APRIL 2022

ADDRESSING EXTREME HEAT IN SPOKANE, WA

OWEN HART
MASTERS OF PUBLIC POLICY CANDIDATE
UNIVERSITY OF VIRGINIA

UVA | FRANK BATTEN SCHOOL *of* LEADERSHIP *and* PUBLIC POLICY

Acknowledgements

Special thanks to Kara Odegard and the Sustainability Action Subcommittee for the opportunity to take on this project and the guidance to see it across the finish line, to Sarah Nuss for her willingness to share her perspective and knowledge, and to Professors Kirsten Gelsdorf and Craig Volden for their invaluable advising and kind words throughout this process.

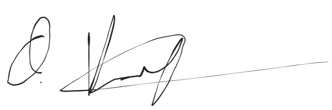
I don't think I could have gotten through my time at Batten let alone this project without the companionship of a truly amazing group of friends. Global pandemics have nothing on us! Thank you to E – truly, madly, and deeply. Finally, thank you to Brad and Michele Hart for always making me feel so loved and supported, now and always. **This is for you guys.**

Disclaimer

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, by the City of Spokane, or by any other agency.

Honor Pledge

On my honor as a University of Virginia student, I have neither given nor received unauthorized aid on this assignment.



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EXECUTIVE SUMMARY

The following report seeks to provide an overview of extreme heat as a public policy issue in Spokane, Washington. Extreme heat is projected to become one of the most significant climate-related threats facing the Spokane community in the coming years. Topics discussed include the historical trends in extreme heat events in the greater Spokane region, projected increases in the frequency and severity of extreme heat events on account of climate change, and the various costs associated with these trends that may impact current and future Spokane residents.

An extensive review of literature covering best practices on extreme heat adaptation and mitigation is also provided, accompanied by a discussion of which approaches are best suited to Spokane's climate and characteristics. From this discussion, the report identifies and assesses three potential policy alternatives to address the threat posed by extreme heat to the members of the Spokane community. These policies will be compared to Spokane's current emergency response protocol to extreme heat events, referred to as the status quo. The policy alternatives are as follows.

Developing a:
(1) Spokane Extreme Heat Action Plan
(2) Air Conditioning Voucher Pilot Program, and
(3) Cool Streets Pilot Program.

Each policy alternative is systematically analyzed according to its performance on four key evaluative criteria:

(1) effectiveness,
(2) equity,
(3) cost, and
(4) political feasibility

These criteria were selected to ultimately generate a policy recommendation that most closely aligns with the values and objectives of the Spokane City Council's policy team. The performance of each policy alternative is evaluated and assigned a score signifying the alternative's performance on each criterion. These scores are then compiled in an outcomes matrix for easy comparison. After extensive analysis, the performance of policy alternative 1 – implementing the Spokane Extreme Heat Action Plan – has been assessed to have the highest performance and is subsequently put forward for recommendation. The report concludes with a series of additional guidelines for the enactment, implementation, and evaluation of the Extreme Heat Action Plan.

INTRODUCTION

The devastating heat wave that struck the Pacific Northwest from late June to mid-July 2021 came as an utter shock to the region's inhabitants. Over thirteen days, the region experienced sustained temperatures in the triple digits, shattering records across the Northwest. In Spokane, temperatures climbed as high as 109°F on June 29, the highest temperature recorded since collection began in 1881 (Epperly and Brown, 2021). Most sobering was the incredible number of human lives lost during the heat wave. The Washington State Department of Health reported that 100 people died from heat-related causes between June 26 and July 2, including 21 fatalities in Spokane County alone (Washington State Department of Health, 2021). Retrospective analysis from an international consortium of climate scientists classified the heat wave as a 1,000-year weather event but found that the heat wave was made 150 times more likely due to the effects of climate change (Philip et al., 2021). Given the current trajectory of global emissions, such extreme heat waves are projected to occur in the Western United States every five to ten years by mid-century (Philip et al., 2021).

Extreme heat is already the greatest cause of weather-related death in the United States (Union of Concerned Scientists, 2018). Despite the significant risk to public health that extreme heat poses, most residents of the Inland Northwest, a region more known for its winters than its historically temperate summers, have not conceived of heat as a major cause for concern. The suffering wrought by the 2021 heat wave has highlighted the need to shift this perception. To adequately prepare the community for the threat posed by future heat waves, Spokane's leaders must develop a comprehensive strategy to develop resiliency among residents who bear the greatest risk from extreme heat. Many city residents lack the resources necessary to cope with extreme heat, leaving them highly vulnerable to future heat waves. Given that the rise in extreme heat is among the most severe manifestations of climate change in Spokane, developing such an approach should be seen as integral to the City's approach to climate action.

Problem Statement

Mean annual temperatures in Spokane are projected to increase by roughly 5°F over the next three decades. This trend will be accompanied by a stark upsurge in the frequency and intensity of heat waves. Extreme heat will soon become a major threat to Spokane, negatively impacting economic productivity, energy demand, and health outcomes for Spokane residents. Spokane's low-income and minority communities bear the greatest burden imposed by extreme heat due to a critical lack of resources and disproportionate exposure to harmful air pollution, exacerbating existing inequities between Spokane's residents as the impacts of climate change become more apparent.

Client Profile: Sustainability Action Subcommittee

Unlike many climate-related threats, extreme heat impacts Spokane residents today, and the city faces increasing pressure to engage in extreme heat mitigation efforts as soon as possible. Ignoring the threat of extreme heat will not only reduce long-term quality of life for Spokane residents but also leave the community vulnerable to a growing public health risk. The Spokane City Council has identified climate adaptation as a central pillar of Spokane's long-term urban planning strategy. However, these efforts have been primarily focused on achieving emissions reductions and transitioning the city's energy mix to renewable sources. The City Council of Spokane created the Sustainability Action Subcommittee in early 2019 in order to focus on issues surrounding climate change and its effects on Spokane and the region. SAS is tasked to research solutions the City and its residents can take to both mitigate Spokane's contribution to climate change and help make the community more resilient in the face of these changes.

These objectives were laid out in the most recent draft of the Sustainability Action Plan from the City Council's Sustainability Action Subcommittee (Spokane City Council Sustainability Action Subcommittee, 2021). To achieve Spokane's climate goals, the City Council may adopt policies that prioritize extreme heat adaptation through crafting legislation and its jurisdiction over the annual budget. The primary objective of this project is to provide a summary of existing research on extreme heat adaptation and to provide policy recommendations that the Sustainability Action Subcommittee and City Council can use to guide future policymaking on extreme heat in Spokane.

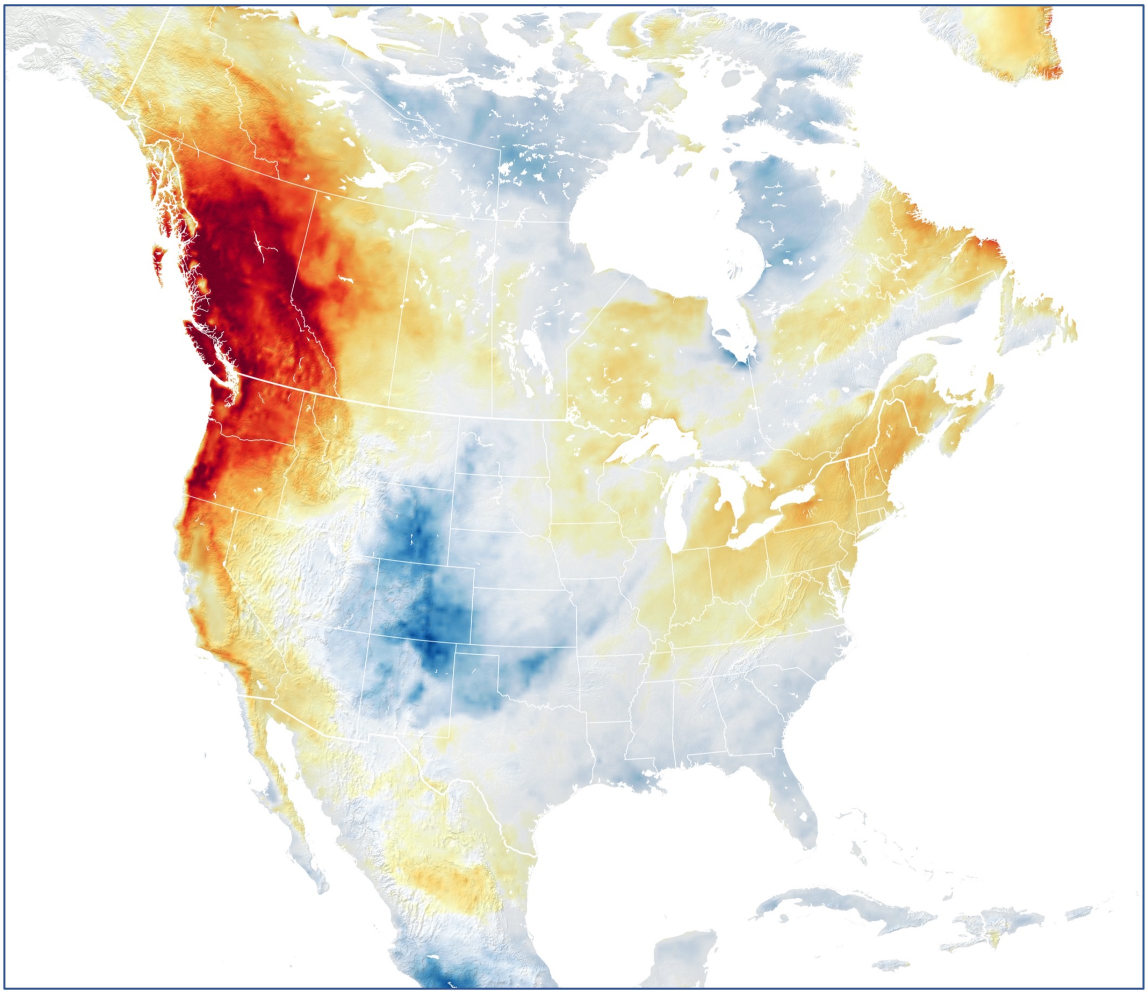

Figure 1: Land Surface Temperatures during the 2021 Heat Wave - June 29, 2021
Red coloration denotes the degree to which temperatures exceed historical daily average.
Source: National Aeronautics and Space Administration

Background

The following section will provide a general overview of extreme heat, including its causes, associated costs, and how it is projected to impact the greater Spokane region in the coming decades. Additional discussion focuses on the role the Spokane City Council plays in addressing this problem, as well as equity considerations concerning how risks posed by extreme heat manifest in Spokane.

Climate Change and Extreme Heat Events in Spokane

Defining Extreme Heat

An extreme heat event can be defined as a prolonged period of high heat in which temperatures and humidity far exceed local averages for a sustained amount of time. Temperature alone cannot be used to assess extreme heat, as the exact specifications that constitute an extreme heat event vary based on the climate conditions of a particular locality, including average temperature, humidity, and cloud cover (EPA, 2016). The National Oceanic and Atmospheric Administration (NOAA) Heat Index can be used to assess the threat to public health posed by extreme heat events (EPA, 2016). The heat index value represents how hot a given temperature actually feels when factoring in humidity, providing a more realistic understanding of the threat posed by a given climatic condition to public health. As the heat index value increases, residents are far more likely to experience debilitating and potentially fatal heat-related illnesses. Given Spokane's climatic norms, the Spokane Climate Project defines extreme heat events as prolonged periods where temperatures exceed 90°F. During the hottest months of the year, relative humidity averages around 30% (Pacific Northwest Climate Impacts Research Consortium, 2021). The National Weather Service issues Heat Advisory warnings, denoting periods where the public health risk of heat-related illness is high when temperatures exceed 95°F in the region (Pacific Northwest Climate Impacts Research Consortium, 2021).

