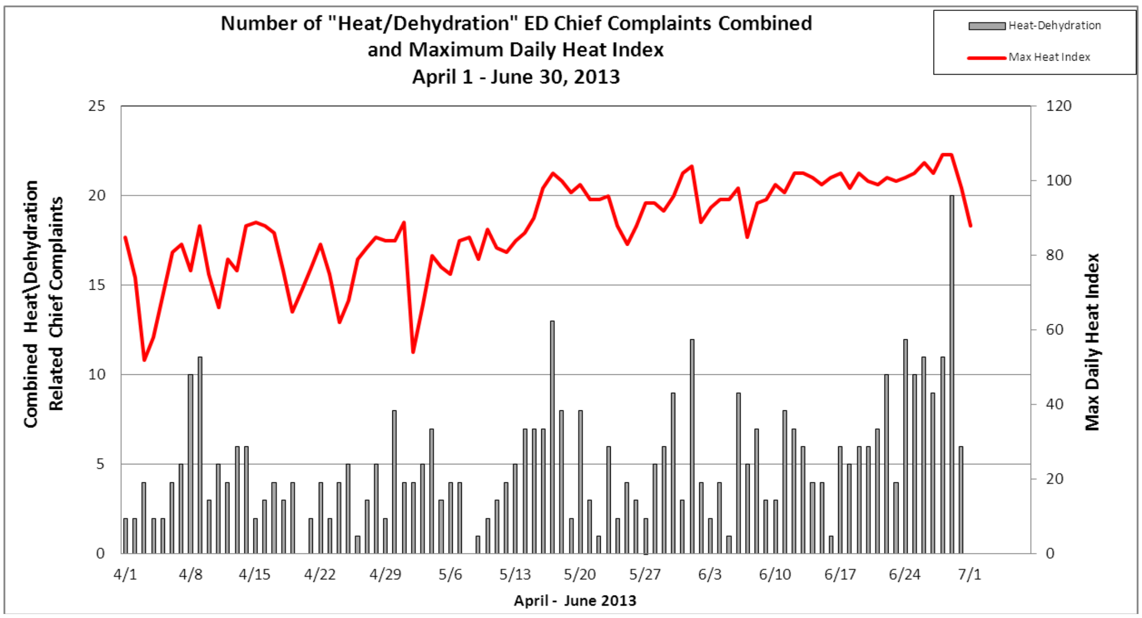

Figure 2.1: Number of "Heat/Dehydration"-Related ED Chief Complaints Combined and Maximum Daily Heat Index: April 1-June 30, 2013. Source: Austin/Travis County Health and Human Services

Exposure to heat alone is not the main threat to human health. "The risk of heat-related mortality increases with natural aging, but persons with particular social and/or physical vulnerability are also at risk. Important differences in vulnerability exist between populations, depending on climate, culture, infrastructure (housing), and other factors" (Kovats, 2007: 41). Other factors include the amount of time spent outdoors during a prolonged period of heat, additional stressor such as negative air quality, lack of safe transportation options and an increase in social isolations. These factors are discussed in the following findings.

FINDINGS 1: LACK OF PHYSICAL ACTIVITY

Obesity

Over the last twenty years, obesity in the United States has increased dramatically. One third (35.7%) of Americans are considered obese and the trend is increasing. In Texas alone, 65.9% of adults were overweight while 31% of adults are considered obese, with a Body Mass Index greater than 30 (CDC, 2012). Obesity is a dangerous health condition that can lead to major health issues, including type-2 diabetes, heart disease, stroke, and some types of cancer (CDC, 2012). According to the Centers for Disease Control and Prevention (CDC), obesity is one of the leading causes of preventable deaths in the United States (CDC, 2012). Austin and Travis County are not immune to this epidemic. During the interview process for the CHA, the community identified obesity and related diseases as a major public health issue (Community, 2013).

According to the CHA, many in low-income areas struggle with obesity and the differences in obesity rates between minorities (Latinos and African American) and majority (white) are significant (Community, 2013). The likelihood that an African American is obese is over twice that of a white individual in Travis County. Less than 20% (19.4%) of whites in Travis County are considered obese while over one-third (36.5%) of Latinos are considered obese and over 40%

(41.7%) of African Americans are obese (Community, 2013: 13). Although there are many social, political and economic factors that might account for these differences (Coplen, 2013), the CHIP focuses its strategies to improving physical activity and access to nutritious foods.

The subject of obesity in low-income areas is complex and full of assumptions (Guthman, 2013). The literature on food highlights a debate around the causes of obesity in low-income and minority areas (Coplen, 2013). There are some who argue that obesity is a supply-side issue and that lack of access to cheap and unhealthy food is the main driver of weight gain. In this viewpoint, "our current environment is characterized by an essentially unlimited supply of convenient, relatively inexpensive, highly palatable, energy-dense foods, coupled with a lifestyle requiring only low levels of physical activity for subsistence" (Hill, 1998: 1371). Others argue that obesity amongst low-income and minority groups is more complex than the supply-side paradigm. For example, by "embedding taken-for-granted assumptions about the causes of obesity—namely, the energy-balance model—these studies foreclose alternative explanations, including the possible role of environmental toxins (Guthman, 2013:142). In this thesis, I focus solely on strategies, outlined in the CHIP, that aim to reduce obesity levels and not on the causes of obesity. These strategies include an increase in physical activity and access to healthier foods (Community, 2013).

In most cases, regular exercise and a healthy diet can help overweight individuals reduce unwanted pounds and decreases their chances of associated diseases. Yet, many individuals struggle to find tried and true methods to eat right and exercise. Several factors might discourage community members from eating healthy foods and exercising. One barrier (identified in the CHA) to eating high quality food is cost, and trade-offs made between food and rent and utilities, making the purchase of fruits and vegetables unaffordable (Community, 2013; Adams et al, 2010). A second barrier is the proximity of fresh foods and vegetables to individuals who do not own and car and dependence on public transportation (Adams et al, 2010). This is covered in the next section about transportation ground-level ozone. The third barrier is the prolonged hot summer months that make it unsafe to exercise outside (Coris et al, 2004).

The CHA identifies Chronic Disease (focus on obesity) as the first of four priority areas. As a recommendation, the CHIP suggests that adults engage in aerobic physical activity for at least 150 minutes per week or more. For children, this number is higher at 60 minutes per day for at least 5 days per week. Creating an educational campaign around physical health and increasing access to outdoor activity areas through joint-use agreements, agreements which allow community members and organizations to jointly use outdoor private spaces. The goal is to have a 5% increase in time spent exercising for adults and children who meet the minimum requirements for physical activity guidelines (Community, 2013: 14).

With a projected increase in heat, the goal to increase outdoor physical activities may, at times, be dangerous for participants. According to the NCA, regional temperatures are expected to rise by 5 degrees by mid-century and 10 degrees by the end of the century (Melillo, 2014). These numbers do not simply mean a daily increase by the given temperature but an increase in variability in temperature (both hot and cold) and precipitation (both intense rain storm and droughts). For Austin, specifically, the climate projections indicate likelihood that summer daytime temperatures will more often surpass the 100ºF and 105ºF mark by mid-century (Melillo, 2014: 444).

The CHIP does offer an ingenious way to combat the lack of transportation options and the need to increase physical activity. The CHIP suggests combining the two activities into what they call, “active transportation” (Community, 2013). Active Transportation is the process of walking, riding a bike or taking public transportation to your proposed destination, thereby getting you there while increasing your physical activity. The goal set out by the CHIP is a 2% increase in Active Transportation for adults that partake in aerobic activity for 150 minutes per week (2% increase by students with aerobic activities of 60 minutes per 5 days) in the short term. In the long term, the CHIP sets a goal of a 15% increase in daily walking and cycling either in minutes per day or miles per capita per day. This aggressive goal aligns with the City of Austin’s goal to increase bike commuting by 5% for those living within the city boundary.

The CHIP goes on to recommend partnerships between government and nongovernmental entities to incorporate active transportation design into future plans. The suggestions range from revising existing policies on transportation to modifying existing transportation systems, to setting design standards for future development (Community, 2013). As a result, the City of Austin Transportation Department and CapMetro could combine and expand their transportation plans to include all forms of mobility. For example, create one master transportation plan that would incorporate the bicycle master plan, the sidewalk master plan and future bus routes. This would make it easier for those who wish to travel by human-power (biking or walking) or bus to navigate through the city. In addition, this could include an urban design strategy similar to what is proposed with the 2012 City of Austin Comprehensive Plan (Imagine Austin), where the future growth scenario includes dense development, a mixture of uses at one location, pedestrian oriented design, better connection between neighborhoods, and development based on transportation nodes. The overall result is an interconnect network of neighborhoods that is easily traversed by any mode of transportation.

Using commuting and general mobility as a means to increase physical activity is a productive, and sometimes fun, way to decrease obesity. Using active transportation when Austin is experiencing a particularly high heat index, however, is potentially lethal. In light of climate change and the increase in days over 100ºF, active transportation may have to occur solely during the cooler months. Over the last decade, Austin has experienced days where the combination of high temperature and high relative humidity has created dangerous conditions for outdoor activity (Figure 1.5). According to the NCA, days over 100ºF are projected to quadruple in Texas by mid-century (Melillo, 2014: 444). As an equivalency, the Texas heat wave and drought of 2011 brought 90 days over 100ºF. In contrast, over the last century, the average summer days over 100ºF only hovered around 12 days per year. From the NCA, we can gather that the 2011 heat wave will represent a typical summer by the middle of the 21st century.

According to the CDC, using active transportation to decrease obesity during a heat wave is not recommended. Individuals who are at greater risk of heat stress include, “those who are 65 years of age or older, are overweight, have heart disease or high blood pressure, or take medications that may be affected by extreme heat” (CDC, 2014: 1). In other words, the CHIP recommendation to increase physical activity through active transportation to help those who are obese focuses on the same segment of the population most at risk of heat stress: those who are obese. This does not decrease the need for those who struggle with obesity to lose weight or engage in active transportation, but it highlights the importance of understanding the dangers of extreme heat and that high temperatures will increase in the near future (Tillett, 2011).

Obesity is a complex problem that cannot be reduced through one approach alone. Yet, reducing weight and living a healthy lifestyle does include some sort of physical activity. Creating actions that promote physical activity is an obvious and good way to promote healthy living practices. But promoting physical activity outdoor during a heat wave is not recommended. New public health policies should incorporate potential changes in climate and further engage relevant social groups to ensure that the CHIP goals are met without harming the same community it is trying to help. This public driven process would aim to "…collect information, be rooted with people in their communities, to foster their active participation in the process, and provide the basis for them to discover their own means of solving their difficulties" (Van Aalst, 2008: 168). Working with those who are most at risk to find workable and accepted strategies is one way to combat obesity.

Ground Level Ozone

Encouraging vulnerable communities to participate in vigorous physical outdoor activities might also conflict with dangerously poor air quality (Forsberg et al, 2012). One particularly dangerous airborne chemical is ground-level ozone (EPA, 2014). According to the former Environmental Protection Agency (EPA) administrator Lisa Jackson, ground-level ozone is "one of the most persistent and widespread pollutants we face" (Weinhold, 2010: A115). Ground-level ozone can cause "premature death from heart or lung disease" (EPA. 2014: 1) for those who experience prolonged exposure. The NSA projects that ozone levels will increase due solely to climate change (Melillo, 2014). According to one author, "the cities' ozone levels are estimated to increase under predicted future climatic conditions, with the largest increases in cities with present-day high pollution" (Bell, 2007: 61).

