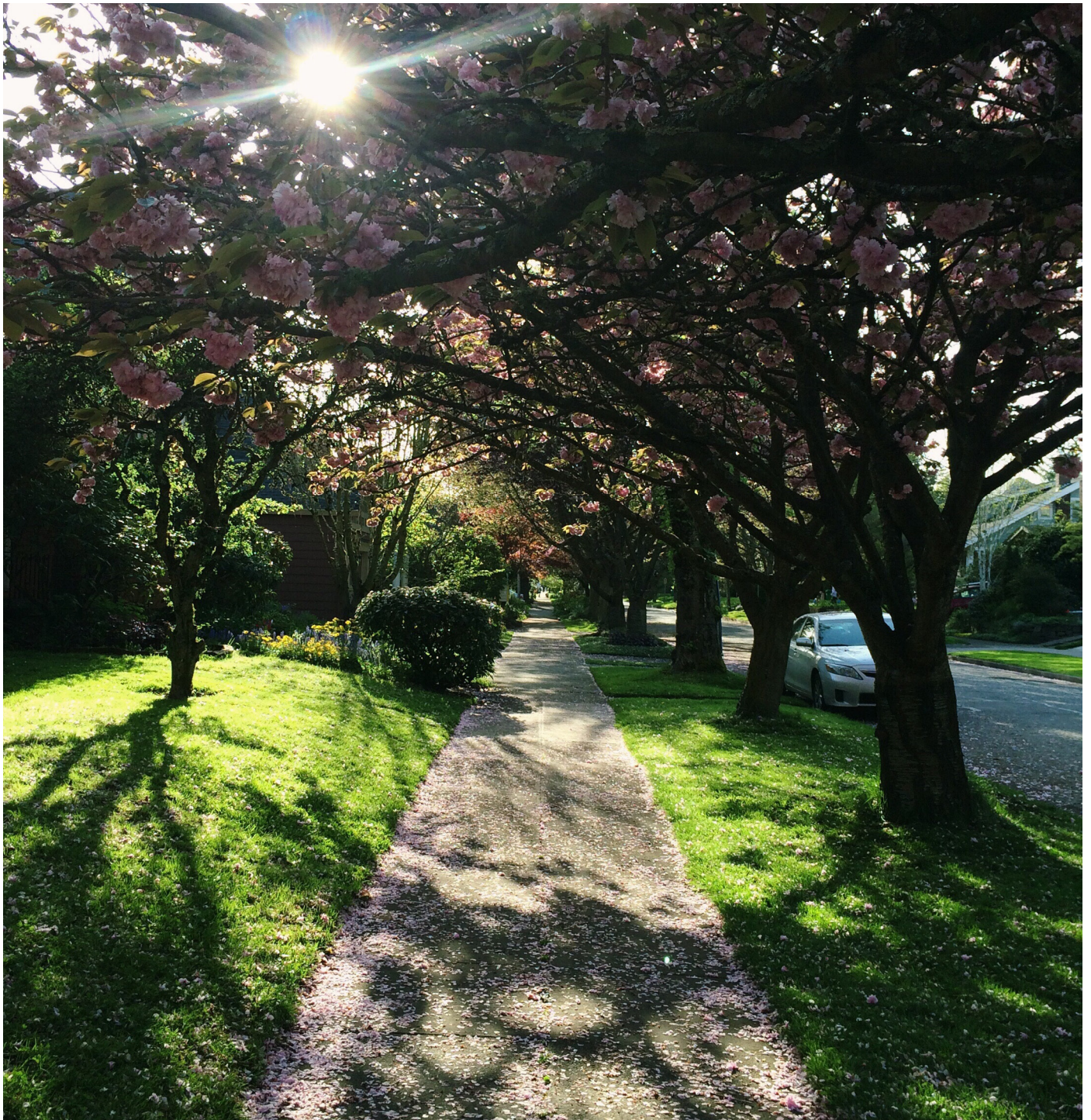


# ASSESSMENT OF INEQUITIES IN URBAN CANOPY COVER

BY RACE AND INCOME ACROSS THE PORTLAND-VANCOUVER  
METROPOLITAN AREA OF OREGON AND WASHINGTON



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**COVER:** Southeast Portland tree-lined street. © vit/Adobe Stock; **ABOVE:** Blooming street trees. © Tanya Pavlova/Adobe Stock

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# Executive Summary

Urban trees provide numerous benefits to people and are essential to maintaining a healthy, livable urban environment in the face of a changing climate. Disparities in tree cover across communities is an environmental justice issue. Studies have found that urban trees and the benefits they provide to people are inequitably distributed in many U.S. cities across race, ethnicity, and income. This disparity has increasing consequences in the Portland-Vancouver metropolitan area of Oregon and Washington states as climate change exacerbates environmental stressors and related health threats in BIPOC (black, Indigenous and people of color) and low-income communities. While the city of Portland has been the focus of multiple urban forestry studies on environmental conditions and their intersections with socio-demographic and economic factors, these relationships have not been broadly investigated across the entire Portland-Vancouver metropolitan region. The absence of information on community and urban forest trends and access to decision support resources across the metropolitan region hinder efforts of local governments, community groups, and the broader public to participate in the vision for a regionally coordinated approach to tree canopy investments and urban forest management.

**Block groups with the largest proportion of BIPOC individuals had, on average, 6% lower canopy cover than whiter block groups. Likewise, block groups with the largest proportion of low-income individuals had, on average, 10% lower canopy cover than wealthier block groups.**

The goals of this baseline assessment were to improve our understanding of environmental inequities related to urban canopy distribution and benefits across the Portland-Vancouver metropolitan region and offer Connecting Canopies—a local community-led partnership in the region that aims to change the way we plan and implement urban forestry—a starting point for monitoring urban canopy cover across the region. This assessment evaluated the distribution and change in canopy cover across the Portland-Vancouver metropolitan area from 2014-2020 and related these trends to dimensions of environmental justice including the percent of low-income and BIPOC community members within the region, jurisdictions, and U.S. Census

block groups. Canopy cover in 2020 was 35% for the region yet varied substantially across jurisdictions and land use types. Not surprisingly, canopy cover was higher in parks, natural areas, and open spaces than other land use types, was consistently lower in multi-family residential areas than single-family residential areas, and in most cases very low in commercial and industrial areas. We found that while canopy cover increased by 0.4% across the region from 2014-2020, nearly 56% of block groups experienced net canopy cover loss. Block groups with the largest proportion of BIPOC individuals had, on average, 6% lower canopy cover than whiter block groups. Likewise, block groups with the largest proportion of low-income individuals had, on average, 10% lower canopy cover than wealthier block groups. To better address inequities in canopy cover, we used these results to identify priority areas in which specific actions—such as increased planting of new trees and enhanced tree protections—would ensure long-term tree persistence and improve benefits to local communities (Figs 8 and 9).

Connecting Canopies will use this baseline information to guide programs that benefit BIPOC and low-income communities in priority areas and identify opportunities for community input in decision-making processes. For example, Connecting Canopies holds community gatherings to better understand community members' interests and concerns regarding urban trees. Additionally, Connecting Canopies programs focus on supporting community education initiatives, increasing community engagement to advocate for better urban canopy policies, and fostering a workforce development program designed to benefit BIPOC individuals entering the green sector.



# Introduction

In cities around the world, trees are recognized as vital to maintaining healthy, livable, urban environments in the face of a warming climate<sup>1</sup>. Urban trees in parks, greenspaces, residential yards, and along street parking strips provide multiple benefits to people (Fig 1) including: reducing summer temperatures<sup>2</sup>, improving air quality<sup>3</sup>, maintaining water quality<sup>4</sup>, absorbing storm water run-off<sup>5</sup>, and improved public health outcomes<sup>6</sup>. Additionally, urban greenspaces, both wooded areas and open spaces, play an important role in providing recreational opportunities and wildlife habitat.

**Increased canopy cover is needed to mitigate the negative impacts of urban climate change** The increased frequency of extreme weather events due to climate change<sup>7</sup> is projected to reduce the benefits urban trees provide to communities<sup>8,9</sup>. Impacts of increased heat and air pollution on large mature trees<sup>10</sup>, which provide critical cooling and air cleaning benefits<sup>11</sup>, are particularly concerning. ‘Canopy cover’, a common measurement of urban tree area, refers to the collection of leaves, branches and stems of trees and tall shrubs which cover the ground when viewed from above. Increased canopy cover is needed to mitigate the negative impacts of urban climate change, such as providing cooling as the number of days exceeding 90 °F increases<sup>12</sup>. However, urban trees are facing a growing number of threats (e.g., development pressure<sup>13,14</sup>) resulting in a decrease in total canopy cover.

The increasing threat of environmental stressors combined with urban tree losses due to development pressure and landowner decisions to remove trees threaten the critical ecosystem services provided by urban trees<sup>15</sup>. Tree planting efforts are essential for increasing future canopy cover and improving equitable canopy distribution<sup>16</sup>. In addition, proactive tree pruning, and maintenance of mature trees are equally important to promote tree health<sup>17</sup>, increase community and infrastructure safety<sup>18</sup>, and ensure that mature trees are not prematurely lost due to development and other factors<sup>16,19</sup>.

Sunrise over the Portland south waterfront. © Atmosphere/Adobe Stock

# Benefits urban trees provide for people and nature

Research has linked the presence of urban trees to...

