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Washington, DC's Urban Forest, 2018



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Abstract

A 2018 analysis of the urban forest in Washington, DC reveals that this area has an estimated 2 million live trees across all ownerships. The most common tree species by number are American beech, red maple, American holly, yellow-poplar, and American elm. Trees in Washington, DC are estimated to store about 487,163 tons of carbon (1.8 million tons of carbon dioxide [CO₂]) valued at \$83.1 million. In addition, it is estimated that these trees remove about 15,000 tons of carbon per year (or 55,000 tons CO₂ per year, valued at \$2.6 million per year, an amount roughly equivalent to the annual emissions associated with 10,900 passenger vehicles or energy usage by 6,000 homes [Greenhouse Gas Equivalencies Calculator, U.S. EPA 2020]) and about 318 tons of air pollution per year (valued at \$11.2 million per year). Washington, DC's urban forest is estimated to reduce annual energy costs of residential buildings by \$4.2 million per year. The overall compensatory value of the urban forest is estimated at \$2.1 billion. Compensatory value describes the replacement value of trees as a structural asset, which tends to increase with trees' size and health. The information presented in this report can be used to support urban forest management programs and to inform policy and planning to improve environmental quality and human health in Washington, DC. The analysis also provides 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 Forestry Division truck in front of the United States Capitol. Courtesy photo by District Department of Transportation, Urban Forestry Division.

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Nancy F. Sonti, Kasey Yturalde, Earl Eutsler, Christina Herrick, Robert E. Hoehn III, Katie Jennings, Lucie C. Lepine

Contact Author

Nancy F. Sonti

nancy.f.sonti@usda.gov

(929) 400-1700

About the Authors

NANCY F. SONTI is a research ecologist with the USDA Forest Service, Northern Research Station, Baltimore, MD.

KASEY YTURALDE was the forest health and community outreach specialist with the Urban Forestry Division, District Department of Transportation, Washington, DC. Kasey is now a natural resource specialist with the USDA Forest Service, Urban and Community Forestry Program, Washington, DC.

EARL EUTSLER is the associate director of the District Department of Transportation's Urban Forestry Division, and serves as the state forester of Washington, DC.

CHRISTINA HERRICK is a research scientist with the University of New Hampshire and a cooperating researcher in Information Management with the USDA Forest Service in Durham, NH.

ROBERT E. HOEHN III is a forester with the USDA Forest Service, Northern Research Station, Syracuse, NY.

KATIE JENNINGS is a biological scientist with the USDA Forest Service, Northern Research Station, Durham, NH.

LUCIE C. LEPINE is a research scientist with the University of New Hampshire and a cooperating researcher in Information Management with the USDA Forest Service, Durham, NH.

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EXECUTIVE SUMMARY



Scarlet oak tree in Washington, DC.
Courtesy photo by District Department of
Transportation, Urban Forestry Division.

The City of Washington, DC was sampled in 2018 to assess the magnitude, composition, and value of its urban forest resource. The sampled area of the city (representing a total of 43,736 acres), is estimated to contain 2 million live trees¹, 58.7 percent of which are less than 5.0 inches in **diameter**². The most common tree species at least 1.0 inch in diameter are American beech, red maple, American holly, yellow-poplar, and American elm. The most common large-diameter tree species (11.0+ inches in diameter) are yellow-poplar, white oak, chestnut oak, American elm, and red maple. The most important species based on the number of trees and leaf area are yellow-poplar, American beech, red maple, white oak, and chestnut oak.

¹ Common and scientific names for all tree species observed in the 2018 Urban FIA inventory of Washington, DC are reported in Appendix 2 (Table 32).

² See glossary for definition of bolded terms.



The majority of trees are found on **forest land** (58.3 percent; 1.2 million trees). Overall, 31.1 percent of trees are classified as growing in maintained areas. Trees on public lands total 1.6 million and account for 78.2 percent of the total live tree population. Trees on private lands total 439,778 and account for 21.8 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) is estimated at \$2.1 billion with the urban forest producing over \$21.5 million in annual benefits (Table 1).

The tree species with the greatest estimated average percent dieback and rot (7.8 and 3.3 percent, respectively) was red maple. The most common urban damages affecting all tree species in the sampling area are bark inclusion (5.8 percent of trees) and conflict with crown (5.4 percent of trees).

Invasive plant species also threaten to alter forest composition and are found on 56.8 percent of the sampled plots; English ivy (*Hedera helix*) was estimated to cover the largest area of any invasive plant species in the city (592 acres).

These natural and anthropogenic threats may affect the health and composition of Washington, DC's urban forest. Through 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.

Table 1.—Summary of urban forest estimates, Washington, DC, 2018

Feature	Estimate
Number of trees^a	
Total live trees	2 million (295,989) ^b
Live saplings (1 to 4.9 inches in diameter)	1.2 million (255,000) ^b
Live trees (at least 5.0 inches in diameter)	831,000 (70,730) ^b
Standing dead saplings (1 to 4.9 inches in diameter)	36,000 (27,000) ^b
Standing dead trees (at least 5.0 inches in diameter)	94,000 (37,000) ^b
Most abundant species by:	
Number of live trees	American beech
Leaf area	yellow-poplar
Ecosystem services	
Pollution removal	318 tons/year (\$11.2 million/year)
Reduction in acute respiratory symptoms	866 cases/year (\$77,000/year)
VOC emissions	480 tons/year
Avoided runoff	30.1 million cubic feet (\$2.0 million/year)
Carbon storage ^c	487,000 tons (\$83.1 million)
Carbon sequestration ^c	15,000 tons/year (\$2.6 million/year)
Net aboveground volume	34.1 million cubic feet
Reduced building energy use ^{c,d}	283,000 GJ/year (\$4.2 million/year)
Reduced carbon emissions ^{c,d}	9,200 tons/year (\$1.6 million/year)
Compensatory value	\$2.1 billion

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

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

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

^b Numbers in parentheses are standard error.

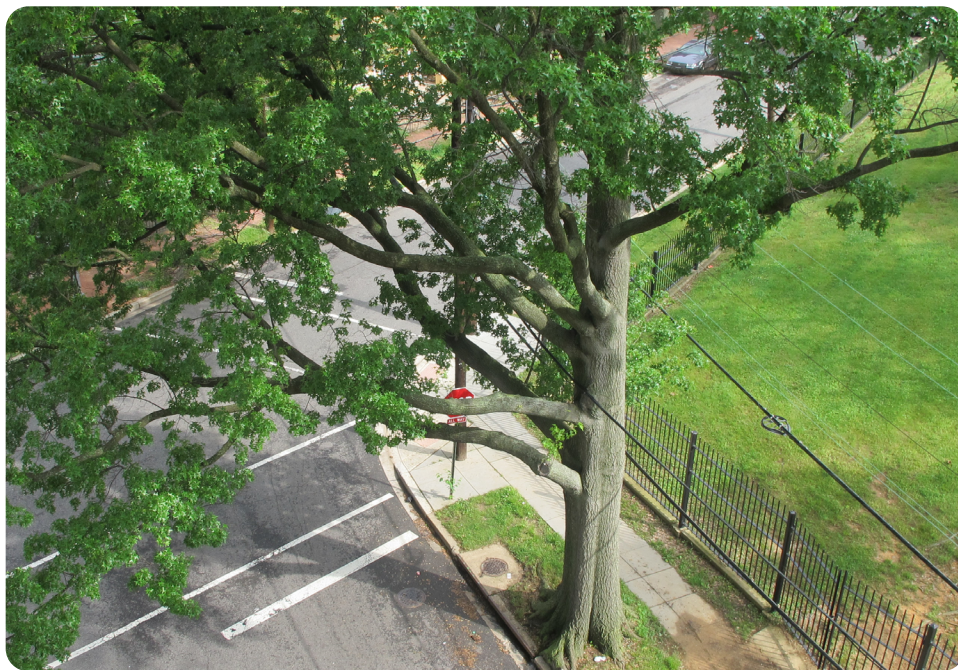
^c Estimates are for the live and dead tree population. All other estimates are based on the live tree population only, except where noted.

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

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BACKGROUND



The canopy of a northern red oak street tree stretches across an intersection in Washington, DC. Courtesy photo by District Department of Transportation, Urban Forestry Division.

Urban **forests**³ 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) that includes a special focus on the Nation's most populous cities.

In this report, the term “urban forest” describes all trees⁴ located in the city across both public and private ownerships, including planted trees along streets and avenues, trees in parks and residential yards, remnant forest 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

³ See glossary for definition of bolded terms.

⁴ Common and scientific names for all tree species observed in the 2018 Urban FIA inventory of Washington, DC are reported in Appendix 2 (Table 32).



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, Washington, DC 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 and is one of the first complete inventories administered by the Forest Service's Northern Research Station. During the 2018 field season, Washington, DC's 7-year measurement cycle was accelerated and completed during a single field season. The District of Columbia State Forest Action Plan (DDOT 2020) aims to: "expand, preserve, and improve the city's urban forest; to cultivate an urban forest that is equitable, inclusive, and accessible; and to foster shared stewardship across multiple jurisdictions in the region." The Urban FIA inventory of Washington, DC's urban forest resource and the estimated values associated with this resource described in this report support District of Columbia State Forest Action Plan (DDOT 2020) objectives by providing a baseline assessment of the extent and composition of the urban forest and associated ecosystem services. This information can inform future management decisions aimed at enhancing forest health, sustainability, and benefits.

Providing accurate data describing Washington, DC's urban forest resources can help natural resource managers and residents understand the numerous environmental, economic, and public health benefits conferred by urban forests and the potential threats to these forests. Urban forest inventory data can be useful in helping managers address interrelated challenges such as a projected population increase of approximately 300,000 people in Washington, DC in the 25 years following this inventory (Government of the District of Columbia 2019), flooding and drought stress related to climate change, and emerging risks from pests and pathogens such as the **invasive** spotted lanternfly (SLF; *Lycorma delicatula*), beech leaf disease (BLD; *Litylenchus crenatae* ssp. *mccannii*), and oak wilt (OW; *Bretziella fagacearum*, formerly known as *Ceratocystis fagacearum*). Data describing Washington DC's urban forest can be utilized to develop management strategies, forecasts, and programs for improving forest health and resilience in partnership with city government, nonprofit organizations, surrounding state and county jurisdictions, the federal government, and private consultants.

METHODS

To evaluate the extent, composition, and benefits of Washington, DC's urban forest and establish a baseline for future monitoring, a sample-based inventory was conducted following Urban FIA monitoring methods and reporting tools described in the Urban FIA Northern Research Station (NRS) Field Guide Version 7.1 (USDA Forest Service 2017) and the [online supplement](#) (Baer et al. 2024) to this report, along with i-Tree Eco modeling software (www.itreetools.org; Baer et al. 2024; Nowak 2020). This process established

survey plots across Washington, DC and aims to revisit those plots every 7 years. Future reports can build on these data and consistently provide information on urban forest extent, diversity, health condition, and benefits. During the 2018 field season, Washington, DC's 7-year measurement cycle was accelerated and completed during a single field season with resources provided by the District of Columbia's Department of Transportation's Urban Forestry Division. The sampling area for Washington, DC was defined by the U.S. Census Bureau Designated Places boundary for Washington, DC (highlighted in red in Fig. 1a). The Urban FIA sample consisted of 187 plots located within the sampling boundary (Fig. 1b). Data were collected on 165 of these plots between May and October 2018. Data were collected on an additional 11 plots located on National Park Service property in July 2021. In total, the urban FIA sample surveyed 176 plots across the city's 43,736 acres within the designated sampling area in Washington, DC (Fig. 1). The remaining 11 plots were not sampled either due to hazardous conditions or lack of permission to access the plot.

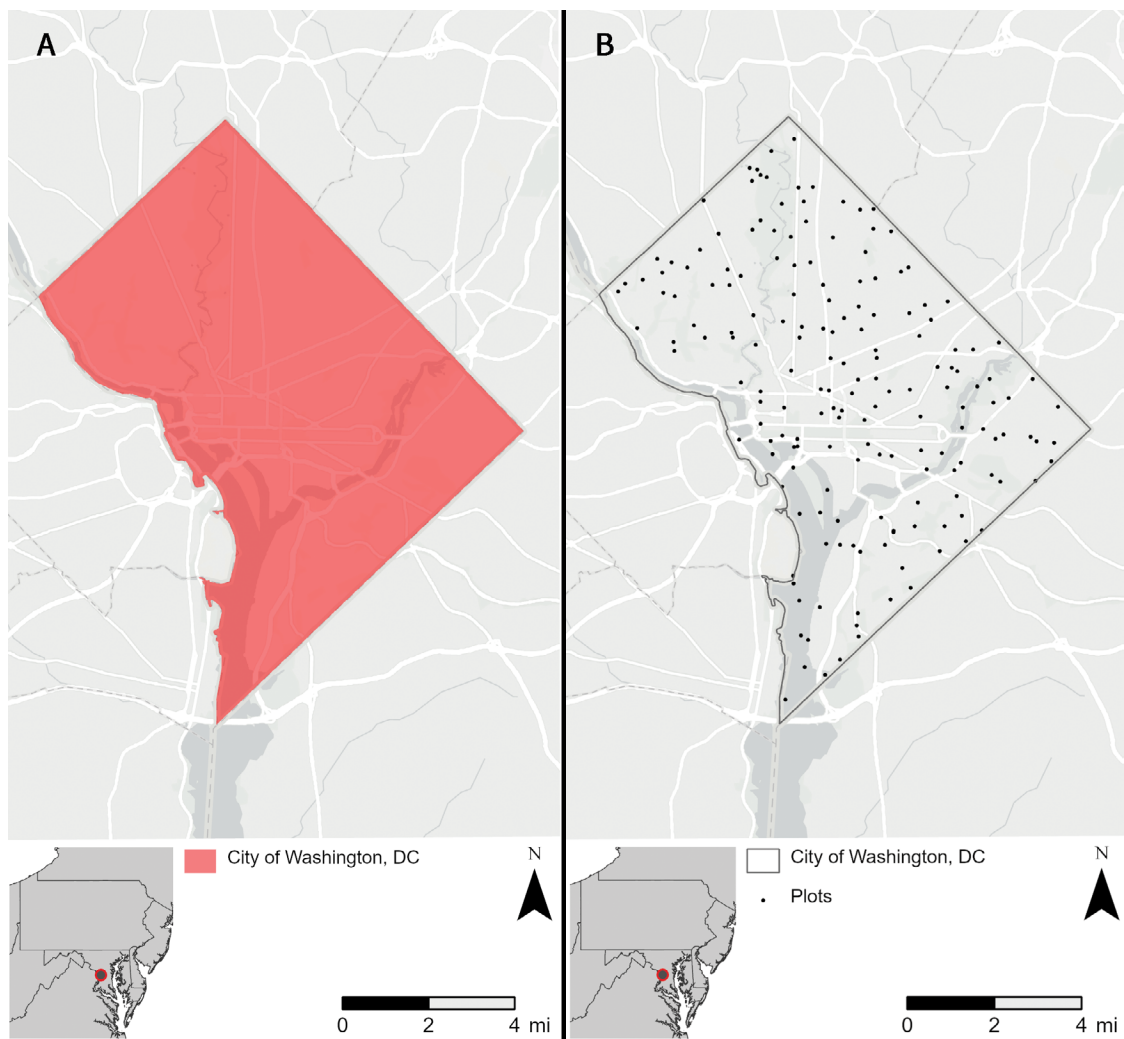


Figure 1.— Study area (A) and approximate plot locations (B) for the Urban Forest Inventory and Analysis (FIA) inventory, Washington, DC, 2018. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

New methods were implemented in the inventory of Washington, DC's urban forest to allow for flexibility in the estimation of tree characteristics for forked trees. In this inventory, all stems of forked trees are quantified and characterized as part of the same tree. All extrapolated estimates for forked trees are based on this approach except for estimates of tree merchantability and volume estimation. Refer to Baer et al. (2024) for more detailed information. Throughout this report, except where explicitly noted, trees refer to woody plant species listed in Appendix 3 and 3B of the Urban FIA NRS Field Guide Version 7.1 (USDA Forest Service 2017) with **diameters** of at least 1.0 inch, and results are given for live trees.

The collected data were analyzed using FIA methodology and i-Tree Eco modeling software outlined in Baer et al. (2024). 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 report were created using ArcGIS® software by Esri (ArcGIS® Pro version 2.9; Esri 2021). ArcGIS® is the intellectual property of Esri and are 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 (C) 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 allows users to explore results and print data queries. Data tables are also available for download from FIA's Urban DataMart.

AREA AND COVER CHARACTERISTICS



American elm tree in Washington, DC.
Courtesy photo by District Department of
Transportation, Urban Forestry Division.

Washington, DC experienced the seventh highest growth rate in the United States during 2010–2020. The 2020 Census reported the District's population at 689,545, a 14.6 percent increase since the 2010 Census. As a result, Washington, DC's population density grew to 11,281 per square mile in 2020, up from 9,857 per square mile in 2010 (US Census Bureau 2020). During the previous decade, between 2000 and 2010, DC's population grew by 5.2 percent, or just under 30,000 people, from 572,059 to 601,723; between 2010 and 2020, the District's population grew by nearly 88,000 people (US Census Bureau 2020). The population increase has been accompanied by urban development across the region, resulting in an increase in impervious cover from 22 percent in 1984 to 26 percent in 2010 (Song et al. 2016). Impervious cover within the District has also increased in recent years, from approximately 37 percent in 2006 to 41 percent in 2020 (PlanIT Geo 2021).



Land Cover

National land cover data were used to analyze 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 (Table 31). The most prevalent land cover classification is developed-medium, followed by developed-low, developed-open/herbaceous, and developed-high (Table 3). Areas of forest/shrub land cover are estimated to contain the greatest proportion of trees in the sampling area of any land cover (55.9 percent), followed by developed-open/herbaceous, developed-medium and developed-low land covers (20.2 percent, 12.6 and 9.1 percent of the trees in the sampling area, respectively).

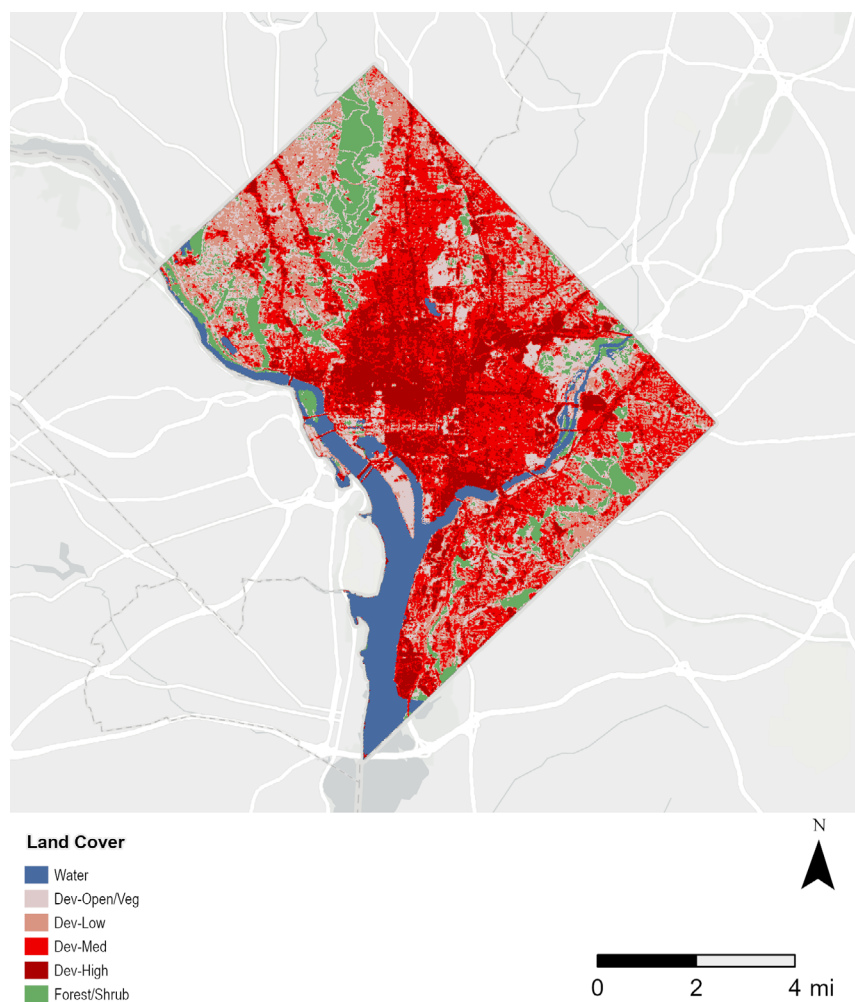


Figure 2.—Distribution of National Land Cover Database (NLCD) (Homer et al. 2015) land cover classes, Washington, DC, 2018. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Table 2.—National Land Cover Database (NLCD) land cover classes and subclasses, Washington, DC, 2018

NLCD land cover	NLCD land cover subclasses
Developed-open/herbaceous	Developed-open space, Grassland/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: Homer et al. 2015.

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

Table 3.—Sample area and count of plots within National Land Cover Database (NLCD) land cover classes in Washington, DC, 2018

NLCD Land cover	Area (acres)	City land area (percent)	Plots (number)
Developed-medium	12,820	29	53
Developed-low	10,260	23	33
Developed-open/herbaceous	7,050	16	32
Developed-high	5,080	12	24
Forest/Shrub	4,452	10	19
Water	4,074	9	15
Total	43,736	100	176

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 Washington, DC.

Rights-of-way is the most prevalent land use class in Washington, DC, covering 23.9 percent of the city area (containing 8.5 percent of the city's trees), followed by commercial/industrial (16.9 percent of the city area), single-family residential (hereafter, residential) (15 percent), multi-family residential (11.8 percent), and water (11.1 percent) (Table 5).

Table 4.—Forest Inventory and Analysis (FIA) land use classes and subclasses, Washington, DC, 2018

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: USDA Forest Service 2017.

Table 5.—Sample area and count of plots within Forest Inventory and Analysis (FIA) land use classes, Washington, DC, 2018

FIA land use class	Area (acres)	Standard error (acres)	City land (percent)	Plots (number)
Forest land	4,482	695	10.2	19.2
Commercial/Industrial	7,406	1,163	16.9	31.4
Multi-family residential	5,177	1,002	11.8	20.8
Residential	6,560	1,007	15.0	23.6
Recreation/Cemetery	4,795	805	11.0	21.4
Rights-of-way	10,451	1,112	23.9	41.1
Water	4,865	463	11.1	18.4
Total	43,736	1,009	100.0	176.0

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

Tree, Shrub, and Ground Cover

Tree cover in Washington, DC is estimated at 20.7 percent and shrub cover at 5.1 percent based on field crew assessments. Field plot estimates are used to evaluate tree cover and can have a relatively high degree of uncertainty due to the nature of tree cover data collection in the field and effects of sample size. Generally, better tree cover estimates can be derived from photointerpretation or high-resolution tree cover maps, such as those produced at regular 5-year intervals by the District's Urban Forestry Division (e.g., PlanIT Geo 2021).

Overall, tree cover ranges from 0.71 percent to 99 percent on plots where trees are present (Fig. 3a). Shrub cover on plots ranges from 0.05 percent to 85 percent on plots where shrubs are present (Fig. 3b). Average tree cover is highest on forest land (82 percent tree cover), residential (24.1 percent), and rights-of-way land use (18.1 percent) (Table 6). Shrub cover is highest on forest land (28.4 percent shrub cover), residential (6.6 percent), and multi-family residential land (4.5 percent). Impervious cover is highest on rights-of-way (75.3 percent impervious cover), commercial/industrial (28 percent), and multi-family residential land (27 percent) (Table 6).

