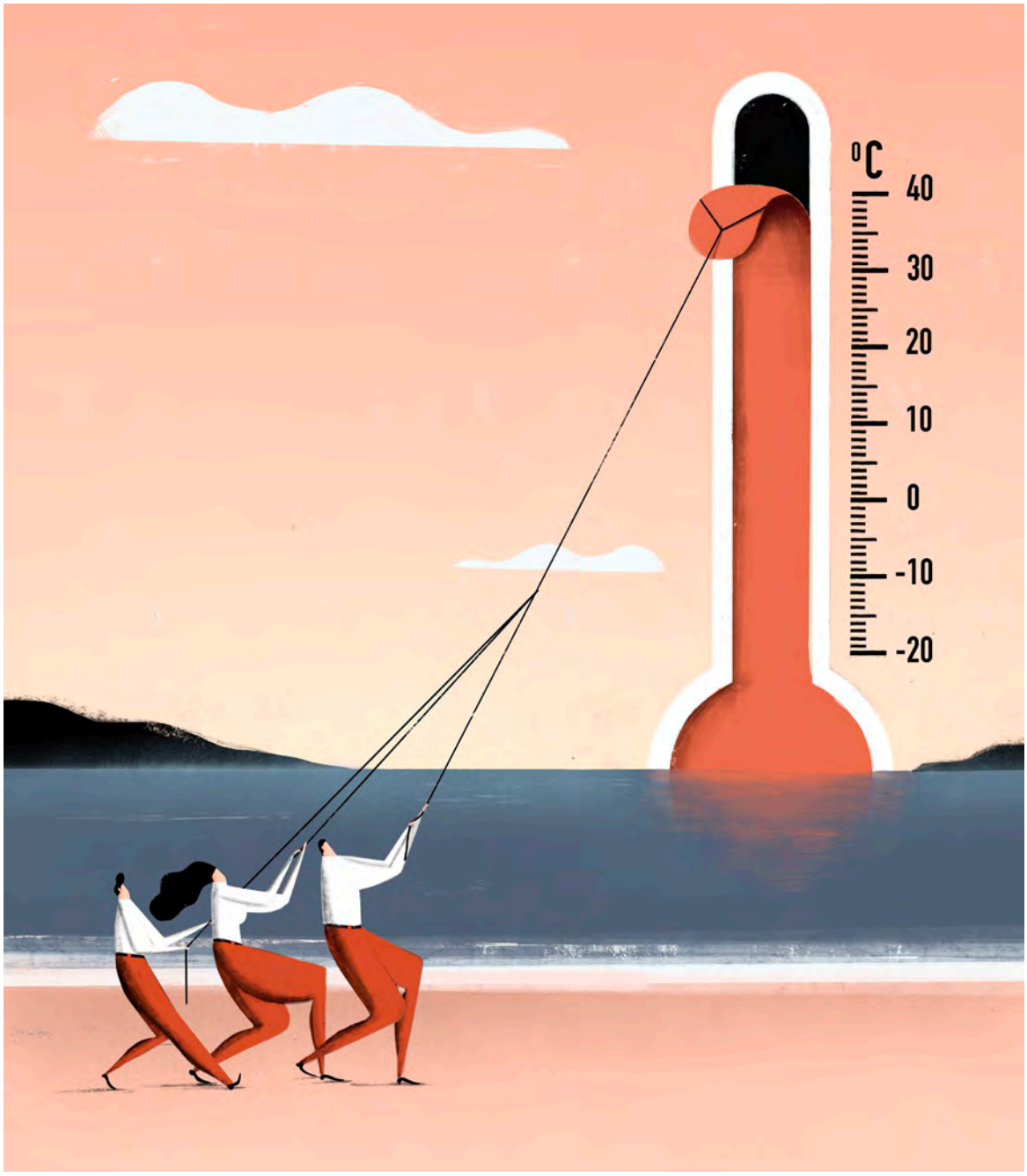

Pepe Serra for ArtistsForClimate.org

Heat Adaptation and Management Report

December 2025

THE BUREAU OF
PLANNING & SUSTAINABILITY

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Summary

In 2022, following a devastating heat dome in 2021 in which 72 Multnomah County residents died, the Portland City Council allocated funding to the Bureau of Planning and Sustainability (BPS) to identify strategies to address and mitigate the problem of elevated and dangerous peak summer temperatures in Portland neighborhoods. This study is a result of that funding, and its purpose is to better understand:

1) how heat is affecting Portlanders
2) how the City's existing programs relate to heat
3) how other cities are addressing increased temperatures, and
4) how Portland might take action to prepare for the impending and long-term impacts of extreme heat and our warming climate.

The foundation of this study is rooted in an examination of extreme heat in Portland—what it is, how it has impacted the region both presently and historically, and how heat resilience will be key to mitigating the effects of frequent and prolonged periods of extreme heat due to climate change in Portland moving forward. This report also analyzes how past government decisions such as restrictive zoning, as well as causal social and environmental factors, have contributed to temperature disparities across the city. The report was written in 2023-2024 with edits and minor additions to sections 2, 5, and the appendix completed in 2025.

Based on data from Multnomah County's Heat Vulnerability Index (HVI), this study recognizes parts of Central City, Lents, Hazelwood, Parkrose Heights, Mill Park, and Powellhurst-Gilbert as being the most vulnerable to heat. The index assesses heat vulnerability at the population level using three key factors:

- *Sensitivity* to heat and illness
- *Exposure* to extreme heat and the elements of our built environments which regulate temperature
- The *capacity to adapt* to extreme heat and lessen harm

The HVI data illustrates that *sensitivity* to extreme heat in the region is highly concentrated in East Portland, with 35 of the 39 tracts (89.7%) in the top quintile for heat sensitivity falling near or east of 82nd Avenue and I-205. These areas appear to have substantially higher youth and senior populations and a greater prevalence of chronic disease. Unlike *sensitivity*, the HVI data shows that areas with higher *exposure* to extreme heat are located around Downtown Portland and the inner Eastside of the city, accounting for 33 of the 39 tracts (84.6%) within the highest quintile of heat exposure. These areas tend to be densely populated, highly developed, and frequently have little vegetation and tree canopy coverage. Finally, *capacity to adapt to* extreme heat more closely resembles *sensitivity* with areas showing lower capacity to adapt located primarily in East Portland, with some areas scattered near Downtown Portland. Data shows a larger share of the populations living in these areas are Black, Indigenous, and people of color (BIPOC,) born outside of the United States and have limited English

proficiency than the tracts that have the highest capacity to adapt and county average. Additionally, more people in the tracts experiencing the lowest degree of capacity to adapt have less than a bachelor's degree education and live in rental housing.

To inform the recommendations of this study, an inventory of the City's existing programs related to heat was conducted (see Appendix A). The inventory documents these efforts categorically as either programs, policies, regulations or studies, details which bureau(s) manage each effort and provides a summary of their key components. The inventory is grouped thematically across major themes: Safety and Emergency Response, Green Infrastructure and Healthy Waterways and Built Environment. The inventory identified a total of 149 such efforts, including 82 policies, 22 programs, three reports and 42 regulations developed and implemented either citywide or by one or more of the following bureaus:

- Bureau of Planning and Sustainability (BPS), including Portland Clean Energy Community Benefits Fund (PCEF)
- Bureau of Environmental Services (BES)
- Portland Bureau of Emergency Management (PBEM)
- Portland Bureau of Transportation (PBOT)
- Portland Parks & Recreation (PP&R), including Urban Forestry (UF)
- Portland Water Bureau (PWB)

This inventory provides structure and clarity to better understand the ongoing and critical work being done throughout the City of Portland to manage and respond to heat and can serve as a springboard from which to propose additional strategies for enhanced heat resilience.

Examining how other cities are mitigating for extreme heat is critical to developing strong recommendations for Portland's heat resilience efforts. As such, six case studies were analyzed to inform this study. These case studies, listed below, include replicable and transferable heat action planning and adaptation methodologies employed in geographies across the US as well as one international example.

- The Boston Tree Alliance Program (Boston, Massachusetts)
- Heat Resilience Solutions for Boston (Boston, Massachusetts)
- Environmental Justice NYC (EJNYC) (New York City, New York)
- The Heat Action Planning Guide for Neighborhoods in Greater Phoenix (Phoenix, Arizona)
- LA Micro Forests (Los Angeles, California)
- Green Corridors (Medellin, Colombia)

The culmination of this study is a series of ten recommendations for long-term strategies to enhance heat resilience in conjunction with near-term actions that complement ongoing emergency preparedness efforts. The recommendations were informed by a collaborative process among City staff through the Resilience Learning Cohort, the BPS Climate Team, and the Inter-Bureau Advisory Group. This diverse group of climate and planning professionals rated potential recommendations based upon their unique institutional perspective and knowledge of their bureau's organizational capacity. The

recommendations fall within three solution types: (1) Policy/Action, (2) Nature-based, and (3) Engineered Solutions and are presented below.

POLICY/ACTION SOLUTIONS	Heat Action Plan
	Environmental Justice Mapping Tool
	Resilience Hubs
NATURE-BASED SOLUTIONS	Street Tree Maintenance
	Private Property Tree Maintenance Assistance Program
	Cool Corridors
	Microforests
	Tree Planting for Heat Resilience Guidelines
ENGINEERED SOLUTIONS	Cool Roof Regulation and Cool Roof Retrofit Career Development Program
	Built Shade Structures

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List of Acronyms

BES	Bureau of Environmental Services
BIPOC	Black, Indigenous, and People of Color
BPS	Bureau of Planning and Sustainability
CBO	Community-based organization
EJ	Environmental Justice
ETC	Equitable Tree Canopy
F	Fahrenheit
FEMA	Federal Emergency Management Agency
FHA	Federal Housing Administration
FLIR	Forward Looking Infrared
HOLC	Home Owners' Loan Corporation
HVI	Heat Vulnerability Index
PCEF	Portland Clean Energy Community Benefits Fund
PBEM	Portland Bureau of Emergency Management
PBOT	Portland Bureau of Transportation
PHB	Portland Housing Bureau
PP&R	Portland Parks & Recreation
PWB	Portland Water Bureau
UF	Urban Forestry
UFP	Urban Forest Plan

1

INTRODUCTION

1. Introduction

In 2021, temperatures in Portland reached 116 degrees Fahrenheit (F) and 72 people across Multnomah County died due to heat-related illness. While City of Portland staff joined other agencies and nonprofits to provide immediate emergency relief to community members by distributing water bottles and staffing cooling centers, the Portland City Council allocated funding to the Bureau of Planning and Sustainability (BPS) to identify strategies to address and mitigate the problem of elevated and dangerous peak summer temperatures. This report is the result of that City Council directive and includes a variety of recommendations based on a review of heat-related data, maps, and programs. The report serves several purposes outlined below.

Provide a series of recommendations for agencies to consider in their efforts to promote heat adaptation, management, and response. Through a collaborative process with climate and planning professionals, this report identifies ten recommendations based on the research conducted as a part of this study.

Serve as a record of ideas and a compilation of research from which to move forward. While there may not be time, capacity, and/or funds available *right now* to create a Citywide Heat Adaptation and Management Plan, or produce Cool Corridors, the City can plan and budget with these recommendations in mind. Because present planning decisions, such as the allocation and distribution of trees and materials used in buildings and hardscapes, will impact Portland for decades to come, the City must consider and plan for the long-term impacts of climate change now.

Serve as a resource for community groups as they continue to advocate for climate justice and shade equity. This report presents data that verifies some areas of Portland are hotter than others. More importantly, it demonstrates that some of these differences stem from historically racist planning practices and decision making. This acknowledgment and data can aide community groups, advocates and climate activists to qualify and apply for funding and to support those most impacted by extreme heat and the worsening effects of climate change.

Underscore the need for heat resilience and adaptation efforts to reflect the needs and context of the local community. To address the differing heat risks between communities, the City needs to consider local perspectives when deciding which resilience and adaptation strategies to deploy. Because there was no scope for community engagement or the co-creation of heat adaptation strategy recommendations in this process, it is essential for community members to have an integral role in identifying and pursuing next steps for enhanced heat resilience and adaptation.

Section 2 of this report reviews information and data on the occurrence of frequent and prolonged periods of extreme heat due to climate change in Portland. Based on data from Multnomah County's Heat Vulnerability Index (HVI), this report recognizes that parts of the Central City, Lents, Hazelwood,

Parkrose Heights, Mill Park, and Powellhurst-Gilbert are the most vulnerable to heat. Section 2 also examines how past government decisions, as well as causal social and environmental factors, have contributed to temperature disparities across the city.

Section 3 summarizes the inventory of the 149 heat resilience efforts ongoing at the City of Portland. A full inventory of these efforts can be found in the Appendix.

Section 4 presents six cases studies to consider replicable and transferable heat action planning and adaptation methodologies employed in other cities. The case studies include:

- Boston Tree Alliance Program (Boston, Massachusetts)
- Environmental Justice NYC (EJNYC) (New York City, New York)
- Green Corridors (Medellin, Colombia)
- Heat Action Planning Guide for Neighborhoods in Greater Phoenix (Phoenix, Arizona)
- Heat Resilience Solutions for Boston (Boston, Massachusetts)
- LA Micro Forests (Los Angeles, California)

Section 5 recommends 10 long-term strategies the City could take to enhance heat resilience in conjunction with near-term actions that complement ongoing emergency preparedness efforts. The recommendations fall within three solution types: (1) Policy/Action, (2) Nature-based, and (3) Engineered. Policy/Action solutions include strategic programs and policies that promote heat adaptation, management, and response. Nature-based solutions use natural features and processes such as trees, plants, and water systems to encourage climate adaptation and resilience. Finally, engineered solutions are designed and built interventions to reduce temperatures and lessen the impacts of extreme heat.

This report will help readers better understand 1) how heat is affecting Portlanders, 2) how the City's existing programs relate to heat, 3) how other cities are addressing increased temperatures, and 4) how Portland might take action to prepare for the impending and long-term impacts of extreme heat and our warming climate.

Background

In 2020, the City of Portland adopted the Climate Emergency Declaration and officially recognized that a climate emergency threatens our city and the world. In doing so, City Council acknowledged that "warmer, wetter winters will increase the risk of localized flooding and landslides, and hotter, drier summers will increase the risk of extreme heat events, both of which will have a direct impact on private

property, public infrastructure, and the health and well-being of frontline communities that are disproportionately at risk from these natural hazards".[1]

Eliminating carbon emissions from our buildings, vehicles, and businesses is one part of addressing the climate emergency. The other part is helping residents become resilient to the experienced impacts of climate change now. Many scientific studies show that greenhouse gases can stay in the atmosphere for centuries once emitted. Thus, even if human-caused emissions of carbon dioxide stop entirely, the earth will continue to experience atmospheric warming and sea-level rise for more than 1,000 years.[2] Therefore, climate adaptation, the actions taken to adapt to and reduce the detrimental impacts of climate change, in combination with mitigation efforts is critical for resilience (Figure 1).

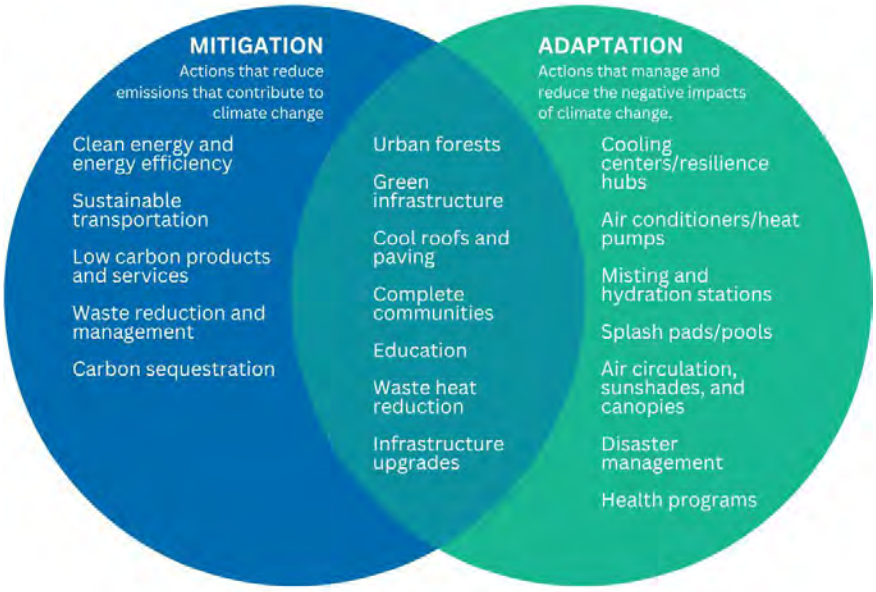

Figure 1. Venn diagram of tools for climate mitigation and adaptation

One year following the adoption of the Climate Emergency Declaration, temperatures in Portland escalated to 116 degrees F. Roads buckled, power cables melted, and 72 people died due to heat-related illness. Scientists predict that the frequency and severity of extreme heat events, such as the

[1] City of Portland, Oregon, Resolution #37494. June 30, 2020.

[2] National Aeronautics and Space Administration, *Short-lived greenhouse gases cause centuries of sea-level rise.* Original publication January 13, 2017. https://climate.nasa.gov/news/2533/short-lived-greenhouse-gases-cause-centuries-of-sea-level-rise/?platform=hootsuite

2021 heat dome, will increase.[3] As a City dedicated to protecting its residents, infrastructure, and built and natural environments from the adverse and potentially lethal effects of climate change, in 2022 the Portland City Council allocated funding to the Bureau of Planning and Sustainability to identify strategies to address and mitigate the problem of elevated and dangerous peak summer temperatures in Portland neighborhoods.

Approach

Several processes and methods were employed to develop this study and to develop the ten recommendations for enhanced heat adaptation and management in the City of Portland.

INVENTORY – To better understand the City's efforts to adapt to and manage heat, this study compiled an inventory of policies and programs that significantly contribute toward cooling/shading and increasing individuals' adaptive capacity. The inventory included a review of City code, project summaries, and strategic plans to ascertain the work of each bureau. It is included in the appendix .

PEER REVIEWED RESEARCH AND CASE STUDIES – The study also included a robust research component including an analysis of numerous peer reviewed journal articles and research papers to understand how climate change will impact the Portland region in the future and to ascertain the effectiveness of various adaptation and management methods. In addition to research related to climate change in the Portland region, this study included an analysis of heat-related work occurring in other cities to investigate strategies that could be relevant and transferable to Portland. Finally, interviews were conducted with Chief Heat Officers, Chief Resilience Officers, Climate Scientists, and other subject matter experts throughout the country to solicit guidance and lessons learned.

RESILIENCE LEARNING COHORT – Early in the process of developing this report, a learning cohort was established to guide this study. The group was comprised of staff from multiple teams within the Bureau of Planning and Sustainability, including Planning (River and Environment, Economic, Central City, Code Development, and Urban Design), Sustainability (Climate), Tech Services, and the Portland Clean Energy Community Benefits Fund (PCEF). The cohort met twice monthly for the first twelve months and once per month for the final six months. Initially, presentations and discussions centered on the meaning of resilience, metrics for defining heat vulnerability, climate change data, previous mapping campaigns, and case studies. The final six months were focused on reviewing and refining recommendations for inclusion in this report.

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[3] Bartusek, S., Kornhuber, K., & Ting, M, "North American heatwave amplified by climate-change-driven nonlinear interactions," *Nature Climate Change*, 12, 1143–1150. (2022). https://doi.org/https://doi.org/10.1038/s41558-022-01520-4

INTER-BUREAU ADVISORY GROUP – As climate and resilience work is enacted by all the bureaus, it was essential to consult with climate and adaptation practitioners across the City. To that end, meetings were held with individuals whose work plan included elements of climate resilience, management, and/or emergency response and they provided recommendations on the report and suggested potential strategies to include in the report.

2

EXTREME HEAT IN PORTLAND

2. Extreme Heat in Portland

Understanding Extreme Heat and Urban Heat Islands

According to the Federal Emergency Management Agency (FEMA), "In most of the United States extreme heat is a long period (2 to 3 days) of high heat and humidity with temperatures above 90 degrees."[4] That said, heat can be very dangerous even when the temperature is under 90 degrees. Other significant factors include duration, humidity, rate of change, nighttime temperature, and surface temperature.

- **DURATION:** Prolonged heat exposure, without time for people, animals, and vegetation to recover, exacerbates the risks associated with heat.
- **HUMIDITY:** Humidity is the amount of water vapor in the atmosphere. High humidity leads to a greater risk of heat illness and compromises the human body's ability to sweat. The evaporation of sweat from our skin cools our bodies; however, high humidity prohibits evaporative cooling.
- **RATE OF CHANGE:** Our bodies need time to acclimate, or adjust, to changes in temperature. A sudden change from cold to hot weather often results in greater public health impacts.
- **NIGHTTIME TEMPERATURE:** High nighttime temperatures, especially 80 degrees F and warmer, don't allow for recovery from the oppressive daytime heat. Without relief, stresses on the body accumulate and increase the likelihood of heat-related illness and death. City dwellers are especially at risk. Concrete, steel, glass, and asphalt absorb heat throughout the day and re-emit it at night, increasing nighttime temperatures. Since records began in 1895, summer overnight low temperatures in the United States have warmed twice as fast as afternoon high temperatures.[5]
- **SURFACE TEMPERATURE:** Urban areas experience consistently higher temperatures than outlying areas. This is known broadly as the ***urban heat island effect***. Buildings, roads, and other built infrastructure absorb and re-emit the sun's heat more than natural landscapes, such as forests and bodies of water. Urban areas become "islands" of higher temperature relative to outlying areas as a result of having higher concentrations of buildings and structures and less greenery (Figure 2).[6]

[4] "Extreme Heat," FEMA Preparedness Community, https://community.fema.gov/ProtectiveActions/s/article/Extreme-Heat.

[5] "Assessing the U.S. climate in August 2018," National Centers for Environmental Information, (Originally published September 6, 2018, https://www.ncei.noaa.gov/news/national-climate-201808.

[6] EPA (n.d.) *Learn About Heat Islands*, https://www.epa.gov/heatislands/learn-about-heat-islands.

Figure 2. Diagram of an urban heat island, Whitney Holt.

In urban areas like Portland, the extent of urban heat islands varies depending on site and neighborhood characteristics, with some areas characterized by extensive heat islands, while others have none. Figure 3 depicts data from Multnomah County's Heat Vulnerability Index[7] (described further in Heat Across Portland section below) to illustrate urban heat islands across Portland. The index identifies heat islands as areas with a mean surface temperature of 85+ degrees between 2016 and 2022 (60th percentile). Of Portland's approximately 93,000 acres, roughly 34,000 acres (36 percent) were encompassed by heat islands in August of 2023.

[7] Multnomah County. 2024 *Heat Vulnerability Index,* *http://experience.arcgis.com/experience/0af8ec76c2024e6980bf83771a165a0a/page/Heat-Vulnerability*.

