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Portland, Oregon's Urban Forest, 2018



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Abstract

An analysis of the urban forest in Portland, Oregon, revealed that this area had an estimated 7.7 million live trees (≥ 1.0 inch in diameter) or 2.7 million live trees (≥ 5.0 inches in diameter) across public and private lands. The most common tree species (≥ 5.0 inches in diameter) were bigleaf maple, Douglas-fir, northern white-cedar, western redcedar, and red alder. Trees in Portland were estimated to store about 1.6 million tons of carbon (equivalent to 5.9 million tons of carbon dioxide [CO₂]) valued at \$267.3 million. In addition, these trees were estimated to remove about 50,000 tons of carbon per year (equivalent to 187,170 tons of CO₂ per year, valued at \$8.6 million per year; roughly equivalent to the annual emissions associated with 36,928 passenger vehicles or energy usage by 30,843 homes per year [Greenhouse Gas Equivalencies Calculator, U.S. EPA 2020]), and about 455 tons of air pollution per year (valued at \$9.2 million per year). Portland's urban forest was estimated to reduce the annual energy costs of residential buildings by \$5.1 million per year. The overall compensatory value of the urban forest was estimated at \$5.8 billion. Compensatory value describes the replacement value of trees as a structural asset, which tends to increase with tree size and health. The information presented in this report may be used to support urban forest management programs and inform policy and planning to improve environmental quality and human health in Portland. The analyses also provide a basis for monitoring changes in the urban forest over time.

Keywords: i-Tree; My City's Trees; tree volume and biomass; carbon sequestration and storage; UFIA; Urban Forest Inventory and Analysis; Urban FIA; urban forest structure and health; urban forest values and ecosystem services

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Cover photo: Urban trees in Cathedral Park, near St. Johns Bridge, Portland, Oregon. USDA Forest Service photo by Suzanne Owen.

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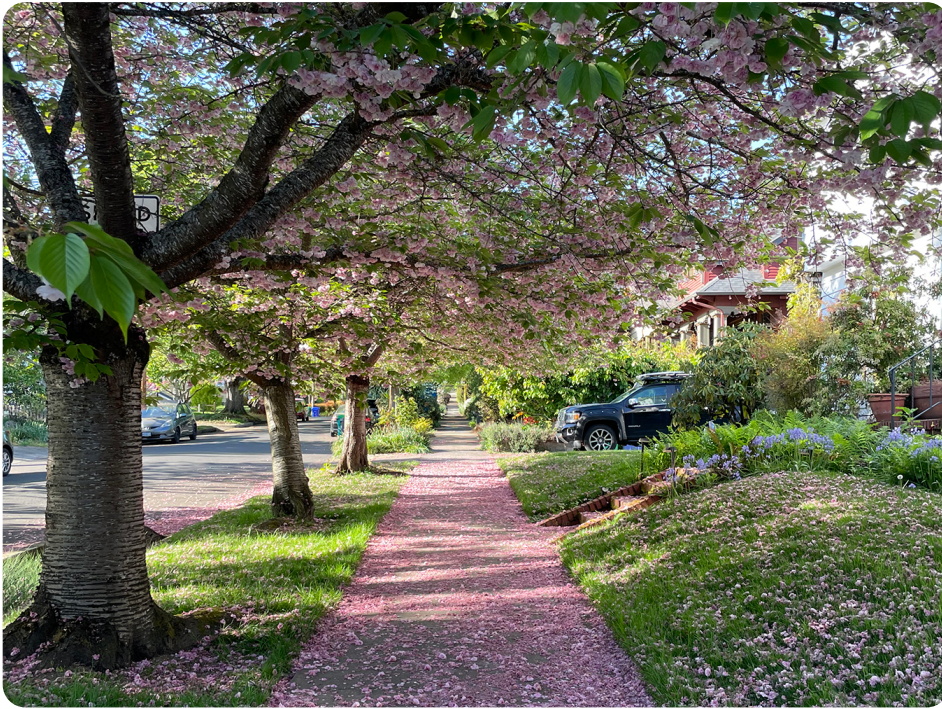
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EXECUTIVE SUMMARY



Cherry trees in blossom in a Portland, Oregon neighborhood. USDA Forest Service photo by Alexa Helms.

The 2018 Urban Forest Inventory and Analysis (Urban FIA) assessment of the City of Portland, Oregon includes estimates of its urban forest composition and value. The sampled area of the city (representing a total of 92,858 acres), is estimated to contain 7.7 million live trees, 64.3 percent of which are less than 5.0 inches in **diameter**¹. Portland's urban trees provide an estimated tree canopy cover of 26.1 percent and store about 1.6 million tons of carbon. The most common tree species² at least one inch in diameter are northern white-cedar, bigleaf maple, camellia, cherry laurel, and Douglas-fir. The most common large-diameter tree species (11.0+ inches in diameter) are Douglas-fir, bigleaf maple, western redcedar, red alder, and Oregon ash. The most important species based on the number of trees and leaf area are bigleaf maple, Douglas-fir, northern white-cedar, western redcedar, and black cottonwood.

¹ See glossary for definition of bolded terms.

² Common and scientific names for all tree species observed in the 2018 Urban FIA inventory of Portland are reported in Appendix 2.



The land use class with the greatest number of trees is single family residential land (41.9 percent; 3.2 million trees), even though this land occupied only 28.3 percent of the study area, highlighting the importance of engaging private landowners to the health and maintenance of the city's urban forest. Overall, 38.7 percent of trees are classified as growing in maintained areas. Trees on public lands total 2.9 million and account for 37.9 percent of the total live tree population. Trees on private lands total 4.8 million and account for 62.1 percent of the population.

Urban forest ecosystem services are evaluated in terms of air pollution removal, carbon sequestration, reduction in stormwater runoff, and effects on residential building energy use and carbon emissions. The compensatory value of the urban forest (roughly equivalent to the replacement value of all trees in the urban forest) of Portland is estimated at \$5.8 billion with the urban forest producing over \$29.8 million in annual benefits (Table 1).

Tree damage, infrastructure issues, and **invasive plant species**³ threaten to alter forest composition. Stem decay and competition are the most common causes of damage in Portland, affecting 8.9 and 4.2 percent of trees, respectively. Bark inclusion and topping/pruning are common infrastructure issues, together occurring in about 20 percent of trees. Invasive plant species are found on 57.7 percent of the sampled plots; English ivy is estimated to cover the largest area (4,456 acres) of any invasive plant species in the city.

These natural and anthropogenic threats may affect the health and composition of Portland's urban forest. Through a better understanding of the benefits conferred by and potential threats to the urban forest, resource managers, arborists, and city planners can improve forest management, leading to healthier urban forests and more livable communities.

³ Common and scientific names for all invasive plant species observed in the 2018 Urban FIA inventory of Portland are reported in Appendix 6.

Table 1.—Summary of the urban forest estimates, Portland, Oregon, 2018

Feature	Estimate
Number of trees^a	
Total live trees	7.7 million (1.1 million) ^b
Live saplings (1 to 4.9 inches in diameter)	4.9 million (1.0 million) ^b
Live trees (at least 5.0 inches in diameter)	2.7 million (234,331) ^b
Standing dead saplings (1 to 4.9 inches in diameter)	77,000 (54,000) ^b
Standing dead trees (at least 5.0 inches in diameter)	212,000 (46,000) ^b
Most abundant species by	
Number of live trees	northern white-cedar
Leaf area	Douglas-fir
Ecosystem impacts and services	
Pollution removal	455 tons/year (\$9.2 million/year)
Reduction in acute respiratory symptoms	803 cases/year (\$72,000/year)
VOC emissions	275 tons/year
Avoided runoff	94.2 million cubic feet (\$6.3 million/year)
Carbon storage ^c	1.6 million tons (\$267.3 million)
Carbon sequestration	50,000 tons/year (\$8.6 million/year)
Net aboveground volume	132.6 million cubic feet
Reduced building energy use ^{c,d}	252,000 GJ/year (\$5.1 million/year)
Reduced carbon emissions ^{c,d}	4,000 tons/year (\$683,000/year)
Compensatory value	\$5.8 billion

Due to rounding, not all values will add up exactly.

VOC = volatile organic compound; Ton = short ton (U.S.) (2,000 lbs.); GJ = gigajoule (one billion [10⁹] joules). To convert carbon estimates to carbon dioxide multiply carbon value by 3.667.

^a Diameter measurements were taken at breast height (d.b.h.) or root collar (d.r.c.) for woodland species (see glossary for definition).

^b Numbers in parentheses are standard error.

^c Estimates are for the live and dead tree population. All other estimates are based on the live tree population only, except where noted.

^d Estimates are calculated using trees greater than or equal to 5 inches in diameter.

Contents

EXECUTIVE SUMMARY	iii
BACKGROUND	1
AREA AND COVER CHARACTERISTICS	5
FOREST STRUCTURE	13
VOLUME AND BIOMASS	25
URBAN FOREST VALUES.....	29
URBAN FOREST HEALTH	41
MANAGEMENT IMPLICATIONS	55
CONCLUSIONS.....	67
REFERENCES	68
GLOSSARY OF TERMS.....	78
APPENDIX 1 – LAND COVER DESCRIPTION.....	80
APPENDIX 2 – TREE SPECIES COMPOSITION.....	82
APPENDIX 3 – TREE CHARACTERISTICS WITHIN NLCD LAND COVER CLASSES AND FIA LAND USE.....	86
APPENDIX 4 – SPECIES COMPOSITION IN MAINTAINED AREAS	101
APPENDIX 5 – DAMAGE, MAINTENANCE AND SITE ISSUES BY SPECIES.....	102
APPENDIX 6 – LIST OF INVASIVE PLANT SPECIES.....	104
APPENDIX 7 – PEST RISK RATING BY TREE SPECIES	105

BACKGROUND



Conifers provide shade during an Arbor Day event in Mt. Scott Park, Portland, Oregon. The City of Portland has been organizing and celebrating Arbor Day since 1889, bringing communities together to recognize the importance of urban trees. Courtesy photo by Ben Brink, Portland Parks & Recreation.

Urban forests offer a wide range of environmental, social, and public health benefits, such as wildlife habitat, aesthetic appeal, social cohesion, enhanced recreational opportunities, reduced air temperatures, improved water quality, mitigated air and noise pollution, and benefits to mental health and well-being. Since 1930, the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) program has provided information on the amount, status, and character of **forest land** across the country. The 2014 U.S. Farm Bill (The Agricultural Act of 2014) directed FIA to explore possibilities to expand the scope of the FIA inventory to include forest monitoring in U.S. urban areas. This effort led to the development of the current FIA Strategic Plan (USDA Forest Service 2016a), which includes a special focus on the Nation's most populous cities.

In this report, the term “urban forest” describes all trees located in the city across both public and private ownerships, including planted trees along streets and boulevards, trees in parks and residential yards, remnant forests along railroads and riparian areas, small woodlots, and larger forested areas. FIA has partnered with the Forest Service [i-Tree](#) team, which has a long tradition of conducting urban forest inventories and delivering

data about urban forests and their associated ecosystem services. This combined national urban forest inventory effort leverages the strengths of both groups, drawing on the urban data processing and reporting strengths of the i-Tree program and FIA's strengths in quality, consistency, and comprehensiveness of data collection.

In 2018, Portland, Oregon joined a growing list of U.S. cities that have completed a full inventory cycle under the Urban Forest Inventory and Analysis (Urban FIA or UFIA) program. During the 2018 field season, Portland's 10-year measurement cycle was accelerated and completed during a single field season, under the administration of the Pacific Northwest (PNW) Research Station, and with funding and data collection provided by the City of Portland, Parks & Recreation (PP&R) Urban Forestry Division. Subsequent resampling is conducted and funded by the PNW Research Station. Through this partnership, the inventory of Portland's urban forest, described in this report, supports the city's objectives by providing a baseline assessment of the extent and composition of the urban forest and associated ecosystem services. This report also complements previous PP&R urban assessments (e.g., City of Portland 2017a, b), by providing a cohesive forest inventory across both public and private lands, and includes summaries of urban land use, tree damage, **invasive plants**, seedlings and saplings, and permeable or impervious surfaces.

Providing accurate data describing Portland's urban forest resources can help managers and residents understand the numerous environmental, economic, and public health services conferred by urban forests and the potential threats to these forests. The City of Portland aims to increase urban tree species diversity and canopy cover in underserved communities, with a citywide canopy goal of 33.3 percent by 2035 (City of Portland 2004, 2012, 2018b). The City of Portland also has a goal to reduce 80 percent of local carbon emissions by 2050, partially through increasing carbon sequestration by expanding the urban forest canopy and protecting existing natural forests (City of Portland 2015). Urban FIA data can inform future management decisions aimed at enhancing forest health, expanding the forest canopy, and maximizing the services provided by Portland's trees. Urban inventory data can also help managers address interrelated challenges such as increased development, drought stress, prolonged heatwaves, storm damage, invasive species, and risks from pests and pathogens such as the emerald ash borer (*Agrilus planipennis*), western spruce budworm (*Choristoneura occidentalis*), Douglas-fir beetle (*Dendroctonus pseudotsugae*), Armillaria root disease, and others. Data describing Portland's urban forest can be utilized to develop management strategies, forecasts, and programs for improving forest health and resilience in partnership with state agencies, city government, nonprofit organizations, and consultants.

METHODS

To evaluate the extent, composition, and benefits of Portland's urban forest and establish a baseline for future monitoring, a sample-based inventory was conducted using a hexagonal grid with random plot placement within each cell. Each plot consists of a 48.0-foot radius circle within which four 6.8-foot radius circles (microplots) are located. Various data are collected from either the entire plot or from within the smaller microplots. Additional information about Urban FIA monitoring methods and reporting tools are described in

the Urban FIA PNW Field Guide Version 7.2 (USDA Forest Service 2018) and the [online supplement](#) (Baer et al. 2024) to this report, along with i-Tree Eco modeling software (Nowak 2020). This process established survey plots across Portland and aims to re-measure all plots every 10 years. Future reports can build on these data and consistently provide information on urban forest extent, diversity, health conditions, and benefits.

The sampling area was limited to the U.S. Census Bureau Designated Places boundary for Portland, Oregon (highlighted in red in Fig. 1a). Portland's 10-year measurement cycle was accelerated and completed during the 2018 field season. In total, the Urban FIA sample surveyed 92,858 acres between May and October 2018, located within the sampling boundary area in Portland (Fig. 1). The Urban FIA sample consisted of 204 plots within the sampling boundary and data were collected on 189 of these plots (Fig. 1b). The remaining 15 plots were not sampled either due to hazardous conditions or lack of permission to access the plot (9 plots were non-sampled for this reason), or they were part of a base inventory that could not be accelerated and will be included in a future report (6 plots were not part of this accelerated sample for this reason).

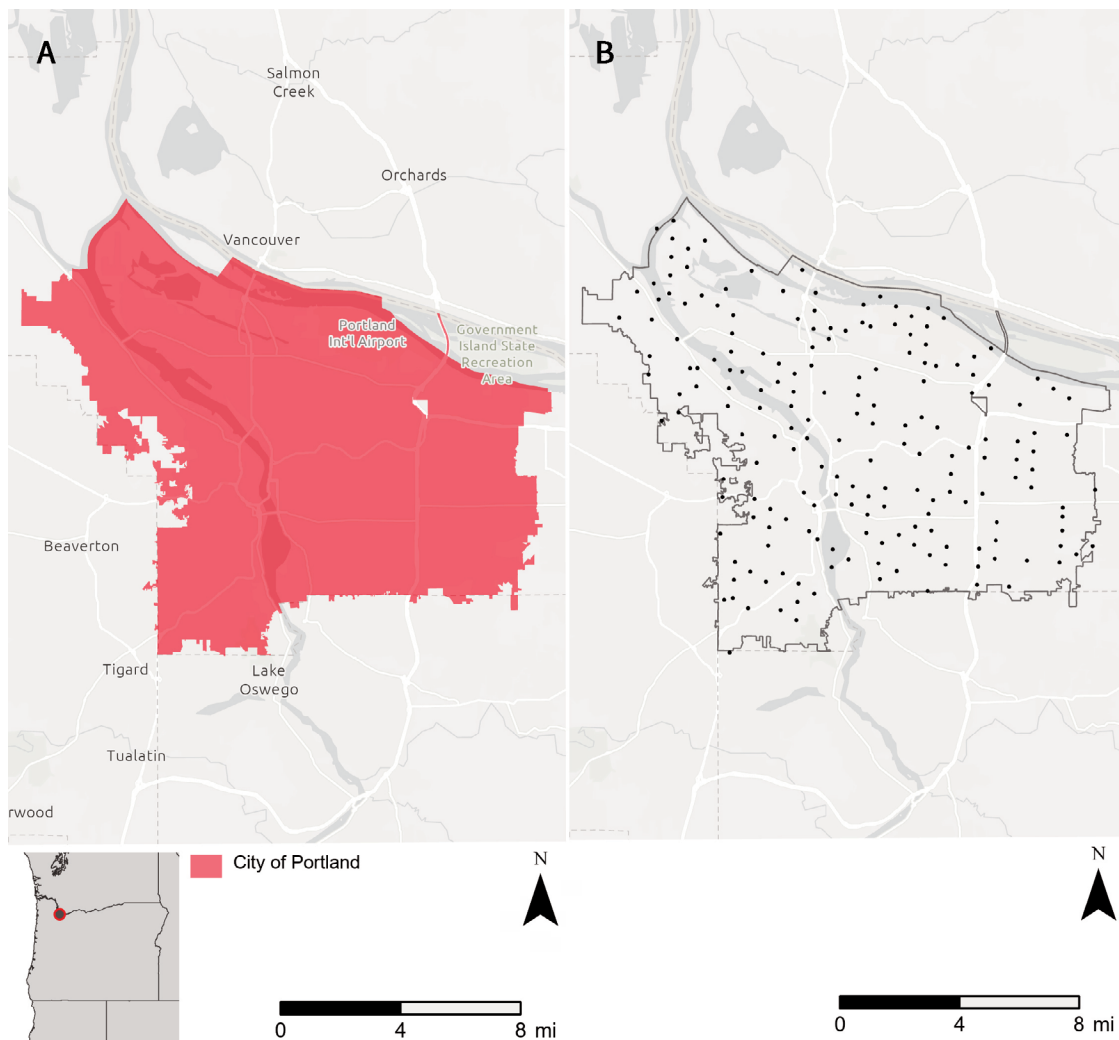


Figure 1.—Study area (A) and approximate plot locations (B) for the Urban FIA inventory of Portland, Oregon, 2018. Map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.

Throughout this report, except where explicitly noted, trees refer to woody plants with **diameters** of at least 1.0 inch, and results are given for live trees. Trees included in this survey are from the Urban FIA PNW Field Guide Version 7.2 (USDA Forest Service 2018) (see Appendix 2 for the complete list). Some trees on this list tend to grow in a shrub form, such as varieties of white cedar (also known as arborvitae, *Thuja occidentalis*) (USDA Forest Service 2018). Urban FIA data collection protocols allow flexibility in the estimation of tree characteristics for forked trees. In this inventory, all stems of forked trees were quantified and characterized as part of the same tree. All extrapolated estimates for forked trees were based on this approach except for estimates of tree merchantability and volume estimation. Refer to Baer et al. (2024) for more detailed information.

The collected data were analyzed using FIA methodology and i-Tree Eco modeling software, mentioned above. Additional analyses were conducted using R Statistical software version 4.2.1 (R Core Development Team 2022) and Microsoft Excel; figures presented in this report were generated using the base, dplyr (Wickham et al. 2022), and ggplot2 (Wickham 2016) packages within the R Statistical Software platform, and Microsoft Excel. Maps throughout this document were created using ArcGIS® software by Esri (ArcGIS Pro version 2.9, Esri 2021). ArcGIS® is the intellectual property of Esri and is used herein under license.

This report summarizes the findings of these analyses and includes information on forest structure, ecosystem services, and associated monetary values. Structure describes various physical attributes of the urban forest, including tree species composition, number of trees, tree density, tree health, leaf area, biomass, and species diversity. Ecosystem services discussed in this report were evaluated based on forest structure in conjunction with local environmental variables and include such attributes as air pollution removal and carbon storage and sequestration. Monetary values are an economic estimate of various ecosystem services or structural attributes.

Urban FIA provides critical information on urban forests on public and private lands, which is helpful for planning and outreach. However, as with all sample-based estimates, standard errors (SEs) must be considered when assessing the data and its potential use. For example, some plots have no trees present, while others are fully forested; some tree species were found on many plots while others were only found on a single plot. Due to the broad range of possible uses for the data, ranging from strategic planning to identifying additional research, this report does not limit results to a minimum SE threshold. Throughout this report, tables provide SEs for many, but not all estimates. The [Urban Forest Stats tool](#) or raw data from the [Urban DataMart](#) can be used for independent calculations and to calculate all SEs. Further details about protocols and plot design can be found in the online supplement (Baer et al. 2024).

In addition to this report, information from this analysis is accessible via [My City's Trees](#), an online interactive tool that allow users to explore results, summarize data by spatial 'themes,' save data queries, and generate reports. Portland's spatial themes include land cover, zoning, equity (uses race and income to determine census tracts where marginalized communities reside), neighborhood coalitions, and urban heat islands. Data tables are also available for download from FIA's Urban DataMart.

AREA AND COVER CHARACTERISTICS



Street trees providing shade in an urban neighborhood, Portland, Oregon. USDA Forest Service photo by Suzanne Owen.

In 2010, Oregon had 708,000 acres of urban land that covered 1.2 percent of the state area, and this urban area is projected to increase to 3.4 percent by the year 2060 (Nowak and Greenfield 2018). Portland is the largest city in Oregon by population (584,000 residents with a population density of 4,375 per square mile in 2010). U.S. Census data from 2010 was used for this report and updated census data will be included in future reports. Between 2010 and 2020, the city's population grew at a rate of 10.5 percent, which exceeded the national average of 7.4 percent (U.S. Census Bureau 2018).

Land Cover

National land cover data were used to analyze the variability of the urban forest across the city by land cover class (Homer et al. 2015, MRLC 2018). Plots were categorized into general land cover classes (Table 2), and Figure 2 shows the distribution of land cover classes across the city.

Land cover definitions are based on the 2011 National Land Cover Database (NLCD) (Homer et. al. 2015) and are described in Appendix 1. The most prevalent land cover classification in Portland is developed-medium, followed by developed-low, developed-high, and forest/shrub (Table 3). Areas of developed-low land cover are estimated to contain the greatest proportion of trees in the sampling area of any land cover (42.7 percent), followed by forest/shrub, developed-medium, and developed-open/herbaceous land covers (26.2 percent, 15.7 percent, and 14.4 percent of the trees in the sampling area, respectively).

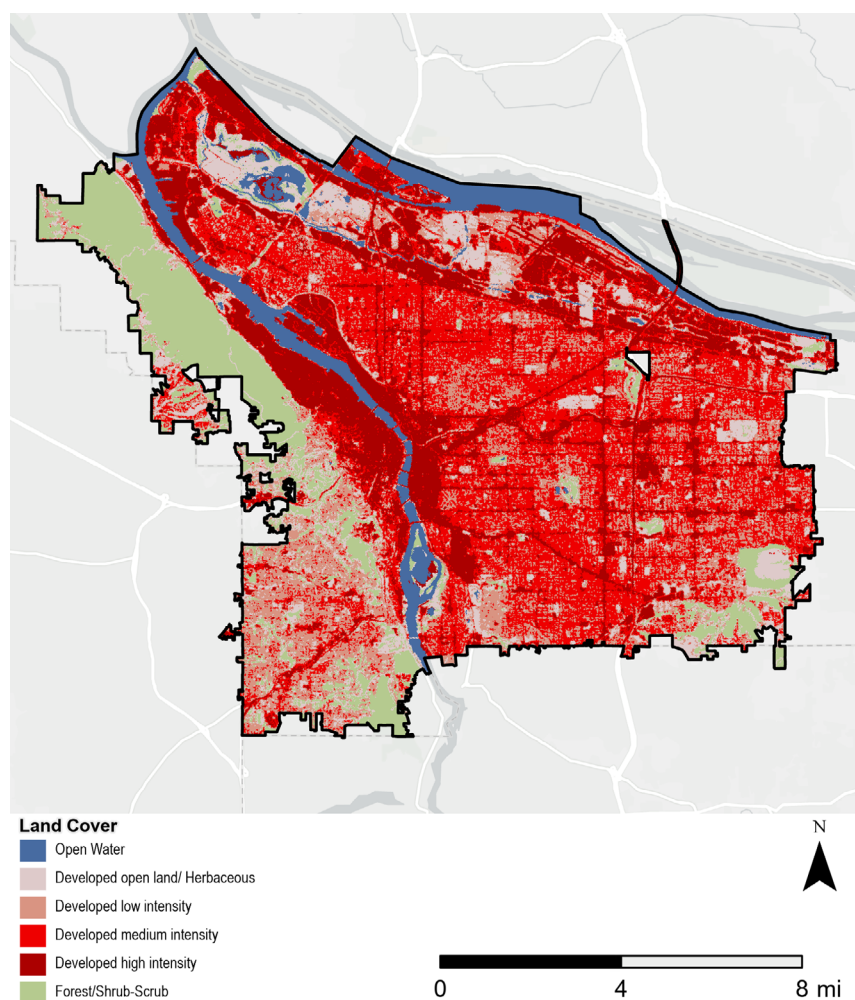


Figure 2.—Distribution of National Land Cover Database (NLCD) (Homer et al. 2015, MRLC 2018) land cover classes, Portland, Oregon, 2018. Map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.

Table 2.—National Land Cover Database (NLCD) land cover classes and subclasses

NLCD land cover	NLCD land cover subclasses
Developed-open/herbaceous	Developed-open space, Herbaceous, Pasture/Hay, Cultivated crops, Emergent herbaceous wetlands
Developed-low	Developed-low intensity
Developed-medium	Developed-medium intensity
Developed-high	Developed-high intensity, Barren land
Forest/Shrub	Mixed forest, Evergreen forest, Deciduous forest, Woody wetlands, Shrub/Scrub
Water	Open water

Source: Completion of the 2011 National Land Cover Database for the conterminous United States—representing a decade of land cover change information (Homer et al. 2015).

See Appendix 1 for descriptions of the NLCD land cover classes.

Table 3.—Sample area and plot counts within National Land Cover Database (NLCD) land cover classes in Portland, Oregon, 2018

NLCD Land cover	Area (acres)	City land area (percent)	Plots (number)
Developed-medium	28,517	31	58
Developed-low	22,868	25	39
Developed-high	15,816	17	40
Forest/Shrub	12,266	13	19
Developed-open /herbaceous	7,844	8	21
Water	5,547	6	12
Total	92,858	100	189

Due to rounding, not all values will add up exactly.

FIA Land Use

In addition to categorization according to NLCD land cover classes, plots were also classified in the field based on FIA land use classes (Table 4). These categories provide a specific look at how the land is being used by the local population in Portland. Residential is the most prevalent land use class in Portland, covering 28.3 percent of the city area (containing 41.9 percent of the city's trees), followed by commercial/industrial (20.8 percent of the city area), **rights-of-way** (19.9 percent), forest (12.2 percent), and water (7.6 percent) (Table 5).

Table 4.—Forest Inventory and Analysis (FIA) land use classes and subclasses

FIA land use	FIA land use subclasses
Agriculture	Agriculture, Christmas tree plantation, cropland, idle farmland, maintained wildlife openings, nursery, orchard, pasture, shelterbelt, windbreak
Commercial/Industrial	Commercial, cultural, developed, industrial, institutional, mining, wasteland
Forest	None
Multi-family residential	None
Natural lands	Beach, nonvegetated land, other, wetland
Rangeland/Chapparral	None
Recreation/Cemetery	Cemetery, golf course, park, recreation
Residential	None
Rights-of-way	Rights-of-way, transportation, utility
Water	None

Source: Field instructions for the urban inventory of San Diego, California and Portland, Oregon: 2018 (USDA Forest Service 2018).

Table 5.—Sample area and plot counts within Forest Inventory and Analysis (FIA) land use classes in Portland, Oregon, 2018

FIA land use	Area (acres)	Standard error (acres)	City land (percent)	Plots (number)
Forest land	11,355	1,433	12.2	19.4
Agriculture	793	623	0.9	1.4
Commercial/Industrial	19,286	2,364	20.8	44.0
Multi-family residential	3,823	1,320	4.1	7.5
Residential	26,278	2,307	28.3	48.9
Recreation/Cemetery	5,724	1,508	6.2	13.2
Rights-of-way	18,503	2,082	19.9	39.4
Water	7,095	830	7.6	15.2
Total	92,858	1,199	100	189

Due to rounding, not all values will add up exactly.

Tree, Shrub, and Ground Cover

On every plot visited, an overall tree canopy cover and shrub cover is estimated for each measured condition. The percent tree cover estimate includes the cover from all trees (species included in Appendix 2) at least 1.0 inch in **diameter**. The percent shrub cover includes cover from the remaining woody vegetation, which is over one foot tall. These two estimates are taken independently and may overlap, for example where shrubs are growing underneath trees. Many cities also have tree canopy estimates derived from photo interpretation or light detection and ranging (LiDAR) technology which can provide high-resolution maps of vegetative cover and an overall, citywide estimate of canopy cover. Although results from these aerial-based methods often differ from the Urban FIA ground-based estimates, the data gathered through Urban FIA estimates can provide additional, valuable information. The independently recorded tree and shrub cover estimates can indicate layered vegetation, which may not be captured through other, aerial-based methods. Urban FIA cover data can also be evaluated to better understand the amount and type of cover across individual FIA land uses.