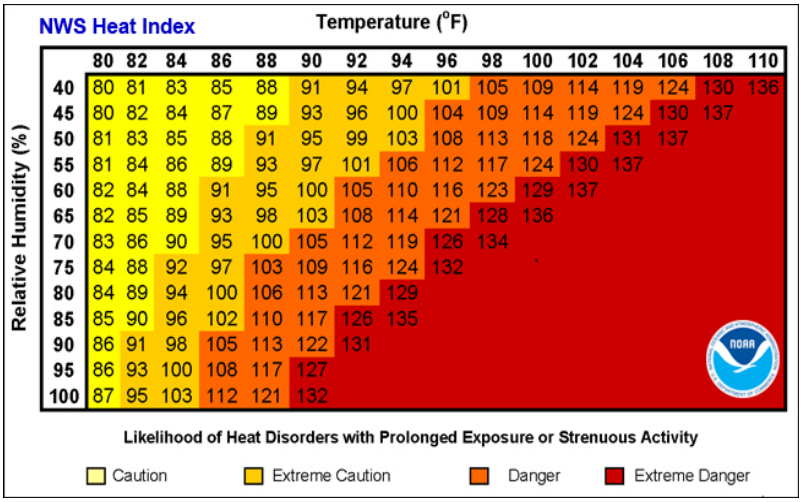

Figure 2: The National Weather Service's Heat Index
Source: National Oceanic and Atmospheric Administration

Projecting Extreme Heat in the Greater Spokane Region

Forecasting how Spokane's climate will change in the coming years is dependent on the degree to which global greenhouse gas emissions can be mitigated (Union of Concerned Scientists, 2018). Climate projections under a low-emissions and a high-emissions scenario, the latter of which includes the current global emissions trajectory, both suggest that Spokane will experience significant warming over the decades to come. By 2050, average annual temperatures in Spokane will increase by roughly 4.5°F and 6°F above late-twentieth-century averages. This warming will be particularly intense in the summer, including a gradual increase in the number of days when temperatures exceed 90°F, 100°F, and 105 °F. Current warming trends suggest that Spokane's hottest summer day will attain temperatures around 106 °F by mid-century and 111 °F in the century's last decades (Pacific Northwest Climate Impacts Research Consortium, 2021).

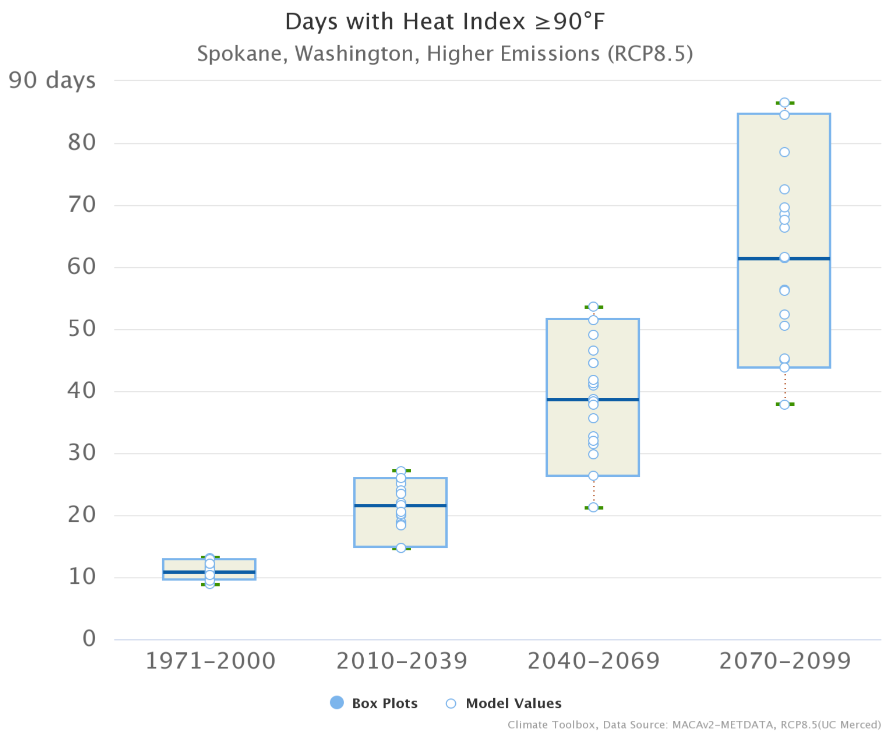

Figure 3: Climate projections show an exponential increase in the number of high heat index days in coming years. Dots indicate projected yearly averages. Blue center lines in box plots indicate average for period. Source: Pacific Northwest Climate Impacts Research Consortium, 2021

While climate change is the primary catalyst for increasing incidences of extreme heat events, local geographic factors and the built environment also contribute to extreme heat. Heavier urban development is correlated with a higher concentration of paved surfaces (Akbari et al., 2001). These surfaces, including roofs, streets, and parking lots, trap heat and raise ambient air temperatures at street level. This effect is pronounced at night, as paved surfaces can continue to radiate heat into the surroundings long after sundown. Extreme heat is also exacerbated by the geographic characteristics of the region. Spokane is located at the confluence of two valleys. The ridges of these valleys create a temperature inversion over the city, raising temperatures while also trapping in air pollution, particularly when air is stagnant (Spokane Regional Clean Air Agency, 2020). Extreme heat can also interact with airborne pollutants to create harmful toxins, particularly surface ozone, which can negatively impact public health in the region. (Peterson et al., 2013). Evidence has also supported a strong connection between extreme heat and wildfires (Sun et al., 2019). Periods of high heat understandably increase the risk of wildfire outbreaks, a phenomenon of particular concern to Spokane, a city surrounded by extensive forests. The connection between extreme heat and wildfires is discussed in greater detail below.

The Costs of Extreme Heat

Public Health Outcomes

Extreme heat is the leading cause of weather-related mortality in the United States (Union of Concerned Scientists, 2018), causing roughly 65,000 emergency room visits and 670 deaths every year (Kumar, 2018). However, because heat often kills by aggravating existing health conditions, heat-related mortality is rarely attributed to extreme heat, meaning the true number of heat-related deaths is likely much higher. Conditions that are linked to extreme heat are known as heat stress-related illnesses (HSIs). The most serious of these is heat stroke, which occurs when the body becomes unable to regulate its internal temperature after prolonged exposure to heat (CDC, 2021). Other common HSI conditions include heat exhaustion, rhabdomyolysis, and heat syncope (CDC, 2021). In turn, exposure to extreme heat may also trigger the onset of a range of other serious conditions, most notably organ failure and cardiac arrest (Fetchter-Legget et al., 2016). An extensive body of literature has connected a range of characteristics to ones' likelihood of experiencing a form of HSI during extreme heat events. The burden of extreme heat is asymmetrically felt across society, with the most risk experienced by low-income households, the young and old – particularly those living alone, those without health insurance, and those with preexisting chronic medical conditions. (Balbus and Malina, 2009; Wolf and McGregor, 2013; Joe et al, 2016; Schramm, 2021).

Increased Wildfire Risk and Air Pollution

A simultaneous rise in the frequency and severity of heat waves, compounded by a longer fire season, presents a potent dual-threat for local policymakers and emergency management personnel (Pacific Northwest Climate Impacts Research Consortium, 2021). As Spokane is surrounded by national forests where wildfires are a natural feature of the ecosystem, Spokane's residents are no strangers to the impact of wildfires. Climate change is predicted to bring rainier springs and drier summers to the region. This catalyzes brush growth in the spring, which dries out in the summer, creating the perfect tinder for wildfires. Increased incidences of extreme heat will also contribute to more frequent and larger wildfires. In turn, the Inland Northwest's fire season is projected to lengthen as average monthly temperatures increase across the board (Pacific Northwest Climate Impacts Research Consortium, 2021). More intense and frequent fires will lead to longer periods of poor air quality in Spokane, primarily during months when temperatures are highest. This greatly increases public health risks during periods of extreme heat and can act as a one-two punch for Heat Vulnerable Populations. Many households in Spokane often do not have access to air conditioning and leave windows open in their homes to cope with the heat. This may contribute to negative health outcomes for low-income residents, particularly during periods of poor air quality (Environmental Protection Agency, 2018).

Fiscal Costs

According to a recently published report from the Atlantic Council, the US economy loses $100 billion a year in lost economic productivity due to extreme heat. These losses will be felt most strongly in the agricultural and construction sectors, where most work is performed outside unprotected from the sun's rays. If current climate trends continue, total losses are projected to reach $500 billion by 2050 (Atlantic Council, 2021). As extreme heat events become more common in Spokane, businesses will suffer lost labor productivity due to employees suffering heat-related illnesses and more frequent workplace injuries. A recent study from UCLA Luskin School of Public Affairs found that higher temperatures increase the likelihood of injuries on the job, particularly among construction and agriculture workers. In California alone, extreme heat causes roughly 20,000 workplace incidents per year (Park, et al., 2021). Lost labor productivity will also lead to reduced tax income for the City.

The growing number of extreme heat events will lead to increased energy demand (Santamouris et al., 2020). Extreme heat also poses a series of long-term economic costs to households. Studies have estimated that roughly 20% of the nation's energy used for air conditioning can be reduced by adopting strategies for extreme heat adaptation (Akbari et al., 2001). Increases in incidences of heat-related illnesses will also contribute to higher medical bills, a cost category that disproportionately impacts low-income households. Instituting heat mitigation measures can bring about significant cost savings for municipal governments, although the magnitude of these savings varies based on geographic location. In turn, pursuing these strategies has been associated with a series of positive spillover effects, including improvements to air quality and real estate values (Akbari et al., 2001).

Equity Implications of Extreme Heat

Extreme heat in Spokane has a disproportionate impact on low-income communities within the city. A study of community-level adaptive capacity to extreme heat in Houston, Texas, determined, "nonhomeowners, African Americans and Latinos, those with incomes less than $30,000 a year, those unemployed, and those in poor health to be most vulnerable to heat stress" (Hayden et al., 2017). The uneven impact of extreme heat experienced by these vulnerable populations is often due to the presence of urban heat islands in these communities. Urban heat islands are localities within cities that experience considerably hotter average temperatures than neighboring areas. Urban heat islands are formed when aspects of the built environment, such as roofing and paved surfaces, absorb the sun's heat and increase local temperatures. Human activity can also contribute to the formation of urban heat islands. Emissions from industrial sites, vehicles, and residences can form a layer of pollutants that blanket entire metropolitan regions, trapping in heat that would normally be reflected into the atmosphere. The compounding impact of these factors on local temperature is known as the "heat island effect" (Hoffman et al., 2020).