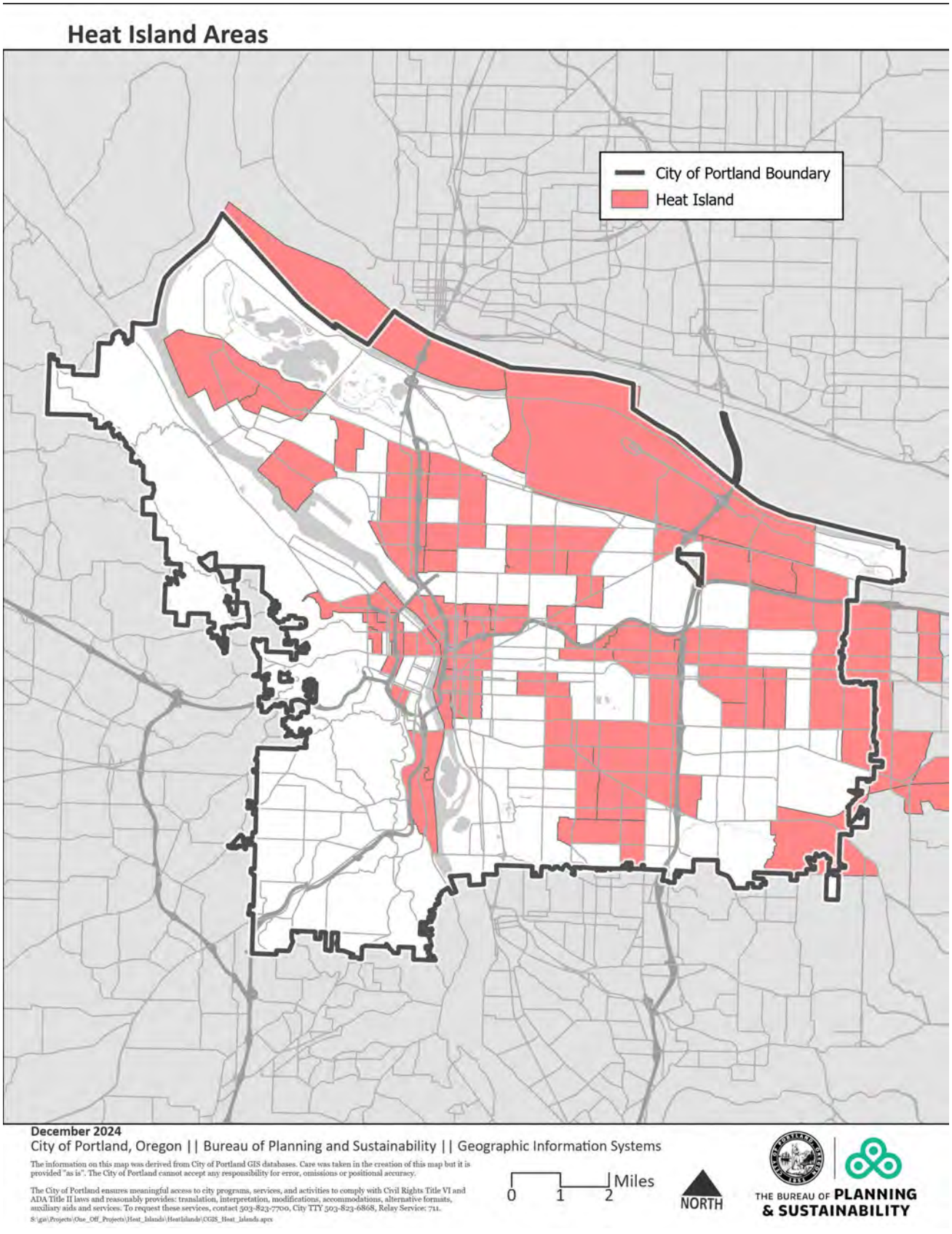

Figure 3. Heat Islands across Portland in August 2023.

How Extreme Heat Impacts the Region

Extreme heat is a national concern. In 2018, the National Climate Assessment identified extreme heat among the most serious threats to human health in urban areas across the United States.[8] Heat is the leading cause of weather-related death in the United States, killing approximately 1,500 people per year from 2008 through 2017.[9]

On January 4, 2023, the Oregon Climate Change Research Institute published the *Sixth Oregon Climate Assessment*, a biennial analysis of the recent scientific findings related to the impacts and risks of climate change in Oregon. The assessment cites multiple scientific studies that conclude Oregon is becoming warmer and drier. The report confirms the number of days warmer than 90 degrees F and nights warmer than 65 degrees F is increasing. Moreover, without significant action, scientists predict Oregon's annual temperature will increase by roughly 5 degrees F by 2050, and 8.2-degrees F by the 2080s.[10] This level of warming will be catastrophic for many.

Although dangerously warm temperatures are less common in Portland than in other parts of the country, Portland residents are less accustomed, physiologically and behaviorally, to high temperatures. For example, in June 2021, 72 Multnomah County residents died due to heat related illness during an historically unprecedented heat dome.[11]

Scientists predict the occurrence and severity of extreme heat events are increasing. A 2023 article in the *Journal of Climate and Atmospheric Science* stated, "in the absence of committed efforts to curtail anthropogenic emissions below intermediate levels, climate model projections indicate a rapidly increasing risk of the PNW [Pacific Northwest] regularly experiencing 2021-like extreme summer temperatures, with a 50% chance of yearly occurrence by 2050."[12] The authors argue that it is imperative for historically temperate regions to establish climate resilience strategies that mitigate and adapt to extreme heat.

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[8] Reidmiller, D., Avery, C. W., Easterling, D. R., Kunkel, K. E., & Lewis, K., *Fourth National Climate Assessment* (2018). Washington D.C.; U.S. Government Publishing Office.

[9] Khatana, S.A.M., R.M. Werner, and P.W. Groenevel. 2022. Association of extreme heat with allcause mortality in the contiguous U.S., 2008–2017. JAMA Network Open 5: e2212957. DOI: 10.1001/jamanetworkopen.2022.12957.

[10] Fleishman, E., editor. 2023. Sixth Oregon climate assessment. Oregon Climate Change Research Institute, Oregon State University, Corvallis, Oregon. DOI: 10.5399/osu/1161.

[11] Multnomah County, Health Impacts from Excessive Heat Events in Multnomah Country, Oregon 2021 (2022), available: Final Heat Report Published June 2022.

[12] Heeter, K.J., Harley, G.L., Abatzoglou, J.T. *et al.* Unprecedented 21st century heat across the Pacific Northwest of North America. *npj Clim Atmos Sci* 6, 5 (2023). https://doi.org/10.1038/s41612-023-00340-3.

Whether looking at the impacts of extreme heat from a national, regional or local context, studies show that risks are increasing. The health and wellbeing of Portland residents is dependent upon building the city's heat resilience and implementing interventions to mitigate the impacts of extreme heat.

The Importance of Heat Resilience

Resilience has become a hot topic of late. Resilient economies, resilient people, resilient businesses—we all seem to want to develop more resilience. But what is resilience, and what does it mean for Portland?

Resilience is the ability to bounce back from disturbance or change, but it has come to express many more specific concepts. Portland's 2035 Comprehensive Plan defines resilience as "The capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment."[13] This report aims to explore resilience to climate change and, more specifically, to extreme heat. As such, resilience can be described as the city's capacity to reduce risk and improve the ability of individuals, communities, environmental systems, and the natural and built environments to withstand, recover from, and adapt to extreme heat.

This means ensuring all Portlanders have access to the resources they need to stay cool during extreme heat events. It also means reducing temperatures in hotspots and heat islands throughout the city to address the unequal impact of heat in Portland.

Heat Across Portland

Overview

Heat discrepancies in Portland are highly influenced by the city's topography, rivers, and streams as well as by social and historical factors. Portland is divided by the Willamette River and the west side of Portland contains a portion of the Tualatin Mountains, often referred to as the West Hills or Southwest Hills. Though more like rolling hills than precipitous mountains, their steep grades and rocky slopes make development challenging. Consequently, the forest canopy is preserved and many of the homes in the area are built on hillsides and amongst the evergreen trees (Figures 4-5). Portland's west side also boasts several large parks and natural areas. The largest, Forest Park, contains more than 5,200 acres of native northwest forest (Figure 6).

[13] City of Portland, Oregon, Bureau of Planning and Sustainability, *2035 Comprehensive Plan*, update through May 2023. https://www.portland.gov/bps/planning/comp-plan-2035/about-comprehensive-plan/2035-comprehensive-plan-and-supporting.

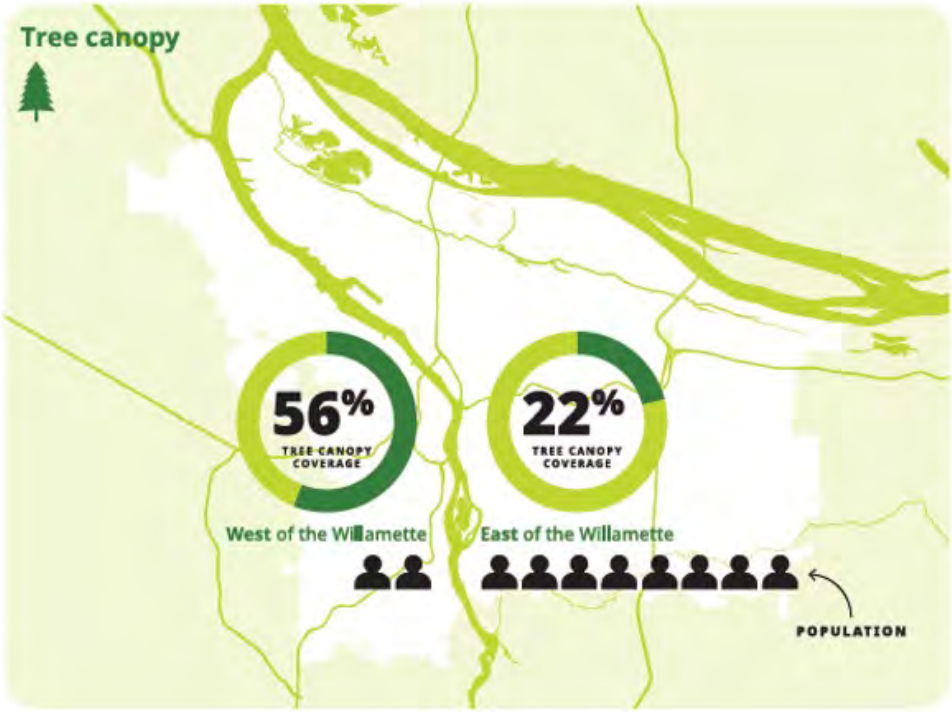

Figure 4. Percentage of tree canopy coverage east and west of the Willamette River in Portland (graphic courtesy of Portland Parks & Recreation).

Figure 5. Portland's West Hills neighborhood of Hillside looking east over Northwest Portland and downtown, 2015 (Image courtesy of Trulia).

Figure 6. Forest Park (Image courtesy of Portland Parks and Recreation).

In contrast, the east side of Portland is relatively flat. A few significant buttes pepper the area including Mt. Tabor, Powell Butte, and Rocky Butte, but the otherwise even terrain lends itself to long extensions of freeway and the regular geometry of city streets that blanket its landscape (Figure 7). The city's once pervasive riverine forests were logged long ago in favor of canneries, grain mills, meat packers and bungalows. While the east side is no longer a hub for logging, much of Portland's industrial land is still sited there, particularly along the Willamette River where tree canopy is quite low (Figure 8).

Figure 7. Looking toward East Portland showing buttes in background and regular geometry of city streets in foreground (Image courtesy of wikimedia).

The topography of Portland and the era of development have contributed to a discrepancy in tree canopy coverage in the city. 56% of the west side of the Willamette River is covered in tree canopy, while only 22% of the east side of the Willamette River is (See Figure 4). Figure 8 demonstrates that a

discrepancy exists even when Forest Park is not included in the figures. The lowest tree coverage areas of the city align with the industrial areas of the city along the Columbia and Willamette Rivers.

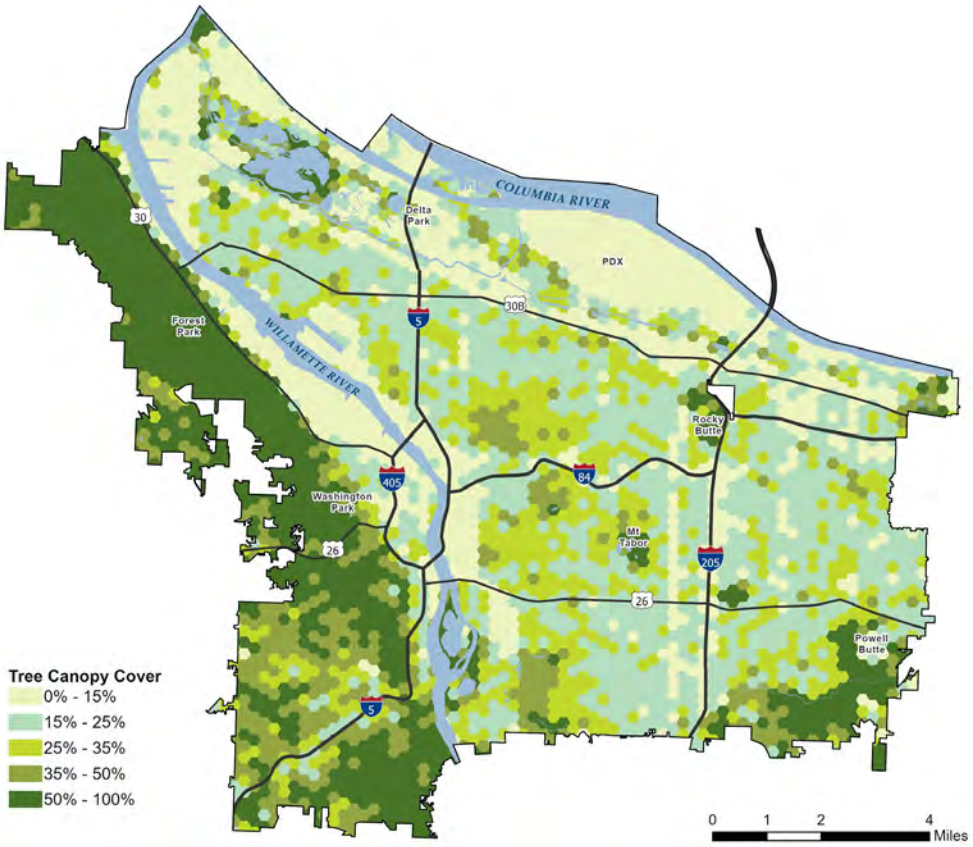

Figure 8. Percentage of tree canopy cover across the Portland area; lowest tree cover areas are clustered in industrial areas along the Willamette and Columbia Rivers (Portland Parks & Recreation, September 2025).

How Heat Affects Portlanders

The best source of information for understanding how heat affects different parts of Portland is Multnomah County's interactive Heat Vulnerability Index[14]. Multnomah County developed a Heat Vulnerability Index (HVI) to help guide extreme heat response and long-term resilience and adaptation planning.

The index assesses heat vulnerability at the population level using three key factors[15]:

[14] Multnomah County. 2024 *Heat Vulnerability Index,* *http://experience.arcgis.com/experience/0af8ec76c2024e6980bf83771a165a0a/page/Heat-Vulnerability*.

[15] Multnomah County Health Department, Environmental Health Services. *Heat Vulnerability Index Methodology*. February 2023. Available: Heat Vulnerability Index Methods Report.

- *Sensitivity* to heat and illness
- *Exposure* to extreme heat and the elements of our built environments which regulate temperature
- The *capacity to adapt* to extreme heat and lessen harm

Sensitivity to extreme heat refers to the physiological susceptibility to the harmful health impacts related to heat exposure and the body's ability to thermoregulate. One of the most prevalent indicators of sensitivity is age, as heat stress has been shown to be especially harmful to both youth and older adults. Living alone or being socially isolated can also increase sensitivity to extreme heat. Another commonly used indicator of sensitivity to extreme heat is the presence of pre-existing conditions or comorbidities. Conditions such as diabetes, cardiovascular diseases, and respiratory diseases have been shown to contribute to complications in the body's physiological response to extreme heat, thus heightening susceptibility to heat-related illness. Studies have also shown that men generally tend to be at higher risk than women to develop a heat-related illness during extreme heat events.

The HVI data shows that sensitivity to extreme heat in Multnomah County is highly concentrated in East Portland, with 35 of the 39 tracts (89.7%) in the top quintile for heat sensitivity falling near or east of 82nd Avenue and I-205 (Figure 9). These areas have substantially higher youth and senior populations and a greater prevalence of chronic disease. Additionally, highly sensitive areas have a smaller male population than both the county and the least sensitive areas.

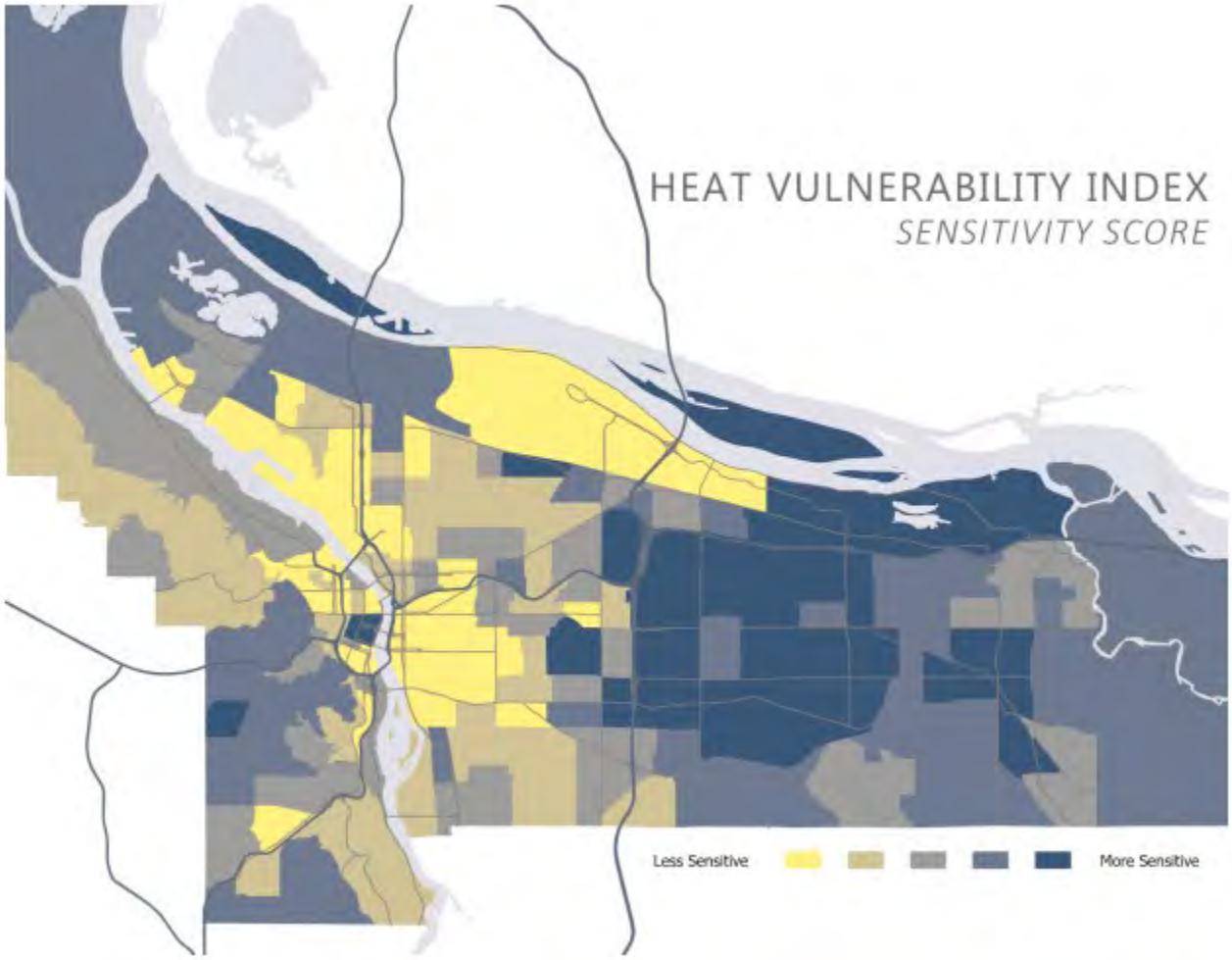

Figure 9. Multnomah County's Heat Vulnerability Index Sensitivity Score (Multnomah County 2023).

Exposure assesses the degree of contact with extreme heat or variables shown to either increase or decrease local temperatures. Prolonged exposure to extreme heat produces stress on the body and can lead to heat-related illness and mortality. Exposure within an urban context focuses mainly on land cover and the structure of the built environment. Areas experiencing higher ambient temperatures are typically characterized by lower levels of vegetative cover, tree canopy, and soil moisture, combined and a greater proportion of land area covered with impervious surfaces. Population growth and density contribute to increased ambient temperatures through the heat generated by daily human activities. Building and housing density also change the cooling potential of the built environment, since detached homes have more space for cooling where more dense areas, such as downtown districts, can further trap heat and absorb radiation. Because most heat-related deaths occur indoors, housing characteristics (including appliance and energy use, window placement and access to air conditioning) are also an important indicator of exposure.

Unlike sensitivity, the HVI data shows that areas in Multnomah County with higher exposure to extreme heat are located around Downtown Portland and the inner Eastside of the city, accounting for 33 of the

39 tracts (84.6%) within the highest quintile of heat exposure (Figure 10). These areas tend to be densely populated and highly developed with little vegetation and tree canopy coverage.

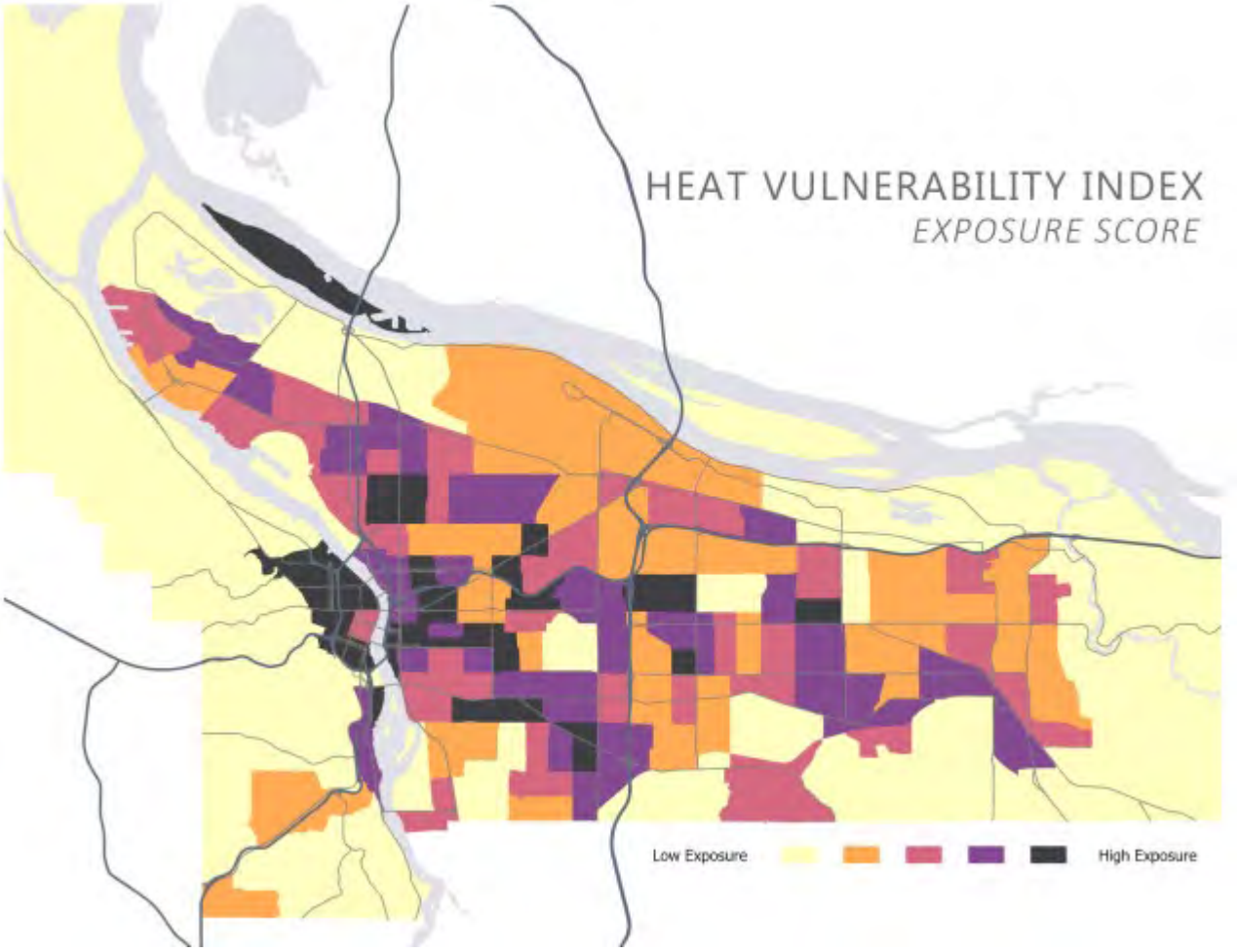

Figure 10. Multnomah County's Heat Vulnerability Index Exposure Score (Multnomah County 2023).