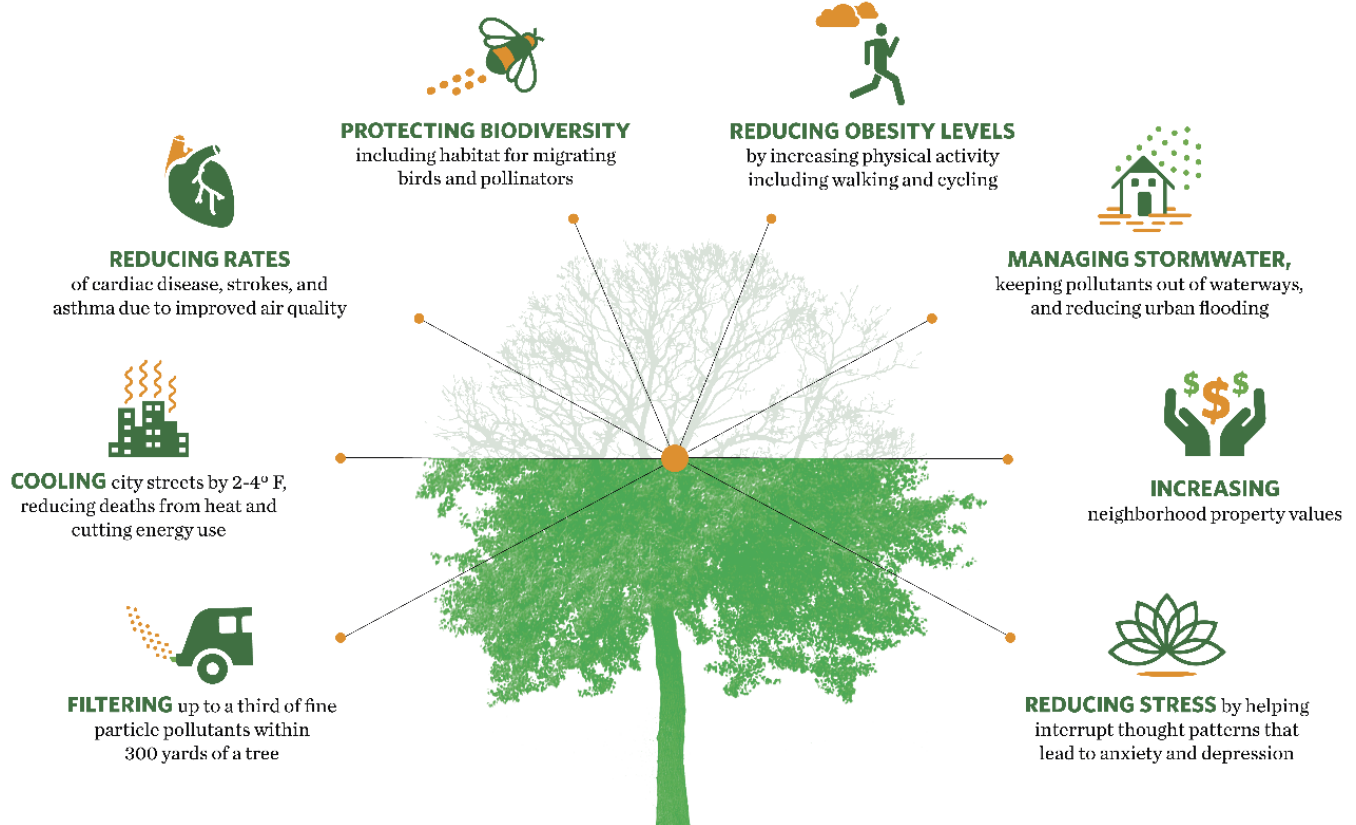


Figure 1. Benefits of urban trees provide to people and nature <sup>20</sup>.

The distribution and loss of canopy cover is also a significant environmental and climate justice issue <sup>21,22</sup>. Multiple studies in cities across the U.S. have found that urban trees and the benefits they provide to people are inequitably distributed across communities by race, ethnicity, and income <sup>23-26</sup>. In this work, we acknowledge inequity as a general term that includes a variety of elements, such as social and racial inequities. Social equity addresses inequalities related not only to race, but also income level disparities. Racial equity, however, addresses disparities resulting from racial policies and practices that can impact income as well as many other factors. This baseline assessment evaluates both components. Neighborhoods with lower incomes and higher proportion of BIPOC (black, Indigenous and people of color) individuals often have lower canopy cover and higher rates of heat and air pollution-related illnesses <sup>21,27-30</sup>. The pursuit of environmental justice in canopy cover focuses on three core principles <sup>31,32</sup>: the equitable distribution of information, resources, and the benefits of canopy cover (distributive justice); a recognition that people with different lived experiences may view the value and burdens of trees differently (recognition justice); and decision-making processes that are fair, transparent, and incorporate community perspectives (procedural justice). Applying ecological tools (e.g., evaluating canopy cover change and community characteristics) through the lens of environmental justice can help researchers, municipal decision-makers and community groups identify areas of high conservation and restoration need <sup>33</sup>.

The importance of urban canopy cover and challenges of inequitable distribution have become particularly acute in the second largest metropolitan region in the Pacific Northwest, encompassing the cities of Portland (Oregon) and Vancouver (Washington). While the city of Portland has a progressive reputation for urban conservation, the inequitable distribution of canopy cover reported in the area<sup>34,35</sup> can exacerbate human health inequities<sup>36</sup>. This is especially problematic as the Portland region is projected to experience hotter summers with increased frequency of extreme heat days and decreased air quality due to climate change<sup>37</sup>. These trends pose a particularly severe threat for BIPOC and low-income communities, which are already more likely to be both exposed to elevated urban heat levels and lack sufficient access to shelter and nearby basic amenities such as air conditioning<sup>38-40</sup>. Over the last decade Oregon has consistently ranked as one of the states with the highest percentage of asthma incidence in adults, and poor air quality is a human health concern that disproportionately impacts low-income and BIPOC communities<sup>37</sup>. In recent years, equity concerns about disparities in tree cover and the benefits provided to people have been popular topics in the media and research studies across the nation, including the Portland area<sup>34,41,42</sup>.

**The absence of information on community and urban forest trends and access to decision support resources across the metropolitan region hinder efforts of local governments, community groups, and the broader public to participate in the vision for a regionally coordinated approach to tree canopy investments and urban forest management**

While the city of Portland has been the focus of multiple urban forestry studies on environmental conditions and their intersections with socio-demographic and economic factors<sup>39,43-45</sup>, these relationships have not been broadly investigated across the entire Portland-Vancouver metropolitan region. A regional versus local perspective is important to determine if the patterns remain consistent at a broader scale, as the city of Portland represents only 31% of the regional population and 26% of the land area. Furthermore, there are substantial differences in urban forestry policies, practices, and levels of investment across the region<sup>46</sup>. The absence of information on community and urban forest trends and access to decision support resources across the metropolitan region hinder efforts of local governments, community groups, and the broader public to participate in the vision for a regionally coordinated approach to tree canopy investments and urban forest management<sup>47</sup>.

The goal of this baseline assessment was to map urban canopy cover across the Portland-Vancouver metropolitan region and better understand the race, ethnicity, and income characteristics of local communities to identify inequities. Specifically, we examined canopy cover distribution (in 2020) and changes in the urban canopy (from 2014-2020) across communities, political jurisdictions (cities and counties) and land uses. This baseline assessment intends to 1) improve our understanding of environmental inequities across communities related to urban canopy distribution and benefits at a regional scale and 2) offer Connecting Canopies, a local community-led partnership (see Discussion for description), a starting point for monitoring urban canopy cover across the region. Importantly, these results identify potential priority areas for future efforts (e.g., tree planting, maintenance programs, tree conservation measures) and provide opportunities for direct community organizing, engagement and workforce development pathways in the green sector.