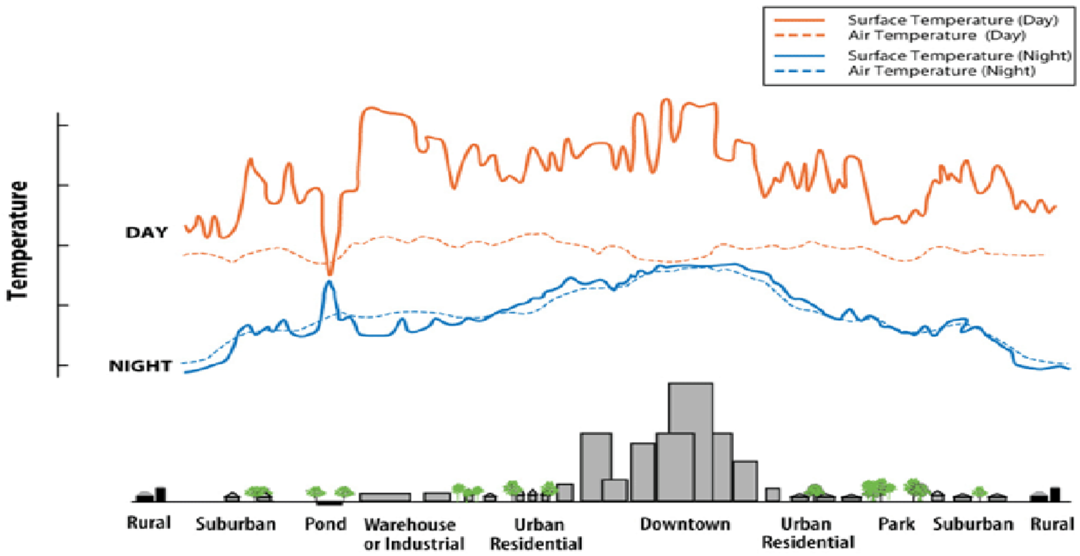

Figure 4 - Diagram of the Urban Heat Island Effect
Source: Environmental Protection Agency

Figure 4 details how the urban heat island effect impacts temperatures in urban environments. Localities with a greater concentration of paved surfaces and emissions experience higher average temperatures at street level than areas with less development. This temperature differential is most pronounced at night. Low-income communities are more likely to be situated within a heat island, often experiencing temperatures as much as 15 °F as nearby wealthier neighborhoods at the same time (Hoffman et al., 2020). In Spokane, most of the city's urban heat islands are concentrated in the north along the Highway 2 Corridor and the east into Spokane Valley. Residents of these areas are also some of the city's poorest. Mitigating urban heat islands in Spokane and beyond may have positive benefits in closing gaps in income inequality experienced by vulnerable communities.

Mapping Spokane's Heat Vulnerable Communities

As previously discussed, heat does not impact city residents equally. Some experience far greater negative impacts than others. To maximize the effectiveness of the city's efforts to build resilience, policymakers must first understand which communities are most vulnerable to the public health impacts of heat waves.

Heat Vulnerable Communities (HVCs)

Heat Vulnerable Communities (HVCs) are neighborhoods that have an above-average concentration of residents whose traits make them physically vulnerable during extreme heat events. These individuals are far more likely to experience heat stress-related illness and other health complications during heat waves.

Individuals at highest risk during extreme heat events include those:

- Living with a preexisting disability
- 65 years and older
- Without health insurance
- Living alone
- Living in poverty

Because the presence of these characteristics is higher among minority households, minority populations bear a disproportionate share of heat-related illnesses and death in the United States (Vaidyanathan et al., 2020). Racial inequities in exposure to the impacts of extreme heat are rooted in a long legacy of systemic racism that has resulted in chronic underinvestment in minority communities. In turn, the unhoused members of Spokane's community are understandably highly vulnerable to heat waves. Using census tract-level data from the Washington State Department of Health, the incidence of these characteristics can be identified and mapped to understand which Spokane neighborhoods can be classified as Heat Vulnerable Communities.

% of People Age 19-64 Without Health Insurance **% Of Population in Poverty**

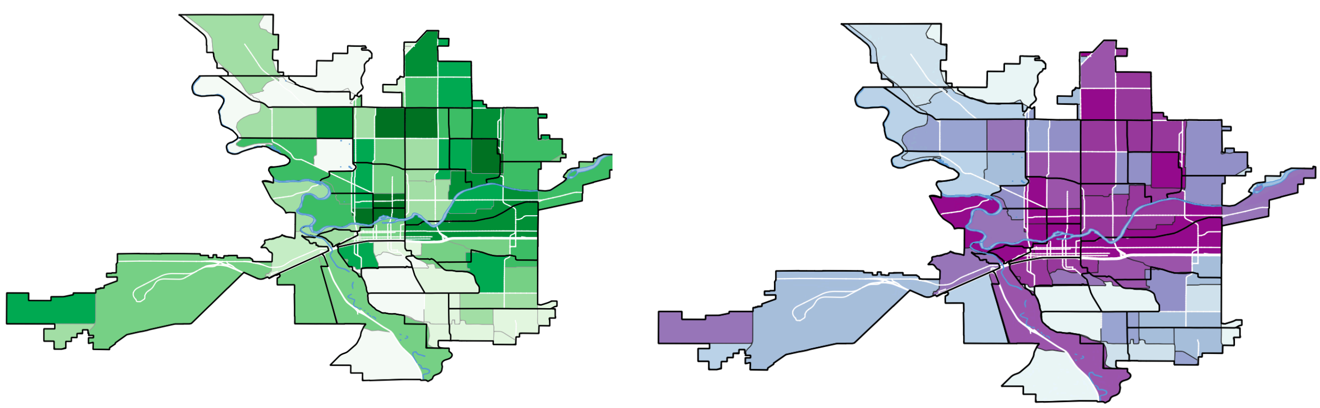

Figure 6: Maps of Demographic Metrics in Spokane. Darker colors indicate a higher concentration of the particular metric.
Source: Constructed by author based on data from Washington State Department of Health

Heat Vulnerability Index (HVI)

To identify Spokane's HVCs, this analysis constructed a Heat Vulnerability Index, which compiles factors that influence vulnerability to heat to assess a community's capacity to cope during heat waves. This approach draws from methodologies used to create similar HVIs for London, UK, Pittsburgh, Pennsylvania, and New York State (Wolf and McGregor, 2012; Bradford et al., 2015; Nayak et al., 2018). The Spokane HVI was constructed makes use of census-tract level data from the Washington State Department of Health's Washington Tracking Network, a comprehensive database of environmental health metrics.

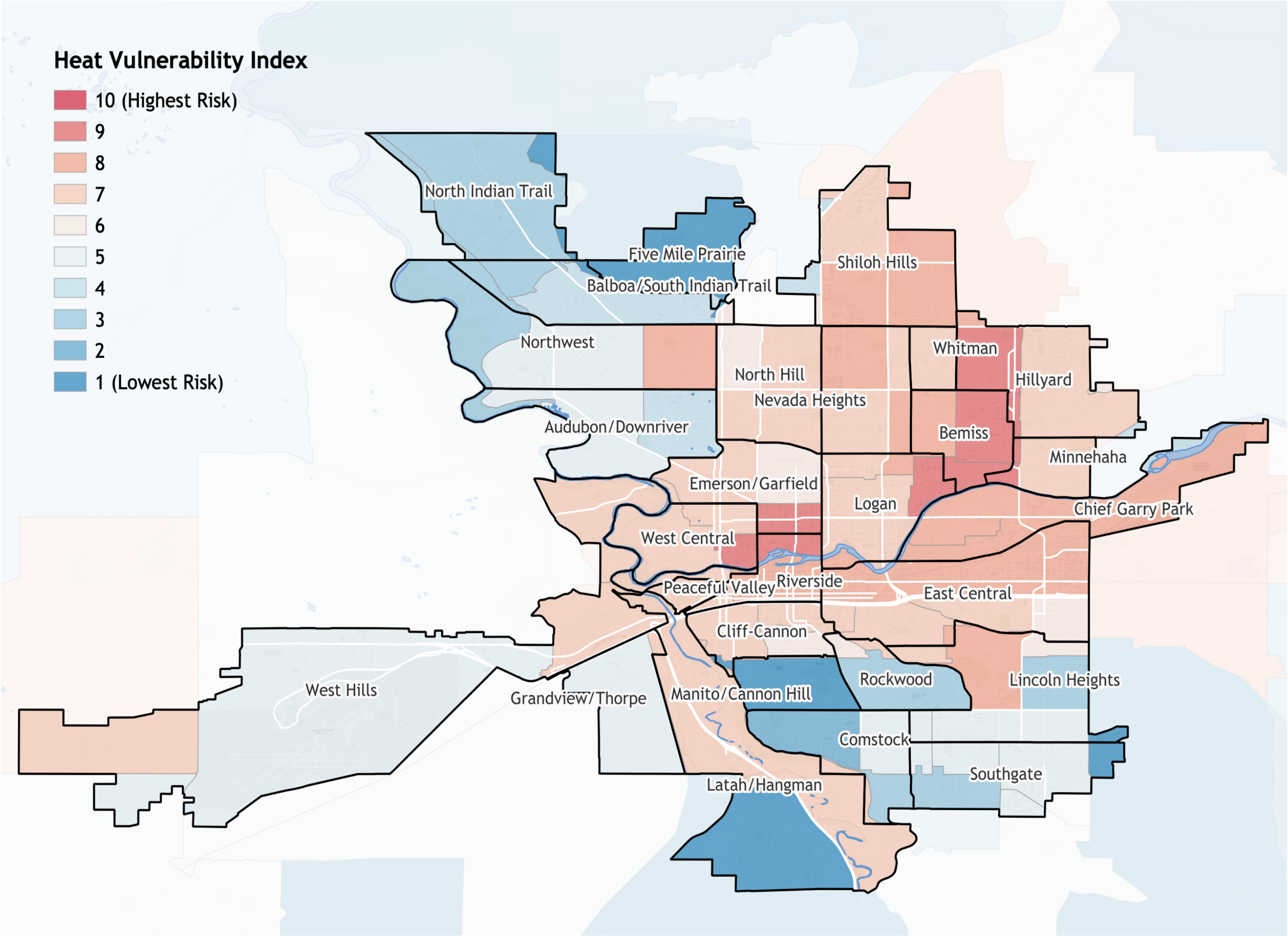

Figure 5: Map of Spokane's Heat Vulnerability Index with Spokane's neighborhood boundaries. Source: Constructed by author based on data from Washington State Department of Health

The above map conveys that Spokane's HVCs are concentrated most strongly in two areas main areas. One straddles the western areas of downtown and stretches across the north bank of the Spokane River. A larger group of HVCs are concentrated in northeast Spokane's Bemiss, Whitman and Hillyard neighborhoods. Analysis reveals that communities with high HVI scores are also among Spokane's poorest. Residents in neighborhoods that are classified as HVCs bear the greatest cost imposed by heat waves. This means they also require the greatest investment from the City to build their resilience to extreme heat. City policymakers should strive to prioritize these communities when deciding on where and how to implement strategies to address extreme heat.

BEST PRACTICES FOR EXTREME HEAT ADAPTATION: SURVEY OF EXISTING LITERATURE

The following section provides an analysis of existing literature on extreme heat adaptation at the local level and identifies four policy strategies that have either already been established as best practice in other cities or have yet to be implemented at scale but are supported by a large body of research. While the characteristics and underlying causes of extreme heat are a matter of consensus among the academic community, there is a significant amount of disagreement over which policy solutions are best suited to mitigate extreme heat in urban environments. This debate is further complicated by the sheer geographic variety of the problem. Approaches to extreme heat that have been shown to work in arid cities such as Phoenix or Las Vegas may be ineffectual or impractical in humid, coastal metropolises such as Houston or Miami, and vice versa. Adaptive capacity to extreme heat may also differ at the national, regional, and local levels (O'Brien et al., 2006). In turn, a handful of studies have shown evidence that urban heat may yield positive benefits to residents of cities such as Chicago that regularly face extreme cold (Yang and Bou-Zeid, 2018). With these obstacles in mind, recent advances in the literature on solutions to extreme heat have been enabled by improvements in remote sensing technology, geospatial information systems (GIS) analysis, and a new emphasis among local governments on climate action.