Capacity to adapt addresses what is needed to minimize both sensitivity and exposure and captures the existing barriers which hinder people from being able to do so. Capacity to adapt is therefore more focused on social and economic forces which reduce the ability to adapt to extreme heat at the population-level rather than for individuals. Educational attainment is one common measure of the capacity to adapt to extreme heat and is closely associated with income. People with a high school education or less have been shown to experience higher rates of heat-related death than people with greater levels of educational attainment. In general, those with a high school education or less are more likely to live in neighborhoods with little tree canopy cover. Like education, living in rental housing is another metric related to income and has been shown to reduce the capacity to adapt to heat due to the availability of household amenities, access to air conditioning, and financial burden related to utilities costs. Additional metrics that influence the capacity to adapt include English language proficiency, cognitive difficulties and foreign-born populations.

There are also racial and ethnic disparities in the capacity to adapt to extreme heat. Throughout the United States, environmental racism and discriminatory housing and economic policies have contributed to segregating BIPOC communities into disinvested neighborhoods which are disproportionately exposed to environmental hazards and have little access to protective factors, such as quality housing stock and air conditioning. Additionally, in the past, BIPOC communities were underrepresented as stakeholders in climate-health discussions and decision-making processes and were often still not actively involved in large environmental movements and groups. This lack of representation in environmental decision-making resulted in limited political power and greater barriers to increasing their capacity to adapt to extreme heat.

The capacity to adapt to extreme heat in Multnomah County more closely resembles sensitivity with areas showing lower adaptive capacity located primarily in East Portland and scattered near Downtown Portland (Figure 11). A larger share of the populations living in these areas are BIPOC, born outside of the United States and have limited English proficiency than tracts estimated to have a higher capacity for adaptation. Additionally, more people in the tracts estimate to have the lowest capacity to adapt have less than a bachelor's degree education and live in rental housing.

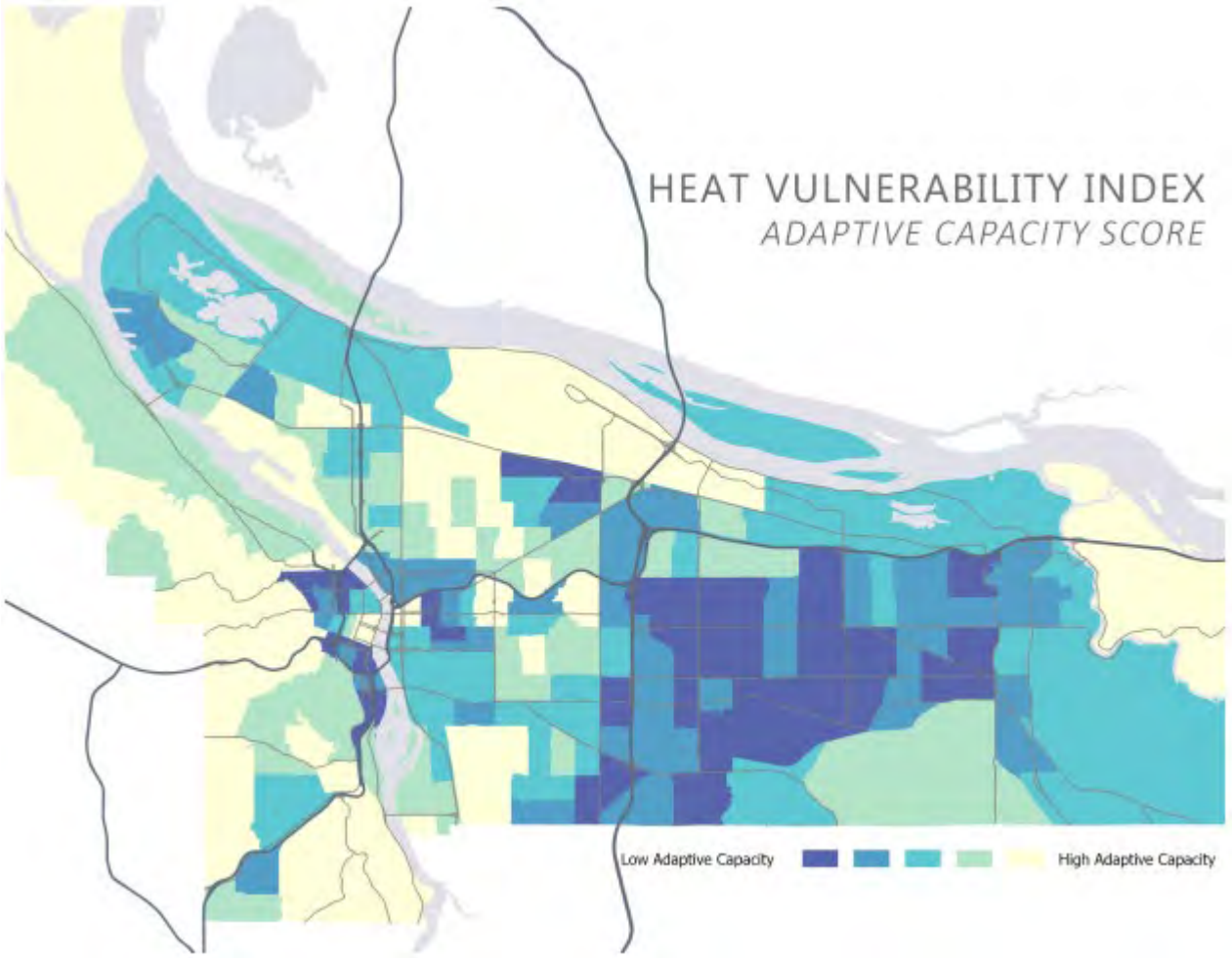

Figure 11. Multnomah County's Heat Vulnerability Index Adaptive Capacity Score (Multnomah County 2023).

Using this framework of analysis around sensitivity, exposure and adaptive capacity, Multnomah County developed an HVI Composite Score to show the least and most vulnerable areas in and around Portland (Figure 12). According to this analysis, within Multnomah County, 39 census tracts (19.8%) made up the top quintile of overall heat vulnerability. Of these 39 tracts, 29 (74%) are located east of I-205. Parts of Downtown Portland and areas around the Portsmouth and Cully neighborhoods are also in the top quintile for heat vulnerability.

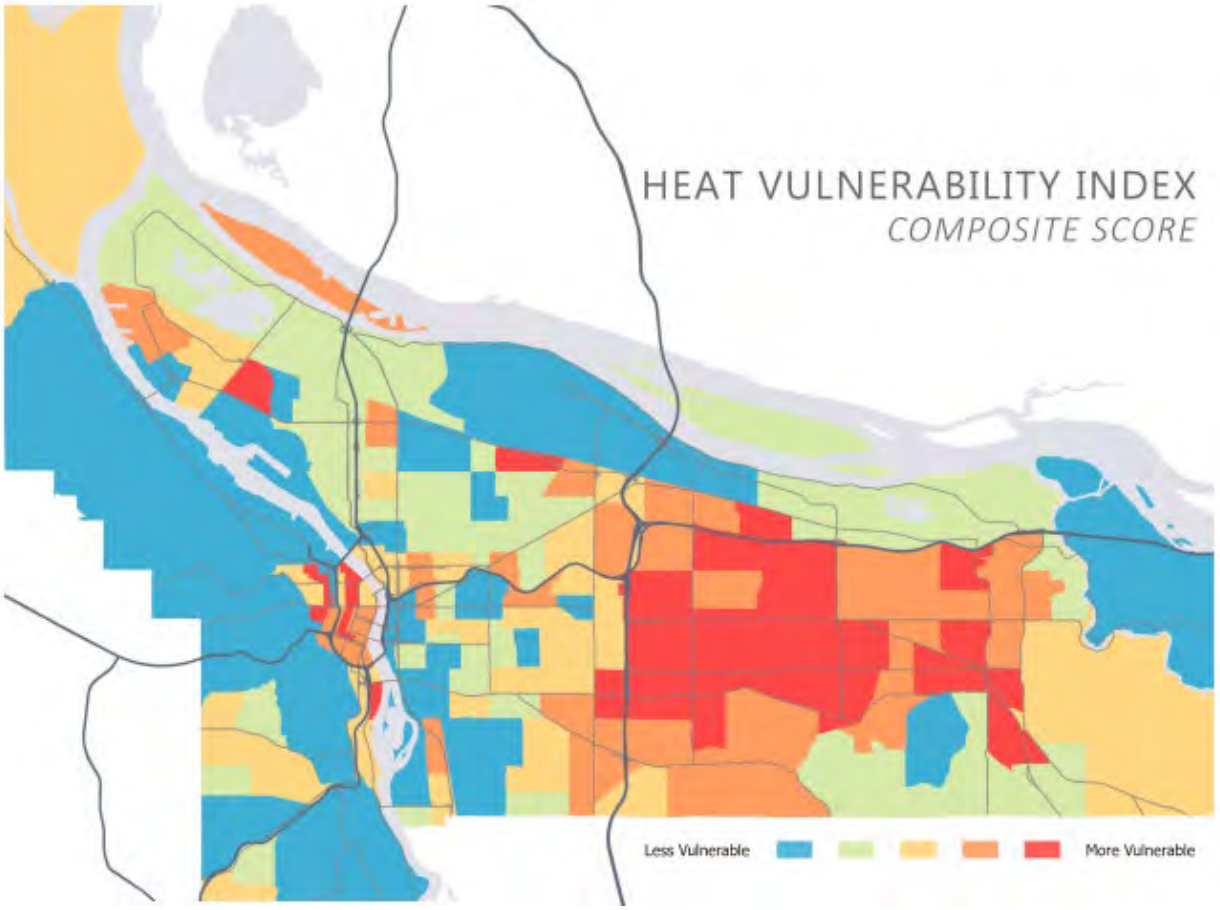

Figure 12. Multnomah County's Heat Vulnerability Index Composite Score (Multnomah County 2023).

Centering Equity

While all of Portland experiences extreme heat, some communities experience disproportionately severe impacts and/or are more vulnerable to extreme heat. Some residents experience greater risk due to environmental factors, the legacy of past planning and real estate decisions, health factors, or age. Residents that may be more vulnerable to the impacts of extreme heat include older adults, children, communities of color, outdoor workers, residents without access to air conditioning/cooling, people without internet access, people with lower English proficiency, people with low incomes, people living in multi-unit housing, people living alone, people who are unhoused, and people with medical illnesses or disabilities.

> "The increasing intensity, duration, and frequency of heat waves due to human-caused climate change puts historically underserved populations in a heightened state of precarity...vulnerable communities—especially those within urban areas in the United States—are disproportionately exposed to extreme heat."[16]

To understand today's urban heat landscape and how it affects areas and communities differently, we need to examine our history. While Portland's natural environment—hills and rivers—contribute to the distribution and experience of heat, so do historically racist planning decisions and discriminatory investments. Two significantly influential categories of decisions are highlighted below: redlining and urban renewal.

In the early 20th century, government officials established policies that reinforced racial and economic segregation and diverted investments away from communities of color. One of the most significant of these policies became known as "redlining." Redlining refers to the discriminatory practice of withholding financial resources from neighborhoods dominated by minority populations. At a federal level, the practice originated in the 1920s and 1930s with the establishment of the Federal Housing Administration (FHA) and the National Housing Act and the proliferation of theories around race and property values popularized by significant economists such as Homer Hoyt. Hoyt was the FHA's first Principal Housing Economist (1934-1940) and developed the agency's first underwriting criteria for mortgages, the criteria that became the backbone of redlining policies across the nation.[17]

At a local level, the historical roots of racially biased real estate and zoning practices originate in the City's earliest planning policies and programs. In 1924, Portland voters approved the city's first zoning policy. Four land uses were identified throughout the city: Zone I-Single Family, Zone II-Multi-Family, Zone III-Business/Manufacturing, and Zone IV-Unrestricted. Fifteen "high quality" neighborhoods—including Irvington, Eastmoreland, Laurelhurst, and Alameda—were zoned for single-dwelling uses. The policy was pushed by homeowners as protecting property values, but it also ensured that apartment buildings and multi-dwelling homes—housing typologies more attainable to low-income residents—were concentrated in separate, less desirable areas.[18] Pertaining to heat adaptation, multi-dwelling developments then (and now) were required to allocate less space for vegetation than single-dwelling

[16] Hoffman, J.S.; Shandas, V.; Pendleton, N. *The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas*. Climate 2020, 8, 12. https://doi.org/10.3390/cli801001

[17] Cook, Joan. "Homer Hoyt, Early Planner of Shopping Centers." The New York Times (December 1, 1984) New York, New York.

[18] Hughes, J., Historical context of racist planning: A history of how planning segregated Portland (2019). Portland, Oregon.

residences, partly because they are allowed greater building coverage. In fact, all multi-dwelling developments were exempt from on-site tree planting requirements until just 2015.[19]

Following the passage of the National Housing Act in 1934, the federal government tasked the Home Owners' Loan Corporation (HOLC) with creating residential security maps for cities across the country, including Portland (Figure 13). Although Portland has expanded since that time, particularly into areas in the northwest, southwest and east, the historic maps clearly indicate where wealthier neighborhoods were developed.

The HOLC classified neighborhoods - largely based on their racial composition and income levels - to guide where mortgage lenders would and would not extend credit. "These maps rated neighborhoods for investment security purposes, with "A" areas being the most desirable and "D" being least desirable. Areas rated "D" were surrounded with red lines on the maps and residents who lived there, often low-income minorities, were frequently denied mortgage loans and insurance."[20] Exclusionary zoning, in concert with discriminatory lending, perpetuated the concentration of BIPOC communities in underinvested neighborhoods. In fact, a 2020 *Climate* article reported that Portland had the largest surface temperature difference between redlined neighborhoods and those identified as "A-graded areas – Best" by the Home Owners' Loan Corporation of the 108 U.S. cities studied.[9] These historically redlined and low-income neighborhoods, with majority BIPOC communities, are significantly hotter than others and can sometimes vary by as much as 20 F°.[21]

[19] City of Portland Oregon, Bureau of Planning and Sustainability, *Planning and Zoning Code*, 33.120.237.
[20] Williams, K. (2020, January 20). Historically racist housing policies exacerbating climate change effects in low-income Portland neighborhoods. *Oregon Live*. Retrieved April 19, 2024.
[21] Williams, K. (2018, August 28). Portland weather hot spots: temperatures can vary as much as 20 degrees by neighborhood. *Oregon Live*. Retrieved April 17, 2024.

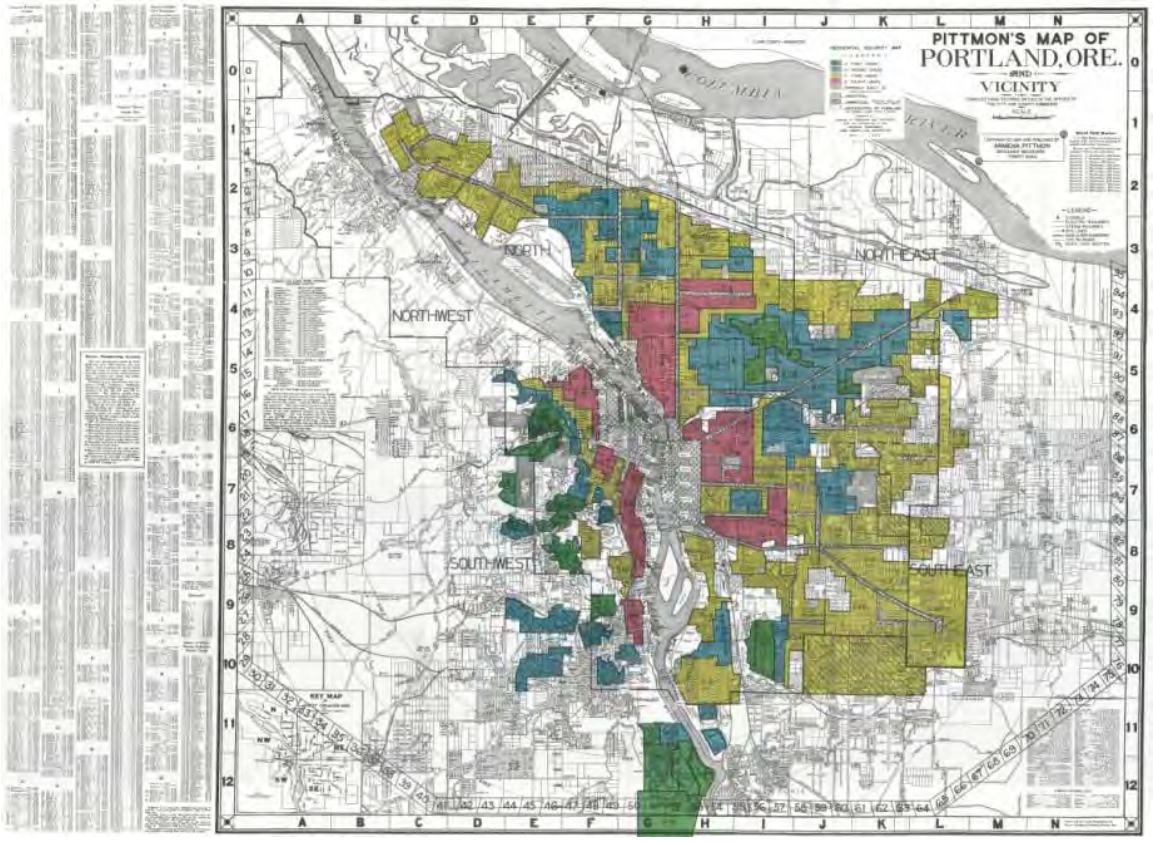

Figure 13. Pittmon's 1934 [Residential Security] Map of Portland, Ore. and vicinity, showing the four neighborhood classifications created by HOLC *(*Image courtesy of Mapping Inequality*)*. Green areas signified "A-Best", blue areas were identified as "B-Still Desirable", yellow signified "C-Declining", and areas marked in red were graded, "D-Hazardous".

Further analysis within this study—presented in Table 1 and in Figures 14 and 15—shows the HVI heat island data overlaid with the 1934 HOLC residential security maps of Portland, illustrating that a disproportionate concentration of present-day heat islands is located in areas historically ranked "C-Declining" and "D-Hazardous". Fifty-six percent of the HOLC-graded C and D neighborhoods are identified as heat islands, whereas only 20 percent of the A and B HOLC-graded neighborhoods are identified as heat islands. Moreover, as the total area of C and D ranked neighborhoods is much greater than A and B, heat islands occur in C and D areas 5 times more than in A and B (Table 1, Figures 5 and 6).

Table 1. Percentage of HOLC-rated neighborhoods identified as heat islands.

	TOTAL AREA (acres)	AREA IDENTIFIED AS HEAT ISLAND (acres)	PERCENTAGE (%) OF TOTAL AREA IDENTIFIED AS HEAT ISLAND
A/B Ranked Neighborhoods	9,173.8	1,844.5	20%
C/D Ranked Neighborhoods	16,936.6	9,420.5	56%

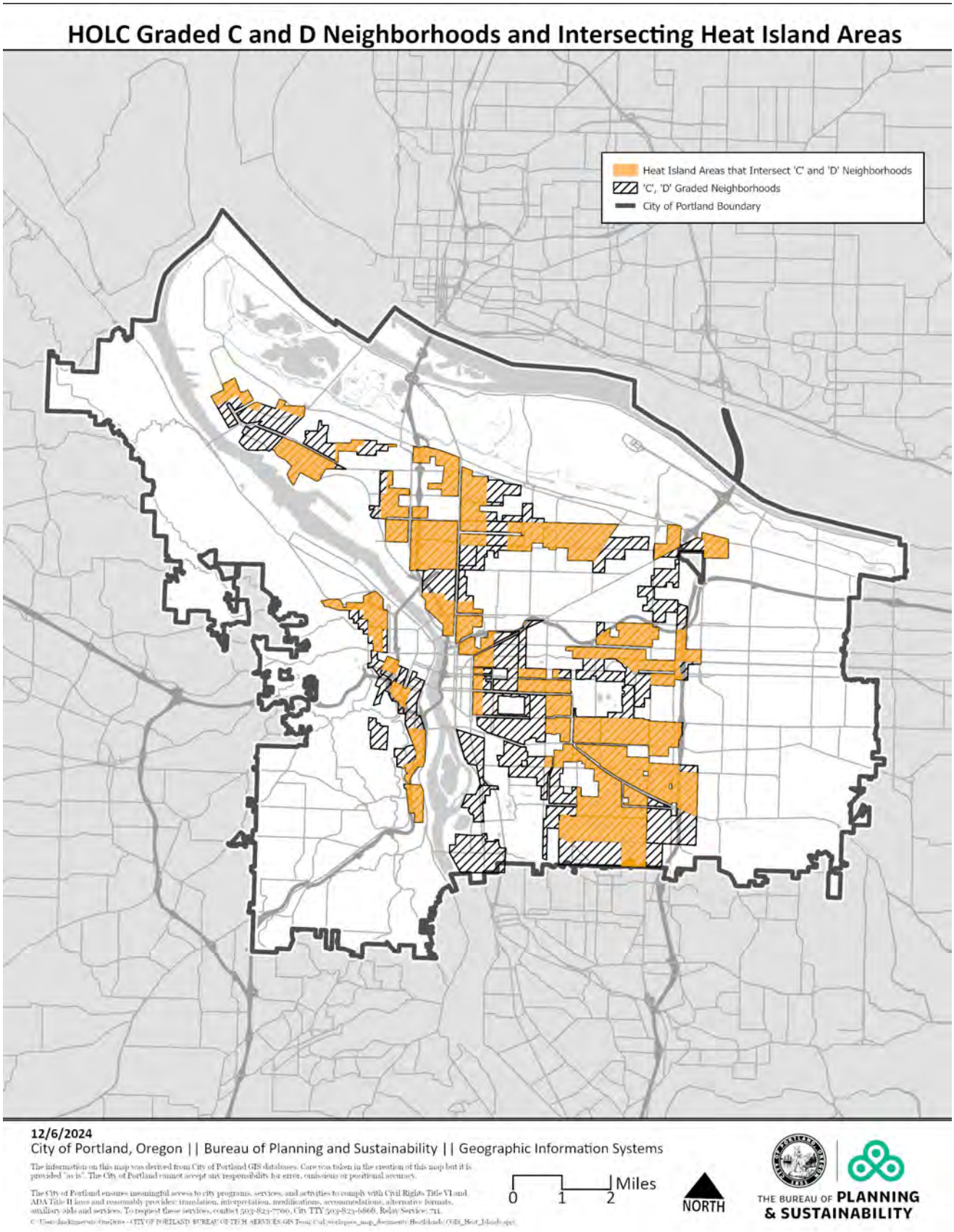

Figure 14. Map figure showing C and D HOLC-graded neighborhoods overlaid with heat islands.