Ground-level ozone is created when air pollutants such as volatile organic compounds (VOCs), methane (CH_4), nitrogen oxides (NO_X), and carbon monoxide (CO) are combined and exposed to sunlight (EPA, 2012). Sources of these chemicals range from large industrial facilities to chemical solvents but the most common source are motor vehicle exhaust gasoline vapors. Although most prevalent from April to October, ozone can occur during winter months, as well (EPA, 2012).

Ground-level ozone is particularly dangerous for children and the elderly (EPA, 2014). Exposure from deep inhalation is found to cause lung and throat irritation and difficulty breathing. The most vulnerable are infants, older adults, those with a lung disease, and people who participate in active outdoor activities (Füssel, 2007; Martens, 2014). Children who spend more time outside are especially sensitive to ground level ozone. A child’s lungs are still developing and exposure to ozone can negatively impact lung function into adulthood. In addition, children are more likely than adults to have asthma and, even at low levels, ozone can aggravate bronchitis and emphysema. Scientists have also linked exposure to ozone to a higher chance of developing pneumonia and heart disease (EPA, 2014).

The City’s Health and Human Health Services Department, Transportation Department, and the federal EPA continuously monitor ozone levels and air quality. The levels for the Austin region have steadily declined over the last the few decades. This is due in part to proactive measures taken by City Council, stricter federal fuel efficiency standards, and a reduction in emissions from manufacturing in East Texas. For example, The City of Austin adopted the Austin / Round Rock Metropolitan Statistical Area Clean Air Action Plan (RCCP) that outlines actions to reduce local vehicle emissions. Actions included in the resolution include enforcing anti-idling measures for heavy-duty diesel trucks, creating a commuter reduction program and reducing NO_X from local power plants (Clark-Madison, 2003). Yet, even with these reductions, ground level ozone levels have barely kept pace with restrictions imposed by the EPA (Figure 2.2). In 1997, the EPA set regional ozone limits at 84 parts per billion. The Austin Region did not lower the regional levels below 84 until 2003. In 2008, the EPA lowered the allowable levels again to 75 parts per billion. The Austin region reached that level the following year. It is still unclear if the EPA will lower the allowable levels again and, if they do, whether or not the region will reach the new levels.

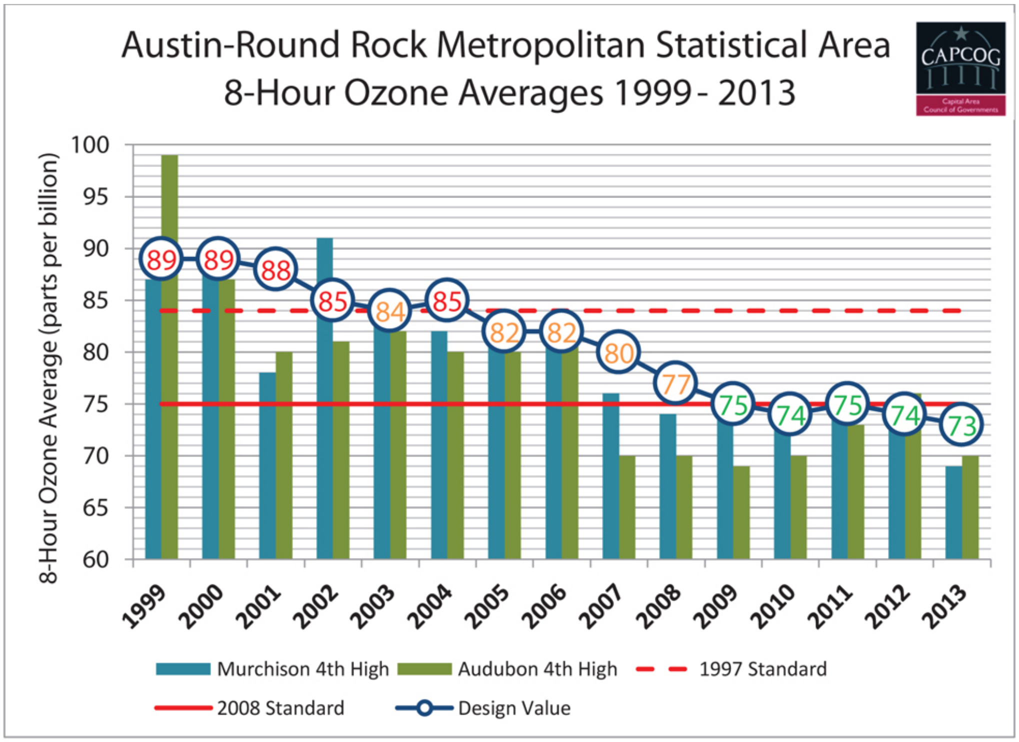

Figure 2.2: Austin-Round Rock 8-hour Ozone Averages 1999-2013 Source: CAPCOG 2013

Although regional levels are decreasing, local exposure is still dangerous to those who are involved in vigorous outdoor activity (EPA, 2014). As mentioned before, ground level ozone is an atmospheric reaction of specific emissions in the presence of sunlight. The sub-humid climate of Austin means the area receives a fair amount of sunlight. On average, Austin has 244 days of sunshine per year with most solar radiation occurring during the summer months (Figure 2.3). In recent years, the most sunshine has occurred in late summer and early fall and created higher levels of ground level ozone.

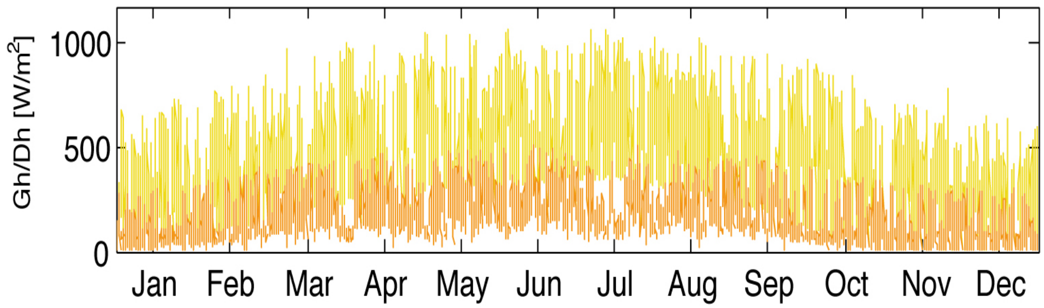

Figure 2.3: Average solar radiation for Austin Texas, 1900-2013, Source: Weather Underground

It is a common misconception that ground-level ozone is tied to high temperatures. In fact, ozone is solely tied to air borne chemicals and sunlight. It is not impacted by heat. For example, ground-level ozone can easily occur on cold winter months (EPA, 2014). Figure 2.4 shows that, from 2006 to 2009, the highest percentage of sunshine happened in late summer and early fall. This is especially disconcerting considering that the highest percentage of sunshine coincides with the start of fall classes and cooler temperatures. The start of school based physical activities means more outdoor events and exposure to an increase in ground level ozone. In comparison, having more sunshine in August during the hottest time of the year would mean that less children and adults would spend time outside.

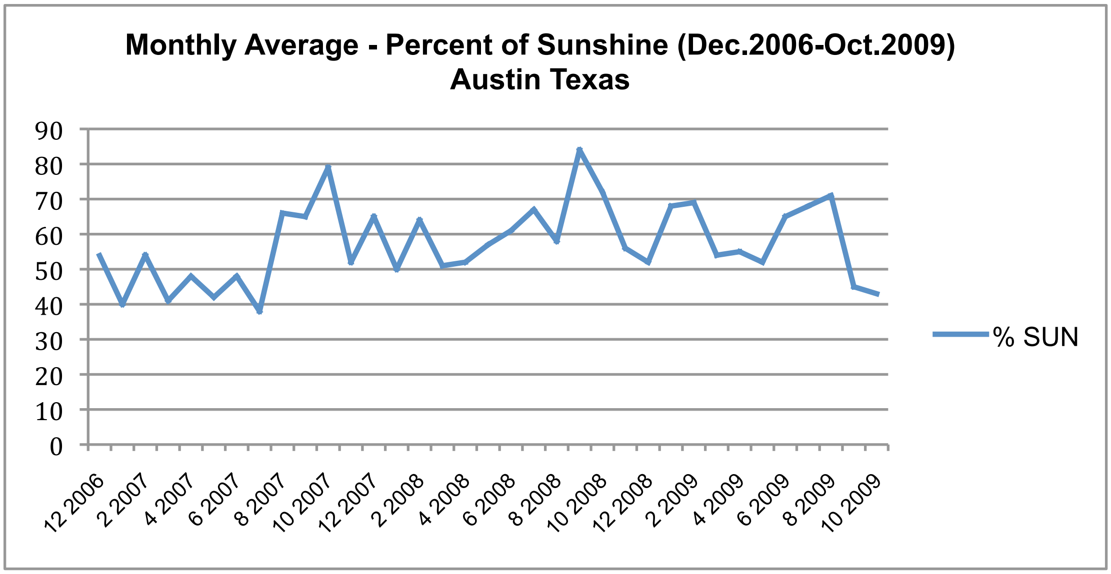

Figure 2.4: Percent of Monthly Average Sunshine for Austin Texas, December 2006 – October 2009. Source: Weather Underground

This study did find one particular anomaly. In 2011, Austin experienced one of the worst droughts on record (Parker, 2011). The regional average for days over 100^{0}F is typically around 12 days. In 2011, the region experienced over 90 days at or above 100^{0}F, combined with virtually zero precipitation and very little cloud cover. With an increased amount of continuous sunshine, it is assumed that ozone levels would reach new heights. In fact, in August of 2011, during the worst drought on record, regional ozone reached the lowest level in a decade (Figure 2.5). Although the exact cause is undetermined, it is assumed that the lack of wind and external factors played a role.