Expanding the Urban Tree Canopy

Figure 7: Urban Greenspace in Spokane's Riverfront Park
Source: City of Spokane

Increasing greenspace and tree canopy cover is a cost-effective strategy to lower air temperature while also increasing the benefits to health and well-being experienced by communities living in heat islands (Rosenszweig, 2009; Jacobs et al., 2018). Numerous studies have demonstrated the importance of urban greenspace, and particularly the presence of trees, in reducing urban heat. Trees have been shown to play a vital role in regulating local temperature in urban landscapes. (Jenerette et al, 2011; Chapman et al., 2018; Gao et al., 2020). In addition to the shade trees can provide to pedestrians, trees also emit moisture throughout the day that can help to keep air temperatures at street level cool (Jacobs et al, 2018). Geospatial analysis has demonstrated that expanding tree cover in urban areas can reduce temperatures by as much as 3°F throughout the day on average, with the greatest impact being felt during the day (Gao et al., 2020). In Berlin, increasing a residential street's tree canopy by 15% reduced average street temperatures by roughly 2°F. (Schubert and Grossman-Clarke, 2013). In many cities, low-income and minority neighborhoods are far less likely to be shaded than their wealthier neighbors, often a consequence of systemic underinvestment in historically marginalized communities. These neighborhoods are more likely to experience an urban heat island effect (Hoffman et al., 2020).

Cool Streets and Cool Roofs

Heat absorption from street surfaces, parking lots, and rooftops is one of the leading causes of extreme heat in urban areas (Hoffman et al., 2020). To address this issue, many local governments have promoted the deployment of "cool" surfaces on existing roofs and streets, in which street surfaces and rooftops are coated with a light, reflective materials that redirect greater amounts of solar radiation back into the atmosphere than traditional paving materials. The resulting increase in local albedo, or reflectivity, leads to reductions in street-level temperature. This effect is felt most strongly at night, as traditional paving materials continue to radiate heat for hours after sundown (Akbari et al., 2001; Schubert and Grossman-Clarke, 2013). Cool streets and roofs have received significant amounts of praise as effective, low-cost solutions to the problem of urban heat. (Jacobs et al., 2018; Berisha et al, 2017; Akbari, et al., 2001). In addition to their impact on temperature, deploying cool streets and roofs may also reduce energy demand for air conditioning in communities hardest hit by extreme heat, lowering peak electricity prices and making air conditioning more affordable to at-risk populations. (Akbari, Pomerantz, and Taha, 2001).

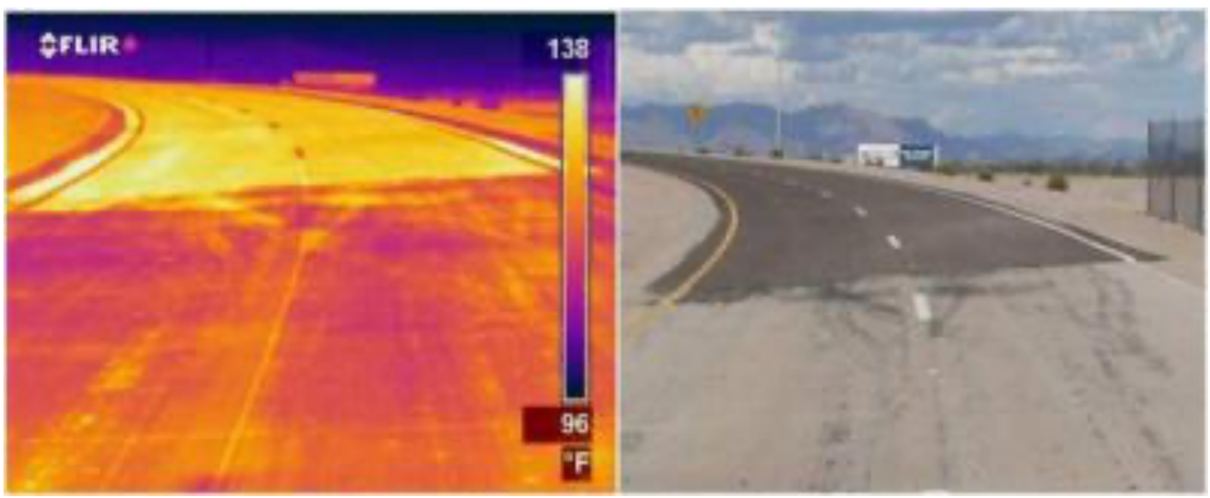

Figure 8 - Thermal infrared (left) and visible (right) images of a road with cool pavements and traditional asphalt. The infrared image shows that the light segment (bottom) is about 30 °F cooler than the dark segment (top). Source: Lawrence Berkeley National Laboratory

From their first deployment in the Los Angeles area, cool streets and roofs have come to be viewed among academics and policymakers alike as an effective approach to extreme heat mitigation. A landmark 1997 study by a team of scientists at the Lawrence Berkeley National Laboratory found that if the combined albedo of Los Angeles' streets and rooftops decreased by 25 percent, local temperatures could fall by as much as three degrees, with potentially greater temperature drops in urban heat islands (Pomerantz et al, 1997). Despite the promise of findings like these and others, it would take another decade for high-albedo resurfacing programs to truly gain national prominence as part of Los Angeles' "cool communities" program, a suite of policies aiming to reduce urban heat (City of Los Angeles, 2015). Similar initiatives have also been rolled out at scale in cities across the country and have largely replicated results similar to the cool communities program. Phoenix, Arizona's Cool Pavement Pilot Program found that daytime street-level temperatures were reduced by 2.4 F on streets with cool pavement (City of Phoenix, 2021). However, a recent study in Phoenix, Arizona found that while cool streets are effective at reducing air temperature, they often reflect solar radiation into their surroundings, including into pedestrians. This may intensify the sensation of heat for residents and workers in districts with cool streets (Middel et al., 2020).

Community Cooling Shelters

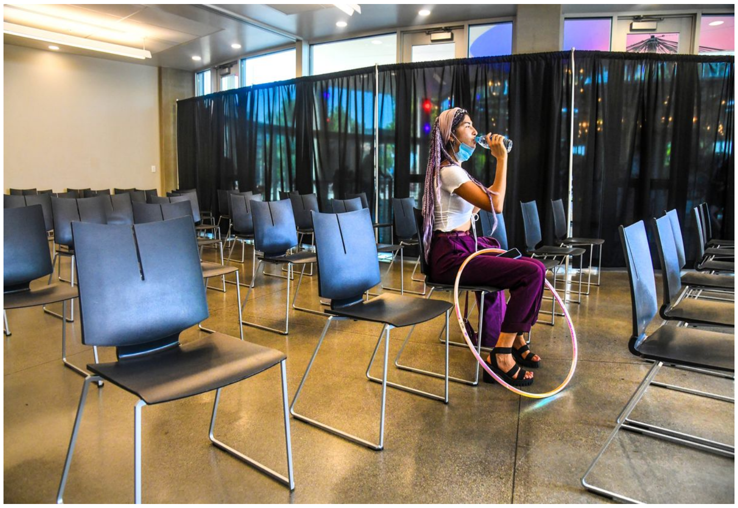

Figure 9: A Spokane resident escaping the heat in the Looff Carousel cooling center in Riverfront Park, June 2021 Source: Spokane Spokesman-Review

While policies focused on changing the existing built environment to lower air temperature are a cornerstone in local approaches to extreme heat, the full impact of these heat mitigation strategies may take time to fully manifest. In the short term, community members must have resources available today to cope with extreme heat. Cooling centers have been increasingly adopted in cities across North America as cornerstones of local governments' approaches to heat waves. They are especially useful in recent years in cities in the Pacific Northwest such as Portland and Seattle, where residential air conditioning is uncommon but summer temperatures regularly climb above 90°F (Office of the Mayor of Seattle, 2015; Perry, 2021). While Spokane has established cooling centers during heat waves this past summer, these programs have faced criticism from community members for the hastiness of the plan's development, a lack of communication with residents, and an inadequate transportation network to allow residents most vulnerable to heat stress to access cooling centers (Shanks and Dreher, 2021).

Research suggests that establishing cooling shelters is an effective intervention for improving a community's resilience to heat stress (Berisha et al., 2017; Widerynski et al., 2017; Hayden et al., 2017). A study of deaths during the 2003 European heat wave found that access to air-conditioning spaces reduced the risk of mortality by roughly 66% (Bouchama et al., 2007). Incorporating cooling shelters into new or existing community shelters can also be an effective way to build community bonds. Communities with strong inter-household bonds are better able to cope with extreme heat, as segments of the population that are most vulnerable – the elderly, young, and infirm – are far more likely to be cared for in a tight-knit community (Hayden et al., 2017).

Informational asymmetries may also play a role in diminishing a community's adaptive capacity to heat stress, including their use of existing cooling shelters. This is particularly true in cities with socio-economic or ethnic disparities (Widerynski et al., 2017). In these cases, soliciting the input of community leaders is crucial to facilitate cooling behaviors among residents (Sampson et al., 2013). Several studies have shown that residents may not be aware of city programs that may help residents cope with extreme heat, undermining the effectiveness of local heat adaptation policies (Hayden et al., 2011; Berisha et al, 2017).

Air Conditioning Subsidies

For many households, access to air conditioning is critical in obtaining relief from heat stress. Air conditioning can directly reduce heat-related morbidity and mortality (O'Neill et al., 2005). However, as climate change continues to increase the frequency of extreme heat events, air conditioning demand has steadily increased, driving up energy prices (Lundgren-Kownacki et al., 2018). A recent survey of eight industrialized countries notes that households in the developed world tend to spend 35-42% more on electricity when they own air conditioners (Randazzo et al., 2020). Increasing peak electricity prices on account of climate change places a disproportionate burden on low-income households with air conditioning, which can drive low-income households into energy poverty (Lundgren-Kownacki et al., 2018; Brown et al., 2020; Randazzo et al., 2020). This is compounded by increasing electricity price volatilities brought about as utilities attempt to transition their energy generation to more sustainable sources. The cost of adopting strategies to improve household energy efficiency and usages, such as rooftop solar and home batteries, is often inaccessible to low-income households, making them more vulnerable to energy insecurity as electricity prices increase (Brown et al., 2020).

This has been an issue of concern in Spokane, as each summer brings hotter temperature highs to the region (Clouse, 2021). Low-income households in Spokane are more likely to not have access to in-home air conditioning. These families instead rely on keeping windows open, using airflow to reduce heat stress. But in the fire season, this strategy can also expose households to dangerous levels of air pollution (Pacific Northwest Climate Impacts Research Consortium, 2021).

To improve low-income households' ability to both access and afford in-home air conditioning, local and state governments have adopted energy subsidies or rebate programs. While Washington State does not have a specific program to assist with utility bills, the state government is allocated over $60 million annually from the federal Low-Income Housing Energy Assistance Program (LIHEAP) (Block, 2021). While LIHEAP has been moderately successful at achieving reductions in household energy poverty (Murray and Mills, 2014), several studies have highlighted flaws in the structure of LIHEAP, namely a lack of policy coordination with other state and federal programs and insufficient targeting (Hernández and Bird, 2012; Bednar and Reames, 2020). However, as LIHEAP only assisted with heating until 2020, there is scarce literature available on LIHEAP's impact on air conditioning usage among low-income households. Existing literature suggests that there may be opportunities for local governments to build upon the limited success of LIHEAP and similar state-level programs by providing subsidies for low-income households.