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 47.7 percent of all ground covers, while building and other impervious cover account for 41.2 percent. An additional 11.2 percent of the city is classified as water (Figs. 4 and 5). Please note that percentages may not add up to 100 percent due to rounding.

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

FIA land use	Tree cover (percent)	Shrub cover (percent)	Impervious cover (percent)
Forest land	82.0	28.4	0.0
Commercial/Industrial	6.9	1.9	28.0
Multi-family residential	9.7	4.5	27.0
Residential	24.1	6.6	19.4
Recreation/Cemetery	17.8	1.5	9.2
Rights-of-way	18.1	0.7	75.3
Water	1.0	0.1	0.0
Total average	20.7	5.1	29.8
Total standard error	1.7	0.9	2.0

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

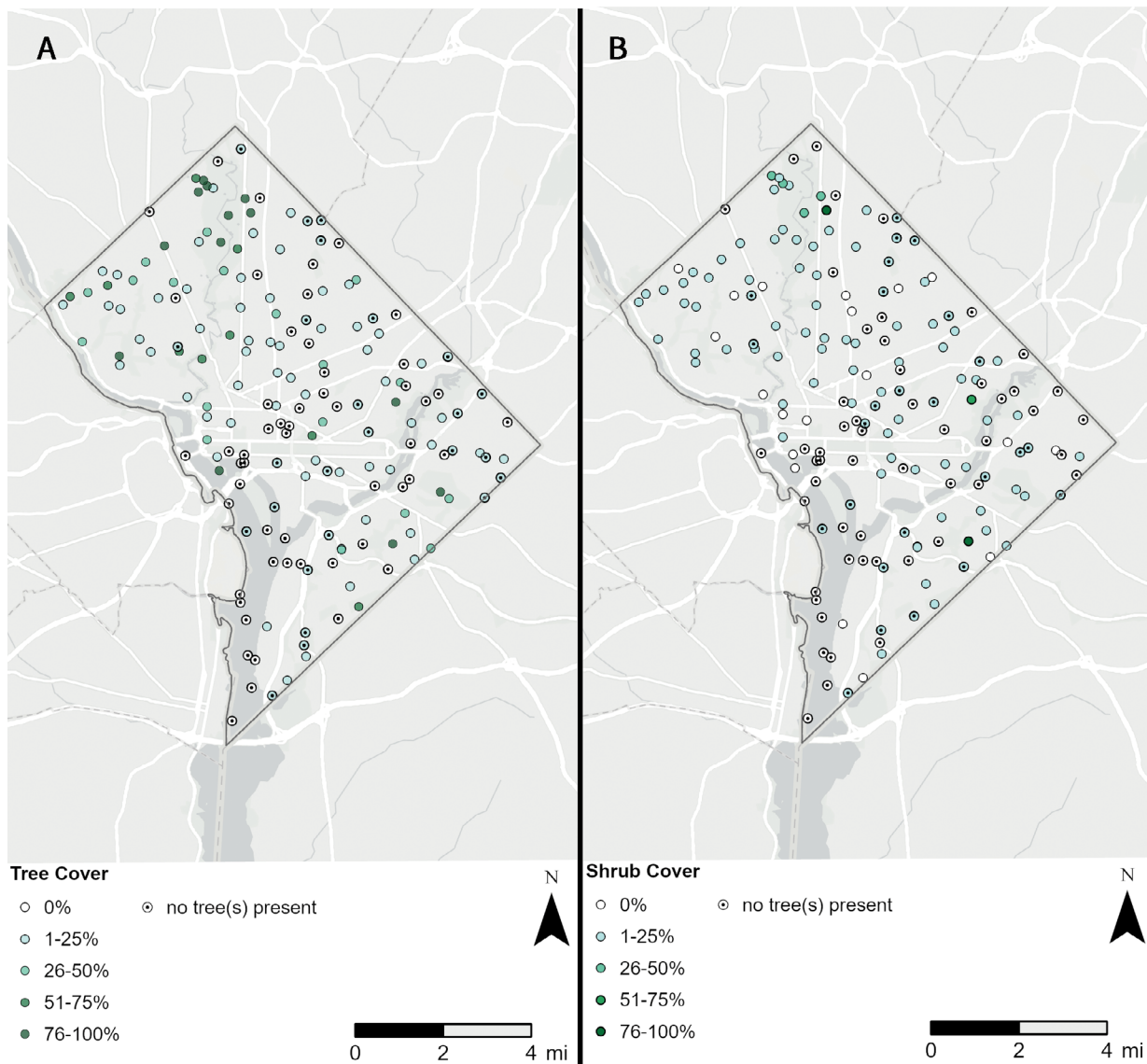


Figure 3.—Tree (A) and shrub (B) cover estimates for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, Washington, DC, 2018. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

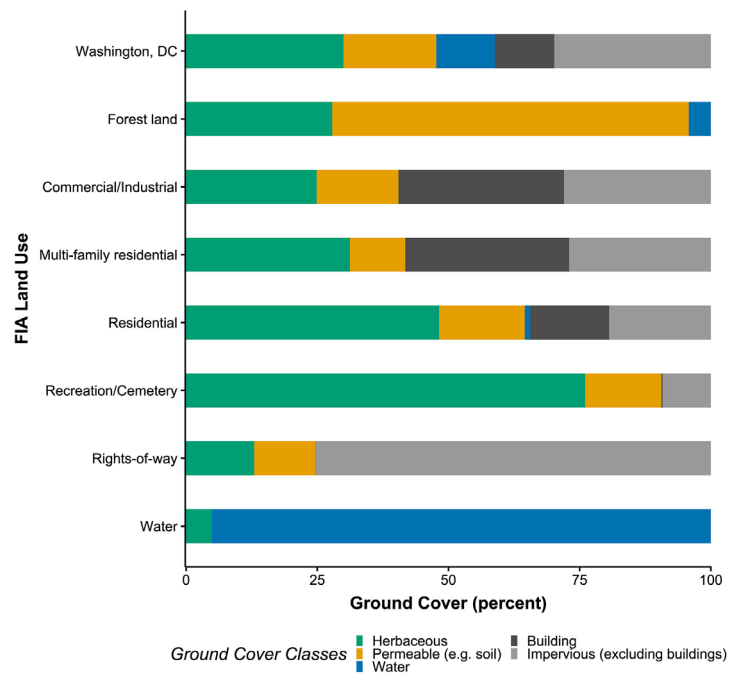


Figure 4.—Ground cover distribution by Forest Inventory and Analysis (FIA) land use class, Washington, DC, 2018.

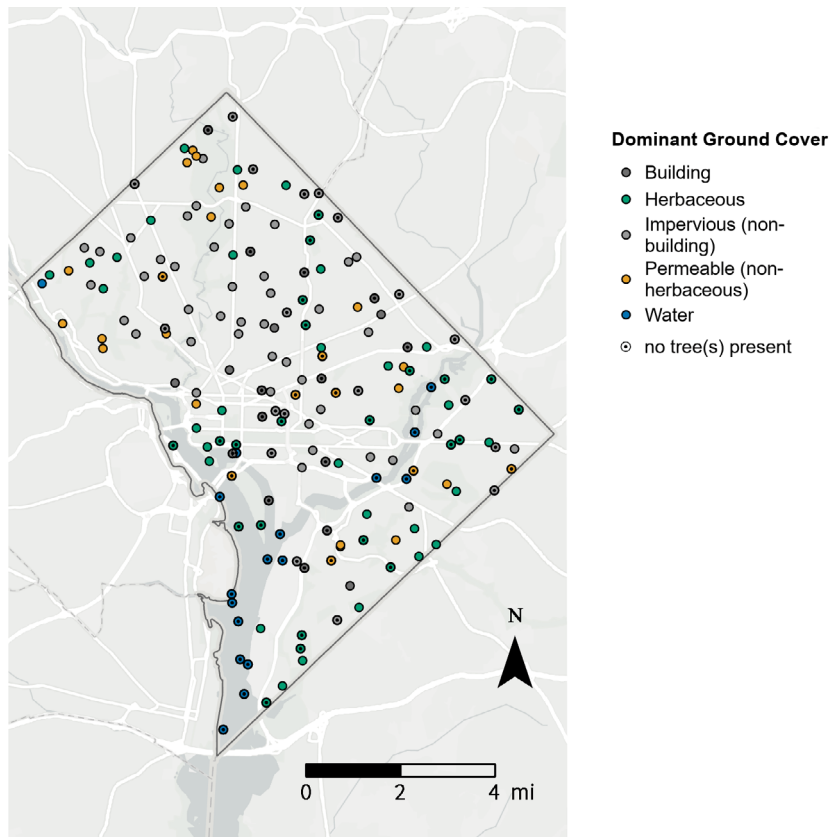


Figure 5.—Dominant ground cover for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, Washington, DC, 2018. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Ownership

Plot ownership was divided into private, State and local government, Federal government, and unknown (water) classes. The most dominant ownership in Washington, DC is private (36.9 percent), followed by State and local (28.3 percent), Federal (23.6 percent), and unknown (water) (11.1 percent) (Table 7). Percent tree cover is greatest in Federal (44.2 percent), followed by State and local (18.2 percent), and private (13.6 percent).

In Washington, DC, there are a total of 1 million trees (61.6 percent of the live tree population) on Federal lands, 439,778 trees (21.8 percent) on private land, and 333,825 trees (16.6 percent) on State and local lands (Table 7). Washington, DC's sapling (trees 1.0–4.9 inches in diameter) population is mostly found on Federal lands (68.7 percent), followed by private lands (16.9 percent), and State and local lands (14.4 percent) (Table 7).

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

Ownership class	1.0–4.9 in. diameter trees (percent)	5.0–10.9 in. diameter trees (percent)	11.0+ in. diameter trees (percent)	Total (percent)	Area (percent)
Private	16.9	34.2	22.1	21.8	36.9
Federal	68.7	47.0	57.2	61.6	23.6
State and Local	14.4	18.8	20.7	16.6	28.3
Unknown (water)	0.0	0.0	0.0	0.0	11.1
Total	100.0	100.0	100.0	100.0	100.0

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

Diameter measurements were taken at breast height (d.b.h.).

FOREST STRUCTURE



A northern red oak tree in spring in Washington, DC. Courtesy photo by Kasey Yturalde, District Department of Transportation, Urban Forestry Division.

Number of Trees

Washington, DC's urban forest has an estimated 2.01 million live trees and 129,000 standing dead trees. The number of trees varies by land use and diameter class. Most of the trees in Washington, DC are located on forest land (58.3 percent, 1.2 million trees) (Table 8). Overall, 58.7 percent of Washington, DC's trees are saplings (1.0–4.9 inches in diameter), while the remaining 22.8 percent and 18.5 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 (56.2 percent) are found within the forest/shrub land cover class. The highest tree density (253 trees per acre) is found on 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, Washington, DC, 2018

FIA land use class	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Standard error (number)	Density (number/acre)
Forest land	794,000	202,000	178,000	1,170,000	284,000	262
Commercial/Industrial	62,000	31,000	16,000	110,000	77,000	15
Multi-family residential	55,000	46,000	31,000	132,000	47,000	26
Residential	145,000	97,000	41,000	283,000	127,000	43
Recreation/Cemetery	71,000	33,000	40,000	145,000	84,000	30
Rights-of-way	55,000	50,000	65,000	171,000	44,000	16
Water	0	0	0	0	0	0
Total	1,180,000	460,000	372,000	2,010,000	–	46
Total standard error	255,000	51,000	40,000	296,000	–	–

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

– = no value for cell

Diameter measurements were taken at breast height (d.b.h.).

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

NLCD land cover class	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Total standard error (number)	Density (number/acre)
Water	0	0	1,600	1,600	1,600	0
Developed-open/herbaceous	268,000	79,000	61,000	408,000	190,000	58
Developed-low	69,000	69,000	46,000	184,000	51,000	18
Developed-medium	103,000	78,000	73,000	254,000	83,000	20
Developed-high	0	29,000	12,000	41,000	13,000	8
Forest/Shrub	743,000	205,000	177,000	1,130,000	205,000	253
Total	1,180,000	460,000	372,000	2,010,000	–	46
Total standard error	255,000	51,000	40,000	296,000	–	–

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

– = no value for cell

Diameter measurements were taken at breast height (d.b.h.).

Species Composition

The 10 most common tree species by number account for 58.3 percent of all recorded live trees and are American beech, red maple, American holly, yellow-poplar, American elm, blackgum, southern magnolia, chestnut oak, black locust, and tree of heaven (Table 10) (Fig. 6). A breakdown of the estimated number of each recorded tree species by diameter classes is presented in Appendix 2 (Table 32). 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 65.4 percent of the total number of trees, while large-diameter trees comprise only 15.3 percent of the total number of trees (Table 11) (Fig. 7). When broken down into 2-inch diameter classes, American beech and red maple, the two most common species by number, showed an abundance distribution similarly skewed toward smaller diameter trees (Fig. 8).

Table 10.—Urban forest species composition, Washington, DC, 2018

Common name	Trees (number)	Percent	Common name	Trees (number)	Percent
American beech	360,000	17.9	American hornbeam, musclewood	21,000	1.1
red maple	191,000	9.5	Amur maple	21,000	1.0
American holly	104,000	5.2	American basswood	18,000	0.9
yellow-poplar	100,000	5.0	English yew	18,000	0.9
American elm	79,000	3.9	river birch	18,000	0.9
blackgum	77,000	3.8	Japanese zelkova	17,000	0.8
southern magnolia	72,000	3.6	Chinese elm	15,000	0.8
chestnut oak	66,000	3.3	pin oak	15,000	0.8
black locust	64,000	3.2	silver maple	15,000	0.8
tree of heaven	60,000	3.0	willow oak	13,000	0.7
sassafras	55,000	2.7	western redcedar	13,000	0.6
black cherry	54,000	2.7	boxelder	10,000	0.5
Siberian elm	48,000	2.4	ginkgo, maidenhair tree	9,800	0.5
sweetgum	42,000	2.1	eastern redcedar	9,700	0.5
flowering dogwood	42,000	2.1	slippery elm	9,700	0.5
northern red oak	42,000	2.1	eastern white pine	8,500	0.4
American sycamore	40,000	2.0	Yoshino flowering cherry	8,200	0.4
white oak	34,000	1.7	Japanese flowering cherry	8,100	0.4
eastern hophornbeam	34,000	1.7	northern white-cedar	7,700	0.4
Norway maple	29,000	1.4	mountain or Fraser magnolia	7,700	0.4
mockernut hickory	22,000	1.1	Japanese maple	7,300	0.4

continued on next page

Table 10 (continued).

Common name	Trees (number)	Percent
bitternut hickory	6,800	0.3
holly	6,600	0.3
hackberry spp.	6,500	0.3
London planetree	6,400	0.3
eastern redbud	5,900	0.3
sugar maple	5,800	0.3
Leyland cypress	5,700	0.3
Callery pear	5,200	0.3
honeylocust	5,000	0.2
white mulberry	4,900	0.2
sawtooth oak	4,900	0.2
scarlet oak	4,400	0.2
northern catalpa	4,300	0.2
black walnut	4,300	0.2
hackberry	3,900	0.2
pignut hickory	3,400	0.2
paulownia, empress-tree	3,300	0.2
sour cherry	3,100	0.2
sweet cherry	3,000	0.2
swamp white oak	2,800	0.1

Common name	Trees (number)	Percent
spruce spp.	2,600	0.1
baldcypress	2,600	0.1
dogwood spp.	2,600	0.1
Virginia pine	1,700	0.1
green ash	1,700	0.1
cherry and plum spp.	1,700	0.1
Freeman maple	1,600	0.1
hinoki false cypress	1,600	0.1
dawn redwood	1,600	0.1
Norway spruce	1,400	0.1
blue spruce	1,400	0.1
Austrian pine	1,400	0.1
eastern hemlock	1,400	0.1
mimosa, silktree	1,400	0.1
northern pin oak	1,400	0.1
Amur corktree	1,300	0.1
littleleaf linden	1,300	0.1
Total	2,010,000	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.—Number of live trees by diameter class for the 10 most common tree species, Washington, DC, 2018

Common name	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)
American beech	297,000	51,000	12,000	360,000
red maple	127,000	48,000	16,000	191,000
American holly	64,000	35,000	5,900	104,000
yellow-poplar	0	16,000	84,000	100,000
American elm	42,000	18,000	18,000	79,000
blackgum	42,000	31,000	3,100	77,000
southern magnolia	64,000	1,700	6,400	72,000
chestnut oak	36,000	4,800	26,000	66,000
black locust	54,000	7,700	3,200	64,000
tree of heaven	41,000	13,000	5,100	60,000
Total	768,000	227,000	180,000	1,170,000

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

Standard errors for each estimate are reported in Appendix 2.

Diameter measurements were taken at breast height (d.b.h.).

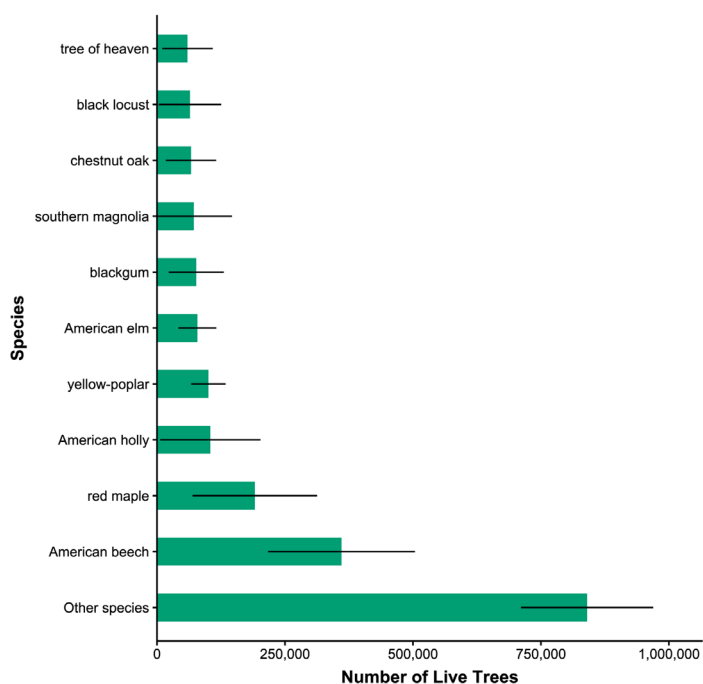


Figure 6.—The 10 most common tree species by number of trees, Washington, DC, 2018. Other species is the total number of the other tree species in the inventory. Error bars represent 68 percent confidence intervals around the estimated means. Values in the bars represent the percent of each species in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

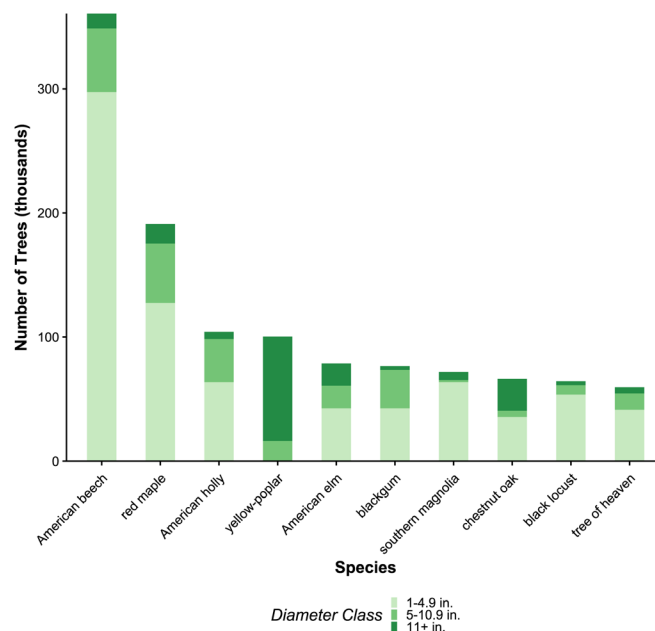


Figure 7.—Number of trees by diameter class for the 10 most common tree species, Washington, DC, 2018.

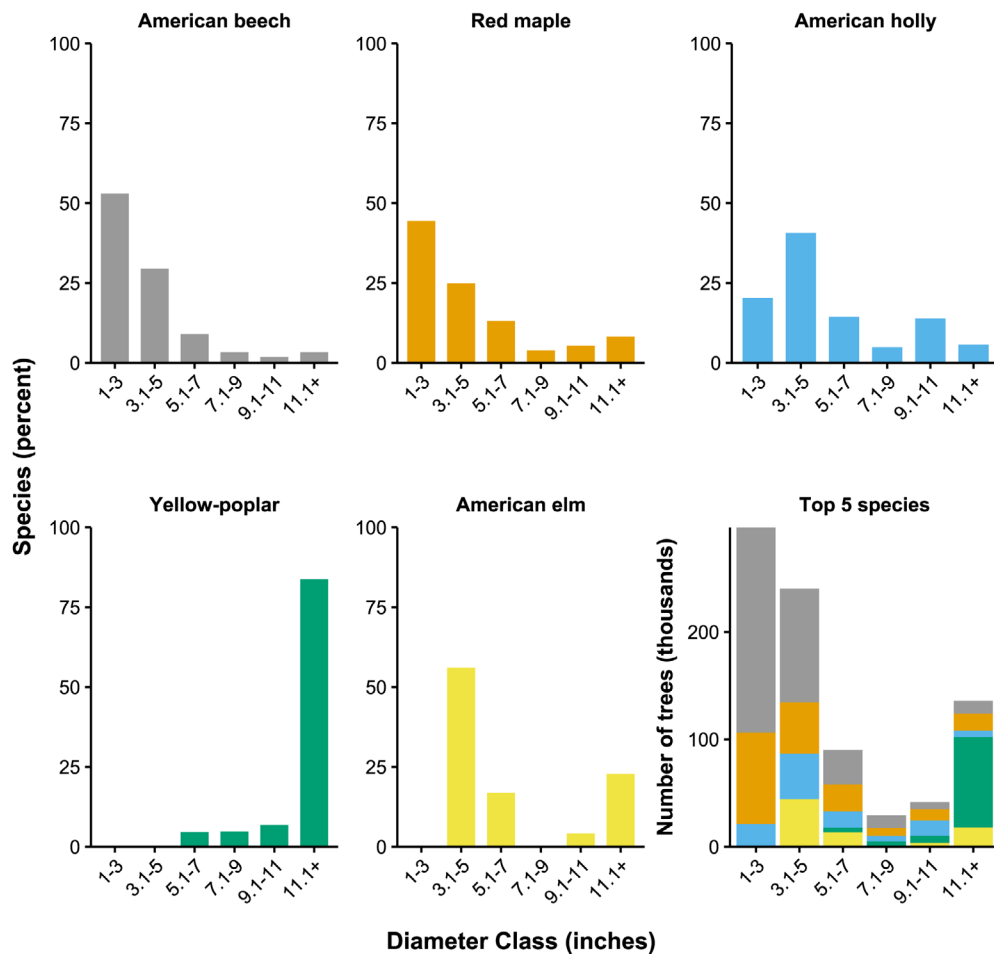


Figure 8.—Percentage of species population by diameter class for the five most common tree species, Washington, DC, 2018.

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 (< 5.0 inches in diameter) are American beech, red maple, and American holly, together representing less than half (41.3 percent) of all live trees less than 5.0 inches in diameter (Table 12, Appendix 2). American beech, red maple, and American holly are the most common species in intermediate diameter size classes, representing 29.1 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 yellow-poplar, white oak, and chestnut oak, comprising 38.9 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, Washington, DC, 2018

Diameter class (inches)	Common name	Trees (number)
1.0–4.9	American beech	297,000
	red maple	127,000
	American holly	64,000
	southern magnolia	64,000
	black locust	54,000
5.0–10.9	American beech	51,000
	red maple	48,000
	American holly	35,000
	blackgum	31,000
	American elm	18,000
11.0+	yellow-poplar	84,000
	white oak	34,000
	chestnut oak	26,000
	American elm	18,000
	red maple	16,000

Estimates are rounded.