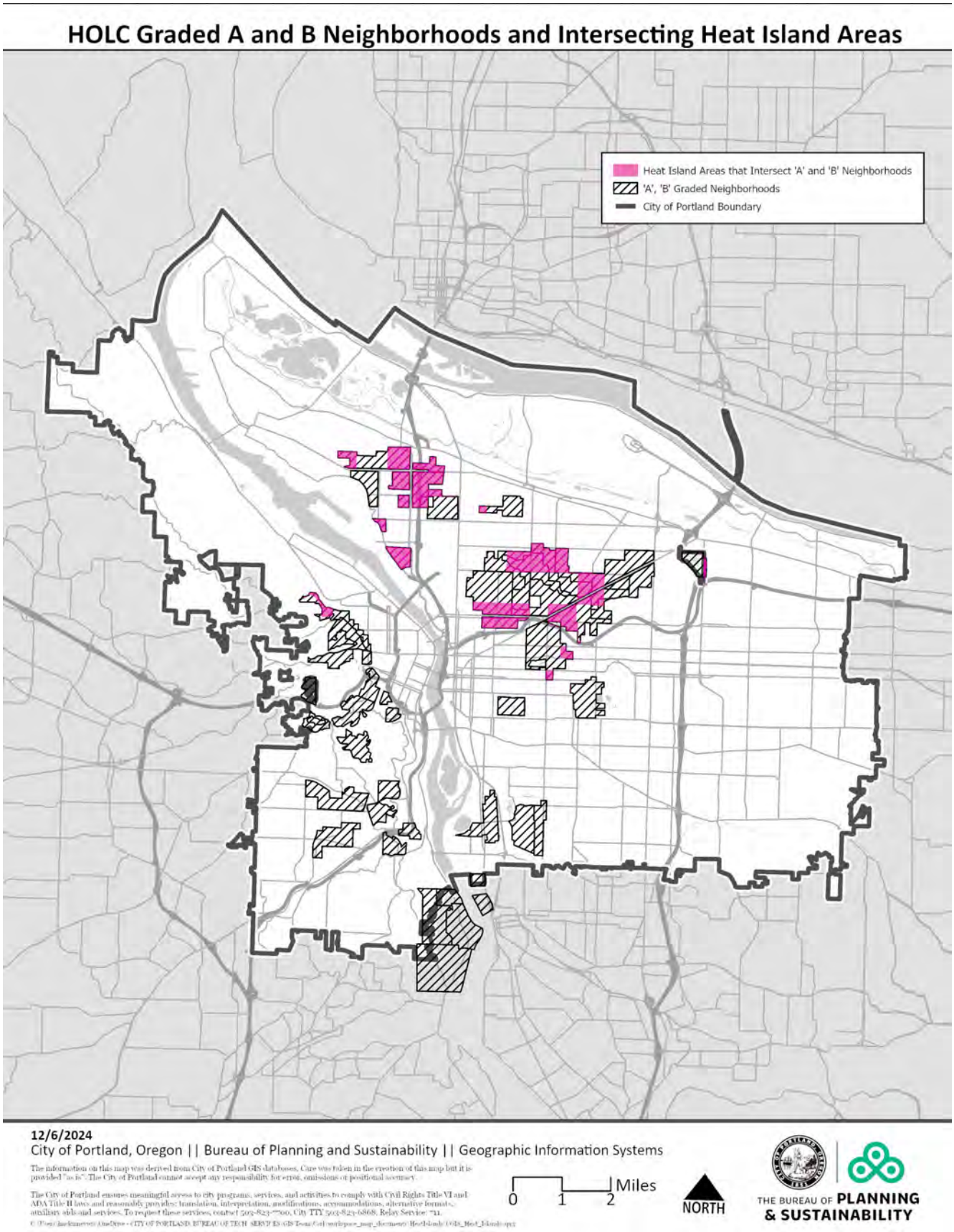

Figure 15. Map figure showing A and B HOLC-graded neighborhoods overlaid with heat islands.

Furthermore, the Housing Act of 1949 and the subsequent Federal Urban Renewal Program ultimately led to the systematic demolition of mostly African American owned homes across the nation. Historically redlined neighborhoods—areas previously identified as blighted by the HOLC—were the primary targets of the federal redevelopment funds. These funds paved the way for the demolition of much of Portland's historic Black community living in the Albina neighborhood, for the subsequent construction of Veterans Memorial Coliseum, Interstate 5, the never-completed expansion of Emanuel Hospital, and other large-scale development projects. These public works projects increased hardscaping in Albina, a key indicator of increased exposure to extreme heat.

In Southeast Portland, a similar disruption occurred in the Lents neighborhood. Lents was classified as "Declining" by the HOLC due to its "heterogeneous population" and lack of "pattern". Because of this and its distance from central Portland, the neighborhood received little investment.[22] That is until Interstate 205 was built in the late 1970s. After years of debate around where to construct the thoroughfare, the freeway was positioned along SE 96th Avenue, effectively dividing the Lents neighborhood in half. Hundreds of dwellings were demolished and there were significant impacts to the commercial corridor near the intersection of SE 92nd Avenue and Foster Road.[23]

Racially biased federal funding programs coupled with zoning changes allowed for the siting of expansive concrete and asphalt infrastructure in and directly adjacent to majority BIPOC and low-income communities. The result is reduced vegetation cover and tree canopy, increased levels of heat from increased surface temperatures, and overall increased exposure to extreme heat in already burdened communities which experience decreased adaptive capacity.

[22] MacColl, E. K. (1979). *The Growth of a City: Power and politics in Portland, Oregon, 1915-1950*. Georgian Press.
[23] Bonner, C. (2018, June 20). *Exploring the Lents Neighborhood*. Love Portland. https://www.loveportland.com/new-blog/2018/5/21/exploring-the-lents-neighborhood.

3

INVENTORY OF PORTLAND HEAT-RELATED PROGRAMS

3. Inventory of Portland's Heat-related Programs

Resilience planning, in large part, is an extension of existing programs and policies. Portland's bureaus have been working to foster resilience for many years. In 2018, resilience was identified as one of the five guiding principles in Portland's 2035 Comprehensive Plan. In the Comprehensive Plan, a variety of policies aim to "reduce risk and improve the ability of individuals, communities, economic systems, and the natural and built environments to withstand, recover from, and adapt to changes from natural hazards, human-made disasters, climate change, and economic shifts".

An inventory of these initiatives was conducted in 2023 as part of this study. Within this inventory, the City of Portland's efforts to manage and adapt to increasing temperatures and extreme heat events are grouped into the following action area categories: (1) Safety and Emergency Response, (2) Green Infrastructure and Healthy Watersheds, and (3) Built Environment and are identified typologically as either a program, policy, regulation or report. Each action area is integral to achieving overall heat resilience. Within each action area, multiple bureaus implement these efforts to reduce the effects of urban heat islands and ultimately acclimatize. In total, this inventory identified 82 policies, 22 programs, three reports and 42 regulations developed and implemented either citywide or by one or more of the following bureaus:

- Bureau of Planning and Sustainability (BPS); including the Portland Clean Energy Community Benefits Fund (PCEF)
- Bureau of Environmental Services (BES)
- Portland Bureau of Emergency Management (PBEM)
- Portland Bureau of Transportation (PBOT)
- Portland Parks and Recreation (PP&R); including Urban Forestry (UF)
- Portland Water Bureau (PWB)

This inventory aims to (1) recognize the ongoing and critical work being done throughout the City of Portland to manage and respond to heat, and (2) serve as a springboard from which to propose new strategies for enhanced heat resilience. For more information, see Appendix A.

4

CASE STUDIES

4. Case Studies

The six cases studies in this section include replicable and transferable heat action planning and adaptation methodologies employed in other cities. They include five projects based in geographies across the US and one international example:

- Boston Tree Alliance Program (Boston, Massachusetts)
- Heat Resilience Solutions for Boston (Boston, Massachusetts)
- Environmental Justice NYC (EJNYC) (New York City, New York)
- Heat Action Planning Guide for Neighborhoods in Greater Phoenix (Phoenix, Arizona)
- LA Micro Forests (Los Angeles, California)
- Green Corridors (Medellin, Colombia)

BOSTON TREE ALLIANCE PROGRAM
BOSTON, MASSACHUSETTS

Figure 16. Boston Mayor, Michelle Wu digs a hole to plant a new tree sapling (https://www.massaudubon.org).

Project Description

The Boston Tree Alliance is a grant making and capacity building program that supports community-based organizations and residents with tree planting and maintenance on private property.

Project Development and Application

The Tree Alliance Program aligns with the guidelines laid out in Boston's initial Urban Forest Plan (UFP). The UFP evaluated Boston's urban forest and provided suggestions for enhancing tree care and promoting equitable distribution of urban trees and their benefits throughout the city.

In May 2023, Boston Mayor Michelle Wu announced that Mass Audubon was selected to be the program lead and fiscal sponsor. As such, Mass Audubon will convene a coalition of nonprofits and community-based organizations to form the Tree Alliance.

The Alliance is charged with:

- The identification of planting locations in environmental justice neighborhoods
- Tree planting and care projects
- The creation of educational materials
- Training on tree planting and care strategies
- Tracking of health and progress of tree planting and care projects funded through this program[24]

Boston will fund the first three years of the program with $1 million from the American Rescue Plan Act.

The Boston Tree Alliance Program's principal goal is "to increase access to trees, address urban heat island impacts, and improve public health in environmental justice communities." The Alliance will prioritize areas where heat vulnerability overlaps with social vulnerability. Initial scoping tools include the Urban Forest Plan's Neighborhood Strategies data, the Heat Plan focus areas, and feedback from Boston residents.

[24] *Boston Tree Alliance Program*. Boston.gov. (2023, June 23). https://www.boston.gov/environment-and-energy/boston-tree-alliance-program.

HEAT RESILIENCE SOLUTIONS FOR BOSTON
BOSTON, MASSACHUSETTS

Figure 17. Boston, Massachusetts (Getty Images/ Lisegagne).

Project Description

Boston's Heat Action Plan, *Heat Resilience Solutions for Boston,* is a framework to prepare Boston for more intense heat events. "The Heat Plan presents 26 strategies that will help build a more just, equitable, and resilient Boston."[25] In addition to citywide strategies, the Heat Plan focuses on five neighborhoods disproportionately impacted by extreme heat. For each neighborhood, the Heat Plan (1) evaluates neighborhood context, (2) conducts a heat analysis, (3) documents community heat experiences and cooling ideas, and (4) recommends heat resilience opportunities.

Project Development and Application

The project team developed the Heat Plan in three phases over 14 months.

PHASE 1: ANALYSIS AND EXISTING INFORMATION REVIEW

Included gathering data, review of existing planning efforts, and a heat analysis. The heat analysis was done citywide, and at a focused neighborhood-level of five environmental justice communities: Chinatown, Dorchester, East Boston, Mattapan and Roxbury. The neighborhood-level analysis evaluated how the experience of heat varies across the city. It also assessed "how racism, inequality, historic urban planning decisions, and other policies have influenced existing heat exposure and vulnerability."[26] This phase also included the establishment of the Community Advisory Board (CAB) to guide the planning process.

PHASE 2: HEAT RESILIENT STRATEGIES

Included drafting a set of strategies for heat resilience informed by the citywide and neighborhood-level heat analysis, and community feedback conducted in Phase 1.

PHASE 3: IMPLEMENTATION ROADMAP AND FINAL REPORT

Focused on refining heat resilience strategies for Boston, "developing a benefit-cost analysis for cooling homes, schools, and streets; creating a neighborhood-scale heat simulation to model

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[25] City of Boston, *Critical actions to mitigate extreme heat in environmental justice communities announced*. (2022, April 22). https://www.boston.gov/news/critical-actions-mitigate-extreme-heat-environmental-justice-communities-announced#:~:text=In%20addition%20to%20citywide%20strategies,Boston%2C%20Mattapan%2C%20and%20Roxbury.

[26] City of Boston, *Heat resilience solutions for Boston: Final report* (2022).

the effectiveness of the physical heat reduction strategies; and developing an implementation roadmap."[26]

The Heat Action Plan identifies the following heat experience factors:

- Personal health and cooling access
- Physical environment (built and natural)
- Air flow
- History and structural inequity

ENVIRONMENTAL JUSTICE NYC (EJNYC)

NEW YORK, NEW YORK

Figure 18. New York City, Nationalgeographic.com.

Project Description

Environmental Justice Areas account for 44% of New York City census tracts which contain 49% of the city's population.

The EJNYC Report is an evaluation of environmental burdens and benefits across New York City. The report assesses Environmental Justice (EJ) Areas and non-EJ Areas to identify disparities and included the development of an interactive environmental justice mapping tool.

In the report, "Environmental Justice Area" or "EJ Area," is defined as a "geographic area that has experienced disproportionate negative impacts from environmental pollution due to historical and existing social inequities without equal protection and enforcement or environmental laws and regulations."**Error! Bookmark not defined.** The report uses New York State's Disadvantaged Communities (DAC) criteria, which used 45 sociodemographic and environmental indicators to identify regions most vulnerable to the impacts of disruption, including climate change.[27]

The report concludes that Environmental Justice Areas account for 44 percent of all New York City census tracts and contain 49 percent of the city's population. Moreover, communities of color and low-income residents are disproportionately exposed to polluted air, polluted water, climate change, and hazardous materials. They also experience reduced access to essential resources such as safe and healthy housing.

Project Development and Application

Development of the EJNYC Report began with a public scoping process that included comments from thousands of New York residents. The City, in partnership with the Environmental Justice Advisory Board, conducted the process to ensure the report directly addressed the issues facing EJ communities. Comments were open to all New Yorkers, though the City prioritized outreach in low-income communities and communities of color "that have borne the brunt of environmental health issues, the climate crisis, and impacts of the fossil fuel industry."[28]

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[27] Department of Environmental Conservation, New York State Disadvantaged Communities Criteria (2023). New York, New York.
[28] New York City Mayor's Office of Climate and Environmental Justice. "Environmental Justice NYC (EJNYC), website, https://climate.cityofnewyork.us/topic/environmental-justice/.

Public input was formalized into *New York City's Environmental Justice for All Scope of Work* for which the following discrete tasks were identified:

Task 1 – An analysis of environmental outcomes and climate vulnerabilities to delineate the boundaries of the City's Environmental Justice Areas. In addition, a description of environmental justice concerns likely to impact Environmental Justice Areas followed by data analysis to assess the distribution of environmental benefits and burdens across the city.

Task 2 – An assessment of the City's historic contribution to environmental justice.

Task 3 –A review of the City's formal engagement processes related to environmental justice, including the City's meaningful involvement of impacted New Yorkers in environmental decision making.[29]

Mapping Tool

Project Description

An interactive mapping tool and data tool hosted online to "equip all New Yorkers with information necessary to advocate for and make more informed decisions about environmental justice in New York City."[30]

Project Development and Application

The mapping tool was developed in concert with the EJNYC Report. Similarly, it uses New York State's Disadvantaged Communities (DAC) criteria, to identify Environmental Justice Areas. The data explorer visualizes access to resources, exposure to polluted air, hazardous materials and polluted water, vulnerability to the impacts of climate change, and the distribution of safe and healthy housing.

Both the EJNYC Report and Mapping Tool will inform the forthcoming EJNYC Plan. The Plan intends to evaluate the challenges and opportunities for environmental justice in New York City. The City has initially identified the following policy initiatives to explore further.

- *Invest in environmental justice communities;*

[29] Environmental Justice Interagency Working Group, *Environmental Justice for All Report Scope of Work* (2021). New York, New York.
[30] EJNYC Full Data Explorer. (n.d.). https://experience.arcgis.com/experience/6a3da7b920f248af961554bdf01d668b/page/Data-Explorer/.

- *Integrate environmental justice in agency decisions through climate budgeting;*
- *Improve accountability through increased data transparency and communication;*
- *Coordinate with permitting authorities to embed equity and environmental justice considerations in the siting and permitting of infrastructure; and*
- *Explore and develop new ways to collaborate with EJ communities.*[31]

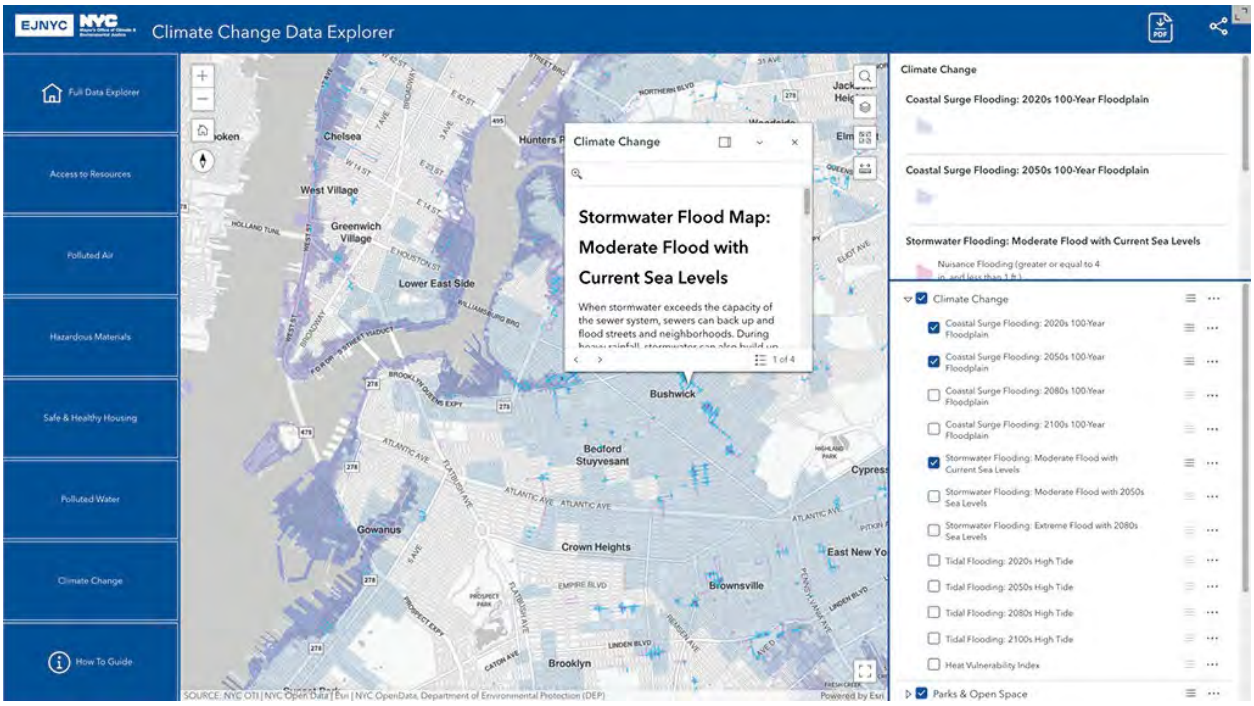

Figure 19. EJNYC Mapping Tool

[31] NYC Mayor's Office of Climate and Environmental Justice, *Conclusion* (n.d.-a). https://climate.cityofnewyork.us/ejnyc-report/conclusion/

HEAT ACTION PLANNING GUIDE FOR NEIGHBORHOODS OF GREATER PHOENIX

PHOENIX, ARIZONA

Figure 20. Pheonix, Arizona (Adobe Stock Image).

Project Description

In May 2017, various public and private entities (The Nature Conservancy, Maricopa County Department of Public Health, Central Arizona Conservation Alliance, Urban Resilience to Extremes Sustainability Research Network, Arizona State University's Urban Climate Research Center, and Center for Whole Communities) initiated an inclusive Heat Action Planning process aimed at identifying strategies for both mitigating and adapting to heat, aiming to reduce heat while enhancing residents' capacity to cope with it.

Project Development and Application

The planning method for this project was adapted from *An Urban Community-Based Intervention to Advance Social Interactions*, Semenza et al. (2007). "Beyond building a community Heat Action Plan, this methodology builds on strengthening relationships within and between neighborhoods, community-based organizations… and decision makers. It combines storytelling wisdom and scientific evidence to understand current and future challenges residents face during extreme heat events."[32]

"Beyond building a community Heat Action Plan, this methodology builds on strengthening relationships within and between neighborhoods, community-based organizations… and decision makers."

Three neighborhood communities, two in Phoenix and one in Mesa, were selected for Heat Action Planning.

CRITERIA FOR NEIGHBORHOOD SELECTION INCLUDED:

- ✓ Community
  - Strong sense of community
  - Potential for mutual learning (resident stakeholders)
  - Previously surveyed
- ✓ Health and Vulnerability
  - High rate of heat deaths/illness
  - Low income
  - High rates of self-reported heat concerns

[32] The Nature Conservancy, *Heat Action Planning Guide for Neighborhoods of Greater Phoenix*, Phoenix, Arizona.

    - Limited access to air conditioning
- ✓ Heat
    - Lower than average vegetation index
    - High surface temperature
- ✓ History and Opportunity
    - High percentage of vacant lots
    - Invitation from community
    - Slated housing, renovation, or capital improvement projects
- ✓ Usage
    - High use of public spaces
    - High transit use

In each selected neighborhood, an active community-based organization (CBO) was selected to be the bridge between residents and the core planning team. CBOs were responsible for the following:

- Workshop recruitment
- Distributing informative recruitment marketing throughout the neighborhood (available in Spanish and English)
- Gathering community data/stories about coping with urban heat prior to workshops
- Collaborating on workshop process
- Deciding the location for the workshops
- Facilitating demonstration projects

Three workshops were held in each neighborhood, all of which were conducted simultaneously in English and Spanish.

- ***Workshop 1*** *– Discover major concerns and potential actions.*
- ***Workshop 2*** *– Invite designers and decision-makers to hear neighborhood concerns and determine feasible actions.*
- ***Workshop 3*** *– Make decisions for implementation.*

Following the workshops, the core planning team, in concert with the CBO liaisons, and neighborhood participants created unique Heat Action Plans with actionable strategies for heat adaptation for each neighborhood.

LA MICRO FORESTS

LOS ANGELES, CALIFORNIA

Figure 21. Los Angeles skyline (Brian van der Brug).

Project Description

The micro forest method is often referred to as the Miyawaki Method, for the pioneering Japanese botanist and ecologist Dr. Akira Miyawaki (1928-2021). Dr. Miyawaki, developed his planting technique in the 1970s, after observing that the dense patches of indigenous trees around Japan's temples and shrines were healthier and more resilient than the managed forests grown in the aftermath of logging.[33] Miyawaki prescribed the randomized planting of shrub and tree saplings—grown from local, regionally adapted seeds—in close proximity, ensuring that trees and shrubs of different heights are planted next to each other. This complex layering enables trees and shrubs to mature to their ideal size, while still maximizing space.[34]

Microforests have numerous benefits. The dense planting scheme grows faster than traditional forests, resulting in enhanced carbon sequestration. In addition, the many layers of vegetation provide ideal habitat for wildlife and microorganisms. Furthermore, after two years of establishment maintenance, the forest becomes self-sustaining, "surviving on natural rainfall and successfully resisting weed invasion due to the dense shade and natural smothering leaf litter it produces."[34]

There are four layers in a conventional Miyawaki forest:

Figure 22. Layers in a conventional Miyawaki forest (Lamicroforests.com).

[33] Buckley, C. (2023, August 24). *Tiny forests with big benefits*. The New York Times. https://www.nytimes.com/2023/08/24/climate/tiny-forests-climate-miyawaki.html
[34] LA Micro Forests. (n.d.). https://www.lamicroforests.com/background#the-miyawaki-method.

Project Development and Application

In 2021, the Los Angeles Parks Foundation piloted the first "Microforest" in Griffith Park. To better suit Los Angeles' unique climate and ecology (more arid and hotter than Japan), the Parks Foundation adapted Miyawaki's original method. The changes include:

- The inclusion of herbaceous perennials within the lowest layer of the forest
- A higher ratio of shrubs and herbaceous perennials and lower ratio of trees compared to a traditional Miyawaki forest
- A reduction in plant density (from 3 trees/shrubs per 10 sq. ft. to 1.6 trees/shrubs per 10 sq. ft.)
- A reduction/elimination of tilling as a soil prep strategy
- An elimination of manure as a fertility strategy. Compost (for the addition of beneficial soil microbes rather than fertility) used instead on a case-by-case basis
- Irrigation weaned off earlier during forest establishment[34]

Figure 23. The Griffith Park Microforest one month after planting (Lamicroforests.com).

Figure 24. The Griffith Park Microsforest one year after planting (Lamicroforests.com).

GREEN CORRIDORS

MEDELLIN, COLOMBIA

Figure 25. Green corridor with lush canopy cover in Medellin, Columbia (Getty Images).

Project Description

Medellin's green corridors consist of more than 30 vegetated avenues and streets that connect the city's green spaces—vertical gardens, streams, parks, and nearby hills. The program was created in 2016 due to concerns of rising temperatures and poor air quality. Since then, the city has planted more than 20,000 trees and hundreds of thousands of shrubs. As a result, there has been a 2°C (3.6°F) temperature reduction across the city, and more than 3°C (5°F) in specific areas directly adjacent to the corridors.[35]

Project Development and Application

According to the local government, the initial investment to establish the project was $16.3 million (US dollars) with an annual maintenance cost of $625,000. The groundwork is carried out by 150 trained citizen-gardeners, who come from disadvantaged and minority backgrounds.