Based on the Urban FIA evaluation, tree cover in Portland is estimated at 26.1 percent and shrub cover at 11.7 percent. The tree and shrub cover recorded on plots varied significantly across the city (Fig. 3). Since overhanging tree canopy is included in the tree cover estimate, it is common to have tree cover reported even where there are no trees located within the plot area. Average tree cover is highest on forest (76.8 percent tree cover), residential (33.1 percent), and multi-family residential (20.6 percent) (Table 6) land uses. Shrub cover is highest on forest (40.2 percent shrub cover), residential (15 percent), and recreation/cemetery (10.6 percent) land uses. Impervious cover is highest on rights-of-way (71.5 percent impervious cover), commercial/industrial (37.9 percent), and multi-family residential (33.1 percent) (Table 6) land uses.

Field crews categorized ground surface cover on each field plot according to five classes: (i) building, (ii) low vegetation, (iii) permeable (soil, leaf litter, mulch, gravel, etc.), (iv) impervious (non-building), or (v) water. Permeable and herbaceous ground covers account for 52.9 percent of all ground covers in Portland, while building and other impervious cover account for 39.5 percent. An additional 7.7 percent of the city is classified as water (Figs. 4 and 5).

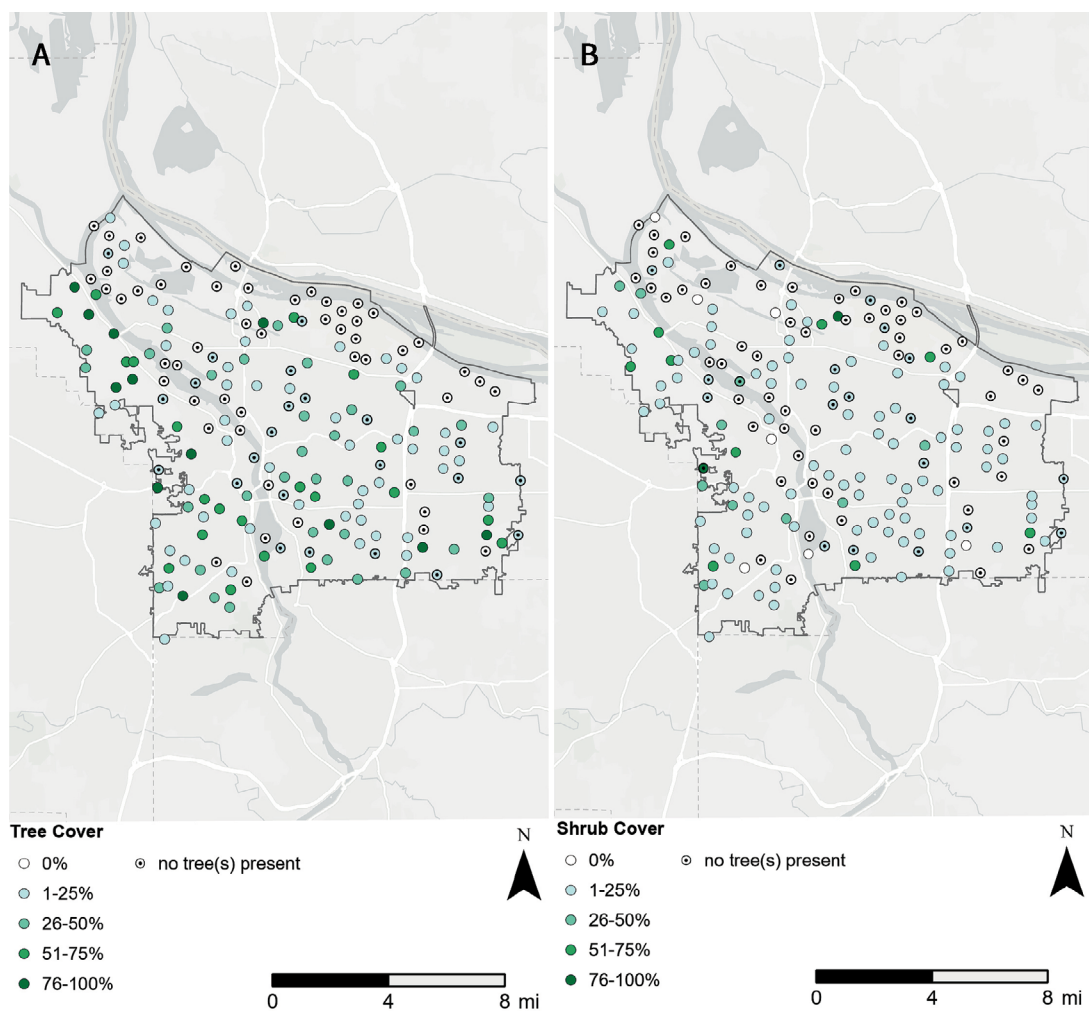


Figure 3.—Tree (A) and shrub (B) cover estimates by plot, Portland, Oregon, 2018. Plot locations are approximate.

Table 6.—Average percent tree, shrub, and impervious cover by Forest Inventory and Analysis (FIA) land use class, Portland, Oregon, 2018

FIA land use	Tree cover (percent)	Shrub cover (percent)	Impervious cover (percent)
Forest land	76.8	40.2	0.0
Agriculture	0.0	0.2	0.0
Commercial/Industrial	10.6	4.6	37.9
Multi-family residential	20.6	4.2	33.1
Residential	33.1	15.0	12.0
Recreation/Cemetery	13.6	10.6	6.1
Rights-of-way	16.7	3.7	71.5
Water	2.2	0.4	0.0
Total average	26.1	11.7	27.3
Total standard error	1.6	1.2	1.9

Due to rounding, not all values will add up exactly.

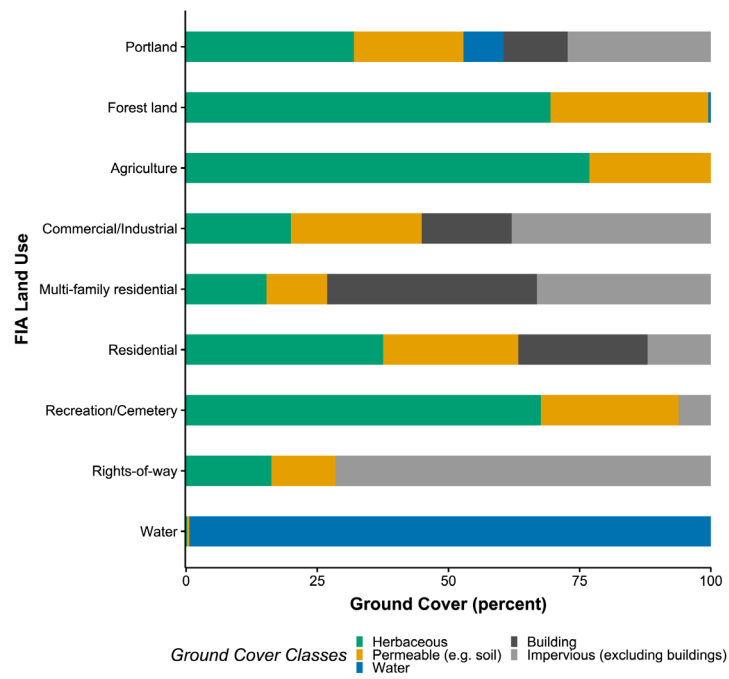


Figure 4.—Ground cover distribution by Forest Inventory and Analysis (FIA) land use class, Portland, Oregon, 2018.

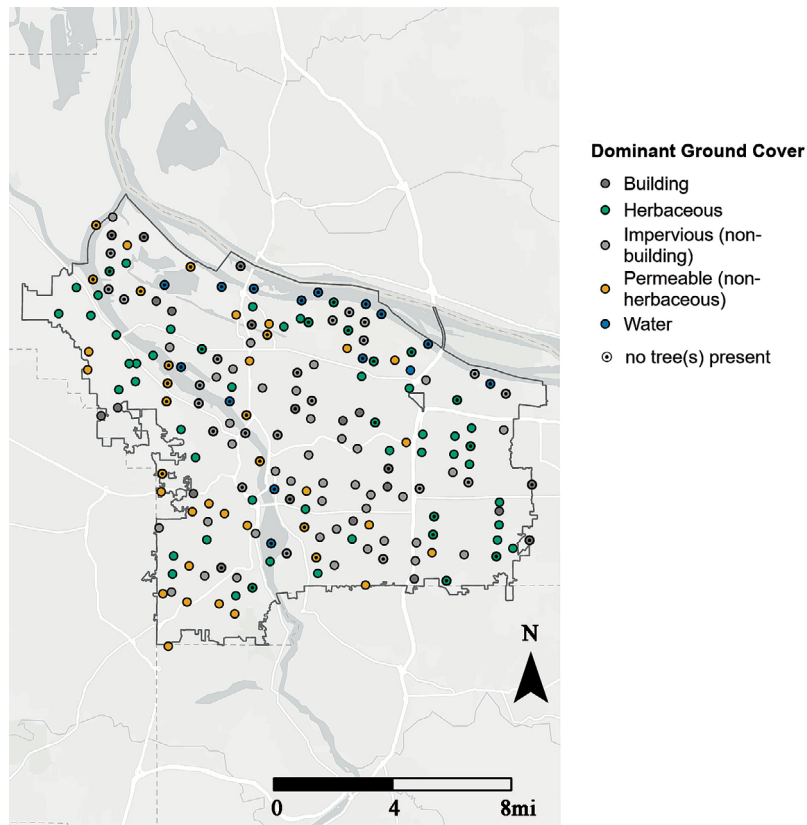


Figure 5.—Dominant ground cover by plot, Portland, Oregon, 2018. Basemap: Esri (2017). Plot locations are approximate.

Ownership

Plot ownership was divided into private, State and local government, Federal government, and unknown (water) classes. The most dominant ownership in Portland is private (54.2 percent), followed by State and local (37.5 percent), unknown (water) (7.6 percent), and Federal (0.7 percent) (Table 7). Percent tree cover is greatest in State and local (32.2 percent), followed by private (25.6 percent), and Federal (3 percent). In Portland, there are a total of 5 million trees (62.1 percent of the live tree population) on private lands, and 3 million trees (37.9 percent) on State and local land (Table 7). Portland's sapling population is mostly found on private lands (68.2 percent), followed by State and local lands (31.8 percent) (Table 7).

Table 7.—Distribution of percent of live trees within diameter classes by ownership, Portland, Oregon, 2018

Ownership class	1–4.9 inch diameter class (percent)	5–10.9 inch diameter class (percent)	11.0+ inch diameter class (percent)	Total (percent)	Area (percent)
Private	68.2	60.0	42.0	62.1	54.2
State and Local	31.8	40.0	58.0	37.9	37.5
Federal	0.0	0.0	0.0	0.0	0.7
Unknown (water)	0.0	0.0	0.0	0.0	7.6
Total	100.0	100.0	100.0	100.0	100.0

Due to rounding, not all values will add up exactly.

FOREST STRUCTURE



Urban FIA crew member, Laura VanFleet, helps to collect measurements of urban forest structure, including the number and sizes of trees in a forest stand and its species composition. Other metrics such as leaf area are calculated from the data collected in the field. Courtesy photo by Nik Desai, Portland Parks & Recreation.

Number of Trees

Portland's urban forest has an estimated 7.68 million live trees and 289,000 standing dead trees. The number of trees varies by land use and diameter class. Most of the live trees in Portland are located on single family residential land (41.9 percent, 3.2 million trees) (Table 8). Overall, 64.3 percent of Portland's trees are saplings (1.0–4.9 inches in diameter), while the remaining 18.1 percent and 17.6 percent are medium trees (5.0–10.9 inches in diameter) and large trees (11.0+ inches in diameter), respectively. The greatest proportion of trees (42.7 percent) are found within the developed-low land cover class. The highest tree density (164 trees per acre) is found in the forest/shrub cover class (Table 9).

Table 8.—Distribution of live trees by Forest Inventory and Analysis (FIA) land use class and diameter class, Portland, Oregon, 2018

FIA land use	1–4.9 inch diameter class (number)	5–10.9 inch diameter class (number)	11.0+ inch diameter class (number)	Total (number)	Standard error (number)	Density (number/acre)
Forest land	943,000	542,000	790,000	2,270,000	384,000	200
Commercial/Industrial	464,000	104,000	86,000	655,000	567,000	34
Multi-family residential	318,000	138,000	22,000	478,000	291,000	125
Residential	2,340,000	521,000	357,000	3,210,000	794,000	122
Recreation/Cemetery	410,000	39,000	17,000	466,000	320,000	81
Rights-of-way	462,000	47,000	80,000	588,000	239,000	32
Agriculture	0	0	0	0	0	0
Water	0	0	0	0	0	0
Total	4,930,000	1,390,000	1,350,000	7,680,000	–	83
Total standard error	1,010,000	182,000	123,000	1,120,000	–	–

Due to rounding, not all values will add up exactly.

– = no value for cell

Table 9.—Distribution of live trees by National Land Cover Database (NLCD) land cover class and diameter class, Portland, Oregon, 2018

NLCD land cover	1–4.9 inch diameter class (number)	5–10.9 inch diameter class (number)	11.0+ inch diameter class (number)	Total (number)	Standard error (number)	Density (number/acre)
Water	0	0	0	0	0	0
Developed-open /herbaceous	822,000	179,000	107,000	1,110,000	614,000	141
Developed-low	2,550,000	439,000	285,000	3,270,000	829,000	143
Developed-medium	787,000	215,000	204,000	1,210,000	330,000	42
Developed-high	0	40,000	33,000	74,000	24,000	5
Forest/Shrub	774,000	517,000	723,000	2,010,000	284,000	164
Total	4,930,000	1,390,000	1,350,000	7,680,000	–	83
Total standard error	1,010,000	182,000	123,000	1,120,000	–	–

Due to rounding, not all values will add up exactly.

– = no value for cell

Species Composition

The 10 most common tree species by number account for 70.2 percent of all recorded live trees and are northern white-cedar, bigleaf maple, camellia, cherry laurel, Douglas-fir, vine maple, black cottonwood, western redcedar, oneseed hawthorn, and Japanese maple (Table 10; Fig. 6). A breakdown of the estimated number of each recorded tree species by diameter classes is presented in Appendix 2. The relative abundance of the most common trees by species and diameter class are presented in Table 11 and Figures 7 and 8. Small diameter trees (saplings) are generally the most abundant of the three tree size classes for the 10 most common tree species, comprising 69.6 percent of the total number of trees, while large diameter trees comprise only 15.8 percent of the total number of trees (Table 11; Fig. 7). When broken down into 2-inch diameter classes, the top five most common species by number showed an abundance distribution similarly skewed toward smaller diameter trees, and this pattern was driven by northern white-cedar, camellia, and cherry laurel (Fig. 8).

Table 10.—Urban forest species composition in Portland, Oregon, 2018

Common name	Trees (number)	Percent	Common name	Trees (number)	Percent
northern white-cedar	1,120,000	14.6	bitter cherry	70,000	0.9
bigleaf maple	1,060,000	13.9	paradise apple	61,000	0.8
camellia	523,000	6.8	blue spruce	56,000	0.7
cherry laurel	484,000	6.3	giant sequoia	50,000	0.7
Douglas-fir	454,000	5.9	English walnut	47,000	0.6
vine maple	449,000	5.9	grand fir	44,000	0.6
black cottonwood	403,000	5.3	common pear	43,000	0.6
western redcedar	321,000	4.2	Japanese zelkova	42,000	0.6
oneseed hawthorn	293,000	3.8	California laurel	39,000	0.5
Japanese maple	277,000	3.6	crapemyrtle	39,000	0.5
pussy willow	219,000	2.8	Leyland cypress	32,000	0.4
arroyo willow	209,000	2.7	western hemlock	31,000	0.4
red alder	123,000	1.6	cherry plum	26,000	0.3
Scouler's willow	105,000	1.4	Japanese flowering cherry	25,000	0.3
English holly	103,000	1.3	Port-Orford-cedar	24,000	0.3
quince	100,000	1.3	Callery pear	20,000	0.3
edible fig	100,000	1.3	European white birch	20,000	0.3
Norway maple	86,000	1.1	European hornbeam	18,000	0.2
golden chain tree	85,000	1.1	sycamore maple	17,000	0.2
sweet cherry	77,000	1.0	European ash	17,000	0.2
Oregon ash	72,000	0.9	Sitka spruce	16,000	0.2

continued on next page

Table 10 (continued).

Common name	Trees (number)	Percent
European mountain-ash	16,000	0.2
lodgepole pine	13,000	0.2
katsura tree	12,000	0.2
flowering dogwood	11,000	0.1
incense-cedar	11,000	0.1
Deodar cedar	11,000	0.1
sawtooth oak	10,000	0.1
sweetgum	8,700	0.1
Pacific dogwood	8,600	0.1
eastern redcedar	8,000	0.1
red maple	7,200	0.1
northern red oak	7,200	0.1
London planetree	7,100	0.1
quaking aspen	6,300	0.1
Amur maple	6,300	0.1
hinoki false cypress	6,300	0.1
littleleaf linden	6,300	0.1
black locust	5,500	0.1
Japanese cedar	4,800	0.1
Rocky Mountain juniper	4,600	0.1
pin oak	4,600	0.1
Norway spruce	4,000	0.1
silver maple	4,000	0.1
sugar maple	4,000	0.1

Common name	Trees (number)	Percent
water birch	4,000	0.1
American chestnut	4,000	0.1
black walnut	4,000	0.1
Japanese tree lilac	4,000	0.1
Japanese red pine	4,000	0.1
Pacific yew	3,900	0.1
Oregon white oak	3,900	0.1
Jeffrey pine	3,100	<0.1
ponderosa pine	3,100	<0.1
Austrian pine	3,100	<0.1
green ash	3,100	<0.1
yellow-poplar	3,100	<0.1
Oregon crab apple	3,100	<0.1
European plum	3,100	<0.1
swamp white oak	3,100	<0.1
black oak	3,100	<0.1
smoketree	3,100	<0.1
paperbark maple	3,100	<0.1
Freeman maple	3,100	<0.1
kousa dogwood	3,100	<0.1
European larch	3,100	<0.1
goldenrain tree	3,100	<0.1
Japanese black pine	3,100	<0.1
white ash	2,400	<0.1
southern magnolia	2,400	<0.1
Total	7,680,000	100.0

Due to rounding, not all values will add up exactly.

For a breakdown of species composition by diameter classes, refer to Appendix 2.

Table 11.—Live trees by diameter class for the 10 most common tree species by number in Portland, Oregon, 2018

Common name	1–4.9 inch diameter class (number)	5–10.9 inch diameter class (number)	11.0+ inch diameter class (number)	Total (number)
northern white-cedar	965,000	153,000	0	1,120,000
bigleaf maple	387,000	319,000	358,000	1,060,000
camellia	500,000	23,000	0	523,000
cherry laurel	428,000	52,000	3,100	484,000
Douglas-fir	50,000	44,000	360,000	454,000
vine maple	443,000	6,300	0	449,000
black cottonwood	357,000	19,000	28,000	403,000
western redcedar	174,000	45,000	102,000	321,000
oneseed hawthorn	277,000	16,000	0	293,000
Japanese maple	168,000	106,000	3,100	277,000
Total (number)	3,750,000	785,000	854,000	5,390,000

Due to rounding, not all values will add up exactly.

Standard errors for each estimate are reported in Appendix 2.

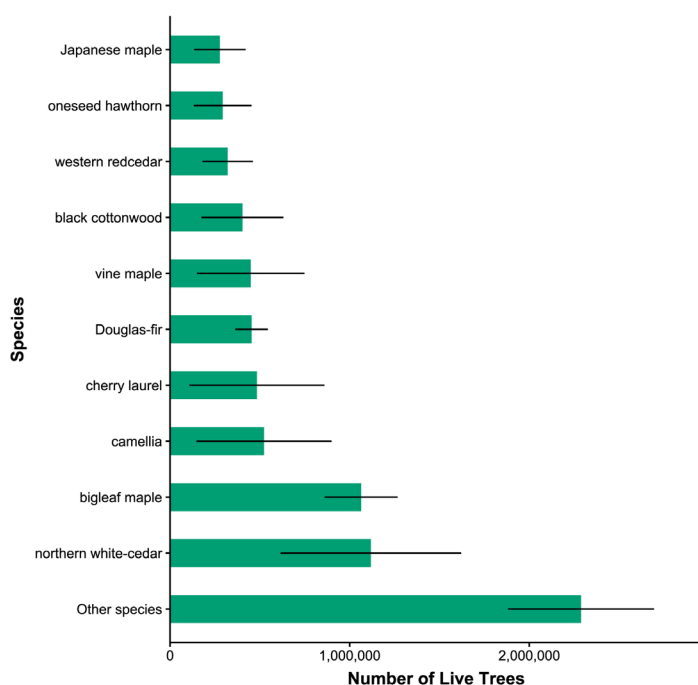


Figure 6.—The 10 most common tree species by number of trees, Portland, Oregon, 2018. Other species is the total number of all other tree species in the inventory. Error bars represent 68 percent confidence intervals around the estimated means.

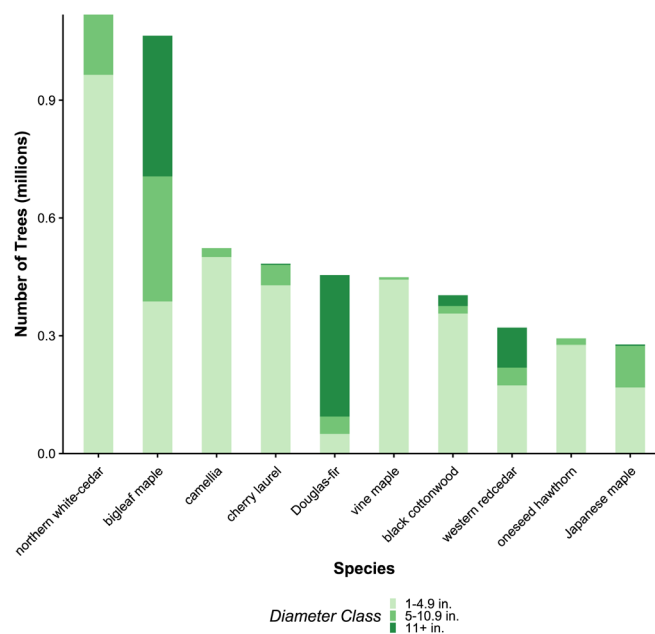


Figure 7.—Trees by diameter class for the 10 most common tree species by number of trees, Portland, Oregon, 2018.

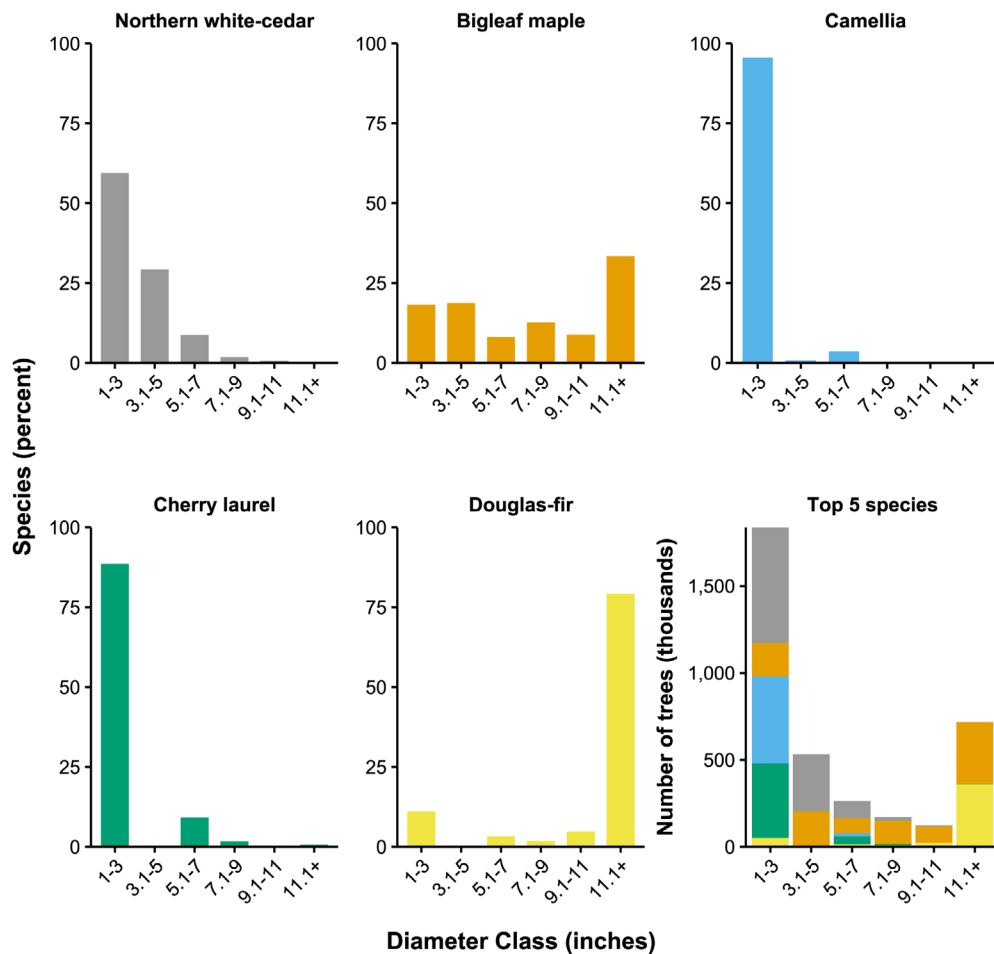


Figure 8.—Percentage of species population by diameter class for the five most common tree species by number of trees, Portland, Oregon, 2018.

The preceding table and figures highlight the most prominent species by number for all trees 1.0 inch in diameter and larger. As smaller diameter trees are generally more abundant per unit area, the overall species composition may be more reflective of the smaller diameter species when analyzing estimates based on number of trees. For this reason, it is also helpful to rank species according to other metrics such as the number of trees within various size classes, leaf area, importance value, volume, or biomass. The three most common species in terms of stem numbers in the smallest-diameter size classes (less than 5.0 inches in diameter) are northern white-cedar, camellia, and vine maple, together representing less than half (38.7 percent) of all live trees less than 5.0 inches in diameter (Table 12; Appendix 2). Bigleaf maple, northern white-cedar, and Japanese maple are the most common species in intermediate diameter size classes, representing 41.6 percent of all live trees between 5.0 and 10.9 inches in diameter. Dominant species in the largest diameter classes, often the most recognizable component of the urban forest canopy, are Douglas-fir, bigleaf maple, and western redcedar, comprising 60.6 percent of live trees at least 11.0 inches in diameter (Table 12; Appendix 2).

Table 12.—The five most common tree species by number of trees within each diameter class, Portland, Oregon, 2018

Diameter class (inches)	Common name	Trees (number)
1.0–4.9	northern white-cedar	965,000
	camellia	500,000
	vine maple	443,000
	cherry laurel	428,000
	bigleaf maple	387,000
5.0–10.9	bigleaf maple	319,000
	northern white-cedar	153,000
	Japanese maple	106,000
	pussy willow	55,000
	cherry laurel	52,000
11.0+	Douglas-fir	360,000
	bigleaf maple	358,000
	western redcedar	102,000
	red alder	72,000
	Oregon ash	57,000

Due to rounding, not all values will add up exactly.

In Portland, tree species composition on private land is dominated by northern white-cedar (16.9 percent), camellia (11 percent), and cherry laurel (9.6 percent) (Table 13). The most common tree species on public lands are bigleaf maple (28.4 percent), northern white-cedar (10.8 percent), and western redcedar (9.4 percent) (Table 14). A total of 71 tree species are recorded on private lands, which has a **Shannon-Wiener diversity index** value of 3.1. Crews recorded 48 species of trees on public lands, which has a Shannon-Wiener diversity index value of 2.7. On private land, the top three genera with the greatest number of trees are maple (*Acer*), cedar (*Thuja*), and plum/cherry (*Prunus*). On public land, they are maple (*Acer*), cedar (*Thuja*), and willow (*Salix*) (Fig. 9). Tree species composition within NLCD land cover classes is detailed in Figures 27 to 31 and Table 34 of Appendix 3. Table 35 (Appendix 3) details tree species composition within FIA land use classes.

