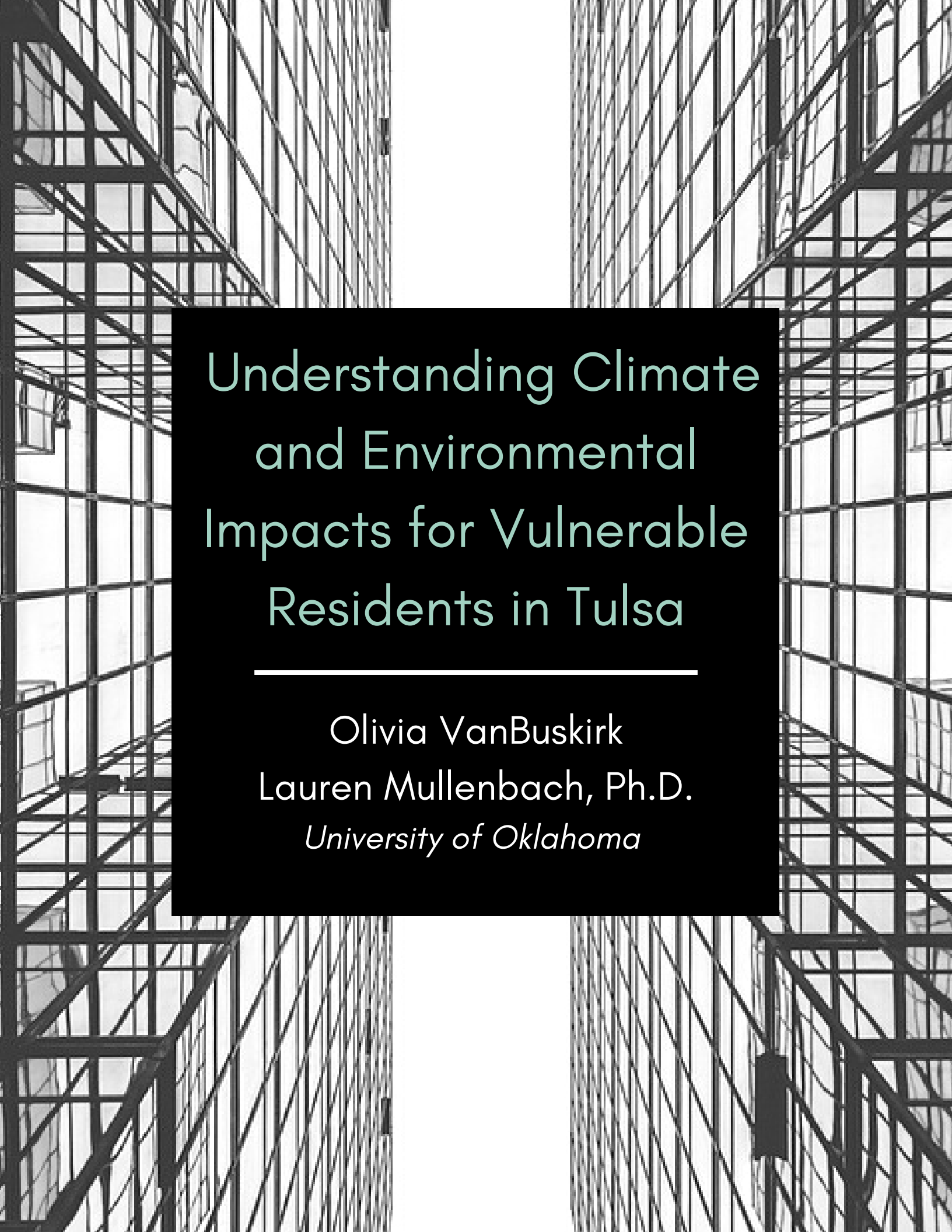


Understanding Climate and Environmental Impacts for Vulnerable Residents in Tulsa

Olivia VanBuskirk
Lauren Mullenbach, Ph.D.
University of Oklahoma

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Located in the south central United States, Tulsa, Oklahoma, has a legacy of injustice that affects resources and adaptation options today. Past injustices include the removal of the Osage people from their land, the Greenwood Massacre, and pollution from oil and gas refineries in the area. Although Tulsa has made great strides in some areas, such as addressing flooding issues that once had them designated as among the most flood-prone communities in the country, the city has not made sufficient progress in other areas that leave them vulnerable to climate change. Root causes from that legacy, including inequities in financial resources, educational achievement, and health outcomes, inhibit Tulsa's ability to manage environmental and climate hazards.

Tulsa is at a crossroads: develop climate adaptation strategies for the future or continue with business as usual. To understand if and how the city is progressing with adaptation, we conducted a series of interviews, analyzed documents from Tulsa city offices, and surveyed residents to hear where they are already experiencing extreme heat and flooding. The results are clear: Tulsa struggles with environmental issues across the board and is doing little when it comes to planning for the future. There is a deep distrust of the city government from residents and even across various agencies. Despite the adoption of a new comprehensive plan in June 2023, there is no sustainability or climate office within the city that can champion the environmental portions of the plan, making it unclear if these actions will be implemented.

This lack of planning will have ramifications for residents and the city if Tulsa does not change course soon. Climate change will greatly affect residents' health, with the greatest impacts felt by poor residents of color. Tulsa is forced into a reactive instead of proactive position for dealing with climate impacts and also has to compete with Oklahoma City, which has started planning for climate change. Overall, Tulsa lags behind for climate adaptation, placing its residents at a disadvantage. However, there are actions Tulsa can take to better prepare; some of which are discussed in this report.