Medellin's Advice for Looking to Implement Green Corridors

1. Target the busiest areas to have the greatest impact.

    Medellin selected Oriental Avenue, one of the city's most polluted and populated streets, to be one of the primary green corridors. "The more polluted the area, the greater the potential environmental returns."[36]

2. Leverage national and local legislation.

    Colombian legislation dictates that part of cities' budgets—Municipal Participatory Budget—must be invested in projects that citizens help to select via democratic vote. The Green Corridors Program received ample funds through this vote, enabling it to be implemented across the city.[35]

[35] Andrade, M. G. de. (2023, September 23). *The city that went green to keep cool*. BBC News. https://www.bbc.com/future/article/20230922-how-medellin-is-beating-the-heat-with-green-corridors.
[36] C40 Knowledge Community. (n.d.). *Cities100: Medellin's Interconnected Green Corridors*. https://www.c40knowledgehub.org/s/article/Cities100-Medellin-s-interconnected-green-corridors?language=en_US.

5

RECOMMENDATIONS

5. Recommendations

Scientists predict that Portland will experience increasingly frequent and prolonged periods of extreme heat due to climate change. Heeter et al.[37] argues, in the absence of committed efforts to curtail anthropogenic emissions below intermediate levels, the Pacific Northwest risks regularly experiencing temperatures above 110 degrees F, with a 50% chance of yearly occurrence by 2050. Moreover, even with committed efforts to curtail human caused emissions, the earth will continue to experience atmospheric warming and sea-level rise for years to come, as many greenhouse gases stay in the atmosphere for upwards of 1,000 years.[38]

The recommendations presented in this study are grouped into three solution types: (1) Policy/Action, (2) Nature-based, and (3) Engineered (Table 2). Action/Policy solutions include strategic programs and policies that promote heat adaptation, management, and response. Nature-based solutions use natural features and processes such as trees, plants, and water systems to encourage climate adaptation and resilience. Finally, engineered solutions are designed and built interventions to reduce temperatures and lessen the impacts of extreme heat.

These recommendations were informed by a collaborative process among City staff through the Resilience Learning Cohort, the BPS Climate Team, and the Inter-Bureau Advisory Group. This diverse group of climate and planning professionals rated potential recommendations based upon their unique institutional perspective and knowledge of their bureau's organizational capacity. A range of strategies were evaluated on three primary criteria, including: ease of implementation, priority level, and perceived level of impact.

[37] Heeter, K.J., Harley, G.L., Abatzoglou, J.T. *et al.* Unprecedented 21st century heat across the Pacific Northwest of North America. *npj Clim Atmos Sci* 6, 5 (2023). https://doi.org/10.1038/s41612-023-00340-3

[38] IPCC (2013). *Climate Change 2013: The Physical Science Basis.* Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Table 2. Summary of Recommendations for Heat Adaptation and Management

POLICY/ACTION SOLUTIONS	Heat Action Plan
	Environmental Justice Mapping Tool
	Resilience Hubs
NATURE-BASED SOLUTIONS	Street Tree Maintenance
	Private Property Tree Maintenance Assistance Program
	Cool Corridors
	Microforests
	Tree Planting for Heat Resilience Guidelines
ENGINEERED SOLUTIONS	Cool Roofs
	Built Shade Structures

HEAT ACTION PLAN

Tang Siu Nam

Policy/Action Solution

WHAT?

A Heat Action Plan identifies adaptation and management strategies for all of Portland with specific attention to the communities most impacted by heat.

WHY?

Heat is the leading weather-related cause of death in the United States[39]. A Heat Action Plan provides an opportunity to:

- Develop a roadmap—with specific, actionable steps—to prepare Portland for hotter summers.
- Ensure expectations for bureaus are grounded in their precise scope of work and organizational capacity.
- Promote coordination among bureaus and clarify roles throughout the City.
- Identify and support Portland's most heat vulnerable neighborhoods by working with community members and indigenous rightsholders to generate culturally and locationally specific solutions.
- Utilize community data[40] to directly inform planning and management decisions.
- Establish measurable goals that can be observed by an oversight body and the public for greater accountability.

[39] Fleishman, E. (Ed.). (2023). (rep.). *Sixth Oregon Climate Assessment*. Corvallis, Oregon: Oregon State University.

[40] Research Justice Institute. (Forthcoming). *Community Data*. Published by the Coalition of Communities of Color.

EXISTING RELATED WORK

In 1993, Portland was the first city in the U.S. to create a local action plan for carbon reduction. Since that time, the City has issued four additional plans, including the 2001 *City of Portland/Multnomah County Local Action Plan on Global Warming*, the 2009 *Climate Action Plan*, the 2015 *Climate Action Plan*, and the 2022 *Climate Emergency Workplan*.

While the City's Climate Action Plans and Emergency Work Plan have principally identified strategies for carbon reduction across the energy, building, and transportation sectors, some also highlight the need for greater resilience to the everyday impacts of climate change. For example, the 2015 *Climate Action Plan* calls for the expansion of tree planting efforts in low canopy neighborhoods, development of a citywide green infrastructure system, and enhanced tree protection.

HOW?

As of 2024, more than 25 major cities in the U.S. (having a population greater than 200,000) have Heat Action Plans. Consequently, there are numerous excellent examples of how to structure and execute a plan. Of these Boston's plan, *Heat Resilience Solutions for Boston* (2022), and Phoenix's *Heat Action Planning Guide* (2017) stand apart. Both documents identify residents most vulnerable to the impacts of extreme heat, and the reasons why. The resilience strategies in each plan promote cooling as well as directly respond to "the why"—the root of unequal distribution and experience of extreme heat. The plans take a whole systems approach and consider a broad array of initiatives, including public health campaigns. They also endeavor to embed

COMMUNITY DATA

Is evidence generated by communities about their everyday lives. Community data can be numbers, words, art, music and sound, and maps – it encompasses the multiple and diverse ways that communities share, express, and articulate their lived experiences. Community data is a reflection of community-centric forms of knowing, being and doing. Community data can be further specified by understanding it as systematic, contextual, and on the terms of community.

***Systematic** – Community data is generated by the systematic gathering and interpreting of evidence about the experiences and everyday lives of community members.*

***Contextual** – Community data captures the cultural, political, economic, and environmental contexts in which community members live (and have historically lived), the struggles they face, and their desires for other possibilities.*

***On the terms of community** – Community data is produced by centering and respecting the terms of the community from which data is gathered (Research Justice Institute)*

heat interventions into existing regulatory frameworks and planning processes. Finally, both plans document community priorities and promote residents' visions for cooler neighborhoods. (For more detailed information see the Boston and Phoenix case studies.)

In addition to all these things, Portland's Heat Action Plan could include clear systems and frameworks to evaluate success. This includes the installation of stationary gauges to measure mean radian temperature, air temperature, air speed, and relative humidity, throughout heat vulnerable areas. Presently, Portland's heat data consists of near-surface air temperature measurements gathered via the July 22, 2023, heat mapping campaign.

Real-time data from stationary instruments could monitor temperature increases and/or decreases due to development, preservation initiatives, cooling initiatives etc. It could also inform emergency management responses during and immediately following extreme heat events. Gauges can quickly identify "hot spots" where intervention is most needed. Moreover, stationary gauges record night-time heat, a significant data metric Portland lacks.

WHERE?

While many adaptation strategies can be deployed throughout the city, immediate intervention should prioritize those disproportionately vulnerable to extreme heat. Based on data from Multnomah County's Heat Vulnerability Index, those neighborhoods include parts of Central City, Lents, Hazelwood, Parkrose Heights, Mill Park, and Powellhurst-Gilbert (see Section 2 of this report). This data could be considered together with community narratives and descriptions (community data) to ensure the City has accurate and comprehensive knowledge of where extreme heat is most severe and simultaneously, management/coping resources are limited. One of the lessons learned from Phoenix's Heat Action Planning Guide was to provide opportunities for communities to self-identify as vulnerable to heat because institutional and quantitative data alone was insufficient.

IMPACTED CITY BUREAUS

BPS
PBOT
PP&R
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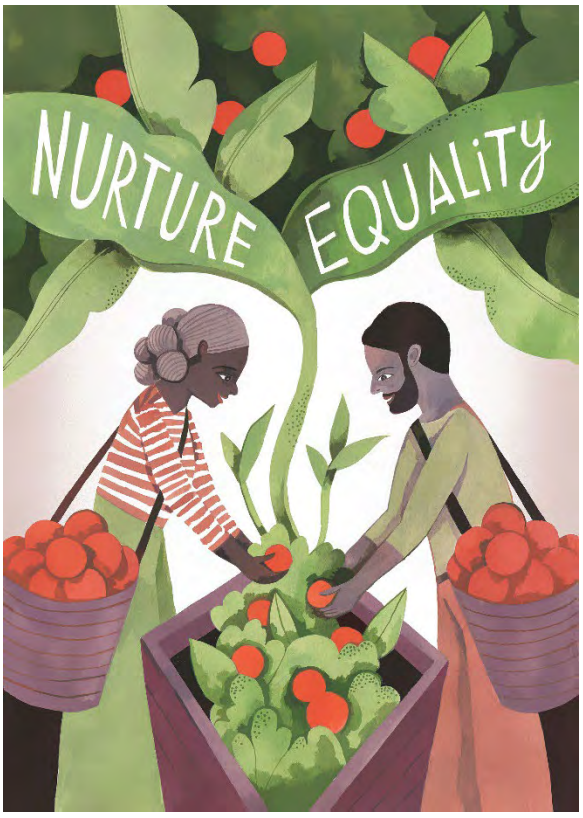
ENVIRONMENTAL JUSTICE MAPPING TOOL



Luisa Rivera for Fine Acts

Policy/Action Solution

WHAT?

An Environmental Justice (EJ) Mapping Tool informed by census data, Multnomah County health data, and community data to guide planning decisions and the City's efforts to advance environmental justice.

WHY?

An EJ Mapping Tool provides an opportunity to…

- Identify areas and communities that are vulnerable to and disproportionately impacted by climate change.
- Elevate and systematize the incorporation of community narratives and experiences into City geospatial tools/indexes.
- Promote continuity across bureaus.
- Improve accountability through data transparency.
- Embed environmental justice considerations in the siting and permitting of infrastructure.
- Embed environmental justice considerations in zoning.

Creating a singular, interactive tool could promote efficiencies across bureaus while still allowing for data interpretation specific to each bureau and/or project. It could also promote a shared definition of vulnerability and focus work throughout the city to benefit underserved populations.

EXISTING RELATED WORK

Multiple bureaus have created matrixes to assess elements of environmental justice:

- Economic Vulnerability Assessment (BPS)
- Equity Data Toolkit (BES, PWB)
- Equity Matrix (PBOT)
- Priority Service Areas (UF)

HOW?

Consider mapping the following criteria, among others informed by content experts and community members:

- Access to food and nutrition
- Air quality
- Chemically intensive small businesses
- Demographics
- Displacement risk
- Economic vulnerability
- Flood vulnerability index
- Hazardous waste material storage
- Health indicators
- Heat vulnerability index
- Historically Redlined Areas
- Hospitals
- Housing quality
- Proximity to parks and open space
- Proximity to transit
- Schools
- Solid waste disposal
- Superfund sites
- Tree canopy
- Water quality

WHERE?

Publish the mapping tool online to provide all Portlanders with information necessary to advocate for and make informed decisions related to environmental justice.

IMPACTED CITY BUREAUS

BES
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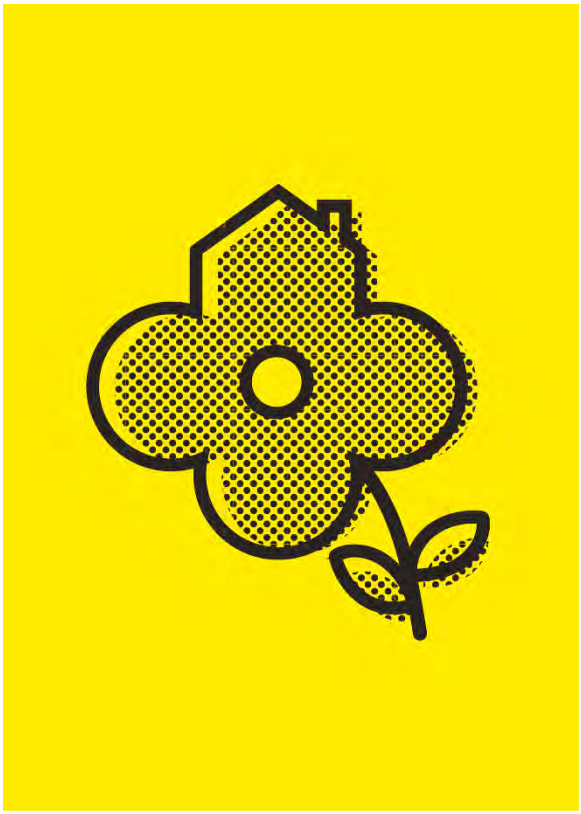
RESILIENCE HUBS



Ulas Eryavuz

Policy/Action Solution

WHAT?

Support the establishment of community resilience hubs strategically located in neighborhoods with the greatest need.

Resilience Hubs, per the Urban Sustainability Directors Network, are "community-serving facilities augmented to support residents… [they] coordinate resource distribution and services before, during, or after a natural hazard event."[41]

Rather than being led by local government, community resilience hubs are *supported* by local government and other partners, but led and managed by trusted community members, and/or community-based organizations.

Resilience hubs operate in three modes, (1) normal/everyday, (2) disruption, and (3) recovery. Most of the time, resilience hubs operate in normal/everyday mode (pre-disruption). Normal/everyday mode looks different in different communities. Some are cultural centers or health centers, while others may be elder care facilities or food incubators. Most important is that they are trusted and well-utilized year-round. Normal/everyday mode is the ideal time to provide training and prepare for emergencies and disruptions.

During disruption, a resilience hub is the central point for gathering, distributing

[41] Network, U. S. D. (n.d.). *Urban Sustainability Directors Network*. USDN. https://www.usdn.org/resilience-hubs.html

resources, sharing information, assessing impact, and organizing response.

Finally, resilience hubs play a critical role in post-disruption recovery. They provide continued communication and information to the community. They can host aid organizations and support networks/organizations. They may also serve as a nexus for repair/(re)construction efforts if there's significant physical damage.

WHY?

"As the globe continues to warm, extreme weather events will continue to threaten and impact communities, infrastructure, and systems worldwide."[42] Consequently, we need systems and structures that support community's adaptive capacity, especially for those that experience increased exposure and sensitively to climate hazards.

Community led resilience hubs equitably enhance community resilience by:

- Reducing burden on local emergency response teams.
- Improving access to resources.
- Fostering community cohesion, which leads to greater social resilience.
- Building local community power and leadership.
- Providing critical communication and information.

EXISTING RELATED WORK

Existing work includes PCEF's strategic program, Building Upgrades for Community Severe Weather Response. "This program will fund building energy upgrades for sites owned and/or managed by eligible government entities and nonprofit organizations that make a long-term commitment to provide critical services during severe weather-related events. These may include solar installations; battery backup; and high-efficiency heating, cooling, and air filtration systems."[43] Some of this work is currently in progress at Mt. Scott Community Center.

While this program signifies progress, it doesn't fund building acquisition or lease and may not produce resilience hubs where they are most needed. Additionally, the funds do not support program implementation.

HOW?

Consider various funding sources and implementation strategies to further this idea.

[42] Baja, K. (n.d.). Guide to Developing Resilience Hubs. The Urban Sustainability Directors Network (USDN).

[43] Bureau of Planning and Sustainability, Climate Investment Plan (2023). Portland, Oregon.

WHERE?

Resilience hubs should be sited where they are most needed. Consider the following:

- Areas where residents have limited access to resources such as air conditioning, air filtration, backup energy systems, charging stations for electronic devices, and internet access.
- Neighborhoods that lack essential community gathering spaces.
- Areas identified as economically vulnerable.

Additionally, resilience hubs should not be established in areas that are at high risk of being impacted by a natural disaster, such as floodplains, landslide and wildfire hazard areas

IMPACTED CITY BUREAUS

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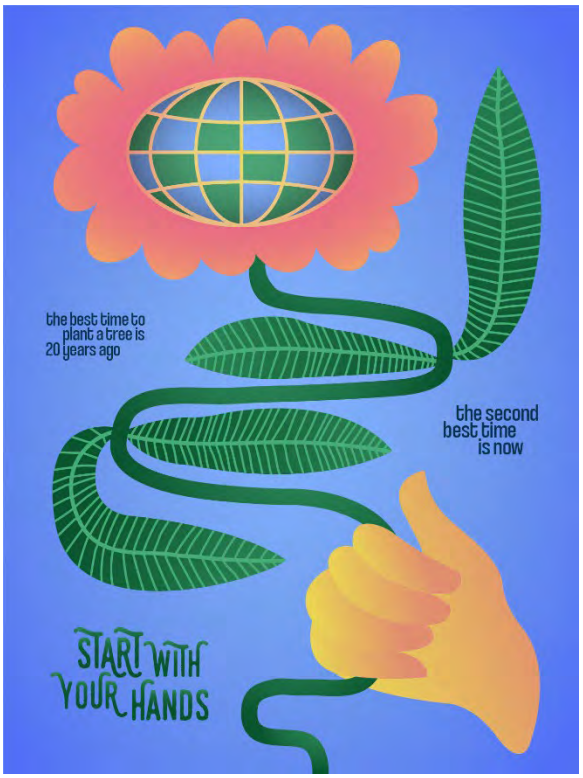
STREET TREE MAINTENANCE



Dorothy Luo for Fine Acts

Nature-Based Solution

WHAT?

Assume the responsibility and/or fund the maintenance of trees in the road right-of-way.

WHY?

To ensure trees and their associated social, environmental, and health benefits are distributed equitably throughout Portland.

Portland's tree canopy is not distributed evenly across the city. Areas that experienced historic disinvestment, and/or are home to low-income and majority BIPOC residents, have fewer trees and are more likely to be hotter than their wealthier counterparts.[44]

Municipal and non-profit tree planting programs in Portland (Urban Forestry, Friends of Trees, and Verde among others) try to address this inequity by targeting low-income neighborhoods; however, often face lack of participation or resistance from residents.

Studies suggest, "despite broad appreciation for trees and greenspaces, residents are concerned about the risks and costs residents assume over the course of a tree's life cycle, the threat of neighborhood development and gentrification associated with trees. Additionally, these barriers to participation may be amplified among low-income and communities of color who face the legacies of historical tree

[44] Anderson, M. (2020, January 14). Racist Housing Practices From the 1930s Linked to Hotter Neighborhoods Today. *All Things Considered*. episode, NPR.

disservices and municipal structural disinvestment."[45]

EXISTING RELATED WORK

The City of Portland has called for the transfer of street tree maintenance responsibilities and costs from adjacent property owners to the City in official documents since 1877. Ordinance No. 2060, "An ordinance providing for the location of shade and ornamental trees on the public streets and for the care thereof."[46]

Since then, there have been numerous documented requests from residents, Parks Bureau staff, and City Commissioners, for the City to assume the responsibility of street tree maintenance. In response, the City conducted several studies of mechanisms to fund street tree maintenance, including the use of general fund dollars, tax levies, and lineal frontage-foot assessments, though none were enacted.

In June 2022, one year following the death of at least 72 Multnomah County residents due to extreme heat, and 78 years after Parks Superintendent Keyser's initial proposal, the PCEF was authorized to establish the Equitable Tree Canopy (ETC) program. The ETC program is a community-centered tree planting and establishment program to be administered by Portland Parks & Recreation (PP&R) with PCEF oversight.

The ETC program was adopted by City Council in 2023. Over the course of five years, starting in 2025, the ETC program will plant at least 15,000 trees on public and private property in Portland's most heat-vulnerable neighborhoods.[47]

A second allocation of PCEF funds ($65 million dollars over five years) was approved by City Council in 2024 for the preservation and care of Portland's urban forest including the maintenance of street trees. The details of implementation are still to be determined, and additional funding will be required to implement the program citywide.

In addition, the City also provides free street trees for neighborhoods that have been identified as high-need for additional tree canopy through the Free Street Trees Along Improved Roads program. The program was initially set-up in BES and is now housed in PP&R and UF.

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[45] Riedman, E., Roman, L. A., Pearsall, H., Maslin, M., Ifill, T., & Dentice, D. (2022). Why don't people plant trees? uncovering barriers to participation in urban tree planting initiatives. *Urban Forestry & Urban Greening*, 73, 127597. https://doi.org/10.1016/j.ufug.2022.127597

[46] An ordinance providing for the location of shade and ornamental trees on the public streets and for the care thereof, 2060 (1877).

[47] Bureau of Planning and Sustainability, *Climate Investment Plan* (2023), Portland, Oregon.

HOW?

- Facilitate and/or fund contracts for the maintenance of trees in the public right-of-way.
- Create an Tree Maintenance Standard Operating Procedure to guide implementation.
- Explore costs and mechanisms to fund sidewalk repair and maintenance necessitated by damage due to trees in the right-of-way.

WHERE?

Throughout the city. Initiate maintenance in PCEF Priority Populations and those identified as heat vulnerable in the Multnomah County Heat Vulnerability Index (HVI).

IMPACTED CITY BUREAUS

BES

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PRIVATE PROPERTY TREE MAINTENANCE ASSISTANCE PROGRAM

Dorothy Luo for Fine Acts

Nature-Based Solution

WHAT?

Establish a Private Property Tree Maintenance Assistance Program to support property owners and residents most vulnerable to the impacts of extreme heat, and those lacking sufficient space for tree planting in the public right-of-way (planting area).

WHY?

The Majority of Portland's trees are located on private property. As such, a Private Property Tree Maintenance Assistance Program could expand and protect the urban forest overall. Moreover, it could support tree planting maintenance for residents most vulnerable to the impacts of climate change (see Tree Alliance Boston, MA Case Study in Section 4 of this report).

EXISTING RELATED WORK

Treebate (BES) provides a one-time credit on City of Portland water, sewer, stormwater bills for planting a tree in residential yards (single home or duplex). Credit amounts vary based on mature tree size.

Portland Parks and Recreation (PP&R) facilitates a free yard tree giveaway each fall. In addition to a free tree, PP&R provides a watering bucket, mulch, and standard instructions for planting and long-term care.

PP&R's Urban Forestry Department also manages a program called Private Property Tree Planting to help restore green space by planting trees on industrial, commercial and multi-family properties. The program is free to Portland residents and includes planting, watering, and maintenance for the first three years.

HOW?

- Provide grants and technical support to community-based organizations and private tree care providers to plant and maintain trees on private property.
- Convene participating organizations to perform tree planting, maintenance, and public education.
- Provide financial support to property owners for the care, removal, and replacement of trees on private property.

WHERE?

- In Environmental Justice (See Environmental Justice Mapping Tool recommendation) and heat vulnerable communities per the Multnomah County Heat Vulnerability Indexes.
- Along streets where curb-tight sidewalks, or a lack of sidewalks, prohibit tree planting in the right-of-way.
- Properties adjacent to Cool Corridors (see Cool Corridors recommendation).
- Single and multi-unit affordable housing (both regulated and naturally occurring).

IMPACTED CITY BUREAUS

BPS

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PWB

BES

UF

COOL CORRIDORS

Iva Tokmakchieva for Fine Acts

Nature-Based Solution

WHAT?

Plan for, design, and build Cool Corridors. Cool Corridors are linear, vegetated throughways along streets and water features. They prioritize pedestrian and bicycle transit. In addition to trees and plants, Cool Corridors may include engineered shade structures, and/or cool pavement.

WHY?

- Increase cooling through shade and evapotranspiration (the absorption of water through a tree or plant's roots and the subsequent emission of water through their leaves or needles into the atmosphere).
- Enhance stormwater management and water quality.
- Promote sustainable transit such as, walking and cycling.
- Filter pollutants.
- Mitigate sound.
- Enhance safe connections to parks, plazas, and transit.
- Increase biodiversity – Providing vegetated networks for wildlife to move through urban areas has shown to increase biodiversity.