Table 13.—Species composition on private lands, Portland, Oregon, 2018

Common name	Trees (percent)	Common name	Trees (percent)	Common name	Trees (percent)
northern white-cedar	16.9	Port-Orford-cedar	0.5	Rocky Mountain juniper	0.1
camellia	11.0	cherry plum	0.4	Pacific dogwood	0.1
cherry laurel	9.6	European hornbeam	0.4	pin oak	0.1
vine maple	7.4	sycamore maple	0.3	Norway spruce	0.1
black cottonwood	6.9	European ash	0.3	red maple	0.1
Japanese maple	5.8	grand fir	0.3	silver maple	0.1
oneseed hawthorn	5.4	Scouler's willow	0.2	water birch	0.1
bigleaf maple	5.0	katsura tree	0.2	Oregon ash	0.1
pussy willow	4.5	flowering dogwood	0.2	black walnut	0.1
Douglas-fir	4.0	incense-cedar	0.2	Japanese tree lilac	0.1
quince	2.1	lodgepole pine	0.2	Japanese red pine	0.1
edible fig	2.1	Callery pear	0.2	Jeffrey pine	0.1
golden chain tree	1.8	sweetgum	0.2	ponderosa pine	0.1
sweet cherry	1.5	eastern redcedar	0.2	Austrian pine	0.1
Norway maple	1.3	English walnut	0.2	yellow-poplar	0.1
blue spruce	1.2	northern red oak	0.2	European plum	0.1
giant sequoia	1.0	Deodar cedar	0.2	swamp white oak	0.1
western redcedar	1.0	London planetree	0.1	smoketree	0.1
common pear	0.9	sawtooth oak	0.1	paperbark maple	0.1
California laurel	0.8	paradise apple	0.1	Freeman maple	0.1
Japanese zelkova	0.8	quaking aspen	0.1	European white birch	0.1
crapemyrtle	0.8	hinoki false cypress	0.1	Japanese black pine	0.1
Leyland cypress	0.7	English holly	0.1	southern magnolia	<0.1
Japanese flowering cherry	0.5	red alder	0.1		

Due to rounding, not all values will add up exactly.

Table 14.—Species composition on public lands, Portland, Oregon, 2018

Common name	Trees (percent)	Common name	Trees (percent)	Common name	Trees (percent)
bigleaf maple	28.4	western hemlock	1.1	European ash	0.1
northern white-cedar	10.8	cherry laurel	1.0	Pacific yew	0.1
western redcedar	9.4	Norway maple	0.8	Oregon white oak	0.1
Douglas-fir	9.0	European white birch	0.6	Deodar cedar	0.1
arroyo willow	7.2	Sitka spruce	0.5	lodgepole pine	0.1
red alder	4.0	European mountain-ash	0.5	red maple	0.1
vine maple	3.4	Callery pear	0.4	green ash	0.1
English holly	3.3	cherry plum	0.2	Oregon crab apple	0.1
Scouler's willow	3.2	Amur maple	0.2	black oak	0.1
black cottonwood	2.6	littleleaf linden	0.2	kousa dogwood	0.1
bitter cherry	2.4	black locust	0.2	European larch	0.1
Oregon ash	2.4	Japanese cedar	0.2	Japanese zelkova	0.1
paradise apple	1.9	sweet cherry	0.2	goldenrain tree	0.1
English walnut	1.4	sugar maple	0.1	sawtooth oak	0.1
oneseed hawthorn	1.3	American chestnut	0.1	white ash	0.1
grand fir	1.1	Pacific dogwood	0.1	pussy willow	0.1

Due to rounding, not all values will add up exactly.

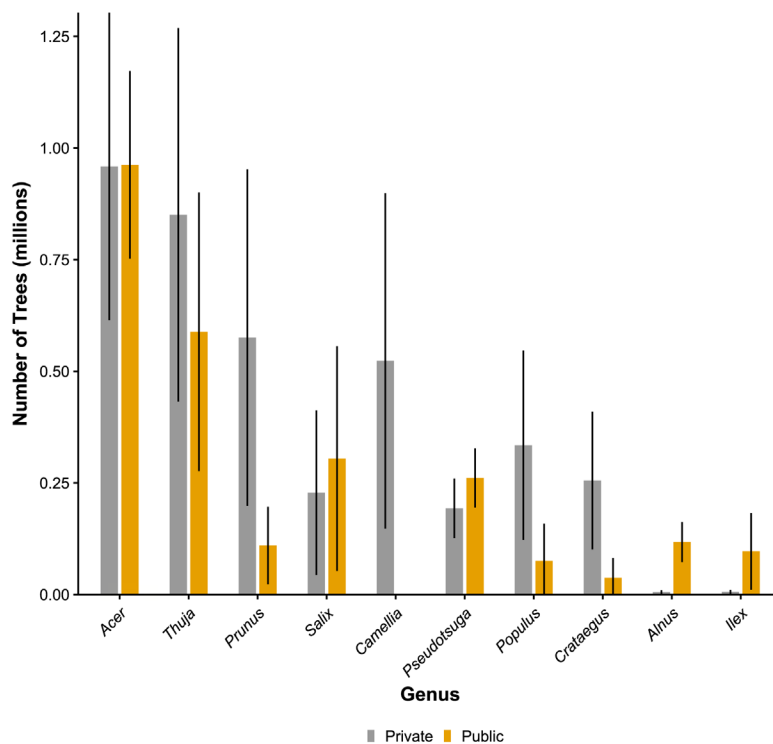


Figure 9.—The 10 most common genera by number of trees within ownership classes, Portland, Oregon, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

Table 15.—The 10 most common tree species in maintained areas by number of trees, Portland, Oregon, 2018

Common name	Trees (number)	Percent of all trees in maintained areas
northern white-cedar	754,000	25.4
camellia	523,000	17.6
Japanese maple	277,000	9.3
vine maple	174,000	5.9
Douglas-fir	116,000	3.9
cherry laurel	104,000	3.5
edible fig	100,000	3.4
blue spruce	56,000	1.9
paradise apple	55,000	1.9
giant sequoia	50,000	1.7

Due to rounding, not all values will add up exactly.

Trees in Maintained Areas

Overall, 38.7 percent of trees in Portland are found in maintained areas. Maintained areas are those which are regularly impacted by mowing, weeding, cutting, brush clearing, herbicide applications, etc. Examples of maintained areas include, but are not limited to, lawns, shrub beds, rights-of-way, and manicured parks. However, a tree found in a maintained area has not necessarily received care. In Portland, the most common tree species in maintained areas are northern white-cedar (25.4 percent of all trees in maintained areas), camellia (17.6 percent), and Japanese maple (9.3 percent) (Table 15). The most common Oregon native tree species in maintained areas was Douglas-fir (3.9 percent) (Table 15; Appendix 4).

Leaf Area

Leaf area is correlated with many ecosystem services provided by the urban forest. It is estimated as the surface area (on one side) of the leaves on a given tree or in an area. The proportion of total leaf area is greatest for trees 29.1+ inches in diameter (27.8 percent), followed by 13.1–15.0 inches in diameter (7.9 percent), and 17.1–19.0 inches in diameter (7.6 percent) (Fig. 10). In Portland, leaf area is greatest in forest land uses (56.7 percent of total leaf area), followed by residential (28.7 percent), and commercial/industrial land uses (5.8 percent) (Fig. 11).

Leaf Area Index (LAI) refers to a standardized measure of leaf surface area per unit of tree cover and is calculated as the total leaf area divided by the total ground area covered by tree canopies. Higher LAI values indicate a greater depth or layering of leaves in the tree canopy. As each land use class has a different amount of area covered by trees, LAI allows for a standardized comparison of leaves per unit canopy area among land use classes (acres of leaves per acre of tree cover). The leaf area index in land uses with trees ranges from 22.5 in forest land use to 5.1 in rights-of-way (Fig. 11).

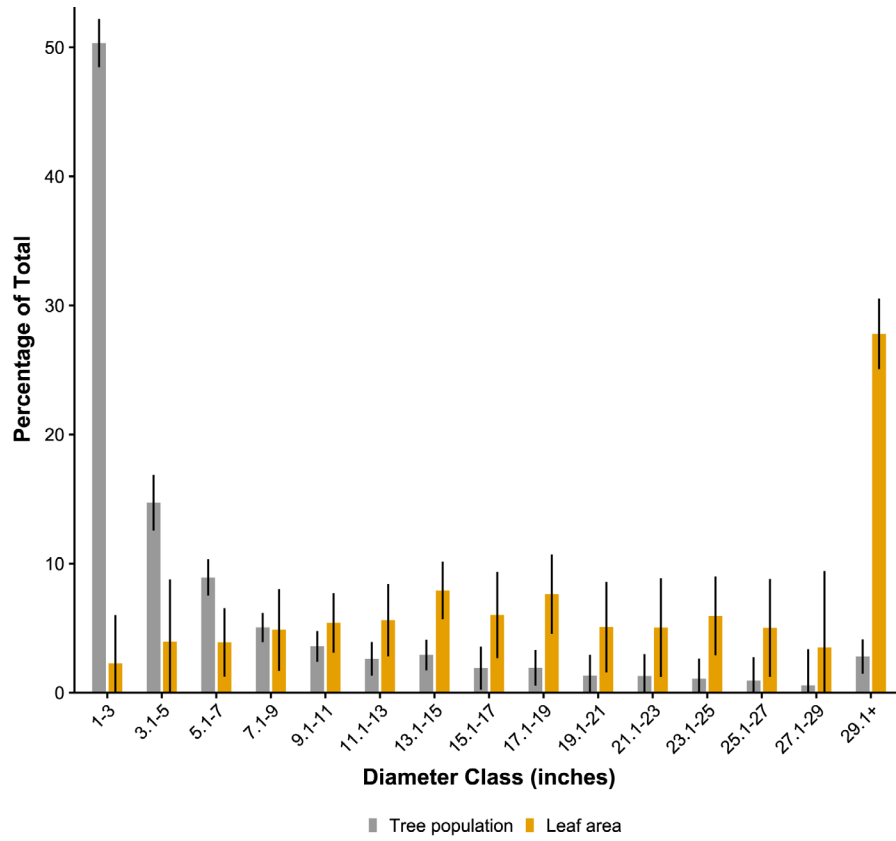


Figure 10.—Percentage of tree population and leaf area by 2-inch diameter class, Portland, Oregon. Error bars represent 68 percent confidence intervals around the estimated means.

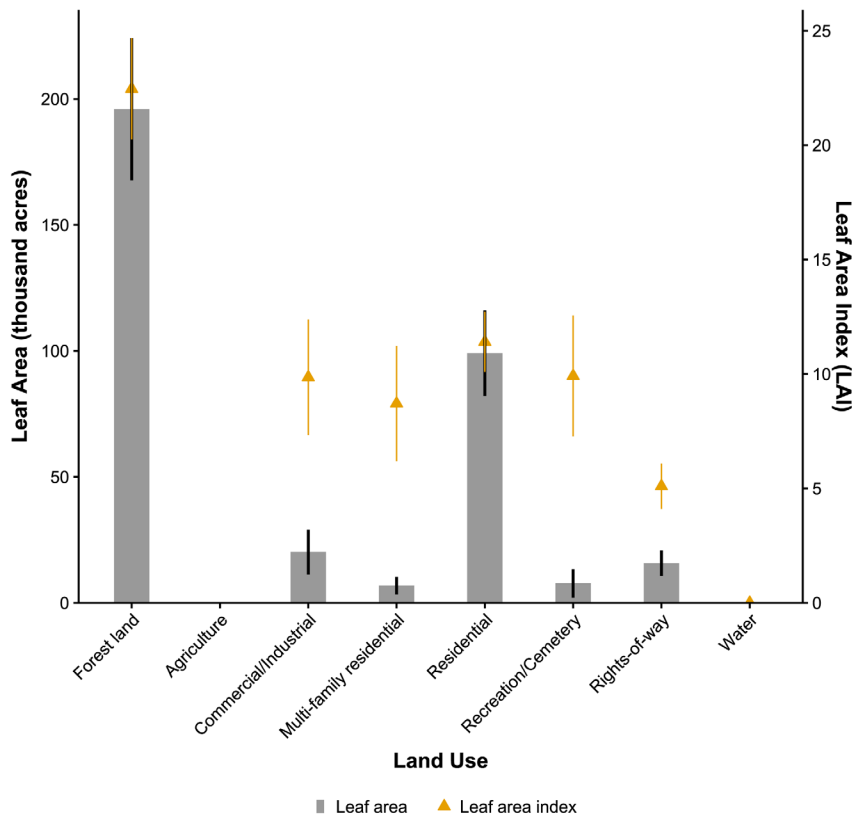


Figure 11.—Leaf area and leaf area index (LAI) by Forest Inventory and Analysis (FIA) land use, Portland, Oregon. Error bars represent 68 percent confidence intervals around the estimated means.

Species Importance

Importance values (IVs) establish the relative contribution of the observed species to the overall species composition of the urban forest and are calculated by summing the values of its relative leaf area and relative abundance. High importance values do not mean that these trees should be encouraged in the future, but rather that they currently dominate the urban forest structure in terms of their population size and leaf area. The species in Portland's urban forest with the greatest IVs are bigleaf maple (38.6), Douglas-fir (37.8), and northern white-cedar (14.9) (Table 16).

Table 16.—The 10 most common species by Importance Value (IV), Portland, Oregon, 2018

Common name	Population (percent)	Leaf area (percent)	IV
bigleaf maple	13.9	24.7	38.6
Douglas-fir	5.9	31.9	37.8
northern white-cedar	14.6	0.3	14.9
western redcedar	4.2	6.3	10.5
black cottonwood	5.3	1.9	7.1
camellia	6.8	0.2	7.0
vine maple	5.9	0.9	6.8
cherry laurel	6.3	0.4	6.7
oneseed hawthorn	3.8	1.1	5.0
red alder	1.6	3.2	4.8

Due to rounding, not all numbers will add up exactly.

IV = Population (%) + Leaf Area (%).

VOLUME AND BIOMASS



Urban Forest Inventory and Analysis crew members, Jessica Deans (left) and Brittany Benjamin (right), measuring the diameter of a large Norway maple tree in Portland, Oregon. A wide variety of native and ornamental trees on both privately and publicly owned lands contribute to the volume and biomass of Portland's urban forest. USDA Forest Service photo by Suzanne Owen.

Wood Volume and Value

Wood volume is a measure of the solid content of the tree stem and is used to estimate wood quantity. A detailed description of methods used to compute wood volume in terms of net cubic foot volume and sawtimber volume for this report is presented in Baer et al. (2024). Understanding the net volume of wood provided by a community's trees can serve a variety of purposes. From a management perspective, a thorough knowledge of wood volume can help predict potential storm damage and support planning for post-disaster recovery, including debris removal and cost. Volume data can also inform urban wood markets, which add value to traditional wood waste derived from tree removal, storm damage, and general tree maintenance. Such data can incentivize repurposing wood waste into traditional wood products such as lumber, handcrafted furniture, nature-based landscape supplies, and biofuel (e.g., Nowak et al. 2019).

In Portland, live trees at least 5.0 inches in diameter are estimated to contain 132.6 million cubic feet of net volume and 618.8 million board feet of net sawtimber volume. To put this value in perspective, the median size of American homes constructed in 2019 was 2,301 square feet (US Census Bureau 2020), which would require roughly 14,500 board feet to construct, assuming 6,300 board feet are required to construct 1,000 square feet of living space. Thus, the net sawtimber volume of Portland's urban forest is roughly equivalent to the amount of wood that would be needed to construct 42,678 median-sized homes. Douglas-fir contributes the greatest net cubic-foot volume at 43.2 percent of the city's total (Table 17). Douglas-fir contributes 55.9 percent of the total net board-foot sawtimber volume (Table 18). By diameter class, the greatest net cubic volume is provided by trees 29.1 inches or greater in diameter (Fig. 12).

Table 17.—Net cubic-foot volume for tree species with greatest net volume, Portland, Oregon, 2018

Common name	Net volume (cubic feet)	Standard error (cubic feet)	Net volume (percent)
Douglas-fir	57,270,000	12,720,000	43.2
bigleaf maple	26,500,000	5,220,000	20.0
western redcedar	11,780,000	6,730,000	8.9
Oregon ash	4,280,000	3,760,000	3.2
Norway maple	3,830,000	1,540,000	2.9
red alder	3,110,000	1,550,000	2.3
black cottonwood	3,080,000	2,690,000	2.3
grand fir	2,470,000	1,360,000	1.9
sugar maple	1,810,000	1,670,000	1.4
black walnut	1,590,000	1,470,000	1.2
Other species	16,900,000	2,550,000	12.7
Total	132,630,000	15,950,000	100.0

Due to rounding, not all values will add up exactly.

Other species is the total for all other tree species in the inventory.

Table 18.—Net board-foot sawtimber volume for tree species with greatest net volume, Portland, Oregon, 2018

Common name	Net volume (cubic feet)	Standard error (cubic feet)	Net volume (percent)
Douglas-fir	346,220,000	74,380,000	55.9
bigleaf maple	93,120,000	23,950,000	15.0
western redcedar	72,720,000	43,170,000	11.8
grand fir	15,210,000	8,670,000	2.5
black cottonwood	14,190,000	13,090,000	2.3
red alder	13,540,000	9,110,000	2.2
Oregon ash	10,140,000	8,910,000	1.6
black walnut	7,860,000	7,250,000	1.3
western hemlock	7,110,000	3,090,000	1.1
Norway maple	5,950,000	3,370,000	1.0
Other species	32,780,000	8,630,000	5.3
Total	618,830,000	93,670,000	100.0

Due to rounding, not all values will add up exactly.

Other species is the total for all other tree species in the inventory.

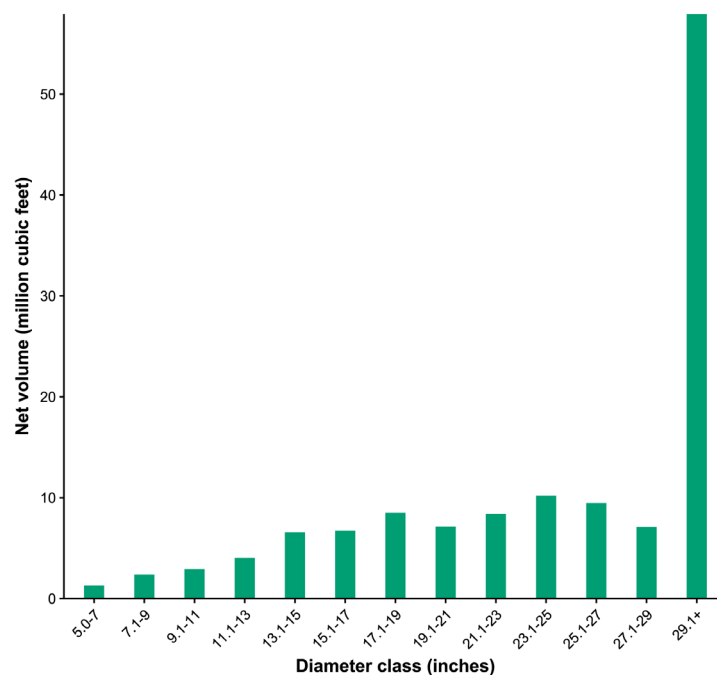


Figure 12.—Net cubic volume by tree diameter class, Portland, Oregon, 2018.

While sawtimber could potentially be derived from urban forests to provide economic value, the broader social-ecological value of this forest is derived from healthy trees. Healthy urban forests provide benefits that support environmental and human health and well-being and are valued at over \$18 billion per year nationally (Nowak and Greenfield 2018). Harvesting healthy urban trees will reduce these local annual benefits. Utilizing urban wood waste, however, does not affect the healthy tree canopy and augments the value of the urban forest. Urban wood waste could produce between \$89–786 million per year nationally depending upon the product derived (e.g., wood chips to lumber; Nowak et al. 2019).

Increasing public interest in environmentally responsible and sustainable products presents opportunities for urban wood utilization programs. In urban settings, trees generally only become a source of wood products after removal for development purposes or because of safety factors including age, pest and disease damage, or storm events. Many of these urban trees are unsuitable for traditional sawtimber products but may still have economic and cultural value.

Methods to evaluate the quality of urban wood for potential products are not well defined since wood markets and products are quite varied across different geographic areas. Further research would allow for the development of metrics to evaluate the amount of urban wood waste available for specialty products. For example, many consumers of urban wood are interested in wood with grain character. Character wood that contains knots, insect damage, and distorted grain is often highly desirable for specialty products, but these are the same wood qualities that make for less desirable traditional lumber. Urban wood waste utilization programs and markets may be better informed by drawing upon available FIA information about net growth, removals, and mortality.

Biomass

Like wood volume, tree biomass information is important in estimating both wood production and carbon storage. The overall aboveground biomass of all live trees in Portland is estimated at 4,120,000 green tons (Table 19). The amount of biomass stored by live trees in Portland varied by species. The tree species with the greatest total aboveground biomass are Douglas-fir (38.9 percent), bigleaf maple (22.1 percent), and western redcedar (5.3 percent) (Table 19).

Table 19.—Aboveground biomass (green tons) for tree species with the greatest biomass, Portland, Oregon 2018

Common name	Biomass (green tons)	Standard error (green tons)	Biomass (percent)
Douglas-fir	1,600,000	356,000	38.9
bigleaf maple	909,000	173,000	22.1
western redcedar	218,000	124,000	5.3
Oregon ash	160,000	140,000	3.9
Norway maple	135,000	54,000	3.3
red alder	107,000	53,000	2.6
black cottonwood	104,000	90,000	2.5
grand fir	77,000	42,000	1.9
sugar maple	69,000	64,000	1.7
black walnut	59,000	55,000	1.4
Other species	680,000	97,000	16.5
Total	4,120,000	446,000	100.0

Due to rounding, not all values will add up exactly.

Other species is the total for all other tree species in the inventory.

URBAN FOREST VALUES



London planetrees in a Portland, Oregon neighborhood. Urban trees provide many benefits to city residents, including shading that reduces cooling costs during the warmer months of the year. Urban trees also provide numerous health and environmental benefits including reduced water runoff and air pollution, as well as increased carbon storage. Courtesy photo by Nik Desai, Portland Parks & Recreation.

Urban forest values can be quantified as functional or structural. Social and biophysical functional values, either positive (e.g., decreased energy use) or negative (e.g., increased energy use) are based on the annual functions the trees perform, including sequestering carbon, removing air pollutants, and influencing surrounding microclimates which affects the amount of energy used to heat or cool buildings. The forest may provide many other functional values that are not quantified in this report (e.g., reduction in ultraviolet radiation, wildlife habitat, enhanced recreational opportunities, fostering social cohesion, or community health and well-being). Thus, the functional estimates provided in this report represent only a portion of the total forest functional values. Structural values include the amount of carbon stored by a tree and the tree's compensatory value, which can be thought of as the replacement value of the tree. Structural and functional values tend to increase as the number and size of healthy trees increases and are usually on the order of several million dollars per year at a city scale.

Forest management activities can increase the values and services provided by the urban forest. However, these values and benefits can also decrease if the amount of healthy tree cover declines. Various costs associated with urban forest management, such as tree pruning, inspection, removal, and disposal are not accounted for in this assessment and may offset some of the estimated monetary benefits described here (McPherson et al. 2005).

Urban forest ecosystem services associated with air pollution removal, avoided runoff, carbon sequestration, and compensatory value exclude dead trees, as these benefits are mainly based on existing leaf area, leaf biomass, or live tree conditions. However, standing dead trees do contribute to carbon storage and energy effects and are included in estimates for these values.

Air Pollution Removal

Poor air quality is a common problem in urban areas. Air pollution can adversely affect human health through increased rates of pulmonary, cardiac, vascular, and neurological diseases and mortality (Pope et al. 2002), along with negatively impacting ecosystem processes and reducing visibility. Urban forests can improve air quality by directly removing pollutants from the air and reducing energy consumption by buildings, which consequently reduces air pollution emissions from power plants and other energy sources. While trees emit volatile organic compounds (VOCs) that can contribute to ozone (O₃) formation (Fehsenfeld et al. 1992, Karlik and Pittenger 2012), integrative studies have revealed that an increase in tree cover tends to reduce O₃ formation, although the extent to which this is the case depends upon species composition (Calfapietra et al. 2013; Manes et al. 2012; Nowak et al. 2000, 2006).

Pollution removal by the urban forest in Portland is greatest for O₃ (355.7 tons per year), followed by nitrogen dioxide (NO₂; 69.9 tons per year), particulate matter less than 2.5 microns (PM_{2.5}; 17.5 tons per year), carbon monoxide (CO; 8.4 tons per year), and sulfur dioxide (SO₂; 3.9 tons per year) (Fig. 13). The economic value of this pollution removed is estimated using i-Tree methodology in one of two ways, depending on the pollutant. The NO₂, SO₂, O₃, and PM_{2.5} estimates are based on avoided health effects due to lower pollution concentrations. The CO estimated value is based on the avoided externality costs of air pollution to society (Nowak 2021). The estimated value associated with pollution removal is greatest for PM_{2.5} (\$7.47 million), followed by O₃ (\$1.7 million), NO₂ (\$33,000), CO (\$11,000), and SO₂ (\$700) (Table 20). It is estimated that trees in Portland remove a total of 455 tons of air pollution per year with an associated value of \$9.2 million. More information on value calculations can be found in Baer et al. (2024).

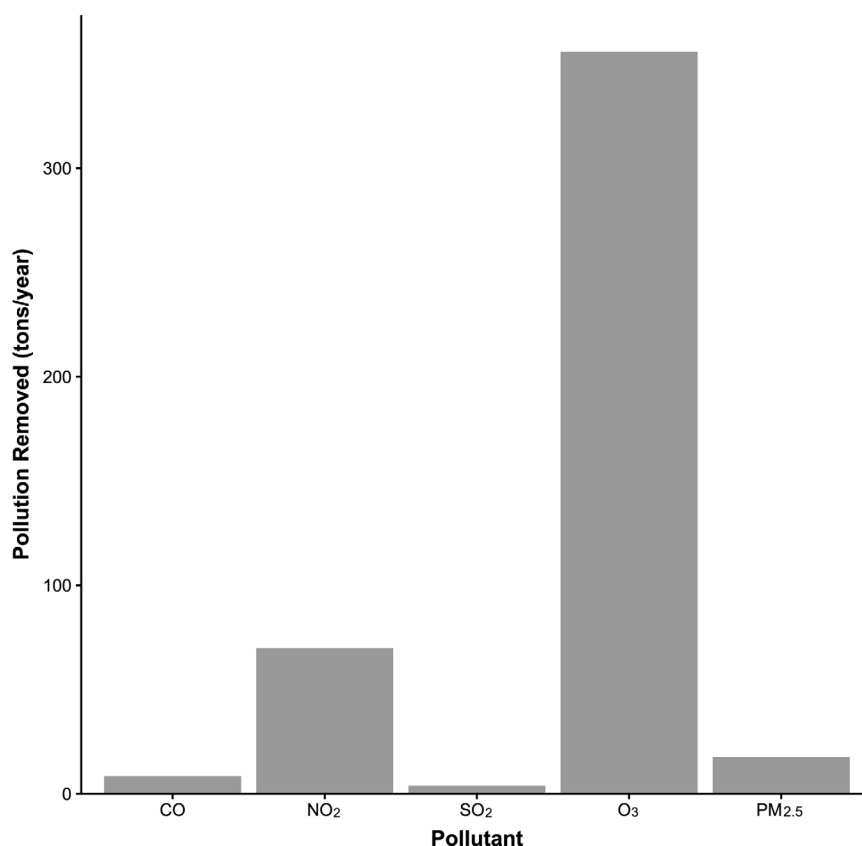


Figure 13.—Air pollution removal in the urban forest, Portland, Oregon 2018.

Decreases in the concentration of various air pollutants due to removal by trees is expected to have a positive effect on human health in Portland (Nowak et al. 2014, U.S. EPA 2012). Using measured field data and pollution data from 2015, air quality improvements from trees produce numerous health benefits including an estimated 803 fewer cases of acute respiratory symptoms per year with an associated value of over \$72,000 (Table 20).

Trees in Portland emitted an estimated 275 tons of VOCs (44 tons of isoprene and 231 tons of monoterpenes) per year. Emissions vary among species based on species characteristics (e.g., some genera such as oaks are high isoprene emitters) and leaf biomass. Douglas-fir and maple species (*Acer* spp.) contribute 68.1 percent of VOC emissions (Fig. 14). These VOCs are precursor chemicals to ozone formation.

Table 20.—Incidence (number of cases per year) and associated value (dollars per year) of avoided health effects from changes in pollution concentrations due to pollution removal by trees in Portland’s urban forest, 2018, using 2016 atmospheric conditions

Health effect	Nitrogen dioxide (NO ₂)		Sulfur dioxide (SO ₂)		Ozone (O ₃)		Particulate matter (PM _{2.5})	
	Cases (number/year)	Value (\$/year)	Cases (number/year)	Value (\$/year)	Cases (number/year)	Value (\$/year)	Cases (number/year)	Value (\$/year)
Acute bronchitis	–	–	–	–	–	–	0.4	36.9
Acute myocardial infarction	–	–	–	–	–	–	0.2	20,000
Acute respiratory symptoms	17.4	550	0.4	12.3	450	38,000	340	33,000
Asthma exacerbation	260	22,000	3.6	280	–	–	200	16,000
Chronic bronchitis	–	–	–	–	–	–	0.3	74,000
Emergency room visits	0.2	96.3	<0.1	6.4	0.2	64	0.3	120
Hospital admissions	0.4	11,000	<0.1	400	0.3	8,400	–	–
Hospital admissions, cardiovascular	–	–	–	–	–	–	0.1	2,100
Hospital admissions, respiratory	–	–	–	–	–	–	<0.1	1,500
Lower respiratory symptoms	–	–	–	–	–	–	5.9	300
Mortality	–	–	–	–	0.2	1,650,000	0.9	7,310,000
School loss days	–	–	–	–	120	12,000	–	–
Upper respiratory symptoms	–	–	–	–	–	–	4	180
Work loss days	–	–	–	–	–	–	55.4	11,000
Total	280	33,000	4	700	570	1,700,000	610	7,470,000

Due to rounding, not all values will add up exactly.

Dash indicates that the value is not estimated for that pollutant and health effect. The same health effects were not analyzed for each pollutant.