SCIPP
A NOAA CAP TEAM

This study was conducted by researchers from the Southern Climate Impacts Planning Program (SCIPP), a multi-institutional research organization. SCIPP works to understand the impacts of climate change and how cities are preparing to handle the challenges associated with them while also building capacity and creating resources on climate hazards in the south-central U.S. The work presented in this report on Tulsa is part of a larger study investigating climate adaptation, equity, and justice in three cities throughout the region: Tulsa, Oklahoma, Fayetteville, Arkansas, and Waco, Texas. This study was approved by the University of Oklahoma's Institutional Review Board (#15845).

STUDY OBJECTIVES

1 EXAMINE CLIMATE ADAPTATION ACTIVITIES IN TULSA

2 ANALYZE CLIMATE ADAPTATION PLANNING PROCESS

3 ASSESS VULNERABILITY AND EQUITY

KEY TERMS

EQUITY

Equal and fair distribution of opportunities, resources, and environments free from climate hazards and risks, regardless of individual/group identity or background [1].

JUSTICE

Recognition that minority groups are structurally vulnerable and continually disadvantaged in terms of their cultural, political, and socioeconomic rights [1].

CLIMATE ADAPTATION

Actions taken to reduce risks from today's changed climate conditions and to prepare for further impacts in the future. It includes diverse activities designed to reduce climate-related risks and increase capacity to prepare for climate impacts [2].

CLIMATE JUSTICE

Although every person on Earth will experience impacts from climate change, certain groups of people will experience more of the burden of climate change than others. These groups are some of society's most vulnerable – people of color, rural communities, those experiencing homelessness, those with low incomes, children, and the elderly.

Climate change impacts can affect people's health and their economic and social wellbeing. People can develop chronic health conditions from exposure to air pollution and water pollution or experience mental health impacts related to loss of livelihood or forced relocation. Economic effects of climate change include higher utility costs or medical bills, particularly from heat-related illnesses. Low-income households can spend nearly 10% of their income on utility costs from extreme weather events, which is nearly three times the percentage that higher-income households pay. Small-scale social effects include separation of communities after relocation, while large-scale social effects include rising inequality in who is able to adapt to climate change, receive emergency help, and receive investments in adaptation.

These effects will occur at different rates for different groups of people. Those with societal privilege, more resources, and higher social status will be able to more effectively adapt to climate change, while those mentioned earlier who are vulnerable will be affected more substantially.

These disparities in effects from climate change are known as *climate injustices*. **But what is climate justice?**

To achieve climate justice, society must not only correct for current inequalities in access to healthy and safe environments, but also prepare for future conditions. Strategies that plan for climate justice include investing in areas that will experience the worst effects and have the most vulnerable residents, engaging with communities to understand their needs about adaptation, or ensuring vulnerable residents have the resources they need in weather and climate emergencies. When conducting research in Tulsa, we were assessing if the city was planning for climate adaptation in the first place, and if so, whether they considered the needs of vulnerable residents in their planning.

Content on this page was adapted from the South Central Climate Adaptation Science Center's *Managing for a Changing Climate* series, specifically the "Climate Justice" video, which was written by Mullenbach.