Capital Region Ozone levels: 2007, 2011, 10 yr Average (2003-2013)

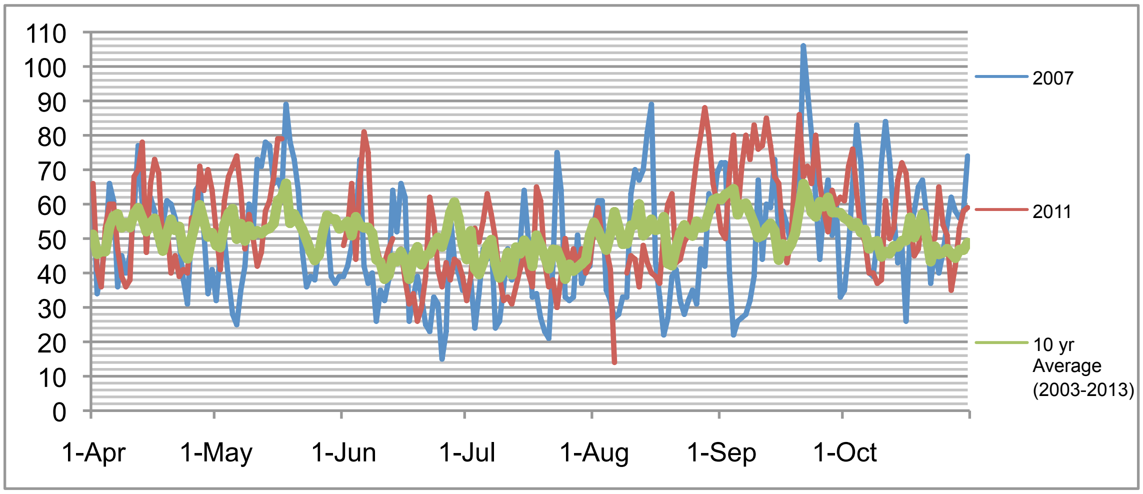

Figure 2.5: Capital Region Ozone levels: 2007, 2011, 10 yr Average (2003-2013)

Source: CAPCOG 2013

My initial findings did connect humidity levels to ground level ozone. Figure 2.6 displays that precipitation decreases in August, creating the expectation that a lack of moisture might mean a decrease in humidity. Figure 13 seems to coincide with Figure 2.7, showing an average decrease in ground level ozone layers in August. With further review, I found that humidity levels have little to no effect on ground level ozone. By comparing the dates that the ozone levels were the highest and lowest in the last ten years with the actual humidity levels of those dates, it was surprising to find that all dates had similar humidity levels. According to the CapCog list of daily ozone levels and the Weather Underground site (weatherunderground.com), the day with the highest levels of ozone, September 21, 2007, had average relative humidity levels around 60%. The day with the lowest ozone levels in 10 years, August 6, 2011, had average relative humidity levels around 55%. Although the humidity levels for both days were similar, I am not able to infer that humidity has an impact on ozone levels without more research.

Decrease in precipitation in middle of summer months

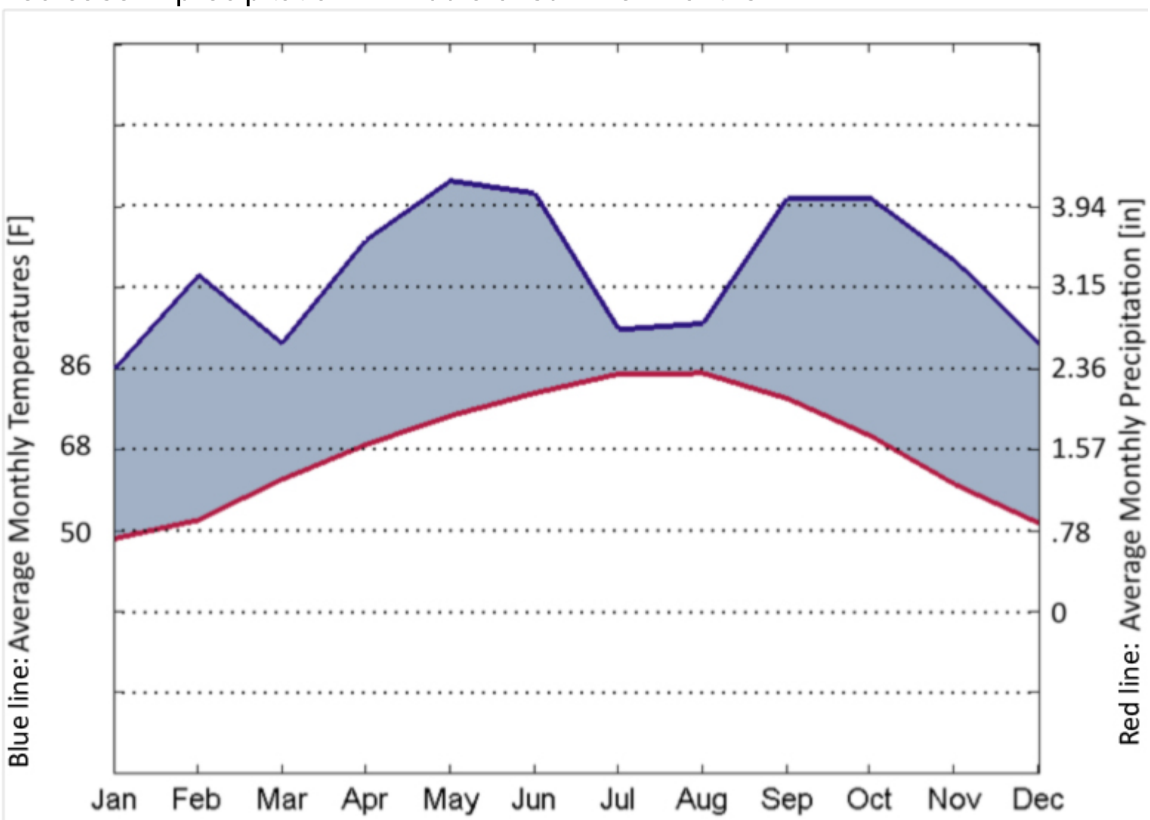

Figure 2.6: Average Monthly Temperatures compared to Average Month Precipitation, Source: Weather Underground.

In further discussions with environmental managers in different parts of the city government, it was pointed out to me that wind would have a greater impact on ozone. A lack of wind would mean that VOC and other pollutants are not pushed out of the region but would lay low to the ground where the emissions are generated. Going back to Weather Underground, I did find that the day with the highest ozone levels (Sept. 21, 2007) had an average wind speed of less than 1 miles per hour (mph) with gust up to 12 mph. The day with the lowest ozone levels (Aug. 6, 2011) had an average wind speed of 6 miles with gust up to 26 mph. This suggests that a lack of wind might have had a greater impact on ground-level ozone concentrations.

Climate projections do indicate an increase in heat but, unfortunately, do not provide data on any change in wind intensity or direction. It is assumed that wind speeds and directions will not change. In addition, while regional ozone levels can vary, local levels are more consistent. Considering that the most common source of VOCs and NOx are motor vehicle exhaust and gasoline vapors, it is assumed that the highest amounts of ground-level ozone occur near major roadways and gas stations (EPA, 2014). An ever-growing population will mean even more vehicles on the roads at any one period in the day. This put some existing schools and community centers in a strange predicament. Schools that we once located on small neighborhood roads with little traffic now find themselves adjacent to heavily traveled roads that emit more air pollution than ever before. With this population growth also comes new construction. Locating new activity centers and schools near major roadways would put children and adults in increasing danger of air borne diseases.

The combination of climate change, increase in population and the location of activity centers near pollution sources create a dangerous scenario. This revelation runs counter to goals set out in the CHIP to increase outdoor activity. Priority area 1 of the CHIP is focused on obesity and has a goal to reduce obesity induced chronic disease by increasing the number of those who meet the physical activity guideline to 5% by June 2016. More specifically, strategy 1.1.1 of priority area 1 of the CHIP directs local organizations to, "increase access to local school facilities, fields, basketball courts, community recreational facilities, parks, play grounds, etc…" (Community, 2013: 16). Locating these facilities near heavily traveled roads or gas stations might do more harm than good. Children or adults engaging in physical activity at these locations on a bright, sunny day may put them at higher risk of exposure to greater amounts of ground level ozone.

As mentioned, exposure to air borne pollutants is particularly dangerous adjacent to busy roads where car fumes and ground level ozone is more abundant and intense (EPA, 2014). By their nature, bus stops are located on roads where waiting passengers are exposed to a constant stream of air pollution. The time it takes for passengers to board a bus means that busses must idle in place making it dangerous for those waiting outside at the bus stop. In addition, excessive daylight during the summer season creates a dangerous situation as busses use additional fuel for air condition. The additional fuel and sunlight means even more exhaust that can turn into ground level ozone (EPA, 2014). Luckily, hybrid vehicles (with automatic engine shut-off when they come to a stop) and electric cars are increasing in population creating hope that air quality will get better in the near future.

Climate change projections in Texas include longer and hotter droughts (Melillo, 2014). These prolonged periods with more sunshine will create the conditions for increased amounts of ozone. According to the NCA, there is a "very high confidence" that climate change will decrease air quality over all (Melillo, 2014). The climate assessment states that climate change will increase concentrations of ground level ozone an additional 1 to 10 parts per billion (Melillo, 2014). This will make it harder for regions to abide by EPA regulations and will certainly push those areas that are typically in air quality compliance into nonattainment. But the connection of ground level ozone to climate change is even more specific. The NCA goes on to state that for every 1.8^{0}F increase in temperature, an additional 1,000 premature deaths will happen every year. So by 2050, we will see an additional 4,300 premature deaths per year connected to climate change and air quality (Melillo, 2014: 222).

The process of locating activity centers away from emission sources highlights the need to incorporate public health planning and climate change projections into large community and regional planning efforts. Similar to the literature review for climate change and health, the literature on climate change and planning is still, "scarce and fragmented" (Wamsler, 2013: 68). Looking at the large context beyond public health to regional planning also adds a greater level of complexity to the process. “Resilient cities can only be achieved if planning for adaptation includes measures that address all types of risk factors and, at the same time, target not only the urban fabric’s characteristic physical features, but also related environmental, socio-cultural, economic and political aspects, which make cities into hotspots of risk” (Wamsler, 2013: 79). As the City of Austin works through the details of implementing the 2012 Imagine Austin Plan, it is reassuring that regional public health agencies are engaged in the process. For reference, regional public health agencies include City of Austin and Travis County Health & Human Services Department, Veteran’s Services, Central Health, St. David’s Foundation, Seton Healthcare Family, the University of Texas Health Science Center at Houston School of Public Health Austin Regional Campus, and Austin/Travis County Integral Care. These organizations work collaboratively to assess current public health issues and provide input on the planning process. One key planning theme that the CHA identifies is the role that transportation plays for the most vulnerable population to access health service.

FINDINGS 2: MOBILE ISOLATION AND HEALTH

The CHA and CHIP addresses two main themes connected to transportation - the limited access to health care facilities and social isolation. Considering current climate scenarios, the two major deterrents to mobility for vulnerable communities are heat and access to public transit. Both of these deterrents speak not just to physical health but mental health, as well. Considering that mental health has an additional stigma attached to it, it makes this segment of the population especially vulnerable.

Mobility

As the 2010 Patient Protection and Affordable Care Act (PPACA) continues to engender debate in Congress, local communities find it increasingly difficult to access healthcare, both physically and financially. The access to health care facilities is a prominent theme in the CHA. The combination of geographic disparity between low-income communities and the physical environment (which has grown faster than the ability for public transportation accommodate most residents) has led to a sector of the community that is physically unable to reach healthcare facilities (Community, 2013).

The interconnection between public transportation and income is complex and full of assumptions (Sanchez, 2008). Yet, studies show that those with low and fixed incomes are more likely to use public transportation than those with medium to high incomes (Giuliano, 2005). According to an article in the publication Science Direct, “the lack of transportation mobility among welfare recipients was illustrated by the low rates of vehicle ownership, in some cases as low as 6%” (Sanchez, 2008: 838). Other research articles document that, “those who use transit regularly have the lowest level of mobility among all population segments” (Giuliano, 2005: 63). and that “from the transportation perspective, the reverse commute represented a significant challenge for [low-income] persons because many did not own automobiles and because transit service did a poor job of serving these types of trips” (Sanchez, 2008: 835).