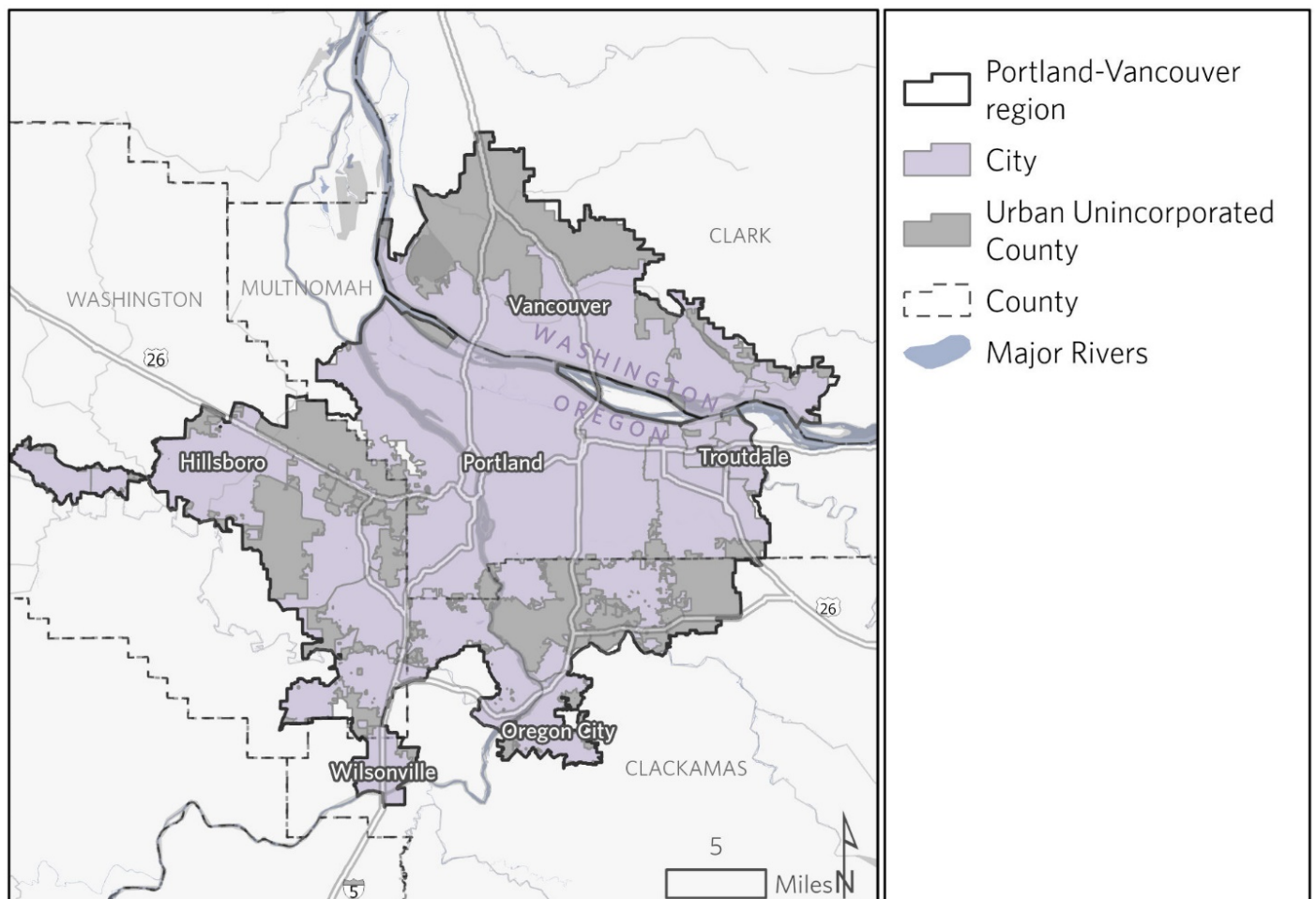


# Data and Methods

Following is a brief description of the data sources and methods used in these analyses. Additional details can be found in the Supplementary Information (SI).

## Portland-Vancouver Metropolitan Region

The region of interest for this assessment includes the two larger cities of Portland, Oregon, and Vancouver, Washington, plus areas surrounding the urban core that are part of the Metro regional governance area <sup>48</sup> and Clark County urban growth area <sup>49</sup>. The Portland-Vancouver Metropolitan region, as defined for this study (Fig 2), encompasses nearly 551 square miles, including 27 cities, 4 counties, and a population of 2.3 million people in 2020 <sup>50</sup>.



**Figure 2.** Map of the Portland-Vancouver Metropolitan Region study area.

Located between the Cascade Mountains and the Coast Range, and bisected by the Columbia and Willamette rivers, the region lies at the northern end of the Willamette Valley, and is characterized by a broad valley floor, a low ridge of hills, and several extinct volcanoes <sup>51</sup>. Prior to European colonization, the region was characterized by forests dominated by large, long-lived conifers (Douglas-fir, western hemlock, western red-cedar) interspersed with hardwoods (big leaf maple and red alder). Prairies and savannahs dominated by Oregon white oak were also common. The region has a moderate climate with relatively wet, mild winters, and clear, dry summers <sup>52</sup>. Temperatures during the wet winter season are mild, with mean daily temperatures of 33.5 to 44.3°F in the coldest month of January. Summers are generally mild, with mean daily temperatures of 55.8 to 79.5°F during the warmest month of July, though extreme temperatures have become more frequent due to climate change <sup>53</sup>. Climate change is shifting these local conditions. Oregon is becoming warmer, with annual average temperature projected to increase by 5°F by 2050, and generally precipitation is expected to increase, though will vary by location and time frame <sup>53</sup>.

The region has experienced rapid population growth and increased racial diversity this century. The population of the Portland-Vancouver metropolitan area increased by 30% from 2000 to 2020, including a 13% increase in residents who identified as BIPOC <sup>50</sup>. Prior to 2010, decades of gentrification in areas with large proportions of non-white residents resulted in a shifting of BIPOC communities from northeast Portland to areas to the east and west <sup>54</sup>; though, after 2010 gentrification has been less pervasive across the region <sup>55</sup>.

## Race, Ethnicity, and Income

To investigate patterns of urban tree canopy inequities related to race, ethnicity, and income we used U.S Census variables which describe population characteristics at the block-group level (SI Table 1). Block groups are the smallest spatial reporting unit for which these population characteristics are available <sup>56</sup>. Nationwide, the size and shape of block groups vary, and are generally mapped by the U.S. Census to have populations of 600 to 3,000 people <sup>57</sup>. In the region, block groups ranged in size from 5 to 7,800 acres (mean = 235 acres) and 292 to 5,132 people (mean = 1,481 people). We calculated percent “low-income” as the percent of the population within each block group whose income was less than two times the federal poverty level (see SI Race and Ethnicity, and Income section). For perspective, in 2020 the federal poverty level was \$12,760 for a single person household <sup>58</sup>. We calculated percent BIPOC (“black, Indigenous and people of color”; a term used to broadly refer to non-white people <sup>59</sup>) as the percent of the population within each block group that identified their race and ethnicity as other than white, non-Hispanic or Latino. To provide information to readers interested in trends at different geographic scales, these population characteristics were also summarized for the region as a whole, as well as individual cities and counties.

## Canopy Cover and Canopy Change Through Time

To investigate patterns of canopy cover and canopy change across the region, we used high-resolution (1-meter) maps derived from NAIP (National Agricultural Imagery Program) imagery <sup>60,61</sup> (see SI Canopy Cover and Canopy Change section). While canopy cover indices often focus on large trees, tall brush and shrubs also provide cover, shading, and cooling benefits that lower surface and air temperatures and help to improve air quality <sup>62</sup>. The canopy cover maps distinguish areas of tree and large shrub canopy cover from other surface types (grass, water, bare soil, impervious surface). The canopy cover change map classifies areas of canopy loss, canopy gain, and canopy persistence from 2014 to 2020 (Fig 3).



**Figure 3.** Example aerial depiction of canopy cover in 2014 and 2020, and canopy change 2014–2020 for a city block in Portland at East Burnside Street and SE 146th Avenue. Conversion of several tax lots to apartments resulted in the loss of canopy cover during the period.

To allow for comparison across communities, canopy cover and canopy change were summarized to block groups. Percent canopy cover for each block group was calculated as the area of the block group with canopy cover in 2020 divided by the total area of the block group. The differences in areas of canopy loss and areas of canopy gain for each block group was calculated as area of net change, then divided by the total area of the block group to calculate percent net change. Percent net change is a positive number for block groups with net gain and negative for block groups with net loss in canopy cover from 2014 to 2020. For example, -5% net canopy change means that the cumulative area of canopy loss exceeded the cumulative area of canopy gain, and that the difference in area was 5% of the total area of the block group.

Since patterns of canopy cover and canopy change differ across land uses (e.g. residential, commercial, industrial), as do the potential opportunities and available space for increasing canopy cover, we also summarized the data by land use type within block groups, the region, and jurisdictions (SI Table 5).

# Canopy Equity Analysis and Prioritization of Block Groups

We used statistical methods to explore the relationships between canopy cover and the race, ethnicity, and income equity variables across block groups (see SI Canopy Equity Analysis section). The results of those analyses helped us identify priority block groups that are important areas of focus to improve canopy cover from an equity perspective (see SI Block Group Prioritization). We defined priority block groups as block groups which had both the highest percent BIPOC and low-income populations and canopy cover in 2020 below 35% (see SI Canopy Cover Goal section).