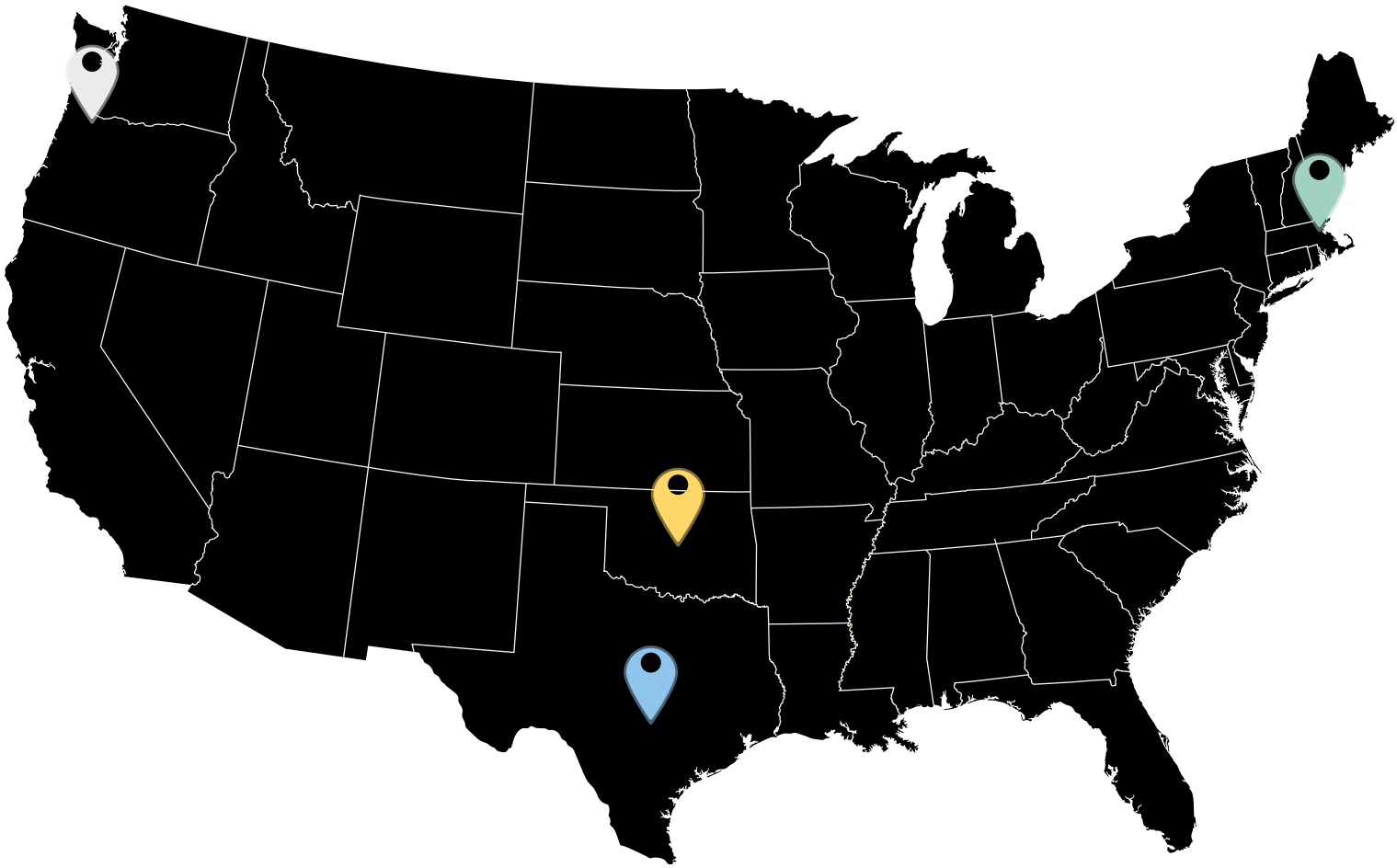
U.S. CLIMATE ADAPTATION

Portland, OR

In 2023, Portland adopted its first *Climate Investment Plan*, which lays out 10 priority areas for the city to take action on climate and the environment. Key focus areas include energy efficiency, transportation decarbonization, and building community organizations' capacity for climate justice work.

Boston, MA

Boston has been a leader in climate adapation since the early 2000s, becoming one of the first cities to include racial equity in plans for the future. While developing *Resilient Boston*, the city engaged with hundreds of residents and community groups. Boston has also implemented initiatives to teach residents about racism.



Austin, TX

Austin was the first major Texas city to adopt a climate plan and updated their strategies in the 2021 *Climate Equity Plan*. Austin anchors their plan in a series of climate justice workshops and takes particular care in naming how the legacies of racism continue to impact residents of color in the city.

Oklahoma City, OK

Oklahoma City adopted its first sustainability plan, adaptokc, in 2020. The plan identifies how the city intends to adapt for future climate conditions by investing in infrastructure, services, and OKC communities. The development of this plan emphasizes that pursuing sustainability and adaptation is possible, even in challenging political environments.

TULSA CONTEXT

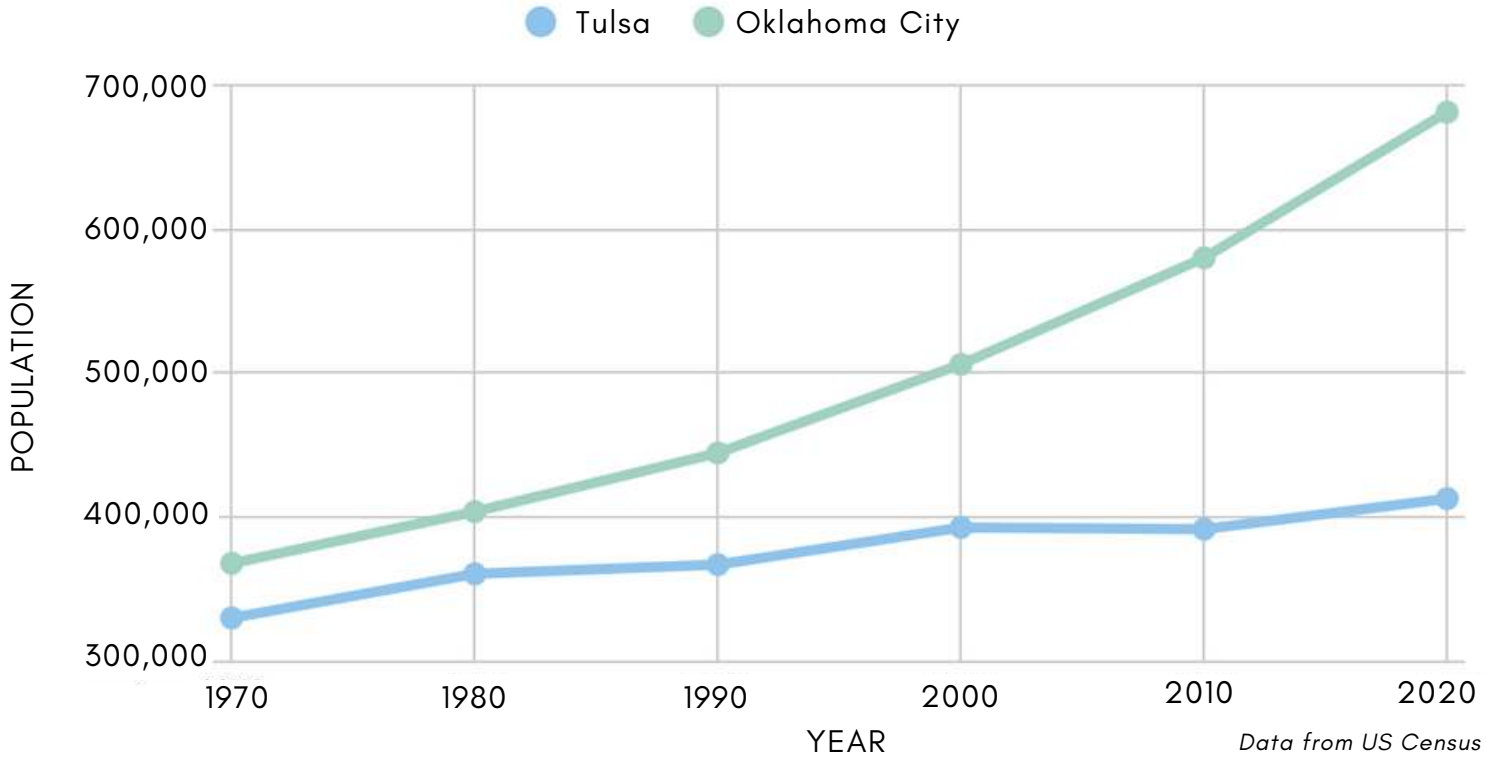
11 year

gap in life expectancy between North and South Tulsa

$31,000

difference in annual median incomes between North and South Tulsa

TULSA AND OKLAHOMA CITY POPULATION GROWTH



Data from US Census

In the last 50 years, Tulsa's population has grown much slower than Oklahoma City's, indicating Tulsa has not been as successful at attracting new residents.