EXISTING RELATED WORK

Portland Comprehensive Plan Chapter 3: Urban Form, states the City intends to "enhance Portland's public realm, integrate nature into the city, and link people, places, and wildlife through active transportation facilities, green infrastructure investments, urban tree canopy, and habitat connections."[48]

[48] City of Portland, Oregon, Bureau of Planning and Sustainability, *2035 Comprehensive Plan*, update through May 2023. https://www.portland.gov/bps/planning/comp-plan-2035/about-comprehensive-plan/2035-comprehensive-plan-and-supporting

In addition, Policy 3.47 Green Infrastructure in Corridors pronounces, "enhance corridors with distinctive green infrastructure, including landscaped stormwater facilities, extensive tree plantings, and other landscaping that both provide environmental function and contribute to a quality pedestrian environment."

Trees in the Curb Zone – A project that pilots tree planting in the curb/parking zone when there isn't sufficient space in the road right-of-way behind the curb. The pilot is currently underway in the Lents and Brentwood Darlington neighborhoods. Ultimately, the project team hopes to develop a framework for tree planting that can be replicated throughout the city.

"The city's Pedestrian Master Plan (PedPDX) (2019) and the Pedestrian Design Guide set the policy direction for PBOT and bureau partners (BES and PP&R/UF) to explore more innovative tree treatments."[49] Specifically, PedPDX Action 8.6 which states, "Update right-of-way design standards to provide sufficient room for trees"[50] and recommends "providing trees within the curb zone intermittent with on-street parking" as a potential solution.

HOW?

Empower a multi-bureau team and community working group to identify and propose routes for Cool Corridors. Next, adopt policy and standards to promote tree planting along designated Cool Corridors. Examples include:

- Expand front setback requirements to 15'-0" for single-family residences sited along Cool Corridors to provide adequate planting area for large canopy trees and promote planting adjacent to the right-of-way.
- Increase the width of the right-of-way adjacent to multi-unit, mixed use, and commercial developments along Cool Corridors to promote large canopy tree planting. In conjunction, reduce on-site tree density requirements to maximize buildable area.
- Require awnings for all new development along Cool Corridors.
- Require engineered shade structures in lieu of street trees along Cool Corridors where planting is prohibited due to utility and/or vision clearance guidelines.

[49] City of Portland, Oregon, Bureau of Transportation, *Trees in the curb zone pilot project*. Portland.gov. (n.d.). https://www.portland.gov/transportation/planning/trees-curb-zone?utm_medium=email&utm_source=govdelivery#toc-site-analysis-and-implementation.

[50] City of Portland, Oregon, Bureau of Transportation, *Portland Pedestrian Master Plan* 2019.

- Utilize silva cells to maximize soil volumes on sites where planting area in the road right of way is limited.
- Implement Trees in the Curb Zone Pilot Project along Cool Corridors.
- Incentivize additional tree and shrub planting adjacent to Cool Corridors.

WHERE?

Along major transit and pedestrian corridors. Prioritize implementation in heat vulnerable areas per the Multnomah County Heat Vulnerability Index.

IMPACTED CITY BUREAUS

BES

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BPS

PBEM

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PP&R

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UF

MICROFORESTS

Jacopo Rosati for ArtistsForClimate.org

Nature-Based Solution

WHAT?

Plant and manage Microforests in remnant parcels owned by the City of Portland.

Microforests are tiny, dense areas of forest that help fight climate change, cool down cities, and absorb carbon.

The concept of micro forestation or Microforests, was introduced in the 1970s by plant ecologist and botanist Akira Miyawaki. The micro forestation model aimed to increase green spaces by developing mostly native species of plants in small areas of land. Since then, Microforests have been implemented across the globe, especially in areas experiencing extreme heat and where there is too much pressure on the land. This has helped to minimize the effects of climate change and environmental degradation by preserving biodiversity, reducing urban temperatures, and serving as a shield against atmospheric and noise pollution.

Using the Miyawaki method, Microforests mature in a few decades rather than a century, meaning the mature trees can absorb high levels of carbon much sooner. Mature forests are also better at cooling through evapotranspiration and the provision of shade.

WHY?

Though Microforests are small—they can be planted in areas as small as 600 SF and only 3'-0" wide[51]— they are planted at a density 20 to 30 times higher than a typical forest, resulting in greater biodiversity per SF and greater carbon sequestration.[52]

[51] Radhakrishnan, S. A. (2020, January 5). *Kerala to turn to miyawaki method*. The Hindu. https://www.thehindu.com/news/cities/Thiruvananthapuram/kerala-to-take-more-cover-under-miyawaki-forests/article30479463.ece

[52] Stevens, C. (2022, November 17). *The power of Microforests in slowing down climate change.* Earth.Org. https://earth.org/microforests/

Because of their micro size, Microforests are ideal for urban environments where space is limited. They deliver maximal ecological benefit in minimal area.

Another benefit is Microforests require less maintenance than traditional urban planting areas. The forest becomes relatively maintenance free after three years from planting, at which point the forest manages itself through natural selection.[53]

HOW?

- Plant and manage Microforests on City-owned property.
- Explore funding opportunities, such as the Portland Clean Energy Community Benefits Fund (PCEF), or the Bureau of Environmental Services (BES) Percent for Green Program.
- Publish a planting guide for private property owners to reference and implement.

WHERE?

- Parcels owned by the City of Portland.
- Prioritize areas identified as heat vulnerable per the Multnomah County Heat Vulnerability Index (HVI).

IMPACTED CITY BUREAUS

BES

BPS

PBOT

PHB

PP&R

PWB

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UF

[53] Miyawaki, A. (2004). Restoration of living environment based on vegetation ecology: Theory and practice. *Ecological Research*, *19*(1), 83–90. https://doi.org/10.1111/j.1440-1703.2003.00606.

TREE PLANTING FOR HEAT RESILIENCE GUIDELINES

Kelly Romanaldi for ArtistsForClimate.org

Nature-Based Solution

WHAT?

Update the Portland Plant List and Tree and Landscape Manual to reflect the most recent research, information, and recommendations of climate adapted species for the Portland Metropolitan Area.

WHY?

- The Portland Plant List was last updated 2016 and is due for an update.
- Portland's United States Department of Agriculture Hardiness Zones Map were updated in 2023 to include Zone 8a (10-15 degrees F).
- Promote climate adapted species selection and planting for new development.
- Ensure newly planted trees and vegetation survive and thrive.
- Guarantee Portland's planting guidelines are congruent

EXISTING RELATED WORK

- Portland Plant List (2016)
- City of Portland Approved Street Tree Lists
- Policy 7.11.f. Resilient Urban Forest, of the Comprehensive Plan, states "encourage planting of Pacific Northwest hardy and climate change resilient native trees and vegetation generally, and especially in urban habitat corridors."[54]

HOW?

Bureau of Environmental Services (BES), Portland Parks & Recreation/Urban Forestry, and Bureau of Planning and Sustainability should coordinate on this effort. They

[54] City of Portland, Oregon, Bureau of Planning and Sustainability, *2035 Comprehensive Plan*, update through May 2023. https://www.portland.gov/bps/planning/comp-plan-2035/about-comprehensive-plan/2035-comprehensive-plan-and-supporting

should consult with horticultural experts to research and propose plants and trees that will thrive in our changing climate.

WHERE?

Throughout Portland.

IMPACTED CITY BUREAUS

BES

BPS

PP&R

UF

COOL ROOF REGULATION & COOL ROOF RETROFIT CAREER DEVELOPMENT PROGRAM

Dipti Lalani for ArtistsForClimate.org

Engineered Solutions

WHAT?

Require cool roofs for all parking structures, commercial buildings, industrial facilities, multi-unit residential buildings with a roof pitch of less than 2:12, as well as city-owned properties. Require existing buildings to comply at the time of major roof repair, additions, alterations, catastrophic damage, or replacement.

Allow exemptions for structures located within locally designated historic districts.

Cool roof requirements will create new jobs as new businesses emerge and existing roofing and construction businesses expand their services to meet growing demand. Establish a Cool Roof Retrofit Career Development Program to provide Portland residents with paid training to install energy-saving cool roofs while supporting the City's climate goals.

What are cool roofs? Cool roofs have high solar reflectance (albedo), as well as high thermal emittance, therefore absorbing and re-emitting minimal sunlight into the atmosphere as heat.

Cool roof products include asphaltic membranes surfaced with reflective granules, liquid-applied roof coatings with light or cool colors, fluid applied membranes with light or cool colors, roofing aggregate that is light or cool colored, single ply membranes with light or cool colored pigments, asphalt shingles surfaced with light or cool colored granules, wood shingles, and roofing tiles such as terra cotta, metal, or tiles with light or cool color glaze or polymer coating.

WHY?

The benefits of cool roofs include:

- Lower local outside air temperature which decreases the urban heat island effect.

- Slow the formation of smog from air pollutants, which are temperature dependent.
- Reduce the demand for energy to cool buildings.
- Decrease roof temperature, which may extend roof service life.
- Help older inefficient (or undersized) air conditioners provide sufficient cooling.
- Improve indoor comfort and safety for spaces that are not air conditioned.
- Costs are comparable to conventional roofing products.

EXISTING RELATED WORK

The design standards adopted in 2021 as part of the Design Overlay Zone Amendments project, encourage the use of eco roofs and photovoltaic panels (sustainable roofing systems) to reduce heat island effect, allow for the reuse or retention of stormwater, and/or reduce greenhouse gases in town centers and inner ring neighborhood centers. The City's Design Guidelines mirror these requirements and uphold the City's commitment to "promote quality and resilience."

HOW?

- Implement policy to require cool roofs.
- Fund career development centers to create or advance cool roof installation and retrofit training programs.

WHERE?

Throughout the city with targeted funding for buildings located in heat vulnerable areas.

IMPACTED CITY BUREAUS

BES

BPS

BPS

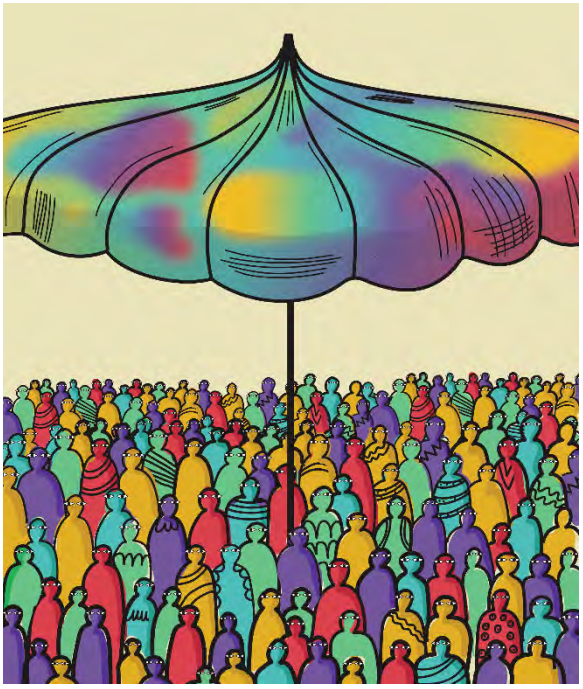
PBEM

PP&R

PWB

PWB

BUILT SHADE STRUCTURES



Barabar Design

Engineered Solutions

WHAT?

Require the integration of built shade structures and/or extended awnings in areas vulnerable to extreme heat and where tree planting is not feasible.

Extend the Design Standard *PR15 Weather Protection Along a Transit Street* beyond the Design Overlay Zone.

WHY?

Shade structures protect people from direct solar radiation, and while they can't reduce air temperature, they do reduce surface temperatures by as much as 40 degrees F (Figures 26-28). Built shade structures throughout Portland could provide shade and reduce surface radiation where tree planting is isn't feasible.

Additionally, as trees take several years to mature and provide shade, built shade structures can be sited to provide immediate relief. Shade structures could also be used temporarily in hot spots to provide essential shade while trees mature.

While built shade structures provide essential heat relief and shelter from rain, they do not provide the ecosystem services and co-benefits of trees, carbon sequestration, pollution filtration, and wildlife habitat among others.

Figure 26. Photograph of an awning at SE 7th Ave & Sandy Blvd. July 28, 2023, 2:09 PM

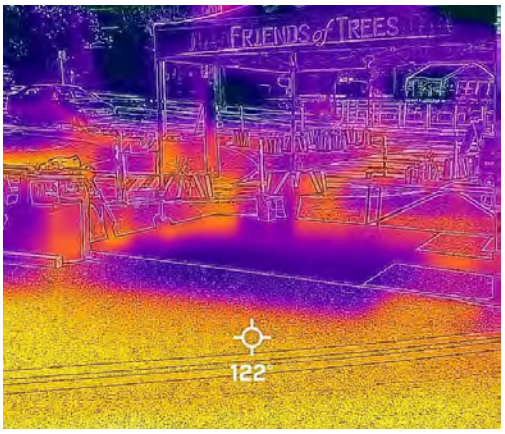


Figure 27. Image taken with a Forward Looking Infrared (FLIR) camera at SE 7th Ave & Sandy Blvd. July 28, 2023, 2:09 PM. Surface temperature of the pavement outside the awning is 122 degrees F.

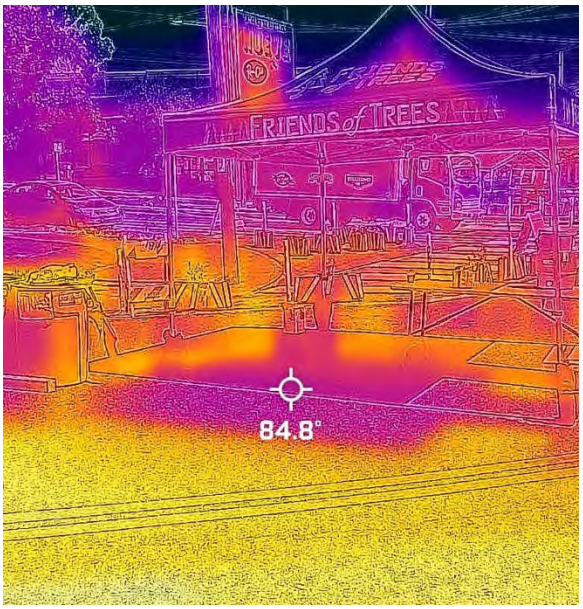


Figure 28. Image taken with a Forward Looking Infrared (FLIR) camera at SE 7th Ave & Sandy Blvd. July 28, 2023, 2:09 PM. Surface temperature of the pavement under the awning is 84.8 degrees F.

EXISTING RELATED WORK

Portland Citywide Design Standards include two regulations related to the topic: *PR15 Weather Protection Along a Transit Street* states that street-facing facades that are located within 20 feet of the street and are over 55 feet in height must provide weather protection along 50 percent of that façade.

C17 Open Area Adjacent to Willamette River Greenway Trail requires "at least 15 percent of the open area is covered by awnings, building eaves, or other covered structures."

HOW?

- Require engineered shade structures in lieu of street trees along cool corridors and heat vulnerable areas when planting is infeasible due to utility and/or vision clearance guidelines.
- Research and propose possible financial or permitting incentives to construct shade structures and canopies in heat vulnerable areas.
- Fund shade structures through grants.

WHERE?

Prioritize built shade structures along cool corridors and in neighborhoods identified as heat vulnerable in the Multnomah County HVI or Environmental Justice Mapping Tool.

Coordinate with TriMet to install built shade structures near transit stops, especially stops along major transit corridors and those that lack cover/weather protection.

IMPACTED CITY BUREAUS

BPS
BES
PBOT
PBEM
PHB
PP&R
PWB

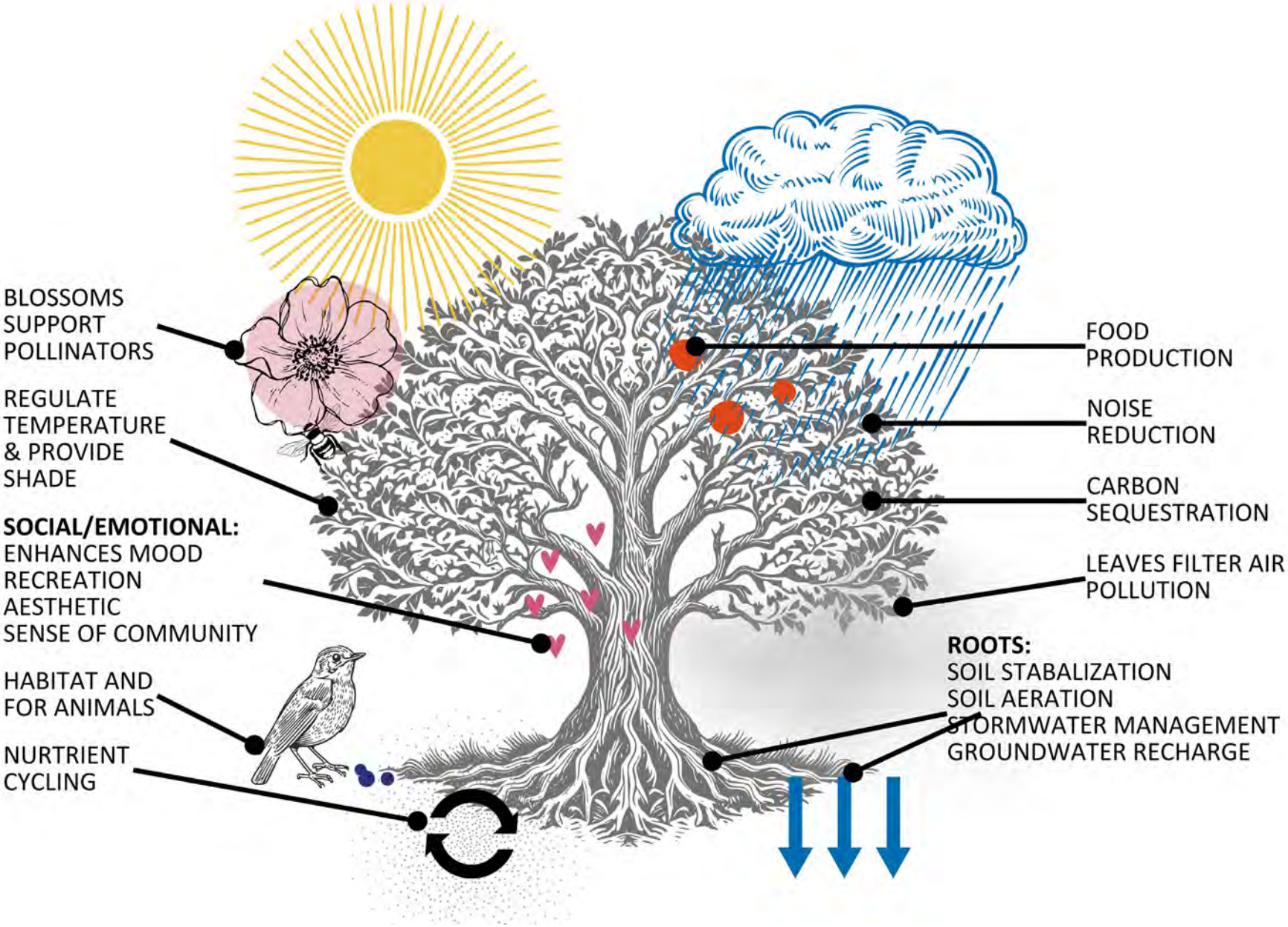


Figure 29. Ecosystem services of trees (Whitney Holt).

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About City of Portland Bureau of Planning and Sustainability
The Bureau of Planning and Sustainability (BPS) develops creative and practical solutions to enhance Portland's livability, preserve distinctive places, and plan for a resilient future.

THE BUREAU OF PLANNING & SUSTAINABILITY

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Heat Adaptation and Management Report Appendix:

INVENTORY OF POLICIES AND PROJECTS THAT FOSTER HEAT RESILIENCE IN PORTLAND

INTRODUCTION

Resilience planning, in large part, is an extension of existing programs and policies. Portland's bureaus have been working hard to foster resilience for many years. In 2018, resilience was identified as one of the five guiding principles in Portland's 2035 Comprehensive Plan. In the Comprehensive Plan, a variety of policies are prescribed to "reduce risk and improve the ability of individuals, communities, economic systems, and the natural and built environments to withstand, recover from, and adapt to changes from natural hazards, human-made disasters, climate change, and economic shifts."

Within this inventory, the City of Portland's efforts to manage and adapt to increasing temperatures and extreme heat events are grouped into the following action area categories: (1) Safety and Emergency Response, (2) Green Infrastructure and Healthy Watersheds, and (3) Built Environment and are identified typologically as either a program, policy, regulation or report. Each action area is integral to achieving overall heat resilience. Within each action area, multiple bureaus implement these efforts to reduce the effects of urban heat islands and ultimately acclimatize. In total, this inventory identified 82 policies, 22 programs, three reports and 42 regulations developed and implemented either citywide or by one or more of the following bureaus:

- Bureau of Planning and Sustainability (BPS); including Portland Clean Energy Fund (PCEF)
- Bureau of Environmental Services (BES)
- Portland Bureau of Emergency Management (PBEM)
- Portland Bureau of Transportation (PBOT)
- Portland Parks and Recreation (PP&R); including Urban Forestry (UF)
- Portland Water Bureau (PWB)

This inventory details the many regulations contained in the Portland City Code that contribute to managing and reducing heat island impacts. In summary:

- Title 11, Trees, known as the tree code, preserves and protects trees to optimize the benefits that trees provide including reducing energy demand and urban heat island through shading of building and impervious areas, filtering stormwater and reducing runoff, and maintaining and improving watershed health. To this end, the regulations in Tile 11 are designed to protect and preserve healthy trees as much as possible in both

development and nondevelopment situations. The regulations address tree maintenance, pruning, removal, and tree planting city-wide. The regulations are focused on achieving baseline tree preservation and maximal tree capacity.

- Title 17, Public Improvements, contains the requirements for new development to contribute to the funding of infrastructure capacity increases, including for new parks. The requirements are called System Development Charges.
- Title 20, Parks and Recreation, contains the requirement to maintain the City's Urban Forestry Management Plan.
- Title 33, Planning and Zoning, known as the zoning code, includes many regulations that are focused on reducing energy demand and heat island impacts. The zoning code includes regulations that limit impervious areas, such as parking and other paved vehicle areas, require both the planting of trees and vegetation and the protection of existing natural resources, such as riparian areas and forest, and require or encourage the installation of ecoroofs or solar panels. Throughout the zoning code, the addition of landscaping, including trees, is required or incentivized when development occurs. In most zones, some portion of every lot must be planted with landscaping, and landscaping is required in setbacks, in and around parking areas, and as screening for certain exterior areas and equipment. The zoning code includes regulations to protect identified natural resource that provide citywide benefits including green infrastructure and watershed health benefits. And, when land is being divided for additional development, regulations require lots and streets to be laid out in way that maximizes the preservation of on-site trees.
- The City's Stormwater Management Manual contains regulations for development that help mitigate urban heat including requiring on-site infiltration of stormwater wherever feasible.

This inventory aims to (1) recognize the ongoing and critical work being done throughout the City of Portland to manage and respond to heat, and (2) serve as a springboard from which to propose new strategies for enhanced heat resilience.

SAFETY AND EMERGENCY RESPONSE

This inventory identified 18 policies, four programs, no regulations, and two reports in the Public Safety and Emergency Response category (Table 1).