Diameter measurements were taken at breast height (d.b.h.).

In Washington, DC, tree species composition on private land is dominated by American holly (22.9 percent), southern magnolia (16.3 percent), and eastern hophornbeam (7.8 percent) (Table 13). The most common tree species on public lands are American beech (22.9 percent), red maple (11.4 percent), and yellow-poplar (6.2 percent) (Table 14), with the majority of these on Federal land. While those are also the most common species found on Federal land, the most common tree species on State/Local (District-owned) land are tree of heaven, Siberian elm, and sweetgum. A total of 48 tree species are recorded on private lands, which has a Shannon-Wiener diversity index value of 3.0. Crews recorded 55 species of trees on public lands, which has a **Shannon-Wiener diversity index** value of 3.0. As calculated, this diversity index takes into account tree species richness (total number of species) and species evenness (relative abundances among species) and ranges from approximately 2.0 to 3.5 within cities measured using the Urban FIA protocol. These numbers are also comparable to index values calculated for urban street tree inventories internationally (Galle et al. 2021). On private land, the top three genera with the greatest number of trees are holly (*Ilex*), magnolia (*Magnolia*), and hophornbeam (*Ostrya*). On public land they are beech (*Fagus*), maple (*Acer*), and oak (*Quercus*) (Fig. 9). Species composition within NLCD land cover classes is detailed in Appendix 3.

Table 13.—Species composition on private lands, Washington, DC, 2018

Common name	Trees (percent)	Common name	Trees (percent)	Common name	Trees (percent)
American holly	22.9	Yoshino flowering cherry	1.5	willow oak	0.6
southern magnolia	16.3	slippery elm	1.5	Siberian elm	0.6
eastern hophornbeam	7.8	eastern redbud	1.3	Callery pear	0.6
mockernut hickory	4.7	Leyland cypress	1.3	black cherry	0.4
English yew	4.1	Chinese elm	1.1	tree of heaven	0.4
river birch	4.0	northern catalpa	1.0	black locust	0.4
western redcedar	2.9	Japanese maple	1.0	hinoki false cypress	0.4
red maple	2.5	honeylocust	0.7	dawn redwood	0.4
eastern redcedar	2.2	northern red oak	0.7	Norway spruce	0.3
eastern white pine	1.9	Norway maple	0.7	blue spruce	0.3
Japanese f lowering cherry	1.8	white oak	0.7	eastern hemlock	0.3
northern white-cedar	1.7	spruce spp.	0.6	boxelder	0.3
mountain or Fraser magnolia	1.7	baldcypress	0.6	scarlet oak	0.3
silver maple	1.7	dogwood spp.	0.6	northern pin oak	0.3
American elm	1.5	yellow-poplar	0.6	sweet cherry	0.3
holly	1.5	pin oak	0.6	Amur corktree	0.3

Estimates are rounded.

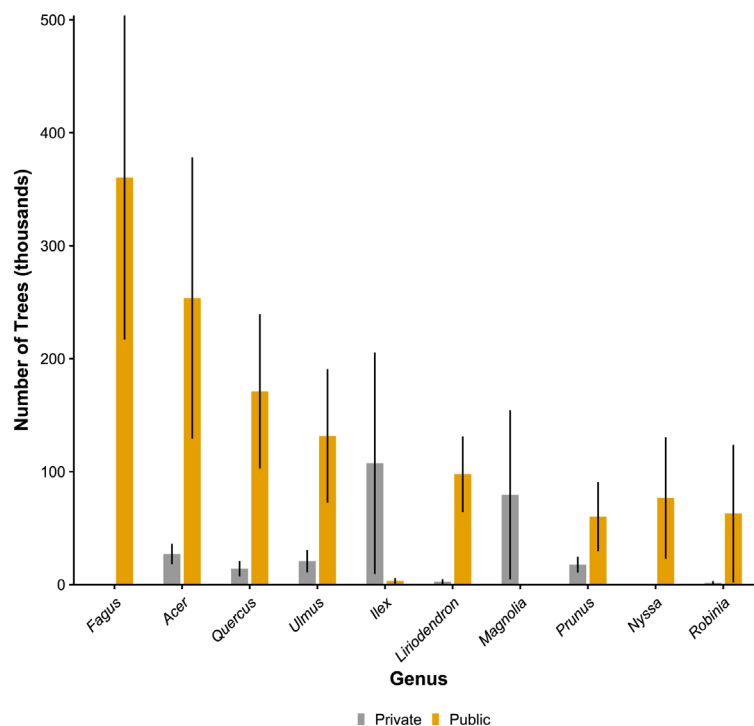


Figure 9.—The 10 most common genera by number of trees within ownership classes, Washington, DC, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

Table 14.—Species composition on public lands, Washington, DC, 2018

Common name	Trees (percent)	Common name	Trees (percent)	Common name	Trees (percent)
American beech	22.9	American basswood	1.1	slippery elm	0.2
red maple	11.4	Japanese zelkova	1.1	sour cherry	0.2
yellow-poplar	6.2	pin oak	0.8	Japanese maple	0.2
blackgum	4.9	willow oak	0.7	scarlet oak	0.2
American elm	4.6	Chinese elm	0.7	swamp white oak	0.2
chestnut oak	4.2	ginkgo, maidenhair tree	0.6	Callery pear	0.2
black locust	4.0	boxelder	0.5	Virginia pine	0.1
tree of heaven	3.7	silver maple	0.5	mockernut hickory	0.1
sassafras	3.5	bitternut hickory	0.4	green ash	0.1
black cherry	3.3	hackberry spp.	0.4	honeylocust	0.1
Siberian elm	2.9	London planetree	0.4	cherry and plum spp.	0.1
sweetgum	2.7	sugar maple	0.4	sweet cherry	0.1
flowering dogwood	2.7	white mulberry	0.3	Freeman maple	0.1
American sycamore	2.5	sawtooth oak	0.3	Yoshino flowering cherry	0.1
northern red oak	2.5	black walnut	0.3	Austrian pine	0.1
white oak	2.0	hackberry	0.2	mimosa, silktree	0.1
Norway maple	1.7	pignut hickory	0.2	littleleaf linden	0.1
American hornbeam, musclewood	1.3	American holly	0.2	Estimates are rounded.	
Amur maple	1.3	paulownia, empress-tree	0.2		

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

Common name	Trees (number)	Percent of all trees in maintained areas
American holly	103,000	16.4
southern magnolia	72,000	11.5
sweetgum	36,000	5.7
eastern hophornbeam	34,000	5.5
red maple	22,000	3.5
Amur maple	21,000	3.3
American basswood	18,000	2.9
English yew	18,000	2.9
river birch	18,000	2.8
Japanese zelkova	17,000	2.7

Estimates are rounded.

Trees in Maintained Areas

Overall, 31.1 percent of trees in Washington, DC are found on 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, maintained shrub beds, rights-of-way and manicured parks. However, a tree found in a maintained area has not necessarily received care. In Washington, DC, the most common tree species in maintained areas are American holly (16.4 percent of all trees in maintained areas), southern magnolia (11.5 percent), and sweetgum (5.7 percent) (Table 15).

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. Although larger trees have more leaf area than smaller trees, total leaf area in a given inventory may be substantial in smaller diameter classes because smaller diameter trees are generally more abundant. The proportion of total leaf area is greatest for trees 29.1+ inches in diameter (24.3 percent), followed by 5.1–7.0 inches in diameter (7.2 percent), and 27.1–29.0 inches in diameter (6.6 percent) (Fig. 10). In Washington, DC, leaf area is greatest in forest land uses (51.5 percent of total leaf area), followed by rights-of-way (15.2 percent), and residential land uses (14.5 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 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 14.0 in forest land use to 8.0 in rights-of-way (Fig. 11).

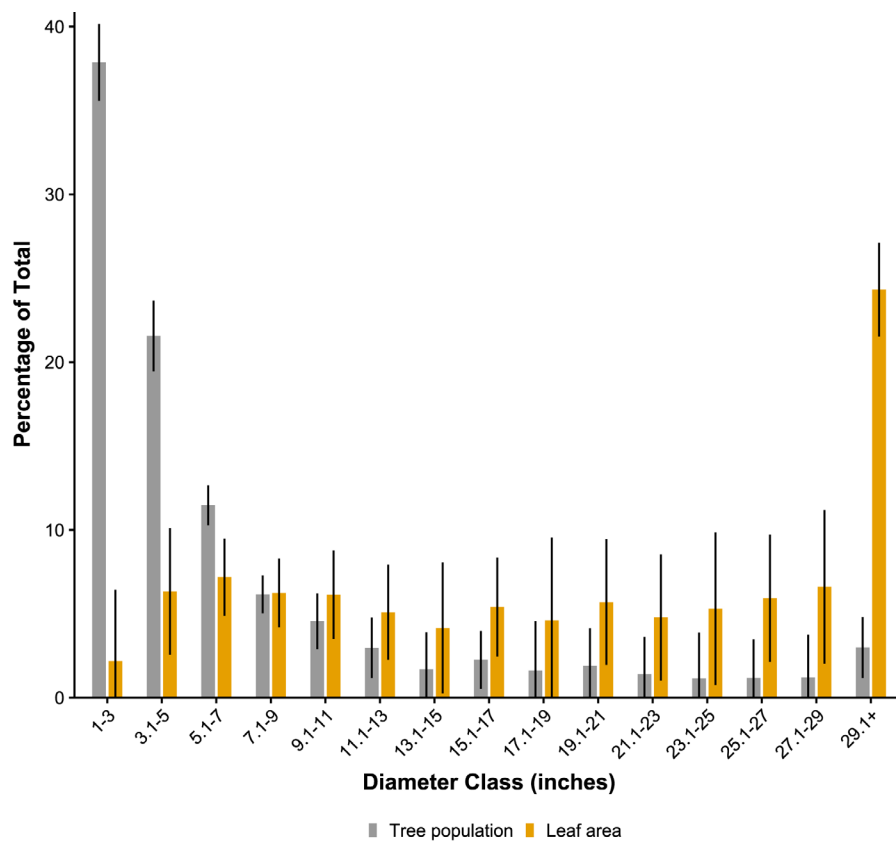


Figure 10.—Percentage of tree population and leaf area by 2-inch diameter class, Washington, DC, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

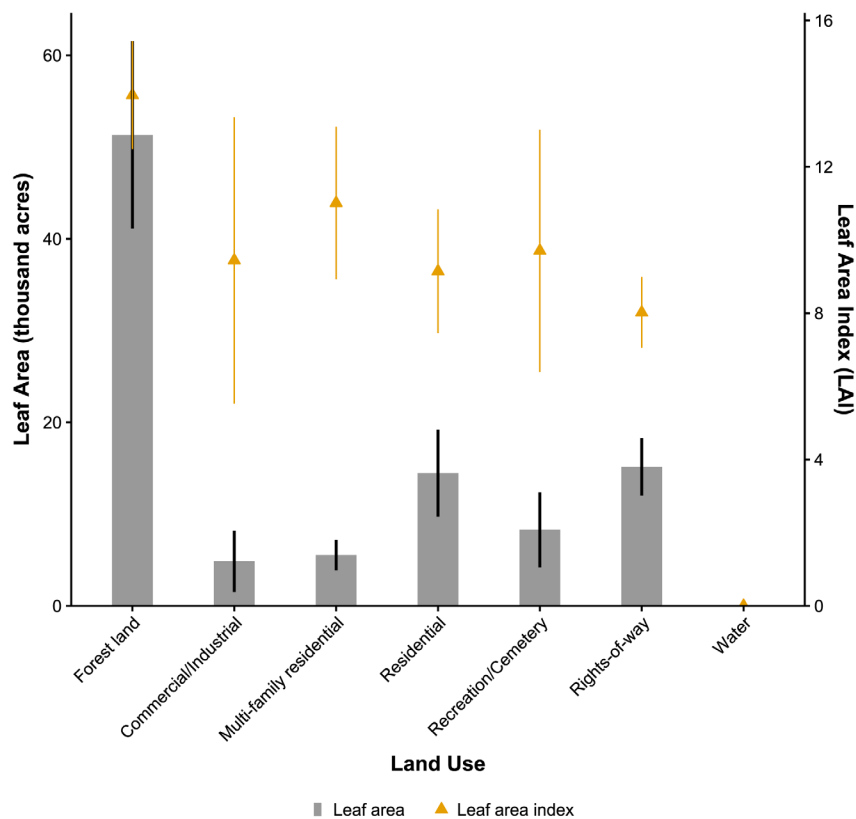


Figure 11.—Leaf area and leaf area index (LAI) by Forest Inventory and Analysis (FIA) land use, Washington, DC, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

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 Washington, DC's urban forest with the greatest IVs are yellow-poplar (30.2), American beech (28.1), and red maple (14.2) (Table 16).

Table 16.—Percentage of total tree population represented by tree species with the highest Importance Value (IV), Washington, DC, 2018

Common name	Population (percent)	Leaf area (percent)	Importance Value
yellow-poplar	5.0	25.3	30.2
American beech	17.9	10.2	28.1
red maple	9.5	4.7	14.2
white oak	1.7	7.2	8.9
chestnut oak	3.3	5.3	8.6
American holly	5.2	2.7	7.9
American elm	3.9	3.5	7.4
southern magnolia	3.6	2.5	6.0
blackgum	3.8	1.3	5.1
northern red oak	2.1	2.4	4.5

Estimates are rounded.

Importance Value = Population (%) + Leaf area (%).

VOLUME AND BIOMASS



Recycled urban wood stools for outdoor classroom in Washington, DC. Courtesy photo by Earl Eutsler, District Department of Transportation, Urban Forestry Division.

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 Washington, DC, live trees at least 5.0 inches in diameter are estimated to contain 34.1 million cubic feet of net volume and 152.6 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 Washington, DC's urban forest is roughly equivalent to the amount of wood that would be needed to construct 10,527 median-sized homes. Yellow-poplar contributes the greatest net cubic-foot volume at 39.4 percent of the city total (Table 17). Yellow-poplar contributes 53.2 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, Washington, DC, 2018

Common name	Net volume (cubic feet)	Standard error (cubic feet)	Net volume (percent)
yellow-poplar	13,420,000	4,370,000	39.4
white oak	3,190,000	1,320,000	9.4
chestnut oak	2,150,000	1,170,000	6.3
pin oak	1,640,000	690,000	4.8
silver maple	1,610,000	769,000	4.7
willow oak	1,430,000	791,000	4.2
American elm	1,350,000	716,000	4.0
American beech	924,000	500,000	2.7
red maple	787,000	296,000	2.3
northern red oak	759,000	370,000	2.2
Other species	6,820,000	1,150,000	20.0
Total	34,080,000	4,870,000	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, Washington, DC, 2018

Common name	Net volume (board feet)	Standard error (board feet)	Net volume (percent)
yellow-poplar	81,280,000	26,550,000	53.2
white oak	18,500,000	7,820,000	12.1
chestnut oak	11,200,000	6,370,000	7.3
pin oak	8,970,000	4,120,000	5.9
willow oak	6,940,000	5,000,000	4.5
American beech	3,970,000	2,970,000	2.6
northern pin oak	3,430,000	3,690,000	2.2
silver maple	3,160,000	1,860,000	2.1
northern red oak	3,070,000	1,820,000	2.0
scarlet oak	1,950,000	1,690,000	1.3
Other species	10,180,000	3,130,000	6.7
Total	152,650,000	29,310,000	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.

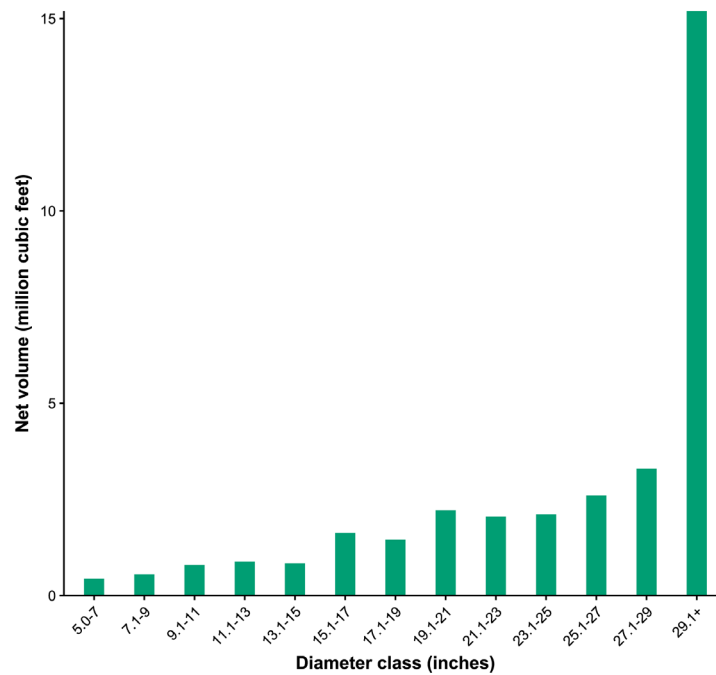


Figure 12.—Net cubic volume by tree diameter class, Washington, DC, 2018.

While sawtimber could potentially be derived from urban forests to provide economic value, the broader social-ecological value of the urban 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 for 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 Washington, DC is estimated at 1,440,000 green tons (Table 19). The amount of biomass stored by live trees in Washington, DC varies by species. The tree species with the greatest total aboveground biomass are yellow-poplar (33.3 percent), white oak (10.3 percent), and chestnut oak (7.3 percent) (Table 19).

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

Common name	Biomass (green tons)	Standard error (green tons)	Biomass (percent)
yellow-poplar	479,000	156,000	33.3
white oak	148,000	61,000	10.3
chestnut oak	105,000	57,000	7.3
pin oak	83,000	34,000	5.8
willow oak	70,000	37,000	4.9
American elm	66,000	34,000	4.6
silver maple	61,000	30,000	4.2
American beech	41,000	21,000	2.9
northern red oak	40,000	19,000	2.8
red maple	35,000	12,000	2.4
Other species	310,000	53,000	21.6
Total	1,440,000	191,000	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



Willow oak street trees create neighborhood shade in Washington, DC. Courtesy photo by District Department of Transportation, Urban Forestry Division.

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, and 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 with increased number and size of healthy trees 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

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 (O_3) formation (Fehsenfeld et al. 1992, Karlik and Pittenger 2012), integrative studies have revealed that an increase in tree cover tends to reduce O_3 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 Washington, DC is greatest for O_3 (234.1 tons per year), followed by nitrogen dioxide (NO_2 ; 54.0 tons per year), particulate matter less than 2.5 microns ($PM_{2.5}$; 16.0 tons per year), sulfur dioxide (SO_2 ; 7.2 tons per year), and carbon monoxide (CO; 6.8 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. For NO_2 , SO_2 , O_3 , and $PM_{2.5}$, estimates are based on avoided health effects due to lower pollution concentrations. For CO, the 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 $PM_{2.5}$ (\$8.79 million), followed by O_3 (\$2.28 million), NO_2 (\$71,000), CO (\$9,100), and SO_2 (\$3,200) (Table 20). It is estimated that trees in Washington, DC remove a total of 318 tons of air pollution per year with an associated value of \$11.2 million. More information about value calculations can be found in Baer et al. (2024).

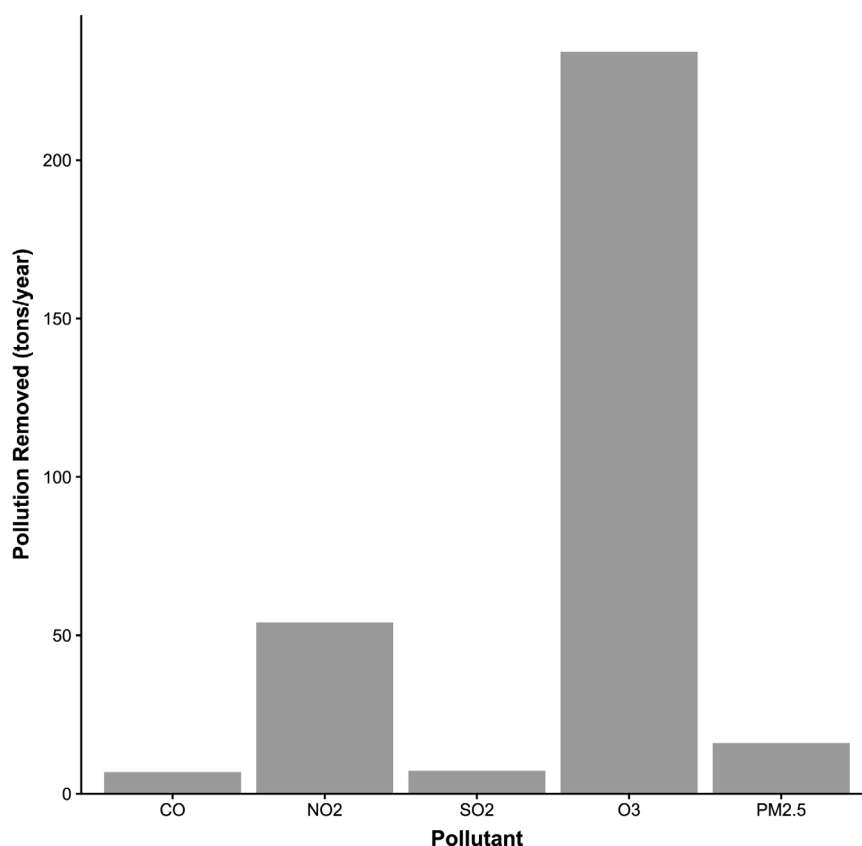


Figure 13.—Air pollution removal by trees, Washington, DC, 2018.

Decreases in the concentration of various air pollutants due to removal by trees is expected to have a positive effect on human health in Washington, DC (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 866 fewer cases of acute respiratory symptoms per year with an associated value of over \$77,000 (Table 20).

Trees in Washington, DC emit an estimated 480 tons of VOCs (146 tons of isoprene and 334 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. Oak (*Quercus* spp.) and magnolia (*Magnolia* spp.) contribute 85.7 percent of VOC emissions (Fig. 14). These VOCs are precursor chemicals to ozone formation.

Table 20.—Associated value (dollars per year) and incidence (number of cases per year) of avoided health effects from changes in pollution concentrations due to pollution removal by trees in Washington, DC's urban forest, 2018, using 2015 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	32
Acute Myocardial Infarction	–	–	–	–	–	–	0.2	22,000
Acute Respiratory Symptoms	21.4	680	1.0	32	500.0	43,000	350.0	34,000
Asthma Exacerbation	330.0	28,000	9.1	710	–	–	150.0	12,000
Chronic Bronchitis	–	–	–	–	–	–	0.3	75,000
Emergency Room Visits	0.4	170	0.1	25	0.2	93	0.3	110
Hospital Admissions	1.4	43,000	0.1	2,400	0.8	23,000	–	–
Hospital Admissions, Cardiovascular	–	–	–	–	–	–	0.1	5,700
Hospital Admissions, Respiratory	–	–	–	–	–	–	0.1	3,600
Lower Respiratory Symptoms	–	–	–	–	–	–	4.4	230
Mortality	–	–	–	–	0.3	2,200,000	1.1	8,620,000
School Loss Days	–	–	–	–	120.0	12,000	–	–
Upper Respiratory Symptoms	–	–	–	–	–	–	3.6	160
Work Loss Days	–	–	–	–	–	–	60.2	12,000
Total	360.0	71,000	10.2	3,200	620.0	2,280,000	560.0	8,790,000

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: Nowak 2021.