Source: Understanding i-Tree: 2021 summary of programs and methods (Nowak 2021).

PM_{2.5} = particulate matter less than 2.5 microns.

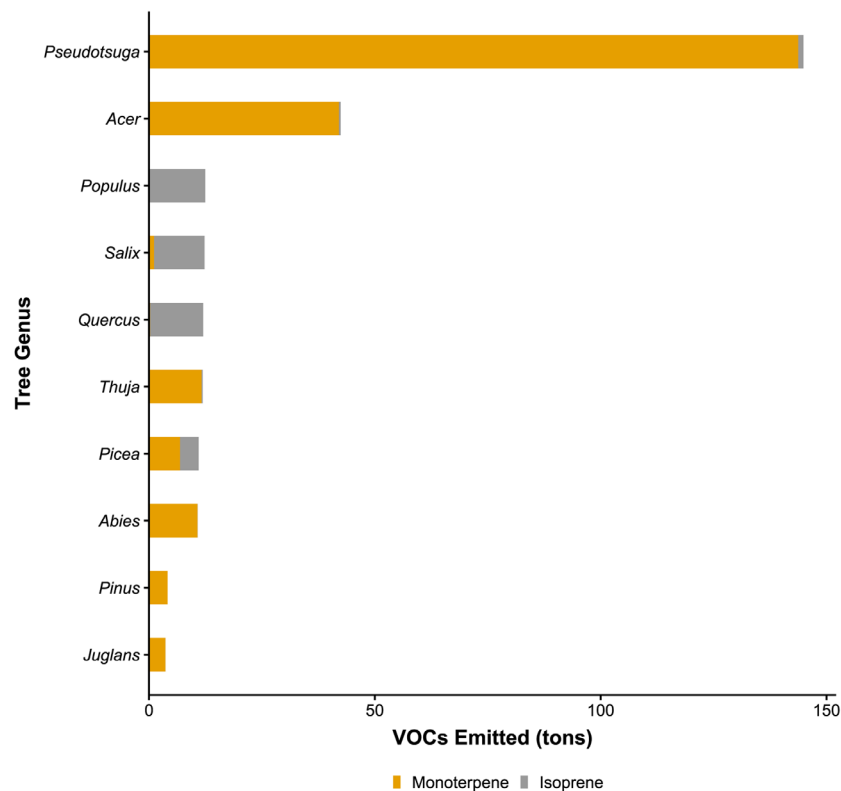


Figure 14.—Volatile organic compound (VOC) emissions by genus, Portland, Oregon 2018.

Avoided Runoff

Surface water runoff (commonly referred to as surface runoff or stormwater runoff) can contribute to pollution in streams, wetlands, rivers, and oceans. During precipitation events, some portion of the precipitation is intercepted by vegetation, while the remainder reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil or end up in surface depression storage becomes surface runoff (Hirabayashi 2013). In urban areas, the large extent of impervious surfaces increases the amount of surface runoff.

Urban trees can reduce surface runoff. Tree canopies intercept precipitation, while root systems promote infiltration and water storage in the soil. The amount of avoided runoff is less than the total amount intercepted because soils also absorb precipitation and thus reduce runoff in the absence of trees. The trees in Portland are estimated to reduce runoff by 94 million cubic feet per year (705 million gallons annually), with an estimated value of \$6 million per year (Baer et al. 2024, Nowak 2021). The majority of this avoided runoff is attributable to interception by tree canopies. Tree species with the greatest overall impact on runoff are Douglas-fir, bigleaf maple, and western redcedar due to their large leaf surface area (Fig. 15).

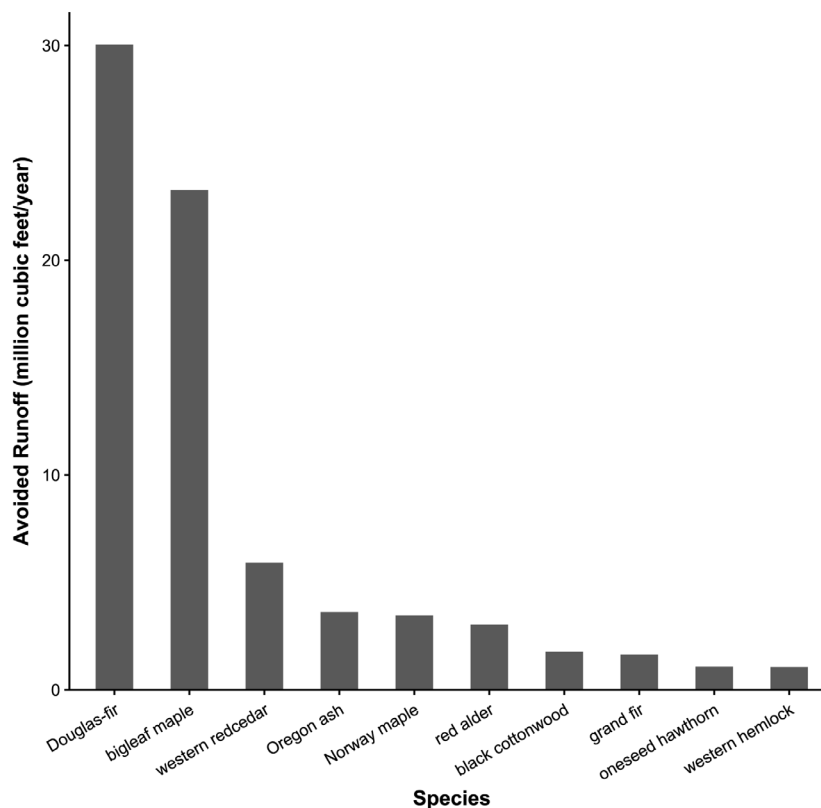


Figure 15.—Avoided runoff for 10 tree species with the greatest leaf area, Portland, Oregon, 2018.

Energy Conservation

Trees can affect building energy use by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months (cooling season) and can either increase or decrease building energy use in the winter months (heating season), depending on the location of the trees around the building (Heisler 1986, Nowak et al. 2017). Estimates of tree effects on energy use are based on field measurements of the tree distance and directions to space-conditioned residential buildings (McPherson and Simpson 1999; Nowak et al. 2008; Nowak 2020; U.S. EIA 2012a, b; U.S. EIA 2014a, b, c).

In Portland, interactions between buildings and trees 5.0 inches in diameter and greater are projected to annually decrease energy requirements by 252,000 gigajoules (GJ) during the heating and cooling seasons (an energy equivalent of 1.6 million gallons of home heating fuel oil) (Table 21), with annual savings in energy costs of \$5.1 million based on average energy costs in 2012 (Table 22). Trees in the urban forest also are estimated to reduce carbon dioxide (CO₂) emissions from fossil-fuel-based power sources by 14,700 tons annually (4,000 tons of carbon; \$683,000) (Baer et al. 2024), equivalent to the burning of over 10.3 million pounds of coal or roughly 30,997 barrels of oil (Hong and Slatick 1994, U.S. EPA 2020). More information about value calculations can be found in Baer et al. (2024).

Table 21.—Annual energy savings (GJ or tons) due to trees 5+ inches in diameter near residential buildings, Portland, Oregon 2018

Reduced energy use and emissions	Cooling	Heating	Total
Carbon avoided (tons) ^a	1,600	2,400	4,000
GJ ^b	108,000	144,000	252,000

Due to rounding, not all values will add up exactly.

^a To convert carbon estimates to carbon dioxide multiply carbon value by 3.667.

^b GJ = gigajoule (one billion [10⁹] joules).

Table 22.—Annual monetary savings due to trees 5+ inches in diameter near residential buildings during heating and cooling seasons, Portland, Oregon, 2018

Reduced energy use and emissions (dollars)	Cooling	Heating	Total
Carbon avoided	270,000	414,000	683,000
Energy effects	3,310,000	1,760,000	5,080,000

Due to rounding, not all values will add up exactly.

Based on 2012 statewide energy costs (U.S. Energy Information Administration 2012a, 2012b, 2014b, 2014c) and 2015 social cost of carbon (Interagency Working Group 2013, U.S. Environmental Protection Agency 2015).

Carbon Storage and Sequestration

Carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose or are consumed in a fire event. Although tree maintenance practices (e.g., pruning) can contribute to carbon emissions, maintaining healthy trees helps to retain carbon stored in trees (Nowak et al. 2002b). Using removed trees for wood products is one way to help forestall carbon emissions related to wood decomposition. Wood from removed trees can also be used to produce energy (e.g., heat or cool buildings), helping to reduce fossil-fuel based carbon emissions. Trees in Portland store an estimated 1.6 million tons of carbon (5.7 million tons of CO₂) valued at \$267.3 million (Table 23). Carbon storage varies across the city (Fig. 16), among land uses, and by species. The species that store the most carbon are Douglas-fir, bigleaf maple, and western redcedar (Fig. 17). Figures 18 and 19 show the distribution of carbon storage and sequestration in trees by diameter class both as a proportion of the total amount of carbon stored and on a per tree basis. Larger trees store more carbon per tree due to their greater size.

In addition to carbon storage, which accounts for past carbon sequestration, healthy trees continue to annually sequester carbon in new tissue growth. Gross sequestration by urban trees in Portland is about 50,200 tons of carbon per year (184,000 tons per year of CO₂) with an associated value of \$8.6 million per year, which is roughly equivalent to the annual emissions associated with 36,300 passenger vehicles or energy usage by 20,100 homes (U.S. EPA 2020). Douglas-fir is estimated to sequester the most carbon of all species in the urban forest (30.1 percent of all sequestered carbon; Fig. 20). Estimates of carbon storage and sequestration in developed and undeveloped land uses, along with evaluations of tree growth, removals, and mortality by ownership, can help assess the impacts of proposed land use changes and management strategies and targets.

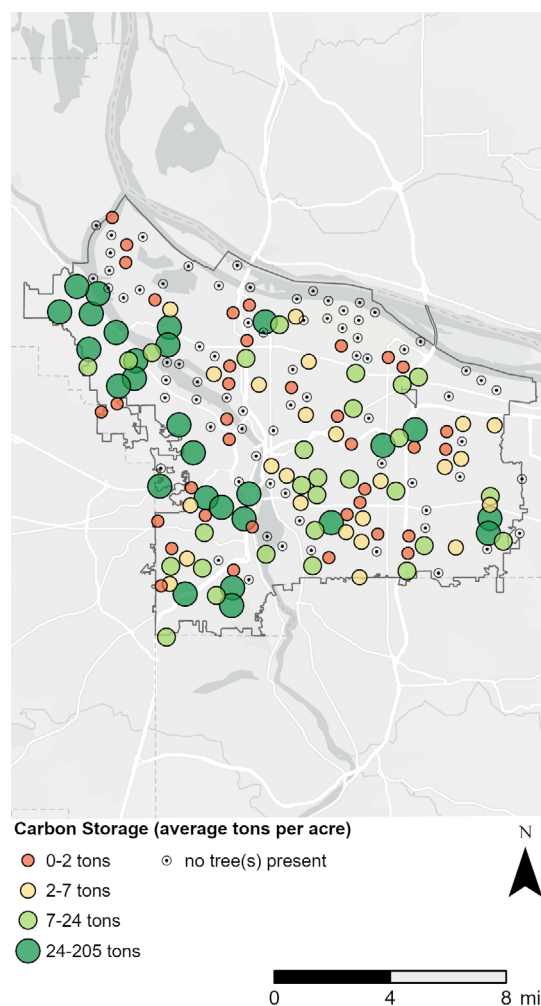


Figure 16.—Carbon storage per acre by plot, Portland, Oregon, 2018. Basemap: Esri (2017). Plot locations are approximate.

Table 23.—Aboveground and belowground carbon (C) in live and standing dead trees by Forest Inventory and Analysis (FIA) land use, Portland, Oregon, 2018

FIA land use	Aboveground in live trees (tons C)	Belowground in live trees (tons C)	Total in standing dead trees (tons C)	Total (tons C)	Standard error (tons C)
Forest land	803,000	170,000	8,200	982,000	161,000
Residential	330,000	68,000	3,400	402,000	87,000
Rights-of-way	59,000	11,000	1,900	72,000	34,000
Commercial/Industrial	55,000	11,000	110	66,000	28,000
Recreation/Cemetery	23,000	4,700	990	29,000	22,000
Multi-family residential	13,000	2,800	0	16,000	7,300
Total	1,280,000	269,000	15,000	1,570,000	–
Standard error	148,000	32,000	2,800	180,000	–

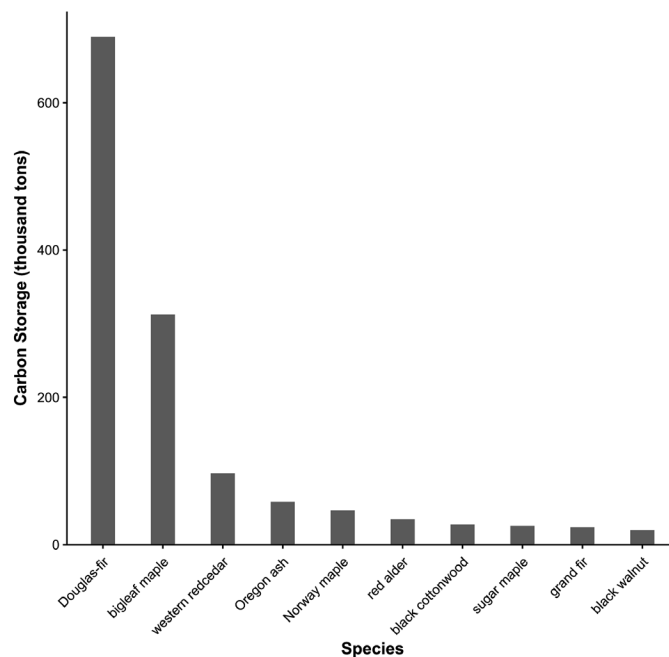


Figure 17.—Estimated carbon storage for 10 tree species with the greatest carbon storage, Portland, Oregon, 2018.

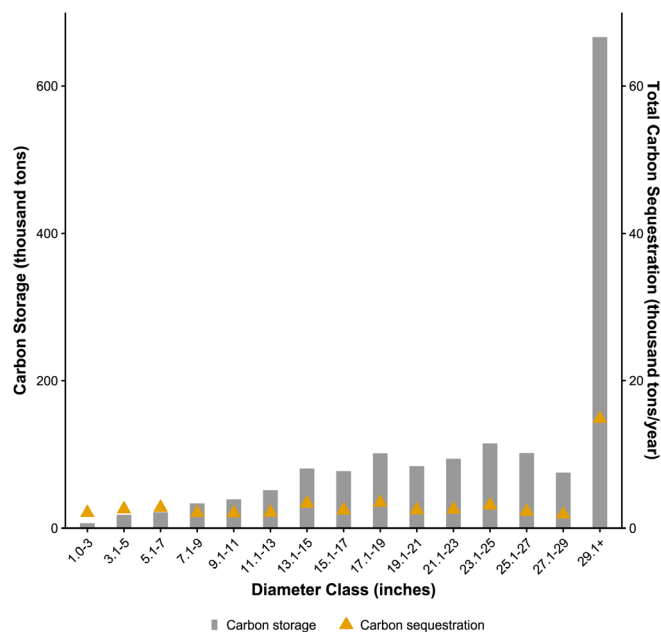


Figure 18.—Estimated total carbon storage and sequestration by diameter class, Portland, Oregon, 2018.

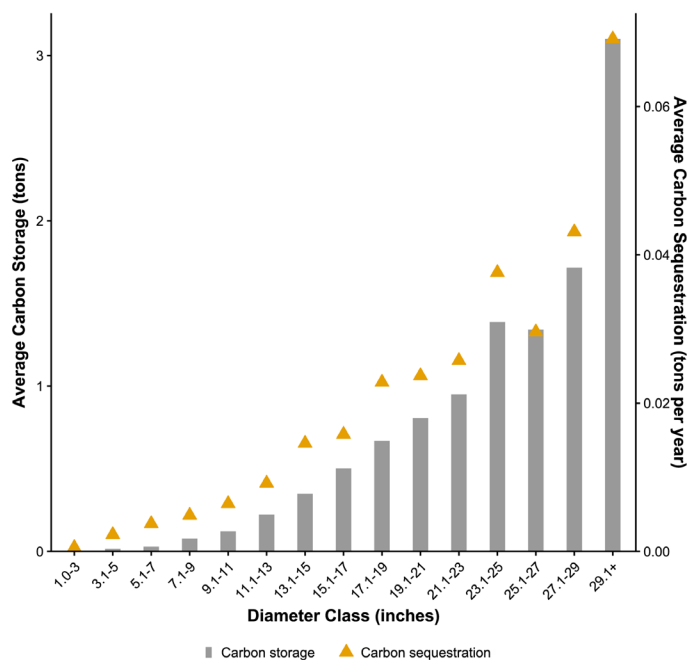


Figure 19.—Average per tree carbon storage and sequestration by diameter class, Portland, Oregon, 2018.

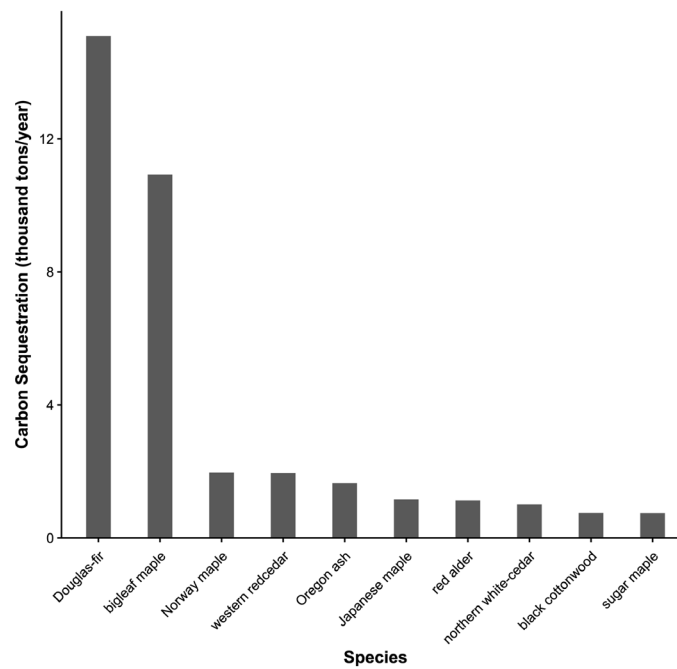


Figure 20.—Estimated annual carbon sequestration for 10 tree species with the greatest carbon storage, Portland, Oregon, 2018.

Structural Values

The city's forest has a structural value that includes the compensatory value and carbon storage value of each tree. The compensatory value is an estimate of the value of the tree as a structural asset, which tends to increase with the size and health of the tree. For small trees, a replacement cost can be used; for larger trees, appraisal procedures are used (Council of Tree and Landscape Appraisers 2000; Nowak et al. 2002a). This appraisal is an estimate based on tree species, diameter, condition, and location, and it does not include many personal, social, functional, or future values that may be ascribed to a tree (e.g., Nowak and Aevermann 2019). Note that invasive tree species have compensatory values because the methods used to estimate compensatory value do not account for whether the species is native, nonnative, or invasive. Additionally, invasive species can still contribute to ecosystem services. The compensatory value of the trees in Portland is estimated to be about \$5.8 billion. This compensatory value is a function of the number, health, diameter, and species of all trees measured, as well as the land use in which they were encountered. The species with the largest compensatory values in Portland are Douglas-fir, bigleaf maple, and Norway maple (Fig. 21). The mean compensatory value per acre for all surveyed plots in Portland is \$54,211; for the 60.8 percent of these plots that contained trees, the mean compensatory value per acre is \$89,100 (Fig. 22). However, compensatory value per acre is estimated to exceed \$133,000 for 29 plots in which the average tree diameter is 13.8 inches. The structural value of urban trees in Portland is a combination of their compensatory value (estimated at \$5.8 billion) and the value associated with carbon storage by the trees (estimated at \$267.3 million).

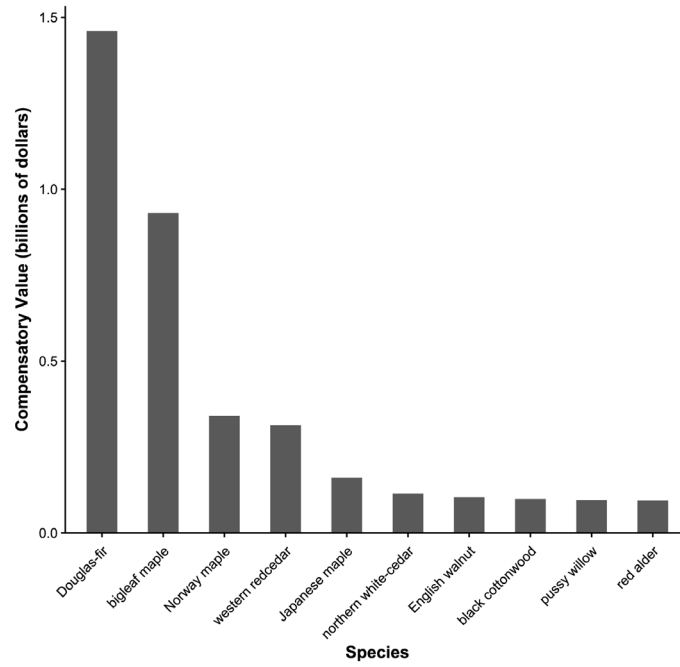


Figure 21.—The 10 tree species with the greatest compensatory value, Portland, Oregon, 2018.

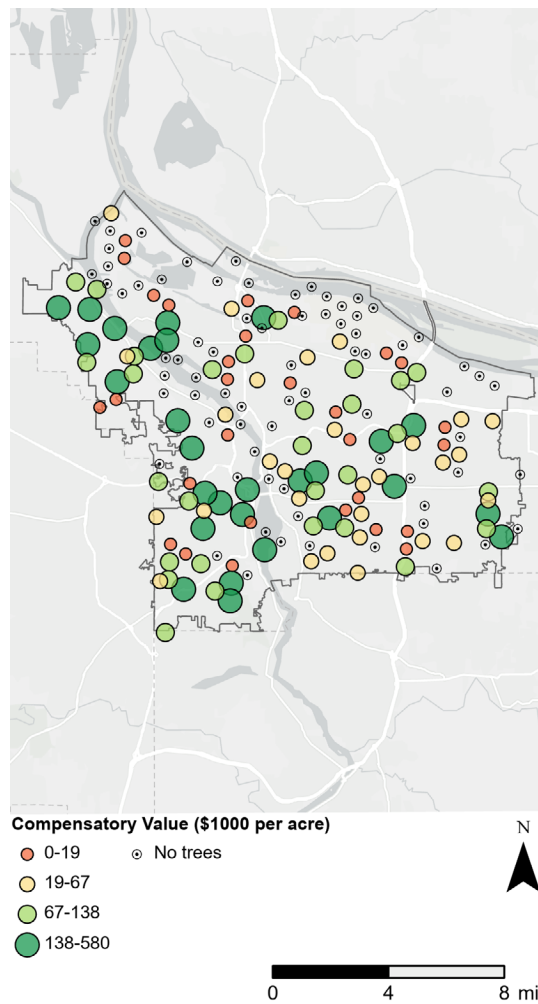


Figure 22.—Compensatory value per acre by plot, Portland, Oregon, 2018. Plot locations are approximate.

URBAN FOREST HEALTH



Urban FIA crews survey plots for nonnative invasive species, such as English ivy (shown growing around a dead apple tree trunk), and Himalayan blackberry (shown in the foreground), both of which can damage and suppress the growth of native plants. USDA Forest Service photo by Suzanne Owen.

A healthy urban forest provides greater benefits to society than an unhealthy one. This section highlights crown dieback, tree damages and rot, the number of standing dead trees, and the presence and prevalence of invasive plant species as indicators of urban forest health in Portland. Detailed methods of invasive species as indicators of urban forest health metrics are presented in the Urban FIA PNW Field Guide Version 7.2 (USDA Forest Service 2018).

Crown Dieback and Bole Rot

Tree crown condition can be used as an indicator of tree health. Large, dense crowns are often indicative of vigorously growing trees, while small, sparsely foliated crowns signal trees with little or no growth. Crown dieback is one of the initial indications that a tree may be in a state of decline. Crown dieback is measured as a percentage of the crown volume with recent mortality of small fine branches and twigs in the upper and outer portion of the tree's crown. Trees with more than 25 percent crown dieback may be in decline (Steinman 2000). High levels of dieback may indicate an insect, disease, or environmental problem associated with a particular tree species.

Of the tree species that have a minimum sample size of 10 trees and show evidence of dieback, red alder has the highest average dieback (8.9 percent) (Table 24). Approximately 12.6 percent of red alder displays greater than 25 percent crown dieback, indicating that this species may be threatened by insect, disease, or environmental stressors in Portland.

In addition to crown dieback, the amount of rot present in the trunk of a tree may indicate tree health issues and serve as a predictor of potentially hazardous trees in urban areas. The percent of the main stem that is **rotten or cull** between 1 foot above the ground and approximately 4.0-inch top diameter outside of bark was recorded for all trees at least 5.0 inches in diameter. The species with the highest average rotten/cull amounts are arroyo willow and red alder, for species with a minimum sample size of 10 trees (Table 25).

Table 24.—Tree species with greatest average dieback, Portland, Oregon, 2018

Common name	Average dieback (percent)	Standard error (percent)	Trees with more than 25% dieback (percent)
red alder	8.9	14.1	12.6
oneseed hawthorn	6.5	8.1	9.7
bigleaf maple	4.8	9.2	7.9
Norway maple	2.2	3.0	0.0
pussy willow	1.8	1.9	1.8
grand fir	1.8	1.4	0.0
Oregon ash	1.5	1.6	0.0
Scouler's willow	1.2	1.8	0.0
camellia	1.1	1.5	0.0
arroyo willow	1.0	1.0	1.1
black cottonwood	1.0	1.6	1.0
Japanese maple	0.8	1.0	0.0
vine maple	0.5	0.6	0.0
Douglas-fir	0.4	0.9	0.0
northern white-cedar	0.2	0.3	0.0
sweet cherry	0.2	0.2	0.0
western redcedar	0.1	0.2	0.0
cherry laurel	0.0	0.0	0.0

Due to rounding, not all values will add up exactly.

Only species with minimum sample size of 10 live trees are included in this analysis to minimize effect of small sample size on percentage estimates.

Table 25.—Tree species with the greatest average rot, Portland, Oregon, 2018

Common name	Average rot (percent)	Standard error (percent)	Trees with more than 15% rot (percent)
arroyo willow	7.8	7.8	5.9
red alder	3	7.1	6.3
Douglas-fir	2.2	5.6	5.8
Norway maple	2	3.7	3.3
bigleaf maple	1.9	3.4	4.3
western redcedar	1.3	2.8	4.2
black cottonwood	1.1	1.6	0.0
northern white-cedar	0.7	1.2	0.0
Oregon ash	0.6	0.6	0.0
Japanese maple	0.4	0.9	0.0

Only species with minimum sample size of 10 live trees are included in this analysis to minimize effect of small sample size on percentage estimates.

Rot is only measured on trees greater than or equal to 5 inches in diameter.

Tree Damage and Potential Infrastructure Issues

Urban trees are susceptible to a wide range of insect, disease, and abiotic (e.g., soil compaction) damage agents that may affect tree survival, growth, and wood quality. Many damage agents are host specific and their impacts may vary by regional and local growing conditions. Live trees at least 1.0 inch in diameter were examined for indications of several damage agents. Up to 3 damage agents were recorded per tree; each recorded agent was required to meet a minimum severity threshold (e.g., 20 percent of the foliage affected). If more than 3 damage agents were observed on a tree, the top 3 were prioritized according to their ability to: (1) prevent the tree from surviving more than 1 to 2 years, (2) reduce the tree's growth in the near term, and (3) negatively affect a tree's marketable wood products. The full list of potential damage agents is presented in the Urban FIA Field Guide Version 7.2 (USDA Forest Service 2018). Stem decay and competition were the most common causes of damage, affecting 6.4 and 4.1 percent of trees, respectively (Table 26).

In addition to damage agents, each live tree at least 1.0 inch in diameter was evaluated for the presence of the following infrastructure issues that affect urban trees:

- Root/stem girdling
- Conflict with roots (sidewalk-root conflict/infrastructure damage)
- Topping/pruning
- Conflict with crown (branches within 5 feet of overhead wires)
- Bark inclusion
- Improper planting
- Excessive mulch

Bark inclusion is the most common issue, occurring in 18.7 percent of trees. Topping/pruning and conflict with crown are the second and third most common urban-specific infrastructure issues, occurring in 4.8 and 3.6 percent of trees, respectively (Fig. 23).

Table 26.—Percentage of trees with observed damage, Portland, Oregon, 2018

Damage type	Percent
Bark beetles	0.2
Beavers	0.1
Boring insects	0.1
Brown cubical rot	<0.1
Cankers	2.0
Competition	4.1
Decline Complexes/Dieback/Wilts	0.1
Defoliators	1.0
General insects	0.1
Human activities	3.1
Nonrust canker	0.6
Red heart rot	0.3
Root/Butt diseases	<0.1
Stem decay	6.4
Stem rusts	0.1
Wild animals	0.2
Other Damages and Symptoms	
Broken top	0.9
Checks, bole cracks	<0.1
Crook or sweep	1.9
Dead top	0.9
Forked below merch top	1.5
Forked top	1.5
Open wound	1.2
Resinosis	0.1
Other damages and symptoms	0.1

Due to rounding, not all values will add up exactly.