Trimet light rail, downtown Portland. © andreykr/Adobe Stock



# Key Findings

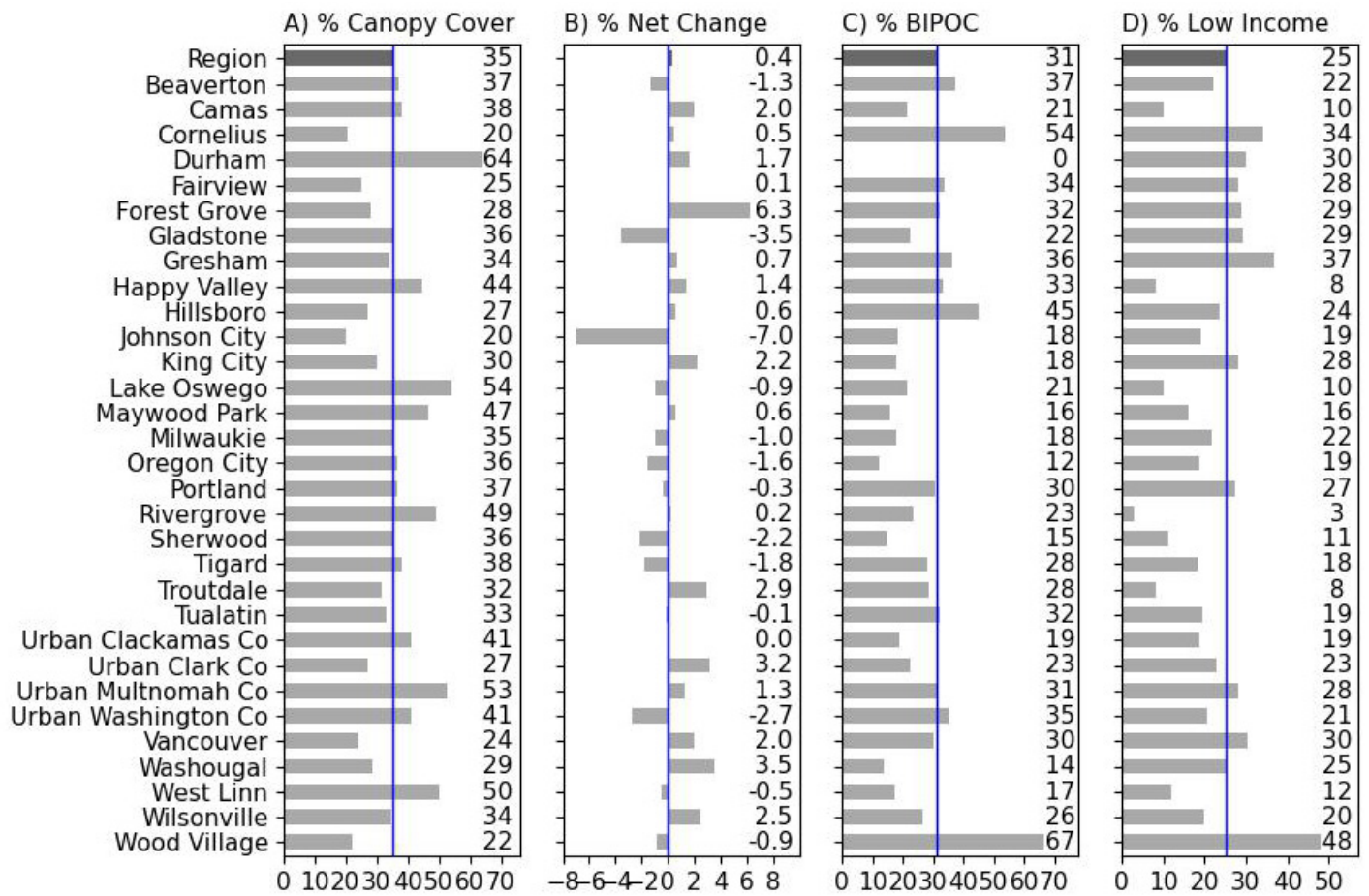
## Patterns Across the Region and Jurisdictions

Thirty-one (31%) percent of the population in the region identified as BIPOC in 2020. The percent of the BIPOC population across jurisdictions ranged broadly from 12 to 67% (Fig 4C). Twelve of the 31 (39%) jurisdictions had a proportionally larger proportion of BIPOC individuals than the region. Twenty-four (24%) percent of the population in the region was low-income. The percent of the low-income population across jurisdictions ranged broadly from 3 to 48% (Fig 4D). Thirteen of the 31 (42%) jurisdictions had a proportionally larger population of low-income individuals than the region (Fig 4D).

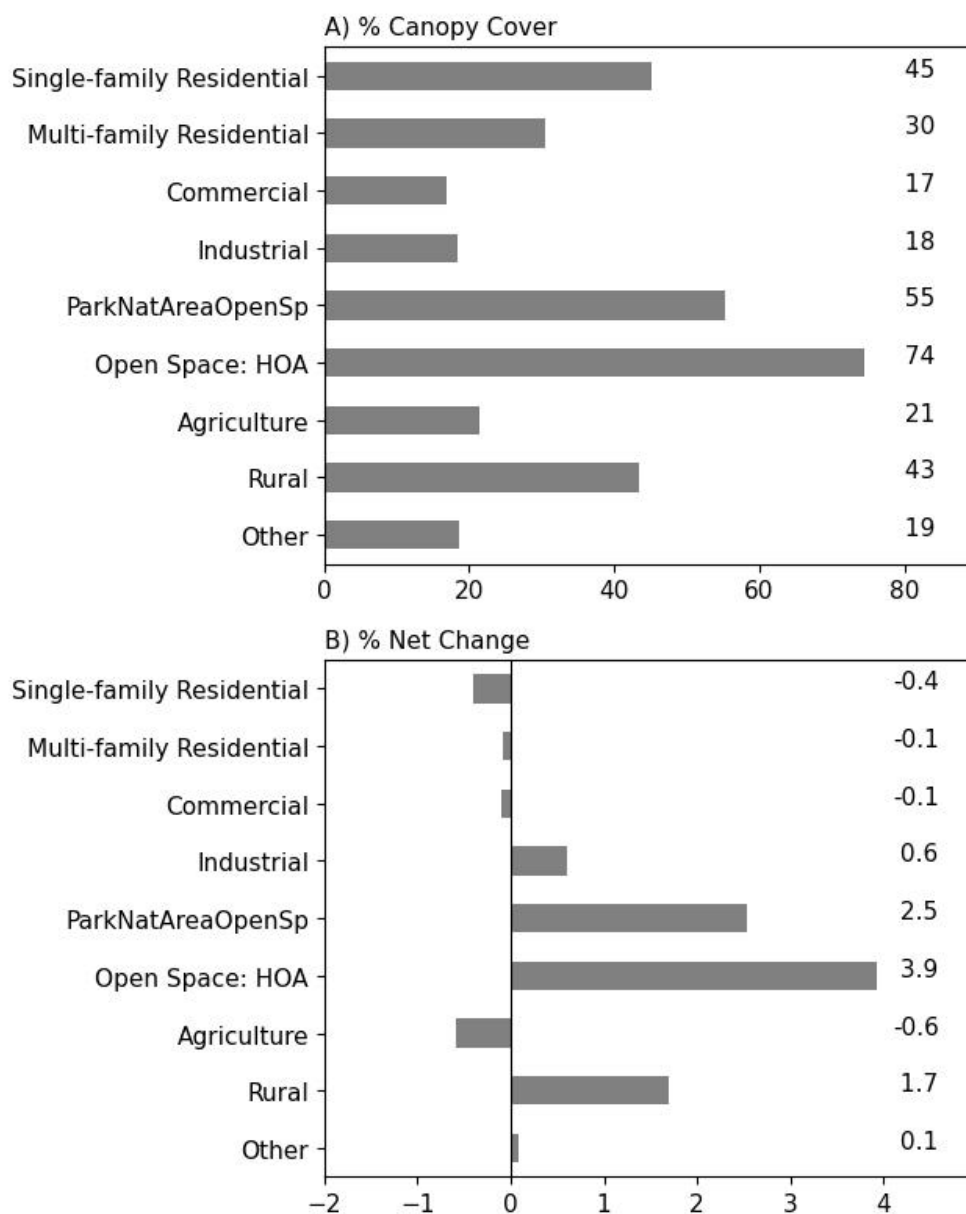
Percent canopy cover for the region was 35% in 2020 and ranged from 20% to 64% across the cities and counties (Fig 4A; SI Table 5). Seventeen of the 31 (55%) jurisdictions had percent canopy cover which equaled or exceeded the regional percent, while 14 did not. Four jurisdictions had a canopy cover below 25%, notably lower than the region. For the period 2014 to 2020, the region experienced a net gain of 0.4%, while the percent net change across jurisdictions ranged from 6.3% gain to 7.0% loss (Fig 4B). Thirteen of the 31 (42%) of the jurisdictions experienced a net loss during the study period.

For the region as a whole, percent canopy cover was 45% in areas of single-family residential (SFR), and 30% in multi-family residential (MFR) areas (Fig 5A and SI Table 6). The percent canopy cover was substantially lower in commercial (17%) and industrial (18%) areas. Across the region, single-family residential, multi-family residential, and commercial areas had a small net canopy loss ( $< -0.5\%$ ), while industrial areas had a small net gain (0.6%; Fig 5B, SI Table 7). The largest areas of net canopy gain were parks, natural areas, and open space (2.5%), with homeowners' association (HOA) open space having the largest gain (3.9%).

Portland landscape. © Cascadia Aerial/Adobe Stock



**Figure 4.** Percent A) canopy cover in 2020, B) net canopy change during 2014 to 2020, C) BIPOC population, and D) low-income population for the Portland-Vancouver metropolitan area region and jurisdictions. Numeric values are provided on the right of each bar. The regional value is marked with the vertical blue line for comparison across jurisdictions.



**Figure 5.** Regional A) Percent canopy cover 2020 and B) percent net canopy change 2014-2020 by land use type.

## Patterns across Block Groups

Examining patterns at the block group level give us a better understanding of the canopy cover and socio-economic patterns at the finest scale available. Block groups with proportionately high BIPOC or low-income populations were dispersed across the region (Fig 6). The percentage of BIPOC people across block groups ranged from zero to 88.5%, with the largest percentages generally occurring in Forest Grove, Hillsboro, and Beaverton on the westside, and North Portland, Gresham and Fairview on the eastside. The percentage of low-income people across block groups ranged from 0 to 95%, with the largest percentages occurring in Portland, Gresham, and Hillsboro. Many of the block groups with the largest proportion of BIPOC individuals also have the largest proportion of low-income individuals; though, not all.

Areas of higher canopy cover were concentrated in areas of the region (Fig 7A), including Portland west of the Willamette River, Lake Oswego and West Linn, and in a separate patch centered around Happy Valley in Clackamas County. Areas of lower canopy cover included much of Portland east of the Willamette River, Gresham, and a large portion of Clark County. Across the region, 55.8% (729 of 1,307) of block groups experienced a net canopy loss during the period 2014 to 2020, with those block groups spread across the region (Fig 7B). A large portion of the block groups with the greatest net canopy gain were in Vancouver and surrounding areas in Clark County, and in Happy Valley.