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

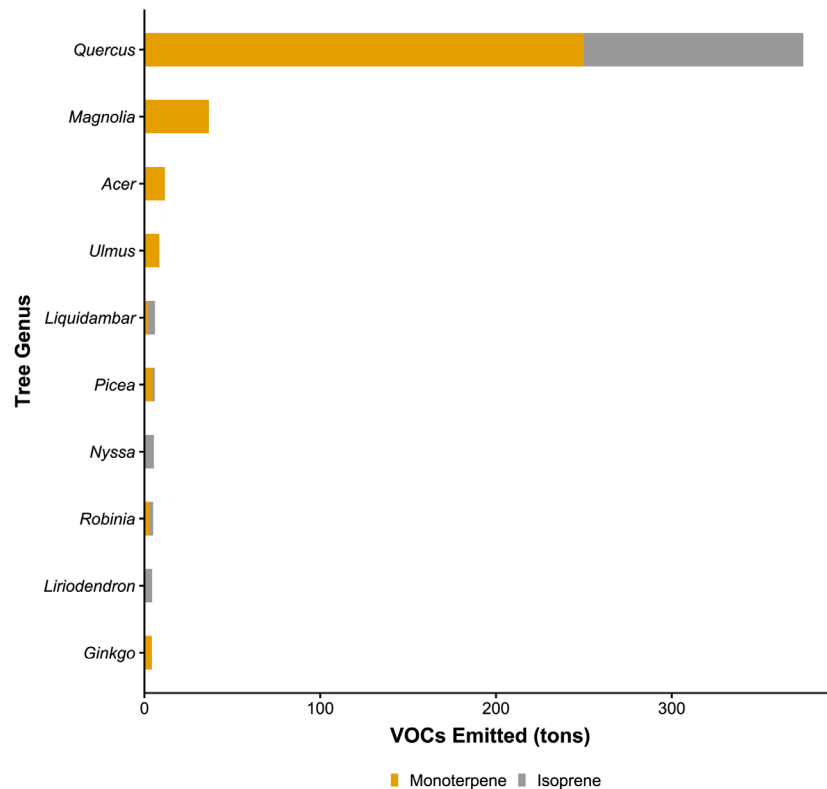


Figure 14.—Volatile organic compound (VOC) emissions by genus, Washington, DC, 2018.

Avoided Runoff

Surface water runoff (commonly referred to as surface runoff or stormwater runoff) can transport pollution to streams, wetlands, rivers, and oceans both within and outside of city limits. 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 Washington, DC are estimated to reduce runoff by 30 million cubic feet per year (225 million gallons annually), with an estimated value of \$2 million per year (Baer et al. 2024). The majority of this avoided runoff is attributable to interception by tree canopies. Tree species with the greatest overall impact on runoff in Washington, DC's urban forest are yellow-poplar, American beech, and white oak due to their large leaf surface area (Fig. 15).

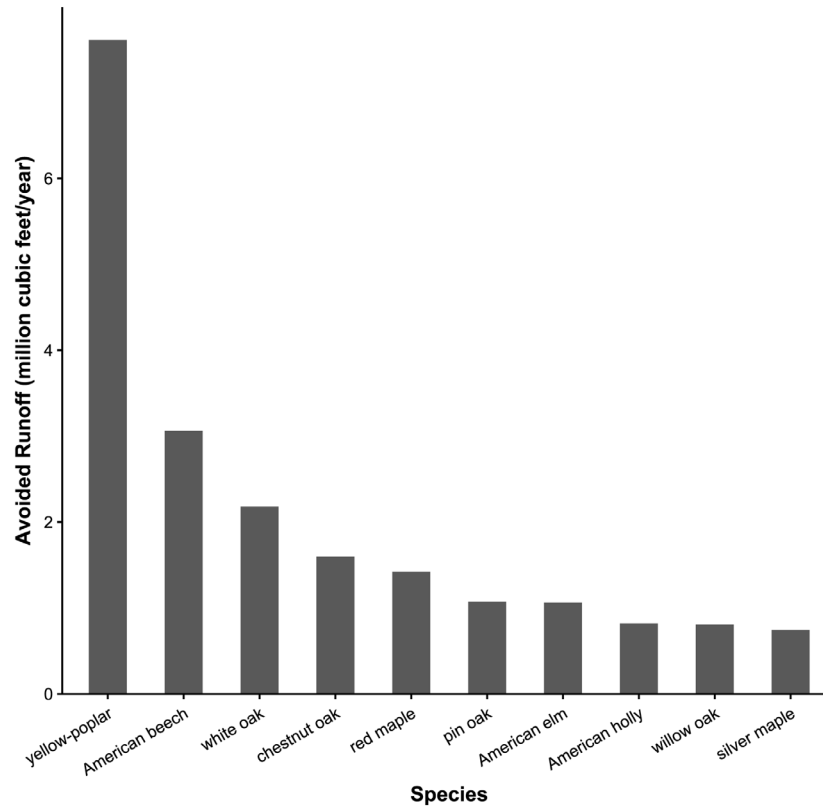


Figure 15.—Avoided runoff for the 10 tree species with the greatest leaf area, Washington, DC, 2018.

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. 2008a; Nowak 2020; U.S. EIA 2012a, b; U.S. EIA 2014a, b, c).

In Washington, DC, interactions between buildings and trees 5.0 inches in diameter and greater are projected to annually decrease energy requirements by 283,000 gigajoules (GJ) during the heating and cooling seasons (an energy equivalent of 1.8 million gallons of number 2 fuel oil) (Table 21), with an annual savings in energy costs of \$4.2 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 33,900 tons annually (9,200 tons of carbon; \$1,577,000) (Baer et al. 2024), equivalent to the burning of over 23.7 million pounds of coal or roughly 71,522 barrels of oil (Hong and Slatick 1994, U.S. EPA 2020).

Table 21.—Annual energy savings (tons or GJ) due to trees 5.0+ inches in diameter near residential buildings, Washington, DC, 2018

Reduced energy use and emissions	Cooling	Heating	Total
Carbon avoided (tons) ^a	2,900	6,300	9,200
GJ ^b	29,000	254,000	283,000

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 5.0+ inches in diameter near residential buildings during heating and cooling seasons, Washington, DC, 2018

Reduced energy use and emissions	Cooling (dollars)	Heating (dollars)	Total (dollars)
Carbon avoided	498,000	1,080,000	1,580,000
Energy effects	1,010,000	3,220,000	4,230,000

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

Climate change is an issue of global concern that threatens vulnerable species and ecosystems (e.g., coral reefs, polar and coastal areas) along with food production, water resources, and human health (Intergovernmental Panel on Climate Change 2014). Reductions in the amount of energy required to heat or cool residential buildings described in the energy conservation section of this report lead to reduced CO₂ emissions from fossil-fuel based power sources (Abdollahi et al. 2000). Trees can also help mitigate climate change by annually sequestering atmospheric carbon (in the form of CO₂) and storing carbon in their accumulated tissue (i.e., biomass).

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 Washington, DC store an estimated 487,163 tons of carbon (1.8 million tons of CO₂) valued at \$83.1 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 yellow-poplar, white oak, and chestnut oak (Fig. 17).

Larger trees store more carbon per tree due to their greater size. Trees with diameters of 29.1 or larger stored the greatest amount of carbon both as a proportion of the total amount of carbon stored and on a per tree basis in Washington, DC (Figs. 18 and 19).

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 Washington, DC is about 15,000 tons of carbon per year (55,000 tons per year of CO₂) with an associated value of \$2.6 million per year, which is roughly equivalent to the annual emissions associated with 10,900 passenger vehicles or energy usage by 6,000 homes (U.S. EPA 2020). Yellow-poplar is estimated to sequester the most carbon of all species in Washington, DC's urban forest (20.6 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 aid in assessing impacts of proposed land use changes and in developing climate change strategies and targets.

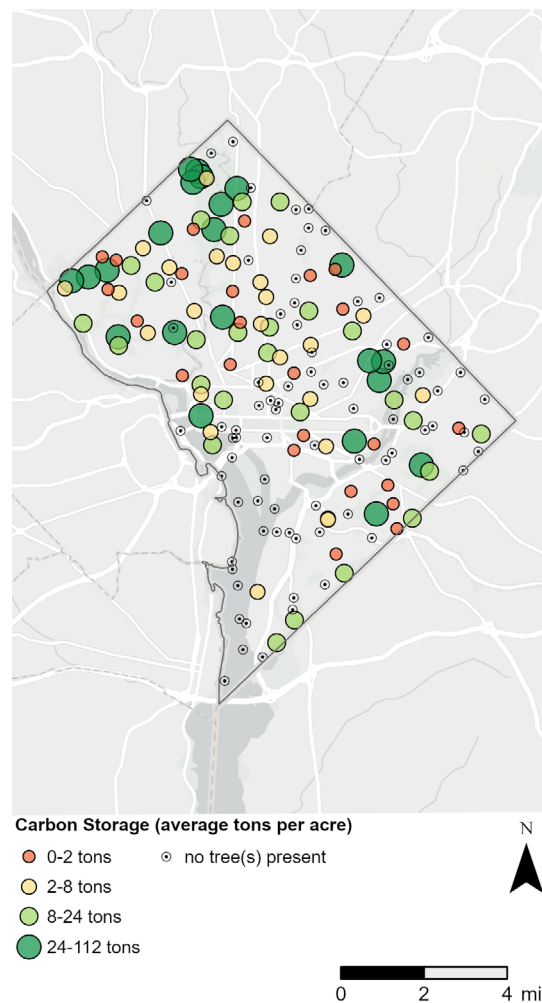


Figure 16.—Carbon storage per acre for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, Washington, DC, 2018. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Table 23.—Aboveground and belowground carbon (C) in live and standing dead trees by FIA land use, Washington, DC, 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	204,000	39,000	16,000	259,000	53,000
Rights-of-way	76,000	14,000	0	90,000	22,000
Residential	45,000	8,600	0	54,000	19,000
Recreation/Cemetery	42,000	8,000	260	50,000	27,000
Multi-family residential	16,000	3,200	1,500	21,000	8,700
Commercial/Industrial	11,000	2,100	0	13,000	9,800
Total	394,000	75,000	18,000	487,000	–
Standard error	51,000	9,800	4,900	61,000	–

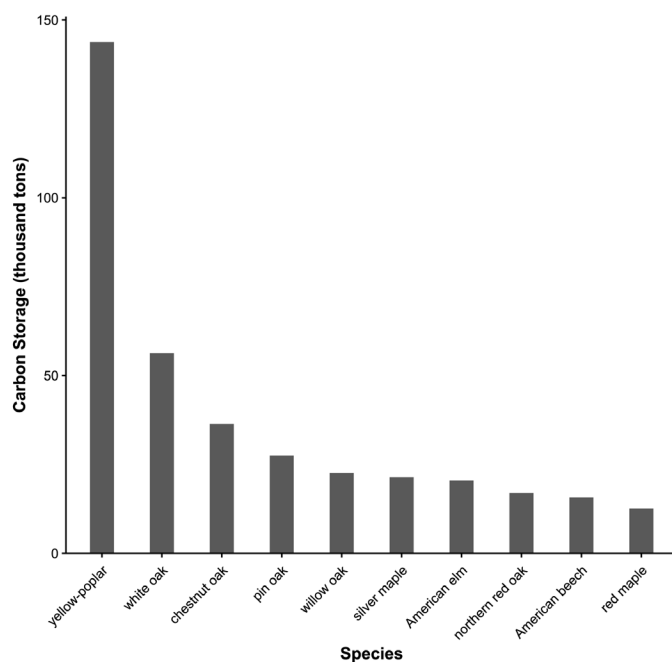


Figure 17.—Estimated carbon storage for the 10 tree species with the greatest carbon storage, Washington, DC, 2018.

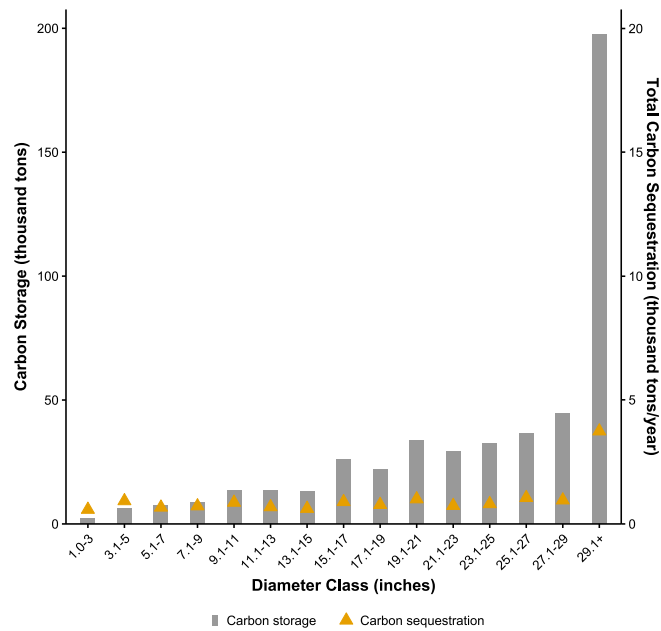


Figure 18.—Estimated total carbon storage and sequestration by diameter class, Washington, DC, 2018.

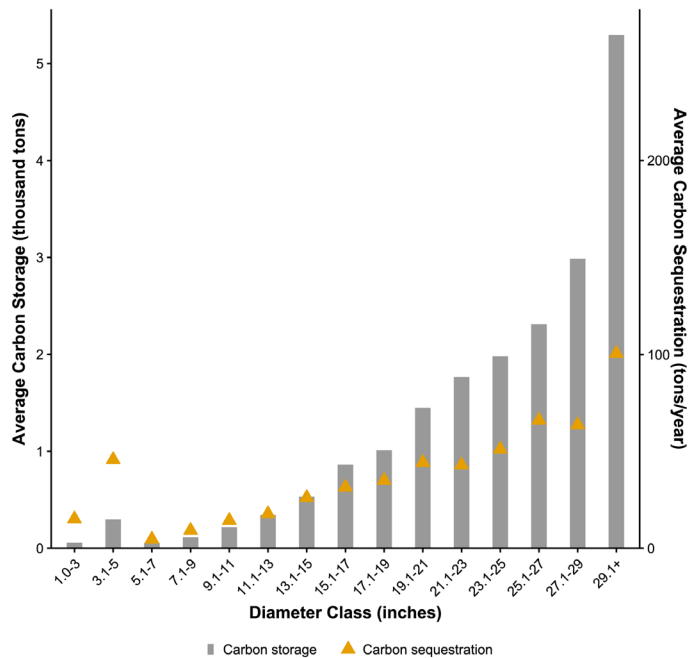


Figure 19.—Average per tree carbon storage and sequestration by diameter class, Washington, DC, 2018.

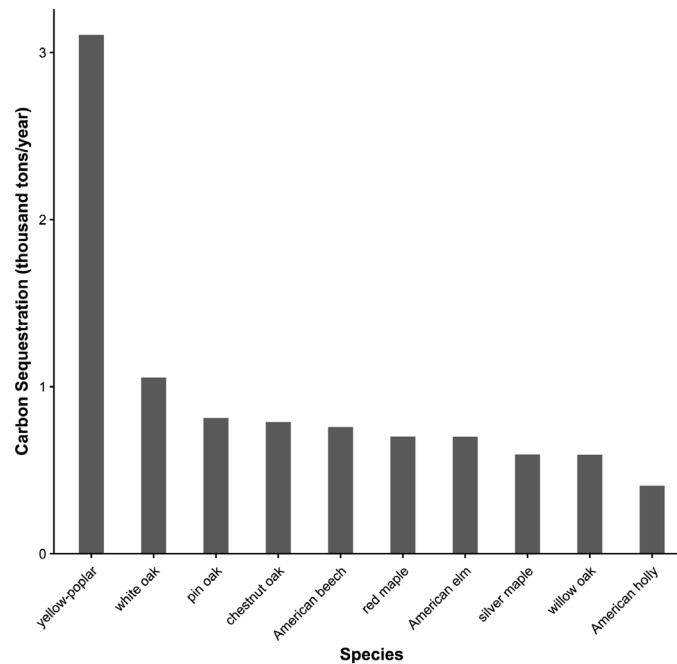


Figure 20.—Estimated annual carbon sequestration for the 10 tree species with the greatest annual carbon sequestration, Washington, DC, 2018.

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 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, non-native, or invasive. Additionally, invasive species can still contribute some ecosystem services. The compensatory value of the trees in Washington, DC is estimated to be about \$2.1 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 Washington, DC are yellow-poplar, white oak, and chestnut oak (Fig. 21). The mean compensatory value per acre for all surveyed plots in Washington, DC is \$42,891; for the 55.7 percent of these plots that contain trees, the mean compensatory value per acre is \$77,000 (Fig. 22). However, compensatory value per acre is estimated to exceed \$97,000 for 25 plots in which the average tree diameter is 14.1 inches. The structural value of urban trees in Washington, DC is a combination of their compensatory value (estimated at \$2.1 billion) and the value associated with carbon storage by the trees (estimated at \$83.1 million).

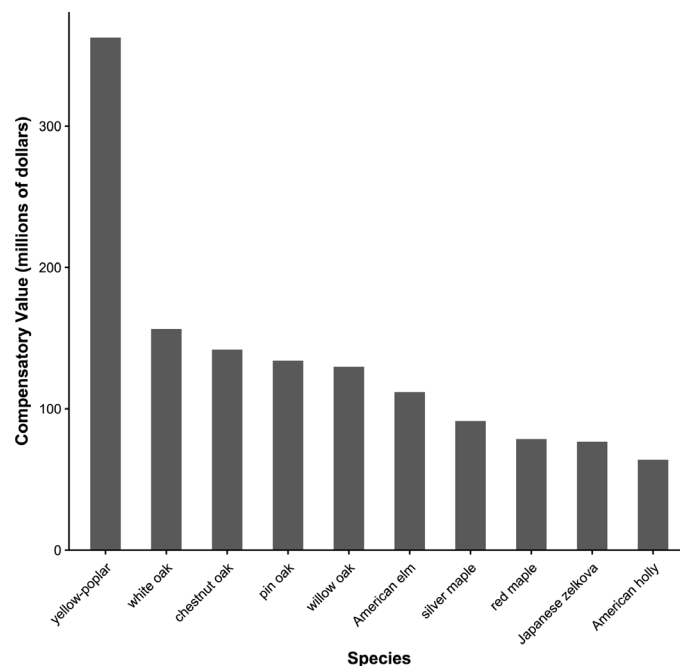


Figure 21.—The 10 tree species with the greatest compensatory value, Washington, DC, 2018.

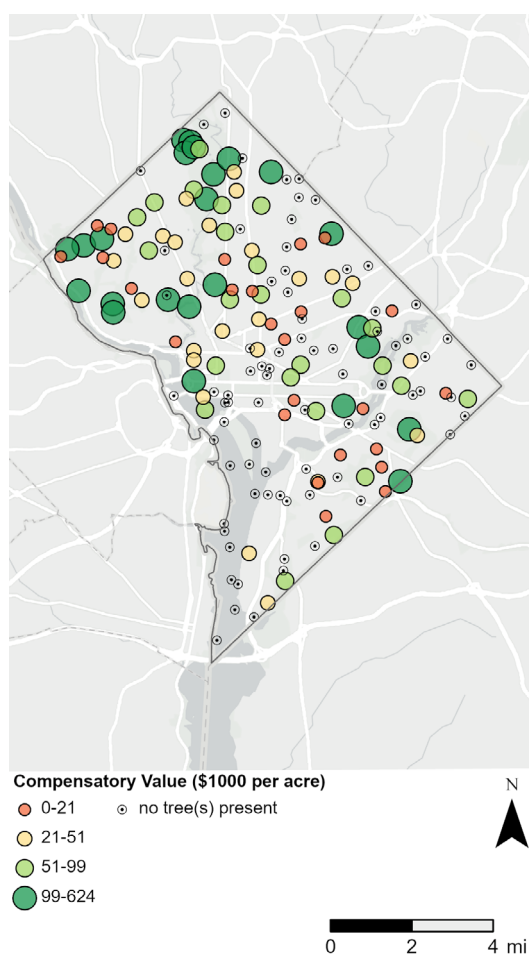


Figure 22.—Compensatory value per acre for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, Washington, DC, 2018. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

URBAN FOREST HEALTH



A street tree branch with crapemyrtle bark scale, sooty mold, and fine twig dieback in Washington, DC. Courtesy photo by Kasey Yturalde, District Department of Transportation, Urban Forestry Division.

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 Washington, DC. Detailed methods of invasive species as indicators of urban forest health metrics are presented in the Urban FIA NRS Field Guide Version 7.1 (USDA Forest Service 2017).



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, tree species, or group of trees. Of the tree species that have a minimum sample size of 10 trees and showed evidence of dieback, red maple has the highest average dieback (7.8 percent) (Table 24). Approximately 12.8 percent of red maple displays greater than 25 percent crown dieback, indicating that this species may be threatened by insect, disease, or environmental stressors in Washington, DC.

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 potential 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. Of species with a minimum sample size of 10 trees, the species with the highest average rotten/cull amounts are red maple and silver maple (Table 25).

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 greater than 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 1–2 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 NRS Field Guide Version 7.1 (USDA Forest Service 2017). Stem decay and broken top are the most common causes of damage, affecting 17.0 and 2.7 percent of trees, respectively (Table 26).

Table 24.—Tree species with the greatest average dieback, Washington, DC, 2018

Common name	Average dieback (percent)	Standard error (percent)	Trees with more than 25% dieback (percent)
red maple	7.8	10.8	12.8
silver maple	5.2	7.5	0.0
white oak	4.3	6.0	5.0
Siberian elm	3.2	2.3	0.0
northern red oak	2.6	3.5	4.0
American elm	2.0	2.5	2.1
chestnut oak	1.8	1.7	2.6
yellow-poplar	1.4	3.4	1.7
black cherry	1.1	1.4	0.0
Japanese zelkova	0.9	1.5	0.0
tree of heaven	0.8	0.7	0.0
black locust	0.3	0.2	0.0
American holly	0.2	0.2	0.0
blackgum	0.1	0.1	0.0
American beech	0.0	0.0	0.0

Estimates are rounded.

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, Washington, DC, 2018

Common name	Average rot (percent)	Standard error (percent)	Trees with more than 15% rot (percent)
red maple	3.3	9.3	2.6
silver maple	2.2	3.7	0.0
American holly	2.1	2.7	0.0
northern red oak	1.8	2.8	0.0
tree of heaven	0.6	1.0	0.0
Japanese zelkova	0.5	1.1	0.0
yellow-poplar	0.4	0.8	0.0
American beech	0.4	0.7	0.0
American elm	0.3	0.7	0.0
chestnut oak	0.3	0.4	0.0
blackgum	< 0.1	0.1	0.0

Estimates are rounded.

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.

Table 26.—Percentage of trees with observed damage, Washington, DC, 2018

Damage type	Percent
Armillaria root disease	0.1
Boring Insects	0.1
Cankers	0.2
Foliage diseases	1.2
Human activities	0.7
Stem decay	17.0
Wild animals	0.4
Imbedded objects	0.9
Shoot borer	0.1
Vine damage	0.7
Other Damages and Symptoms	
Other damages and symptoms	2.2
Broken top	2.7
Dead top	0.7
Dieback	2.1
Foliage discoloration	0.1

Estimates are rounded.

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

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

Bark inclusion is the most common issue, occurring in 5.8 percent of trees. Conflict with crown and excess mulch are the second and third most common urban specific infrastructure issues, occurring in 5.4 and 2.1 percent of trees, respectively (Fig. 23).