Gaps in Existing Literature

Although extreme heat events affect entire regions, the magnitude of the event's impact is experienced differently from neighborhood to neighborhood based on natural geography and the characteristics of a locality's built environment. Strategies that work in one area of a city may not work as effectively in another. With this in mind, city policymakers must consider combining multiple approaches in varying combinations depending on factors at play in each neighborhood to most effectively reduce heat stress. However, most studies examining extreme heat mitigation strategies only analyze individual policies. Consequently, multi-faceted approaches to heat stress, despite their potential efficacy, have rarely been studied in current literature (Fernandez-Milan and Creutzig, 2015). Future analysis will need to focus heavily on which policies work best in tandem, and where. Local policymakers will need to do the same in tailoring the most effective approach for heat in their jurisdiction.

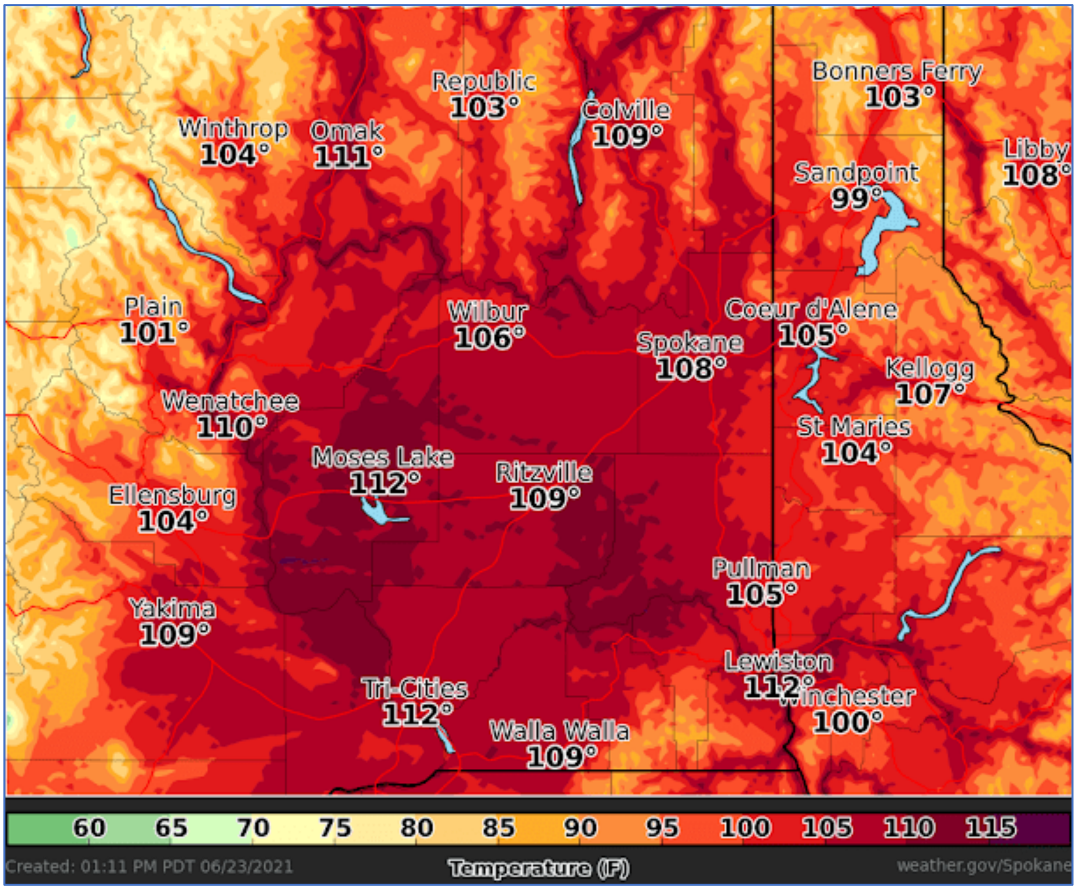

Figure 10: Afternoon temperature highs in Inland Northwest - June 29, 2021
Source: National Weather Service

Overview of Evaluative Criteria

The following section details the four evaluative criteria used to assess and compare the performance of each policy alternative. Policy alternatives are graded on a 3-point scale, with 1 signifying poor performance and a 3 signifying excellent performance on the criterion in question. The point assignments on the rubric for each criterion can be found in parenthesis after each listing. This grading scale corresponds with a rubric unique to each criterion based on existing literature, outlined in subsequent subsections.

Criterion 1: Effectiveness - *Does this policy improve the targeted population's resilience to the threat of extreme heat?*

Effectiveness gauges a policy's capacity to generate improvements to the community's capacity to cope with the public health threats posed by extreme heat. The impacts of exposure to extreme heat on an individual's health typically manifest as heat stress illness (HSI). Common conditions associated with HSI include heat stroke, heat exhaustion, rhabdomyolysis – the rapid breakdown of muscle tissue, liver damage and failure, and cardiac arrest – the most common cause of heat-related mortality (Choudhary and Vaidyanathan, 2014). A policy's effectiveness is assessed according to three sub-criteria – (1) the magnitude of the policy's impact on HSI risk among targeted populations, (2) the scope of the policy's impact within the Spokane community, and (3) the timeframe in which the policy can deliver benefits.

Rubric for evaluation

- **Highly effective (3):** the policy drastically improves the targeted population's risk of experiencing heat-related morbidity, impacts a broad population, and delivers benefits within six months of implementation

- **Moderately effective (2):** the policy somewhat improves the targeted population's risk of experiencing heat-related morbidity, reaches only some members of the Spokane community, and delivers benefits within 1-2 years of implementation.

- **Minimally effective (1):** the policy does little to nothing to improve the targeted population's risk of experiencing heat-related morbidity, impacts a small subsection of the Spokane residents, and delivers benefits more than 2 years after implementation.

Criterion 2: Equity - *Are the benefits of this policy targeted to Spokane's heat vulnerable communities?*

Vulnerability to extreme heat is not spread evenly among Spokane's population. A particular population's susceptibility to heat stress is dependent on the interaction of a complex series of socioeconomic, health, and environmental factors present in that community (Hayden et al., 2011; Hayden et al., 2017; Seebaß, 2017). As these populations are those who bear the greatest cost associated with extreme heat, policy alternatives must prioritize delivering the greatest share of benefits to heat vulnerable communities. This criterion assesses the degree to which policy alternatives can generate positive improvements in heat-related morbidity among Spokane's heat vulnerable communities, which are identified according to a Heat Vulnerability Index (HVI). Details on the HVI can be found in the appendix. Policy alternatives are then evaluated based on whether policy alternatives are effective at generating improvements to heat resilience in Spokane's heat vulnerable communities as defined by the HVI.

Rubric for evaluation:

- **High impact (3):** this policy tightly targets a majority of its benefits on heat vulnerable communities. Risk of heat-related morbidity is greatly reduced.

- **Moderate impact (2):** this policy somewhat improves risk of heat-related morbidity for Spokane's heat vulnerable communities. Benefits are slightly concentrated in heat vulnerable communities, but impacts are disparate as a whole.

- **Low impact (1):** this policy does not concentrate benefits to heat vulnerable communities. Risk of heat related morbidity is not reduced by policy alternative.

Criterion 3: Cost - *What costs are associated with this policy? How much of a strain does this policy place on the City of Spokane's fiscal resources?*

This criterion assesses the fiscal cost accrued by the City of Spokane associated with enacting and implementing this policy on a five-year basis. Future costs are discounted to reflect that the value of future spending is less than spending today. Policy alternatives will be evaluated and compared according to their overall cost over five years represented in a single net present value figure. These costs only represent those borne by the City of Spokane and do not represent the costs of policies that are borne by third parties. A comprehensive breakdown of costs for each policy alternative, as we as the assumptions that were used to generate the estimates, can be found in the report's appendix.

Rubric for Evaluation:

The net present value of each policy's cost over five years will be provided along with a normative score of 1-3 based on the relative size of the cost.

- **Low Cost (3):** this policy's five-year cost is under $800,000.00

- **Moderate Cost (2):** this policy's five-year cost is between $800,000.00 and $900,000.00

- **High Cost (1):** this policy's five-year cost is over $900,000.00

Criterion 4: Political Feasibility - *Will this policy be accepted as a viable solution to the problem by policymakers and community stakeholders?*

Political feasibility evaluates the degree to which policy alternatives will be accepted as viable approaches to address extreme heat by Spokane policymakers and the broader public. It considers how well the alternative aligns with the City Council's legislative agenda, potential support within the City's executive offices, potential support among major community stakeholders, and the long-term political sustainability of the alternative. The criterion also evaluates the ease of implementation and the strain the policy will place on City resources.

Rubric for evaluation:

- **Very Feasible (3):** Alternative aligns with the priorities of policymakers in the City Council and the Mayor's Office. Alternative will be viewed favorably by community stakeholders and the general public. Alternative enactment does not require significant policy changes to the current status quo. Alternative implementation places minimal strain on existing city resources.

- **Moderately Feasible (2):** While a degree of political support is present, alternative may face opposition from some policymakers and community stakeholders.

- **Infeasible (1):** Alternative is likely to meet with heavy resistance from policymakers, stakeholders, and the general public. Enactment will significantly change city policy and implementation will require a significant commitment of City resources.

Evaluation And Findings

The following section will outline three policy alternatives – enacting a Spokane extreme heat action plan, developing an air conditioning installation voucher program, and implementing a cool streets pilot program. These alternatives represent cutting edge policy approaches that are well-suited to Spokane's unique context. Each will be described and evaluated based on their effectiveness, equity, cost, and political feasibility. There relative performance will then be scored on three-point scale, which is then tallied in the subsequent outcomes matrix to generate a final policy recommendation. It is important to note that some of the policies discussed in the previous survey of best practices, most notably expanding the urban canopy, are not evaluated in this report as they are already incorporated into existing programs in Spokane.

Status Quo

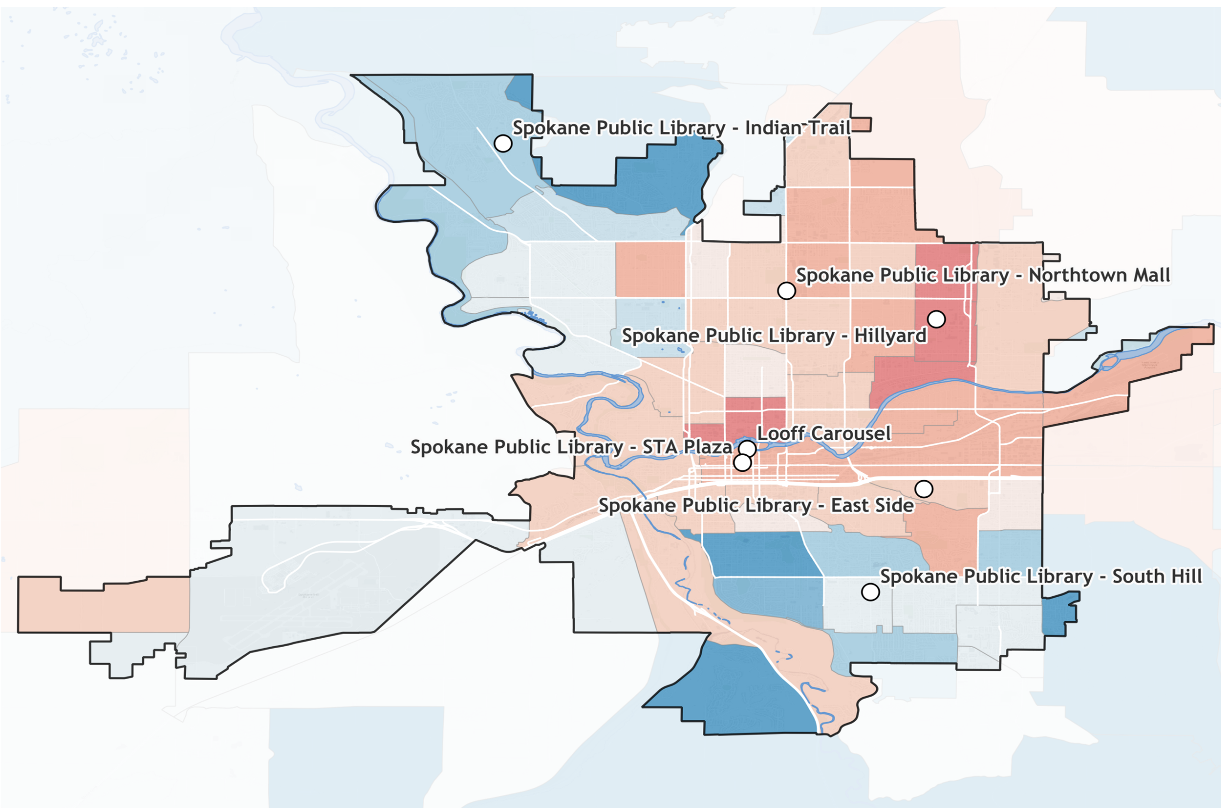

Figure 11: Map of Spokane cooling centers in summer 2021 overlaid on HVI.. Spokane's current cooling centers currently do not adequately reach Spokane's Heat Vulnerable Communities.
Source: Constructed by author based on data from Washington State Department of Health