## Inequity in Canopy Cover

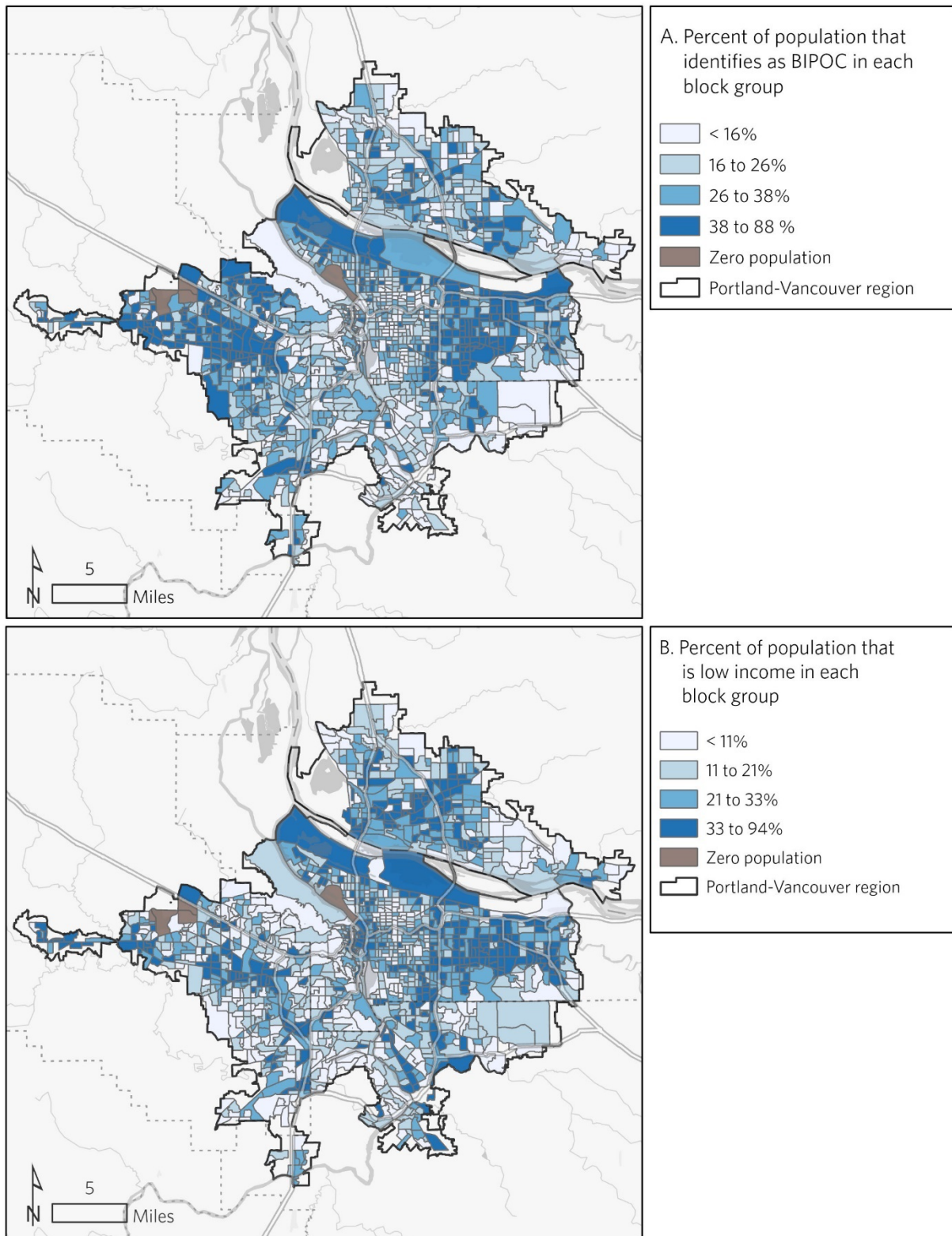
**Canopy cover in block groups with the largest proportion of BIPOC individuals was on average 6% lower than all other whiter block groups. And canopy cover in block groups with the largest proportion of low-income individuals was on average 10% lower than all other wealthier block groups.**

Our results show disparities in canopy cover for BIPOC and low-income communities. Canopy cover in block groups with the largest proportion of BIPOC individuals (SI Table 4A) was on average 6% lower than all other whiter block groups (30% compared to 36%;  $p < 0.001$ ). And canopy cover in block groups with the largest proportion of low-income individuals (SI Table 4B) was on average 10% lower than all other wealthier block groups (27% compared to 37%;  $p < 0.001$ ). Additionally, block groups with the highest proportion of BIPOC individuals experienced a net canopy loss (-0.8%) while the whiter block groups experienced a small net canopy gain (+0.04%). There was no statistically significant difference in the relationship between percent net canopy change and income ( $p = 0.56$ , SI Table 4B).

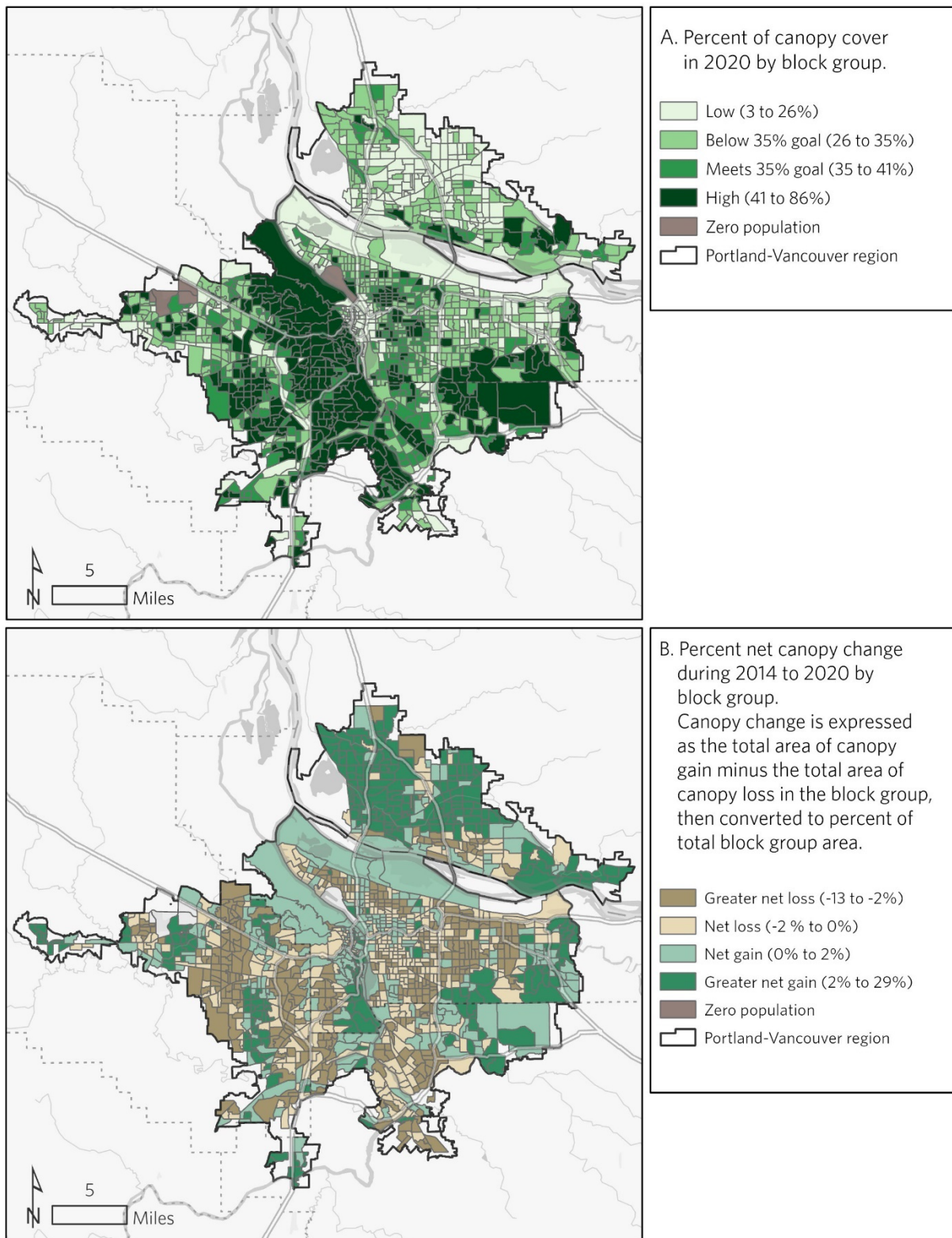


Workforce training participants © The Blueprint Foundation





**Figure 6.** Maps showing the percentage of the 2020 population that were A) BIPOC and B) low-income for block groups in the Portland-Vancouver metropolitan region.



**Figure 7.** Maps showing A) percent canopy cover in 2020 and B) percent net canopy change during 2014 to 2020 for block groups in the Portland-Vancouver metropolitan region.