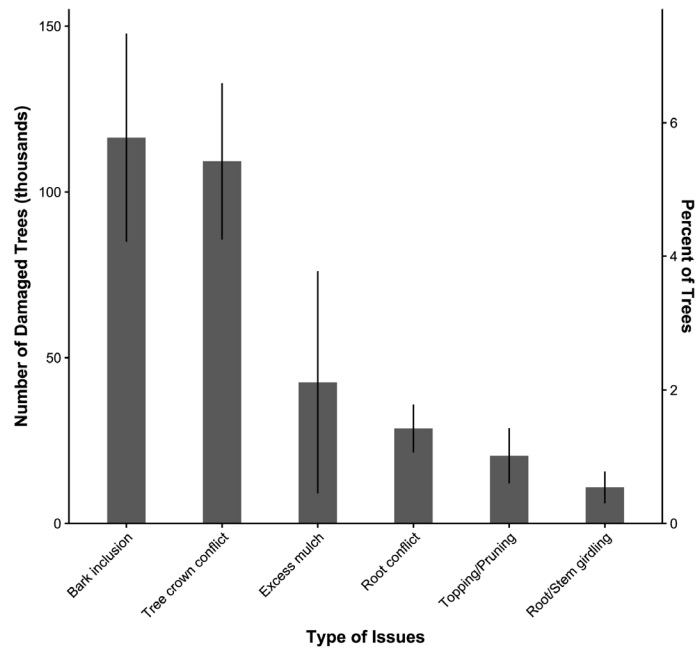


Figure 23.—Number and percentage of trees by urban infrastructure issue category, Washington, DC, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

Differences exist in the prevalence of these issues among the FIA-designated land uses and may further inform forest health and management priorities. In Washington, DC, excess mulch occurs in 29.1 percent of trees on multi-family residential land, conflict with crown in 22.3 percent of trees on rights-of-way land, and conflict with crown in 19.1 percent of trees on residential land.

The species with the greatest proportion of their population affected by urban-specific damages are Japanese zelkova (55.2 percent affected by bark inclusion) and Chinese elm (36.2 percent affected by bark inclusion) (Table 27, Appendix 5).

Table 27.—Tree species with the greatest proportion of their population with infrastructure issues, by damage type, Washington, DC, 2018

Damage type	Common name	Percent
Bark inclusion	American elm	7.4
	American holly	20.3
	Chinese elm	36.2
	Japanese zelkova	55.2
	black locust	4.4
	blackgum	3.7
	red maple	14.1
	tree of heaven	5.4
Conflict with crown	American beech	0.5
	American elm	7.4
	American holly	11.5
	Siberian elm	5.3
	northern red oak	6.0
	red maple	0.7
	silver maple	30.8
	tree of heaven	2.7
Conflict with roots	American elm	2.1
	red maple	1.7
	silver maple	9.4
	tree of heaven	2.7
Excess mulch	Japanese zelkova	15.8
Root/Stem girdling	Japanese zelkova	9.7
	red maple	3.1
	silver maple	10.7
Topping/Pruning	silver maple	8.7

Estimates are rounded.

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.

Standing Dead

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 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 numbers of standing dead trees.

Standing dead trees were found on 17 plots in Washington, DC. Of the total live and dead tree population, 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 white ash (Table 29). Land uses with the highest estimated number of standing dead trees are forest, multi-family residential, and recreation/cemetery (Fig. 24). The majority of standing dead trees are on unmaintained land in forest land uses.

Table 28.—Number of trees classified as standing dead by species, Washington, DC, 2018

Common name	Standing dead trees (number)	Standard error (number)	Species (percent)
white ash	19,000	20,000	100.0
pignut hickory	1,700	1,800	33.3
Siberian elm	18,000	19,000	27.0
sassafras	18,000	19,000	24.4
white oak	10,000	6,400	22.9
black locust	17,000	12,000	20.8
northern red oak	9,900	4,800	18.9
eastern redcedar	1,700	1,800	14.9
river birch	2,900	3,100	13.9
boxelder	1,400	1,500	12.5
yellow-poplar	10,000	5,300	9.3
black cherry	5,100	3,900	8.7
silver maple	1,400	1,500	8.6
chestnut oak	3,400	2,500	4.9
American elm	3,400	2,500	4.2
blackgum	3,100	2,400	3.9
red maple	1,600	1,700	0.8
American beech	1,700	1,800	0.5

Estimates are rounded.

Table 29.—Proportion of total dead tree population by species, Washington, DC, 2018

Common name	Standing dead trees (percent)
white ash	14.5
sassafras	13.8
Siberian elm	13.8
black locust	13.1
yellow-poplar	7.9
white oak	7.9
northern red oak	7.6
black cherry	4.0
chestnut oak	2.6
American elm	2.6
blackgum	2.4
river birch	2.2
eastern redcedar	1.3
pignut hickory	1.3
American beech	1.3
red maple	1.3
boxelder	1.1
silver maple	1.1
Total	100.0

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

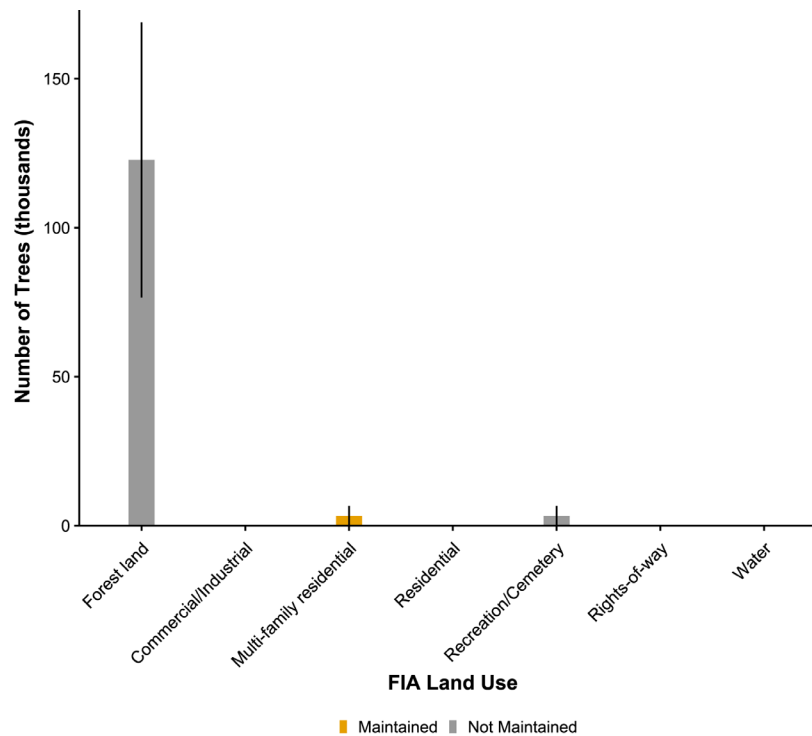


Figure 24.—Proportion of standing dead trees by Forest Inventory and Analysis (FIA) land use classes and maintenance status, Washington, DC, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

Invasive Species

Invasive plant species are often noted for their vigor, ability to adapt to novel environments, high reproduction capacity, and lack of natural enemies in their invaded range. 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 non-native 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 Washington, DC examined each plot for the presence of select invasive species based on a species list developed by the Forest Service, Northern Research Station (Appendix 6, Table 37). Of the 176 plots examined, invasive species were identified on 56.8 percent (100 plots).

Invasive species found in Washington, DC 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 total area covered by each species within the city (Bechtold and Scott 2005). These estimated areas may offer insights into which species are having the greatest impact in the city. Of the invasive species recorded, English ivy (*Hedera helix*) covered the largest area (592 acres; 1.4 percent of the sampling area), followed by tree of heaven (327 acres; 0.7 percent of the sampling area), and common reed (*Phragmites australis*) (290 acres; 0.6 percent of the sampling area). Of particular concern is the potential for these and other invasive species to spread beyond their current distribution into the surrounding landscape, potentially displacing native species and altering local ecosystems (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 Washington, DC are classified as trees, data on individual trees were collected in addition to descriptions of species cover on the plot. In Washington, DC, tree data were collected for black locust, tree of heaven, Siberian elm, and Norway maple. Taken together, these invasive trees are estimated to account for 10.0 percent of all live trees surveyed (estimated total trees: 201,000), and 3.9 percent of the total leaf area.

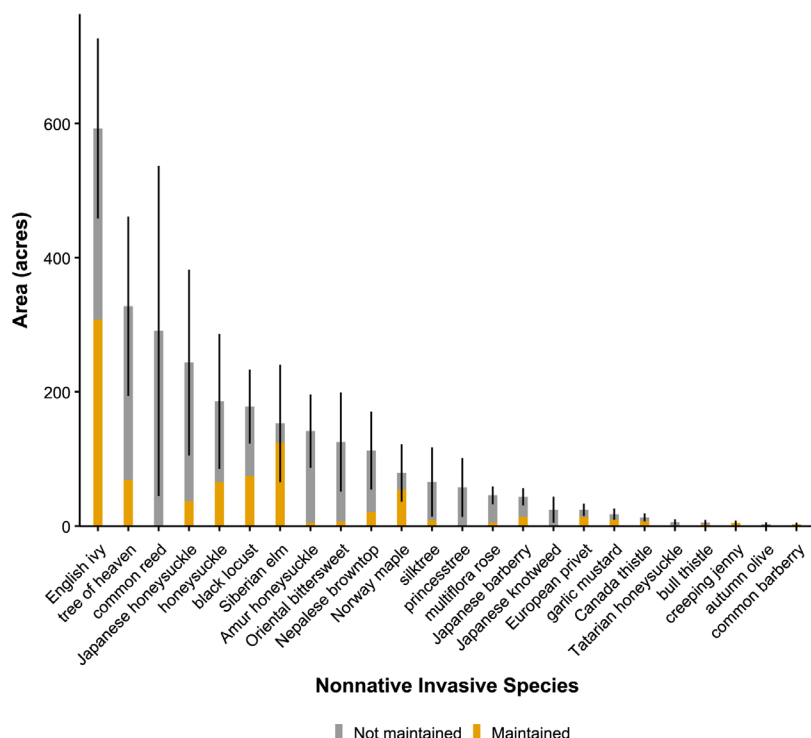


Figure 25.—Area of non-native invasive species cover by species on maintained and unmaintained land, Washington, DC, 2018. Error bars represent 68 percent confidence intervals around the estimated means.

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 37 insects and diseases, along with their tree hosts in Washington, DC, to quantify their potential impact on the urban forest (Table 30). This list of pests and pathogens was generated in consultation with the District of Columbia Urban Forestry Division, U.S. Forest Service State and Private Forestry Forest Health Protection, and range maps of pests and pathogens for the United States (Nowak 2021). An emphasis was made to highlight primary pests and pathogens in the urban forest, while acknowledging that certain secondary threats may serve as contributing factors in mortality (Manion 1991). 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 or infection.

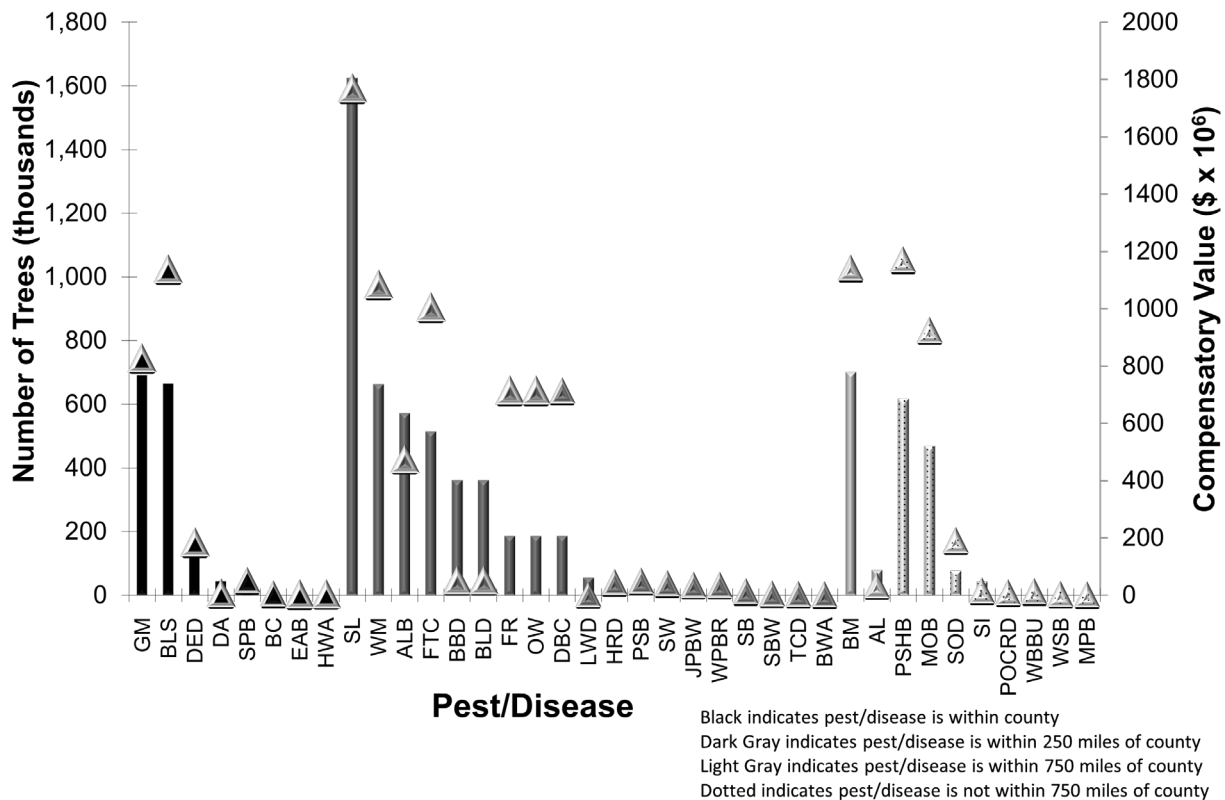


Figure 26.—Number of trees at risk due to pests and pathogens and their associated compensatory values, Washington, DC, 2018. Pest abbreviations are presented in Table 30.

Table 30.—Potential risk associated with various insects and diseases, Washington, DC, 2018

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value (dollars)
Within District	SM	Spongy Moth	<i>Lymantria dispar</i>	690,045	34.3	824.1
	BLS	Bacterial Leaf Scorch	<i>Xylella fastidiosa</i>	664,323	33.0	1,133.9
	DED	Dutch Elm Disease	<i>Ophiostoma ulmi</i>	152,297	7.6	181.5
	DA	Dogwood Anthracnose	<i>Discula destructiva</i>	45,038	2.2	3.7
	SPB	Southern Pine Beetle	<i>Dendroctonus frontalis</i>	18,462	0.9	49.3
	BC	Butternut Canker	<i>Ophiognomonia clavignenti-juglandacearum</i>	4,290	0.2	2.2
	EAB	Emerald Ash Borer	<i>Agrilus planipennis</i>	1,707	0.1	0.6
	HWA	Hemlock Woolly Adelgid	<i>Adelges tsugae</i>	1,430	0.1	1.4
Within 250	SLF	Spotted Lanternfly	<i>Lycorma delicatula</i>	1,624,813	80.7	1,765.2
	WM	Winter Moth	<i>Operophtera brumata</i>	662,288	32.9	1,080.9
	ALB	Asian Longhorned Beetle	<i>Anoplophora glabripennis</i>	571,275	28.4	473.8
	FTC	Forest Tent Caterpillar	<i>Malacosoma disstria</i>	513,864	25.5	1,001.9
	BBD	Beech Bark Disease	<i>Cryptococcus fagisuga/Neonectria</i> spp. complex	360,481	17.9	49.7
	BLD	Beech Leaf Disease	<i>Litylenchus crenatae</i> ssp. <i>mccannii</i>	360,481	17.9	49.7
	FR	Fusiform Rust	<i>Cronartium quercuum</i> f. sp. <i>fusiforme</i>	185,212	9.2	710.8
	OW	Oak Wilt	<i>Bretziella fagacearum</i> (formerly <i>Ceratocystis fagacearum</i>)	185,212	9.2	710.8
	DBC	Diplodia Bot Canker	<i>Botryosphaeria corticola</i>	185,212	9.2	710.8
	LWD	Laurel Wilt	<i>Raffaelea lauricola</i>	55,231	2.7	1.0
	HRD	Heterobasidion Root Disease	<i>Heterobasidion annosum</i>	19,645	1.0	42.9
	PSB	Pine Shoot Beetle	<i>Tomicus piniperda</i>	17,032	0.8	47.9
	SW	Sirex Wood Wasp	<i>Sirex noctilio</i>	13,041	0.6	38.0

continued on next page

Table 30 (continued).

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value (dollars)
Within 250 (cont.)	JPBW	Jack Pine Budworm	<i>Choristoneura pinus</i>	8,474	0.4	35.1
	WPBR	White Pine Blister Rust	<i>Cronartium ribicola</i>	8,474	0.4	35.1
	SB	Spruce Beetle	<i>Dendroctonus rufipennis</i>	5,421	0.3	10.5
	SBW	Spruce Budworm	<i>Choristoneura freemani</i>	4,290	0.2	3.9
	TCD	Thousand Canker Disease	<i>Geosmithia morbida</i>	4,290	0.2	2.2
	BWA	Balsam Woolly Adelgid	<i>Adelges piceae</i>	1,430	0.1	0.6
Within 750	BM	Browntail Moth	<i>Euproctis chrysorrhoea</i>	701,304	34.8	1,140.2
	AL	Aspen Leafminer	<i>Phyllocnistis populiella</i>	77,892	3.9	33.2
Farther than 750	PSHB	Polyphagous Shot Hole Borer	<i>Euwallacea fornicatus</i>	616,676	30.6	1,168.9
	MOB	Mediterranean Oak Borer	<i>Xyleborus monographus</i>	468,936	23.3	922.5
	SOD	Sudden Oak Death	<i>Phytophthora ramorum</i>	75,476	3.7	190.1
	SI	Sweetgum Inscriber	<i>Acanthotomicus suncei</i>	42,495	2.1	13.2
	POCRD	Port-Orford-Cedar Root Disease	<i>Phytophthora lateralis</i>	9,307	0.5	7.3
	WBBU	Western Blackheaded Budworm	<i>Accleris gloverana</i>	5,421	0.3	10.5
	WSB	Western Spruce Budworm	<i>Choristoneura occidentalis</i>	2,860	0.1	2.5
	MPB	Mountain Pine Beetle	<i>Dendroctonus ponderosae</i>	1,430	0.1	0.6

Estimates are rounded.

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. For Washington, DC, proximity was classified for insects and diseases in the District of Columbia; within 250 miles of the District; between 250 and 750 miles of the District; or greater than 750 miles away. Since there are no pest range maps for Dutch elm disease (DED; *Ophiostoma* spp.), the range of this pest was based on known occurrence and the known host range, respectively (Nowak 2021). Proximity data for insects and diseases, along with the numbers of trees potentially affected and their compensatory values, are illustrated in Table 30.

Based on the host tree species for each pest 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 (Table 38), each pest that could pose a threat to a tree species is scored as 4 points if it occurs within the District of Columbia, 3 points if it occurs within 250 miles of the county, 2 points 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 Washington, DC, but are not listed in Appendix 7 (Table 38), are not known to be hosts to any of the 37 insects and diseases evaluated. This table also excludes the pests and diseases that were not a threat to any of the species sampled.

MANAGEMENT IMPLICATIONS



Early Detection Rapid Response pest trapping in Pope Branch Park, Washington, DC. Courtesy photo by Kasey Yturalde, District Department of Transportation, Urban Forestry Division.

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 Washington, DC's urban forest while minimizing the cost associated with its maintenance.



Washington, DC's population is rapidly growing. The city's population will grow to an estimated 987,000 by 2045 (an increase of 29.6 percent from 2015) and the region's population will grow to 6,876,000 by 2045 (an increase of 28.0 percent from 2015) (Government of the District of Columbia 2019). With an average increase in population of 800 to 1,000 per month over the five years preceding the inventory, the District recognizes the need to balance population growth and economic development with the conservation and management of natural resources (Government of the District of Columbia 2018). Identifying priority areas for the enhancement or maintenance of tree growth, survival, and cover may assist the District in managing the benefits of urban forests. Tree density and its benefits are highly variable among NLCD land classes in Washington, DC, with density ranging from only 0 and 8 trees per acre in water and developed-high land covers, respectively, to 250 trees per acre in the forest/shrub land cover class (Table 9). Chinese elm, sweetgum, eastern hophornbeam, and tree of heaven are the most abundant species in residential and other developed areas and American beech, red maple, American holly, and yellow-poplar are most common in the forest/shrub areas (Appendix 3). Understanding the relationship between land cover or land use, species composition and density of trees, and the potential benefits associated with conserving or augmenting tree resources may be useful in developing plans to enhance or protect urban forests. For example, the District could leverage residential tree planting programs to enhance biodiversity of the tree population occurring on private property or identify opportunities for planting of climate resilient tree species.

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 amount or species composition of trees in the urban forest. Changes in climate, land cover, species composition, or interactions with pests or pathogens can also shape urban forests. Using this Urban FIA inventory, it is possible to estimate which species may be more or less threatened by changing land use, climate change, human activity, or host-specific pests and pathogens and estimate the monetary value associated with these potential threats.

Tree Planting

Recruitment of new trees into urban forests can result from both natural seed-based regeneration and intentional planting, although the relative proportions of naturally occurring versus intentionally planted trees can vary widely among cities (Nowak 2012). The majority of trees that make up Washington, DC's urban forest are the result of natural recruitment, but UFIA data suggest that 34.1 percent of trees in the city are planted rather

than naturally occurring. Planted trees may be native or introduced; the native American holly is the most common tree in Washington, DC's inventory recorded as planted rather than naturally occurring. The highest percentages of planted trees are found in rights-of-way and residential land uses (93 and 88 percent respectively), whereas only 6 percent of inventoried forest trees are planted. The District Department of Transportation administers public space tree permits for planting or removal of trees in the public rights-of-way, and sets minimum size requirements and approved species lists for planting stock, selecting species that are not invasive or prone to fatal pests or diseases, including the emerald ash borer (EAB; *Agrilus planipennis*) and Dutch elm disease (DDOT 2020).

Washington, DC had a tree canopy cover of 38 percent at the time of the inventory (assessed using remotely sensed imagery and LiDAR data) with a goal to increase canopy cover to 40 percent by 2032 (Government of the District of Columbia 2018). As part of protecting, restoring, and expanding land ecosystems to meet this target, the District strives to plant and maintain 10,500 new trees per year in priority areas, and averaged close to 12,000 tree plantings per year in the five years prior to Urban FIA data collection (Government of the District of Columbia 2018). As part of their efforts to expand, preserve and improve the urban forest, District Government plans to increase urban tree canopy across all ownerships (DDOT 2020) and prioritizes tree plantings by identifying areas that experience vulnerabilities to climate change such as areas prone to flooding, the heat island effect, and areas lacking sufficient coverage and shade. Furthermore, they work with communities to shape tree plantings in their neighborhoods so that residents have a voice in the process. Community support can help ensure effective tree stewardship and increased survival rates across the urban landscape.

Because the majority of trees on rights-of-way, residential, and recreational land uses are not the result of natural recruitment, meeting the District's tree canopy goal will require knowledge of the tree species likely to thrive in the future and availability of high-quality stock from local nurseries. It will also require the participation of private landowners, as a significant portion of the District's trees occur on residential and other private lands (Table 7). Commercial/industrial and rights-of-way land uses have the lowest tree densities (Table 8) and may present an opportunity for canopy expansion. This type of information may inform planting initiatives by local non-governmental organizations (NGOs) and community organizations, such as Casey Trees, who actively participate in and encourage the planting of trees on public and private property, helping augment tree canopy across developed land uses and restoring healthy canopy of urban natural areas.