The City's current response to extreme heat involves the usage of six public libraries and one public events center (Looff Carousel) as cooling centers. The City's municipal code was updated in 2021 to mandate that centers should be activated when the daily temperature is projected to exceed 95 degrees Fahrenheit or higher for two consecutive days. In turn, the City emergency response team utilizes the National Weather Services' temperature projections to disseminate public health warnings via websites, news broadcast public service announcements, and notices in City printed publications which are distributed at City facilities. This program is administered by the Spokane Office of Emergency Management, which does not have any staff dedicated to heat. The program relies on a partnership with Avista Utilities, which provides rideshare services to community members in need of transportation to cooling centers.

Effectiveness

The status quo is primarily intended for supplying Spokane's homeless population with cooled spaces during extreme heat events. While the cooling centers are open to the broader public, the sites saw only limited usage, although the exact number of patrons was not recorded. Because the cooling center program is publicly framed as serving those experiencing homelessness, many public facilities that could serve as cooling centers, such as schools and community centers, have refused to participate. This program has therefore only served a narrow geographic range with little utilization from members of heat vulnerable communities. For these reasons, the status quo is assessed as being minimally effective.

Score: 1 – Minimally Effective

Equity

The limited geographic range of the cooling center network means that heat vulnerable communities are unlikely to easily access these facilities. Even when cooling centers are located in close vicinity to Heat Vulnerable Populations, as the Looff Carrousel facility is to downtown populations, the program's focus on the homeless and the limited public perception of the risk posed by heat waves results in underutilization and a general failure to target benefits in heat vulnerable communities. Potential community partners active in these communities have not been tapped to assist with community outreach.

Score: 1 – Low Impact

Cost

The city's current emergency response program to extreme heat receives a budget of $150,000 per year for the operation of cooling centers. No additional resources are earmarked within this spending allowance. In turn, the Office of Emergency Management does not devote any additional accounts or resources to the City's extreme heat response and relies on volunteers to staff cooling centers. Projected over five years with future spending discounted accordingly, costs associated with the current Status Quo is $8335,956

Total Cost: $836,956.08

Score: 2 – Moderate Cost

Political Feasibility

As this program is currently in existence under a politically divided city government and does not require additional commitment of political efforts or city resources, the status quo is assessed to be very feasible.

Score: 3 – Very Feasible

Alternative 1: Developing a Heat Action Plan

This policy would consist of a comprehensive expansion of Spokane's Emergency Readiness Plan for extreme heat events by (1) expanding Spokane's network of cooling centers, (2) developing a city-sponsored shuttle system to allow residents experiencing mobility impairment to access cooling centers, (3) creating a registry of residents that would opt for mobility assistance and periodic monitoring in the event of a heat wave, and (4) deploying a Heat Wave Early Warning System

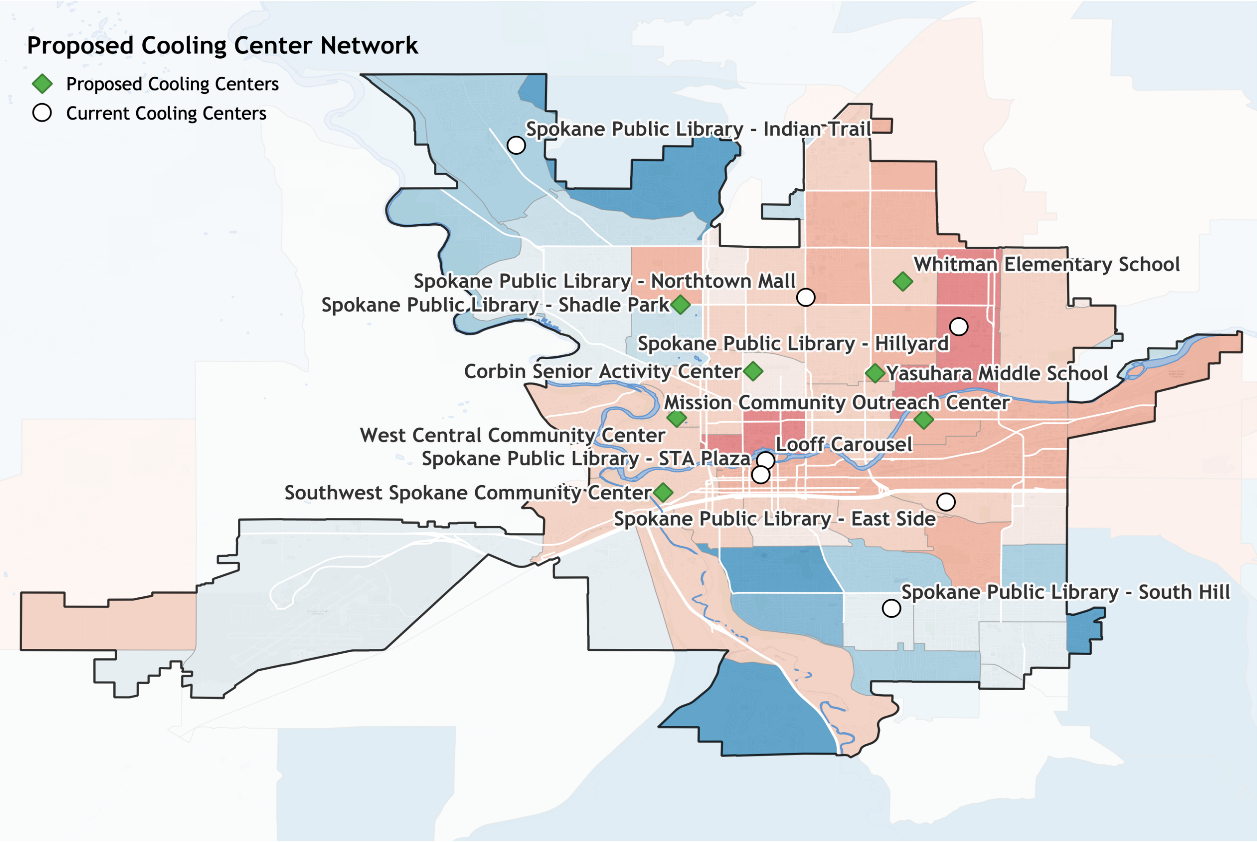

Figure 12: Map of Proposed Cooling Center Network under Spokane Extreme Heat Action Plan
Source: Constructed by author based on data from Washington State Department of Health

(HEWS) and implementing a public communications campaign. This would be accomplished by passing an amendment to the Spokane Municipal Code Section 18.05.020.

The above map shows a hypothetical expanded network of cooling centers under the Heat Action Plan. The number of centers would be increased from seven to fourteen, prioritizing facilities located in or near HVCs. Candidate facilities include community centers, Spokane public schools, and other libraries. Inclusion in this hypothetical network is simply proposed. None of the proposed cooling centers have been contacted.

Effectiveness

By building out Spokane's existing network of cooling centers in underserved areas, this alternative would moderately improve the ability of Spokane community members to access cooled spaces to find relief during extreme heat events. Providing a reliable transportation network and a registry of residents who would use the system would allow for improved access for those most vulnerable to extreme heat events across the city. A HEWS system would automatically alert residents of an impending heat wave by distributing information on mobile devices, computers, and televisions in Spokane, ensuring widespread public knowledge of the heat wave and providing a list of resources available to the community. This means that the alternative would reach a broad swath of Spokane's population. Assuming the alternative is met with support by City policymakers, passing a legislation package updating and codifying the Heat Action Plan through the City Council could take place within the span of several weeks. Following enactment, the policy itself could be implemented rapidly, as the basic infrastructure of the program is already in place. For these reasons, alternative 1 is assessed to be highly effective.

Score: 3 – Highly Effective

Equity

This alternative largely involves expanding the city's network of cooling centers in neighborhoods where commuting to one of the seven existing shelters is untenable on foot and tedious via public transit. While choosing facilities to utilize as cooling shelters will be based on the facility's presence in heat vulnerable communities, this is not the alternative's sole objective. In turn, evidence shows that even when cooling shelters are available to the community during heat waves, many residents do not make use of these facilities often because they are perceived to primarily serve the unhoused population. In turn, past shelters have failed to provide a suitable range of amenities to entice locals. A public communication campaign will be included in the readiness plan update to attempt to change this commonly-held perception. However, without guarantees that this program expansion will directly increase usage among heat vulnerable communities, alternative 1 is assessed to have a moderate impact on equity.

Score: 2 – Moderate Impact

Cost

Over five years, the projected cost for implementing the Heat Action Plan is $735,577.92. The greatest portion of costs occurs in year 0 upon implementation, as the plan calls for a one-time capital investment of $150,000 for the purchase of three class diesel three minibusses for the heat action plan's shuttle program. The annual costs of the program sharply decline after year 1, decreasing to under $100,000. Of the four alternatives put forward, this alternative presents the lowest fiscal cost to implement.

Total Cost: $735,576.92

Score: 1 – Low Cost

Political Feasibility

This alternative expands and codifies an existing City program. The additional facilities used in the cooling center network expansion would utilize existing city resources, such as schools and community shelters. As this program would target usage by local households rather than the unhoused population, as previous City shelter programs have done, it is also likely to be supported by the broader public and community stakeholders. In August 2021, City Council was able to amend the municipal code to issue new guidance on the city's cooling shelters, against the wishes of the Mayor's Office. The City Council's willingness to improve the emergency heat response plan, together with the City Emergency Management Department's enthusiasm to obtain more funding for its extreme heat response, makes this policy alternative very feasible to enact and implement.

Score: 3 – Very Feasible

Alternative 2: A/C Installation Voucher Pilot Program

This policy would involve the provision of vouchers covering the purchase of window air conditioning units to Spokane residents who are most vulnerable to heat stress. Members of households meeting the parameters for heat vulnerable communities as established in the Spokane HVI can enter a lottery for a voucher. Those selected in the lottery can use the vouchers they are issued to redeem the purchase of a window air conditioning unit. This pilot program will issue 200 vouchers initially, which can be redeemed by recipients for a refund of up to $300. After a two-year evaluation period to assess the program's efficacy at reducing rates of heat-related illness among voucher recipients, City policymakers can elect to expand the program.