Once an oil and gas hub, Tulsa today is a city of stark inequality [3]. Indigenous people from the Osage Nation were removed from their land to create the city of Tulsa. Being the site of one of the largest race-based massacres in American history -- the Greenwood Massacre in 1921 -- the legacies of racial injustice still linger [4]. Disparities exist between Black and white Tulsans in education, income, housing, and health, and continue to affect Black lives in the city [5]. Between North Tulsa (predominantly Black) and South Tulsa (predominantly white), there is an 11-year gap in life expectancy, and substantial income inequality [6]. Economically, Tulsa continues to rely on the oil, gas, and manufacturing industries, leaving the city vulnerable to economic downturns.

However, the city has taken steps in recent years to acknowledge these injustices. For example, Tulsa has received funding for public art installations about the Greenwood Massacre [7] and has pledged financial support to renovate the Greenwood Cultural Center [8]. The city has also removed questions about criminal history on job applications, giving formerly incarcerated people a chance to become employed [9]. A new park, The Gathering Place, also opened in 2018, creating a new space for the community [10].

Contech Engineered Solutions

Government in Oklahoma

Oklahoma, and Tulsa specifically, has a divided political landscape. Many residents believe the role of government should be small [11], limiting the ability of municipalities to take large-scale action. Therefore, any climate or environmental solutions will likely come from the private sector, rather than being implemented by local governments [12]. Any policy recommendations or solutions centered on expanding the scope of the city may require bridging these political divides.

CLIMATE ISSUES

FLOODING AND PRECIPITATION

Eastern Oklahoma is the wetter portion of the state and Tulsa is no stranger to flooding [13]. With a complex set of levees, other stormwater management infrastructure, and dams along the Arkansas River, the city of Tulsa works with partners such as the Army Corps of Engineers to manage flooding [14]. While effective so far, it remains untold how this infrastructure will fare in a world with more intense precipitation.

EXTREME HEAT

Hotter temperatures are likely in Tulsa as the climate warms. Without significant emissions reduction, the average temperature is expected to rise 5 degrees Fahrenheit and there could be up to 30 more days per year with temperatures over 100 degrees [15]. In the summer of 2023, the city's hazard response was tested when a severe windstorm moved through and caused power outages for up to a week at the same time that temperatures soared to over 100 degrees [16]. Such events could become more common. Severe storms are also expected to become more intense in the future, leaving the city susceptible to more hail and intense winds [17].

CLIMATE ADAPTATION

For cities like Tulsa, climate adaptation planning offers an opportunity to reimagine themselves and prepare residents for a warmer world. These plans often outline strategies a city will pursue to limit emissions and help residents adapt [18]. Topics can range from waste management to public transportation to energy efficiency. Additionally, if cities make intentional effort, climate adaptation can be a way to increase equity and justice across the city by providing vulnerable residents with more support [19]. However, Tulsa does not currently have a climate adaptation plan and the city's sustainability plan has not been updated since 2012. In the time since, the Office of Sustainability has been disbanded within the Tulsa government.

RESILIENT TULSA

While not specifically related to climate adaptation, Tulsa does have its *Resilient Tulsa* plan. Developed in 2018, in partnership with the Rockefeller Foundation's 100 Resilient Cities program, the plan takes a racial equity approach to resilience. *Resilient Tulsa* outlines how the city plans to decrease the racial health and wealth gap and make Tulsa a "world-class city" where everyone can thrive. The plan was updated in 2019 and each year the city updates its Equality Indicators, which track progress on implementing *Resilient Tulsa* initiatives. The plan, its strategies, and subsequent programs are administered by the Mayor's Office of Resilience and Equity (MORE) within the City of Tulsa [20].

RESEARCH METHODS

Interviews

We conducted 12 interviews with neighborhood leaders, planners, and city staff to understand what residents would like to see and what is currently being done in the city regarding climate adaptation. We contacted neighborhood leaders from the city's list of neighborhood liaisons - composed of people involved with their neighborhood associations. Our second group of interviewees was planners at the Indian Nation Council of Governments (INCOG), a regional planning organization which oversees planning activities in Tulsa and surrounding communities. Our final group of interviewees were from the Mayor's Office of Resilience and Equity, with whom we discussed the *Resilient Tulsa* plan and subsequent activities.

To understand Tulsa's approach to resilience, we analyzed the *Resilient Tulsa* plan and documented key themes and strategies that were included. Doing so allowed us to understand how the city is thinking about its future challenges, and to help frame our interviews with the Mayor's Office of Resilience and Equity. Additionally, we were interested in the extent that Tulsa discussed, understood, and planned for the environmental challenges associated with resilience.

Document Analysis

Resident Survey

Another component of this study was understanding where residents in the city experience extreme heat and flooding in their daily lives, as well as what type of action they would like to see the city take to ameliorate these conditions. Using ArcGIS Survey123, we conducted participatory mapping practices with residents from across Tulsa, sharing the survey link with non-profits, interviewees, and through a news story on FOX23. While we struggled with responses, we did gather some data about where residents were experiencing these impacts of climate change.