One main contributor to the lack of access is geographic disparity. The city demographer recently stated that, on average, 110 people move to Austin each day and that the population of Austin is expected to double over the next 30 years (Pope, 2014). This growth has increased demand for housing and made historically low-income minority neighborhoods with inexpensive land values and proximity to downtown an attractive place for new development. This, in turn, has increased home values and property taxes making the area unaffordable for those with fixed incomes (Dominguez, 2014). The growth pressure from an increasing population has pushed low-income communities to areas with more affordable housing but farther from jobs, public transit routes, and healthcare services (Community, 2013: 20).

According to the CHA, living in a community that was not “walkable” and lacking public transit within the approximate vicinity were identified as the two main factors that hindered residents' access to health services (Community, 2013). The communities most likely to feel this effect are suburban style neighborhoods that are segregated from amenities by large freeways and rural neighborhoods whose low density necessitates some kind of motorized vehicle to accomplish basic tasks. This suburban and rural landscape is especially difficult for seniors and children who are not able to drive. Low-income seniors on fixed incomes are not able to afford an apartment in the downtown area and may need to distance themselves from family and friends in order to find an affordable place to live. This gives vulnerable communities few choices for mobility, as the majority of new suburban neighborhoods do not include pedestrian friendly streets, shaded bus stops, or crossing signs on busy streets.

The goals identified in the CHIP to increase access to healthcare facilities and encourage active transportation are potentially hindered by an increase in overall temperature. Both goals create a situation where low-income individuals have to spend time walking along streets or waiting at an unsheltered bus stop. This exposes individuals to dangerously high temperatures and higher levels of ground-level ozone. According to the U.S. Department of Commerce, less than 4% of Travis County workers over the age of 16 use public transportation (Community, 2013: 20). The same study also states that nearly 80% of worker used a car, truck or van to get work (Community, 2013: 20). Those who decide to take the bus sometimes wait a long time for a bus to arrive only to then transfer multiple times before reaching their destination. In addition, bus stops without shade make waiting for a bus in the summer heat especially dangerous.

To better understand the impact of heat on public transit ridership, Figure 2.7 shows the comparison of daily ridership and temperature. The graph shows a clear correlation between high summer heat and a drastic decrease in ridership. Where daily temperature (in red) peaks in the summer months to temperatures hovering around 100^0F, ridership (in blue) drops. Although it might appear that high temperatures have a causal relationship with a decrease in ridership, the assumption is anecdotal. According to the graph, this phenomenon appears to happen year after year. Yet, there are many social and economic factors that may create a similar trend. One explanation is the seasonal nature of local schools and universities. Austin is home to several large universities including the University of Texas at Austin, St. Edwards, Concord University and the Austin Independent School District that, together, represent hundreds of thousands of students. A drop in summertime ridership might correlate with summer break. In addition, a decrease in overall student population and their purchasing power may also decrease the amount of summer jobs – hence a decrease in ridership. Plus, large events like SXSW and ACL might boost the numbers in the Spring and Fall. A reorganization of bus routes by CapMetro might also explain some variability in ridership as daily riders get accustom to new alignments. This would impact ridership both seasonally and annually, depending on when the routes area adjusted. Lastly, a correlation may exist between gas prices and ridership or other economic factors. Whatever the reason for a drop in bus ridership in the summer, there still remains the issue that heat does impact those exposed to the elements while waiting for a bus. For those who are not in school but need to use public transit to get healthcare or for daily commuting, taking public transportation in the summer is still a potentially dangerous endeavor.

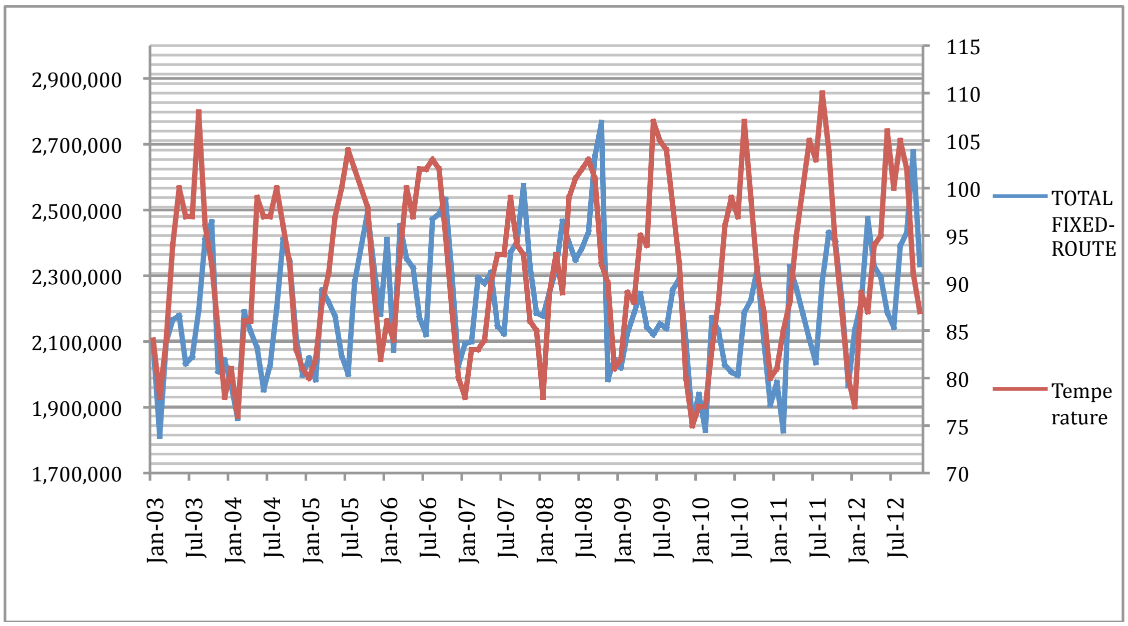

Figure 2.7: Bus Ridership and High Temperatures 2003-2012, Source: CapMetro.

Taking public transit means waiting outside for a bus. Although, thankfully, most busses are air-conditioned and can provide reprieve from the summer heat, riders still need to spend time outside -in the direct sun. Considering that only 651 (23.7%) of the 2,746 bus stops within the control of CapMetro have shelters

(CapMetro, 2014), this is especially disconcerting. With more days expect to reach 100^0F and some days as high as 110^0F, public health and safety should continue to take top priority when considering policies to increase public transportation.

The built environment also plays a role in heat mitigation. “Added to the climate change-driven increases in temperature are the effects of the urban ‘built’ environment. In fact, cities and their climates are co-evolving in a manner that will amplify the effect of heat as well as the vulnerability of urban populations to heat-related deaths” (Luber, 2009: 114). Roads and buildings absorb and retain the sun’s heat during the day, increasing daytime and nighttime temperatures (Gartland, 2012). Called the Heat Island Effect, temperatures in urban areas can sometime increase to 9°–11°F hotter than surrounding rural areas (Allaby, 2002). When considering that temperature might rise to 110^0F, the Heat Island Effect could raise temperatures closer to 120^0F, not including humidity or heat index (Allaby, 2002). By their nature, bus stops are located on roads with the stop itself on sidewalks. These materials retain heat during the day making the act of standing outside, unprotected, particularly dangerous. In addition, wind can exacerbate the health impacts of the urban heat island effect. While wind was previously identified to ameliorate regional ozone levels, wind created by the heat island effect might negatively impact air quality. “…Mesoscale wind produced by urban heat island help the pollutants to circulate and move in upward direction, thus making the problem of air pollution more severe in urban areas” (Agarwal, 2010: 2520). All of these factors can make waiting for a bus, on a hot summer day, a potentially dangerous activity.

Now consider an elderly person who needs to get to a health care facility by public transportation on a hot day. Also consider that, “older adults are less efficient at dispersing heat and noticing when they are thirsty”. (Uejio, 2011: 501) Standing at a bus stop without shade is potentially lethal. Consider a single mother or father who does not own a car but needs to go to the grocery store for food. Transporting perishable foods in the heat may decrease the safety of the products. Not having a safe route to and from health-based facilities (be they hospitals or grocery stores with healthier food) will have a major impact on the health of individuals in vulnerable communities. These issues go beyond just transportation. Having healthy food options, adequate employment, or health care facilities in the neighborhood are keys to a more sustainable community. With an increasing geographic disparity and increasing temperatures, these health issues will not get better, but worse.

Isolation

Those who have minimal contact with the outside community are especially vulnerable to heat-related illness and death (Hajat, 2014). “All persons are at risk for hyperthermia when exposed to a sustained period of excessive heat; however, factors that increase the risk for hyperthermia and heat-related death include age (e.g., the elderly), chronic health conditions (e.g., cardiovascular disease or respiratory diseases), mental illness (e.g., schizophrenia), social circumstances (e.g., living alone), and other conditions that might interfere with the ability to care for oneself" (Heat, 2000:35). This is alarming considering that this segment of the population is increasing. "The number of people living alone is rising almost everywhere in the world, making it one of the major demographic trends of the contemporary era" (Klinenberg, 2002: 43). Mental health plays a large role in isolation as well as those with certain physical ailments. "Patients with severe mental illness such as schizophrenia are at risk during hot weather because their medications may interfere with temperature regulation or even directly cause hyperthermia" (Melillo, 2014: 228). Whether a community member does, or does not, have a mental illness, social isolation is especially dangerous during a heat wave (Hajat, 2014).

In addition to those with mental illnesses, the elderly, children and minority groups are also at risk from increasing temperatures (Hajat, 2014). "Mental health" can either include actual mental illnesses or addictions but often times, both issues are intricately intertwined (Community, 2013). In the CHA, stakeholders identify depression and stress as a motivator for people to abuse drugs and alcohol. Those who suffer from mental illness are especially isolated due to the multitude of barriers that prevent them from getting help. "These barriers reflect issues for the individual in terms of the direct impact of the illness on function, for the broader community, in terms of the impact of expectations and attitudes on service provision and employment outcomes, and for policy settings, impact on access to/availability of services" (Harris, 2014: 68). In addition to these barriers, the individuals must overcome the stigma attached to mental health and addiction, complexity of health care regulations, funding cuts to services, limited hours of health service operations, and lack of knowledge of existing services (Community, 2013; Harris, 2014).

The growing Hispanic population is especially vulnerable to isolation and mental health as their low-wage earnings can neither pay enough to live close to their employment nor afford them the ability to purchase a car (Hurtado-de-Mendoza, 2014). In a recent study of Latinos living in the United States, "…women brought up environmental obstacles to establishing relationships or to spending time with others that included the structure of their surrounding physical space, limited access to public transportation, and weather conditions" (Hurtado-de-Mendoza, 2014: 77). In addition, the cultural and linguistic differences can further isolate them from existing resources and services. Either they do not feel comfortable navigating the healthcare system in another language or feel that it is not available to them (Community, 2013). Yet, in some cases, Hispanic communities fare better during a heat wave than other minority groups (Klinenberg, 2002). The author, Klinenberg, believes this is due to Hispanics often behaving in a more communal way, with people checking-in on friends and family during major weather events resulting in fewer incidents of illness and death (Klinenberg, 2002). What is uncertain is if the Hispanic Community in Austin is "tight-knit" or isolated. Assuming that the Hispanic population is not homogenous, it is likely that some in the Hispanic community are “tight-knit” and some are isolated. According to the CHA, Austin’s minority population experience the most mental health issues with Latinos/Hispanics representing the largest group at 26.6% followed by Blacks/African Americans with 24.3% (Community, 2013: 45). Considering this trend, the Hispanic population is expected to grow over the coming years, which will have a substantial impact the city’s ability to maintain an adequate level of public health services.