Effectiveness

Participants in the A/C voucher pilot program would be greatly impacted by receiving in-home access to air conditioning. As the access to air conditioning is highly correlated with a reduced risk of heat-related morbidity, this alternative is highly effective at generating benefits among voucher recipients. The number of vouchers available in the pilot program is extremely limited relative to the population of Spokane, meaning that the alternative would have an extremely narrow scope.

However, if future evaluation of the pilot program demonstrates the effectiveness of the alternative, a future rollout of a broader means-tested program could reach a much wider population. If the benefits of providing access to in-home air conditioning to program recipients align with existing literature, the impacts of this program should be felt immediately by these households. However, the timing of this impact would depend on the program take-up rate - whether voucher recipients actually redeem their vouchers and purchase an air-conditioning unit.

Score: 2 – Moderately Effective

Equity

Because participation in the A/C Voucher Pilot Program would be restricted to members of heat vulnerable communities, the impacts of this alternative are entirely concentrated in communities that suffer the most from extreme heat. In turn, as a large body of evidence demonstrates, access to air conditioning within the home is one of the most effective ways to lower households' risk of heat stress. Although the quantifiable impacts of this program on incidences of heat-related morbidity in Spokane will not be evident until after the two-year evaluation period, extensive literature and the program's targeting suggest that the A/C Installation Voucher Pilot Program will have a high impact on equity.

Score: 3 – High Impact

Cost

The AC Voucher program is estimated to cost $825,768 over five years. The two main cost categories for the proposed program are labor costs and voucher reimbursement. The proposal calls for hiring a program coordinator to administer the pilot program. The costs associated with creating and distributing access to an online registration system, as well as the cost of labor required to authorize voucher reimbursements is built into this position's salary. The greatest proportion of this alternative's cost is accounted to voucher reimbursement. Monitoring and evaluation represent a third cost category.

Total Cost: $825,768.35

Score: 2 – Moderate Cost

Political Feasibility

The relatively limited size and low cost of this pilot program lend themselves to yielding greater degrees of political support among City policymakers in the short term. In turn, facilitating the purchase of air conditioning units aligns with existing programs – namely the federally-funded Low-Income Home Energy Assistance Program (LIHEAP), which distributes financial aid to support low-income households with utility bills. This alternative would also enjoy significant support from community stakeholders already engaged with this issue, such as Spokane Neighborhood Action Partners (SNAP). Despite the alternative's alignment with existing programs and low cost, expansion of the program following evaluation may accrue significant costs to the City, reducing its long-term viability. Some voters may also oppose such a direct transfer program to low-income members of the Spokane community.

Score: 2 – Somewhat Feasible

Alternative 3: Cool Streets Pilot Program

This policy alternative would implement a pilot program to deploy cool paving materials on streets in heat vulnerable areas of Spokane. The program could follow a similar model to Los Angeles' Cool Streets program, which applied cool pavements in three neighborhoods on 10-12 contiguous blocks per neighborhood. All three neighborhoods would be located in Heat Vulnerable Communities, ideally in Whitman, Hillyard, Bemiss, or West Central. This program would reduce heat-related morbidity by decreasing average ambient street-level temperatures experienced by pedestrians and residents significantly. The efficacy of the pilot program at reducing temperatures would be assessed throughout the summer months in the first year of implementation, after which period the City Council can decide to expand the program.

Effectiveness

Cool Streets pilot programs in other major metropolitan areas have been shown to reduce average local ambient temperatures by as much as 3°F (City of Phoenix, 2021). In Los Angeles, cool pavements were found to be 9°F cooler than neighboring streets with traditional asphalt or concrete pavements during heat waves. (City of Los Angeles, 2015). Reduced average temperatures may yield benefits to However, additional studies have found that the increased reflectivity of cool pavements induces increased sensations of heat for pedestrians and residents, even when ambient temperature is decreased (Middel et al., 2020) It is unclear how this sensation impacts the risk of heat-related morbidity for residents. Due to this ambiguity, together with the limited geographic scope of the program, the Cool Streets Pilot Program is evaluated to be minimally effective.

Score: 1 – minimally effective.

Equity

Because this program will focus the deployment of cool pavements in residential streets in three neighborhoods classified as heat vulnerable communities, the benefits of this program will be almost entirely concentrated in heat vulnerable communities. However, as this program may potentially increase sensations of extreme heat among pedestrians in neighborhoods where cool streets are deployed, this alternative is assessed to have a moderate impact on equity.

Score: 2 – Moderate Impact

Cost

Costs for this alternative can be broken down into three main categories: capital investments, operations and labor, and monitoring and evaluation. Capital investments involve the procurement of CoolSeal, a high-albedo pavement sealant used in similar pilot programs in Los Angeles, CA and

Phoenix, AZ. Operations and labor costs include labor hours and machinery operation required for CoolSeal deployment. Last, monitoring and evaluation will make up the third and smallest cost category. Within all three categories, the greatest share of cost is concentrated in the first year after implementation. Monitoring and evaluation is the only category that involves additional costs through year five. Of the four alternatives put forward, this alternative presents the greatest fiscal cost to implement.

Total Cost: $1,042,780.43

Score: 1 – High Cost

Political Feasibility

Unlike other policy alternatives, such as expanding the city's network of cooling centers, the Cool Streets Pilot Program debuts a policy approach intended to change Spokane's built environment to develop long-term resilience to extreme heat. While addressing the long-term challenges posed by extreme heat is important, the kinds of policies that do so typically bear higher costs and involve a greater level of change, and may subsequently attract opposition from City policymakers. Cool streets are also highly visible changes to the existing urban landscape, which may negatively impact their public support. Lastly, to be effective, cool streets will need to be implemented across wide swathes of Spokane, accruing upfront costs for deployment as well as maintenance. These tasks also add to the existing responsibilities of the Spokane Street Maintenance Division, which may oppose the additional workload and expense. Accordingly, the Cool Streets Pilot Program is assessed as politically infeasible.

Score: 1 – Infeasible

Outcomes Matrix

	Effectiveness	Equity	Political Feasibility	Cost	Total Score
Status Quo	1	1	3	$836,956.08 (2)	7
1. Heat Action Plan	3	2	3	$735,576.92 (3)	11
2. A/C Vouchers Pilot Program	2	3	2	$825,768.35 (2)	9
3. Cool Streets Pilot Program	1	2	1	$1,042,780.43 (1)	5

Recommendation: Enact And Implement Spokane Extreme Heat Action Plan

After an in-depth comparison of the status quo and three policy alternatives, the analysis concludes that instituting an extreme heat action plan is the best option for the City to pursue. This alternative takes advantage of current City resources and expands on the City's cooling centers program to optimize the City's emergency response to extreme heat events. The heat action plan's high effectiveness score stems from the program proposal's multi-faceted approach to improving community resiliency among the greatest number of Spokane residents. Doubling the number of cooling centers greatly improves the geographic coverage of the program, while the shuttle system provides quick access to community members who would otherwise be unable to utilize the program's resources. In turn, a heat early warning system improves public awareness of extreme heat events as well as the likelihood that this program's resources will be utilized by those most vulnerable to extreme heat. The policy also presents the lowest five-year cost of any alternative and provides cost savings to current city policies on extreme heat. In turn, policymakers have already expressed support publicly for the cooling center program and will likely be enticed by potential cost savings, even as a new City-run shuttle system during heat waves is introduced. While uncertainties regarding the program's potential community usage and the degree to which the program is targeted to Heat Vulnerable Populations results in the heat action plan's moderate score on equity, no other option earns similarly high scores across effectiveness, cost, and political feasibility.

The Heat Action Plan's utility to Spokane may also extend past the summer months. Spokane also faces similar resiliency challenges during the winter, when extreme cold can pose a serious public health risk, and throughout the year during wildfire season, during which Spokane can see air quality fall to dangerous levels. The resources put forward in the Extreme Heat Action Plan can be easily retooled to provide resources to the community during such events as well.

IMPLEMENTATION GUIDELINES FOR EXTREME HEAT ACTION PLAN

The following guide provides an overview of a potential rollout of the Spokane Extreme Heat Action Plan, beginning with policy enactment and through the monitoring and evaluation phase. The guide concludes with a discussion of a series of concerns that may arise during policy implementation.

Enactment

The heat action plan will follow in the format of previous legislation passed by the City Council amending Spokane Municipal Code 18.05.020, which governs the City's cooling center program. The legislative package instituting the heat action plan will originate in the City Council Sustainability Action Subcommittee for comment and amendment before being passed onto the entire City Council for passage. Before the legislative package is passed, the City Council should seek comment from the Mayor's Office and the Office of Emergency Management to ensure cooperation between the Mayor and executive agencies involved in the program's operation.

Implementation

Cooling Center Program

1. ***Identify and secure partnerships with cooling center facilities.*** Partnerships should be explored with City-operated facilities community centers and local schools. When approaching these facilities, it is crucial that those conducting outreach note that the program is intended for use by the local community and should attempt to only secure part of the facility. Candidate facilities for the cooling center network expansion should target air-conditioned spaces large enough to accommodate fifty people and accompanying pets.

2. ***Hire, train, and contract with cooling center staff.*** The Office of Emergency Management will hire or promote a program coordinator to administer the heat action plan program. While this coordinator may be tasked with external responsibilities, the coordinator will act as the point person for the rollout of the heat action plan. Attendant staff for cooling centers may be drawn from current city employees who receive a formal release from their supervisors to serve as attendants when the cooling center network is activated. Additional volunteers may be drawn from among local non-profit members or interested community members, as needed. Attendants and volunteers will undergo a training session in addressing heat stress and engaging in public outreach. A security detail will be contracted to provide a single security attendant for all fourteen cooling centers.

3. ***Prepare for Program Activation.*** The program coordinator will orchestrate program activation and act as a liaison between the three different program arms.

Shuttle Program

1. ***Establish registry for residents in need of transit.*** Such residents should be identified by their response to public notice and through partnerships with local community organizations. Registrants

will be contacted in the event of program activation. The Shuttle system will prioritize offering transit for registrants.

2. ***Procure class 3 diesel minibusses.*** Minibus procurement should be facilitated by the Office of Emergency Management in partnership with the Spokane Transit Authority and the Spokane Public Works Department. Procurement will also involve the purchase of proper insurance packages and licensing. The Office of Emergency Management will secure storage and maintenance for shuttle system vehicles at a City facility. The City should also explore alternate uses for the vehicles.

3. ***Hire shuttle system drivers.*** As the shuttle system operation is only periodical, shuttle system drivers shall be drawn from current Spokane Transit Authority drivers, who will be offered their normal hourly wage.

Public Communication Program

1. ***Establish Heat Early Warning System (HEWS):*** The program coordinator will facilitate the creation of a HEWS system by registering with the Federal Communication Commission's Emergency Alert System (EAS). This system will push extreme heat alerts to mobile devices and computers. The HEWS system will involve an opt-out for recipients to improve public perception. It is recommended that the operator of the HEWS program should consider implementing a tiered warning system tied to colors.

2. ***Redirect and expand public communications campaign.*** The program coordinator will direct the existing public communications campaign to find ways to change the image of the cooling center program. The program is currently associated with aid for the population experiencing homelessness, which has discouraged wider public use. The coordinator shall field insights from and consider partnerships with community organizations to increase usership.

Monitoring and Evaluation

Monitoring and evaluation of the heat action plan will involve a post-action analysis of the program conducted for internal review by the Office of Emergency Management. This analysis will track the cooling shelter program and shuttle system usage, conduct a survey of cooling shelter patrons. Yearly reports will provide recommendations for improving the program for the following summer. In turn, funds marked for monitoring and evaluation should conduct a health survey to track heat-related morbidity among Spokane residents during extreme heat events.