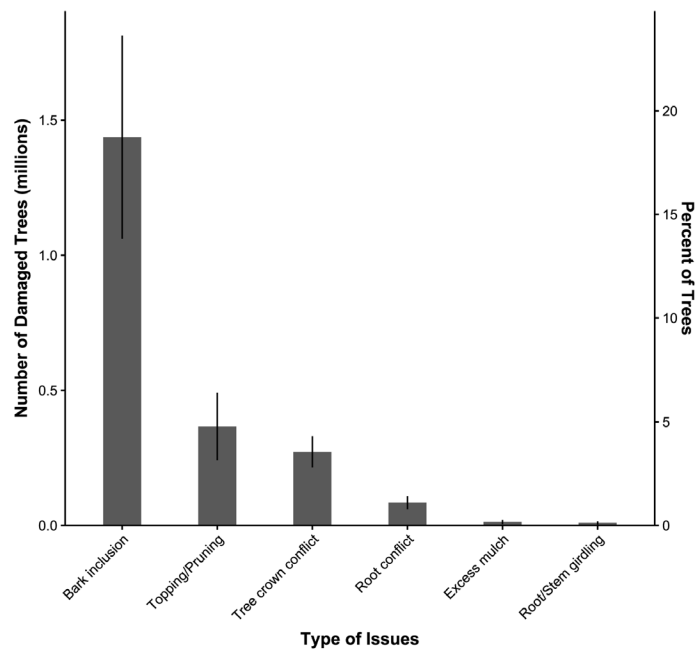


Figure 23.—Number and percentage of trees by urban infrastructure issue category, Portland, Oregon, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

Differences exist in the prevalence of these issues among the FIA-designated land uses and may further inform forest health and management priorities. In Portland, bark inclusion occurs in 36.2 percent of trees on recreation/cemetery land, in 30.2 percent of trees on residential land, and severe topping or poor pruning occurs in 19.9 percent of trees on multi-family residential land. The species with the greatest proportion of their population affected by urban-specific damages are northern white-cedar (53.6 percent affected by bark inclusion) and Japanese maple (52 percent affected by bark inclusion) (Table 27, Appendix 5).

Table 27.—Species with the greatest proportion of their population with infrastructure issues, by damage type, Portland, Oregon, 2018

Damage type	Common name	Percent	Damage type	Common name	Percent
Excess mulch	Japanese maple	1.4	Bark inclusion	Douglas-fir	4.1
Conflict with crown	Douglas-fir	4.7		Japanese maple	52.0
	Japanese maple	1.1		Norway maple	13.6
	Norway maple	19.2		Oregon ash	26.8
	bigleaf maple	0.7		Scouler's willow	8.1
	grand fir	9.2		arroyo willow	1.1
	northern white-cedar	0.2		bigleaf maple	5.0
	sweet cherry	4.1		camellia	38.8
	western redcedar	2.0		cherry laurel	2.5
Conflict with roots	Douglas-fir	0.7		grand fir	5.3
	Japanese maple	1.1		northern white-cedar	53.6
	Norway maple	10.9		oneseed hawthorn	17.8
	red alder	2.6		red alder	9.5
Topping/Pruning	Norway maple	8.3		sweet cherry	8.1
	bigleaf maple	4.5		vine maple	1.4
	cherry laurel	7.5		western redcedar	0.7
	northern white-cedar	6.5			
	sweet cherry	4.1			
	vine maple	28.6			

Only species with minimum sample size of 10 live trees are included in this analysis to minimize effect of small sample size on percentage estimates.
Due to rounding, not all values will add up exactly.

Standing Dead Trees

The number of standing dead trees serves as another measure of urban forest health and can be useful data for management planning. The extent to which a standing dead tree poses a threat to humans and/or infrastructure depends on the location of the tree. Standing dead trees in maintained areas where human activity is likely high, such as residential and institutional land uses or transportation corridors, will generally be considered hazardous trees and prioritized for removal. Conversely, standing dead trees in patches of forest away from heavy human use are of minimal risk but beneficial for wildlife habitat and their removal may be deemed undesirable. Because of the variability of removal rates among land use classes, caution is advised when interpreting forest health issues based on the number of standing dead trees.

Standing dead trees were found on 26 plots in Portland. Of the total live and dead tree population, 3.6 percent are estimated to be standing dead trees. The number of standing dead trees by species is shown in Table 28. The species that comprises the largest proportion of the dead tree population is bigleaf maple (36.9 percent), followed by western redcedar (16.5 percent) (Table 29). Land uses with the highest estimated number of standing dead trees are forest, rights-of-way, and commercial/industrial (Fig. 24). The majority of standing dead trees were observed on unmaintained land in forest land uses.

Table 28.—Number of trees classified as standing dead by species, Portland, Oregon, 2018

Common name	Standing dead trees (number)	Standard error (number)	Species (percent)
paper birch	2,400	2,700	100.0
white spruce	2,300	2,700	100.0
European plum	4,000	3,700	56.1
Pacific yew	3,900	3,400	50.0
incense-cedar	4,000	3,700	26.5
golden chain tree	28,000	33,000	25.0
lodgepole pine	3,100	3,200	20.0
red alder	27,000	10,000	18.1
Japanese flowering cherry	4,000	3,700	13.6
western redcedar	48,000	29,000	12.9
western hemlock	3,900	3,400	11.1
bigleaf maple	107,000	48,000	9.1
Douglas-fir	43,000	25,000	8.6
bitter cherry	4,600	5,500	6.2
black cottonwood	4,000	3,700	1.0

Due to rounding, not all values will add up exactly.

Table 29.—Proportion of total dead tree population by species, Portland, Oregon, 2018

Common name	Standing dead trees (percent)
bigleaf maple	36.9
western redcedar	16.5
Douglas-fir	14.8
golden chain tree	9.8
red alder	9.4
bitter cherry	1.6
incense-cedar	1.4
black cottonwood	1.4
European plum	1.4
Japanese flowering cherry	1.4
Pacific yew	1.3
western hemlock	1.3
lodgepole pine	1.1
paper birch	0.8
white spruce	0.8
Total	100.0

Due to rounding, not all values will add up exactly.

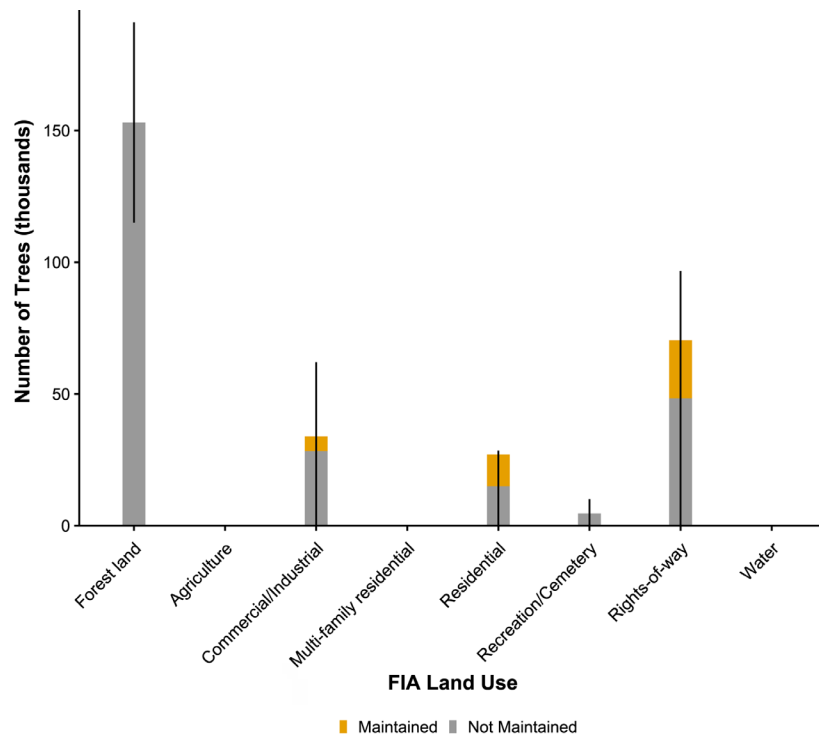


Figure 24.—Proportion of standing dead trees by Forest Inventory and Analysis (FIA) land use and maintenance status, Portland, Oregon, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

Invasive Plant Species

Invasive plant species are often noted for their vigor, ability to adapt to novel environments, high reproduction capacity, and lack of natural enemies. These factors may enable them to displace native plants and threaten natural areas (Davis 2009, Simberloff 2013). In accordance with Executive Order 13112 (1999), the Forest Service defines an invasive species as a nonnative species whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Important considerations for invasive plant control efforts include weighing short- and long-term trade-offs in terms of ecosystem services provided or disrupted by invasive species. The removal of invasive species and loss of ecosystem services they provide may lead to a subsequent need to increase the abundance of desirable species to offset these losses. Field crews in Portland examined each plot for the presence of select invasive species based on a species list developed for the city (Appendix 6; includes scientific and common names for each invasive plant species). Of the 189 plots examined, invasive species were identified on 57.7 percent (109 plots).

Nonnative invasive species found in Portland are presented in Figure 25. Beyond noting simple presence or absence, crews noted the percentage of the plot area covered by the invasive species, allowing for the estimation of the total area covered by each species within the city (Bechtold and Scott 2005). These estimated areas may offer insights into which species have the greatest impact in the city. English ivy (4,456 acres; 4.8 percent of the sampling area), Himalayan blackberry (3,894 acres; 4.2 percent of the sampling area), and cherry laurel (545 acres; 0.5 percent of the sampling area) cover the largest area of the invasive species recorded. The potential for invasive species to spread beyond their current distribution into the surrounding landscape, potentially displacing native species and altering local ecosystems, is of particular concern (Pimentel et al. 2000).

Additional measurements are recorded in the field for most tree species. As some of the species on the invasive plants list for Portland are classified as trees, data on individual trees were collected in addition to descriptions of species cover on the plot. In Portland, tree data were collected for cherry laurel and English holly. Taken together, these invasive trees account for about 7.6 percent of all live trees surveyed (estimated total trees: 586,700) and 0.6 percent of the total leaf area.

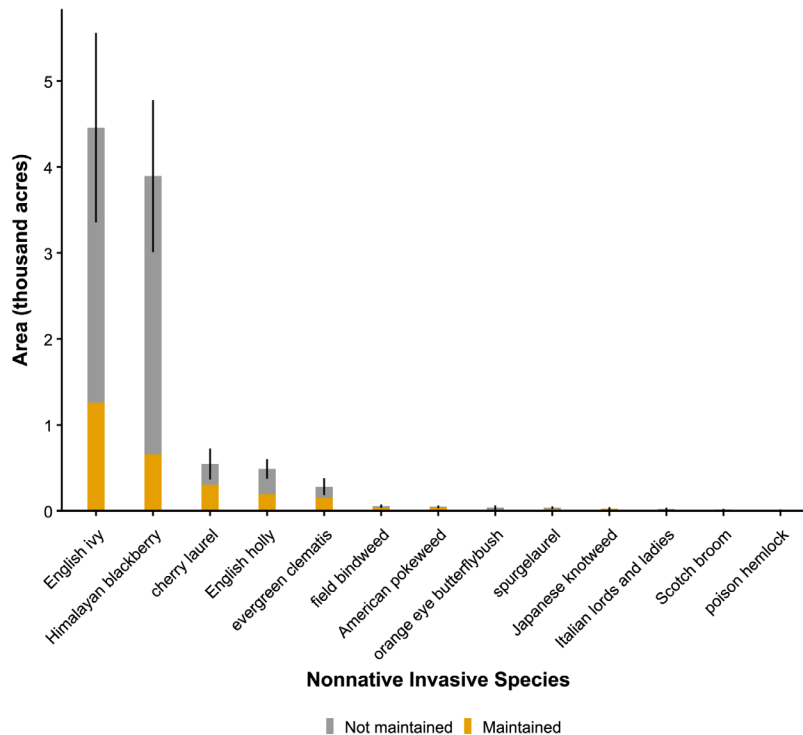


Figure 25.—Nonnative invasive species by maintained and unmaintained land, Portland, Oregon, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

Pests and Pathogens

Pathogens and insect pests can affect the health, sustainability, and benefits of urban forests. Identifying pathogens and pests of concern and their potential host-specific impacts allows managers to prioritize specific insects and diseases for monitoring and control measures. We evaluated 52 insects and diseases, along with their tree hosts in Portland, to quantify their potential impact on the urban forest (Table 30). The number of trees at risk (Fig. 26) reflects all the known host tree species that could experience damage or mortality either directly or indirectly due to the pest or pathogen and does not necessarily include only trees that are known to be directly at risk of attack and/or infection. As FIA crews did not attribute tree damage or mortality to specific pests or pathogens, it was not possible to identify what portion of each host tree's population was directly at risk from or affected by the focal pests and pathogens. Pest range maps (Nowak 2021) were used to determine the proximity of each pest to the area, and these ranges are updated continually by i-Tree as new regional references are added. For Portland, proximity was classified for insects and diseases in Multnomah County; within 250 miles of any of this county; between 250 and 750 miles of the county; or greater than 750 miles away.

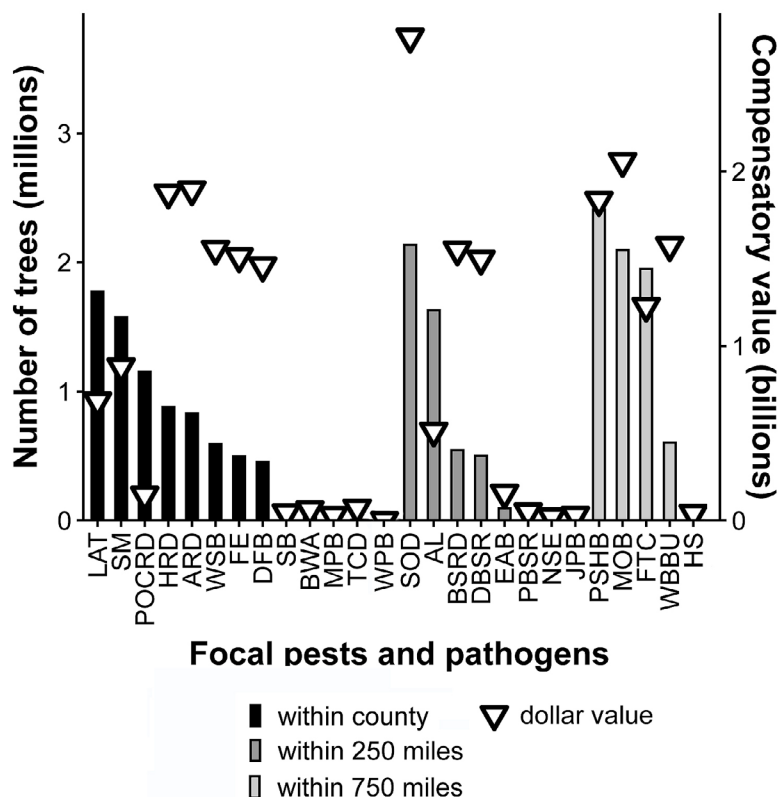


Figure 26.—Number of trees at risk due to pests and pathogens and their associated compensatory values, Portland, Oregon, 2018. Pest abbreviations are presented in Table 30.

Table 30.—Potential risk associated with various insects and diseases, Portland, Oregon, 2018

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value (dollars)
within county	LAT	Large Aspen Tortrix	<i>Choristoneura conflictana</i>	1,774,796	23.1	685,764,260
	SM	Spongy Moth	<i>Lymantria dispar</i>	1,575,824	20.5	881,360,549
	POCRD	Port-Orford-Cedar Root Disease	<i>Phytophthora lateralis</i>	1,152,129	15.0	145,710,936
	HRD	Heterobasidion Root Disease	<i>Heterobasidion annosum</i>	877,338	11.4	1,877,673,444
	ARD	Armillaria Root Disease	<i>Armillaria spp.</i>	829,668	10.8	1,896,019,569
	WSB	Western Spruce Budworm	<i>Choristoneura occidentalis</i>	591,823	7.7	1,555,554,749
	FE	Fir Engraver	<i>Scolytus ventralis</i>	497,685	6.5	1,512,568,656
	DFB	Douglas-Fir Beetle	<i>Dendroctonus pseudotsugae</i>	454,075	5.9	1,459,988,693
	SB	Spruce Beetle	<i>Dendroctonus rufipennis</i>	75,457	1.0	
	BWA	Balsam Woolly Adelgid	<i>Adelges piceae</i>	47,622	0.6	62,285,146
	MPB	Mountain Pine Beetle	<i>Dendroctonus ponderosae</i>	19,716	0.3	29,070,753
	TCD	Thousand Canker Disease	<i>Geosmithia morbida</i>	4,012	0.1	71,950,291
	WPB	Western Pine Beetle	<i>Dendroctonus brevicomis</i>	3,141	0.0	700,092
within 250 miles	SOD	Sudden Oak Death	<i>Phytophthora ramorum</i>	2,134,165	27.8	2,770,909,794
	AL	Aspen Leafminer	<i>Phyllocnistis populiella</i>	1,628,186	21.2	512,604,688
	BSRD	Black Stain Root Disease	<i>Leptographium wageneri</i>	544,469	7.1	1,551,397,155
	DBSR	Douglas-fir Black Stain Root Disease	<i>Leptographium wageneri</i> var. <i>pseudotsugae</i>	500,859	6.5	1,498,817,191
	EAB	Emerald Ash Borer	<i>Agrilus planipennis</i>	94,469	1.2	156,965,194
	PBSR	Pine Black Stain Root Disease	<i>Leptographium wageneri</i>	18,845	0.2	49,880,083
	NSE	Northern Spruce Engraver	<i>Ips perturbatus</i>	15,540	0.2	22,076,202
	JPB	Jeffrey Pine Beetle	<i>Dendroctonus jeffreyi</i>	3,141	0.0	30,514,512
within 750 miles	PSHB	Polyphagous Shot Hole Borer	<i>Euwallacea fornicatus</i>	2,410,016	31.4	1,835,635,205
	MOB	Mediterranean Oak Borer	<i>Xyleborus monographus</i>	2,096,626	27.3	2,058,482,945
	FTC	Forest Tent Caterpillar	<i>Malacosoma disstria</i>	1,949,591	25.4	1,228,141,941
	WBBU	Western Blackheaded Budworm	<i>Acleris gloverana</i>	604,222	7.9	1,576,930,859
	HS	Hemlock Sawfly	<i>Neodiprion tsugae</i>	46,620	0.6	41,539,130
farther than 750 miles	ALB	Asian Longhorned Beetle	<i>Anoplophora glabripennis</i>	3,745,294	48.8	2,542,114,155
	BM	Browntail Moth	<i>Euproctis chrysorrhoea</i>	3,300,343	43.0	2,477,695,720
	SLF	Spotted Lanternfly	<i>Lycorma delicatula</i>	2,659,533	34.7	1,944,106,531
	WM	Winter Moth	<i>Operophtera brumata</i>	2,245,956	29.3	1,927,382,985
	PSB	Pine Shoot Beetle	<i>Tomicus piniperda</i>	561,812	7.3	1,591,497,479

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Table 30 (continued).

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value (dollars)
farther than 750 miles (cont.)	SBW	Spruce Budworm	<i>Choristoneura freemani</i>	548,213	7.1	1,515,632,280
	SW	Sirex Wood Wasp	<i>Sirex noctilio</i>	490,367	6.4	1,556,303,387
	SPB	Southern Pine Beetle	<i>Dendroctonus frontalis</i>	135,676	1.8	137,614,127
	LWD	Laurel Wilt	<i>Raffaelea lauricola</i>	39,330	0.5	2,161,435
	FR	Fusiform Rust	<i>Cronartium quercuum</i> f. sp. <i>fusiforme</i>	32,232	0.4	178,639,952
	OW	Oak Wilt	<i>Ceratocystis fagacearum</i>	32,232	0.4	178,639,952
	HWA	Hemlock Woolly Adelgid	<i>Adelges tsugae</i>	31,080	0.4	19,462,927
	DA	Dogwood Anthracnose	<i>Discula destructiva</i>	22,951	0.3	30,936,940
	JPBW	Jack Pine Budworm	<i>Choristoneura pinus</i>	12,563	0.2	18,665,479
	RPS	Red Pine Scale	<i>Matsucoccus matsumarae</i>	7,153	0.1	22,423,336
	ARCA	Aspen Running Canker	<i>Neodothiora populina</i>	6,282	0.1	4,047,942
	BC	Butternut Canker	<i>Ophiognomonia clavignenti-juglandacearum</i>	4,012	0.1	71,950,291
	CB	Chestnut Blight	<i>Cryphonectria parasitica</i>	4,012	0.1	53,792,147
	DED	Dutch Elm Disease	<i>Ophiostoma ulmi</i>	No threat to trees sampled	NA	NA
within county	SFM	Subalpine Fir Mortality	na – multiple pests	No threat to trees sampled	NA	NA
	WFNPM	Western Five-Needle Pine Mortality	na – multiple pests	No threat to trees sampled	NA	NA
	WPBR	White Pine Blister Rust	<i>Cronartium ribicola</i>	No threat to trees sampled	NA	NA
	GSOB	Goldspotted Oak Borer	<i>Agrilus auroguttatus</i>	No threat to trees sampled	NA	NA
farther than 750 miles	BBD	Beech Bark Disease	<i>Cryptococcus fagisuga</i> / <i>Neonectria</i> spp. complex	No threat to trees sampled	NA	NA
	BLD	Beech Leaf Disease	<i>Litylenchus crenatae</i> ssp. <i>mccannii</i>	No threat to trees sampled	NA	NA
	BOB	Bur Oak Blight	<i>Tubakia iowensis</i>	No threat to trees sampled	NA	NA

Due to rounding, not all values will add up exactly.

Taken together, this approach yielded 44 individual insect and disease species or pest-pathogen complexes that may have substantial negative effects on common tree species inventoried in Portland (Table 30). Some of Portland's insects and diseases are native, such as the Douglas-fir beetle, and some are introduced, such as Port-Orford-cedar root disease (*Phytophthora lateralis*). Since i-Tree did not have pest range maps for Dutch elm disease (*Ophiostoma* spp.) and chestnut blight (*Cryphonectria parasitica*), the ranges of these pathogens were based on known occurrence and the known host range, respectively (Nowak 2021), but other sources indicate occurrences of Dutch elm disease in Portland (City of Portland 2018c, City of Portland 2018–2021), and this is discussed further in the Management Implications section. We also consulted with the Oregon Department of Forestry and PP&R Urban Forestry Division on additional pests and diseases of concern (not included in i-Tree's list) and discussed their potential impacts in the Management Implications section.

Out of the 13 pests/pathogens present in Multnomah County and included in this assessment, the large aspen tortrix (*Choristoneura conflictana*) has the potential to impact the most trees from our inventory, and Armillaria root disease could cause the highest monetary loss from susceptible trees (Fig. 26; Table 30). The large aspen tortrix has the potential to impact an estimated 1,774,796 trees, at least 1-inch diameter, including quaking aspen, balsam poplar, willow, and birch species. The large aspen tortrix is a moth and its larvae can defoliate host trees causing branch death, growth loss, weakening trees leaving them more susceptible to other damaging agents, or tree death. The large aspen tortrix is especially problematic when aspen is a major component of a forest stand (USDA Forest Service 2011). In contrast, Armillaria root disease is caused by the fungus *Armillaria mellea*, and could impact some of Portland's largest trees, such as Douglas-fir and grand fir. This is one of the most common conifer root rot causes in the Pacific Northwest and could lead to growth loss, uprooting, and mortality (Williams et al. 1986). The compensatory value of trees at risk from Armillaria root disease is estimated at \$1.9 billion (Fig. 26; Table 30).

Based on the potential host tree species and the current range of the pest, it is possible to estimate the risk faced by each tree species sampled in the urban forest to attack by each of these insects or diseases and assign each tree species a relative risk weight. In Appendix 7, each pest that could pose a threat to a tree species is scored as 4 points if it occurs within Multnomah county, 3 points if occurs within 250 miles of the county, and 2 point if it occurs within 750 miles of the county, and 1 point if it is not present within 750 miles of the county. These values are summed across each row to determine the relative risk weight for each tree species recorded in the city. Tree species that were sampled in Portland, but are not listed in this matrix, are not known to be hosts to any of the 45 insects and diseases evaluated. This table also excludes the pests and diseases that were not a threat to any of the tree species sampled. Douglas-fir had the highest relative risk weight (score = 34), compared to other tree species in this inventory (Appendix 7).

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MANAGEMENT IMPLICATIONS



A maintained park with large elm and maple trees in Portland, Oregon. Field crews record tree damages, threats from pests and diseases, and record tree growth and mortality over time. This long-term data can help support urban forest management. USDA Forest Service photo by Suzanne Owen.

The primary goal of Urban FIA is to provide an accurate estimate of the composition, distribution, health, and values of urban forests to aid in sustainable urban forest management and planning. This report presents a baseline against which future monitoring efforts can be compared, including re-measurement of the Urban FIA plots. These comparisons will allow managers to assess rates of tree growth and mortality, as well as changes in species composition, the distribution of size classes, and the benefits associated with the urban forest. Effective monitoring allows for the formulation of data-driven management strategies to maximize the benefits of Portland's urban forest while minimizing the cost associated with its maintenance. Identifying priority areas for the enhancement or maintenance of tree growth, survival, and cover may assist in managing the benefits of urban forests.

In addition to identifying areas of high priority for management, it is also essential to understand the forces that may alter the future condition, composition, or benefits of the urban forest. Human activities such as population growth, changing infrastructure, increased development, or activities related to natural resource management may affect the abundance or species composition of trees in the urban forest. Changes in climate or local weather patterns, land cover, species composition, or interactions with pests or pathogens also shape urban forests. Using this Urban FIA inventory, it is possible to estimate which species may be threatened by changing land use, human activity, or host-specific pests and pathogens and estimate the monetary value associated with these potential threats.

Portland's Urban Forestry Programs and Landowner Survey

State and City urban forestry programs provide many social, economic, and environmental services to urban communities. Portland Parks & Recreation's Urban Forestry Program has received global recognition for its commitment to effective urban forest management. The Arbor Day Foundation has awarded Portland its 44th Tree City USA Award, 24th Growth Award, and 2nd Tree Cities of the World Award (City of Portland 2021a). In 2020, the City of Portland's Urban Forestry Program achieved the Society of Municipal Arborists (SMA) international accreditation for its excellent management practices (City Trees 2020). Additionally, the Oregon Department of Forestry, Urban and Community Forestry Program has assisted communities with improving and expanding their urban forestry programs for over 30 years (ODF 2021). Some of Portland's management goals include focused tree planting and outreach in underserved communities, increasing tree diversity and urban tree resilience to climate change, mitigating the impact of development on natural resources, and preserving and enhancing Urban Habitat Corridors (City of Portland 2018a,b). The importance of urban forest composition and canopy cover is highlighted in the City of Portland's Urban Forest Management Plan (2004), the Urban Forest Action Plan (2007), the Climate Action Plan (2015), the Portland Plan (2012), the 2035 Comprehensive Plan (2016), and the Citywide Tree Planting Strategy (2018). Information in this report can inform future management decisions and help support the state's urban forestry programs.

Portland's residents recognize the importance of urban trees for the environment and the health and well-being of community members. Portland has some truly remarkable trees that help to bring communities together, including over 300 Heritage Trees, recognized for their unique size, age, or historical significance. The Portland area also has many parks, including Forest Park, one of the largest urban parks in the United States. Volunteers in Portland dedicated the most hours out of any city in the U.S. to planting and caring for city trees. The City of Portland celebrates Arbor Day annually with volunteers and community members (City of Portland 2021a). Finally, several non-profit organizations such as Friends of Trees and Save Our Elms help to raise awareness and funding and organize events to care for Portland's urban trees. The high degree of engagement in the health and resilience of Portland's urban forest by city residents will undoubtedly aid in identifying and addressing potential threats to the urban forest.

Portland is among the initial cohort of cities included in the Urban National Landowner Survey (UNLS), the urban counterpart to FIA's [National Woodland Owner Survey](#) (NWOS). The UNLS is an effort to survey private owners of residential properties in cities and urban areas, to better understand who owns the urban forest and how these landowners use, value, and manage their urban trees and greenspaces. The UNLS was fielded within the city boundaries of Portland (not including the metropolitan areas) starting in 2019. As of 2022, four years of data have been collected and processed. During this survey cycle, 112 valid responses have been collected, for a total cooperation rate of 24.5 percent. Early analysis of this data shows that an estimated 195.1 thousand private, residential ownerships own one or more properties in the City of Portland (SE = 81.3 thousand ownerships), with 91.1 percent of these ownerships residing on their own property (SE = 9.5 percent). The most common structures on these properties are single-family homes (88.3 percent of ownerships, SE = 8.3 percent) and townhouses or duplexes (9.5 percent of ownerships, SE = 8.2 percent). At least 96.1 percent of residential ownerships have one or more trees on their land, with 55.6 percent agreeing strongly that trees make their neighborhoods a "better place to live" (SE = 9.3 percent). Landscaping/tree care professionals; employees at lawn and garden centers; and family and friends represent the most trusted sources of information on tree care for residential landowners in Portland, while damage from branches and roots on property structures and powerlines represent landowners' biggest concerns about their trees. More information on the UNLS can be found at the [Urban FIA program website](#) or in Butler et al. (In Press).