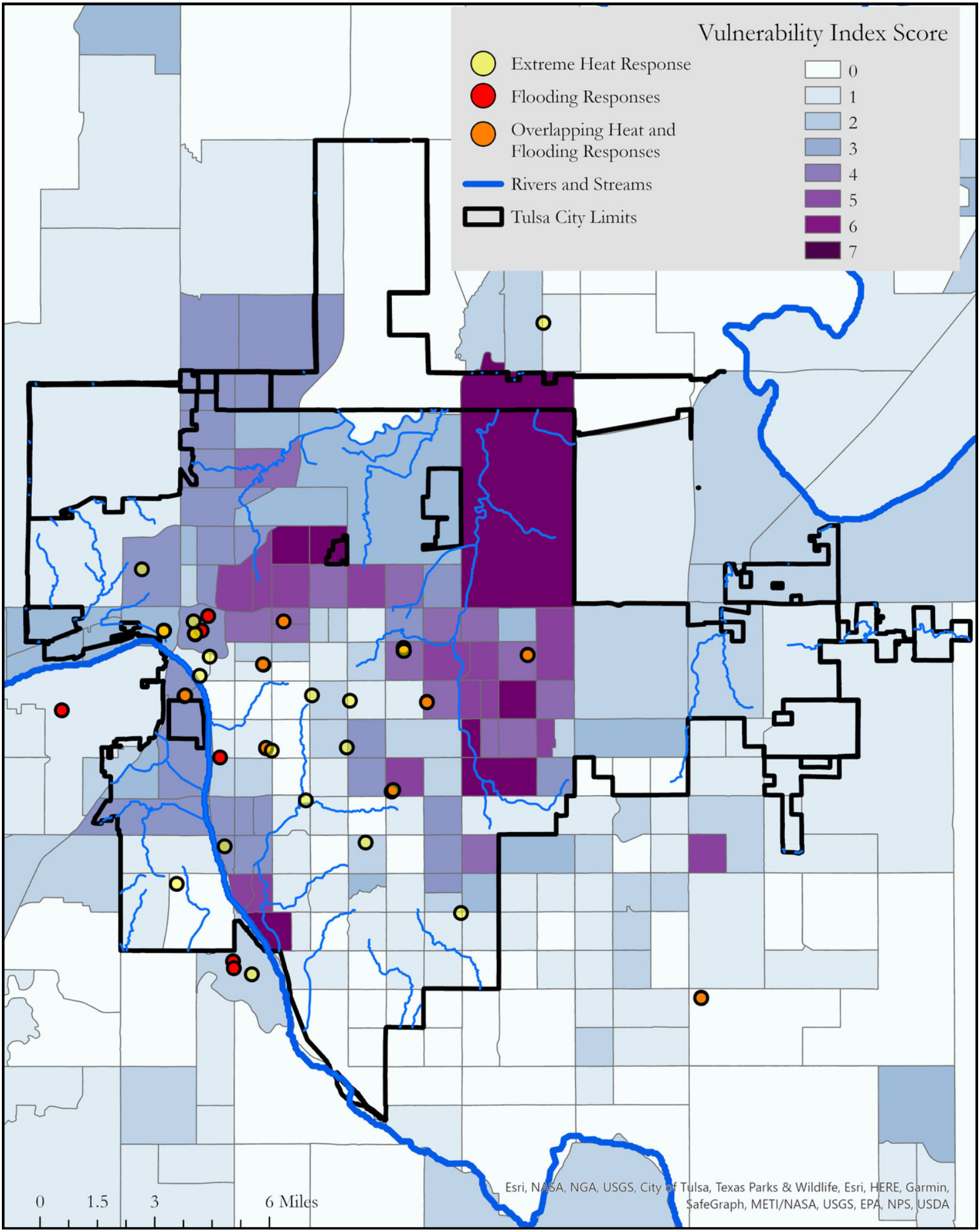
SURVEY RESULTS

We surveyed Tulsa residents about where they experience the warmest temperatures in the city and where they experience flooding on rainy days. Survey123 allows residents to pinpoint locations on a map and provide specific locations where they experience these conditions. Surveys were shared at the Tulsa Farmer's Market, on social media, and in a news story on FOX23. Twenty-nine residents responded to the extreme heat survey and 21 responded to the flooding survey.

We created a vulnerability index to measure different demographic variables in Tulsa, then mapped these across the city on a scale of zero to seven. Census tracts receiving a score of seven would be considered highly vulnerable. Demographic variables included were the percentage of Black or Hispanic residents, the percentage of renters, median incomes, average home values, the percentage of residents who were non-citizens and the percentage of residents who were non-English speakers. Specific thresholds (listed in the table below) were based on the 2020 Census or American Community Survey data for Tulsa and Oklahoma.

Black and Hispanic: > 10%	Renters: > 50%
Median income: < $45,000	Home value: < $180,000
Non-English speakers: > 20%	Non-citizens: > 13%

In the map on page 10, we combine survey responses with this vulnerability index. Heat impacts tended to be felt throughout the city and often overlapped with flooding in the more vulnerable areas of Tulsa, suggesting residents in these areas may have to deal with both hazards.



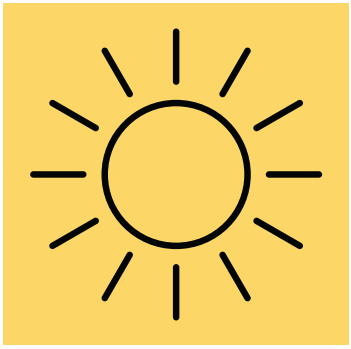
Demographic map data from American Community Survey 2017-2022 5-year estimates

INTERVIEW RESULTS

1. MULTIPLE CLIMATE HAZARDS
2. OTHER ENVIRONMENTAL ISSUES
3. LACK OF TRUST IN GOVERNMENT
4. ENVIRONMENT NOT A PRIORITY
5. HOPE FOR THE FUTURE

WorldAtlas

MULTIPLE CLIMATE HAZARDS



Extreme Heat

Increased Flooding

Severe Storms

Through all our interviews, many climate risks were identified by participants. Most frequently they described extreme heat, more severe storms, wind, and flooding as issues that the city would have to grapple with in the future. Importantly, the city had experienced a significant severe storm on Father's Day weekend just weeks prior to our interviews, with winds over 100 miles per hour, as recorded at the Tulsa Airport. Residents were without power for up to a week as temperatures soared above 100 degrees. These experiences substantially shaped how residents felt about their city's response to extreme weather and climate change. In the aftermath of this storm, residents were left without information from the city about handling debris and cleaning up or how to stay cool in extreme temperatures.