Concerns for Implementation

The City Council should be mindful of three important groups of stakeholders which represent obstacles to successful program implementation. Mayor Woodward has demonstrated opposition to Spokane's warming centers program over damages accrued from their use and has expressed reservations about targeting the current warming and cooling centers toward the homeless population. Framing the program as a resource for the broader community and the program's cost savings relative to the current cooling center program will be useful in obtaining support from the Mayor's office. Two other groups of important stakeholders that may present opposition to the program are the departments that will be responsible for program implementation as well as local community and environmental justice activists. It is therefore important to solicit and incorporate feedback from these groups into the final design of the program. Seeking out partnerships with community activists may also provide cost-savings and a valuable source for facilities and volunteers. The multifaceted characteristics of the heat action plan present a range of potential complications to implementation. All sub-programs within the policy must operate in sync during periods where city resources are already under serious strain. However, if these challenges can be properly addressed, the Extreme Heat Action Plan can make great progress in ensuring that Spokane residents have the resources to cope during future heat waves.

It is important to note that while implementing a heat action plan is the best strategy to build community heat resilience in the short term, it does not address the city's growing need to adapt to the growing dangers of climate change. The two pilot programs, while not found to be effective in this analysis, should both be considered as candidates for the city's long-term climate adaptation strategy.

CONCLUSION

The 2021 heat wave demonstrated that without the necessary resources and preparedness, both the city government and the Spokane community are currently unprepared to take on a serious extreme heat event. Heat represents a clear threat to the health and well-being of Spokane residents, one that will only grow more dangerous in coming years. However, thoughtful policymaking and careful forward planning can ensure that resilience to heat can be developed across Spokane, especially among its most vulnerable community members. Heat will be one of the most impactful symptoms of climate change in Spokane. It is therefore absolutely essential that City policymakers incorporate planning for extreme heat into Spokane's climate action strategy. It is therefore recommended that Spokane's policymakers enact and implement the Spokane Extreme Heat Action Plan, a framework for which is put forward in this report. It is the hope of the author that this report can serve as a guide for the Sustainability Action Subcommittee, who can use its information in shaping the City's future approach to extreme heat.

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APPENDIX

A: Major Assumptions

Assumptions	Cost/Figure	Source
General		
Social Discount Rate	3%	NOAA
Timeline of Evaluation	5 years	
Total Population - City of Spokane, 2020	228,989	US Census
Population		
Average Annual Population Growth Rate, 2010-2020 - City of Spokane	0.96%	US Census
Projected Population - City of Spokane, 2022	233407	
Total Population - Spokane County, 2020	539,339	US Census
Average Annual Population Growth Rate, 2010-2020 - Spokane County	1.45%	US Census
Projected Population - Spokane County, 2022	555039	
Climate		
Global emissions scenario	RCP 4.5	Spokane Climate Project
Average annual number of days over 90 degrees, 1970-2000	11	Spokane Climate Project
Average annual number of days over 100 degrees, 1970-2000	0.2	Spokane Climate Project
Average annual number of days over 105 degrees, 1970-2000	0	Spokane Climate Project
Average annual number of days over 90 degrees in 2050	30.6	Spokane Climate Project
Average annual number of days over 100 degrees in 2050	3.5	Spokane Climate Project
Average annual increase in number of days over 90 degrees in Spokane since 2000	0.392	Spokane Climate Project
Average annual increase in number of days over 100 degrees in Spokane since 2000	0.066	Spokane Climate Project
Average annual increase in number of days over 105 degrees in Spokane since 2000	0.012	Spokane Climate Project
Historical mean summer maximum temperature in Spokane, 1970-2000 (°F)	82	Spokane Climate Project
Average mean summer maximum temperature in Spokane, 2050 (°F)	104	Spokane Climate Project

Average annual increase in mean summer maximum temperature in Spokane (°F)	0.44	Spokane Climate Project

B. Cost Figures – Status Quo

Cost Category	2022	2023	2024	2025	2026	2027	NPV (2022 USD)
Budgeted Program Cost	$150,000	$145,631	$141,389	$137,271	$133,273	$129,391	$836,956

C. Cost Figures – Spokane Extreme Heat Action Plan

Assumptions

Assumptions	Cost/Figure	Source
General		
Number of planned Cooling Shelters	14	Heat Action Plan Proposal
Expected maximum cooling center capacity at one time	50	Spokane Emergency Response Department
Number of days active (max temperature over 90F), 2022	19.624	Spokane City Ordinance
Average annual increase in number of days active	0.392	Spokane Climate Project
Number of hours of operation for cooling shelters	8	Heat Action Plan Proposal
Bottled water case (24 bottles) per cooling shelter	4	Berisha et al., 2017
Program monitoring cost as ratio of program cost	15%	Knowledge Advisory Group
Volunteer usage discount	50%	Heat Action Plan Proposal
Average FEMA Public Assistance grant program insurance cost-share for city governments	31%	Dixxon et al., 2021
Shuttle mileage per hour of operation	10	Heat Action Plan Proposal

Shuttle gas mileage	12	Pacific Gas & Electric
Personnel Requirements		
Cooling shelter attendants per facility	1	Heat Action Plan Proposal
Cooling center volunteers per facility	2	Heat Action Plan Proposal
Security personnel per shelter	1	Heat Action Plan Proposal
Shuttle System Vehicles	3	Heat Action Plan Proposal
Shuttle System Drivers	3	Heat Action Plan Proposal
Network Coordinator	1	Heat Action Plan Proposal
Capital Investments		
Class 3 Shuttle Van Price	$50,000	Pacific Gas & Electric
Rideshare shuttle permitting	$50	Optimoroute.com
Establishing Wireless Emergency Alert (WEA) System	$0	Federal Communications Commission
Bottled Water Case (24 bottles)	$3.48	Walmart Online Retail
Operating Costs		
Network coordinator hourly wage	$30.00	City of Spokane
Cooling Center attendant hourly wage	$14.49	Washington State Minimum Wage
Security personnel hourly wage	$15.17	Indeed
Cooling Center Operation Cost	$0.00	Spokane Emergency Response Department
Cost of diesel fuel per gallon	$3.90	Pacific Gas & Electric
Shuttle fuel cost per hour	$2.56	
Shuttle driver hourly wage	$22.71	Glassdoor
Average annual maintenance costs	$2,500	Kevin Smith Transportation Group

Cost Calculations

Cost Category	2022	2023	2024	2025	2026	2027	NPV (2022 USD)
Personnel Costs							
Shuttle System Labor	$10,696	$10,592	$10,485	$10,375	$10,262	$10,148	$62,557
Cooling Center Labor	$31,847	$31,537	$31,219	$30,891	$30,557	$30,216	$186,267
Cooling Center Volunteer Training	$240	$233	$226	$220	$213	$207	$1,339
Cooling Center Security	$33,342	$33,017	$32,684	$32,341	$31,991	$31,634	$195,009
Capital Costs							
Shuttle Purchase	$150,000	$0	$0	$0	$0	$0	$150,000
Operating Costs							
Cooling Shelter Facility Operation	$0	$0	$0	$0	$0	$0	$0
Shuttle System Operation	$8,708	$8,477	$8,253	$8,035	$7,822	$7,615	$48,911
Public Comms. Campaign Operation	$0	$0	$0	$0	$0	$0	$0
Monitoring & Evaluation							
N/A	$35,225	$12,212	$11,716	$11,237	$10,775	$10,328	$91,493

TOTAL COST	**$270,058**	**$96,069**	**$94,583**	**$93,099**	**$91,620**	**$90,147**	**$735,577**

D. Cost Figures – AC Voucher Pilot Program

Assumptions

Assumptions	Cost/Figure	Source
General		
Social Discount Rate	3%	NOAA
High-end estimate of price of window A/C unit in Spokane	$239.45	ProMatcher Air Conditioners
Vouchers distributed in pilot program	300	AC Voucher Pilot Program Proposal
Personnel Requirements		
Program coordinator required	1	AC Voucher Pilot Program Proposal
Capital Investments		
Cost to establish and maintain online registration portal for program enrollment	$0	AC Voucher Pilot Program Proposal
Operating Costs		
Maximum voucher reimbursement amount	$300	AC Voucher Pilot Program Proposal
Average voucher reimbursement	$239.45	ProMatcher Air Conditioners
Program coordinator salary	$56,856.24	City of Spokane

Cost Calculations

Cost Category	2022	2023	2024	2025	2026	2027	NPV (2022 USD)
Personnel Costs							
Labor Costs	$56,856	$55,200	$53,592	$52,032	$50,516	$49,045	$317,241
Capital Costs							
N/A	$0	$0	$0	$0	$0	$0	$0
Operating Costs							

Voucher Program Reimburse. Costs	$71,835	$69,743	$67,711	$65,739	$63,824	$61,966	$400,818
Monitoring & Evaluation							
N/A	$19,304	$18,741	$18,196	$17,666	$17,151	$16,652	$107,709

TOTAL COST	**$147,995**	**$143,684**	**$139,499**	**$135,436**	**$131,492**	**$127,662**	**$825,768**

E. Cost Figures – Cool Streets Pilot Program

Assumptions

Assumptions	Cost/Figure	Source
General		
Pilot Program Neighborhoods	3	Cool Streets Pilot Program Proposal
Square footage per neighbohood program		Cool Streets Pilot Program Proposal
# of blocks per neighborhood	12	Cool Streets Pilot Program Proposal
# of 4 block streets per neighborhood	10	Cool Streets Pilot Program Proposal
Average Spokane local access street width (ft)	36	Spokane Municipal Code
Average Spokane 4 block North/South street length (ft)	1,300	Spokane Municipal Code
Average Spokane 4 block East/West street length (ft)	2,050	Spokane Municipal Code
Total centerline feet of deployment	50,250	
Square footage per neighbohood program	603,000	Cool Streets Pilot Program Proposal
Total area of CoolSeal deployment (sq ft)	1,809,000	Cool Streets Pilot Program Proposal
Hours required for 4 block street sealcoating project	60	Spokane Pavement Maintenance and Repair
Hours required for 12 block sealcoating project	600	Spokane Pavement

		Maintenance and Repair
Hours required for deployment in entire pilot program area	1800	
Personnel		
Street Maintenance Forepersons required	1	Cool Streets Pilot Program Proposal
Street maintenance operators required	3	Cool Streets Pilot Program Proposal
Capital Investments		
Cost of CoolSeal pavement per square foot	$0.15	CoolSeal
CoolSeal Procurement Cost	$271,350	Cool Streets Pilot Program Proposal
Operating Costs		
Average Street Maintenance Foreperson salary	$68,126.22	City of Spokane
Average Street Maintenance Operator salary	$49,844.74	City of Spokane
Average Street Maintenance Foreperson hourly wage	$32.75	City of Spokane
Average Street Maintenance Operator hourly salary	$23.96	City of Spokane
Average Annual Cool Pavement Maintenance over 5 years	$0	Environmental Protection Agency
Equipment operation costs per centerline foot	$0.06	USDA

Cost Calculations

Cost Category	2022	2023	2024	2025	2026	2027	NPV (2022 USD)
Personnel Costs							
Street Maintenance Labor Costs	$565,080	$0	$0	$0	$0	$0	$565,080
Capital Costs							
CoolSeal Procurement	$271,350	$0	$0	$0	$0	$0	$271,350
Operating Costs							

Street Maintenance Equipment Costs	$2,855	$0	$0	$0	$0	$0	$2,855
Monitoring & Evaluation							
N/A	$125,893	$18,334	$17,281	$15,815	$14,051	$12,121	$203,495

TOTAL COST	**$965,178**	**$18,334**	**$17,281**	**$15,815**	**$14,051**	**$12,121**	**$1,042,780**