## Priority Block Groups

Based on the results of the canopy equity analysis, we identified block groups that are important areas to focus on improving canopy cover to address inequities based on race, ethnicity, and income (highest percent BIPOC and low-income populations and canopy cover in 2020 below 35%). The 151 priority block groups are in 17 of the 31

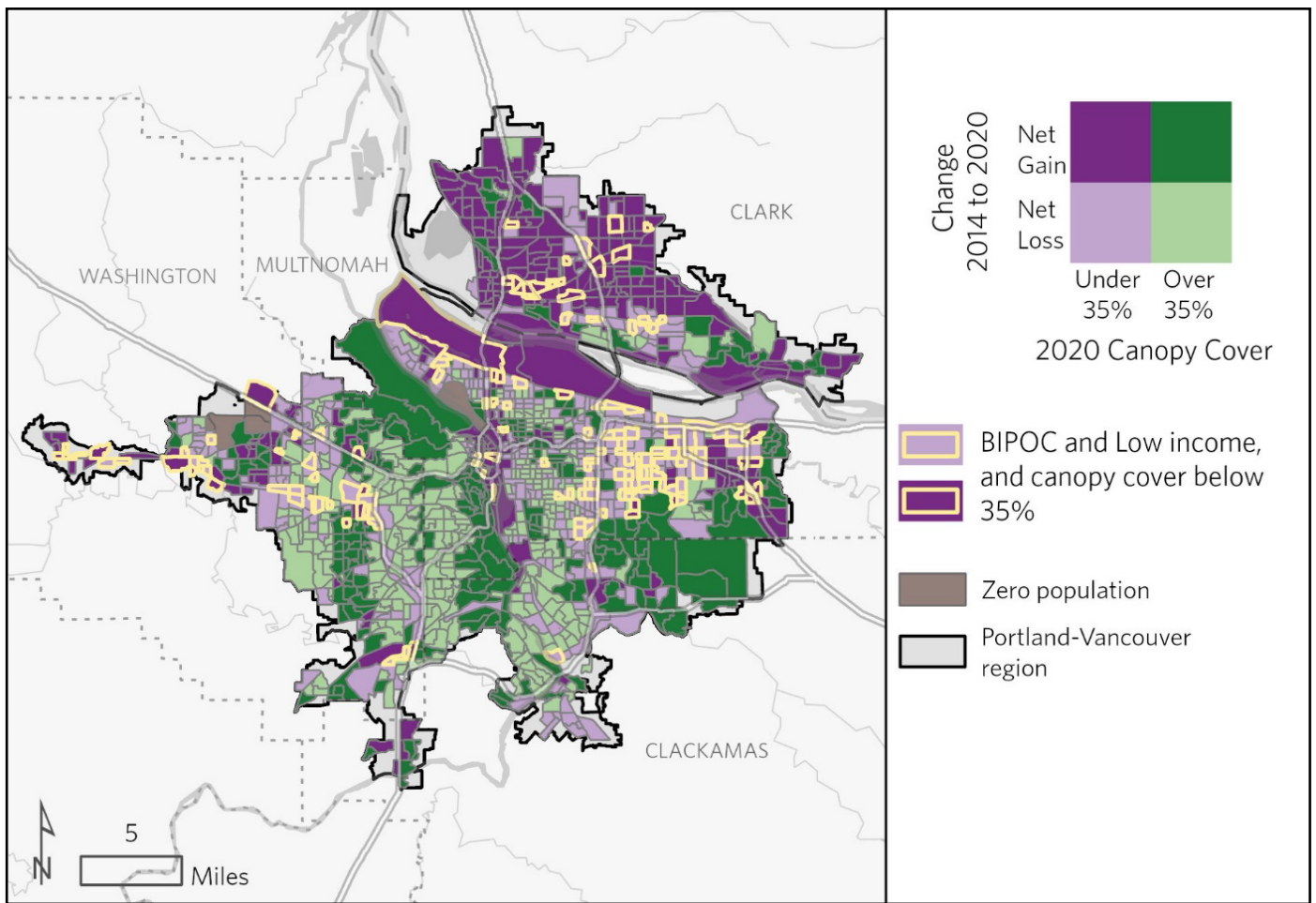
**Over half of the priority block groups are in jurisdictions other than the city of Portland.** jurisdictions (Table 1, Fig 8). Over half (54%) of the priority block groups are in jurisdictions other than the city of Portland. This region-wide focus on inequities in canopy cover draws attention to areas that may have previously been overlooked.

The diagram in Figure 9 uses the relationship between canopy cover and net canopy change to propose urban tree planting and conservation actions in different block groups. While in general, all areas would benefit from tree planting, maintenance, and protection activities, there are not sufficient resources to accomplish all activities everywhere. Therefore, we recommend targeting areas in the most need with the action(s) that have the greatest potential to increase canopy cover and address equity disparities. Fifty-seven (57%) percent of block groups in the region had a canopy cover below the 35% canopy goal, and 32% also experienced a net canopy cover loss in 2014-2020 (SI Table 8). The 25% (332) of block groups which had low canopy cover and a net canopy gain would benefit both from planting of trees and maintenance of existing trees to promote healthy tree growth to maturity. The 32% (420 of 1,307) of block groups with low canopy and a net canopy loss would benefit from a focus on planting to increase the total number of trees, and protection measures to sustain the existing trees into the future.

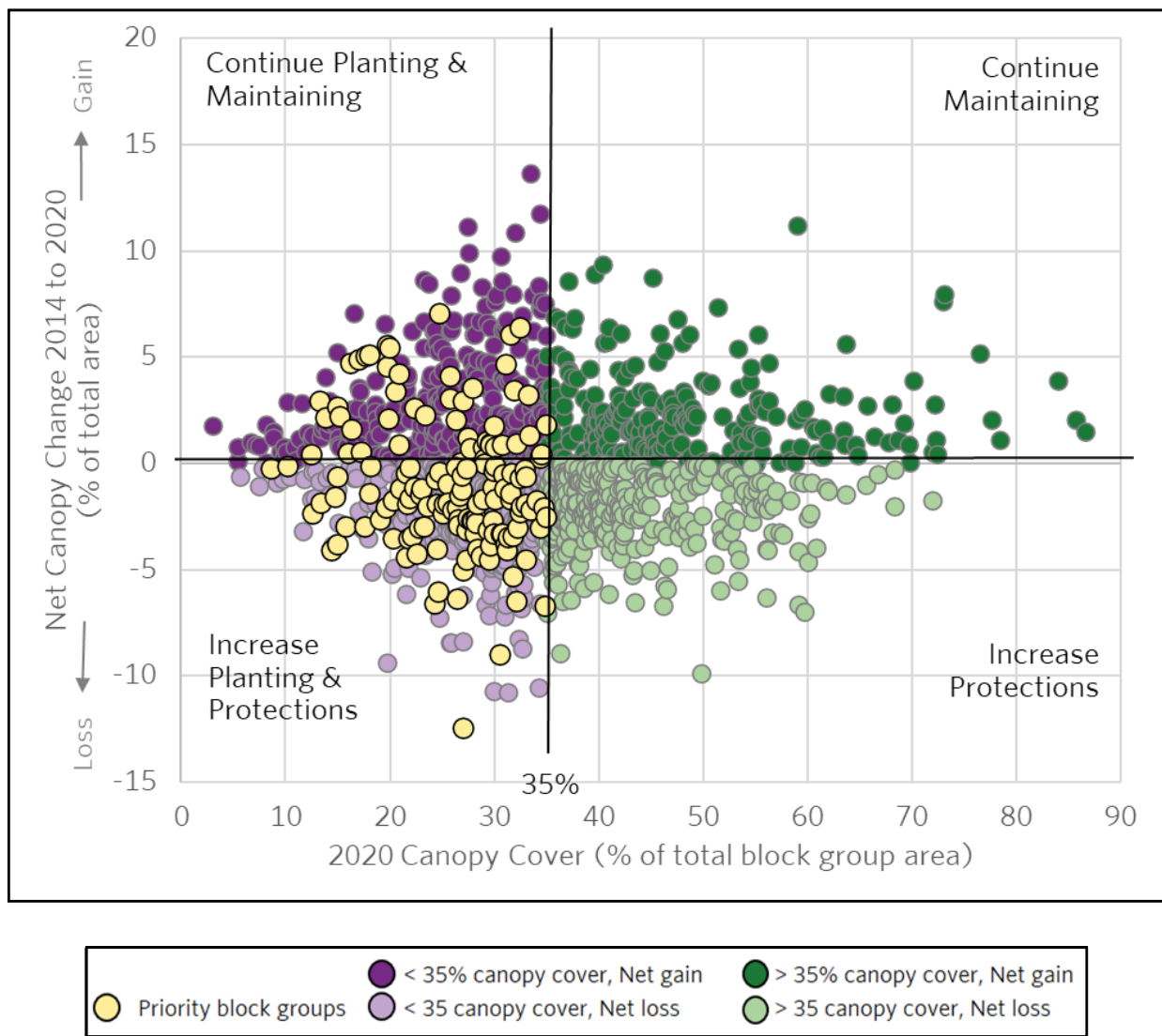
While we show all block groups in the diagram, we highlight the 151 priority block groups (Fig 9, SI Table 8) to emphasize the importance of focusing on addressing canopy inequities across the region. Sixty-eight percent (102 of 151) of the priority block groups experienced net canopy loss from 2014 to 2020 (SI Table 8). Priority actions for these block groups include increased planting of new trees and enhanced tree protections to ensure long-term tree persistence.

**Table 1.** Distribution of priority block groups across jurisdictions. Block group boundaries do not all align with jurisdiction boundaries and may cross two or more jurisdictions. For example, a priority block group within Fairview, also crosses into Gresham and Wood Village. Given the extent of overlap between block groups and jurisdictions, each priority area warrants further investigation into the specific locations of need for canopy cover related activities.