Another challenge mentioned was flooding, particularly because of the city's precarious relationship with the Army Corps of Engineers, the entity responsible for managing dams along the Arkansas River. In 2019, the Corps came under scrutiny after releasing water from the Keystone Dam and flooding parts of Sand Springs and Tulsa during heavy rainfall [21]. As a result of multiple floods in the city's history, Tulsa has invested in substantial stormwater management systems, earning the city the highest rating from the National Flood Insurance Program [22]. However, due to increasing development and a large number of urban creeks, Tulsa faces flooding risk both along the Arkansas River and in other parts of the city. The Army Corps of Engineers and Tulsa's stormwater management department will have to work together to manage an increasing risk of more intense precipitation events in the future.

OTHER ENVIRONMENTAL ISSUES

Tulsa also has its share of environmental issues outside of weather and climate hazards. Two one-hundred-year-old oil refineries sit on the banks of the Arkansas River in west Tulsa, an area of predominantly low-income, white residents. Environmental activists in Tulsa have discovered that the refineries are leaching chemicals and hydrocarbons into the Arkansas River, polluting an area where the city is actively building a new watersports park.

Tulsa World

Regarding air pollution, particulate matter continues to affect residents in the city. Small particulates like PM2.5 are prominent and are also carcinogenic, causing a host of other health problems for residents. Additionally, ozone concentrations are high, and the city struggles to reduce levels to a healthy amount. The city is often out of compliance with EPA regulations and standards. These issues are likely only going to get worse as higher temperatures trap more pollutants lower to the ground, exacerbating air quality issues.

LACK OF TRUST IN GOVERNMENT

Interviewees also expressed a lack of trust in the Tulsa city government, both from a resident perspective and from within agencies responsible for working with other government offices. Among residents, these concerns included worrying about cleaning up tree debris and that the city's solutions to dealing with extreme heat during power outages would be out of touch with reality. For example, the city suggested residents go pick up bags of ice to help deal with the heat, but this requires a car and the ability to leave home (i.e. bring kids and pets with you or have another adult home with them). When calling to ask what to do with storm debris, some residents were met with lengthy waiting times and little more information than "we'll get back to you."

"HAVE SOME KIND OF WAY TO REACH OUT TO US LIKE THEY CARE BECAUSE ***I REALLY FEEL LIKE THEY DON'T CARE."***
– Tulsa resident

Away from the direct aftermath of the Father's Day storm, interviewees also wanted the city to take action for climate and sustainability purposes. Some proposed actions were working to make electricity costs lower. Residents suggested the city could make it easier to access renewable energy options, or that the city could work with power companies to expand weatherization programs for low-income residents. Other interviewees wanted quicker relief, describing programs that their friends in other cities had participated in, wherein those who met income requirements were able to receive fans or air conditioners from the city to help keep cool. Overall, interview participants felt the city had been caught off guard by the storm in June and had little hope that the city would be able to handle more storms in a warmer climate.

ENVIRONMENT NOT A PRIORITY

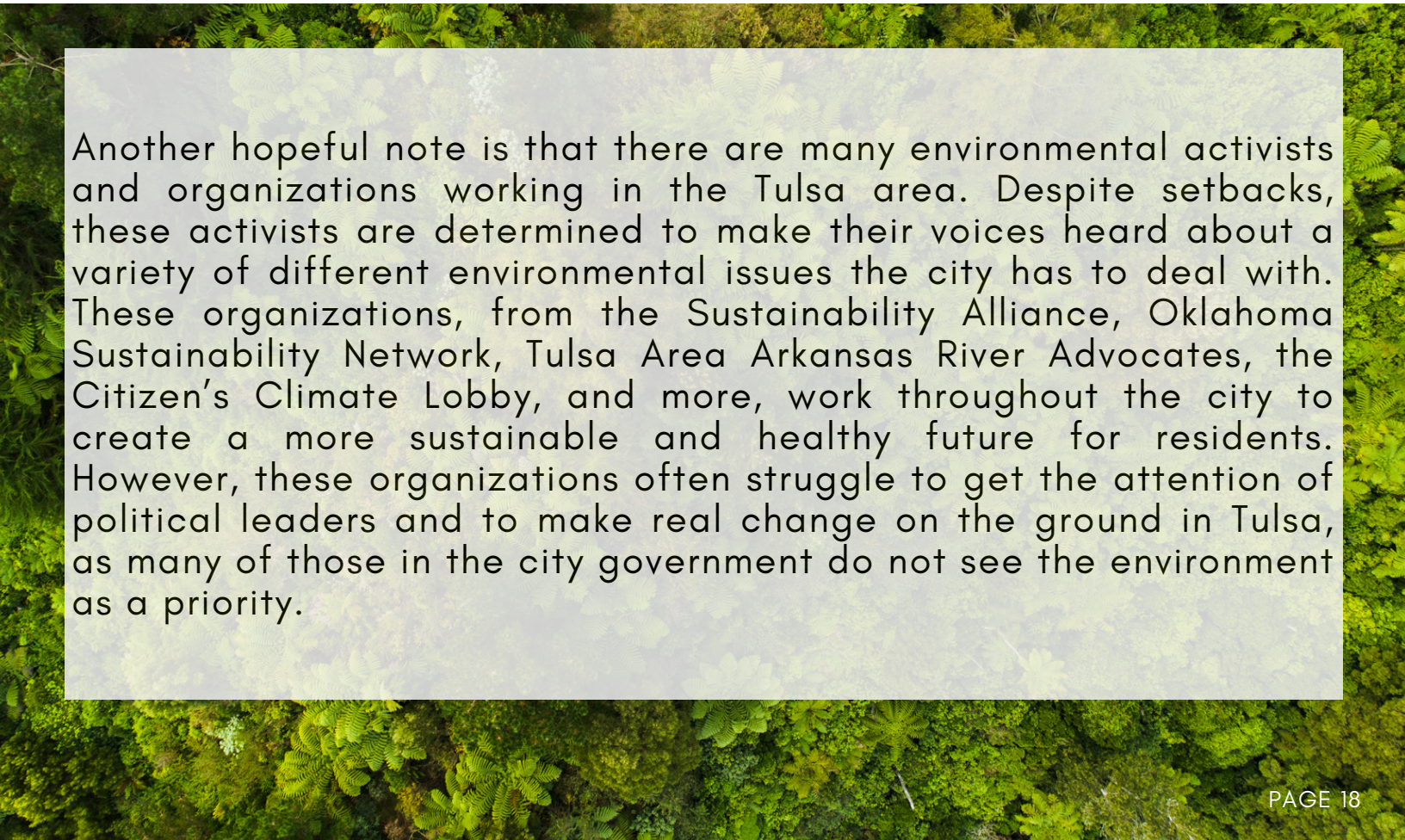
Tulsa has a fraught relationship with sustainability. The city's last sustainability plan was created in 2012. **After being disbanded by a previous mayor, there has not been an Office of Sustainability within the city government in multiple years**. This creates challenges for any long-term planning initiatives which are related to the environment as it is unclear which office within the city government would be responsible for implementing programs. **Any environment or climate-related programs within the city are done through non-profits or INCOG**, though these efforts often do not receive the city's support. Programs have changed language to avoid saying "climate change" and have instead taken alternative approaches like focusing on the economy or health.