Another growing segment of the population that is vulnerable to isolation is the elderly population (Martens, 2014). The reasons for isolation amongst the elderly are a lack of family members, restricted personal choice, fixed-income, and/or severe mental illness (Martens, 2014). The CHA indicates that transportation is particularly challenging for the elderly (Community, 2013), thereby creating a possibility of a feed-back cycle of isolation and depression (Klinenberg, 2002). Mental illness is also a major risk for the elderly. For example, “Dementia is a risk factor for hospitalization and death during heat waves” (Melillo, 2014: 253). As the population of Austin grows and ages, the elderly population will also grow, putting additional stain on the health system and testing its ability to provide adequate services.

Providing services to isolated or reclusive community members is not an easy task for several reasons. “Isolated and recluses are by definition difficult to locate and contact because they have few ties to informal or formal support networks” (Klinenberg, 2002: 45). This makes it especially difficult to increase outreach and education. In some cases, education is not enough. According to the CHA, “some patients with mental illness are especially susceptible to heat. Suicide varies seasonally and rises with hot weather, suggesting potential climate impacts on depression (Melillo, 2014: 228).

The NCA also references the impacts of heat and isolation. With temperatures expected to rise, members of the most vulnerable community will get hurt. This is the case if, during a heat wave, a community member decides to stay indoors. “The body’s defense can only take about forty-eight hours of uninterrupted exposure to such heat before they break down” (Klinenberg, 2002: 5). If temperatures are expected to rise during the daytime and nighttime as well, the body will not have the ability to appropriately cool down. According to climate projections, Austin will see high temperatures of 110^{0}F more often. What is especially worrisome is that nighttime temperatures will also remain high. Climate projections estimate fewer nights when temperatures will get below 80^{0}F. Having high nighttime temperatures means that buildings and people without air-conditioning cannot cool down (Schmid, 2014). Those in isolation are more likely to not ask for help, putting themselves in extreme danger of heat-related illness or death.

CHICAGO HEAT WAVE 1995

The findings provided above are eerily similar to real life heat waves that have recently impacted major urban centers. Both France in 2003 (Fouillet, 2006) and Russia in 2010 (Bondur, 2011) experienced extended periods of extreme heat that harmed thousands of people. The incident most relevant to this thesis occurred in the United States in the mid-nineties (Klinenberg, 2002).

During the summer of 1995, the City of Chicago experienced one of the worst heat waves in living memory. A short-lived heat wave had lethal consequences for a city that was unprepared for such as catastrophe. Over the period of several days in July of 1995, an estimated 730 Chicagoans died from exposure to extreme heat. This was a dramatic increase to the dozen or so death that was typically reported during the same time the year before. In fact, this was the worst natural disaster to ever hit Chicago. The most lethal event in Chicago prior to the heat wave was the famous Chicago fire of 1871 that lasted several days. That event razed the city and killed around 300 people. The 1995 heat wave had twice the amount of deaths in about the same amount of time (Klinenberg, 2002).

The Chicago heat wave illustrated that not all sectors of the community were impacted equally by the event. “The medical examiner’s data show that disproportionate numbers of the heat wave victims were, in fact, members of the city’s most vulnerable groups: the elderly, African-Americans, and the poor” (Klinenberg, 2002: 30). The elderly were especially vulnerable. “The victims were primarily elderly: 73 percent of the heat-related casualties were older than sixty-five years of age” (Klinenberg, 2002: 18). Yet, even amongst the elderly, race played a role in who was most likely to get hurt. “African Americans had the highest proportional death rates of any ethnoracial group” (Klinenberg, 2002: 18).

Other minority groups did not have the same experience. “In contrast, Latino Chicagoans, whose overall level of poverty placed them at a heightened risk of mortality, experienced a surprisingly low death rate” (Klinenberg, 2002: 19).

The one social characteristic that was the most lethal was isolation. “Just a minority of victims, including a mother and child who succumbed together and two sisters who lived in the same building, perished with company nearby. Hundreds died alone behind locked doors and sealed windows that entombed them in suffocating private spaces where visitors came infrequently and the air was heavy and still” (Klinenberg, 2002: 5). According to the author, the driving reason for this isolation was the perception of crime and an inability to get around. The elderly population had the perception, fed by nightly new programs, that the city was an increasingly dangerous place to live. Compounded by the difficulty for most elderly to walk to the store or take a bus, most felt it was safer to stay indoors than to walk to cooling stations. For a variety for reasons, this segment of the population, whose social safety net could have saved them, lost connections to family and community.

According to Klinenberg, the City of Chicago’s emergency services were also slow to respond (Klinenberg, 2002). There were no past events that had ever reached this magnitude of danger. This touches on the true dangers of climate change. Most cities were built, and now operate, on the assumption that the climate will not change and that past events are a good measure on what might happen in the future. The record-breaking heat waves in Chicago, France and Russia are an indicator that things are moving past historic trends. A lesson learned from the Chicago event is that “the heat wave was a cultural event as well as a public health crisis” (Klinenberg, 2002: 23).

Chapter 4 Discussion

The question asked in this thesis is, *how will climate change impact the public health issues outlined in the Austin/Travis County Community Health Assessment and Community Health Improvement Plan*? The following question is, *what are some potential strategies to mitigate these impacts*? This section is a critique and evaluation of this thesis and its findings followed by suggestions on strategies to reduce the impacts of heat on vulnerable communities. It starts with the strengths of this thesis, followed by its weaknesses, the opportunities, and the threats. This section ends with possible policy solutions to ensure that the most vulnerable communities are safe during major heat events.

The strength of this thesis lies in the use of real data provided by experts from multiple fields with the inclusion of public input. The comparison of both Community Health Assessment and the National Climate Assessment means that the data used in this thesis are the best available data at the time. Both documents were drafted by experts, reviewed by the public and include local stakeholders' data. Both are understood to have the most up-to-date and accurate information. The fact that the seemingly disparate documents reference the same issues and conclusions further strengthens the relevance and the legitimacy of the findings. The findings represent real life data that, in turn, outlines real life ramifications for public health.

With all research topics that include people living in urban areas, there is an inherent weakness in trying to quantify and encompass such a broad and complex social landscape. In order to compare and contrast different urban scenarios, specific topics are generalized and viewed through the same lens. Consequently, this takes away from the finer scales processes, complexities and experiences of dense urban living. Generalizing strips away the many characteristics of vulnerable communities beyond public health, such as long-term unemployment, access to education, lack of social safety net, and environmental justice, to name a few. More poignantly, this report is void of the many personal lives and emotions connected to individual people, their stories, and their hardships. Yet, generalization is needed to better understand one specific issue amongst a broad and complex landscape. Generalizing allows us to compare and contrast one or two specific issues to a few key inputs thus honing in on a select group of recommendations.

Although necessary, it is worth noting that generalization can cause a distortion in perception. It makes it easier for the reader and/or decision-maker to dismiss the findings as someone else's problem. Without specific neighborhoods or communities to target, policies to mitigate heat exposure might not reach those most in need. Another issue of simplifying complex health issues is the lack of a defining event or engagement strategy to galvanize communities to act. Keeping the discussion large and vague does not inspire local communities to come together and find solutions. The solutions identified later in this chapter only focus on what the public health agencies can accomplish and does not provide strategies for what individuals or communities can take.

Without a full vulnerability assessment, it is difficult to allocate the correct amount of resources to the community groups that are most vulnerable. The findings in this thesis are broad in scope and do not have the depth to assess location-based vulnerabilities. In addition, the current research on climate change and health is limited and is only now starting to see traction in journals and institutions. The limited body of research means that assumptions are made to fill the gap. It is these assumptions that hamper the ability to truly understand the impacts and actions needed to help those in danger. It is also these many assumptions that make this thesis unpalatable to publishers and not part of the greater discussion of climate change.

On the positive side, there are many opportunities in considering climate change in public health policy discussions. Climate change is still a new topic and is currently peaking the interest of many research institutions. Although we have known that the earth is warming for some time (Richardson, 2011), it is only recently that cities and health organizations have begun to incorporate climate change resiliency into their operations and services (Hess, 2012). It is still an emerging topic and energetic researchers have the enthusiasm to take on such a daunting challenge. It is now clear that climate change is happening and it is time to take action. Regional public health agencies can rally around recent extreme weather events, such as the local heat wave of 2011 and floods of 2013, to discuss the impacts of climate change in the planning process.

For others, the opportunity lies in discussing climate change and health in terms of risk assessments (Van Aalst, 2008). Understanding that climate change will happen, it is time to prepare for the inevitable. Not preparing will mean more people will get hurt and health costs will go up. Reducing the impacts of climate change now is reducing the potential negative impacts of an event in the future. From this perspective, climate resilience is an economic issue. If climate resilience is defined as, “maintaining well-being under adversity as well as recovery” (Robertson, 2013: 176) than implementing climate change safeguards now will pay off in the long run. To clarify, the cost of not preparing for climate change is much greater than small, less expensive, interventions now. Overtime, this “ounce of prevention” approach may ensure the availability of resources for future extreme weather events.

It is by leveraging resources from public health agencies and nongovernmental organizations that less people are harmed by climate change. This is made possible by finding solutions to climate related issues that have multiple benefits and are engendered by the community. “Through engagement with the grass roots, the activities that emerge will have the people’s ‘ownership’ and participation, be based on trust and therefore have more chance of success” (Van Aalst, 2008: 168). By finding solutions that benefit multiple stakeholders, more people are engaged and ready to help.

For example:

> Public health researchers also recognize that solutions to climate-related problems may also benefit health—for instance, a community designed so that residents can safely walk and bike to shop and work not only reduces greenhouse gas emissions but offers the cardiovascular benefits of physical exercise, which in turn may further protect individuals against extreme heat (Barrett, 2013:134).

The threat to this thesis and other public health strategies is the public belief that extreme heat events are an anomaly and that they may not happen again. Since the heat wave of 2011, we have had few years without equivalent temperatures or duration. Some city departments and community members have (off record) expressed that they, and their community, had no short-term or long-term impacts from the 2011 heat wave. If true, this perception will inevitably lead to public apathy and political inaction. There is also the chance that climate change is seen as a long-term threat, happening far in the future. Simultaneously, there are those who think that heat is simply an emergency management issue and not something to worry about for others such as transportation planners or mental health workers. To this third group of skeptics, there is nothing stopping ambulances from making it to people's homes or anything stopping vulnerable populations from going to cooling stations. Studies show that simply telling people about climate projections is not enough and that further engagement strategies are necessary for meaningful action (Van Aalst, 2008). Regional and local decision-makers have the means to put policies and procedures in place to protect vulnerable communities during major events. The decision-makers should take actions to ensure the safety of all citizens, even if the actions have no seemingly immediate impact.