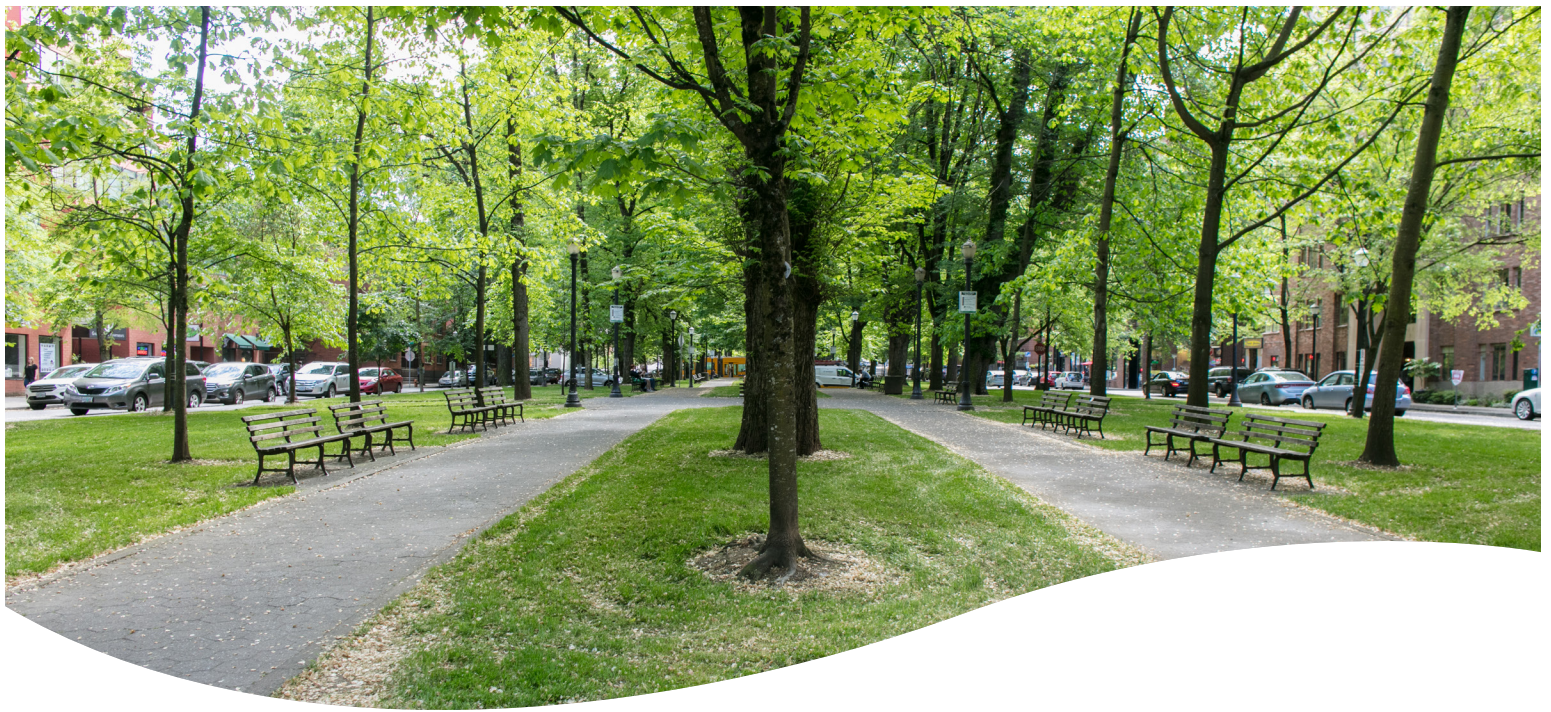
Jurisdiction by County	Jurisdiction Size (Acres)	Number of priority block groups	Percent of Jurisdiction in priority block groups
<b>Washington County</b>			
Beaverton	12,582	11	10 %
Cornelius	1,494	5	21 %
Durham	260	1	7 %
Forest Grove	3,855	5	13 %
Hillsboro	16,537	13	14 %
Tualatin	5,356	3	7 %
Urban Washington County	29,935	13	6 %
<b>Multnomah County</b>			
Fairview	2,257	3	21 %
Gresham	15,133	22	22 %
Portland	92,785	69	15 %
Troutdale	3,719	1	3 %
Urban Multnomah County	5,783	2	1 %
Wood Village	609	3	76 %
<b>Clackamas County</b>			
Gladstone	1,591	1	15 %
Urban Clackamas County	25,385	2	0.2 %
<b>Clark County</b>			
Urban Clark County	37,011	4	2 %
Vancouver	33,442	21	8 %



**Figure 8.** Map highlighting priority block groups and showing percent canopy cover in 2020 and percent net canopy change 2014 to 2020 across block groups. Priority block groups, defined as block groups which had the highest percent BIPOC and low-income populations, and canopy cover below 35% in 2020, are highlighted in yellow.



**Figure 9.** Priority block groups with recommended actions. This diagram shows all block groups and highlights the 151 priority block groups identified to address inequities in canopy cover. Tree-related actions are proposed depending upon the relationship between canopy cover and net canopy change for each block group. A 35% canopy cover goal is shown to separate block groups that exceeded the canopy cover threshold from those that did not. Block group points above zero percent net canopy change experienced net canopy gain over the period, and those below zero experienced net canopy loss.



## Discussion

We found that canopy cover in 2020 was 35% for the region yet varied substantially across jurisdictions and land use types. Not surprisingly, canopy cover was higher in parks, natural areas, and open spaces than in other land use types. Canopy cover was also consistently lower in multi-family residential areas than in single-family residential areas, and in most cases very low within commercial and industrial areas (Fig 5 and SI Table 6). Though the benefits of canopy cover apply across land uses, the actions taken to increase canopy cover need to consider the various ways communities use these spaces (e.g., to live, work or recreate). Tree planting and maintenance efforts will face different challenges across land use types and require different strategies. For example, the Tacoma Mall Greening Project in Tacoma, Washington, found that direct outreach to commercial properties did not lead to meaningful expansion of tree canopy and attributed that to three primary reasons: lack of appropriate planting space, lack of control over landscape management, and lack of interest <sup>63</sup>.

Prior to our regional canopy cover assessment, local city canopy cover estimates were measured using different methods and in different years (e.g., 2007 in Gresham <sup>64</sup> and Lake Oswego <sup>65</sup>, 2014 in Milwaukie <sup>66</sup>, 2021 in Vancouver <sup>67</sup>) making comparisons to our results, and across the region, challenging. For example, the Vancouver canopy assessment <sup>67</sup> utilized imagery from 2019 and 2020 (we only used imagery from 2019) but with a different method than ours and reported a lower canopy cover estimate (18.9%) compared to our results (24.0%). Methods commonly used to assess canopy cover have different capabilities and limitations, spatial resolution (fine vs. coarse detail), costs, and accuracy <sup>68</sup>. The methodological inconsistency amongst jurisdictions highlights the value of this region wide evaluation. We suggest that the regional conversation about tree canopy would benefit from consensus around methods to allow for comparison through time and across areas.

In regards to changes in canopy cover in recent years, multiple studies have shown urban tree canopy is declining across the United States <sup>9,69</sup>. A nationwide study showed a -0.7% decline in Washington (2009-2014) and -1.7%

Portland park block. © SHELL/Adobe Stock

decline in Oregon (2008-2014), the latter ranking as the 5th largest statistically significant annual percent loss (-0.38%/year) of all 50 states <sup>9</sup>. In Oregon, most of this historic and forecasted decline occurs in the Portland area (Multnomah and Washington counties; Fig 1 in <sup>13</sup>). A 20-year assessment of canopy cover in the city of Portland showed a shift in trend, with a 3.4% gain from 2000-2015 followed by a 0.9% loss from 2015-2020 <sup>35</sup>. Similarly, our study found a 0.3% loss in canopy cover within the city of Portland from 2014-2020 (SI Table 5). Our results also indicate small net gain in canopy cover across the entire Portland-Vancouver metropolitan region (0.4%; SI Table 5), although nearly 56% of block groups experienced net canopy loss. However, as mentioned above, since the aforementioned studies assessed canopy cover using different canopy change methods (i.e., point interpretation of aerial photos), timeframes and spatial extents <sup>35,69</sup>, directly comparing these trends to our study is challenging. A more nuanced understanding of canopy change trends is evident when examined by zoning class <sup>70</sup>, land use type or extent of initial canopy cover <sup>71</sup>. Interestingly, a recent study by Ock *et al.* used the same tree canopy change maps as our study to assess drivers of canopy loss in the city of Portland and found neighborhoods with moderate canopy cover levels (20–25%) experienced notable loss whereas the decline in neighborhoods with low and high canopy cover was less severe <sup>71</sup>. These joint findings indicate that while tree canopy is slowly increasing in some areas across the Portland-Vancouver metropolitan area, there are specific neighborhoods where canopy cover continues to decline at a disproportional rate.

The decline in urban tree canopy nationwide has been attributed to multiple mortality factors including housing and infrastructure development, tree age, fire, insects, disease, storms, and shifts in landowner choices <sup>13</sup>. Within the Portland area, likely factors include new development <sup>14</sup>, changes in landowner street tree planting preferences (larger-form to smaller-form trees or outright tree removal), more frequent extreme weather events (e.g., heat domes, ice storms <sup>53,72,73</sup>) and an increase insect-related tree diseases and mortality <sup>13</sup>. While industrial and commercial land use types had the lowest percent canopy cover in our study (Fig 5A), the greatest losses were observed in the agriculture, single-family residential, multi-family residential and commercial land use types (Fig 5B). Similarly, the 20-year assessment of canopy cover in the city of Portland indicated most canopy loss from 2015-2020 occurred in residential areas <sup>35</sup>. Ock and authors also found significant canopy loss in areas with more multi-family housing units, although canopy loss was less extreme in those areas when compared to the impacts of landowners increasing their building footprint <sup>71</sup>.