In addition to planting efforts described above, the Tree Canopy Protection Amendment Act of 2016 discourages the removal of healthy, mature trees (Government of the District of Columbia 2018), which is critical to ensuring overall tree canopy gain and preventing net loss. Urban FIA can support the District's sustainability targets 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. In particular, continued monitoring of the urban forest will offer information on rates of growth and mortality among the city's trees through time.

Insect and Disease Impacts

Pests and pathogens directly impact urban forests via increased mortality, reduced vigor, and shifts in urban forest composition (Lovett et al. 2016, Poland and McCullough 2006), while indirect impacts include increased susceptibility to environmental stressors. Mortality of urban trees leads to the loss of associated benefits such as reduced stormwater runoff, improved air and water quality, and adaptation to urban heat island conditions (Lovett et al. 2016). The economic impacts of invasive wood borers such as the emerald ash borer caused over \$11 billion dollars of damage in the first 10 years of the infestation in Michigan (Herms et al. 2004). White ash was the most common dead tree species in the Washington, DC inventory, likely reflecting years of emerald ash borer infestation (Chen 2021). Impacts of pests and pathogens are significant in Eastern North American forests, which are subject to the highest number of invasive forest pests in the United States (Liebholt et al. 2013). The majority of costs associated with non-native forest insect pests falls to local communities and governments (Aukema et al. 2011).

The greatest threats to Washington, DC's urban forest posed by pests and pathogens include bacterial leaf scorch (BLS; *Xylella fastidiosa*), spongy moth (SM; *Lymantria dispar*), and the disease complex of Dutch elm disease and the smaller European elm bark beetle (*Scolytus multistriatus*) (Table 30; Fig. 26). Bacterial leaf scorch impacts streets trees in the late summer and occurs throughout the city (Harris et al. 2014). Pin oak and northern red oak are the most commonly infected trees, followed by other species such as American elm and sycamore (Harris et al. 2014). Spongy moth is known to occur in the District of Columbia and was actively managed by the National Park Service and U.S. Forest Service during outbreaks in the 1980s and 1990s (Favre et al. 1993). Dutch elm disease occurs throughout the District and is managed by the District's Urban Forestry Division. The management plan includes treatment of mature American elms with fungicide, expedited removal of elms with advanced symptoms of DED, and replanting with DED resistant or tolerant elm cultivars (DDOT 2020).

Additional threats within 250 miles of the District include spotted lanternfly, winter moth (WM; *Operophtera brumata*), Asian longhorned beetle (ALB; *Anoplophora glabripennis*), beech leaf and beech bark disease, oak wilt, and diplodia bot canker (DBC; *Botryosphaeria corticola*). Asian longhorned beetle poses a threat to a significant proportion of trees in the District given that its hosts include two of the most commonly occurring genera in the District (Nowak 2021), *Acer* (maple) and *Ulmus* (elm), which account for approximately 22 percent of the trees in the urban forest. Asian longhorned beetles attack healthy trees, their larvae eating through the sapwood and then into heartwood. Over time the feeding can girdle the tree, cutting off its movement of sugars, as well as leading to structural weakness (Meng et al. 2015).

The new invasive species, spotted lanternfly, is identified as having the greatest compensatory impact (Fig. 26, Table 30), due to its large host range that includes over 100 plant and tree species, many of which occur in North America (Barringer and Ciafré 2020). Impacts of spotted lanternfly presence and activity on landscape, nursery, and agriculture industries are well-documented (Urban and Leach 2022) and can result in economic losses directly due to feeding or indirectly due to feeding and honeydew production, or even due to its nuisance presence alone. The impacts of spotted lanternfly on tree and forest health have yet to be determined (Urban 2020, Urban and Leach 2023). However, given the public response to the proliferation of spotted lanternfly in other northeastern cities, it will likely pose a threat as an urban nuisance pest in the District (Urban 2020).

Forest health threats to *Quercus* (oak) species include both pests and pathogens, such as spongy moth or oak wilt, respectively. *Quercus* species are ranked as having the highest pest and pathogen relative risk weight due to a combination of several pests and pathogens that occur within the District, and several within 250 to 750 miles (Appendix 7, Table 38). Pathogens that currently occur in the District and impact oak health include bacterial leaf scorch and anthracnose. Pathogens such as oak wilt or sudden oak death (SOD; *Phytophthora ramorum*) (found within 250 miles and more than 750 miles away, respectively) also pose significant threats to the urban forest in DC (Juzwik et al. 2011, Kovacs et al. 2011). Additional pathogens include *Diplodia* spp. which have been implicated in causing bleeding cankers and dieback in a variety of oak species such as white oak, black oak, and chestnut oak (Haines et al. 2019, Martin et al. 2017, Munck et al. 2017).

Beech trees are the most common tree in the District of Columbia and are threatened by two different disease complexes: beech bark disease and beech leaf disease. Beech leaf disease is an emerging disease in the Northeast and symptoms include dark banding in between leaf veins and abnormal leaf texture and shape, while impacts include canopy

loss and mortality in young saplings (Martin et al. 2019). Beech bark disease (BBD) is a complex of the beech scale (*Cryptococcus fagisuga*) and several fungi, mostly *Neonectria* spp. The risks associated with beech bark disease are high due to its impacts that include reduced growth, crown dieback, compromised bark health, and mortality (Cale et al. 2017).

The District's urban forest is threatened by various lepidoptera, such as spongy moth, winter moth, and browntail moth (BM; *Euproctis chrysorrhoea*) (Fig. 26), all of which are invasive. Browntail moth is a particular concern given the impacts on humans, due to the poisonous hairs from caterpillars that cause rashes and respiratory issues (USDA Forest Service, n.d.).

The District of Columbia's forestry agency, the Urban Forestry Division, deploys a variety of early detection protocols to detect and prevent the establishment of invasive pest and pathogen species. These include a cryptic wood borer survey using rearing chambers (DiGirolomo et al. 2022), participation in the U.S. Forest Service, Early Detection Rapid Response Program (Rabaglia et al. 2019), coordination with USDA Animal and Plant Health Inspection Service (APHIS) for trapping of spotted lanternfly, and ad hoc testing of symptomatic foliage and branch samples for pathogens in coordination with federal and university diagnostic laboratories. These efforts are supported by contributions from the public via the [Urban Forestry Division's Forest Health website](#) and portal for reporting invasive species such as Asian longhorned beetle, spotted lanternfly, and spongy moth.

Climate Impacts

Threats posed to trees by insects and diseases are expected to be compounded by extreme weather conditions, which weaken trees' ability to defend against pests and pathogens. In recent years, the District has seen record-breaking extreme weather (e.g., heat waves and tornados), higher tides caused by rising sea level, heavy rains and flooding, warmer average temperatures, and an increase in dangerously hot days (DOEE 2020). Washington, DC also experiences the "urban heat island" effect, described by the U.S. Environmental Protection Agency (U.S. EPA) as a phenomenon where urbanized areas experience higher temperatures than outlying areas as a result of structures, such as buildings, roads and other infrastructure, absorbing and re-emitting the sun's heat more than natural landscapes. A recent study found air temperatures in some places were 10 to 20 degrees Fahrenheit warmer than cooler parts of the District with more green space (Shandas et al. 2019). Street trees and other trees located in developed land uses are at a particularly elevated risk of both heat and drought stress, which may in turn make them increasingly susceptible to attack by pests and pathogens.

Several District of Columbia government initiatives recognize the importance of tree canopy in reducing the urban heat island effect and mitigating dangers of extreme heat for city residents (e.g., State Forest Action Plan, Keep Cool DC, Climate Ready DC). In addition to cooling effects, urban trees contribute to stormwater capture which improves regional water quality and mitigates flooding impacts intensified by climate change. Yellow-poplar makes up the greatest amount of leaf area in Washington, DC's urban forest by far (Table 16), which means that it contributes significantly to cooling the city and also prevents the greatest amount of stormwater runoff (Fig. 15). However, an examination of ecosystem services by land use shows that ginkgo and pin oak, due to their frequent siting close to buildings and adjacent to impervious surfaces, are the species with greatest residential energy cost savings and avoided runoff (respectively) in developed areas of the city.

Climate impacts are not distributed equally across Washington, DC. The heat sensitivity-exposure index created by District Department of Energy Environment as part of Keep Cool DC, integrates heat sensitivity variables that influence an individual's ability to cope with extreme heat, including socioeconomic, demographic, and health variables; and heat exposure variables including ambient air temperature, impervious surfaces, and lack of tree canopy cover (DOEE 2022). The city's Urban FIA data summarized by the heat sensitivity-exposure index can be found on the My City's Trees application and shows that communities at the greatest heat risk often have the lowest tree densities. By coupling an understanding of the urban tree population with demographic information, managers can identify and prioritize areas to increase tree planting efforts to help counteract the effect of heat islands on communities that are most vulnerable to the impacts of extreme heat.

As recognized by Carbon Free DC, the District's urban forest also has an important role to play in counteracting climate change via carbon sequestration (DOEE 2021). More than half of the carbon stored by the city's trees is found on forest land (Table 23). By species, yellow-poplar contributes most to carbon storage, followed by white oak, chestnut oak, pin oak, and willow oak (Fig. 17). These same species also contain the largest net board-foot sawtimber volume (Table 18). While the District does not allow removal of large trees unless they are hazardous, the Urban Forestry Division's urban wood material reuse program can extend the "useful life" of Washington, DC's trees and prolong trees' carbon sequestration (DDOT 2020). The District Urban Forestry Division has noted a recent increase in reports of rapid decline for both chestnut oak and white oak throughout the mid-Atlantic region. The loss of these two species would have significant implications for climate mitigation, in addition to other ecosystem services.

An analysis of the climate change vulnerability of Washington, DC's tree species reveals that most of the top species recorded in the Urban FIA inventory are at low to moderate climate risk under both low and high greenhouse gas emissions scenarios (NIACS 2021). However, yellow-poplar is at high risk under both emissions scenarios and is an important species for mitigating impacts of climate change as described above. Urban forest managers may want to think about transitioning sites dominated by yellow-poplar to more climate-adapted species that will continue to provide critical ecosystem services into the future.

Native, Introduced, and Invasive Species in Washington, DC

The majority of Washington, DC's trees are native to the area. Only three of the top 20 live tree species recorded by Urban FIA crews in the city are introduced, and the remaining are native to Washington, DC and surrounding counties. Tree of heaven, Siberian elm, and Norway maple represent 3, 2.4, and 1.4 percent of the city's tree population (≥ 1 -inch diameter), respectively (Table 10). All three of these introduced species are found on both forest and developed land uses (Table 34) and on public and privately owned land, although all three make up a greater proportion of trees found on public land than private land (Tables 13 and 14). These three tree species are included in the Northern Research Station FIA's invasive species list, as well as mimosa tree and paulownia. However, most introduced species tallied in the inventory are not invasive. These may be ornamental species planted on developed land (e.g., Yoshino flowering cherry) or species known to thrive as street trees in difficult planting conditions (e.g., ginkgo). The District's Urban Forestry Division encourages removal of invasive tree species through an exemption of such species (Norway maple, mulberry, and tree of heaven) from fees associated with tree removal permits.

Native species with the greatest number of stems include American beech, red maple, American holly, and yellow-poplar, which represent 17.9, 9.5, 5.2, and 5.0 percent of the city's tree population (≥ 1 -inch diameter), respectively. Many native species are found across urban land uses and site types, while others are only found in forested conditions. For example, in addition to being some of the most prevalent species recorded on forest/scrub land, American holly, and red maple are found in developed areas such as residential lands or in the public rights-of-way. In contrast, species such as American hornbeam and American sycamore are typically found in the forest and not frequently planted. The District of Columbia Government recognizes the importance of native species in providing a diverse, resilient urban forest by planting only native tree species on sites outside the public rights-of-way and by maintaining a public directories of native plant species for use on private lands, and encouraging wildlife-friendly backyard habitats (Government of the District of Columbia 2018). The District also has a large amount of

forest land managed by the National Park Service that serves as an important cultural and ecological resource supporting biodiversity and critical ecosystem services.

Washington, DC is home to 240 species of birds, 78 fish, 32 mammals, 21 reptiles, 19 amphibians, and thousands of invertebrates (DOEE 2015). The District's Department of Energy and the Environment is responsible for the conservation and management of all species of wildlife and their habitats as outlined in the Fisheries and Wildlife Omnibus Amendment Act of 2016, and the District's State Wildlife Action Plan. Native tree species from *Fagus* (beech), *Quercus* (oak), *Ilex* (holly), and *Prunus* (cherry) genera are important food sources for local wildlife across public and private lands (Fig. 9).

The District's efforts to conserve habitat also include removal of invasive plant species on hundreds of acres of critical habitat (Government of the District of Columbia 2018). In addition to the invasive tree species described above, English ivy, common reed, and honeysuckle (*Lonicera*) species are some of the most prevalent invasive plant species recorded in the inventory (Fig. 25). Common reed is a major threat to critical wetland habitat throughout the Eastern United States, while English ivy and honeysuckle are found across maintained and unmaintained urban areas and often escape from landscaped sites to threaten forest canopy health and prevent regeneration in the understory. Both English ivy and Japanese honeysuckle (*Lonicera japonica*) were found in more than 50 percent of National Park Service long-term vegetation monitoring plots in the Washington, DC's Rock Creek Park (Miller et al. 2021). Tracking the spread of these species will be important in limiting their impacts on natural ecosystems throughout Washington, DC.

Current Tree Size Distribution and Potential Species Composition Changes

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 sufficient numbers of young trees are present to compensate for the mortality of older trees. The size distribution in Washington, DC'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 Washington, DC's urban forest is forecasted to be self-sustaining. However, this pattern is not consistent across the urban landscape. Trees on private land, state and local land, and rights-of-way were not represented by an inverse J-shaped distribution, and instead had more trees falling into the large-diameter class (11.0+ inch) than in the smallest class (1.0–3.0 inch). The interactions of several drivers which have not been

analyzed in this report, including rates of growth, mortality, natural regeneration, and planting, may influence these diameter class curves. Continued monitoring over time will provide insight into these processes and their influence on changing species composition across size classes.

The species composition of Washington, DC's urban forest may change in the future depending upon the current size distribution of individual species. Species whose size composition is skewed towards more small, young trees may come to dominate the future classes of medium- and large-diameter trees, while those species in which large adult trees are currently more common may decline in abundance through time. For example, yellow-poplar and white oak are only found in the larger diameter size classes, which 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, these large stature native tree species may become a less common component of Washington, DC's urban forest over time, with implications for carbon sequestration and other ecosystem services. American beech and red maple dominate the smallest diameter class and make up significant portions of larger classes, indicating that these species are likely to continue their prevalence in Washington, DC's urban forest for years to come. Other species such as sassafras, flowering dogwood, and eastern hophornbeam are almost exclusively found in the smallest tree class and are small- or medium-stature species that are not expected to attain very large diameters. Actions such as pest management, enhancing 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.

CONCLUSION



Red maple street trees with fall color in Washington, DC. Courtesy photo by Mario Sessions, District Department of Transportation, Urban Forestry Division.

Washington, DC's urban forest contributes to the city's environmental, economic, and societal well-being. Throughout the city, an estimated 2.01 million trees, representing 80 species, provide tree canopy cover and associated ecosystem services to District residents. This information can help the city strategize to meet its canopy cover goals of expanding overall urban tree canopy cover to 40 percent by 2032 (Government of the District of Columbia 2018). These trees provide 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. Urban trees and green space also correlate with mental and physical health benefits and lower crime rates (Donovan et al. 2013, Gilstad-Hayden et al. 2015, Li and Sullivan 2016, Nutsford et al. 2013).



There are several forces that may impact Washington, DC'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 current urban forest resource and associated ecosystem services and values, future monitoring will identify how the forest is changing over time. The plots measured in Washington, DC will be re-measured annually on a 7-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 that provides ecosystem services for future generations. In the future, change analyses can be used to evaluate the success of Washington, DC's 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 (Table 32) (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 (Table 37).

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).

APPENDIX 1 – LAND COVER DESCRIPTION

Table 31.—National Land Cover Database (NLCD) land cover descriptions

NLCD land cover class	NLCD code	Land cover description
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.
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.
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.
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.
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-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.
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.
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.
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.
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.
Lichens	73	Alaska only areas dominated by fruticose or foliose lichens generally greater than 80 percent of total vegetation.
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.
Moss	74	Alaska only areas dominated by mosses, generally greater than 80 percent of total vegetation.
Open water	11	Areas of open water generally with less than 25 percent of vegetation or soil.

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Table 31 (continued).

NLCD land cover class	NLCD code	Land cover description
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.
Perennial ice/snow	12	Areas characterized by a perennial cover of ice and/or snow, generally greater than 25 percent of total cover.
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.
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.
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.

Source: Homer et al. 2015.

APPENDIX 2 – TREE SPECIES COMPOSITION

Table 32.—List of all live tree species and their characteristics, Washington, DC, 2018

Genus	Species	Common name	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (inches)
<i>Acer</i>	<i>ginnala</i>	Amur maple	21,000	0	0	21,000	1.0	21,000	2.8
<i>Acer</i>	<i>negundo</i>	boxelder	0	7,100	2,900	10,000	0.5	6,900	10.0
<i>Acer</i>	<i>palmatum</i>	Japanese maple	0	1,700	5,600	7,300	0.4	3,700	11.6
<i>Acer</i>	<i>platanooides</i>	Norway maple ^a	21,000	6,300	1,400	29,000	1.4	23,000	3.0
<i>Acer</i>	<i>rubrum</i>	red maple	127,000	48,000	16,000	191,000	9.5	122,000	4.9
<i>Acer</i>	<i>saccharinum</i>	silver maple	0	1,400	14,000	15,000	0.8	5,900	26.0
<i>Acer</i>	<i>saccharum</i>	sugar maple	0	5,800	0	5,800	0.3	3,300	9.6
<i>Acer</i>	<i>x freemanii</i>	Freeman maple	0	1,600	0	1,600	0.1	1,700	6.0
<i>Ailanthus</i>	<i>altissima</i>	tree of heaven ^a	41,000	13,000	5,100	60,000	3.0	49,000	5.0
<i>Albizia</i>	<i>julibrissin</i>	mimosa, silktree	0	1,400	0	1,400	0.1	1,500	8.8
<i>Betula</i>	<i>nigra</i>	river birch	0	18,000	0	18,000	0.9	13,000	6.7
<i>Carpinus</i>	<i>caroliniana</i>	American hornbeam, musclewood	21,000	0	0	21,000	1.1	22,000	1.9
<i>Carya</i>	<i>alba</i>	mockernut hickory	21,000	0	1,700	22,000	1.1	21,000	2.5
<i>Carya</i>	<i>cordiformis</i>	bitternut hickory	0	3,400	3,400	6,800	0.3	4,200	13.0
<i>Carya</i>	<i>glabra</i>	pignut hickory	0	1,700	1,700	3,400	0.2	2,500	11.3
<i>Catalpa</i>	<i>speciosa</i>	northern catalpa	0	1,400	2,900	4,300	0.2	3,400	22.6
<i>Celtis</i>	<i>occidentalis</i>	hackberry	0	3,900	0	3,900	0.2	2,700	5.9
<i>Celtis</i>	spp.	hackberry spp.	0	4,900	1,600	6,500	0.3	6,600	8.7
<i>Cercis</i>	<i>canadensis</i>	eastern redbud	0	4,300	1,600	5,900	0.3	4,400	7.5
<i>Chamaecyparis</i>	<i>obtusa</i>	hinoki false cypress	0	1,600	0	1,600	0.1	1,700	5.3
<i>Cornus</i>	<i>florida</i>	flowering dogwood	42,000	0	0	42,000	2.1	45,000	2.8
<i>Cornus</i>	spp.	dogwood spp.	0	2,600	0	2,600	0.1	2,300	7.3
<i>Cupressocyparis</i>	<i>leylandii</i>	Leyland cypress	0	4,300	1,400	5,700	0.3	6,200	8.0
<i>Fagus</i>	<i>grandifolia</i>	American beech	297,000	51,000	12,000	360,000	17.9	143,000	3.5
<i>Fraxinus</i>	<i>pennsylvanica</i>	green ash	0	1,700	0	1,700	0.1	1,800	8.1
<i>Ginkgo</i>	<i>biloba</i>	ginkgo, maidenhair tree	0	1,300	8,500	9,800	0.5	5,200	19.7
<i>Gleditsia</i>	<i>triacanthos</i>	honeylocust	0	3,300	1,600	5,000	0.2	3,800	9.9
<i>Ilex</i>	<i>opaca</i>	American holly	64,000	35,000	5,900	104,000	5.2	98,000	5.7

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Table 32 (continued).

Genus	Species	Common name	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (inches)
<i>Ilex</i>	spp.	holly	0	6,600	0	6,600	0.3	4,900	5.4
<i>Juglans</i>	<i>nigra</i>	black walnut	0	2,900	1,400	4,300	0.2	3,400	9.5
<i>Juniperus</i>	<i>virginiana</i>	eastern redcedar	0	9,700	0	9,700	0.5	9,900	6.5
<i>Liquidambar</i>	<i>styraciflua</i>	sweetgum	34,000	1,600	6,500	42,000	2.1	32,000	4.5
<i>Liriodendron</i>	<i>tulipifera</i>	yellow-poplar	0	16,000	84,000	100,000	5.0	34,000	22.8
<i>Magnolia</i>	<i>fraseri</i>	mountain or Fraser magnolia	0	7,700	0	7,700	0.4	6,900	7.3
<i>Magnolia</i>	<i>grandiflora</i>	southern magnolia	64,000	1,700	6,400	72,000	3.6	74,000	4.7
<i>Metasequoia</i>	<i>glyptostroboi- des</i>	dawn redwood	0	0	1,600	1,600	0.1	1,700	15.0
<i>Morus</i>	<i>alba</i>	white mulberry	0	4,900	0	4,900	0.2	3,700	7.6
<i>Nyssa</i>	<i>sylvatica</i>	blackgum	42,000	31,000	3,100	77,000	3.8	54,000	4.7
<i>Ostrya</i>	<i>virginiana</i>	eastern hophornbeam	34,000	0	0	34,000	1.7	31,000	3.1
<i>Paulownia</i>	<i>tomentosa</i>	paulownia, empress-tree	0	1,700	1,600	3,300	0.2	2,400	11.1
<i>Phellodendron</i>	<i>amurense</i>	Amur corktree	0	0	1,300	1,300	0.1	1,500	11.5
<i>Picea</i>	<i>abies</i>	Norway spruce	0	1,400	0	1,400	0.1	1,500	5.4
<i>Picea</i>	<i>pungens</i>	blue spruce	0	1,400	0	1,400	0.1	1,500	9.2
<i>Picea</i>	spp.	spruce spp.	0	0	2,600	2,600	0.1	2,300	14.4
<i>Pinus</i>	<i>nigra</i>	Austrian pine	0	0	1,400	1,400	0.1	1,500	11.0
<i>Pinus</i>	<i>strobus</i>	eastern white pine	0	1,600	6,900	8,500	0.4	4,400	16.3
<i>Pinus</i>	<i>virginiana</i>	Virginia pine	0	0	1,700	1,700	0.1	1,800	14.3
<i>Platanus</i>	<i>hybrida</i>	London planetree	0	5,100	1,300	6,400	0.3	4,800	12.3
<i>Platanus</i>	<i>occidentalis</i>	American sycamore	36,000	0	4,000	40,000	2.0	40,000	3.7
<i>Prunus</i>	<i>avium</i>	sweet cherry	0	3,000	0	3,000	0.2	2,300	6.8
<i>Prunus</i>	<i>cerasus</i>	sour cherry	0	3,100	0	3,100	0.2	2,400	8.2
<i>Prunus</i>	<i>serotina</i>	black cherry	38,000	8,400	6,800	54,000	2.7	30,000	5.6
<i>Prunus</i>	<i>serrulata</i>	Japanese flowering cherry	0	8,100	0	8,100	0.4	3,900	7.8
<i>Prunus</i>	spp.	cherry and plum spp.	0	1,700	0	1,700	0.1	1,800	8.1
<i>Prunus</i>	<i>x yedoensis</i>	Yoshino flowering cherry	0	5,600	2,600	8,200	0.4	5,100	9.2

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Table 32 (continued).