Sustainability and climate change are rarely mentioned within *Resilient Tulsa*, and the only strategy within the plan to talk about resilience when it comes to the environment focuses on creating "resilience hubs" for residents to utilize when there is severe weather. **Strategies within the Mayor's Office of Resilience and Equity seem disconnected from their stated goals of racial equity, and they also ignore how the environment intersects with race.** While racial equity is considered the goal of the plan, language within the document frames solutions in language around helping "all Tulsans," instead of taking an equity-oriented approach that would prioritize helping marginalized communities. Programs from this office treat symptoms of racial injustice but do little to undo injustices that are present across the city.

When asked about how resilience might be related to climate concerns, the Mayor's Office of Resilience and Equity described Tulsa as a "data driven city" and they had no data on climate impacts in Tulsa, therefore they could not discuss that with us. The *Resilient Tulsa* plan includes few considerations of the environment and climate besides preparing for future disasters. Additionally, the Tulsa Equality Indicators, which are used to track progress across the city, leave out the environment entirely, focusing on economic opportunities, housing, education, justice, public health, and services. **This leaves many questions about whether or not the government is thinking long-term** and whether or not they will be prepared to address the challenges associated with a warmer world.

HOPE FOR THE FUTURE

In June 2023, the Tulsa City Council adopted the city's new comprehensive plan, planitulsa. This plan contains a chapter on environment and natural resources which discusses challenges and strategies for dealing with flooding, air pollution, energy resources, and conservation. Concepts of environmental justice are also woven through the plan, which represents more attention to equity than previous versions. While this is a big step, one of the key implementation challenges is a lack of clarity. Because the city does not have a sustainability office and the Mayor's Office of Resilience and Equity does not consider the environment part of their purview, many action items within the environment chapter simply list the City of Tulsa as the responsible party -- meaning no one is directly responsible for implementation. For climate and sustainability plans, clear implementation guidelines are key to a plan's success, and without it, it is unclear how much effect the new comprehensive plan will have.



Another hopeful note is that there are many environmental activists and organizations working in the Tulsa area. Despite setbacks, these activists are determined to make their voices heard about a variety of different environmental issues the city has to deal with. These organizations, from the Sustainability Alliance, Oklahoma Sustainability Network, Tulsa Area Arkansas River Advocates, the Citizen's Climate Lobby, and more, work throughout the city to create a more sustainable and healthy future for residents. However, these organizations often struggle to get the attention of political leaders and to make real change on the ground in Tulsa, as many of those in the city government do not see the environment as a priority.

IMPLICATIONS

1. POOR HEALTH
2. REACTIVE PLANNING
3. STATEWIDE STATUS

POOR HEALTH

Poor water and air quality can have detrimental effects on residents, particularly children, older adults, or those with chronic health problems. Air pollution can increase respiratory issues, likelihood of cardiovascular problems, or even cancer [23]. Particularly harmful is small particulate matter, PM2.5, which Tulsa has seen an increase of in recent years. Short-term exposures to high levels of PM2.5 can cause hospitalizations, bronchitis, heart attacks, or even premature deaths [24]. Managing air pollution as temperatures continue to warm will be an important step for the city in order to prevent residents from feeling adverse health effects.

Water quality and quantity also matter a great deal. Tulsa receives its drinking water from surface water sources, which are significantly affected by drought [25]. Hotter future temperatures will increase evaporation of water and precipitation patterns are likely to be more variable in the future, possibly leaving Tulsa with water availability issues [26]. Even when water is available, its quality is also important. Pollution from runoff and other waste that ends up in rainwater plays a role, as do larger-scale polluters like manufacturing or industry. With two refineries on the Arkansas River and other nearby polluting industries, ensuring healthy and safe water access will be key for Tulsa in the future.