Our study corroborates research across the United States that consistently finds a disproportionate decrease in canopy cover in low-income <sup>23,26,41,74,75</sup> and BIPOC communities <sup>24,34,39</sup>. In a nationwide study of tree canopy and temperature disparity across 100 urban areas in the United States, low-income block groups had 15% less tree cover than high income block groups and there was a positive relationship between the proportion of non-Hispanic white individuals and canopy cover <sup>76</sup>. According to Ock and authors, areas with the highest median household incomes in the city of Portland had 20% more canopy cover on average than areas with the lowest median household incomes <sup>41</sup> and socio-economic characteristics were key drivers of tree canopy loss <sup>71</sup>. We must pay attention to these trends now because social and racial disparities in canopy cover are forecasted to worsen as the region increasingly experiences the impacts of climate change. In recent years instances of acute heat waves, wind and ice storms have increased in the Pacific Northwest. The “heat dome” of June 2021—coupled with two previous years of drought—resulted in widespread tree foliage scorch and increased the potential for changes in tree growth and mortality <sup>53</sup>. Winter precipitation can cause extensive tree damage when it occurs as freezing rain <sup>77</sup>, and over the past few years



ice storms <sup>73,78</sup> and a severe windstorm <sup>79</sup> have swept across the region causing significant damage to mature trees and urban infrastructure. Just this year, an ice and windstorm in the Portland area caused over 675 downed trees <sup>80</sup>, with associated power outages, blocked roads, and damage to homes and structures <sup>81</sup>.

To facilitate tree-related planning and direct investments toward activities and areas where they are most beneficial, we offer the diagram in Figure 9 as a starting point to guide tree planting and conservation actions depending upon the canopy cover and canopy change dynamics. In areas where tree canopy cover is high and canopy has increased, tree maintenance activities to promote tree health and sustain the canopy are important. Whereas in areas of where canopy cover is high and canopy has decreased, additional tree protections may be warranted to protect the existing mature canopy. While simplified, the actions we recommend are meant to guide limited resources to those areas and activities likely to result in sustained canopy cover. In practice, the choice of which actions to consider depend on the community's needs and interest, plus an understanding of where there are gaps in the desired canopy cover and challenges to tree survival. In general, potential actions and activities to grow and sustain canopy cover and the benefits it provides to communities may include tree planting, maintenance such as pruning and watering, protection measures, plus public education and awareness activities.

Figure 9 also highlights priority block groups with equity disparities in which tree-related planning and activities should be focused. Of the 151 priority block groups, 82 (54%) are outside the city of Portland (Table 1), drawing attention to areas that may have been overlooked in previous studies. For example, Cornelius, Gresham, and Wood Village stand out on the Oregon side as ideal jurisdictions to consider for efforts to encourage improved tree policies and programs and activities to promote canopy growth. These three cities had the lowest canopy cover in 2020 (20%, 20% and 22%) and the highest low-income (34%, 37%, and 48%) populations of the region (SI Table 5). Cornelius and Wood Village had the highest BIPOC (54% and 67%) populations and Gresham had the 5th highest of the region (SI Table 5). Targeting tree related actions in the 30 priority block groups (Cornelius, 5; Gresham, 22; Wood Village, 3; Table 1) in these cities would contribute toward addressing canopy cover inequities. Municipal policy and program change could benefit future canopy cover in Cornelius and Wood Village as these two cities lack tree codes (the legal regulations that govern urban forest management) and forest management plans <sup>46</sup>.

The Washington portion of the region also stands out as an ideal area to explore for canopy and equity opportunities. The Washington state portion of the region covers four jurisdictions, representing 20% of the population (430,344 people) and 24% of the total land area of the region. Twenty-five of the priority block groups are within either the city of Vancouver or urban Clark County (Table 1), identifying important locations to focus canopy cover-related programs. Vancouver has a tree code <sup>46</sup> and recently updated its urban forestry management plan <sup>67</sup> to include equity and climate goals <sup>82</sup>, actions that show interest and momentum for urban forestry activities. In contrast, Urban Clark County lacks a tree code and an urban forest management plan, so raising community awareness and advocating for policy change could be affective actions to increase future canopy cover <sup>46</sup>.



# Connecting Canopies: Creating Change through Community Engagement & Organizing

While many studies have highlighted urban tree canopy decline and notable differences in canopy cover among low-income and BIPOC communities, few took additional steps to acknowledge the important role community input plays in decision-making processes<sup>45</sup>. In this region, a community-led partnership called Connecting Canopies was formed by the Blueprint Foundation and The Intertwine Alliance with support from The Nature Conservancy. Connecting Canopies aims to change the way we plan and implement urban forestry by bringing together community members, business professionals and government representatives to all participate in decision making. The near term objectives are: 1) Foster a workforce development program designed to build career and educational pathways into the green sector for low-income and BIPOC individuals; 2) Develop a region-wide tree policy and program report that includes a breakdown of jurisdictional tree policies, codes, programs and investment levels; 3) Complete a baseline assessment (this report) to identify canopy inequities across communities and provide a baseline for monitoring future canopy change in priority areas.; 4) Organize community gatherings across the region with groups representing diverse races, ethnicities and socio-economic statuses to learn about their relationships and concerns regarding urban trees. Connecting Canopies will combine both quantitative data analyses, such as this assessment, with the non-quantitative perspectives and lived-experiences heard during community conversations to develop effective resources and community-centered programs to address racial and environmental equity deficiencies, and to help maintain and accelerate the growth of urban tree canopy across the region.

As a community-led platform, Connecting Canopies intends to advance programs and policies towards the maintenance of and increase in tree canopy within the priority areas identified in this study (Fig 9). For example, in

Workforce training participants meet the trainers, at Leach Botanical Garden © Max Meyers/Leach Botanical Garden

2023, Connecting Canopies began organizing with the Cully neighborhood to understand the relationship of community members with trees in terms of their value and concerns. The Cully Neighborhood is within one of the identified priority block groups. In partnership with Verde and members of their environmental leadership development program (Lideres Verdes), Connecting Canopies held a community gathering to hear from neighborhood members. The proximity of the Cully neighborhood to a large industrial area and international airport has caused concern about air quality and led to an interest in the potential air pollution mitigating services urban trees provide. The primary message from the community was the need for funded tree maintenance programs, especially within low-income neighborhoods. Many residents stated that they lack municipal support given that the city of Portland does not claim responsibility for maintaining trees in the sidewalk strips, placing the cost of tree maintenance on adjacent property owners. This has given trees a negative connotation for some residents for whom the financial burden outweighs health benefits. A public survey by Portland Parks and Recreation also found high community interest in a city-funded tree maintenance program <sup>42</sup>. Implementation of city-provided maintenance program in response to expressed community need would be a step toward recognition justice <sup>32</sup>. This one example from the Cully neighborhood demonstrates the importance of hearing from community members themselves on the issues of interest and concern to them, which can then help guide Connecting Canopies to tailor initiatives that align with the values held by the community.

## Looking Forward

Connecting Canopies aims to support environmental justice principles <sup>32</sup> across its programs by: providing access to data and tools for targeting tree planting, maintenance, and protection locations (distributional justice); hosting community conversations to listen and learn from community members about their values, beliefs, and concerns (recognition justice); and partnering with community groups local to areas of inequity to facilitate inclusion in planning processes (procedural justice). Though, significant progress toward environmental justice will involve transformational changes in decision making across all entities which influence the policies, programs, and locations of urban tree canopy activities.

Looking forward, Connecting Canopies will continue organizing community gatherings and expanding the workforce development program. In conjunction with this baseline assessment, the *Connecting Canopies Portland-Vancouver Regional Urban Tree Policy and Program Report* <sup>46</sup> recently published by The Intertwine Alliance will provide a roadmap for where to focus our advocacy efforts for equitable tree canopy policies in the Portland-Vancouver metropolitan area. Next steps include providing access to the results of this assessment and the Policy and Program report through an interactive web platform designed to assist in decision making and targeting tree related activities. Additionally, we will continue to build upon these data to better inform decisions, such as estimating potential available space for planting, and include land surface temperature or urban heat islands maps to assist with planning efforts.

As an established platform that now includes comprehensive data and regular communication with many community advocates and partners, Connecting Canopies intends to use the 151 priority block groups identified in this assessment as focal areas to enhance programs and advocate for policies that maintain and increase tree canopy. In addition, Connecting Canopies will also seek opportunities to work in areas achieving success in protecting or increasing canopy cover, such as the city of Milwaukie. City of Milwaukie urban forest staff have been

consistent contributors in Connecting Canopies task forces and are exemplary advocates for urban tree canopy programs and policy. Approaching both successful areas in addition to areas in need will help us understand how certain jurisdictions that represent those block groups are prioritizing programs and policy that support and maintain tree canopy as positive examples to share with neighboring cities and communities.

Lastly, there are additional opportunities on the horizon for program development in urban forestry in the region. In 2023, the U.S. Department of Agriculture announced more than 1 billion dollars to urban tree canopy projects nationwide. This includes 58 million to the State of Oregon with the goal to increase equitable access to trees and nature for neighborhoods that need it in efforts to increase resilience to the effects of climate change. This funding opportunity aligns with Connecting Canopies' goal to support and promote a coordinated approach to tree planning investment in historically underserved areas. We hope these federal funds will create pathways to support new and existing programs to increase tree planting, maintenance, and protections in the priority areas identified in this study.

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All maps displayed use the Human Geography Basemap provided by ESRI in ArcGIS Pro. Credit: Esri, CGIAR, USGS, Oregon Metro, Oregon State Parks, State of Oregon GEO, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS.

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ABOVE: Work party in winter deciduous forest. © Mitch Maxson/TNC; BACK COVER: Mt Hood over Portland. © Sean Pavone/Adobe Stock



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