Genus	Species	Common name	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (inches)
<i>Pyrus</i>	<i>calleryana</i>	Callery pear	0	5,200	0	5,200	0.3	3,700	7.9
<i>Quercus</i>	<i>acutissima</i>	sawtooth oak	0	3,200	1,600	4,900	0.2	5,000	10.6
<i>Quercus</i>	<i>alba</i>	white oak	0	0	34,000	34,000	1.7	16,000	23.1
<i>Quercus</i>	<i>bicolor</i>	swamp white oak	0	1,300	1,400	2,800	0.1	2,100	11.6
<i>Quercus</i>	<i>coccinea</i>	scarlet oak	0	0	4,400	4,400	0.2	2,700	22.4
<i>Quercus</i>	<i>ellipsoidalis</i>	northern pin oak	0	0	1,400	1,400	0.1	1,500	44.6
<i>Quercus</i>	<i>palustris</i>	pin oak	0	2,900	12,000	15,000	0.8	5,700	24.6
<i>Quercus</i>	<i>phellos</i>	willow oak	0	1,600	12,000	13,000	0.7	5,300	24.7
<i>Quercus</i>	<i>prinus</i>	chestnut oak	36,000	4,800	26,000	66,000	3.3	49,000	11.2
<i>Quercus</i>	<i>rubra</i>	northern red oak	21,000	11,000	10,000	42,000	2.1	25,000	7.8
<i>Robinia</i>	<i>pseudoacacia</i>	black locust ^a	54,000	7,700	3,200	64,000	3.2	61,000	3.6
<i>Sassafras</i>	<i>albidum</i>	sassafras	54,000	1,700	0	55,000	2.7	58,000	2.1
<i>Taxodium</i>	<i>distichum</i>	baldcypress	0	0	2,600	2,600	0.1	2,300	16.2
<i>Taxus</i>	<i>baccata</i>	English yew	18,000	0	0	18,000	0.9	19,000	2.4
<i>Thuja</i>	<i>occidentalis</i>	northern white-cedar	0	7,700	0	7,700	0.4	6,900	7.1
<i>Thuja</i>	<i>plicata</i>	western redcedar	0	13,000	0	13,000	0.6	8,600	6.8
<i>Tilia</i>	<i>americana</i>	American basswood	18,000	0	0	18,000	0.9	19,000	1.1
<i>Tilia</i>	<i>cordata</i>	littleleaf linden	0	1,300	0	1,300	0.1	1,500	8.5
<i>Tsuga</i>	<i>canadensis</i>	eastern hemlock	0	1,400	0	1,400	0.1	1,500	8.3
<i>Ulmus</i>	<i>americana</i>	American elm	42,000	18,000	18,000	79,000	3.9	37,000	8.5
<i>Ulmus</i>	<i>parvifolia</i>	Chinese elm	0	15,000	0	15,000	0.8	7,400	7.3
<i>Ulmus</i>	<i>pumila</i>	Siberian elm ^a	36,000	7,100	5,400	48,000	2.4	46,000	5.6
<i>Ulmus</i>	<i>rubra</i>	slippery elm	0	1,600	8,100	9,700	0.5	7,000	16.4
<i>Zelkova</i>	<i>serrata</i>	Japanese zelkova	0	5,900	11,000	17,000	0.8	7,600	15.8
Total			1,180,000	460,000	372,000	2,010,000	100.0	296,000	7.2

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.

– = no value for cell

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

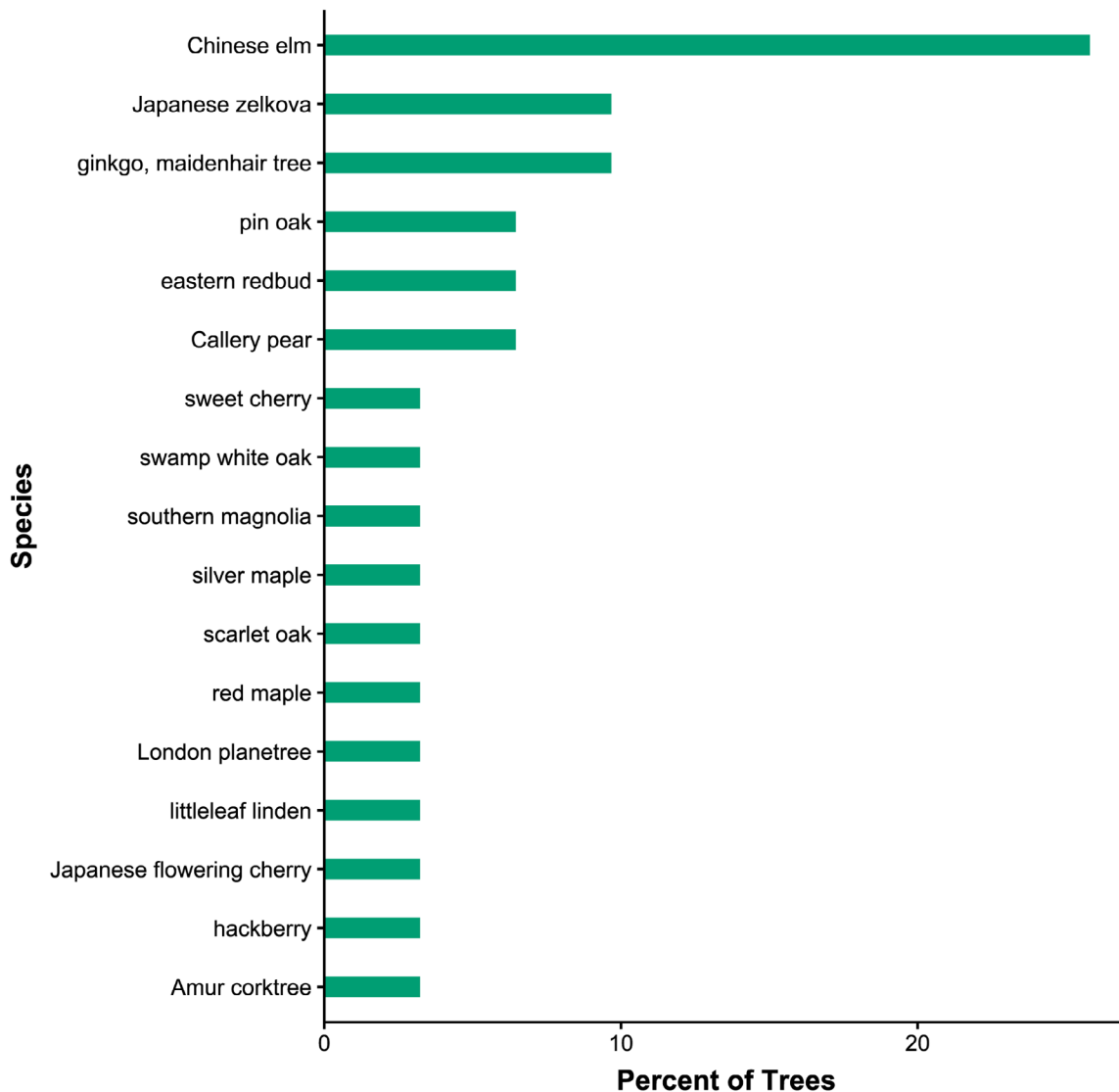


Figure 27.—Percent of the total tree population for up to 20 of the most common tree species observed in the Developed-medium National Land Cover Database (NLCD) land cover classes, Washington, DC, 2018.

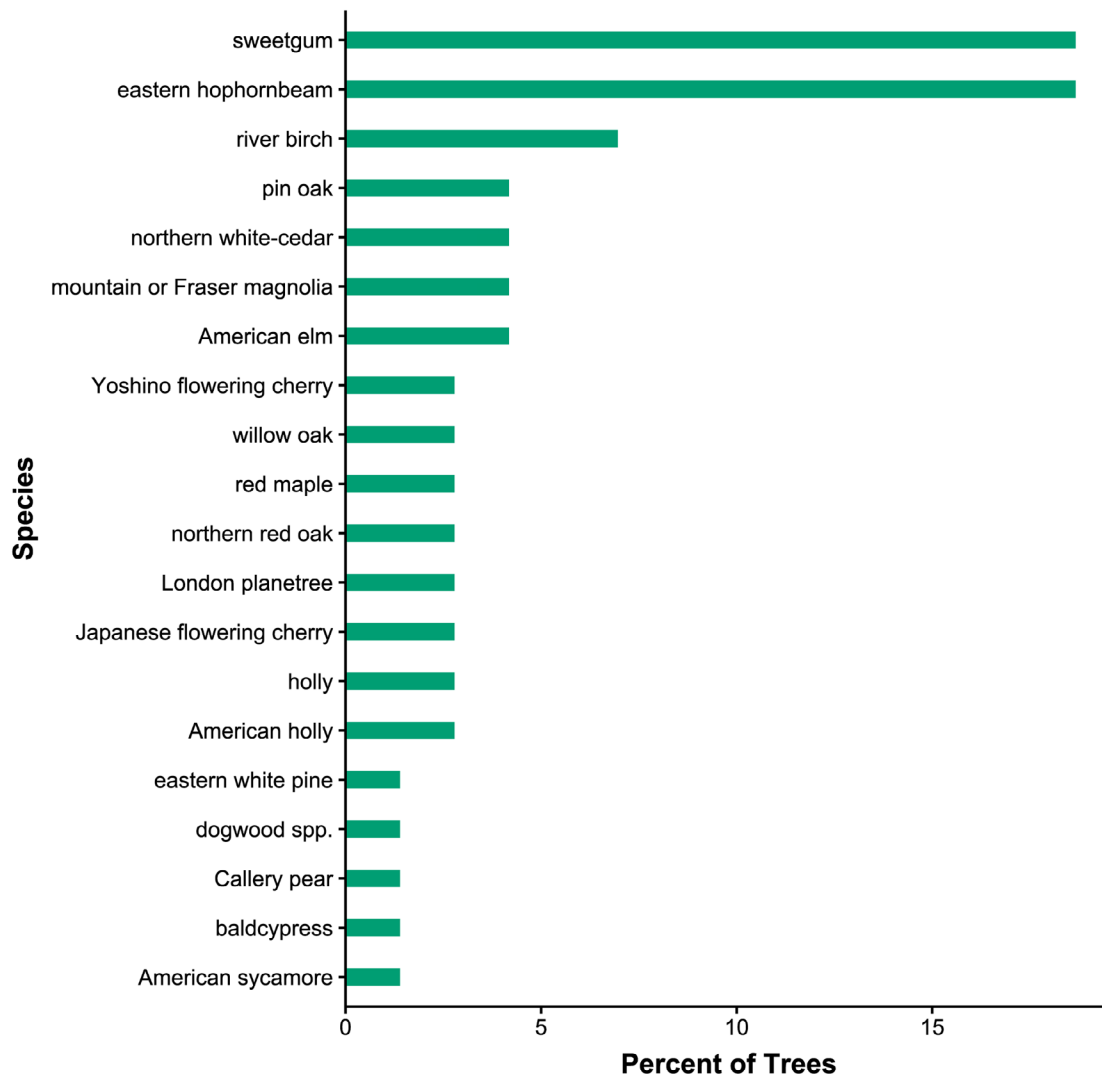


Figure 28.—Percent of the total tree population for up to 20 of the most common tree species observed in the Developed-low National Land Cover Database (NLCD) land cover classes, Washington, DC, 2018.

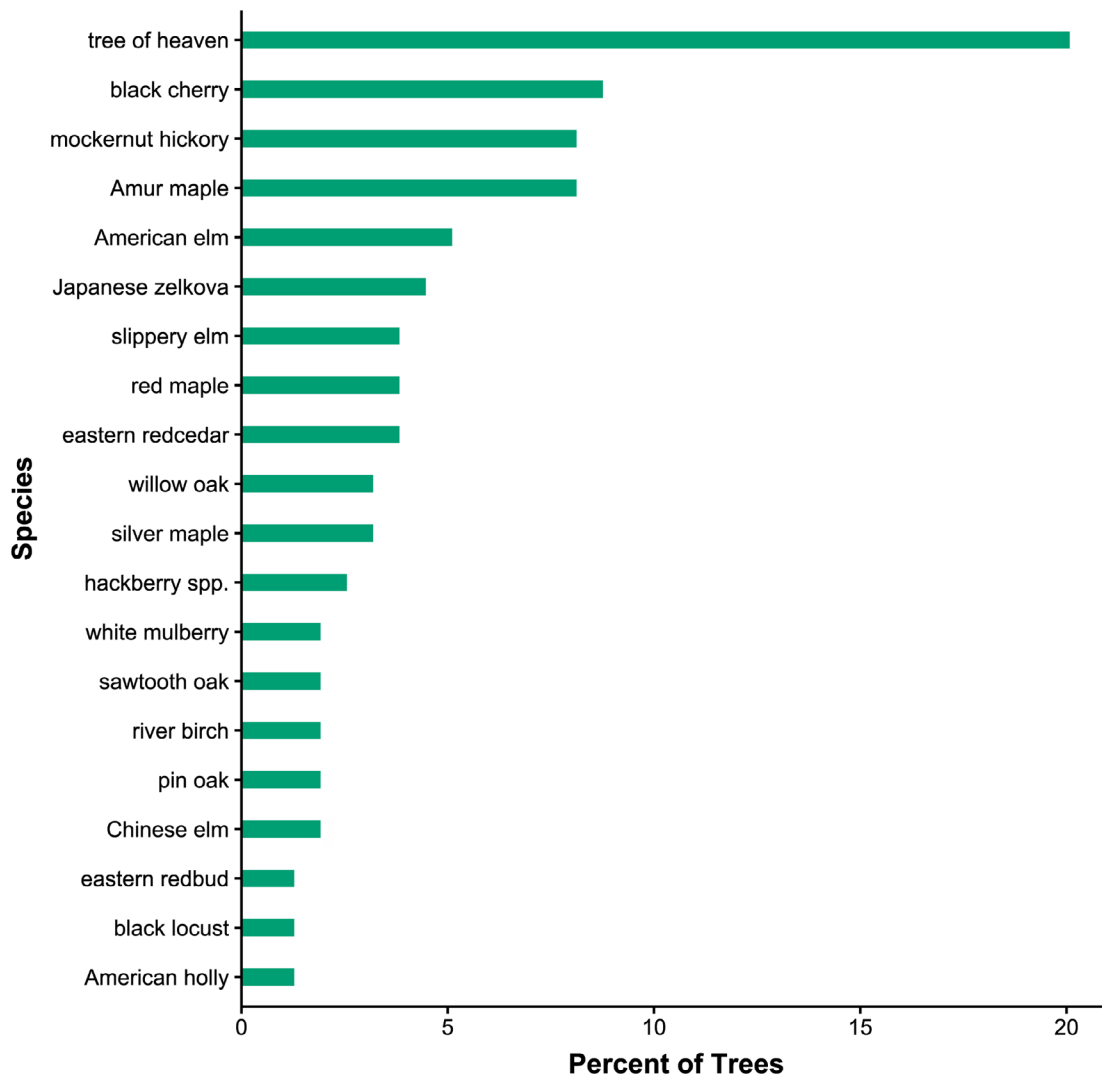


Figure 29.—Percent of the total tree population for up to 20 of the most common tree species observed in the Developed-high National Land Cover Database (NLCD) land cover classes, Washington, DC, 2018.

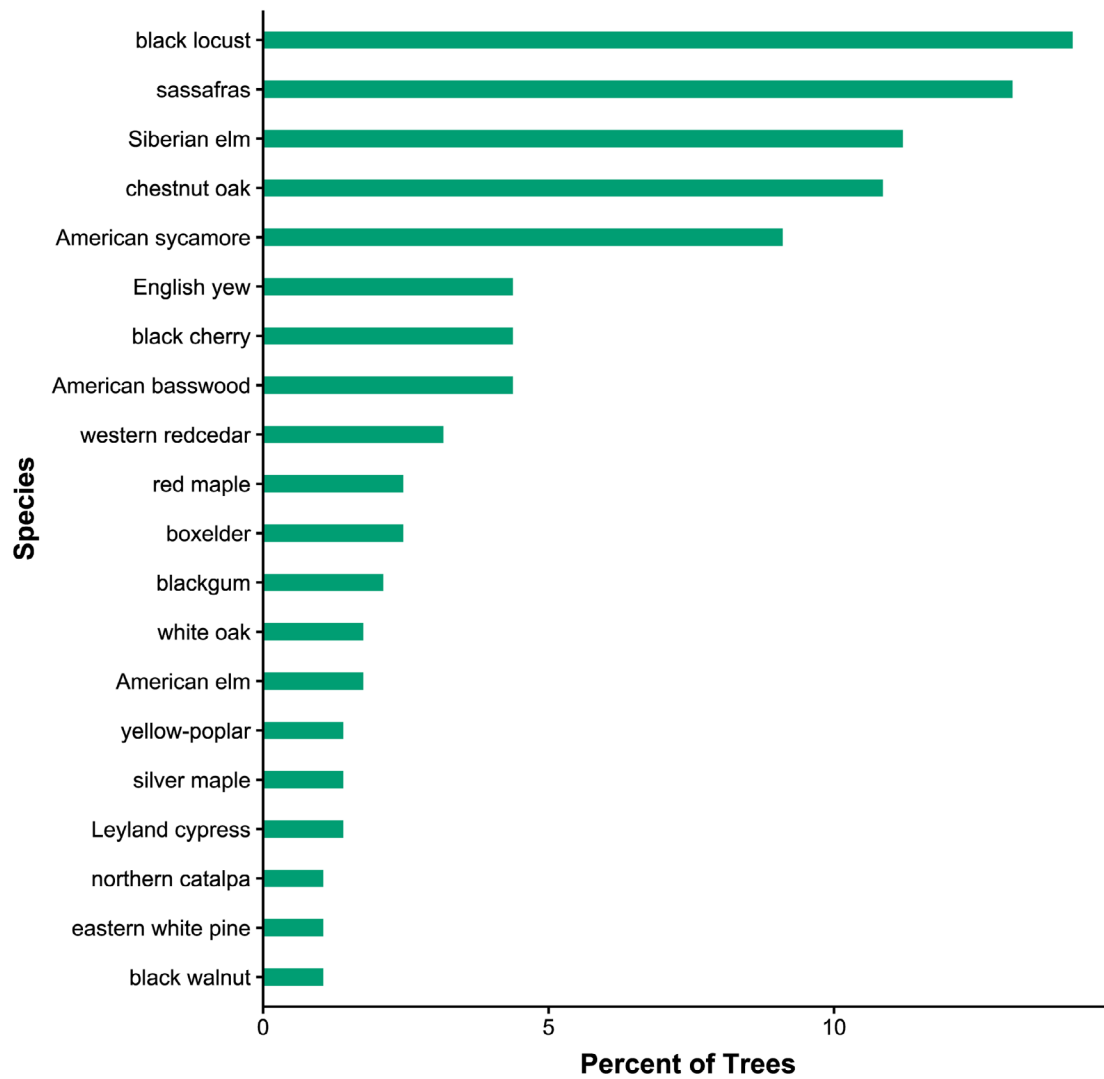


Figure 30.—Percent of the total tree population for up to 20 of the most common tree species observed in the Developed-open/herbaceous National Land Cover Database (NLCD) land cover classes, Washington, DC, 2018.

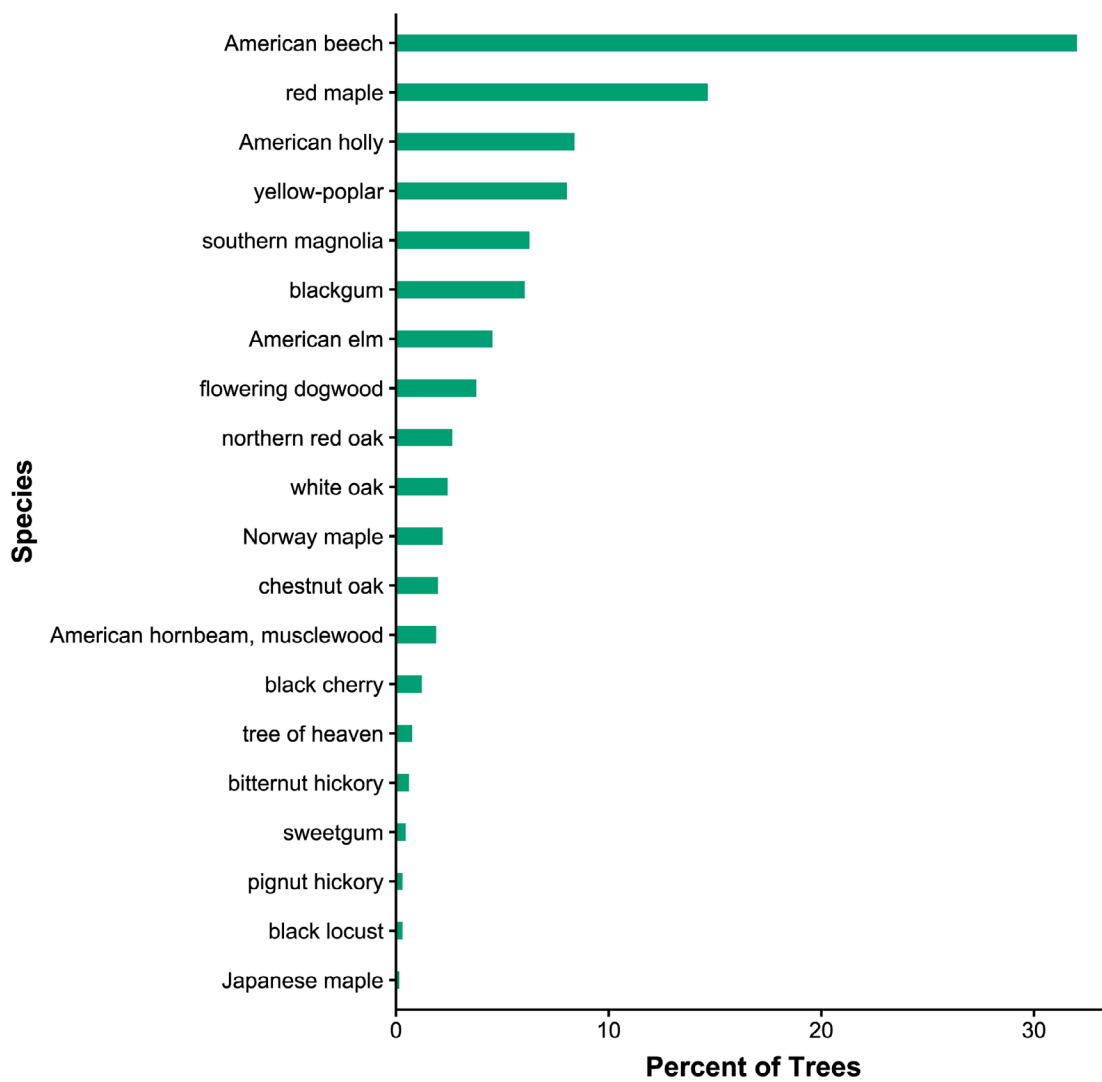


Figure 31.—Percent of the total tree population for up to 20 of the most common tree species observed in the Forest/Shrub National Land Cover Database (NLCD) land cover classes, Washington, DC, 2018.