POTENTIAL MITIGATION STRATEGIES

Partnering with other agencies

"Climate change will increase the frequency and the intensity of heat waves, and a range of measures—including improvements to housing, management of chronic diseases, and institutional care of the elderly and the vulnerable—will need to be developed to reduce future impacts of heat" (Kovats, 2008:50). In this thesis, I attempt to find weaknesses amongst already vulnerable communities and identify opportunities to safely implement the CHIP. The method to indentify these opportunities consists of finding alternative solutions to accomplish the same goals while considering an increase in heat. These solutions range from greater public outreach to increasing collaboration with regional partners to very specific policy changes.

Engaging people in the most vulnerable communities, such as the elderly, communities of color, and the poor, is an initial and cost effective method to protect those most at risk. Public health agencies can reduce the exposure to risks for the most vulnerable community members by enhancing public outreach and expanding partnership programs to include more city departments and regional organizations. For example, public health agencies could strengthen partnerships with other city departments, such as Austin Energy's weatherization program, Parks & Recreation Department (PARD), and Captmetro. By leveraging existing community outreach through greater partnership opportunities, the message can reach a larger amount of people without substantially increasing the advertising cost of any one department. These efforts would focus on populations that are most at risk to climate change health impacts. More specifically, public health agencies could partner with the Austin Energy Green Building program to expand efforts make affordable housing projects more energy efficient. "Reliance on air conditioning could be reduced through better building design and use of materials that reflect heat or insulate against it in new construction and renovations" (Barrett, 2013:134).

Another partnership opportunity for public health agencies is to work with PARD to expand access to, and availability of, indoor exercise facilities for summer months. PARD has many recreational facilities in and around the city. Most of these facilities are used year around but the two departments can work together to ensure that facilities in the most vulnerable communities offer indoor recreational alternatives during the day and into the evening. This might also include prioritizing the timing of community events so they more frequently occur during cooler months or avoid months with high ozone levels. In addition, PARD can work with public health agencies to consider canceling outdoor athletic games and events during ozone action days when air quality reaches dangerous levels.

A/TCHHSD and partners are currently working with CapMetro to better understand the transportation needs for areas with greater concentrations of poverty. This partnership can lead, for instance, to an increased number of bus shelters in areas that have larger percentages of vulnerable members. This partnership might also look at circulation patterns of low-income residents to better understand how they travel to and from work or shopping for basic needs.

Many city departments and local organizations have programs that can help the most vulnerable communities take actions to protect themselves from heat. Often times, unfortunately, these efforts are not coordinated and can cause confusion amongst residents. Community members will often not take advantage of city programs if they are confused with other programs, difficult to understand, difficult to participate in, and perceived as expensive to implement. Sometimes, if basic questions are not immediately understood - like whom in the government community members should talk with in order to get more information, how the programs work, if there are any applicable rebates - then they will not participate. By enhancing existing partnerships and reaching out to new partners to better coordinate and communicate programs and benefits, pubic health agencies can increase enrollment in a multitude of health programs that will exist locally. This could take the form of a ‘one-stop-shop’ retail-like space in the vicinity of vulnerable communities or more community meetings with multiple organizations to distribute information or answer any questions.

Education campaign

Educating community members about safety can take many forms. Methods can range from television commercials that communicate safety to the general public, to large billboards that communicate information to a specific region, down to in-person discussion that focuses a message to a handful of people. In the case of heat, the end goal is always the same: make sure people are safe during and after an event.

Messaging around heat can include knowing to keep yourself hydrated, knowing the symptoms of a heat stroke, knowing when to avoid vigorous outdoor activity, knowing where cooling stations are located, and asking neighbors to check in on each other during extended heat events (Costello, 2009). The communication strategy focuses on reducing the sensitivity of vulnerable community members to exposure from heat.

It is important that the messaging is accessible to all community members. According to the NCA, portions of the most vulnerable community members are non-native English speakers. For this reason, it is important to provide the information in multiple languages. Equally important is how and where you provide the messaging. Different community groups have different social networks and a one-size-fits-all education campaign is not always the best way to engage a diverse collection of communities. Having several communication strategies to reach multilingual and socially isolated communities is vital.

Other programs can focus on decreasing social-isolation. By organizing town hall style meetings, community members can come together, meet each other, and discuss ways to better coordinate public outreach and social networking. The actions proposed by community members act to engage more community members while also reducing the exposure of the most vulnerable communities to climate change risk factors. Other suggested actions for public health agencies to reduce social isolation can include increasing preemptive mental health treatment and, “integrating mental health services into a primary care setting” (Community, 2013). Identifying potential mental health issues early in the health care process is another effective action to reduce health risks. Although increasing early detection of mental health may necessitate additional training for caretakers, it is still a relatively less expensive means of treating long-term illness. As mental illnesses are complicated and can sometimes instigate other health issues, identifying and treating mental illnesses early can decrease long-term health costs.

With a potential growth in mental health case in the coming years (Costello, 2009), there is a possible need for more public health facilities. Further study is needed to determine if additional facilities would help those most vulnerable to climate change and, if so, where to locate and how to fund those facilities. It has come to my attention that local health organizations are currently planning to locate facilities near vulnerable communities and on public transit routes. Understanding the impacts of climate change on mental health issues may help to determine the locations of the facilities and illuminate which services to provide.

Physical design

An opportunity to protect vulnerable community members is to mitigate heat by replacing the heat retaining physical urban environment with one that decreases ambient air temperatures. The phenomenon called the urban heat island effect, described in chapter 3, is a condition where thermal massing from buildings and roads retain heat over time and raise the overall ambient temperature for a given area (Allaby, 2002). Studies have shown that the urban heat island effect is more likely to happen in low-income areas than in more affluent areas (Costello, 2009). This puts additional strain on communities already vulnerable to excess heat and obesity. Several examples of alterations to improve the physical environment are to plant more trees, select building materials that are light in color, provide more green spaces, and incorporate more impervious surfaces (Akbari, 2008). Cumulatively, these small design features add up to significant reductions in ambient air temperatures (Saneinejad, 2014). In places like Chicago and New York City, these techniques have already shown positive results (Akbari, 2008).

As a city organization, it is important to make clear the potential ramifications of inaction. It is already established that heat is dangerous and not preparing for longer and hotter summers puts more people at risk of harm (Kovats, 2008). Yet, impacts of climate change are not just a hazard for community members. Extended heat waves can also endanger public health staff who are in the field helping community members. Heat can also, at times, negatively impact the infrastructure, facilities and trucks used during emergency situations (Smoyer-Tomic, 2003). These impacts can hinder an agencies' ability to sustain the same performance levels and achieve its core mission. Having key health functions and assets compromised by the same event may create cascading hazards, making the event exponentially more dangerous for vulnerable communities.

This brings up the point that climate change is not a simple binary event, but a cumulative stressor (Costello, 2009). One thing I've learned from this exercise is that climate change is not an equalizer. "Climate change both reflects and exacerbates social and health inequalities" (Griffiths, 2013: 1). Although everyone will feel a heat wave, not everyone is equally vulnerable to it. Those with resources will have access to air conditioning, transportation and healthy food. Those without resources risk a higher chance of harm (Griffiths, 2013). In essence, climate change accentuates current stressors and can make them worse. In the case of public health and transportation, if it is difficult to get around, a heat wave will make it worse. If someone struggles with mental health, a heat wave will not make it easier. In light of climate change, it is the vulnerable population that faces a heightened sensitivity to weather related hazards (Turner, 2013).

QUESTIONS THIS RESEARCH RAISES

The intersection of climate change and public health is broad and diverse (Costello, 2009; Hess, 2008; Uejio, 2011) Many subtopics identified in this thesis need additional research. To further this research, public health agencies would have to undertake a full climate change vulnerability assessment. This would include incorporating additional climate projection information such as precipitation amounts and duration. Including additional climate information would mean considering the additional impacts of climate change such as flooding and the impacts of drought on species migration. For example, the impacts of such changes may trigger other public health issues such as an increase in vector, air, and water borne disease.

The health agencies should also consider expanding the dialog to other community members. This might include adding more stakeholders in the public engagement process. Additional stakeholders could include even more businesses, local nongovernment organizations, and faith-based organizations. This would ensure that a greater amount of community members would have a voice in, and basic understandings of, the impacts of climate change on public health.

As Hess describes in his book, Integrating Climate Change Adaptation into Public Health Practice, “Increasing public health capacity will be necessary for certain climate–health threats. Focusing efforts to increase climate resiliency in specific areas, promoting institutional learning, embracing adaptive management, and developing tools to facilitate these processes are important priorities and can improve the resilience of local public health systems to climate change.” (Hess, 2012: 171)

The output for this research is a series of recommendations to ensure that the Austin community is less vulnerable to climate change. The goal of public health agencies is to promote and protect a healthy community through the use of best practices and community partnerships. Understanding the impacts of climate change is the first step towards ensuring the Austin residents are safe from harm (Patz, 2000). For public health agencies to take a course of inaction could have dire consequences. As fewer people doubt that the climate is changing, it is time for us to consider alternative actions now to protect the health and wellbeing of all community members now and in the future (Costello, 2009). This thesis is intended for those who wish to make a difference. Hopefully, it will intrigue folks at public health agencies to take action and help save lives.

Glossary

- Adaptation: Adaptation is the augmentation to human and natural systems to mitigate harm from environmental change such as climate change.
- Asthma: Asthma is a chronic (long-term) disease of the lungs. The disease narrows the airways causing recurring periods of coughing, wheezing and shortness of breath.
- Climate: Climate is narrowly defined as the "average weather," or more specifically, the average temperatures, precipitation, and winds over the prior three decades.
- Climate Change: Climate change is a major change in temperature, precipitation, or wind patterns, over the period of several decades or longer. Climate change typically refers to a change in longer-term weather caused by an increase in greenhouse gas emissions in the atmosphere.
- Climate Resiliency: Climate resiliency is defined as the anticipation of, response to, and ability to recover from an extreme weather event.
- Intergovernmental Panel on Climate Change (IPCC)**:** Established by the United Nations Environment Program and the World Meteorological Organization in 1988, the IPCC assess scientific and technical information related to climate change. The IPCC authors consist of hundreds of scientists and thousands as expert reviewers.
- Mitigation: In this thesis, mitigation refers to acts or policies that reduce the impacts of a real or potential harm typically related to a change in climate and/or environment.

- Obesity: Obesity is physiological condition where excess fat accumulates on and inside the body, causing negative health effects. This condition can lead to a reduced life expectancy and/or increased health problems. Typically, an obese person has a body mass index (BMI), of 30 kg/m^2. BMI is a function of dividing a person's weight by the square of the person's height.
- Ground-level ozone: Ground-level ozone, or tropospheric ozone, is created through a photochemical reaction involving organic gases exposed to sunlight.
- Particulate Matter (PM)**:** Particulate matter is a small amount of liquid or solid that is suspended in air. Examples of PM can include dust, soot, fumes, mists, or aerosols.
- Vulnerability: Vulnerability is the degree in which a system is susceptible to climate exposure and climate variation. Vulnerability is function of exposure, sensitivity, and adaptive capacity of the overall system (Adger, 2006).
- Vulnerable Communities: Vulnerable communities are broadly described as children, the elderly, the sick, the poor, and some communities of color who are susceptible to climate exposure and climate variation (Melillo, 2014:221; Luber, 2009).