Climate, Weather, and Fire Impacts

Evidence suggests an increased frequency and duration of extreme weather events, such as longer-lasting heat waves, which will likely impact human mortality, regional economies, and forested ecosystems (Meehl and Tebaldi 2004). In the 2010s, Portland had more days of 90+ °F than any prior decade on record. Recently, Portland's June 2021 heatwave sent temperatures to a record high of 116 °F, with at least 5 consecutive days of 100+ °F. Portland's summers are becoming hotter, which adds stress to urban trees and may have dire consequences for public health and safety. The latest heatwave in Oregon led to 96 heat-related deaths. Residents of areas consistently warmer than the rest of the city, termed urban heat islands, may be particularly vulnerable to heat-related illness. Urban heat islands are discussed in greater detail below.

Along with heatwaves, Oregon has recently experienced prolonged periods of severe to extreme drought. Since 2000, the longest duration of drought in Oregon occurred in 2011 and lasted 270 weeks. Oregon has experienced drought conditions since then, and the most intense period of drought occurred in 2021, when 27 percent of the state, including Portland, was in the highest drought category of 'exceptional drought' for over a week (National Drought Mitigation Center 2021). Extreme drought and heat conditions weaken trees' ability to defend against pests and pathogens. Threats posed to trees by insects and diseases are expected to be compounded by heat and drought stress.

Hot and dry conditions have also increased the risk of wildfire throughout the state, including urban parks with dense forest stands. The risk of wildfires in city parks such as Forest Park and Powell Butte Nature Park is a major concern of city managers (City of Portland 2009a). During severe drought, normally moist park vegetation could dry out enough to carry fire. Dry conditions combined with high fuel loads from dense stands and underbrush could lead to disastrous canopy fires, especially with strong winds. Wildfires in these urban parks would be very difficult to control and almost certainly threaten surrounding structures, as well as produce thick smoke that would affect thousands of urban residents. Wildfire represents a significant threat to the environmental, economic, and public health and safety benefits conferred by Portland's urban forest detailed in this report. Predicting the areas of greatest risk and the potential losses of urban trees to wildfires in different parts of the city may help urban foresters prioritize areas to focus wildfire prevention efforts. Doing so is also expected to decrease the risk of tree mortality posed by insects and pathogens, as fire weakens surviving trees and renders them more susceptible to attack.

Local weather events, such as ice storms, also impact urban forests and the safety of city residents. Winter cold spells and ice storms could become more common in warmer climates (Klima and Morgan 2015). Ice is heavy and may cause branches or even whole trees to break, ultimately damaging or killing trees. Portland Parks & Recreation staff responded to more than 750 tree emergencies in public streets from ice storms that occurred in 2021 (City of Portland 2021b). Fallen trees and branches caused power outages for thousands of Portland residents. Urban forestry crews were tasked with the dangerous and technical job of removing entire trees or large broken limbs that blocked roadways, and unstable limbs that were at risk of falling. Portland's parks staff evaluates areas with hazardous trees and works to ensure public safety. In the long term, ice-damaged trees could also be more susceptible to pests and diseases. Urban forest inventories can help track damages over time.

Urban Heat Islands

Urban heat islands run 10+ degrees hotter than the rest of the city due to exposed dark colored surfaces that absorb and radiate heat from the sun, and a lack of tree canopy cover, which would provide a shading and cooling effect (Voelkel and Shandas 2017). Portland State University researchers and community scientists have mapped urban heat islands to help communities strategize plans to mitigate them (PSU 2024). Unsurprisingly, Portland has the greatest temperature relief in areas with high tree canopy cover. However, tree canopy cover is not evenly distributed throughout the city and tends to be lower in areas with lower-income and communities of color (City of Portland 2018b, Poracsky and Banis 2005). Urban heat islands are correlated with low tree canopy cover and poor infrastructure design (Hoffman et al. 2020, Voelkel and Shandas 2017). East Portland neighborhoods have more heat islands than western neighborhoods, and residents who

live in these areas or near major highways such as Interstate 205 are at the greatest risk for heat-related illness (Voelkel and Shandas 2017). Portland's Urban FIA data summarized by equity and heat island themes are found at My City's Trees. By coupling an understanding of urban tree inventories with demographic information, public health practitioners can identify residents who may be more vulnerable to extreme heat events, and managers can identify priority areas to increase tree planting efforts to help counteract the effect of heat islands.

Population Growth

The population of Oregon is projected to reach 4.7 million people in the year 2030, with an annual average growth rate of approximately 1.0 percent (DAS 2019). Portland's metro area is expected to grow to almost 3 million people by 2030. This population increase is expected to affect Portland's urban forest. Portland's urban growth boundary law promotes urban 'infill' to accommodate new housing in already developed areas. The growth boundary law limits urban expansion, but it is revisited every 20 years using results from growth forecasts to predict future household demands, and Portland's urban boundary is still expanding. Portland's Metro Council predicts that in 2035 there will be approximately 345,000 to 376,000 homes in the City of Portland, an increase of 44 to 57 percent from 2005 (the baseline year used for their models) (City of Portland 2009b, Oregon Metro 2018). Changes in land use and land cover associated with the increased housing and infrastructure needs of a growing population may alter tree cover and composition and affect services provided by the urban forest (Steenberg et al. 2017; e.g., Kreuter et al. 2001; Nowak et al. 2004; Steenberg et al. 2018, 2019). Managing urban forest composition to a desirable outcome is critical in urban environments where numerous external forces affect forest structure and benefits. Urban FIA supports management efforts by tracking changes in the urban forest through time via plot re-measurement and determining how observed changes are correlated with changes in population, land use, and other attributes of the city.

Insect and Disease Impacts

The nationally consistent methods used in the Urban Forest Health section above included pest and pathogen range maps and i-Tree's list of species of concern (Nowak 2020, 2021). These methods are a useful way to make national comparisons, however, local expertise is critical to understanding risks at a regional/city level. We consulted with the Oregon Department of Forestry and PP&R Urban Forestry Division on additional pests and diseases of concern (not included on i-Tree's list) and those that may not be included in the range maps, or were recently updated (e.g., the emerald ash borer) and added this information to our discussion here. Chief among the most destructive threats to Portland's ash trees is the emerald ash borer (EAB). This insect was found greater than 700 miles from Portland when this inventory was completed in 2018, and unfortunately, the EAB was recently discovered in Washington County in July 2022 (ODF 2022), approximately

25 miles from Portland. The EAB attacks ash trees (*Fraxinus* spp.) and is responsible for the mortality of millions of ash trees in over 30 states. Results from this inventory indicate that EAB infestations could lead to the death of almost 95,000 urban ash trees (≥ 1 -inch diameter), including Oregon ash, a vital species in riparian areas providing shade and soil stability. The compensatory value of susceptible ash trees is estimated at \$157 million. Largescale ash mortality could threaten local waterways, habitats, and economies (Bliss-Ketchum et al. 2021; City of Portland 2017a, 2022; ODF 2022). The EAB Readiness and Response Steering Committee developed an EAB plan that guides managers on strategies to cope with the introduction and likely spread of this devastating insect (Bliss-Ketchum et al. 2021). Some of these strategies have already been implemented such as removing susceptible ash trees from Portland's Approved Street Tree Planting Lists and identifying susceptible ash populations.

Portland's conifer trees face threats from several species of bark beetles that may render them susceptible to decline or mortality. Bark beetles live between the bark and wood of host trees and damage or destroy vascular tissue. They deposit their eggs under the bark where their larvae burrow into the surrounding cambium and vascular tissue (Seybold et al. 2008). Bark beetles play important ecological roles, but occasionally their populations reach high densities and cause extensive tree mortality. Throughout western North American forests, bark beetles have caused tree mortality across tens of millions of acres. Outbreaks of this magnitude are usually triggered by disturbances such as fire, defoliation, or windfall, and they can be prolonged by periods of drought, but typically last 2 to 4 years.

Some species of bark beetles found in Portland, include the Douglas-fir beetle, mountain pine beetle (*Dendroctonus ponderosae*), western pine beetle (*Dendroctonus brevicomis*), fir engraver (*Scolytus ventralis*), and various pine engravers (*Ips* spp.). The Douglas-fir beetle is the most destructive bark beetle of Douglas-fir in the Northwest. If an outbreak occurred in areas of high Douglas-fir densities, such as Forest Park, it would have extensive economic and social impacts. The other pine and bark beetles infest ponderosa pine and other pines, and the fir engraver attacks firs (*Abies* spp.); each of these can cause physical defects in wood and introduce other pathogens, and may lead to mortality, especially for drought-stressed trees (Kegley et al. 1997, Schultz and Bedard 1987, Seybold et al. 2008). Re-measurement of plots through time will allow for further evaluation of the extent to which declines in susceptible host species occur. Urban FIA data suggest that about 500,000 trees may be at risk of bark beetle attack within the Portland city boundary. The combined compensatory value of these trees is estimated at over \$1.6 billion (Table 30).

Other pests that threaten Portland's urban trees include the balsam woolly adelgid (*Adelges piceae*), amethyst borer (*Semanotus amethystinus*), cedar borer (*Trachykele blondeli*), bronze birch borer (*Agrilus anxius*), spongy moth (*Lymantria* spp.), various oak galls, miners, lacebugs, carpetworms, and webworms. The balsam woolly adelgid infests several fir species (*Abies* spp.) and mainly causes slow tree decline, but persistent infestations along with other stressors could lead to tree mortality (Overhulser et al. 2004). Both the amethyst and cedar borers are typically secondary invaders to stressed or damaged western red cedars, and they could lead to slow mortality. The bronze birch borer causes yellowing foliage and ridges in a lightning pattern with a distinctive D-shaped hole in the bark; this pest can kill birch trees (*Betula* spp.) within a couple of years. Spongy moths are not established in Oregon, but individuals were detected in Portland in 2015 (ODA 2016). European and Asian spongy moths (*Lymantria dispar*, *L. dispar asiatica*, respectively) feed on the foliage of hardwood trees, occasionally completely defoliating trees. Heavy defoliation may lead to other stressors and/or cause direct mortality (Coleman et al. 2020). Other pests, such as oak galls, miners, lacebugs, carpetworms, and webworms lead to aesthetic damage, branch die-off, and tree stress with heavy defoliation. Trees under heavy stress, such as many growing in urban areas, are more susceptible to these pests. Information and management guides for common tree pests in Oregon are found in [Common Insects that Cause Plant Damage in Central Oregon](#) by the Oregon State University Extension Service.

The most destructive threat to Portland's elm trees is Dutch elm disease, or DED. Even though this FIA inventory did not encounter elm species on measured plots, it is worth mentioning DED here because other city inventories estimated about 3,500 susceptible elms throughout Portland (City of Portland 2018c; City of Portland 2018–2021). Dutch elm disease is one of the deadliest tree pathogens in the U.S.; an infected tree can die within weeks of first showing symptoms. The first case of DED in Oregon was discovered in 1973, subsequent outbreaks occurred in Portland in 1977 and 1986, and from then on, Portland has averaged about 39 DED tree removals each year (City of Portland 2018c). Dutch elm disease is caused by a fungus (*Ophiostoma* spp.), which invades tree vascular tissue and prohibits water conduction, ultimately resulting in wilt and death. The DED fungus spreads by bark beetles, nearby roots of infected trees, and human activity, such as transporting infected firewood. Bark beetle vectors of DED include the native elm bark beetle (*Hylurgopinus rufipes*) and the European elm bark beetle (*Scolytus multistriatus*). Portland Parks & Recreation Urban Forestry works diligently to manage the impact of DED by monitoring and testing for DED each year, swiftly removing any infected trees or trimmed elm debris that would attract bark beetles, applying sanitation procedures (i.e., disposing of all elm wood and disinfecting tools), using prevention measures such as inoculating DED-susceptible species with fungicide and planting DED-resistant species, and educating the public to raise community awareness about identifying and reporting symptoms of DED and encouraging prevention by inoculation and/or planting DED-resistant trees (City of Portland 2018c; City of Portland 2018–2021).

Fungal or insect-fungal disease complexes can be problematic for Portland's urban forest. Douglas-fir black stain root disease (*Grosmannia wageneri*) and thousand cankers disease (TCD) are found within the city and just outside the city; together they could impact 458,000 potential tree hosts with an estimated compensatory value of \$1.5 million. Douglas-fir black stain root disease primarily infects Douglas-fir trees, is spread by several species of root-feeding beetles and weevils, and it infects trees through nearby roots (Mellen-McLean et al. 2017). Infected trees will show a dark brown to purple stain within their roots and older sapwood. This disease blocks water-conducting vessels and may cause substantial mortality in some areas. Thousand cankers disease is an insect-fungal disease complex native to the western United States and caused by the combined activity of a fungus (*Geosmithia morbida*) and the walnut twig beetle (*Pityophthorus juglandis*). Thousand cankers disease primarily affects black walnut trees, where the beetles carry the fungal spores into their galleries and cause a fungal infection that produces cankers that merge and girdle branches and stems. Once TCD symptoms appear, susceptible trees are expected to die within a few years (Cranshaw and Tisserat 2012). Another fungal pathogen is white pine blister rust (*Cronartium ribicola*), which greatly impacts five-needle pines. It was introduced to the West Coast in the early 1900's and has subsequently spread through stands of western white pine and sugar pine. Port-Orford-cedar root disease is another disease found within the city; it is caused by a water mold (*Phytophthora lateralis*) that spreads through water and soil and can kill Port-Orford-cedars of all ages (Betlejewski et al. 2011).

Several pathogens have been recorded within 250 miles of Portland, including sudden oak death (SOD; *Phytophthora ramorum*) and pine black stain root disease (*Leptographium wageneri*) (Table 30). These species have the potential to invade Portland's urban forests in the future. Sudden oak death is a nonnative pathogen found in Curry County and since its discovery in 2001, managers have worked diligently to contain and slow its spread (Parke and Rizzo 2011, ODF 2023). Sudden oak death causes cankers and tree mortality in over 100 tree species, with the strongest impacts seen in tanoaks and rhododendron. The spores of SOD become abundant in the rainy season and spread via wind and other vectors into unimpacted areas. Pine black stain root disease is a fungal disease carried by several species of bark beetles. Infected trees will show a dark brown to purple stain within their roots and older sapwood. This disease blocks water-conducting vessels and can kill several conifer species. The compensatory value of SOD and pine black stain root disease susceptible trees in Portland is estimated at over \$2 billion.

Although the Asian longhorned beetle (ALB; *Anoplophora glabripennis*) has not been detected within 750 miles of Portland, it nevertheless represents a potential threat to Portland's urban forest due to its ability to move great distances via human transport networks. Similar to the EAB, the ALB can be transported long distances on firewood or other vectors; unlike the EAB this pest attacks dozens of species from 15 different plant families, some common within the city of Portland, including maples, elms, and willows. The ALB leads to tree death within 10 to 15 years after infestation and could cause

considerable damage if allowed to spread (USDA 2020). If ALB reaches Portland's urban forest, it may have devastating impacts on city trees with an estimated compensatory value of over \$2 billion. A loss of this magnitude within the urban forest would be expected to have significant impacts on the local economy and human health (Donovan et al. 2013; Nowak et al. 2002a, 2019). Increased tree diversity may help reduce the risk of spread and tree mortality from various pests and diseases, which often attack only certain species or genera. In addition, aggressive management is needed to prevent the spread and eradicate infestations of major threats like ALB (Portland Parks & Recreation 2017a, USDA 2020).

Native vs. Introduced Trees

The majority of Portland's tree species are not native to the area. Of the 91 live tree species recorded by Urban FIA crews in the city (Appendix 2), 74 percent are introduced, and the remaining are native to Portland and surrounding counties according to the [USDA PLANTS database](#) and the City of Portland (2016) (Table 31). Introduced species represent an estimated 4.3 million individual trees ($\geq$ 1-inch diameter), roughly 56 percent of the trees in the city. Introduced species with the greatest number of stems include northern white cedar, camellia, and cherry laurel. Native species ($\geq$ 1-inch diameter) with the greatest number of stems include bigleaf maple, Douglas-fir, and red alder. The urban ecosystem has very different conditions than native ecosystems, such as poor soils and crowded growing conditions. Nonnative tree species may perform better in these conditions than native trees that grow larger and require better soil drainage and more growing space. Additionally, some introduced species that are drought tolerant and fare well in unpredictable winters may be more resilient to changes in climate in urban forests than native species adapted to survive or thrive under local 'natural' forest conditions. Therefore, the adaptability of tree species is an important consideration for planting efforts (Carignan 2022).

Two of the inventoried introduced tree species, cherry laurel and English holly, are also included in PNW FIA's invasive species list; see the full list of FIA inventoried invasive species for Portland in 2018 in Appendix 6. Other species such as tree-of-heaven and Russian olive were not inventoried using the FIA invasive species protocol in 2018 but will be included in the 2024 inventory list.

Table 31.—Oregon native tree species recorded in the Urban Forest Inventory and Analysis (FIA) inventory, Portland, Oregon, 2018

Scientific name	Common name	Portland native?	Number	Percent of all trees
<i>Abies grandis</i>	grand fir	Yes	44,000	0.57
<i>Acer circinatum</i>	vine maple	Yes	449,000	5.85
<i>Acer macrophyllum</i>	bigleaf maple	Yes	1,060,000	13.80
<i>Alnus rubra</i>	red alder	Yes	123,000	1.60
<i>Betula occidentalis</i>	water birch	No	4,000	0.05
<i>Calocedrus decurrens</i>	incense cedar	No	11,000	0.14
<i>Chamaecyparis lawsoniana</i>	Port-Orford-cedar	No	24,000	0.31
<i>Cornus nuttallii</i>	Pacific dogwood	Yes	8,600	0.11
<i>Fraxinus latifolia</i>	Oregon ash	Yes	72,000	0.94
<i>Malus fusca</i>	Oregon crab apple	Yes	3,100	0.04
<i>Picea sitchensis</i>	Sitka spruce	No	16,000	0.21
<i>Pinus contorta</i>	lodgepole pine	No	13,000	0.17
<i>Pinus jeffreyi</i>	Jeffrey pine	No	3,100	0.04
<i>Pinus ponderosa</i>	ponderosa pine	Yes	3,100	0.04
<i>Populus tremuloides</i>	quaking aspen	Yes	6,300	0.08
<i>Prunus emarginata</i>	bitter cherry	Yes	70,000	0.91
<i>Pseudotsuga menziesii</i>	Douglas-fir	Yes	454,000	5.91
<i>Quercus garryana</i>	Oregon white oak	Yes	3,900	0.05
<i>Salix lasiolepis</i>	arroyo willow	Yes	209,000	2.72
<i>Salix scouleriana</i>	Scouler's willow	Yes	105,000	1.37
<i>Taxus brevifolia</i>	Pacific yew	Yes	3,900	0.05
<i>Thuja plicata</i>	western redcedar	Yes	321,000	4.18
<i>Umbellularia californica</i>	California laurel	No	39,000	0.51
Total			3,046,000	39.66

Due to rounding, not all values will add up exactly.

Tree native status is based on the USDA PLANTS database and the Portland Plant List (City of Portland, 2016).

Planting

Recruitment of new trees into urban forests results from both natural seed-based/resprouting regeneration and intentional planting, and the relative proportions of naturally occurring versus intentionally planted trees may vary widely among cities (Nowak 2012). Most new trees added to Portland's managed or developed urban forest are the result of intentional planting rather than natural recruitment. Urban FIA data suggest that 68 percent of trees in residential/multifamily and recreational lands were planted rather than naturally occurring. A higher percentage of naturally recruited trees were found in natural areas and rights-of-ways (98 and 67 percent, respectively) compared to planted trees throughout the city. Portland's urban forestry goals, strategies, and areas of planting potential are outlined in Portland's Urban Forest Management Plan, Citywide Tree Planting Strategy, 2035 Comprehensive Plan, and Climate Action Plan (City of Portland 2004, 2015, 2018b).

Meeting the city's urban forestry goals will require the availability of high-quality stock from certified nurseries, sufficient water resources to invest in the establishment of newly planted trees, and knowledge of the tree species likely to thrive in the future (City of Portland 2012, 2017a). It will also require the participation of private landowners, as the majority of the city's trees occur on private and residential lands. Urban FIA can help meet some of these requirements by identifying the number and estimated monetary value of trees that are likely to be affected by a variety of agents of damage or change. This information can help managers identify which trees may be susceptible to current and future environmental constraints. In addition, continued monitoring of the urban forest will offer information on growth and mortality rates among the city's trees over time. Finally, the City of Portland regulates trees on public and private property, and in development and non-development circumstances. They have an Approved Street Tree Planting List that corresponds to planting site conditions, and requirements for private property planting, such as minimum diameter requirements and selecting species that are not invasive or prone to fatal pests or diseases, including the emerald ash borer and Dutch elm disease (City of Portland 2018–2020, 2018–2022). Only those plants on the Native Plants List are allowed to be planted within the City's Environmental Overlay Zone, and native plants are encouraged to be planted where appropriate in other zones (City of Portland 2021c).

Tree Size Distribution and Potential Species Composition Change

The current size distribution of tree species helps shape the future composition of the urban forest. Small, young trees that survive will grow to become larger, older trees, while those trees that are currently large and old will eventually decline and die. An inverse J-shaped distribution curve of tree size classes with more young trees than older trees is thought to indicate the long-term sustainability of tree cover, as enough young trees are present to compensate for the mortality of older trees. The size distribution in Portland's urban forest is represented by such an inverse J-shaped curve, with most trees falling into the 1.0 to 3.0-inch diameter class (Fig. 10). This shape could indicate that Portland's urban forest is forecasted to be self-sustaining and/or the forest contains more species known for smaller diameters. Interactions of several drivers which have not been analyzed in this report, including rates of growth, mortality, natural regeneration, and planting, could influence the diameter class curve.

The species composition of Portland's urban forest may change in the future depending upon the current size distribution of individual species. Species whose size composition is skewed towards smaller, young trees may come to dominate the future classes of intermediate- and large-diameter trees, while those species in which large adult trees are currently more common, may decline in abundance through time. Species such as incense-cedar and sycamore maple were only found in the larger diameter size classes; this could be due to random sampling of plot locations or could indicate that without natural regeneration or continued planting of smaller-diameter trees to replace them, some larger tree species may become a less common component of Portland's urban forest over time. Northern white-cedar, camellia, vine maple, black cottonwood, and cherry laurel dominated the small tree class. These small-diameter species are not planted by the city as street trees and only black cottonwood has the potential to grow into a large diameter class. Some of these small diameter species have a 'shrubby' growth form and are known to have continuously small diameters. Northern white-cedar, camellia, and vine maple are included in FIA's tree list, but are more shrub-like in certain areas. Portland aims to increase tree diversity and reduce tree threats, so they have paused planting certain species like maple (*Acer* spp.) in rights-of-ways because they are overrepresented and ash (*Fraxinus* spp.) because they are susceptible to EAB. Actions such as pest management, targeted regeneration or planting of certain species, and restoration of habitats suitable for those species whose populations are expected to decline may aid in maintaining the current composition of the city's urban forest or increasing tree diversity and resilience.

CONCLUSIONS



Trees near Portland State University provide many ecological, health, and social benefits. Urban forest health and sustainability are high priorities for Portland's urban forest managers and residents. USDA Forest Service photo by Suzanne Owen.

Portland's urban forest contributes to the city's environmental, economic, and societal well-being. Throughout the city, an estimated 7.68 million trees, representing 93 species, provide an estimated tree canopy cover of 26.1 percent. This information can help the city strategize to meet its canopy cover goals of expanding overall urban tree canopy cover to a minimum of 33.3 percent by 2035 (City of Portland 2004, 2015, 2018b). Portland's urban canopy provides a wide range of important environmental benefits including air pollution removal, reduced carbon emissions, carbon storage and sequestration, reduced energy use for buildings, stormwater capture, and many others. Additionally, local studies from Portland and broad-scale studies found that urban trees are positively correlated with mental and physical health benefits and lower crime rates (Donovan and Butry 2010, Donovan and Prestemon 2012, Van den Berg 2017).

There are several forces that may impact Portland's urban forest structure, health, and the environmental benefits provided to the city's residents in the future. These include insect and disease infestations, aging and loss of larger trees, the expansion of invasive species, changes in the management and use of the forest, and growth of the human population.

This analysis provides a baseline for future monitoring. While data from this report capture attributes of the 2018 urban forest resource and associated ecosystem services and values, future monitoring will identify how the forest changes over time. The plots measured in Portland are re-measured annually on a 10-year cycle as part of the continuing Urban FIA program. Future analyses of the city's forest can be used to determine the role that natural and human forces play in shaping forest structure and composition.

For now, managers can use the data in this report to inform long-term management plans and policies to sustain a healthy urban tree population and ecosystem services for future generations. Planning and management of the urban forest resource can help sustain vital ecosystem services and values for current and future generations in Portland. In the future, change analyses can be used to evaluate the success of urban forest management programs.

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GLOSSARY OF TERMS

Diameter: For timber species, diameter is measured at breast height (d.b.h.), which is usually measured at 4.5 feet above the ground line on the uphill side of the tree. For woodland species, if the tree has multiple stems, the diameter of each is taken and combined to establish the total diameter of the tree. Woodland diameters are measured at the ground line or at the stem(s) root collar (d.r.c.), whichever is higher. Timber and woodland tree species are listed in Appendix 2 and woodland species are identified with a superscript “b” following the common name (USDA Forest Service 2018).

Forest/forest land/forested area: Land that has at least 10 percent crown cover by live trees or land formerly having such tree cover and is not currently developed for nonforest use. The minimum area for classification as forest land is 1 acre and 120 feet in width. Unimproved roads and trails, streams and other bodies of water, or natural clearings in forested areas shall be included within surrounding forested conditions if less than 120 feet in width and 1.0 acre in size (<30 feet wide for streams and rivers). Forest land is divided into timberland, reserved forest land, and other forest land (such as woodland) (USDA Forest Service 2016b).

Invasive species: A nonnative species whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112, 1999). A list of potential invasive plant species included in this inventory is presented in Appendix 6.

Rights-of-way: Developed lands including improved and/or maintained roads, railways, power or gas line clearings, and maintained canals (USDA Forest Service 2018).

Rotten or cull: Missing or rotten main stem or large branch volume caused by agents including cankers, punky knots, hollow sounding stems, or embedded metal in the wood (USDA Forest Service 2016b, 2018).

Shannon-Wiener diversity index: An index of species diversity (also known as the Shannon diversity index) which takes into account both species richness (total number of species in a community) and species evenness (relative abundances among species in a community). Shannon diversity (H') is calculated as follows:

$$H' = - \sum_{i=1}^s p_i \ln(p_i)$$

where: S = the total number of species in the community (species richness) and p_i = proportion of the total assemblage of individuals represented by individuals of species i (Shannon 1948, Spellerberg and Fedor 2003).

Woodland: A subset of Forest Inventory and Analysis-designated forest land that is dominated by woodland species (Dooley 2019).

Woodland species: Forest Inventory and Analysis classifies all tree species into either woodland or timber categories. Woodland species are typically small, slow-growing trees characterized by a multi-stemmed growth form; timber species generally grow from a single central stem (USDA Forest Service 2018). This difference in typical form induced some differences in data collection and calculation, such as how diameters are determined (see Diameter definition). Woodland species are identified with a superscript “b” following the common name in Appendix 2.

APPENDIX 1 – LAND COVER DESCRIPTION

Table 32.—National Land Cover Database (NLCD) land cover descriptions

NLCD land cover class	NLCD code	Land cover description
Open water	11	Areas of open water generally with less than 25 percent of vegetation or soil.
Perennial ice/snow	12	Areas characterized by a perennial cover of ice and/or snow, generally greater than 25 percent of total cover.
Developed-open space	21	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed-low intensity	22	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 percent to 49 percent of total cover. These areas most commonly include single-family housing units.
Developed-medium intensity	23	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 percent to 79 percent of the total cover. These areas most commonly include single-family housing units.
Developed-high intensity	24	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 percent to 100 percent of the total cover.
Barren land (rock/sand/clay)	31	Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.
Deciduous forest	41	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen forest	42	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed forest	43	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Dwarf scrub	51	Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20 percent of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
Shrub/Scrub	52	Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Grassland/Herbaceous	71	Areas dominated by graminoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Sedge/Herbaceous	72	Alaska only areas dominated by sedges and forbs, generally greater than 80 percent of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.

continued on next page

Table 32 (continued).

NLCD land cover class	NLCD code	Land cover description
Lichens	73	Alaska only areas dominated by fruticose or foliose lichens generally greater than 80 percent of total vegetation.
Moss	74	Alaska only areas dominated by mosses, generally greater than 80 percent of total vegetation.
Pasture/Hay	81	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Cultivated crops	82	Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Woody wetlands	90	Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent herbaceous wetlands	95	Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Source: Completion of the 2011 National Land Cover Database for the conterminous United States—representing a decade of land cover change information (Homer et al. 2015).