Tulsa World

Failing to take action regarding water and air pollution will lead to poor health outcomes for residents across Tulsa. These impacts will be uneven and **disproportionately impact low-income residents of color** who are more likely to live in or near harmful environments.

REACTIVE PLANNING

Every day counts when planning for climate change. If Tulsa were to consider taking a more proactive approach, to guard against the possible impacts of climate change, the city could avoid leaving residents and other organizations to pick up the slack. Developing a climate adaptation plan will help the city be prepared for the future, instead of being surprised by it. Plus, taking action for climate change has benefits for the economy, infrastructure, and health [18]. Many climate adaptation actions also bring economic benefits by allowing the development of renewable energy, savings to residents if their homes are more energy efficient, or reducing the amount of money that has to be spent each year on infrastructure repairs. Tulsa understands this when it comes to flooding and has invested in one of the best stormwater management systems in the country, setting the standard for other cities to aspire to. Tulsa has an opportunity to similarly set the standard for climate adaptation too. Residents, and the city overall, will benefit from a proactive approach on climate change.

STATEWIDE STATUS

Finally, in a state that continues to experience population growth, Tulsa has to compete with Oklahoma City to attract people and businesses. One way to do so is to show residents and companies that the city is thinking about the future and is ready for what is to come. Oklahoma City has already developed an adaptation plan [27] and thought about its future, separating itself from Tulsa in this regard. If Tulsa is to compete in a warmer world, it too needs to consider adaptation actions. If Oklahoma City is prepared, then they will be doing more to help their residents adapt as well, which means those same residents can contribute to the economy more instead of dealing with health challenges like Tulsans might experience. Multiple interview participants indicated people are already choosing to leave Tulsa for many reasons and this trend is likely to continue if the city does not prove it is willing to help residents prepare for the future.

REFERENCES

[1] Chu & Cannon (2021). Equity, inclusion, and justice as criteria for decision-making on climate adaptation in cities. *Current Opinion in Environmental Sustainability*.

[2] Wasley et al. (2023). Ch. 31: Adaptation. In: *Fifth National Climate Assessment*. U.S. Global Change Research Program, Washington DC, USA.

[3] Kemm, J.O. (2004). *Tulsa: Oil capital of the world*. Arcadia Publishing.

[4] Biu et al. (2021). *The color of wealth in Tulsa, Oklahoma: The destruction of Greenwood and the legacy of land loss*. The New School Institute on Power, Race, and Political Economy.

[5] Darity Jr. et al. (2023). Racial disparities in family income, assets, and liabilities: A century after the 1921 Tulsa massacre. *Journal of Family and Economic Issues*.

[6] United States Census American Community Survey, 2017-2022 5-year estimates.

[7] Greenwood Art Project. (2021). *Greenwood Art Project Description*.

[8] City of Tulsa. (2021). *City selects award-winning architectural firm for Greenwood Cultural Center Renovation*.

[9] City of Tulsa. (2019). *Ban the Box*.

[10] Brown, P.L. (2018). Transforming Tulsa, Starting with a Park. *The New York Times*.

[11] Pew Research Center. (2015). *Views about size of government among adults in Oklahoma*.

[12] Palus, C. K. (2010). Responsiveness in American local governments. *State and Local Government Review*.

[13] Oklahoma Climatological Survey. (2011). *Climate of Oklahoma*.

[14] Lyles, W., Pennel, P., and Riley, R. (2021). Jazz on Tulsa time: The remarkable story of the network of flood mitigation champions behind the Tulsa turnaround. *Natural Hazards Review*.

[15] South Central Climate Adaptation Science Center. (2020). *Temperature projections*.

[16] Simons, M., Shular, D., and K. Boothe. (2023). *Aftermath of high winds Father's Day weekend in Tulsa*. Tulsa World.

[17] United States Environmental Protection Agency. (2016). *What climate change means for Oklahoma*.

[18] Stults, M., and Woodruff, S.C. (2017). Looking under the hood of local adaptation plans: Shedding light on actions prioritized to build local resilience to climate change. *Mitigation and Adaptation Strategies for Global Change*.

[19] Hughes, S. (2020). Principles, drivers, and policy tools for just climate change adaptation in legacy cities. *Environmental Science and Policy*.

[20] City of Tulsa Mayor's Office of Resilience and Equity. (2019). *Resilient Tulsa*. https://www.cityoftulsa.org/government/resilient-tulsa/

[21] Fernandez, M. & J. Schwartz. (2019). Army Corps under fire: In a flood, it released more water. *The New York Times*.

[22] Halblieb, B. (2022). Tulsa awarded Class 1 rating in FEMA's National Flood Insurance Program. *2NewsOklahoma*.

[23] National Institute of Environmental Health Sciences. (2023). *Air pollution and your health*. https://www.niehs.nih.gov/health/topics/agents/air-pollution/index.cfm

[24] Martins, N.R., and Carrilho de Graca, G. (2018). Impact of PM2.5 in indoor urban environments: A review. *Sustainable Cities and Society*.

[25] Apurv,T. and Cai, X. (2020). Impact of droughts on water supply in U.S. watersheds: The role of renewable surface and groundwater resources. *Earth's Future*.

[26] Dai, A., Zhao, T., and Chen, J. (2018). Climate change and drought: A precipitation and evaporation perspective. *Current Climate Change Reports*.

[18] Boyd, D., Pathak, M., van Dieman, R., and Skea, J. Mitigation co-benefits of climate change adaptation: A case study analysis of eight cities. *Sustainable Cities and Society*.

[27] City of Oklahoma City Planning Department. (2020). *adaptOKC*. https://www.okc.gov/departments/planning/what-we-do/plans-studies/adaptokc