BIBLIOGRAPHY

Adams, A. T., Ulrich, M. J., & Coleman, A. (2010). *Food Deserts.* Journal of Applied Social Science, 4(2), 58–62. Retrieved from http://www.jstor.org/stable/23548938

Adger, W. N. (2006). *Vulnerability.* Global Environmental Change, 16(3), 268–281. doi:10.1016/j.gloenvcha.2006.02.006

Agarwal, M., & Tandon, A. (2010). *Modeling of the urban heat island in the form of mesoscale wind and of its effect on air pollution dispersal.* Applied Mathematical Modelling, 34(9), 2520–2530. doi:10.1016/j.apm.2009.11.016

Akbari, H., & Rose, L. S. (2008). *Urban Surfaces and Heat Island Mitigation Potentials.* Journal of the Human-Environment System, 11(2), 85–101. doi:10.1618/jhes.11.85

Allaby, M. (Ed.). (2002). *Heat Island*. In Encyclopedia of Weather and Climate, Rev. ed. (Vol. 1, pp. 269–270). New York: Facts on File. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX4065401233&v=2.1&u=txshracd2598&it=r&p=GVRL&sw=w&asid=d1981009db2016c9a112b516086859e7

Anderson, G. B., & Bell, M. L. (2010). Heat Waves in the United States: Mortality Risk during Heat Waves and Effect Modification by Heat Wave Characteristics in 43 U.S. Communities. *Environmental Health Perspectives*, *119*(2), 210–218. doi:10.1289/ehp.1002313

Association, P. (2014, February 1). *Heat-related deaths will rise 257% by 2050 because of climate change.* The Guardian. Retrieved from http://www.theguardian.com/environment/2014/feb/04/heat-related-deaths-climate-change

Balogh, S. (2007, March 17). *Sceptics fire up against Gore.* The Courier Mail (Australia), p. 48. Retrieved from http://www.lexisnexis.com.ezproxy.lib.utexas.edu/lnacui2api/api/version1/getDocCui?lni=4N8M-4J30-TX5P28H&csi=244788&hl=t&hv=t&hnsd=f&hns=t&hgn=t&oc=00240&perma=true

Barrett, J. R. (2013). *Climate Change Adaptation: Weighing Strategies for Heat-Related Health Challenges.* Environmental Health Perspectives,121(4), a134–a134. doi:10.1289/ehp.121-a134

Bell, M. L., Goldberg, R., Hogrefe, C., Kinney, P. L., Knowlton, K., Lynn, B., … Patz, J. A. (2007). *Climate change, ambient ozone, and health in 50 US cities.* Climatic Change, 82(1-2), 61–76. doi:10.1007/s10584-006-9166-7

Bierbaum, R., Smith, J. B., Lee, A., Blair, M., Carter, L., Iii, F. S. C., … Verduzco, L. (2013). *A comprehensive review of climate adaptation in the United States: more than before, but less than needed.* Mitigation and Adaptation Strategies for Global Change, 18(3), 361–406. doi:10.1007/s11027-012-9423-1

Bondur, V. G. (2011). *Satellite monitoring of wildfires during the anomalous heat wave of 2010 in Russia.* Izvestiya, Atmospheric and Oceanic Physics, 47(9), 1039–1048. doi:10.1134/S0001433811090040

Bouchama, A., & Knochel, J. P. (2002). *Heat Stroke.* New England Journal of Medicine, 346(25), 1978–1988. doi:10.1056/NEJMra011089

Buscail, C., Upegui, E., & Viel, J.-F. (2012). *Mapping heatwave health risk at the community level for public health action.* International Journal of Health Geographics, 11(1), 38. doi:10.1186/1476-072X-11-38

Carmody, K. (2001). *Winds keeping ozone out of Austin.* (2001, August 7). *Austin American-Statesman (Texas)*. Retrieved from http://www.lexisnexis.com.ezproxy.lib.utexas.edu/lnacui2api/api/version1/getDocCui?lni=43P3-F4N0-0094-G4GH&csi=147871&hl=t&hv=t&hnsd=f&hns=t&hgn=t&oc=00240&perma=true

CDC. (2012). *Obesity and Overweight for Professionals: State Programs: Funded: Texas - DNPAO - CDC*. (n.d.). Retrieved February 16, 2014, fromhttp://www.cdc.gov/obesity/stateprograms/fundedstates/texas.html

CDC. (2014). *Heat Stress - NIOSH Workplace Safety and Health Topic.* (n.d.). Retrieved February 22, 2014, from http://www.cdc.gov/niosh/topics/heatstress/

Community Health Planning. (n.d.). Retrieved March 12, 2014, from http://austintexas.gov/healthforum

Clark-Madison M. (2003). *Where the (Early Action) Rubber Meets the (Clean Air) Road*. (n.d.). Retrieved July 31, 2014, from http://www.austinchronicle.com/news/2003-06-27/165625/

Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., … Patterson, C. (2009). *Managing the health effects of climate change: Lancet and University College London Institute for Global Health Commission.* The Lancet, 373(9676), 1693–1733. doi:10.1016/S0140-6736(09)60935-1

Dominguez, F (2014). *Austin's growing population is gentrifying the city's East side and hurting Austinities in the process* - The Daily Texan. (n.d.). Retrieved July 31, 2014, from http://www.dailytexanonline.com/opinion/2014/03/30/austins-growing-population-is-gentrifying-the-citys-east-side-and-hurting

Dunne, J. P., Stouffer, R. J., & John, J. G. (2013). *Reductions in labour capacity from heat stress under climate warming.* Nature Climate Change, 3(6), 563–566. doi:10.1038/nclimate1827

EPA. (2012). (n.d.). *Ground Level Ozone Basic Information. Reviews & Factsheets.* Retrieved February 8, 2014, from http://www.epa.gov/glo/basic.html

Flax, L., Jackson, R., & Stein, D. (2002). *Community Vulnerability Assessment Tool Methodology.* Natural Hazards Review, 3(4), 163–176. doi:10.1061/(ASCE)1527-6988(2002)3:4(163)

Forsberg, B., Bråbäck, L., Keune, H., Kobernus, M., Krauss, M. K. von, Yang, A., & Bartonova, A. (2012). *An expert assessment on climate change and health – with* *a European focus on lungs and allergies.* Environmental Health, 11(Suppl 1), S4. doi:10.1186/1476-069X-11-S1-S4

Fouillet, A., Rey, G., Laurent, F., Pavillon, G., Bellec, S., Guihenneuc-Jouyaux, C., … Hémon, D. (2006). *Excess mortality related to the August 2003 heat wave in France.* International Archives of Occupational and Environmental Health, 80(1), 16–24.

Füssel, H.-M. (2007). *Vulnerability: A generally applicable conceptual framework for climate change research.* Global Environmental Change,17(2), 155–167. doi:10.1016/j.gloenvcha.2006.05.002

Gartland, L. M. (2012). *Heat Islands : Understanding and Mitigating Heat in Urban Areas*. Hoboken: Taylor and Francis.

Gerrard, M. B., & Welton, S. (2014). *US Federal Climate Change Law in Obama's Second Term †.* Transnational Environmental Law, 3(01), 111–125. doi:10.1017/S2047102514000016

Giuliano, G. (2005). *Low Income, Public Transit, and Mobility.* Transportation Research Record: Journal of the Transportation Research Board, 1927(-1), 63–70. doi:10.3141/1927-08

Glaeser, E. L. (2011). *Triumph of the city: how our greatest invention makes us richer, smarter, greener, healthier, and happier*. New York: Penguin Press.

Griffiths, J. (2013). *Improving public health by tackling climate change.* Israel Journal of Health Policy Research, 2, 22. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CA336420385&v=2.1&u=txshracd2598&it=r&p=AONE&sw=w&asid=c9ed88a5a88e90668398a974ac58623e

Guthman, J. (2013). *Too much food and too little sidewalk? Problematizing the obesogenic environment thesis.* Environment and Planning A, 45(1), 142 – 158. doi:10.1068/a45130

Green, A. R. (2010, March 25). *FINANCE: IMF Proposes 100-Billion-Dollar Climate Fund.* IPS - Inter Press Service. Montevideo, United States. Retrieved fromhttp://search.proquest.com.ezproxy.lib.utexas.edu/docview/192361775

Hadad, E. (2012) *Heat Stroke - Springer.* (n.d.). Retrieved fromhttp://link.springer.com.ezproxy.lib.utexas.edu/article/10.2165%2F00007256-200434080-00002/fulltext.html

Hajat, S., Vardoulakis, S., Heaviside, C., & Eggen, B. (2014). *Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s.* Journal of Epidemiology and Community Health, jech–2013–202449. doi:10.1136/jech-2013-202449

Hall, P. (1988). *Cities of tomorrow: an Intellectual History of City Planning in the Twentieth Century*. Oxford, UK ; New York, NY, USA: Blackwell.

Harris, L. M., Matthews, L. R., Penrose-Wall, J., Alam, A., & Jaworski, A. (2014). *Perspectives on barriers to employment for job seekers with mental illness and additional substance-use problems.* Health & Social Care in the Community, 22(1), 67–77. doi:10.1111/hsc.12062

Harlan, S. L., Brazel, A. J., Prashad, L., Stefanov, W. L., & Larsen, L. (2006). *Neighborhood Microclimates and Vulnerability to Heat Stress.* Social Science & Medicine, 63(11), 2847–2863. doi:10.1016/j.socscimed.2006.07.030

Heat-related illnesses, deaths, and risk factors—cincinnati and dayton, ohio, 1999, and united states, 1979-1997. (2000). JAMA, 284(1), 34–35. doi:10.1001/jama.284.1.34

Hendrix, C. S., & Glaser, S. M. (2007). *Trends and triggers: Climate, climate change and civil conflict in Sub-Saharan Africa.* Political Geography, 26(6), 695–715. doi:10.1016/j.polgeo.2007.06.006

Hess, J. J., Malilay, J. N., & Parkinson, A. J. (2008). *Climate Change: The Importance of Place.* American Journal of Preventive Medicine, 35(5), 468–478. doi:10.1016/j.amepre.2008.08.024

Hess, J. J., McDowell, J. Z., & Luber, G. (2012). *Integrating Climate Change Adaptation into Public Health Practice: Using Adaptive Management to Increase Adaptive Capacity and Build Resilience.* Environmental Health Perspectives, 120(2), 171–179. doi:10.1289/ehp.1103515

Hurtado-de-Mendoza, A., Gonzales, F. A., Serrano, A., & Kaltman, S. (2014). *Social Isolation and Perceived Barriers to Establishing Social Networks Among Latina Immigrants.* American Journal of Community Psychology, 53(1-2), 73–82. doi:10.1007/s10464-013-9619-x

Jeffers, G. (2009 12–17). *Texas Gov. Rick Perry takes jab at ex-ally Al Gore on climate change*. Retrieved June 7, 2014, from http://www.dallasnews.com/news/politics/texas-legislature/headlines/20091217-Texas-Gov-Rick-Perry-takes-6477.ece

Johnson, D. P., & Wilson, J. S. (2009). The socio-spatial dynamics of extreme urban heat events: The case of heat-related deaths in Philadelphia. *Applied Geography*, *29*(3), 419–434. doi:10.1016/j.apgeog.2008.11.004

Kahn, M. E. (2010). *Climatopolis: How Our Cities Will Thrive in the Hotter Future*. Basic Books.