APPENDIX 2 – TREE SPECIES COMPOSITION

Table 33.—List of all live tree species and their characteristics, Portland, Oregon, 2018

Genus	Species	Common name	1–4.9 inch diameter class (number)	5–10.9 inch diameter class (number)	11+ inch diameter class (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (inch)
<i>Abies</i>	<i>grandis</i>	grand fir	0	23,000	20,000	44,000	0.6	25,000	14.7
<i>Acer</i>	<i>circinatum</i>	vine maple	443,000	6,300	0	449,000	5.9	299,000	1.8
<i>Acer</i>	<i>ginnala</i>	Amur maple	0	3,100	3,100	6,300	0.1	6,300	12.1
<i>Acer</i>	<i>griseum</i>	paperbark maple	0	3,100	0	3,100	0.0	3,200	5.7
<i>Acer</i>	<i>macrophyllum</i>	bigleaf maple	387,000	319,000	358,000	1,060,000	13.9	203,000	9.3
<i>Acer</i>	<i>palmatum</i>	Japanese maple	168,000	106,000	3,100	277,000	3.6	144,000	5.1
<i>Acer</i>	<i>platanooides</i>	Norway maple	0	35,000	52,000	86,000	1.1	32,000	15.1
<i>Acer</i>	<i>pseudoplatanus</i>	sycamore maple	0	0	17,000	17,000	0.2	9,600	18.8
<i>Acer</i>	<i>rubrum</i>	red maple	0	7,200	0	7,200	0.1	4,900	5.9
<i>Acer</i>	<i>saccharinum</i>	silver maple	0	0	4,000	4,000	0.1	3,700	34.8
<i>Acer</i>	<i>saccharum</i>	sugar maple	0	0	4,000	4,000	0.1	3,700	40.3
<i>Acer</i>	<i>x freemanii</i>	Freeman maple	0	0	3,100	3,100	0.0	3,200	21.6
<i>Alnus</i>	<i>rubra</i>	red alder	0	51,000	72,000	123,000	1.6	45,000	11.6
<i>Betula</i>	<i>occidentalis</i>	water birch	0	0	4,000	4,000	0.1	3,700	17.8
<i>Betula</i>	<i>pendula</i>	European white birch	0	6,300	13,000	20,000	0.3	13,000	13.2
<i>Calocedrus</i>	<i>decurrens</i>	incense-cedar	0	0	11,000	11,000	0.1	8,900	25.9
<i>Camellia</i>	<i>japonica</i>	camellia	500,000	23,000	0	523,000	6.8	376,000	2.1
<i>Carpinus</i>	<i>betulus</i>	European hornbeam	0	18,000	0	18,000	0.2	11,000	7.2
<i>Castanea</i>	<i>dentata</i>	American chestnut	0	0	4,000	4,000	0.1	3,700	32.7
<i>Cedrus</i>	<i>deodara</i>	Deodar cedar	0	4,000	7,000	11,000	0.1	6,000	15.3
<i>Cercidiphyllum</i>	<i>japonicum</i>	katsura tree	0	12,000	0	12,000	0.2	10,000	8.3
<i>Chamaecyparis</i>	<i>lawsoniana</i>	Port-Orford-cedar	0	20,000	4,000	24,000	0.3	19,000	10.5
<i>Chamaecyparis</i>	<i>obtusa</i>	hinoki false cypress	0	6,300	0	6,300	0.1	6,300	5.1
<i>Cornus</i>	<i>florida</i>	flowering dogwood	0	8,000	3,100	11,000	0.1	6,100	11.2
<i>Cornus</i>	<i>kousa</i>	kousa dogwood	0	3,100	0	3,100	0.0	3,200	6.7
<i>Cornus</i>	<i>nuttallii</i>	Pacific dogwood	0	8,600	0	8,600	0.1	5,300	6.6
<i>Cotinus</i>	<i>obovatus</i>	smoketree	0	3,100	0	3,100	0.0	3,200	6.2
<i>Crataegus</i>	<i>monogyna</i>	oneseed hawthorn	277,000	16,000	0	293,000	3.8	161,000	2.7

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Table 33 (continued).

Genus	Species	Common name	1–4.9 inch diameter class (number)	5–10.9 inch diameter class (number)	11+ inch diameter class (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (inch)
<i>Cryptomeria</i>	<i>japonica</i>	Japanese cedar	0	0	4,800	4,800	0.1	5,400	19.4
<i>Cupressocyparis</i>	<i>leylandii</i>	Leyland cypress	0	32,000	0	32,000	0.4	30,000	6.6
<i>Cydonia</i>	<i>oblonga</i>	quince	100,000	0	0	100,000	1.3	92,000	1.2
<i>Ficus</i>	<i>carica</i>	edible fig	100,000	0	0	100,000	1.3	92,000	1.8
<i>Fraxinus</i>	<i>americana</i>	white ash	0	0	2,400	2,400	0.0	2,700	17.2
<i>Fraxinus</i>	<i>excelsior</i>	European ash	0	0	17,000	17,000	0.2	13,000	22.0
<i>Fraxinus</i>	<i>latifolia</i>	Oregon ash	0	16,000	57,000	72,000	0.9	59,000	15.2
<i>Fraxinus</i>	<i>pennsylvanica</i>	green ash	0	3,100	0	3,100	0.0	3,200	5.7
<i>Ilex</i>	<i>aquifolium</i>	English holly ^a	97,000	6,200	0	103,000	1.3	86,000	1.6
<i>Juglans</i>	<i>nigra</i>	black walnut	0	0	4,000	4,000	0.1	3,700	38.0
<i>Juglans</i>	<i>regia</i>	English walnut	39,000	0	8,000	47,000	0.6	40,000	6.9
<i>Juniperus</i>	<i>scopulorum</i>	Rocky Mountain juniper ^b	0	4,600	0	4,600	0.1	5,500	7.4
<i>Juniperus</i>	<i>virginiana</i>	eastern redcedar	0	8,000	0	8,000	0.1	7,400	8.5
<i>Koelreuteria</i>	<i>paniculata</i>	goldenrain tree	0	3,100	0	3,100	0.0	3,200	5.7
<i>Laburnum</i>	<i>anagyroides</i>	golden chain tree	85,000	0	0	85,000	1.1	100,000	1.8
<i>Lagerstroemia</i>	<i>indica</i>	crapemyrtle ^b	39,000	0	0	39,000	0.5	40,000	4.4
<i>Larix</i>	<i>decidua</i>	European larch	0	0	3,100	3,100	0.0	3,200	22.3
<i>Liquidambar</i>	<i>styraciflua</i>	sweetgum	0	3,100	5,500	8,700	0.1	5,200	13.1
<i>Liriodendron</i>	<i>tulipifera</i>	yellow-poplar	0	0	3,100	3,100	0.0	3,200	20.2
<i>Magnolia</i>	<i>grandiflora</i>	southern magnolia	0	0	2,400	2,400	0.0	2,700	21.5
<i>Malus</i>	<i>fusca</i>	Oregon crab apple	0	3,100	0	3,100	0.0	3,200	5.6
<i>Malus</i>	<i>pumila</i>	paradise apple	39,000	2,300	20,000	61,000	0.8	43,000	6.7
<i>Picea</i>	<i>abies</i>	Norway spruce	0	0	4,000	4,000	0.1	3,700	18.3
<i>Picea</i>	<i>pungens</i>	blue spruce	39,000	13,000	3,100	56,000	0.7	41,000	4.1
<i>Picea</i>	<i>sitchensis</i>	Sitka spruce	0	12,000	3,900	16,000	0.2	14,000	11.8
<i>Pinus</i>	<i>contorta</i>	lodgepole pine	0	6,300	6,300	13,000	0.2	6,100	11.7
<i>Pinus</i>	<i>densiflora</i>	Japanese red pine	0	0	4,000	4,000	0.1	3,700	14.8
<i>Pinus</i>	<i>jeffreyi</i>	Jeffrey pine	0	0	3,100	3,100	0.0	3,200	32.8
<i>Pinus</i>	<i>nigra</i>	Austrian pine	0	3,100	0	3,100	0.0	3,200	5.9
<i>Pinus</i>	<i>ponderosa</i>	ponderosa pine	0	3,100	0	3,100	0.0	3,200	5.6

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Table 33 (continued).

Genus	Species	Common name	1–4.9 inch diameter class (number)	5–10.9 inch diameter class (number)	11+ inch diameter class (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (inch)
<i>Pinus</i>	<i>thunbergii</i>	Japanese black pine	0	0	3,100	3,100	0.0	3,200	26.9
<i>Platanus</i>	<i>hybrida</i>	London planetree	0	7,100	0	7,100	0.1	8,100	6.3
<i>Populus</i>	<i>balsamifera</i>	black cottonwood	357,000	19,000	28,000	403,000	5.3	228,000	3.3
<i>Populus</i>	<i>tremuloides</i>	quaking aspen	0	6,300	0	6,300	0.1	6,300	6.8
<i>Prunus</i>	<i>avium</i>	sweet cherry	48,000	17,000	12,000	77,000	1.0	44,000	4.7
<i>Prunus</i>	<i>cerasifera</i>	cherry plum	0	10,000	16,000	26,000	0.3	11,000	12.9
<i>Prunus</i>	<i>domestica</i>	European plum	0	0	3,100	3,100	0.0	3,200	13.6
<i>Prunus</i>	<i>emarginata</i>	bitter cherry	57,000	13,000	0	70,000	0.9	78,000	4.5
<i>Prunus</i>	<i>laurocerasus</i>	cherry laurel ^a	428,000	52,000	3,100	484,000	6.3	376,000	1.7
<i>Prunus</i>	<i>serrulata</i>	Japanese flowering cherry	0	8,000	17,000	25,000	0.3	14,000	14.3
<i>Pseudotsuga</i>	<i>menziesii</i>	Douglas-fir	50,000	44,000	360,000	454,000	5.9	91,000	21.4
<i>Pyrus</i>	<i>calleryana</i>	Callery pear	0	6,300	14,000	20,000	0.3	13,000	11.8
<i>Pyrus</i>	<i>communis</i>	common pear	0	39,000	4,000	43,000	0.6	40,000	5.9
<i>Quercus</i>	<i>acutissima</i>	sawtooth oak	0	5,500	4,800	10,000	0.1	8,700	9.7
<i>Quercus</i>	<i>bicolor</i>	swamp white oak	0	0	3,100	3,100	0.0	3,200	11.0
<i>Quercus</i>	<i>garryana</i>	Oregon white oak	0	3,900	0	3,900	0.1	3,400	9.0
<i>Quercus</i>	<i>palustris</i>	pin oak	0	0	4,600	4,600	0.1	5,500	23.2
<i>Quercus</i>	<i>rubra</i>	northern red oak	0	0	7,200	7,200	0.1	4,900	24.0
<i>Quercus</i>	<i>velutina</i>	black oak	0	0	3,100	3,100	0.0	3,200	14.5
<i>Robinia</i>	<i>pseudoacacia</i>	black locust	0	3,100	2,300	5,500	0.1	4,200	9.8
<i>Salix</i>	<i>discolor</i>	pussy willow	163,000	55,000	0	219,000	2.8	184,000	4.1
<i>Salix</i>	<i>lasiolepis</i>	arroyo willow	170,000	37,000	2,300	209,000	2.7	247,000	2.6
<i>Salix</i>	<i>scouleriana</i>	Scouler's willow	78,000	23,000	3,900	105,000	1.4	58,000	4.2
<i>Sequoiadendron</i>	<i>giganteum</i>	giant sequoia	50,000	0	0	50,000	0.7	46,000	1.6
<i>Sorbus</i>	<i>aucuparia</i>	European mountain-ash	0	16,000	0	16,000	0.2	14,000	7.1
<i>Syringa</i>	<i>reticulata</i>	Japanese tree lilac	0	4,000	0	4,000	0.1	3,700	6.7
<i>Taxus</i>	<i>brevifolia</i>	Pacific yew	0	3,900	0	3,900	0.1	3,400	7.5
<i>Thuja</i>	<i>occidentalis</i>	northern white-cedar	965,000	153,000	0	1,120,000	14.6	503,000	2.9
<i>Thuja</i>	<i>plicata</i>	western redcedar	174,000	45,000	102,000	321,000	4.2	141,000	9.4

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Table 33 (continued).

Genus	Species	Common name	1–4.9 inch diameter class (number)	5–10.9 inch diameter class (number)	11+ inch diameter class (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (inch)
<i>Tilia</i>	<i>cordata</i>	littleleaf linden	0	0	6,300	6,300	0.1	6,300	12.8
<i>Tsuga</i>	<i>heterophylla</i>	western hemlock	0	16,000	16,000	31,000	0.4	18,000	13.1
<i>Umbellularia</i>	<i>californica</i>	California laurel	39,000	0	0	39,000	0.5	40,000	1.5
<i>Zelkova</i>	<i>serrata</i>	Japanese zelkova	39,000	0	3,100	42,000	0.6	40,000	5.6
Total			4,930,000	1,390,000	1,350,000	7,680,000	100.0	1,120,000	6.3

Due to rounding, not all values will add up exactly.

Diameter measurements were taken at breast height (d.b.h.) or root collar (d.r.c.) for woodland species.

^a Invasive species.

^b Woodland species.

APPENDIX 3 – TREE CHARACTERISTICS WITHIN NLCD LAND COVER CLASSES AND FIA LAND USE

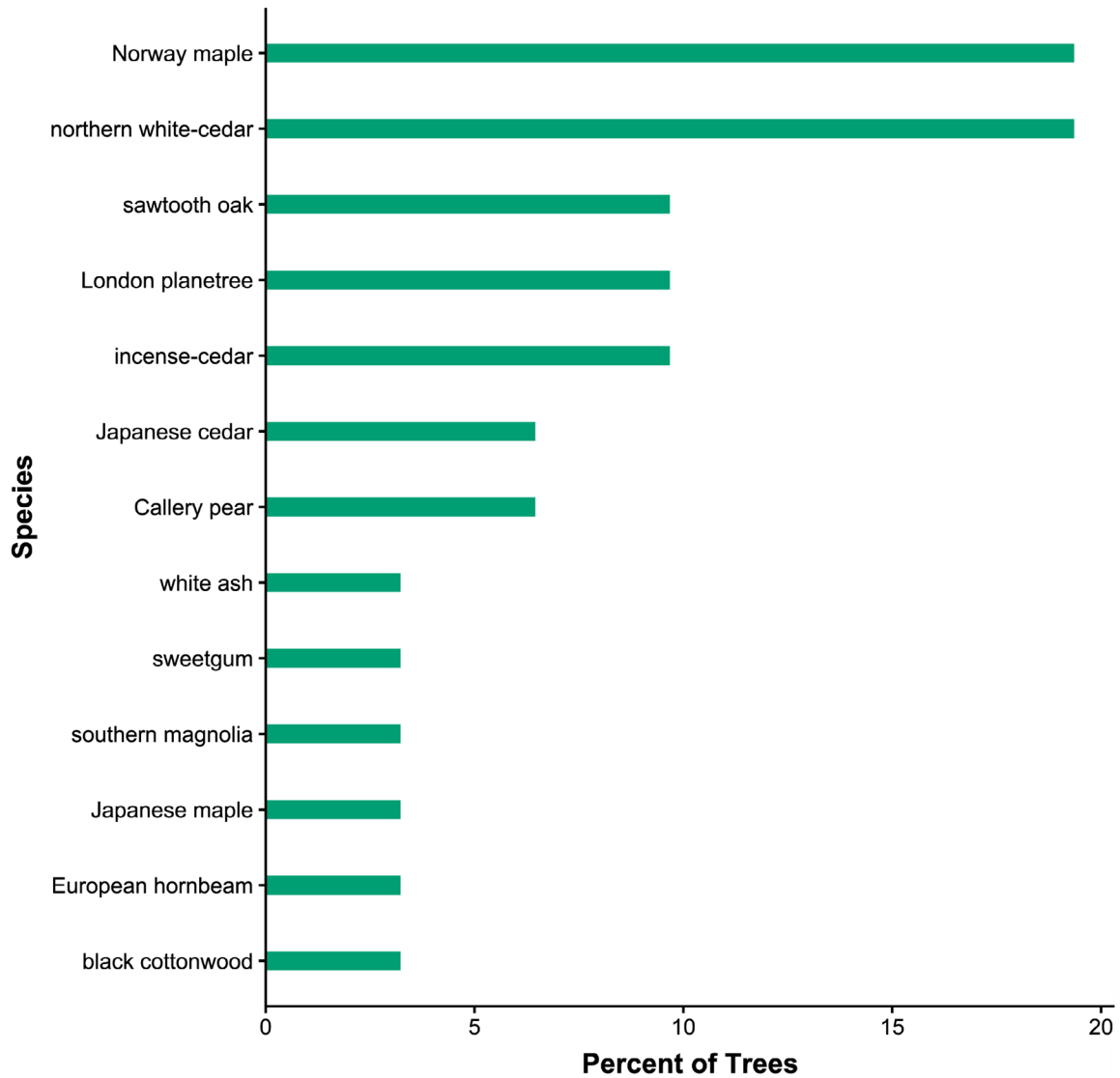


Figure 27.—Percentage of total tree population in Developed-high National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, Portland, Oregon, 2018.

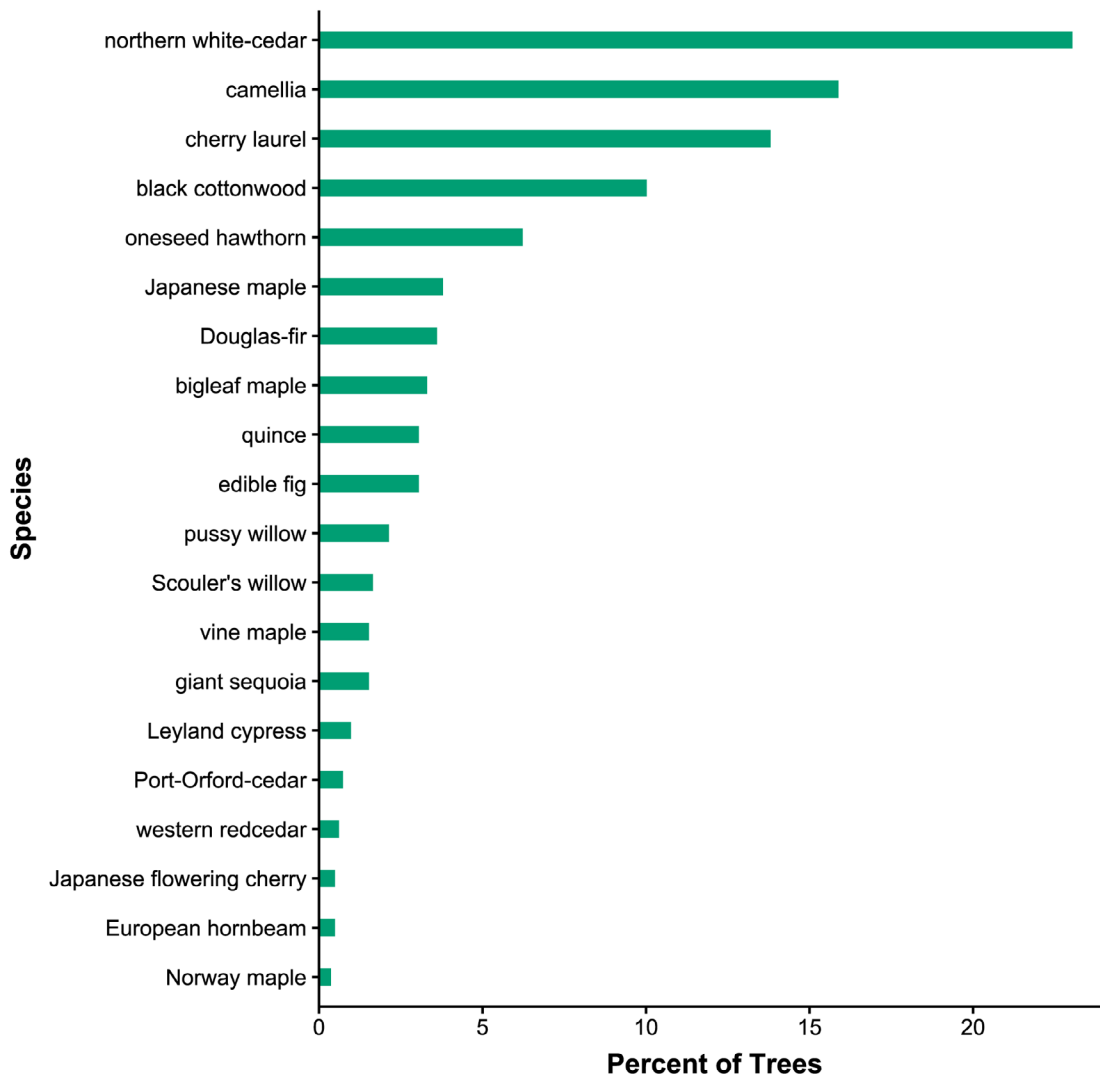


Figure 28.—Percentage of total tree population in Developed-low National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, Portland, Oregon, 2018.

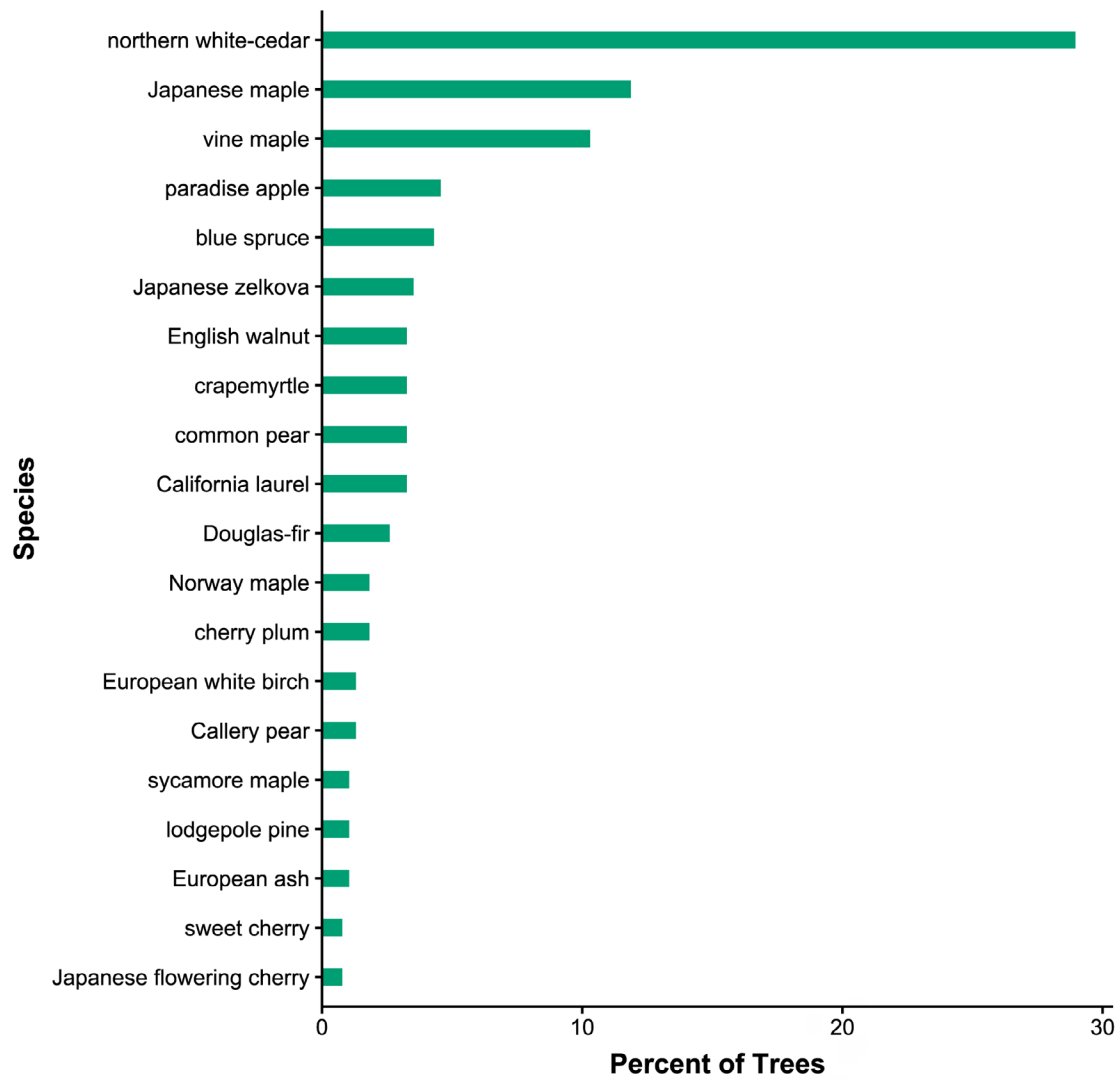


Figure 29.—Percentage of total tree population in Developed-medium National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, Portland, Oregon, 2018.

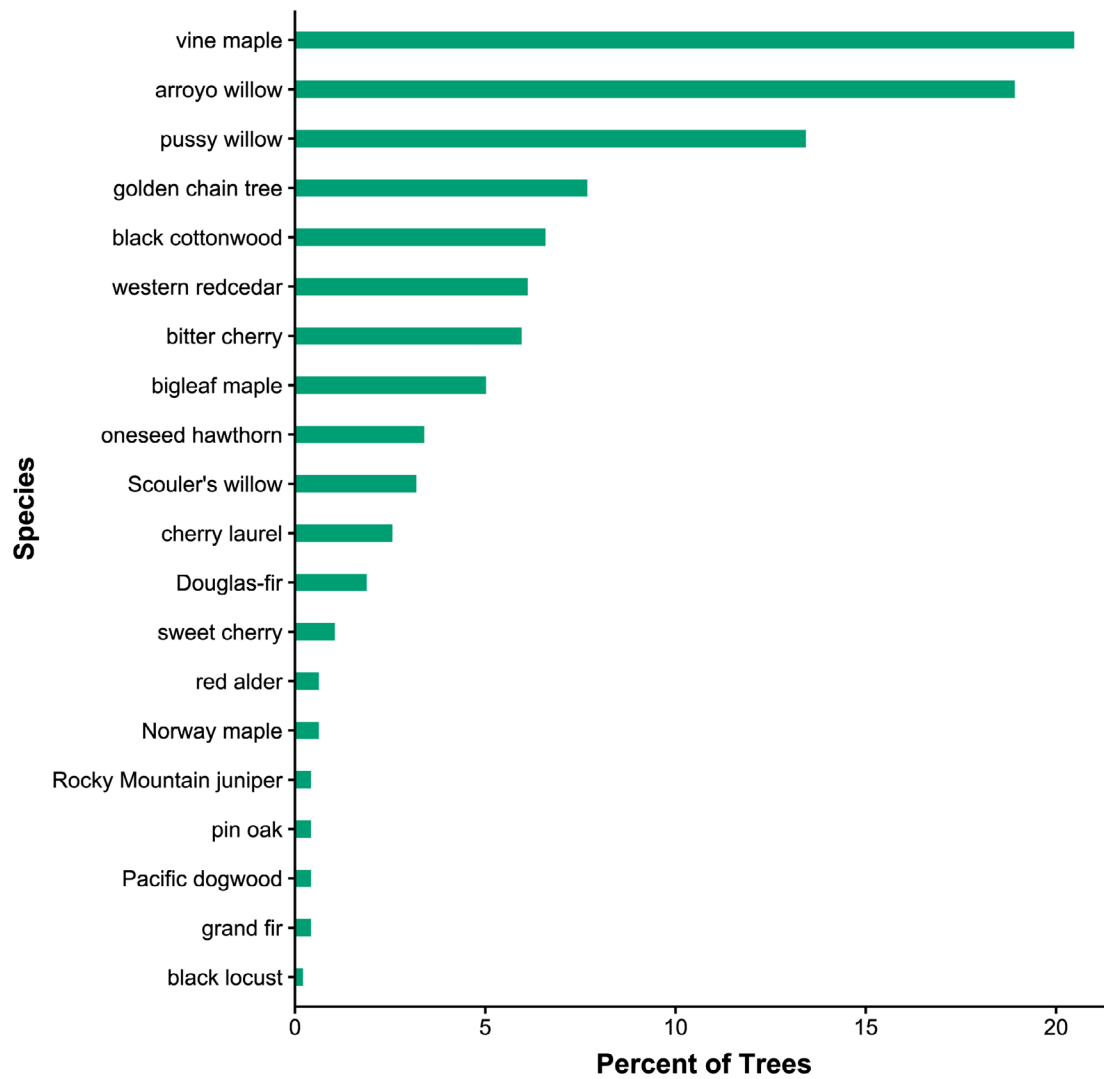


Figure 30.—Percentage of total tree population in Developed-open National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, Portland, Oregon, 2018.