Table 1. City of Portland heat resilience programs, policies and regulations related to Public Safety and Emergency Response

Program, Policy or Regulation	Citywide or Specific Bureau(s)	Name	Summary
Policy	Citywide	Comprehensive Plan Chapter 4: Design and Development, *Hazard-Resilient Design Policy 4.81 Disaster-resilient Development*	Encourage development and site management approaches that reduce the risks and impacts of natural disasters or other major disturbances and that improve the ability of people, wildlife, natural systems, and property to withstand and recover from such events.
Policy	Citywide	Comprehensive Plan Chapter 4: Design and Development, *Hazard-Resilient Design Policy 4.84 Planning and Disaster Recovery*	Facilitate effective disaster recovery by providing recommended updates to land use designations and development codes, in preparation for natural disasters.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *GOAL 8.C: Reliability and Resiliency*	Public facilities and services are reliable, able to withstand or recover from catastrophic natural and manmade events and are adaptable and resilient in the face of long-term changes in the climate, economy, and technology.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *Public Safety and Emergency Response Policy 8.104 Emergency Preparedness, Response, and Recovery Coordination*	Coordinate land use plans and public facility investments between City bureaus, other public and jurisdictional agencies, businesses, community partners, and other emergency response providers, to ensure coordinated and comprehensive emergency and disaster risk reduction, preparedness, response, and recovery.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *Public Safety and Emergency Response*	Provide adequate public facilities – such as emergency coordination centers, communications

		Policy 8.105 Emergency Management Facilities	infrastructure, and dispatch systems – to support emergency management, response, and recovery.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *Public Safety and Emergency Response Policy 8.107 Community Safety Centers*	Establish, coordinate, and co-locate public safety and other community services in centers.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *Public Safety and Emergency Response Policy 8.109 Mutual Aid*	Maintain mutual aid coordination with regional emergency response providers as appropriate to protect life and ensure safety.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *Public Safety and Emergency Response Policy 8.110 Community Preparedness*	Enhance community preparedness and capacity to prevent, withstand, and recover from emergencies and natural disasters through land use decisions and public facility investments.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *Public Safety and Emergency Response Policy 8.111 Continuity of Operations*	Maintain and enhance the City's ability to withstand and recover from natural disasters and human-made disruptions to minimize disruptions to public services.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *School Facilities Policy 8.118 Schools as Emergency Aid Centers*	Encourage the use of seismically safe school facilities as gathering and aid-distribution locations during natural disasters and other emergencies.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services*, Public Investment Policy 8.25*	Increase the resilience of high-risk and critical infrastructure through monitoring, planning, maintenance, investment, adaptive technology, and continuity planning.
Policy	PBEM	Mitigation Action Plan (MAP): *Mitigation Actions*	Develop a curriculum and templates plans to assist local businesses in preparing for disasters;

		PBEM-1	promote business continuity planning for local businesses; encourage or require City vendors to develop business continuity plans.
Policy	PBEM	Mitigation Action Plan (MAP): *Mitigation Actions* *PBEM-3*	Provide air conditioner units to low-income Portlanders at great risk of hyperthermia; prioritize people who live in the hottest part of the city.
Policy	PBEM	Mitigation Action Plan (MAP): *Mitigation Actions* *PBEM-4*	Continue to support the Public Alerts program for emergency communications to the community.
Policy	PBEM	Mitigation Action Plan (MAP): *Mitigation Actions* *PBEM-5*	Audit how existing disaster planning and plans respond to people with disabilities and make a plan to systematically improve service to people with disabilities; update all PBEM response plans and guidelines; provide training to other bureau emergency managers on disaster response for people with disabilities.
Policy	PBEM	Mitigation Action Plan (MAP): *Mitigation Actions* *PBEM-8*	Support the Neighborhood Emergency Team program by providing essential supplies and storage space for NETs, providing access to culturally appropriate training, supporting neighborhood-level resilience planning. Prioritize neighborhoods that have been underserved by government in the past.
Policy	PBEM	Mitigation Action Plan (MAP): *Mitigation Actions* *PBEM-10*	Work with affordable housing providers to monitor indoor temperatures at buildings where residents face risks from extreme heat; inform all housing providers when problems are detected in high-risk buildings. Develop and share templated action plan for when protective action is needed.

			Engage public health and university research partners to ensure remote sensor data is reliable and action plan reflects public health best practices.
Policy	PBEM	Mitigation Action Plan (MAP): *Mitigation Actions* *PBEM-12*	Implement a relationship-management system to ensure the City maintains consistent and coherent communication with community-based organizations that are active in disasters; provide consistent communication with these organizations about natural hazards, including in blue skies; acknowledge strong relationships of trust between government and CBOs as social infrastructure for hazard risk reduction.
Program	PWB	Water Misting Stations	During extreme heat events, Portland Water Bureau, in conjunction with Portland Parks & Recreation, installs temporary water misting stations at community centers in underserved communities in east and north Portland. The misting stations provide drinking water and a continuous spray of cool water.
Program	PBEM	Portland COAD (Community Organizations Active in Disaster)	COAD is a network of Portland community organizations that prepare for and respond to emergencies and disasters like heatwaves, winter weather and earthquakes. COAD is a national model that brings together community organizations under four principles: Communication, Cooperation, Coordination and Collaboration. Each organization retains full autonomy and authority in how they serve their

			communities. Note: COAD limited duration program manager position ended July 2023.
Program	PBEM	NET (Neighborhood Emergency Team) Training	Neighborhood Emergency Teams (NETs) are Portland residents trained by PBEM and Portland Fire & Rescue to provide emergency disaster assistance within their neighborhoods. NET members are trained to save lives and property until professional responders can arrive. These volunteers are specially trained to help others without putting themselves in harm's way. NET members are: - Prepared to be self-sufficient for two weeks during any emergency. - Able to provide emergency assistance to their family and immediate neighbors. - Able to work within an emergency response team to save lives and property in their neighborhood. - Able to guide untrained volunteers who want to help others during a disaster. (Volunteer to be a Neighborhood Emergency Team (NET) Member | Portland.gov)
Program	BES	Willamette River Water Quality Testing	BES tests and shares river water quality levels every week during the summer. This helps to inform recreational river usage, which is an important cooling resource during stretches of extreme heat.
Report	PWB	Heat Impacts on Infrastructure and Personnel Study - In partnership with	More than half of PWB employees work outdoors in the elements. Outdoor work is necessary 24

		the Water Utility Climate Alliance (WUCA), and the Association of Metropolitan Water Agencies (AMWA)	hours a day, 365 days a year, and extreme weather events, such as heat waves, compromise their health and safety. The well-being of PWB's personnel is at the center of the bureau's short and long-term planning as they actively forecast and respond to extreme weather events. This study projected the increase in extreme heat days and changes in the heat index over the Portland service area based on outputs from downscaled climate models. The study evaluated the effect and cost of future air temperature and extreme heat conditions on (1) the health, safety, and productivity of outdoor personnel and (2) six drinking water facilities. The study also recommended a series of extreme heat climate adaptation strategies for PWB to implement to reduce heat impacts to personnel and mechanical/electrical equipment and increase resilience.
Report	PBEM	Home Forward Indoor Temperature Assessment (2022-2023)	The Portland Bureau of Emergency Management (PBEM), in partnership with Home Forward and the Multnomah County Health Department, initiated an effort with CAPA Strategies to track summer temperatures inside of public/affordable housing units. It was "an integrative quantitative-qualitative study of affordable housing properties, for which residents exposed to indoor heat played a significant role in collecting data, grounding results, and identifying solutions" (Home Forward

			Indoor Temperature Assessment). The assessment found that concrete high-rise buildings retained more heat than low-profile wood structures, and that resident owned, portable AC units have considerable limitations, especially in the event of building envelope inefficiencies. While these findings are significant, additional research and analysis is needed. The report concluded that indoor air temperature should not be the sole responsibility of the tenant/resident. Solutions for enhanced heat management necessitate cross sectoral response and shared responsibility among public agencies.

GREEN INFRASTRUCTURE AND HEALTHY WATERSHEDS

For this inventory, ***green infrastructure*** refers to an array of practices that use or mimic natural systems to enhance the urban environment and manage stormwater—street trees, bioswales, wetlands, and forests.

Healthy watersheds comprise intact and functioning headwater streams, floodplains, riparian corridors, instream habitat, and natural vegetation in the landscape.

This inventory identified 46 policies, 17 programs, 29 regulations, and no reports in the Green Infrastructure and Healthy Watersheds category (Table 2).

Table 2. City of Portland heat resilience programs, policies and regulations related to Green Infrastructure and Healthy Watersheds

Program, Policy or Regulation	Citywide or Specific Bureau(s)	Name	Summary
Policy	Citywide	Comprehensive Plan – Guiding Principles, *Resilience*	Reduce risk and improve the ability of individuals, communities, economic systems, and the natural and built environments to withstand, recover from, and adapt to changes from natural hazards, human-made disasters, climate change, and economic shifts.
Policy	Citywide	Comprehensive Plan – Guiding Principles, *Resilience – Extreme Heat Events*	Extreme heat events are identified as a threat to an individual's personal health and jeopardize the viability of construction and other outdoor employment.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *GOAL 3.G: Nature in the City*	A system of habitat corridors weaves nature into the city, enhances habitat connectivity, and preserves natural resources and the ecosystem services they provide.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Citywide Design and Development Policy 3.20 Green Infrastructure in Centers*	Integrate nature and green infrastructure into centers.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Corridors Policy 3.47 Green Infrastructure in Corridors*	Enhance corridors with distinctive green infrastructure, including landscaped stormwater facilities, extensive tree plantings, and other landscaping that both provide environmental function and contribute to a quality pedestrian environment.

Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Urban Habitat Corridors Policy 3.64 Urban Habitat Corridors*	Establish a system of connected, well-functioning, and diverse habitat corridors. Enhance the quality and connectivity of existing habitat corridors and establish new habitat corridors in developed areas.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Urban Habitat Corridors Policy 3.65 Habitat Connection Tools*	Improve habitat corridors using a mix of tools including natural resource protection, property acquisition, natural resource restoration, tree planting and landscaping with native plants, and ecological design integrated with new development.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Citywide Design and Development Policy 3.7 Integrate Nature*	Integrate nature and use green infrastructure throughout Portland.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *River Pattern Area Policy 3.82 Willamette River Greenway*	Maintain multi-objective plans and regulations to guide development, infrastructure investments, and natural resource protection and enhancement within and along the Willamette Greenway.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Eastern Neighborhood Pattern Area Policy 3.94 Eastern Neighborhoods Trees and Natural Features*	Encourage development and right-of-way design that preserves and incorporates Douglas Fir trees and groves, and that protects the area's streams, forests, wetlands, steep slopes, and buttes.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Eastern Neighborhoods Pattern Area Policy 3.96 Eastern Neighborhoods Corridor Landscaping*	Encourage landscaped building setbacks along residential corridors on major streets.

Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Western Neighborhoods Pattern Area Policy 3.100 Western Neighborhoods Development*	Encourage new development and infrastructure to be designed to minimize impacts on the area's streams, ravines, and forested slopes.
Policy	Citywide	Comprehensive Plan – Chapter 3: Urban Form, *Western Neighborhoods Pattern Area Policy 3.101 Western Neighborhoods Habitat Corridors*	Preserve, enhance, and connect the area's network of habitat areas and corridors, streams, parks, and tree canopy.
Policy	Citywide	Comprehensive Plan – Chapter 4: Urban Form, *Context Policy 4.4 Natural Features and Green Infrastructure*	Integrate natural and green infrastructure such as trees, green spaces, ecoroofs, gardens, green walls, and vegetated stormwater management systems, into the urban environment. Encourage stormwater facilities that are designed to be a functional and attractive element of public spaces, especially in centers and corridors.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience*	The City of Portland acknowledges that preventing environmental degradation is more economical than addressing problems retroactively. In addition, healthy natural systems reduce natural hazard risks and help the city to mitigate and adapt to climate change.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.3 Ecosystem Services*	Consider the benefits provided by healthy ecosystems that contribute to the livability and economic health of the city.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and*	Enhance the ability of rivers, streams, wetlands, floodplains, urban forest, habitats, and wildlife to

		Resilience Policy 7.4.b. Climate Adaptation and Resilience	limit and adapt to climate-exacerbated flooding, landslides, wildfire, and urban heat island effects.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.11 Urban Forest*	Improve, or support efforts to improve the quantity, quality, and equitable distribution of Portland's urban forest through plans and investments.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.11.a. Tree Preservation*	Require and incent preservation of large healthy trees, native trees and vegetation, tree groves, and forested areas.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.11.b. Urban Forest Diversity*	Coordinate plans and investments with efforts to improve tree species diversity and age diversity.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.11.c. Tree Canopy*	Coordinate plans and investments toward meeting City tree canopy goals.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.11.d. Tree Planting*	Invest in tree planting and maintenance, especially in low-canopy areas, neighborhoods with under-served or under-represented communities, and within and near urban habitat corridors.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.11.e. Vegetation in Natural Resource Areas*	Require native trees and vegetation in significant natural resource areas.

Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.11.f. Resilient Urban Forest*	Encourage planting of Pacific Northwest hardy and climate change resilient native trees and vegetation generally, and especially in urban habitat corridors.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.11.g. Trees in Land Use Planning*	Identify priority areas for tree preservation and planting in land use plans and incent these actions.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.15 Brownfield Remediation*	Improve environmental quality and watershed health by promoting and facilitating brownfield remediation and redevelopment that incorporates ecological site design and resource enhancement.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience Policy 7.18 Community stewardship*	Encourage voluntary cooperation between property owners, community organizations, and public agencies to restore or re-create habitat on their property, including removing invasive plants and planting native species.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Planning for Natural Resource Protection Policy 7.19 Natural Resource Protection*	Protect the quantity, quality, and function of significant natural resources identified in the City's natural resource inventory.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Planning for Natural Resource*	Maintain an up-to-date inventory by identifying the location and evaluating the relative quantity and quality of natural resources.

		Protection Policy 7.20 Natural Resource Inventory	
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Planning for Natural Resource Protection Policy 7.21 Environmental Plans and Regulations*	Maintain up-to-date environmental protection plans and regulations that specify the significant natural resources to be protected and the types of protections to be applied, based on the best data and science available and on an evaluation of cumulative environmental, social, and economic impacts and tradeoffs.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Planning for Natural Resource Protection Policy 7.21.a*.	Improve the effectiveness of environmental protection plans and regulations to protect and encourage enhancement of ecological functions and ecosystem services.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Planning for Natural Resource Protection Policy 7.21.b*.	Prevent or reduce disproportionate environmental impacts on underserved and under-represented communities.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Protecting Natural Resources in Development Situations Policy 7.26 Improving Environmental Conditions through Development*	Encourage ecological site design, site enhancement, or other tools to improve ecological functions and ecosystem services in conjunction with new development and alterations to existing development.
Policy	Citywide	Comprehensive Plan – Chapter 8: Public Facilities and Services, *Public Facilities & Services, Policy 8.10 Co-location*	Encourage co-location of public facilities and services across providers where co-location improves service delivery efficiency and access for historically under-represented and under-served communities.

Policy	Citywide	Comprehensive Plan – Chapter 8: Public Facilities and Services, *Public Benefits Policy 8.32, Community Benefits*	Encourage providing additional community benefits with large public facility projects as appropriate to address environmental justice policies.
Policy	Citywide	Comprehensive Plan – Chapter 8: Public Facilities and Services, *Public Benefits Policy 8.35 Natural Systems*	Protect, enhance, and restore natural systems and features for their infrastructure service and other values.
Policy	Citywide	Comprehensive Plan – Chapter 8: Public Facilities and Services, *Public Rights-Of-Way Policy 8.42 Stormwater Management Function*	Improve rights-of-way to integrate green infrastructure and other stormwater management facilities to meet desired levels-of-service and economic, social, and environmental objectives.
Policy	Citywide	Comprehensive Plan – Chapter 8: Public Facilities and Services, *Public Rights-Of-Way Policy 8.43 Trees in the Rights-of-way*	Integrate trees into public rights-of-way to support City canopy goals, transportation functions, and economic, social, and environmental objectives.
Policy	Citywide	Comprehensive Plan – Chapter 8: Public Facilities and Services, *Parks and Recreation Policy 8.97 Natural Resources*	Preserve, enhance, and manage City-owned natural areas and resources to protect and improve their ecological health, in accordance with both the natural area acquisition and restoration strategies, and to provide compatible public access.
Policy	Citywide	Comprehensive Plan – Chapter 8: Public Facilities and Services, *Parks and Recreation Policy 8.98 Urban Forest Management*	Manage urban trees as green infrastructure with associated ecological, community, and economic functions, through planning, planting, and maintenance activities, education, and regulation.
Policy	PP&R/UF	Levels of Service for Developed Parks, Natural Areas, and Community Centers	Summary: The Level of Service (LOS) examined natural areas, full-service community centers, and twelve recreational assets (play areas, basketball courts, community gardens, spray play, dog off-

			leash areas, group picnic areas, skate parks, sports fields, ballfields, plazas, specialty gardens, and tennis courts) provided by Portland Parks and Recreation, and recommends how those assets and facilities can be equitably distributed across the city, and at what frequency. See maps in the Executive Summary. How the LOS will be used: LOS guidance will be a prioritization tool for long-term planning of the City's parks and recreation system. "The LOS will prove particularly useful in advancing equity, as it has identified gaps and which gaps are the most urgent given demographics and the number of parks, natural areas, and recreational opportunities in nearby existing park assets.
Policy	PP&R/UF	Parks 2020 Vision Plan	Provide a wide variety of high-quality recreation services and opportunities for all residents: • Provide a basic developed Neighborhood Park facility or natural area within a one half (½) mile (10–15-minute walk) of every Portland resident, and a full-service community center with a pool, within three (3) miles of every resident. • Maintain the current ratio of parkland to population – 20 acres per thousand residents. Preserve, protect, and restore Portland's natural resources to provide "Nature in the City": • "Acquire sufficient land to protect existing resources, to complete natural resource

			areas, and to protect locally significant natural areas." • "Protect, expand, and restore interconnected ecosystems and wildlife corridors." • Increase the amount of protected habitat land. • "Expand urban forest on city streets from 60% to 80% and within parks from 80% to 90%." Develop parks and recreation facilities and programs that promote "Community in the City": • "Build public plazas and 'green connections' in the regional and town centers and along the main streets." Integrate parks, community centers, and trails into neighborhoods throughout the city.
Policy	PP&R/UF	Portland Urban Forest Plan (2025)	The Portland Urban Forest Plan "is a guide for preserving, expanding and caring for Portland's urban forest. It documents community priorities to direct City decisions about funding, management, policies, and programs. This Plan provides common goals and a unified vision to City staff and community members who work with trees in different ways. It presents an implementation strategy to address current challenges and take the City beyond what has been accomplished under previous plans. The City and community members can use this Plan to work together to create a healthier, more resilient community."

Policy	BES	Combined Sewer Overflow (CSO) Program, *Clean River Plan*	"The CSO program separates the combined storm and sanitary sewers that overflow into the Willamette River and Columbia Slough during times of heavy rain to eliminate the resulting pollution. The Clean River Plan addresses the combined sewers as well as protection and improvements to important urban watersheds through its 'Ten Actions for Success.' It aims to reduce stream flow, restore floodplains, and foster environmental education and stewardship. Action 2 reads, *"Plant trees, native vegetation and create buffers and shade along streams." The plan calls for the City to develop partnerships with agencies, neighborhoods, schools, organizations and businesses for restoration and planting projects. It also mandates that the City adopt and enforce development standards that protect vegetation*, respond to the requirements of the ESA, increase the in-stream structures in creeks and create slow-moving backwater areas and braided channels. *The plan calls for planting 63,000 trees along 350 miles of bare curb to increase tree canopy by 100 acres."*
Policy	PP&R/UF	Priority Planting Area	Urban Forestry uses data to determine priority neighborhoods for planting, education, and outreach services. Canopy cover, along with economic and demographic data determine priority neighborhoods - areas where resources have the potential to provide the most benefit.
Program	BES	Clean River Rewards	Clean River Rewards offers a discount on on-site stormwater charges when property owners safely

			contain rain on their property and keep it out of the city's sewer and stormwater pipes. Many natural stormwater management solutions such as rain gardens, ecoroofs and trees also reduce urban heat and help Portland adapt to increasing summer temperatures.
Program	PP&R/UF	Private Property Tree Planting	PP&R's Urban Forestry department helps restore green space by planting trees on industrial, commercial, and multi-family properties—all for free. That includes planting, watering, and maintenance for the first three years.
Program	BES	Percent for Green	Program Summary: Percent for Green grants support community groups completing large-scale green infrastructure projects. Eligible Projects (that also mitigate urban heat): • Stormwater management solutions such as rain gardens, ecoroofs, and projects on buildings that increase vegetation in the urban environment. • Depaving projects that remove pavement and replace it with vegetation or pervious paving. • "Green street projects that manage stormwater in the street or right-of-way." • Pervious paving installation.
Program	BES	Treebate	Treebate provides a one-time credit on City of Portland water, sewer, stormwater bills for planting a tree in residential yards (single home or duplex). Credit amounts vary based on mature tree size.

Program	BES	Community Watershed Stewardship Program (CWSP) Grant	Program Summary: The Community Watershed Stewardship Program (CWSP), a partnership between Environmental Services and the Portland State University Indigenous Nations Study Department, provides funding for Portland community groups and residents to improve the health of Portland watersheds. In addition to contributing to watershed health, many eligible projects also mitigate the effects of urban heat islands and/or provide cooling. Eligible Projects with heat mitigation/adaptation co-benefits: • Pavement removal and urban restoration • Rain gardens and stormwater management solutions such as ecoroofs and rain gardens • Community and Native gathering gardens
Program	BES	Portland Green Streets Program	Green Streets are streets that use vegetated stormwater facilities to reduce stormwater flows, improve water quality and enhance overall watershed health.
Program	BES	Watershed and Floodplain Restoration	Watershed restoration reclaims habitat and repairs the damage done to our environment and natural systems by poor development choices, and human activities. Along with the help of community partners, BES completes and then monitors numerous watershed restoration projects around Portland.
Program	BES	Natural Area Management	BES manages approximately 800 acres of natural area throughout Portland.

Program	PP&R/UF	Neighborhood Tree Liaison Program	"Urban Forestry Program staff train community volunteers to serve as neighborhood-based resources for information and education about urban forestry issues and to organize community tree-related projects, including planting and pruning street trees. They also lead educational walks through the community. To date, 120 people have completed training (UF Management Plan)."
Program	PP&R/UF	Free Street Tree Planting Program	Portland Parks & Recreation, in conjunction with Urban Forestry, will fund the planting of 1500 street trees in the public right-of-way. The street trees will be watered and maintained for three summers following planting. "After the third summer, trees become the responsibility of the adjacent property owner to maintain, which is the same for all street trees under Portland City Code 11.60.060.A.2.a." The Free Street Tree Planting Program is funded by Portland's Tree Planting and Preservation Fund.
Program	PP&R/UF	Yard Tree Giveaway	PP&R facilitates a free yard tree giveaway each fall. In addition to a free tree, PP&R provides a watering bucket, mulch, and standard instructions for planting and long-term care.
Program	BPS (PCEF)	Strategic Program 5: Building Upgrades for Community Severe Weather Response Five-year Funding Allocation: $30,000,000	This program will fund building energy upgrades for sites owned and/or managed by eligible government entities and nonprofit organizations that make a long-term commitment to provide critical services during severe weather-related events. These may include high heat events, snowstorms, and wildfire smoke events. Types of

			upgrades may include solar installations; battery backup; and high-efficiency heating, cooling, and air filtration systems.
Program	BPS (PCEF)	Strategic Program 8: Equitable Tree Canopy Five-year Funding Allocation: $40,000,000	The Equitable Tree Canopy program will work in Portland's most heat-vulnerable neighborhoods to equitably plant and establish at least [15,000 – 25,000] trees on public and private property. The program will also support the development of a diverse well-trained workforce and contracting community for tree planting and maintenance.
Program	BPS (PCEF), PP&R/UF	Tree Canopy Maintenance Reserve Five-year Funding Allocation: $5,000,000	Funding for the targeted long-term maintenance of tree canopy to ensure the sequestration of carbon emissions. This program will enable low-income property owners to access funds for the maintenance of existing established street trees.
Program	BPS (PCEF)	Strategic Program 11: 82nd Avenue Climate Infrastructure and Community Resilience Grant Program Five-year Funding Allocation: $5,000,000	This program supports and develops existing community and business leadership in the 82nd Avenue corridor to enhance the ability of current residents and business to deal with and alleviate the impacts of climate change. Funding will be allocated to existing programs: • PCEF community responsive grants for green infrastructure projects located within .25-mile west and .5-mile east of the 82nd Avenue corridor. • PCEF mini grants to fund small scale projects that help build community resilience and address the impacts of climate change in historically underserved communities.