Kovats, R. S., & Hajat, S. (2008). Heat Stress and Public Health: A Critical Review. *Annual Review of Public Health*, *29*(1), 41–55. doi:10.1146/annurev.publhealth.29.020907.090843

Krause, R. M. (2012). *An Assessment of the Impact that Participation in Local Climate Networks Has on Cities' Implementation of Climate, Energy, and Transportation Policies.* Review of Policy Research, 29(5), 585–604. doi:10.1111/j.1541-1338.2012.00582.x

Kuehn BM. (2010). *CDC targets climate change.* JAMA, 304(20), 2232–2232. doi:10.1001/jama.2010.1684

Ki-moon, B. (2013) *The Secretary- General's Five-Year Action Plan. United Nations Secretary-General Ban.* (n.d.). Retrieved November 17, 2013, from http://www.un.org/sg/priorities/index.shtml

Klinenberg, E. (2002). *Heat wave: a social autopsy of disaster in Chicago*. Chicago: University of Chicago Press.

Koetse, M. J., & Rietveld, P. (2009). *The Impact of Climate Change and Weather on Transport: An Overview of Empirical Findings.* Transportation Research Part D: Transport and Environment, 14(3), 205–221. doi:10.1016/j.trd.2008.12.004

Künzli, N. (2010). *Climate changes health.* International Journal of Public Health, 55(2), 77–78. doi:10.1007/s00038-010-0123-x

Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., & Rosenthal, S. (2014) *Climate change in the American mind: April, 2014.* Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication.

Leiserowitz, A. A. (2005). *American Risk Perceptions: Is Climate Change Dangerous? Risk Analysis, 25*(6), 1433–1442. doi:10.1111/j.1540-6261.2005.00690.x

Luber, G., & Prudent, N. (2009). *Climate Change and Human Health.* Transactions of the American Clinical and Climatological Association,120, 113–117. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2744549/

Obesity and Overweight for Professionals: State Programs: Funded: Texas - DNPAO - CDC. (n.d.). Retrieved February 16, 2014, from http://www.cdc.gov/obesity/stateprograms/fundedstates/texas.html

Martens, P. (2014). *Health and Climate Change: Modelling the impacts of global warming and ozone depletion*. Hoboken: Taylor and Francis.

Mashhood, F. (2011) *City of Austin created emergency heat plan after 2009 heat wave*. (n.d.). American Statesman, printed Wednesday, Aug. 10, 2011. Retrieved July 30, 2014, from http://www.statesman.com/news/news/local/city-of-austin-created-emergency-heat-plan-after-2/nRdP7/

Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., (2014). *Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program,* 841 pp. doi:10.7930/J0Z31WJ2.

Measham, T. G., Preston, B. L., Smith, T. F., Brooke, C., Gorddard, R., Withycombe, G., & Morrison, C. (2011). *Adapting to climate change through local municipal planning: barriers and challenges.* Mitigation and Adaptation Strategies for Global Change, 16(8), 889–909. doi:10.1007/s11027-011-9301-2

NACCHO, (2012). *Community Health Assessments and Community Health Improvement Plans for Accreditation Preparation Demonstration Sites*. Retrieved

July 27, 2014, from: http://www.naccho.org/topics/infrastructure/chachip/accreditation-demo-sites.cfm

National Research Council, (U.S.). (2002). *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards.* Washington, D.C.: National Academy Press.

Neighmond, P. (n.d.). *Taking The Pulse Of Latino Health Concerns.* NPR.org. Retrieved January 21, 2014, from http://www.npr.org/blogs/health/2014/01/21/263505386/taking-the-pulse-of-latino-health-concerns

NWS Office of Climate, W. and W. S. (n.d.). *NWS Office of Climate, Weather and Water Services*. Retrieved February 17, 2014, from http://www.nws.noaa.gov/om/hazstats.shtml

O'Neill, Marie S., Carter, Rebecca, Kish, Jonathan K., Gronlund, Carina J., White-Newsome, Jalonne L., Manarolla, Xico, Zanobetti, Antonella, Schwartz, Joel D. (2009). *Preventing heat-related morbidity and mortality: New approaches in a changing climate.* Maturitas, *64*(2), 98–103. doi:10.1016/j.maturitas.2009.08.005

Ozone - Environments Air Contaminants - CDC Tracking Network. (n.d.). Retrieved February 9, 2014, from http://ephtracking.cdc.gov/showAirContaminants.action

Patz, J. A., McGeehin, M. A., Bernard, S. M., Ebi, K. L., Epstein, P. R., Grambsch, A., … Trtanj, J. (2000). *The potential health impacts of climate variability and change for the United States: executive summary of the thesis of the health sector of the*

U.S. National Assessment. Environmental Health Perspectives, 108(4), 367–376. Retrieved fromhttp://www.ncbi.nlm.nih.gov/pmc/articles/PMC1638004/

Pierce, D. W., Barnett, T. P., Santer, B. D., & Gleckler, P. J. (2009). *Selecting global climate models for regional climate change studies*. Proceedings of the National Academy of Sciences of the United States of America, 106(21), 8441–8446. doi:10.1073/pnas.0900094106

Pinkerton, K. E., & Rom, W. N. (2013). *Global Climate Change and Public Health* (1st ed.). Dordrecht: Springer.

Pope, C. (2014). *How many people move to Austin a day? Here's the official number.* (n.d.).Austin Business Journal. Retrieved March 13, 2014, from http://www.bizjournals.com/austin/blog/at-the-watercooler/2014/02/how-many-people-move-to-austin-a-day-heres-the.html

Posas, P. J. (2011). *Climate Change in Development Bank Country Environmental Analyses.* Journal of Environmental Assessment Policy & Management, 13(3), 459–481. Retrieved from http://ezproxy.lib.utexas.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bah&AN=66798596&site=ehost-live

Rappaport, S. (2014). *Meet the world's first chief resilience officer: Patrick Otellini*. GreenBiz.com. Published April 16, 2014. Retrieved July 30, 2014, from http://www.greenbiz.com/blog/2014/04/16/first-chief-resilience-officer-CRO-SF-patrick-otellini

Richardson, K. (2011). *Climate Change: Global Risks, Challenges and Decisions*. Cambridge: Cambridge University Press.

Robertson, I., & Cooper, C. L. (2013). *Resilience*. Stress and Health, 29(3), 175–176. doi:10.1002/smi.2512

Sanchez, T. W. (2008). *Poverty, policy, and public transportation.* Transportation Research Part A: Policy and Practice, 42(5), 833–841. doi:10.1016/j.tra.2008.01.011

Saneinejad, S., Moonen, P., & Carmeliet, J. (2014). *Comparative assessment of various heat island mitigation measures.* Building and Environment, 73, 162–170. doi:10.1016/j.buildenv.2013.12.013

Schuff, S. (2010, February 1). *Cap-and-trade fading? Feedstuffs*, 82(5), 2. Retrieved from: http://go.galegroup.com/ps/i.do?id=GALE%7CA218449838&v=2.1&u=txshracd2598&it=r&p=AONE&sw=w&asid=d3e1ae9e201d2ba4900791aca1696fce

Schmid, R.E. (2014). *Hot nights can compound danger from heat waves*. (n.d.).Lubbock Online | Lubbock Avalanche-Journal. Associated Press. Retrieved July 25, 2014, from http://lubbockonline.com/national-news/2011-07-22/hot-nights-can-compound-danger-heat-waves

Scutchfield, F. D., Hall, L., & Ireson, C. L. (2006). *The public and public health organizations: Issues for community engagement in public health.* Health Policy, 77(1), 76–85. doi:10.1016/j.healthpol.2005.07.021

Smoyer-Tomic, K. E., Kuhn, R., & Hudson, A. (2003). Heat Wave Hazards: An Overview of Heat Wave Impacts in Canada. *Natural Hazards*, *28*(2-3), 465–486. doi:10.1023/A:1022946528157

Tillett, T. (2011). *Heat Effects Are Unique: Mortality Risk Depends on Heat Wave, Community Characteristics.* Environmental Health Perspectives, 119(2), a81–a81. doi:10.1289/ehp.119-a81

Tonn, B. (2007). *The Intergovernmental Panel on Climate Change: A global scale transformative initiative.* Futures, 39(5), 614–618. doi:10.1016/j.futures.2006.10.010

Turner, L. R., Alderman, K., Connell, D., & Tong, S. (2013). *Motivators and Barriers to Incorporating Climate Change-Related Health Risks in Environmental Health Impact Assessment.* International Journal of Environmental Research and Public Health, 10(3), 1139–1151. doi:10.3390/ijerph10031139

Uejio, C. K., Wilhelmi, O. V., Golden, J. S., Mills, D. M., Gulino, S. P., & Samenow, J. P. (2011). *Intra-urban societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability.* Health & Place, 17(2), 498–507. doi:10.1016/j.healthplace.2010.12.005

Van Aalst, M. K., Cannon, T., & Burton, I. (2008). *Community level adaptation to climate change: The potential role of participatory community risk assessment.* Global Environmental Change, 18(1), 165–179. doi:10.1016/j.gloenvcha.2007.06.002

Wamsler, C., Brink, E., & Rivera, C. (2013). *Planning for climate change in urban areas: from theory to practice.* Journal of Cleaner Production, *50*, 68–81. doi:10.1016/j.jclepro.2012.12.008

Wang, L., Gu, M., & Li, H. (2012). Influence path and effect of climate change on geopolitical pattern. Journal of Geographical Sciences, 22(6), 1117–1130. doi:10.1007/s11442-012-0986-2

Weinhold, B. (2008). *Ozone Nation EPA Standard Panned by the People.* Environmental Health Perspectives, 116(7), A302–A305. Retrieved from http://www.jstor.org/stable/25071084

Weinhold, B. (2010). EPA's ground-level ozone standard redux.*Environmental Health Perspectives*, *118*(3), A115. Retrieved fromhttp://go.galegroup.com/ps/i.do?id=GALE%7CA222476912&v=2.1&u=txshracd2598&it=r&p=AONE&sw=w&asid=e185724eb12470f797ed720904406e7c

WHO | World Health Organization. (n.d.). *WHO*. Retrieved November 17, 2013, fromhttp://www.who.int/globalchange/en/

Vita

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As an Environmental Programs Coordinator with the Office of Sustainability, Marc helped create the Austin Green Business Leaders, the local carbon offsets challenge grant and helps imbed climate resilience into city operations. Marc holds a degree in Urban Planning from Arizona State University and is a LEED Accredited Professional and a Envision™ Sustainability Professional.

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