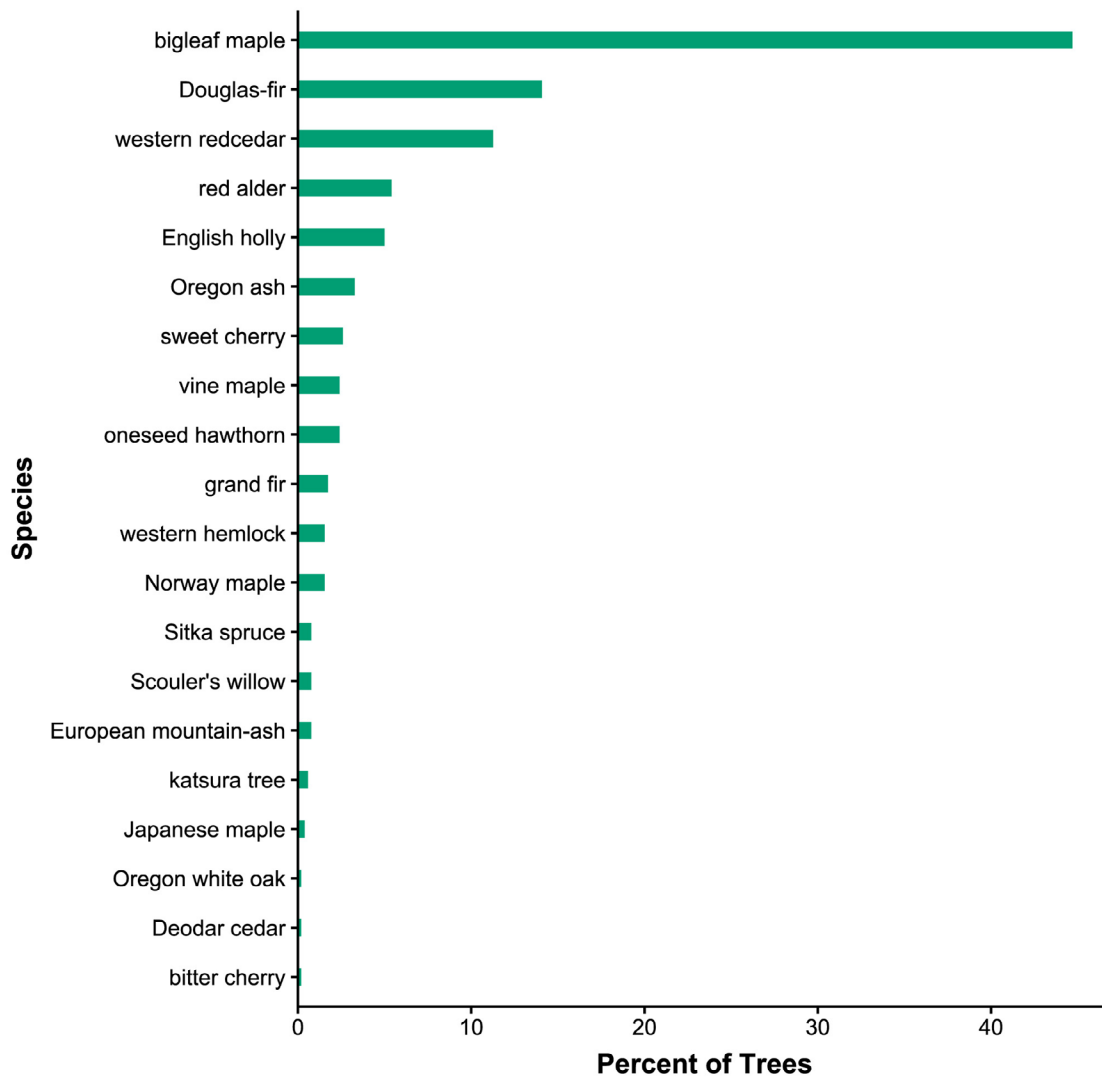


Figure 31.—Percentage of trees in Forest/Shrub National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, Portland, Oregon, 2018.

Table 34.—Estimates of total number of trees, basal area (square feet per acre), and average diameter by aggregated National Land Cover Database (NLCD) land cover class for Portland, Oregon, 2018

NLCD land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inch)
Developed-high	Callery pear	4,759	0.6	19.2
	European hornbeam	2,380	< 0.1	5.3
	Japanese cedar	4,759	0.6	19.4
	Japanese maple	2,380	< 0.1	5.4
	London planetree	7,139	< 0.1	6.3
	Norway maple	14,277	0.5	9.4
	black cottonwood	2,380	< 0.1	9.8
	incense-cedar	7,139	1.3	21.9
	northern white-cedar	14,277	0.2	6.3
	sawtooth oak	7,139	0.3	11.1
	southern magnolia	2,380	0.4	21.5
	sweetgum	2,380	0.1	11.1
	white ash	2,380	0.2	17.2
	American chestnut	4,012	1.0	32.7
	Deodar cedar	4,012	< 0.1	5.9
Developed-low	Douglas-fir	118,216	13.2	15.9
	English walnut	8,024	2.2	33.8
	European ash	4,012	0.3	17.9
	European hornbeam	16,049	0.2	7.5
	European white birch	4,012	0.5	22.3
	Japanese flowering cherry	16,049	0.7	13.2
	Japanese maple	124,090	1.0	5.6
	Japanese red pine	4,012	0.2	14.8
	Japanese tree lilac	4,012	< 0.1	6.7
	Leyland cypress	32,098	0.3	6.6
	Norway maple	12,037	1.2	18.3
	Norway spruce	4,012	0.3	18.3
	Oregon ash	4,012	< 0.1	5.4
	Pacific dogwood	4,012	< 0.1	7.8
	Port-Orford-cedar	24,073	0.8	10.5
	Scouler's willow	54,021	0.2	3.5
	bigleaf maple	108,330	6.9	15.5
	black cottonwood	328,136	3.6	3.4
	black walnut	4,012	1.4	38.0
	blue spruce	4,012	< 0.1	6.6

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Table 34 (continued).

NLCD land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inch)
Developed-low (cont.)	camellia	520,145	0.6	2.0
	cherry laurel ^c	452,226	0.6	1.7
	cherry plum	4,012	< 0.1	9.3
	common pear	4,012	0.2	12.9
	eastern redcedar	8,024	0.1	8.5
	edible fig	100,017	< 0.1	1.8
	flowering dogwood	8,024	0.2	9.8
	giant sequoia	50,008	< 0.1	1.6
	grand fir	4,012	1.0	31.8
	incense-cedar	4,012	1.0	33.0
	northern red oak	4,012	1.0	31.6
	northern white-cedar	754,426	2.5	3.2
	oneseed hawthorn	204,046	0.5	3.0
	paradise apple	4,012	0.2	14.6
	pussy willow	70,069	0.3	3.4
	quince	100,017	< 0.1	1.2
	red alder	4,012	< 0.1	5.4
	red maple	4,012	< 0.1	5.3
	silver maple	4,012	1.2	34.8
	sugar maple	4,012	1.6	40.3
	sweet cherry	4,012	< 0.1	7.1
	sycamore maple	4,012	0.5	23.5
	vine maple	50,008	0.2	3.8
	water birch	4,012	0.3	17.8
	western redcedar	20,061	0.9	12.8
Developed-medium	Amur maple	6,282	0.2	12.1
	Austrian pine	3,141	< 0.1	5.9
	California laurel	39,330	< 0.1	1.5
	Callery pear	15,704	0.3	9.5
	Deodar cedar	3,141	0.6	30.6
	Douglas-fir	31,408	3.5	21.4
	English walnut	39,330	< 0.1	1.4
	European ash	12,563	1.3	23.4
	European larch	3,141	0.3	22.3
	European plum	3,141	0.1	13.6
	European white birch	15,704	0.4	10.9
	Freeman maple	3,141	0.3	21.6

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Table 34 (continued).

NLCD land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inch)
Developed-medium (<i>cont.</i>)	Japanese black pine	3,141	0.4	26.9
	Japanese flowering cherry	9,422	0.5	16.1
	Japanese maple	143,115	0.7	4.5
	Japanese zelkova	42,470	0.3	5.6
	Jeffrey pine	3,141	0.6	32.8
	Norway maple	21,986	1.6	18.9
	Oregon crab apple	3,141	< 0.1	5.6
	black locust	3,141	< 0.1	9.0
	black oak	3,141	0.1	14.5
	blue spruce	51,893	0.3	3.9
	camellia	3,141	< 0.1	5.3
	cherry laurel ^c	3,141	< 0.1	11.3
	cherry plum	21,986	0.8	13.6
	common pear	39,330	0.2	5.2
	crapemyrtle ^d	39,330	0.1	4.4
	flowering dogwood	3,141	0.1	14.9
	goldenrain tree	3,141	< 0.1	5.7
	green ash	3,141	< 0.1	5.7
	hinoki false cypress	6,282	< 0.1	5.1
	kousa dogwood	3,141	< 0.1	6.7
	littleleaf linden	6,282	0.2	12.8
	lodgepole pine	12,563	0.4	11.7
	northern red oak	3,141	0.1	14.4
	northern white-cedar	349,186	0.4	1.9
	oneseed hawthorn	3,141	< 0.1	9.5
	paperbark maple	3,141	< 0.1	5.7
	paradise apple	55,034	0.9	6.2
	ponderosa pine	3,141	< 0.1	5.6
	quaking aspen	6,282	< 0.1	6.8
	red alder	3,141	0.1	15.0
	red maple	3,141	< 0.1	6.6
	sawtooth oak	3,141	< 0.1	6.3
	smoketree	3,141	< 0.1	6.2
	swamp white oak	3,141	< 0.1	11.0
	sweet cherry	9,422	0.2	9.4
	sweetgum	6,282	0.3	13.9
	sycamore maple	12,563	0.8	17.4

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Table 34 (continued).

NLCD land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inch)
Developed-medium (<i>cont.</i>)	vine maple	124,270	0.2	2.1
	western redcedar	6,282	0.6	21.0
	yellow-poplar	3,141	0.2	20.2
Developed-open/Herbaceous	Douglas-fir	20,848	14.0	29.8
	English holly ^c	2,316	0.1	8.0
	Norway maple	6,949	2.4	19.5
	Oregon ash	2,316	0.2	11.4
	Pacific dogwood	4,633	< 0.1	5.5
	Rocky Mountain juniper ^d	4,633	0.2	7.4
	Scouler's willow	35,293	0.3	2.4
	arroyo willow	209,441	1.9	2.6
	bigleaf maple	55,594	8.8	13.2
	bitter cherry	65,953	0.9	4.3
	black cottonwood	72,902	0.8	2.6
	black locust	2,316	0.2	11.0
	cherry laurel ^c	28,344	< 0.1	1.4
	golden chain tree	85,031	0.2	1.8
	grand fir	4,633	1.8	22.4
	oneseed hawthorn	37,609	0.4	2.9
	paradise apple	2,316	< 0.1	6.2
	pin oak	4,633	1.8	23.2
	pussy willow	148,668	2.0	4.4
	red alder	6,949	0.8	11.8
	sweet cherry	11,582	1.2	11.4
	vine maple	226,750	0.3	1.3
	western redcedar	67,723	11.9	11.4
Forest/Shrub	Deodar cedar	3,885	0.3	12.7
	Douglas-fir	283,603	80.9	23.1
	English holly ^c	100,673	0.1	1.4
	European mountain-ash	15,540	0.4	7.1
	Japanese maple	7,770	0.2	7.5
	Norway maple	31,080	2.7	12.8
	Oregon ash	66,045	8.1	15.9
	Oregon white oak	3,885	0.1	9.0
	Pacific yew	3,885	< 0.1	7.5
	Scouler's willow	15,540	1.0	11.1

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Table 34 (continued).

NLCD land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inch)
Forest/Shrub (<i>cont.</i>)	Sitka spruce	15,540	1.4	11.8
	bigleaf maple	899,970	44.0	8.3
	bitter cherry	3,885	0.1	8.3
	grand fir	34,965	2.9	11.8
	katsura tree	11,655	0.4	8.3
	oneseed hawthorn	48,394	< 0.1	1.1
	red alder	108,779	7.2	11.7
	sweet cherry	52,279	0.3	2.2
	vine maple	48,394	< 0.1	1.4
	western hemlock	31,080	2.7	13.1
	western redcedar	226,767	18.6	8.3

^a Basal area is the cross-sectional area of the tree stems measured at the diameter.

^b Diameter measurements were taken at breast height (d.b.h.) or root collar (d.r.c.) for woodland species.

^c Invasive species.

^d Woodland species.

Table 35.—Estimates of total number of trees, basal area, and average diameter by Forest Inventory and Analysis (FIA) land use, Portland, Oregon, 2018

FIA land use	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inch)
Commercial/Industrial	Callery pear	6,282	0.2	8.9
	Deodar cedar	3,141	0.8	30.6
	Douglas-fir	10,914	1.5	19.8
	European hornbeam	2,380	< 0.1	5.3
	Japanese cedar	4,759	0.5	19.4
	Japanese flowering cherry	6,282	0.3	13.6
	Japanese maple	10,150	0.1	7.0
	Japanese zelkova	39,330	0.3	4.9
	Jeffrey pine	3,141	1.0	32.8
	London planetree	7,139	< 0.1	6.3
	Norway maple	14,182	0.6	11.6
	Pacific dogwood	2,316	< 0.1	5.9
	Rocky Mountain juniper ^d	4,633	< 0.1	7.4
	Scouler's willow	6,949	0.1	8.1
	bigleaf maple	15,540	1.5	17.9
	black cottonwood	2,316	< 0.1	9.9
	cherry plum	3,141	0.3	19.0
	golden chain tree	85,031	< 0.1	1.8
	katsura tree	11,655	0.2	8.3
	lodgepole pine	9,422	0.6	13.9
	pin oak	4,633	0.7	23.2
	pussy willow	146,352	0.8	4.4
	sawtooth oak	7,139	0.3	11.1
	southern magnolia	2,380	0.3	21.5
	sweetgum	2,380	< 0.1	11.1
	vine maple	226,750	0.1	1.3
	western redcedar	13,898	1.7	16.3
	white ash	2,380	0.2	17.2
Forest land	Douglas-fir	266,422	90.7	24.6
	English holly ^c	54,596	0.2	1.8
	Norway maple	31,080	2.9	12.8
	Oregon ash	68,361	8.9	15.8
	Oregon white oak	3,885	0.2	9.0
	Pacific dogwood	2,316	< 0.1	5.1

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Table 35 (continued).

FIA land use	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inch)
Forest land (<i>cont.</i>)	Pacific yew	3,885	0.1	7.5
	Scouler's willow	93,892	1.4	3.8
	arroyo willow	209,441	1.3	2.6
	bigleaf maple	816,193	53.2	9.8
	bitter cherry	3,885	0.1	8.3
	black cottonwood	70,586	0.5	2.4
	cherry laurel ^c	28,344	< 0.1	1.4
	grand fir	39,598	4.4	13.0
	oneseed hawthorn	48,394	< 0.1	1.1
	pussy willow	2,316	< 0.1	5.7
	red alder	113,412	8.0	11.6
	sweet cherry	57,660	0.8	3.2
	vine maple	48,394	< 0.1	1.4
	western hemlock	31,080	2.9	13.1
	western redcedar	280,718	25.4	8.6
Multi-family residential	Callery pear	9,422	1.5	10.0
	Douglas-fir	6,282	1.0	10.4
	European hornbeam	8,024	1.1	10.0
	European white birch	3,141	0.3	8.3
	Japanese black pine	3,141	3.2	26.9
	Japanese maple	3,141	0.2	5.9
	Norway maple	3,141	1.4	17.6
	camellia	3,141	0.1	5.3
	cherry plum	6,282	0.9	9.8
	northern red oak	3,141	0.9	14.4
	northern white-cedar	298,457	11.6	5.1
	oneseed hawthorn	3,141	0.4	9.5
	ponderosa pine	3,141	0.1	5.6
	red alder	3,141	1.0	15.0
	swamp white oak	3,141	0.5	11.0
	vine maple	117,989	0.5	1.7
Recreation/Cemetery	Douglas-fir	2,316	4.0	42.8
	Norway maple	8,024	4.4	24.1
	bigleaf maple	18,531	3.4	10.3
	bitter cherry	65,953	1.2	4.3
	black locust	2,316	0.3	11.0

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Table 35 (continued).

FIA land use	Common name	Trees (number)	Basal area^a (square feet/acre)	Average diameter^b (inch)
Recreation/Cemetery (cont.)	northern white-cedar	275,307	0.7	1.6
	oneseed hawthorn	37,609	0.5	2.9
	red alder	4,012	0.1	5.4
	sweet cherry	2,316	0.1	8.0
	vine maple	50,008	0.7	3.8
Residential	Austrian pine	3,141	< 0.1	5.9
	California laurel	39,330	< 0.1	1.5
	Deodar cedar	7,897	0.2	9.2
	Douglas-fir	164,129	15.5	16.3
	English walnut	8,024	1.9	33.8
	European ash	12,563	1.4	23.4
	European hornbeam	8,024	< 0.1	5.0
	European mountain-ash	15,540	0.2	7.1
	European plum	3,141	0.1	13.6
	Freeman maple	3,141	0.3	21.6
	Japanese flowering cherry	19,190	0.9	14.5
	Japanese maple	264,065	1.6	5.0
	Japanese red pine	4,012	0.2	14.8
	Japanese tree lilac	4,012	< 0.1	6.7
	Leyland cypress	32,098	0.3	6.6
	Norway maple	17,243	1.6	18.8
	Norway spruce	4,012	0.3	18.3
	Oregon ash	4,012	< 0.1	5.4
	Port-Orford-cedar	24,073	0.7	10.5
	Scouler's willow	4,012	< 0.1	8.0
	Sitka spruce	15,540	0.7	11.8
	bigleaf maple	68,447	4.2	16.1
	black cottonwood	178,111	3.0	5.1
	black walnut	4,012	1.2	38.0
	blue spruce	55,905	0.4	4.1
	camellia	520,145	0.5	2.0
	cherry laurel ^c	455,366	0.6	1.8
	cherry plum	9,422	0.4	14.4
	common pear	43,342	0.4	5.9

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Table 35 (continued).

FIA land use	Common name	Trees (number)	Basal area^a (square feet/acre)	Average diameter^b (inch)
Residential (<i>cont.</i>)	crapemyrtle ^d	39,330	0.2	4.4
	eastern redcedar	8,024	0.1	8.5
	edible fig	100,017	< 0.1	1.8
	flowering dogwood	11,165	0.3	11.2
	giant sequoia	50,008	< 0.1	1.6
	grand fir	4,012	0.8	31.8
	hinoki false cypress	6,282	< 0.1	5.1
	incense-cedar	11,151	1.7	25.9
	lodgepole pine	3,141	< 0.1	5.0
	northern red oak	4,012	0.8	31.6
	northern white-cedar	504,795	0.9	2.4
	oneseed hawthorn	204,046	0.5	3.0
	paperbark maple	3,141	< 0.1	5.7
	paradise apple	6,329	0.2	11.5
	pussy willow	70,069	0.2	3.4
	quaking aspen	6,282	< 0.1	6.8
	quince	100,017	< 0.1	1.2
	red alder	2,316	0.2	18.1
	red maple	4,012	< 0.1	5.3
	silver maple	4,012	1.0	34.8
	smoketree	3,141	< 0.1	6.2
	sweet cherry	14,179	0.3	9.8
	sweetgum	6,282	0.3	13.9
	sycamore maple	16,576	1.3	18.8
	vine maple	6,282	< 0.1	8.5
	water birch	4,012	0.3	17.8
	western redcedar	26,215	1.4	14.6
	yellow-poplar	3,141	0.3	20.2
Rights-of-way	American chestnut	4,012	1.3	32.7
	Amur maple	6,282	0.3	12.1
	Callery pear	4,759	0.5	19.2
	Douglas-fir	4,012	0.8	25.2
	English holly ^c	48,394	< 0.1	1.3
	English walnut	39,330	< 0.1	1.4
	European ash	4,012	0.4	17.9

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Table 35 (continued).

FIA land use	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inch)
Rights-of-way (<i>cont.</i>)	European larch	3,141	0.5	22.3
	European white birch	16,576	1.1	14.2
	Japanese zelkova	3,141	0.2	13.9
	Norway maple	12,659	0.8	13.3
	Oregon crab apple	3,141	< 0.1	5.6
	Pacific dogwood	4,012	< 0.1	7.8
	bigleaf maple	145,182	0.2	2.0
	black cottonwood	152,405	0.2	1.6
	black locust	3,141	< 0.1	9.0
	black oak	3,141	0.2	14.5
	cherry plum	7,153	0.3	11.1
	goldenrain tree	3,141	3< 0.1	5.7
	green ash	3,141	< 0.1	5.7
	kousa dogwood	3,141	< 0.1	6.7
	littleleaf linden	6,282	0.3	12.8
	northern white-cedar	39,330	< 0.1	1.1
	paradise apple	55,034	1.4	6.2
	red maple	3,141	< 0.1	6.6
	sawtooth oak	3,141	< 0.1	6.3
	sugar maple	4,012	1.9	40.3
	sweet cherry	3,141	< 0.1	6.7

Due to rounding, not all values will add up exactly.

^a Basal area is the cross-sectional area of the tree stems measured at the diameter.

^b Diameter measurements were taken at breast height (d.b.h.) or root collar (d.r.c.) for woodland species.

^c Invasive species.

^d Woodland species.

APPENDIX 4 – SPECIES COMPOSITION IN MAINTAINED AREAS

Table 36.—Species composition in maintained areas, Portland, Oregon, 2018

Common name	Number of trees	Common name	Number of trees	Common name	Number of trees
northern white-cedar	754,000	sweet cherry	13,000	American chestnut	4,000
camellia	523,000	lodgepole pine	13,000	Oregon ash	4,000
Japanese maple	277,000	Sitka spruce	12,000	black walnut	4,000
vine maple	174,000	katsura tree	12,000	Japanese tree lilac	4,000
Douglas-fir	116,000	flowering dogwood	11,000	Japanese red pine	4,000
cherry laurel	104,000	incense-cedar	11,000	Jeffrey pine	3,100
edible fig	100,000	Deodar cedar	11,000	ponderosa pine	3,100
blue spruce	56,000	sawtooth oak	10,000	Austrian pine	3,100
paradise apple	55,000	sweetgum	8,700	red alder	3,100
giant sequoia	50,000	eastern redcedar	8,000	oneseed hawthorn	3,100
bingleaf maple	48,000	English walnut	8,000	green ash	3,100
common pear	43,000	red maple	7,200	yellow-poplar	3,100
Japanese zelkova	42,000	northern red oak	7,200	Oregon crab apple	3,100
Norway maple	41,000	London planetree	7,100	European plum	3,100
California laurel	39,000	quaking aspen	6,300	swamp white oak	3,100
crapemyrtle	39,000	Amur maple	6,300	black oak	3,100
Leyland cypress	32,000	hinoki false cypress	6,300	black locust	3,100
western redcedar	31,000	littleleaf linden	6,300	smoketree	3,100
cherry plum	26,000	Japanese cedar	4,800	paperbark maple	3,100
Japanese flowering cherry	25,000	pin oak	4,600	Freeman maple	3,100
Callery pear	20,000	grand fir	4,000	kousa dogwood	3,100
European white birch	20,000	Port-Orford-cedar	4,000	European larch	3,100
European hornbeam	18,000	Norway spruce	4,000	goldenrain tree	3,100
sycamore maple	17,000	silver maple	4,000	Japanese black pine	3,100
European ash	17,000	sugar maple	4,000	white ash	2,400
European mountain-ash	16,000	water birch	4,000	southern magnolia	2,400

Due to rounding, not all values will add up exactly.

APPENDIX 5 – DAMAGE, MAINTENANCE AND SITE ISSUES BY SPECIES

Table 37.—Percent of live trees identified with damage, maintenance and site issues, Portland, Oregon, 2018

Common name	Sample (n)	Bark inclusion (percent)	Crown conflict (percent)	Excess mulch (percent)	Improper planting (percent)	Root conflict (percent)	Root/stem girdling (percent)	Topping/pruning (percent)
American chestnut	1	100.0	0.0	0.0	0.0	100.0	0.0	0.0
Amur maple	2	0.0	0.0	0.0	100.0	0.0	0.0	0.0
arroyo willow	23	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Austrian pine	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0
bigleaf maple	191	0.7	4.5	0.0	5.0	0.0	0.0	0.0
bitter cherry	7	0.0	0.0	0.0	6.6	0.0	0.0	0.0
black locust	2	57.6	0.0	0.0	42.4	0.0	0.0	0.0
black oak	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
black walnut	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
blue spruce	6	5.6	0.0	5.6	0.0	0.0	0.0	0.0
California laurel	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Callery pear	7	23.3	0.0	0.0	69.3	54.0	0.0	0.0
camellia	16	0.0	0.0	0.0	38.8	0.0	0.0	0.0
cherry laurel	23	0.0	7.5	0.0	2.5	0.0	0.0	0.0
cherry plum	8	63.8	27.5	0.0	84.6	12.1	0.0	0.0
common pear	2	0.0	0.0	0.0	90.7	0.0	0.0	0.0
Douglas-fir	110	4.7	0.0	0.0	4.1	0.7	0.0	0.0
European ash	5	100.0	37.9	0.0	0.0	75.8	0.0	0.0
European hornbeam	5	21.8	0.0	0.0	65.3	0.0	0.0	0.0
European larch	1	100.0	100.0	0.0	0.0	0.0	0.0	0.0
European mountain-ash	4	0.0	0.0	0.0	100.0	0.0	0.0	0.0
European plum	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0
European white birch	6	84.1	20.3	0.0	15.9	31.9	0.0	15.9
flowering dogwood	3	71.9	0.0	0.0	100.0	0.0	0.0	0.0
goldenrain tree	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0
grand fir	12	9.2	0.0	0.0	5.3	0.0	0.0	0.0
green ash	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
incense-cedar	4	36.0	21.3	0.0	42.7	0.0	0.0	0.0
Japanese flowering cherry	7	12.3	15.8	0.0	59.6	15.8	0.0	0.0
Japanese maple	22	1.1	0.0	1.4	52.0	1.1	0.0	0.0
Japanese red pine	1	100.0	100.0	0.0	0.0	0.0	0.0	0.0
Japanese zelkova	2	7.4	0.0	0.0	100.0	0.0	0.0	0.0

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Table 37 (continued).

Common name	Sample (n)	Bark inclusion (percent)	Crown conflict (percent)	Excess mulch (percent)	Improper planting (percent)	Root conflict (percent)	Root/stem girdling (percent)	Topping/pruning (percent)
kousa dogwood	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Leyland cypress	8	0.0	100.0	0.0	25.0	0.0	0.0	0.0
littleleaf linden	2	100.0	0.0	0.0	100.0	0.0	0.0	0.0
lodgepole pine	4	0.0	0.0	0.0	25.0	0.0	0.0	0.0
northern red oak	2	56.1	43.9	0.0	0.0	0.0	0.0	0.0
northern white-cedar	64	0.2	6.5	0.0	53.6	0.0	0.0	0.0
Norway maple	27	19.2	8.3	0.0	13.6	10.9	0.0	0.0
oneseed hawthorn	12	0.0	0.0	0.0	17.8	0.0	0.0	0.0
Oregon ash	19	0.0	0.0	0.0	26.8	0.0	0.0	0.0
Oregon crab apple	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
paperbark maple	1	100.0	0.0	100.0	0.0	0.0	0.0	0.0
paradise apple	8	25.6	0.0	0.0	6.5	0.0	0.0	0.0
Port-Orford-cedar	6	16.7	0.0	0.0	83.3	16.7	0.0	0.0
red alder	33	0.0	0.0	0.0	9.5	2.6	0.0	0.0
red maple	2	43.9	0.0	0.0	100.0	0.0	0.0	56.1
sawtooth oak	4	30.6	0.0	0.0	46.3	46.3	0.0	0.0
Scouler's willow	10	0.0	0.0	0.0	8.1	0.0	0.0	0.0
southern magnolia	1	100.0	0.0	100.0	0.0	100.0	0.0	0.0
sugar maple	1	100.0	0.0	0.0	100.0	100.0	0.0	0.0
swamp white oak	1	0.0	100.0	0.0	0.0	100.0	0.0	0.0
sweet cherry	11	4.1	4.1	0.0	8.1	0.0	0.0	0.0
sweetgum	3	36.3	0.0	0.0	36.3	0.0	0.0	27.5
sycamore maple	5	37.9	0.0	0.0	100.0	37.9	0.0	0.0
vine maple	15	0.0	28.6	0.0	1.4	0.0	0.0	0.0
water birch	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0
western redcedar	49	2.0	0.0	0.0	0.7	0.0	0.0	0.0
yellow-poplar	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0

Due to rounding, not all values will add up exactly.
This table includes only the live tree population.

APPENDIX 6 – LIST OF INVASIVE PLANT SPECIES

Table 38.—List of invasive plant species inventoried in Portland, Oregon, 2018

Genus	Species	Common name
<i>Alliaria</i>	<i>petiolata</i>	garlic mustard
<i>Arum</i>	<i>italicum</i>	Italian lords and ladies
<i>Buddleja</i>	<i>davidii</i>	orange eye butterflybush
<i>Clematis</i>	<i>vitalba</i>	evergreen clematis
<i>Conium</i>	<i>maculatum</i>	poison hemlock
<i>Convolvulus</i>	<i>arvensis</i>	field bindweed
<i>Cytisus</i>	<i>scoparius</i>	Scotch broom
<i>Daphne</i>	<i>laureola</i>	spurgelaurel
<i>Hedera</i>	<i>helix</i>	English ivy
<i>Ilex</i>	<i>aquifolium</i>	English holly
<i>Impatiens</i>	<i>capensis</i>	jewelweed
<i>Impatiens</i>	<i>glandulifera</i>	ornamental jewelweed
<i>Iris</i>	<i>pseudacorus</i>	paleyellow iris
<i>Lamium</i>	<i>galeobdolon</i>	yellow archangel
<i>Lythrum</i>	<i>salicaria</i>	purple loosestrife
<i>Phytolacca</i>	<i>americana</i>	American pokeweed
<i>Polygonum</i>	<i>cuspidatum</i>	Japanese knotweed
<i>Prunus</i>	<i>laurocerasus</i>	cherry laurel
<i>Ranunculus</i>	<i>ficaria</i>	fig buttercup
<i>Rubus</i>	<i>armeniacus</i>	Himalayan blackberry

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