			• Prosper Portland business stabilization and event grants.
Program	BPS (PCEF)	Strategic Program 12: 82nd Avenue Street Tree Expansion Five-year Funding Allocation: $5,000,000	Increasing street trees along the 82nd Avenue corridor to address a key community priority, urban heat island effects, and enhance investments in critical safety repairs made by Portland Bureau of Transportation (PBOT). This program aims to create space for trees in the right-of-way along 82nd Avenue – one of the lowest areas for tree canopy coverage in Portland. PCEF's investment will fund approximately thirteen blocks of sidewalk expansion and tree planting along 82nd Avenue. In consultation with PP&R, the program will prioritize large tree species to maximize shade potential.
Program	BPS (PCEF)	Strategic Program 16: Climate-friendly Public Schools Five-year Funding Allocation: $50,000,000	This investment enables school districts to implement physical infrastructure projects that reduce greenhouse gas emissions and improve climate resilience. Building upgrades in schools may provide the opportunity to support community members during severe weather events, such as heat waves. School yards present an opportunity to increase green infrastructure and urban tree canopy to promote cooling in spaces used by youth during the school day, and the surrounding community throughout the year.
Regulation	BES	Stormwater Management Manual 2025	Manual Summary: BES maintains and implements policy and design requirements for stormwater management for all new development, redevelopment, and improvement projects. Stormwater Management Requirements:

			The City's stormwater management requirements prioritize onsite infiltration and the use of vegetated facilities. The following stormwater management requirements help to mitigate and adapt to urban heat. • Require infiltration wherever feasible to restore historic hydrologic function and recharge groundwater. • Protect watershed health by mimicking pre-development hydrologic conditions.
Regulation	PP&R/UF	Title 11: Trees, *11.10.070 Fees B. Fees in Lieu of Planting or Preserving Trees*	"Where allowed by other provisions of this Title, a fee may be paid into the Tree Planting and Preservation Fund in lieu of planting or preserving trees. The fee per tree is the entire cost of establishing a new tree in accordance with standards described by the City Forester. The cost includes materials and labor necessary to plant the tree and maintain it for five (5) years."
Regulation	PP&R/UF	Title 11: Trees, *11.1.15.010 Tree Planting and Preservation Fund B. Expenditures*	"Money in the Tree Planting and Preservation Fund may be used only as follows: 1. To plant trees on public or private property, including streets. Planting trees includes the cost of materials and labor necessary to install and establish a tree for a five (5) year period. 2. To purchase conservation easements for the perpetual retention of trees and tree canopy. Such conservation easements shall allow the City to replace trees that are removed when they die or become dangerous.

			3. To acquire land to permanently protect existing trees or groves."
Regulation	PP&R/UF	Title 11: Trees, *11.1.15.010 Tree Planting and Preservation Fund D. Administration of the Tree Planting and Preservation Fund*	"The Tree Planting and Preservation Fund is administered by the City Forester, maintained in a dedicated separate account, and is independent of the general fund. Any balance in the Tree Planting and Preservation Fund will be carried forward into subsequent fiscal years."
Regulation	PP&R/UF	Title 11: Trees, *11.15.020 Urban Forestry Fund, A. Purpose and B. Expenditures*	A. Purpose: The purpose of the Urban Forestry Fund is to replace Street or City Trees illegally removed or damaged, to enhance the urban forest through the planting of new Street or City Trees, and to increase public awareness of trees, tree care, and values of the urban forest. B. Expenditures: Money in the Urban Forestry Fund may be used as follows: - To replace, establish, and maintain Street or City Trees illegally removed or damaged. - To plant, establish and maintain Street or City Trees where, in the judgment of the Forester, they will enhance the values of the Urban Forest. - To provide education, outreach, and technical assistance to the community. Other Forestry-related actions or programs, as determined by the City Forester.
Regulation	PP&R/UF	Title 11: Trees, *11.20.060 Heritage Tree Program*	The Heritage Tree Program protects and preserves trees that have been formally recognized by City Council for their unique size, age, historical or horticultural significance. Once accepted by

			Council, Heritage Trees are protected by City Code and cannot be removed without the approval of the Urban Forestry Commission and Portland City Council. A permit from Urban Forestry is required to prune, apply chemicals, or do any other tree work on a Heritage Tree, whether the tree is in the City right-of-way or on private property. "A Heritage Tree can only be approved for removal if it is dead, dying, or dangerous."
Regulation	PP&R/UF	Title 11: Trees, *11.30 Tree Permit Procedures*	This chapter establishes application requirements and procedures for all tree permits required by Title 11 to safeguard the legal rights of individual property owners and ensure the public is protected. Tree permits are typically required for specific tree related activity when not associated with development.
Regulation	PP&R/UF	Title 11: Trees, *11.40 Tree Permit Requirements (No Associated Development)*	"The purpose of this chapter is to manage, conserve and enhance the urban forest when development activity is neither proposed nor occurring. The provisions of this chapter encourage preservation of high-quality trees, large trees, and groves; regulate pruning and planting on City-owned and managed sites and streets to protect public safety and public infrastructure; and ensure replacement for trees that are removed. The permitting procedures that are required to implement these provisions are intended to not only enforce maintenance, removal, and preservation requirements but also to educate property owners about the intrinsic

			urban benefits of trees as well as the principles of tree care."
Regulation	PP&R/UF	Title 11: Trees, *11.50 Trees in Development Situations*	The regulations of this chapter support and complement other City development requirements, focused on achieving baseline tree preservation and maximal tree capacity on a site, considering the anticipated use and level of development. "This Chapter regulates the removal, protection, and planting of trees through the development process to encourage development, where practicable, to incorporate existing trees, particularly high quality or larger trees and groves, into the site design, to retain sufficient space to plant new trees, and to ensure suitable tree replacement when trees are removed." It is the intent of these provisions to reduce the impact of tree removal and to guarantee mitigation when tree preservation standards are not met.
Regulation	PP&R/UF	Title 11: Trees, *11.70 Enforcement*	This Chapter establishes an enforcement system to prohibit illegal tree activity to advance the City's goals for protecting and enhancing the urban forest.
Regulation	PP&R/UF	Title 17: Public Improvements, *17.13 Parks and Recreation System Development Charge (SDC)*	New development within the City of Portland necessitates the expansion of the park system (parks, trails, and natural areas) to meet the needs of a growing population. As a result, new development is required to contribute to the funding for such capacity-increasing improvements via System Development Charges (SDC), one-time fees assessed on new development.

Regulation	PP&R/UF	Title 20: Parks and Recreation	The purpose of this chapter is to manage, conserve and enhance the existing trees located in the parks and public areas to and protect the urban forest as an important environmental and economic resource. It establishes the Urban Forestry Commission and mandates the creation of the Portland Urban Forestry Management Plan.
Regulation	BPS	Title 33, Planning and Zoning, *Community Design Standards 33.218.150.A Standards for I Zones Building Placement and the Street Foundation landscaping option*	All street-facing elevations must have landscaping along their foundation. The foundation landscaping must meet the following standards: • The landscaped area must be at least 3 feet wide. • There must be at least one three-gallon shrub for every 3 lineal feet of foundation. Ground cover plants must fully cover the remainder of the landscaped area.
Regulation	BPS	Title 33, Planning and Zoning, *Community Design Standards 33.218.150.B Standards for I Zones Building Placement and the Street Landscape coverage*	On sites outside conservation districts, at least 15 percent of the total site area must be landscaped.
Regulation	BPS	Title 33, Planning and Zoning, *Additional Use and Development Regulations 33.266.130.C.4*	Surface parking and driveway paving limitations. In the RM1 through RM4 zones, the following parking area and driveway size and paving material limitations apply: • No more than 30 percent of total site area may be paved or used for surface parking and driveways • Asphalt paving for surface parking and driveways may not cover more than 15 percent of total site area

Regulation	BPS	Title 33, Planning and Zoning, Overlay Zones 33.420.050 Design Overlay Zone Design Standards Landscaping C10 Tree Preservation	Sites with at least one tree 20 inches or greater in diameter – Earn one point for each tree 20 inches or greater in diameter that is protected as specified in Title 11, Trees. No more than 6 points can be earned.
Regulation	BPS	Title 33, Planning and Zoning, Overlay Zones 33.420.050 Design Overlay Zone Design Standards Landscaping C11 Grouping of Trees	Site located within the Eastern Pattern Area shown on Map 130-2 – Plant a minimum of five evergreen trees in an area that is at least 500 square feet in area and measures at least 20 feet in all directions. Trees planted must be a minimum of 5 feet in height and listed on the Portland Plan List.
Regulation	BPS	Title 33, Planning and Zoning, Overlay Zones 33.420.050 Design Overlay Zone Design Standards Landscaping C13 Trees in Setbacks Along a Civic Corridor	Plant trees within the 10-foot required building setback for the civic corridor. The row of trees must meet the following. • The row must extend along at least 50 percent of the street frontage. • A minimum of 4 trees must be planted, and the trees must meet the L1 standard for tree spacing. • Trees planted to meet perimeter parking lot landscaping do not count toward meeting this standard.
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards Adjacent Natural Areas C14 Setback from Waterbodies*	Site that: (1) Has at least one wetland, water body, seep or spring, and (2) is located outside of environmental zones – Locate all buildings, structures, and outdoor common areas that are more than 50 percent impervious a minimum of 50 feet from the edge of wetlands, the top of bank or water bodies, and seeps or springs located on the site.

Regulation	BPS	Title 33, Planning and Zoning, Environmental zones 33.430	Environmental zones protect resources and functional values (benefits provided by resources) that have been identified by the City as providing benefits to the public" These regulations also help meet regional, state, and federal goals and regulations. • *The Environmental Protection Zone* provides the highest level of protection to the most important resources and functional values. • *The Environmental Conservation Zone* conserves important resources and functional values in areas where the resources and functional values can be protected while allowing environmentally sensitive urban development.
Regulation	BPS	Title 33, Planning and Zoning, *Landscaping and Screening 34.248*	The City of Portland recognizes the aesthetic, ecological, and economic value of landscaping and regulates use throughout the city.
Regulation	BPS	Title 33, Planning and Zoning, *Tree Preservation 33.630.010*	The regulations require trees be considered early in the design process with the goal of preserving high value trees and mitigating for the loss of trees. Desire benefits of trees include reducing energy demand and urban heat island impacts, among others.
Regulation	BPS	Title 33, Planning and Zoning, *Minimum Tree Preservation Standards 33.630.100 A.*	The applicant must choose one of the following options: • Option 1: Preserve all of the trees that are 20 or more inches in diameter and at least 20 percent of the total tree diameter on the site;

			• 2. Option 2: Preserve at least 75 percent of the trees that are 20 or more inches in diameter and at least 35 percent of the total tree diameter on the site; • 3. Option 3: Preserve at least 50 percent of the trees that are 20 or more inches in diameter and at least 40 percent of the total tree diameter on the site; • 4. Option 4: Where all trees are less than 20 inches in diameter, preserve at least 45 percent of the total tree diameter on the site; • 5. Option 5: If one or more tree groves are located completely or partially on the site, preserve all the grove trees located on the site and at least 20 percent of the total tree diameter or canopy area on the site; or •
Regulation	BPS	Title 33, Planning and Zoning, *Minimum Tree Preservation Standards 33.630.100 B. Heritage Trees*	Heritage Trees located on the land division site may be counted toward meeting preservation standards. Heritage Trees must be preserved unless removal has been approved by the Urban Forestry Commission.
Regulation	BPS	Title 33, Planning and Zoning, *Tree Preservation Approval Criteria 33.630.200 A.*	To the extent practicable, tree preservation is maximized while allowing reasonable development, taking into consideration: • 1. The specific development proposed; • 2. The uses and intensity of development expected in the zone and the area in which the site is located;

			• 3. Requirements to provide services to the site under Chapters 33.651 through 33.654, including street connectivity and street plan requirements. Options to limit impacts on trees while meeting these service requirements must be evaluated; • 4. Requirements to protect resources in Environmental, Pleasant Valley Natural Resources, or Greenway Natural, Water Quality, and River Environmental overlay zones. Protection of environmental resources and retention of benefits from trees should be maximized for the site as a whole; and • 5. Other site constraints that may conflict with tree preservation, such as small or oddly shaped sites or trees located in existing utility easements .
Regulation	BPS	Title 33, Planning and Zoning, *Tree Preservation Approval Criteria 33.630.200 B.*	To the extent practicable, trees proposed for preservation provide the greatest benefits. In general, healthy native or non nuisance trees that are 20 or more inches in diameter and tree groves are the highest priority for preservation. However, specific characteristics of the trees, site and surrounding area should be considered and may call for different priorities • .
Regulation	BPS	Title 33, Planning and Zoning, *Tree Preservation Approval Criteria 33.630.200 C.*	Trees proposed for preservation are suitable based on their health, overall condition and potential for long-term viability.

Regulation	BPS	Title 33, Planning and Zoning, *Tree Preservation Approval Criteria 33.630.200 D. Mitigation*	Where at least one tree preservation standards cannot be fully met, mitigation must be provided as needed to replace the functions of trees removed from the site. Options for mitigation may include preservation of smaller diameter or native trees, permanent preservation of trees within a tree preservation or environmental resource tract, tree planting, payment into the City's Tree Planting and Preservation Fund, or other options that are consistent with the purpose of this chapter.
Regulation	BPS	Title 33, Planning and Zoning, *Tree Preservation Credit 33.630.500*	Trees that are preserved in a tree preservation tract that is outside of an Environmental or Pleasant Valley Natural Resources overlay zone may count toward meeting the tree density standards for individual lots in Chapter 11.50, Trees in Development Situations. If this option is chosen, at least one tree must be planted or preserved on each lot created for single-dwelling or duplex development. The preliminary plan must indicate the lots where the credit from the preserved trees will be used.

BUILT ENVIRONMENT

This inventory identified 19 policies, one program, 13 regulations and one report in the Built Environment category (Table 3).

Table 3. City of Portland heat resilience programs, policies and regulations related to the Built Environment

Program, Policy or Regulation	Citywide or Specific Bureau(s)	Name	Summary
Policy	Citywide	Comprehensive Plan – Chapter 4: Design and Development, *Goal 4.C: Human and Environmental Health*	Neighborhoods and developments are efficiently designed and built to enhance human and environmental health: they protect safety and livability; support local access to healthy food; limit negative impacts on water, hydrology, and air quality; reduce carbon emissions; encourage active and sustainable design; protect wildlife; address urban heat islands; and integrate nature and the built environment.
Policy	Citywide	Comprehensive Plan Chapter 4: Design and Development, *Goal 4.D: Urban Resilience*	Buildings, streets, and open spaces are designed to ensure long-term resilience and to adjust to changing demographics, climate, and economy, and withstand and recover from natural disasters.
Policy	Citywide	Comprehensive Plan – Chapter 4: Design and Development, *Resource-efficient Design and Development Policy 4.69, Reduce Carbon Emissions*	Encourage a development pattern that minimizes carbon emissions from building and transportation energy use.
Policy	Citywide	Comprehensive Plan – Chapter 4: Design and Development, *Designing with Nature Policy 4.73, Design with Nature*	Encourage design and site development practices that enhance, and avoid the degradation of, watershed health and ecosystem services and that incorporate trees and vegetation.
Policy	Citywide	Comprehensive Plan – Chapter 4: Design and Development, *Designing with Nature Policy 4.74, Flexible Development Options*	Encourage flexibility in the division of land, the siting and design of buildings, and other improvements to reduce the impact of development on environmentally sensitive areas

			and to retain healthy native and beneficial vegetation and trees.
Policy	Citywide	Comprehensive Plan – Chapter 4: Design and Development, *Designing with Nature Policy 4.75, Low-impact Development and Best Practices*	Encourage use of low-impact development, habitat-friendly development, bird-friendly design, and green infrastructure.
Policy	Citywide	Comprehensive Plan – Chapter 4: Design and Development, *Design with Nature Policy 4.76, Impervious Surfaces*	Limit use of and strive to reduce impervious surfaces and associated impacts on hydrologic function, air and water quality, habitat connectivity, tree canopy, and urban heat island effects.
Policy	Citywide	Comprehensive Plan Chapter 4: Design and Development, *Hazard-Resilient Design Policy 4.81 Disaster-resilient Development*	Encourage development and site management approaches that reduce the risks and impacts of natural disasters or other major disturbances and that improve the ability of people, wildlife, natural systems, and property to withstand and recover from such events.
Policy	Citywide	Comprehensive Plan – Chapter 4: Design and Development, *Hazard-resilient Design Policy 4.83, Urban Heat Islands*	Encourage development, building, landscaping, and infrastructure designs that reduce urban heat island effects.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Improving Environmental Quality and Resilience, Policy 7.2 Environmental Equity*	Prevent or reduce adverse environment-related disparities affecting under-served and under-represented communities through plans and investments. This includes addressing disparities relating to air and water quality, natural hazards, contamination, climate change, and access to nature.

Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Protecting Natural Resources in Development Situations Policy 7.23, Impact Evaluation*	Evaluate the potential adverse impacts of proposed development on significant natural resources, their functions, and the ecosystem services they provide to inform and guide development design and mitigation.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Protecting Natural Resources in Development Situations Policy 7.24, Regulatory Hierarchy: Avoid, Minimize, Mitigate*	Maintain regulations requiring that the potential adverse impacts of new development on significant natural resources and their functions first be avoided where practicable, then minimized, then lastly, mitigated.
Policy	Citywide	Comprehensive Plan – Chapter 7: Environment and Watershed Health, *Protecting Natural Resources in Development Situations, Policy 7.25 Mitigation Effectiveness*	Require that mitigation approaches compensate fully for adverse impacts on locally and regionally significant natural resources and functions. Require mitigation to be located as close to the impact as possible.
Policy	Citywide	Comprehensive Plan Chapter 8: Public Facilities and Services, *Public Investment Policy 8.25*	Increase the resilience of high-risk and critical infrastructure through monitoring, planning, maintenance, investment, adaptive technology, and continuity planning.
Policy	Citywide	Comprehensive Plan – Chapter 8: Public Facilities and Services, *Public Rights-Of-Way Policy 8.50, Undergrounding*	Encourage undergrounding of electrical and telecommunications facilities within public rights-of-way, especially in centers and along Civic Corridors.
Policy	PBOT	Transportation System Plan, *Parking Management Policies—Curb Zone*	Recognize that the Curb Zone is a public space, a physical and spatial asset that has value and cost. Evaluate whether, when, and where parking is the highest and best use of this public space.

Policy	PBOT	Transportation System Plan, *Parking Management Policies—Off-street parking*	Limit the development of new parking spaces to achieve land use, transportation, and environmental goals, especially in locations with frequent transit service.
Policy	PBOT	Transportation System Plan, *Parking Management Policies—Public Rights-of-way Policy, Undergrounding*	Encourage undergrounding of electrical and telecommunications facilities within public rights-of-way, especially in centers and along Civic Corridors (See also Comprehensive Plan Policy 8.50).
Policy	PBOT	Moving to Our Future, PBOT's Strategic Plan (2019-2022), *Goal 2: Moving People and Goods Objective 2: Make the most efficient use of our limited road space, Strategic Initiative B.*	Develop clear practices for allocating space in the public right-of-way when either public or private development occurs.
Program	PWB	Climate change and drinking water, *Water system climate resilience*	The Portland Water Bureau has been working to understand and prepare for the impacts of climate change on the water system for over two decades. The recent Supply System Master Plan incorporates climate change into long-range water resource planning. PWB is developing responsive, flexible plans that consider changing conditions and new data.
Regulation	BPS	Title 33, Planning and Zoning, *Parking, Loading, And Transportation and Parking Demand Management 33.266.115 Maximum Allowed Parking Spaces*	Limits the number of spaces allowed to promote efficient use of land, enhance urban form, encourage use of alternative modes of transportation, provide for better pedestrian movement, and protect air and water quality.

Regulation	BPS	Title 33, Planning and Zoning, *Parking, Loading, And Transportation And Parking Demand Management 33.266.130 Development Standards for All Other Development*	Vehicle area location regulations to "limit the size of paved parking area and the type of paving material allowed in order to limit increases in temperature associated with asphalt and reduce impacts from heat islands." Also "to shade and cool parking areas."
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards PR14 Weather Protection at Entrances*	New main entrances at a new or existing building – Provide weather protection at new main entrances that face a street lot line. The weather protection may be an awning, a portion of the building, a balcony, or other covered structure. The weather protection must meet the following: • The weather protection must project out at least 4 feet from the wall above the doorway • The weather protection is four feet wider than the doorway, unless there is a building wall that prohibits this width • The height of the weather protection must be between 9 feet and 15 feet above the grade underneath it.
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards PR15 Weather Protection Along a Transit Street*	New building on a transit street as follows: The standard is required for a new building with a height that exceeds 55 feet. The standard is optional for new buildings that are 55 feet or less in height. Weather protection must be provided along at least 50 percent of the street-facing façade

			located within 20 feet of a transit street lot line. The weather protection must meet the following: • The weather protection must project out at least 4 feet from the adjoining wall. • The height of the weather protection must be between 9 feet and 15 feet above the grade underneath it. When this standard is met as an optional standard, the street facing façade within 20 feet of a transit street lot line must have a length of at least 50 feet.
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards Vehicle Areas PR17 Pervious Paving Materials*	New parking area with at least 10 parking spaces – At least 50 percent of the vehicle area must be paved with pervious pavement, approved by the Bureau of Environmental Services as being in compliance with the Stormwater Management Manual.
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards Vehicle AreasPR18 No Parking Area*	Site with a minimum area of 10,000 square feet – Provide no parking areas on site.
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards Vehicle AreasPR19 Structured Parking and Vehicle Areas*	At least 80 percent of the proposed vehicle area is covered by a building. The vehicle area may meet PR19 or PR20, but not both.
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards*	New vehicle areas – At least 50 percent of the proposed vehicle area is covered by buildings, structures containing photovoltaic panels,

		Vehicle Areas PR20 Alternative Shading of Vehicles	reflective roof shade structures with a Solar Reflectance Index (SRI) greater than 75, or tree canopy. The amount of shade from tree canopy is determined by the diameter of the mature crown spread stated for the species of tree. The vehicle area may meet PR19 or PR20, but not both.
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards Art and Special Features PR22 Water Feature*	Any site – Provide a water feature, such as a fountain, waterfall, or reflecting pool. The feature must be setback a minimum of 20 feet from the street lot line with the highest street classification. The water feature must have the following: • A feature area of at least 6 square feet that contains water year-round • A bench or seat with 6 linear feet of seating adjacent to it
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards Windows and Balconies QR11 Sunshades for Windows*	New windows above the ground floor on facades that face south and west – Provide awnings or eaves directly above 50 percent of the window openings on facades that are facing within 45 degrees of south or west. The awning or eave must project out at least 2 feet.
Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards RoofsQR21 Ecoroof*	New building or alteration – Provide an ecoroof that covers at least 40 percent of the total building roof area or 2,000 square feet whichever is greater. The ecoroof must meet the Stormwater Management Manual's *Ecoroof Facility Design Criteria*.

Regulation	BPS	Title 33, Planning and Zoning, *Overlay Zones 33.420.050 Design Overlay Zone Design Standards Roofs QR23 Reflective Roof Surface*	New building or alteration – Meet the Energy Star requirements for solar reflectance on at least 90 percent of the roof area not covered by rooftop equipment, vents, skylights, stairwells, or elevator enclosures. This standard does not apply if either standard QR21 or QR22 are met.
Regulation	BPS	Title 33, Planning and Zoning, *Modification That Will Meet Tree Preservation Requirements 33.630.400 B. Minimum Density*	In multi-dwelling zones, minimum density may be reduced to preserve trees. The review body will approve the reduction in minimum density if the following are met: (1) The reduction in minimum density will result in improved tree preservation, considering the tree preservation priorities for the site; and (2) The lot or lots where trees are proposed to be preserved are not large enough to be further divided under the current zoning. Trees proposed for preservation may be placed in a tree preservation tract to reduce lot sizes and provide better protection for the trees to be preserved.
Report	PWB	Water Utility Climate Alliance Engineering Case Studies	PWB has advocated for the development of climate adaptation practices to redesign infrastructure to withstand extreme conditions, including extreme heat. PWB evaluated eight Engineering Case Studies that showcase how the water sector is using climate change information in engineering design and project delivery. (https://www.wucaonline.org/adaptation-in-practice/engineering-case-studies/index.html)