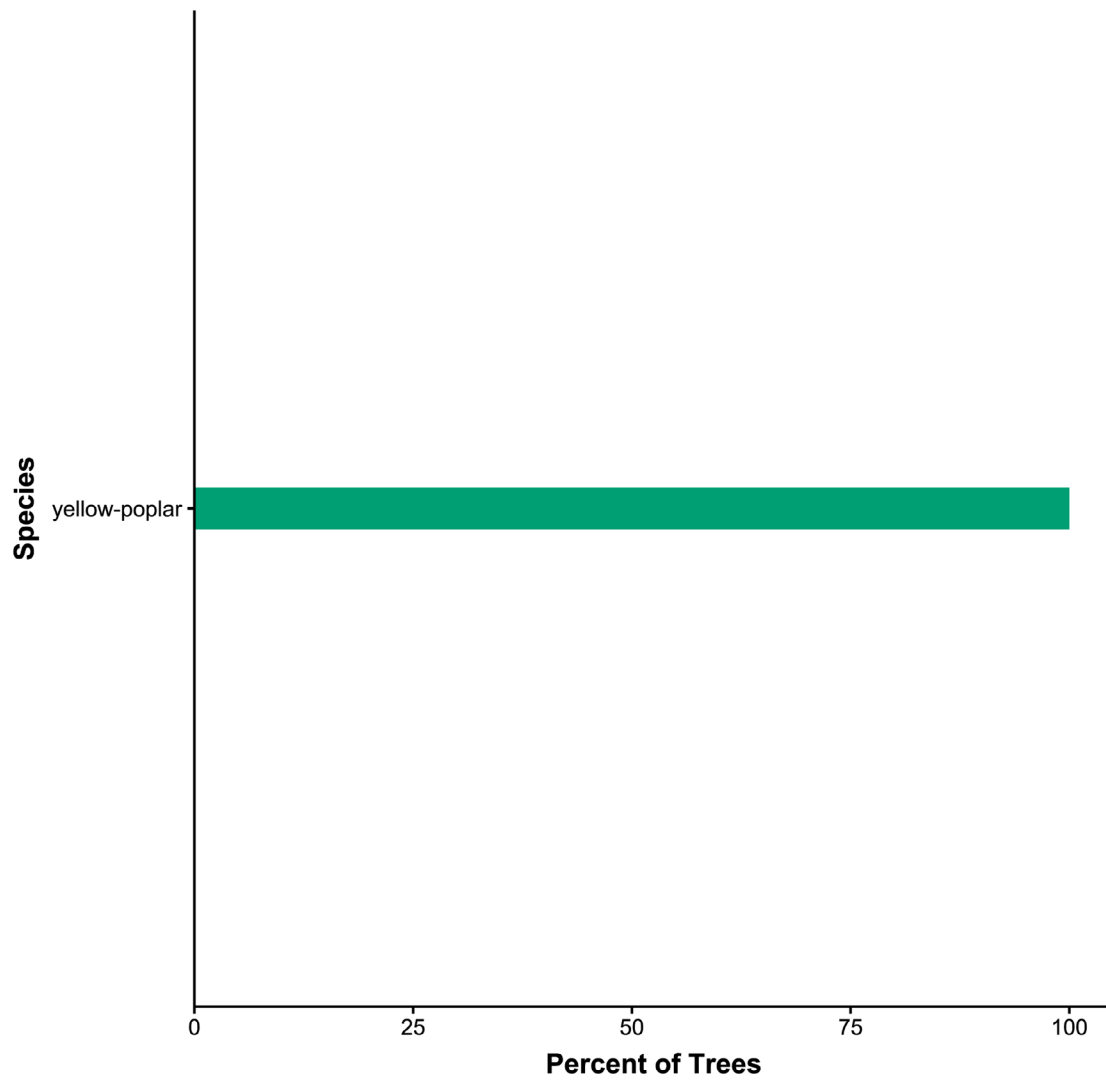


Figure 32.—Percent of the total tree population for up to 20 of the most common tree species observed in the Water National Land Cover Database (NLCD) land cover class, Washington, DC, 2018.

Table 33.—Tree statistics by National Land Cover Database (NLCD) land cover class, extrapolated to sampling area scale from plot inventory, Washington, DC, 2018

NLCD land cover class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Developed-open/herbaceous	American basswood	17,841	< 0.1	1.1
	American elm	7,150	2.8	20.1
	American holly	1,430	< 0.1	5.2
	American sycamore	37,113	0.6	2.9
	Austrian pine	1,430	0.1	11.0
	English yew	17,841	< 0.1	2.4
	Japanese maple	1,430	0.2	12.9
	Japanese zelkova	1,430	0.2	14.6
	Leyland cypress	5,720	0.3	8.0
	Norway maple ^a	4,290	0.2	7.7
	Norway spruce	1,430	< 0.1	5.4
	Siberian elm ^a	45,693	1.8	5.1
	Yoshino flowering cherry	1,430	0.1	10.0
	black cherry	17,841	0.2	4.0
	black locust ^a	57,814	0.4	2.8
	black walnut	4,290	0.3	9.5
	blackgum	8,580	0.9	9.8
	blue spruce	1,430	< 0.1	9.2
	boxelder	10,010	0.9	10.0
	chestnut oak	44,263	4.9	7.0
	eastern hemlock	1,430	< 0.1	8.3
	eastern white pine	4,290	1.7	22.2
	holly	1,430	< 0.1	5.2
	mimosa, silktree	1,430	< 0.1	8.8
	northern catalpa	4,290	2.2	22.6
	northern pin oak	1,430	2.2	44.6
	northern red oak	4,290	0.9	12.6
	red maple	10,010	2.4	15.0
	sassafras	53,524	0.2	2.0
	scarlet oak	1,430	1.1	32.1
	silver maple	5,720	4.8	28.6
	sour cherry	1,430	< 0.1	5.9
	swamp white oak	1,430	0.4	17.8
	sweetgum	1,430	0.1	11.2
	western redcedar	12,870	0.5	6.8
	white oak	7,150	3.6	25.3
	yellow-poplar	5,720	1.0	12.1

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Table 33 (continued).

NLCD land cover class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Developed-low	American elm	7,683	0.7	10.6
	American holly	5,122	0.3	11.2
	American sycamore	2,561	0.3	15.6
	Callery pear	2,561	< 0.1	8.0
	Japanese flowering cherry	5,122	0.2	8.4
	Japanese maple	2,561	0.2	12.4
	London planetree	5,122	0.2	8.7
	Siberian elm ^a	2,561	0.3	15.4
	Yoshino flowering cherry	5,122	0.2	9.2
	baldcypress	2,561	0.4	16.2
	dogwood spp.	2,561	< 0.1	7.3
	eastern hophornbeam	34,322	0.2	3.1
	eastern white pine	2,561	0.2	12.1
	ginkgo, maidenhair tree	2,561	0.6	20.4
	hackberry	2,561	< 0.1	6.0
	holly	5,122	< 0.1	5.5
	mountain or Fraser magnolia	7,683	0.2	7.3
	northern red oak	5,122	0.9	17.6
	northern white-cedar	7,683	0.2	7.1
	pin oak	7,683	3.7	29.6
	red maple	5,122	0.2	8.9
	river birch	12,805	0.3	6.6
	spruce spp.	2,561	0.3	14.4
	sugar maple	2,561	0.1	10.1
	sweetgum	34,322	< 0.1	1.9
	willow oak	5,122	1.0	18.3
	yellow-poplar	2,561	2.6	43.3
Developed-medium	American elm	12,988	2.7	17.6
	American holly	3,247	0.2	11.6
	Amur maple	20,653	< 0.1	2.8
	Chinese elm	4,870	< 0.1	6.8
	Freeman maple	1,623	< 0.1	6.0
	Japanese flowering cherry	1,623	< 0.1	7.5

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Table 33 (continued).

NLCD land cover class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Developed-medium (cont.)	Japanese maple	1,623	0.1	14.6
	Japanese zelkova	11,364	1.7	17.5
	Yoshino flowering cherry	1,623	< 0.1	8.7
	black cherry	22,276	0.1	3.1
	black locust ^a	3,247	0.3	14.4
	dawn redwood	1,623	0.2	15.0
	eastern redbud	3,247	0.1	8.4
	eastern redcedar	9,741	0.2	6.5
	eastern white pine	1,623	< 0.1	7.2
	ginkgo, maidenhair tree	3,247	0.9	25.4
	hackberry spp.	6,494	0.2	8.7
	hinoki false cypress	1,623	< 0.1	5.3
	honeylocust	3,247	0.1	9.9
	mockernut hickory	20,653	< 0.1	1.4
	northern red oak	3,247	< 0.1	8.1
	paulownia, empress-tree	1,623	0.1	14.1
	pin oak	4,870	1.2	21.4
	red maple	9,741	0.8	13.2
	river birch	4,870	0.1	7.1
	sawtooth oak	4,870	0.2	10.6
	scarlet oak	1,623	0.1	14.7
	silver maple	8,117	1.9	23.2
	slippery elm	9,741	1.3	16.4
	sugar maple	3,247	0.1	9.3
	sweetgum	1,623	< 0.1	5.9
	tree of heaven ^a	51,046	0.5	3.9
	white mulberry	4,870	0.1	7.6
	willow oak	8,117	3.3	28.8
Developed-high	Amur corktree	1,325	0.2	11.5
	Callery pear	2,650	0.2	7.8
	Chinese elm	10,601	0.7	7.6
	Japanese flowering cherry	1,325	< 0.1	5.6
	Japanese zelkova	3,976	0.6	11.3
	London planetree	1,325	1.0	26.1

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Table 33 (continued).

NLCD land cover class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Developed-high (cont.)	eastern redbud	2,650	0.1	6.3
	ginkgo, maidenhair tree	3,976	1.0	14.6
	hackberry	1,325	< 0.1	5.7
	littleleaf linden	1,325	0.1	8.5
	pin oak	2,650	0.8	16.2
	red maple	1,325	0.2	10.3
	scarlet oak	1,325	0.7	21.4
	silver maple	1,325	1.4	31.8
	southern magnolia	1,325	0.2	11.6
	swamp white oak	1,325	< 0.1	5.0
	sweet cherry	1,325	0.1	8.4
Forest/Shrub	American beech	360,481	10.6	3.5
	American elm	51,010	1.2	4.2
	American holly	94,434	3.9	5.2
	American hornbeam, musclewood	21,238	< 0.1	1.9
	Japanese maple	1,707	< 0.1	6.4
	Norway maple ^a	24,652	0.3	2.2
	Virginia pine	1,707	0.4	14.3
	bitternut hickory	6,826	1.6	13.0
	black cherry	13,653	2.5	11.5
	black locust ^a	3,413	0.2	6.1
	blackgum	68,076	2.0	4.0
	cherry and plum spp.	1,707	0.1	8.1
	chestnut oak	22,186	11.3	19.4
	flowering dogwood	42,477	0.4	2.8
	green ash	1,707	0.1	8.1
	honeylocust	1,707	0.2	9.8
	mockernut hickory	1,707	0.5	15.2
	northern red oak	29,771	3.2	5.4
	paulownia, empress-tree	1,707	0.1	8.2
	pignut hickory	3,413	0.7	11.3
	red maple	164,975	3.8	3.6
	sassafras	1,707	< 0.1	6.0
	sour cherry	1,707	0.2	10.1
	southern magnolia	70,541	3.9	4.6

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Table 33 (continued).

NLCD land cover class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Forest/Shrub (cont.)	sweet cherry	1,707	< 0.1	5.6
	sweetgum	5,120	2.6	19.2
	tree of heaven ^a	8,533	1.5	11.7
	white oak	27,306	18.9	22.5
	yellow-poplar	90,450	69.1	23.0
Water	yellow-poplar	1,634	0.9	20.6

Estimates are rounded.

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

Diameter measurements were taken at breast height (d.b.h.).

^a Invasive species.

Table 34.—Tree statistics by Forest Inventory and Analysis (FIA) land use, Washington, DC, 2018

FIA land use class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Commercial/Industrial	American holly	1,707	0.1	9.0
	Amur corktree	1,325	0.1	11.5
	Chinese elm	4,870	0.2	6.8
	Japanese maple	1,623	0.3	14.6
	bitternut hickory	1,707	< 0.1	6.9
	black cherry	20,653	0.1	2.8
	paulownia, empress-tree	3,330	0.3	11.1
	red maple	6,447	0.4	9.2
	sawtooth oak	4,870	0.4	10.6
	tree of heaven ^a	54,626	1.4	4.6
	white mulberry	3,247	< 0.1	6.4
	yellow-poplar	5,120	2.4	23.7
Forest land	American beech	360,481	10.5	3.5
	American elm	53,870	1.5	4.5
	American hornbeam, musclewood	21,238	< 0.1	1.9
	American sycamore	37,113	1.0	2.9
	Japanese maple	1,707	< 0.1	6.4
	Norway maple ^a	26,082	0.3	2.4
	Siberian elm ^a	45,693	2.8	5.1
	Virginia pine	1,707	0.4	14.3
	bitternut hickory	5,120	1.5	15.0
	black cherry	11,946	2.2	11.5
	black locust ^a	59,798	0.8	3.0
	black walnut	4,290	0.5	9.5
	blackgum	72,366	3.2	4.6
	boxelder	8,580	0.9	8.5
	chestnut oak	22,186	11.2	19.4
	flowering dogwood	42,477	0.4	2.8
	green ash	1,707	0.1	8.1
	honeylocust	1,707	0.2	9.8
	mimosa, silktree	1,430	0.1	8.8
	mockernut hickory	1,707	0.5	15.2
	northern red oak	29,771	3.2	5.4

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Table 34 (continued).

FIA land use class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Forest land (cont.)	pignut hickory	3,413	0.7	11.3
	red maple	169,265	5.9	4.0
	sassafras	55,231	0.3	2.1
	silver maple	2,860	0.9	15.5
	sour cherry	3,137	0.3	8.2
	sweet cherry	1,707	< 0.1	5.6
	sweetgum	6,550	2.8	17.5
	tree of heaven ^a	1,707	0.2	10.0
	white oak	27,306	18.8	22.5
	yellow-poplar	91,254	67.0	22.5
Multi-family residential	American holly	6,746	0.7	9.9
	Japanese flowering cherry	5,510	0.3	6.6
	Japanese maple	2,561	0.4	12.4
	Yoshino flowering cherry	5,122	0.5	9.2
	black locust ^a	1,623	0.5	17.5
	blue spruce	1,430	0.1	9.2
	dawn redwood	1,623	0.4	15.0
	dogwood spp.	2,561	0.1	7.3
	eastern hophornbeam	34,322	0.3	3.1
	eastern redbud	5,897	0.4	7.5
	eastern redcedar	9,741	0.5	6.5
	eastern white pine	3,053	1.0	15.2
	honeylocust	3,247	0.3	9.9
	mockernut hickory	20,653	< 0.1	1.4
	northern catalpa	2,860	2.9	30.5
	northern red oak	8,369	1.9	13.9
	red maple	3,247	0.5	12.5
	river birch	4,870	0.3	7.1
	silver maple	3,247	1.9	23.4
	southern magnolia	1,325	0.2	11.6
	sweet cherry	1,325	< 0.1	8.4
	tree of heaven ^a	1,623	0.1	8.7
	western redcedar	1,430	0.1	8.9

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Table 34 (continued).

FIA land use class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Recreation/Cemetery	American basswood	17,841	< 0.1	1.1
	American elm	7,537	4.1	19.5
	American holly	1,623	0.5	17.1
	Austrian pine	1,430	0.2	11.0
	Japanese maple	1,430	0.3	12.9
	Japanese zelkova	6,300	3.4	21.0
	Leyland cypress	5,720	0.5	8.0
	Yoshino flowering cherry	1,623	0.1	8.7
	black cherry	19,465	0.4	4.3
	black locust ^a	3,053	0.3	8.6
	blackgum	4,290	0.2	6.2
	chestnut oak	44,263	7.1	7.0
	eastern white pine	2,860	1.5	21.2
	hackberry spp.	6,494	0.6	8.7
	northern pin oak	1,430	3.2	44.6
	northern red oak	1,430	< 0.1	5.1
	red maple	4,290	0.3	7.1
	silver maple	1,623	0.5	16.8
	slippery elm	1,623	< 0.1	7.1
	swamp white oak	1,430	0.5	17.8
	tree of heaven ^a	1,623	0.2	9.6
	white mulberry	1,623	0.2	10.0
	white oak	4,290	3.1	24.8
	yellow-poplar	1,430	< 0.1	6.8
Residential	American elm	6,746	0.3	7.3
	American holly	94,157	2.6	5.1
	Callery pear	2,561	0.1	8.0
	English yew	17,841	< 0.1	2.4
	Japanese flowering cherry	2,561	0.2	10.3
	Norway maple ^a	2,860	0.2	8.8
	Norway spruce	1,430	< 0.1	5.4
	Siberian elm ^a	2,561	0.5	15.4
	Yoshino flowering cherry	1,430	0.1	10.0

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Table 34 (continued).

FIA land use class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Residential (cont.)	baldcypress	2,561	0.6	16.2
	black cherry	1,707	0.2	11.6
	boxelder	1,430	0.4	18.4
	cherry and plum spp.	1,707	< 0.1	8.1
	eastern hemlock	1,430	< 0.1	8.3
	eastern white pine	2,561	0.3	12.1
	hinoki false cypress	1,623	< 0.1	5.3
	holly	6,552	0.2	5.4
	mountain or Fraser magnolia	7,683	0.3	7.3
	northern catalpa	1,430	< 0.1	6.7
	northern white-cedar	7,683	0.3	7.1
	pin oak	2,561	1.1	23.1
	red maple	1,430	1.0	29.1
	river birch	12,805	0.5	6.6
	scarlet oak	1,430	1.2	32.1
	silver maple	4,185	5.7	38.5
	southern magnolia	70,541	2.7	4.6
	spruce spp.	2,561	0.4	14.4
	western redcedar	11,440	0.4	6.6
	white oak	2,860	1.6	26.2
Rights-of-way	willow oak	2,561	0.4	13.7
	yellow-poplar	2,561	4.0	43.3
	American elm	10,678	3.6	21.6
	American sycamore	2,561	0.3	15.6
	Amur maple	20,653	< 0.1	2.8
	Callery pear	2,650	< 0.1	7.8
	Chinese elm	10,601	0.3	7.6
	Freeman maple	1,623	< 0.1	6.0
	Japanese zelkova	10,470	1.0	12.7
	London planetree	6,447	0.7	12.3
	ginkgo, maidenhair tree	9,784	2.2	19.7
	hackberry	3,886	< 0.1	5.9
	littleleaf linden	1,325	< 0.1	8.5
	northern red oak	2,860	0.6	16.4

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Table 34 (continued).

FIA land use class	Common name	Trees (number)	Basal area (square feet/acre)	Average diameter (inches)
Rights-of-way (cont.)	pin oak	12,643	4.7	25.0
	red maple	6,494	0.7	13.6
	scarlet oak	2,949	0.5	17.7
	silver maple	3,247	1.2	26.2
	slippery elm	8,117	1.5	18.3
	sugar maple	5,808	0.3	9.6
	swamp white oak	1,325	< 0.1	5.0
	sweetgum	35,945	< 0.1	2.1
	willow oak	10,678	4.7	27.4

Estimates are rounded.

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

Diameter measurements were taken at breast height (d.b.h.).

^a Invasive species.

APPENDIX 4 – SPECIES COMPOSITION IN MAINTAINED AREAS

Table 35.—Tree species composition in maintained areas, Washington, DC, 2018

Common name	Number of trees	Common name	Number of trees
American holly	103,000	scarlet oak	4,400
southern magnolia	72,000	northern catalpa	4,300
sweetgum	36,000	hackberry	3,900
eastern hophornbeam	34,000	honeylocust	3,200
red maple	22,000	Norway maple	2,900
Amur maple	21,000	white oak	2,900
American basswood	18,000	swamp white oak	2,800
English yew	18,000	spruce spp.	2,600
river birch	18,000	baldcypress	2,600
Japanese zelkova	17,000	dogwood spp.	2,600
American elm	17,000	yellow-poplar	2,600
Chinese elm	15,000	American sycamore	2,600
pin oak	15,000	Siberian elm	2,600
western redcedar	13,000	Callery pear	2,600
willow oak	12,000	cherry and plum spp.	1,700
northern red oak	11,000	black cherry	1,700
silver maple	11,000	tree of heaven	1,600
ginkgo, maidenhair tree	9,800	black locust	1,600
eastern redcedar	9,700	slippery elm	1,600
eastern white pine	8,500	Freeman maple	1,600
Yoshino flowering cherry	8,200	hinoki false cypress	1,600
Japanese flowering cherry	8,100	dawn redwood	1,600
northern white-cedar	7,700	Norway spruce	1,400
mountain or Fraser magnolia	7,700	blue spruce	1,400
holly	6,600	Austrian pine	1,400
hackberry spp.	6,500	eastern hemlock	1,400
London planetree	6,400	boxelder	1,400
eastern redbud	5,900	northern pin oak	1,400
sugar maple	5,800	sweet cherry	1,300
Leyland cypress	5,700	Amur corktree	1,300
Japanese maple	5,600	littleleaf linden	1,300
sawtooth oak	4,900		

Estimates are rounded.

APPENDIX 5 – DAMAGE, MAINTENANCE AND SITE ISSUES BY SPECIES

Table 36.—Percent of live trees identified with damage, maintenance and site issues, Washington, DC, 2018

Common name	Sample (number)	Bark inclusion (percent)	Crown conflict (percent)	Excess mulch (percent)	Improper planting (percent)	Root conflict (percent)	Root/stem girdling (percent)	Topping/pruning (percent)
American beech	51	0.5	0.0	0.0	0.0	0.0	0.0	0.0
American elm	23	7.4	0.0	0.0	7.4	2.1	0.0	0.0
American holly	26	11.5	0.0	0.0	20.3	0.0	0.0	0.0
Austrian pine	1	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Callery pear	3	25.4	0.0	0.0	74.6	0.0	0.0	0.0
Chinese elm	11	0.0	0.0	0.0	36.2	0.0	0.0	0.0
Freeman maple	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Japanese flowering cherry	4	0.0	0.0	51.8	0.0	0.0	0.0	0.0
Japanese zelkova	11	0.0	0.0	15.8	55.2	0.0	0.0	9.7
Leyland cypress	4	0.0	0.0	0.0	25.0	0.0	0.0	0.0
London planetree	3	39.7	0.0	0.0	0.0	39.7	0.0	0.0
Norway maple	6	11.8	0.0	0.0	0.0	0.0	0.0	0.0
Siberian elm	10	5.3	0.0	0.0	0.0	0.0	0.0	0.0
Yoshino flowering cherry	4	17.5	0.0	0.0	0.0	0.0	0.0	0.0
baldcypress	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0
black locust	10	0.0	0.0	0.0	4.4	0.0	0.0	0.0
blackgum	23	0.0	0.0	0.0	3.7	0.0	0.0	0.0
boxelder	7	14.3	0.0	0.0	0.0	0.0	0.0	0.0
cherry and plum spp.	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
dawn redwood	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
eastern hophorn-beam	1	0.0	0.0	100.0	0.0	0.0	0.0	0.0
eastern redbud	4	55.1	0.0	0.0	22.5	0.0	0.0	0.0
ginkgo, maidenhair tree	6	59.4	0.0	0.0	0.0	0.0	0.0	0.0
hackberry	2	65.9	65.9	0.0	0.0	65.9	0.0	0.0
hackberry spp.	4	0.0	0.0	0.0	50.0	0.0	0.0	0.0
holly	3	0.0	0.0	0.0	21.8	0.0	0.0	0.0
honeylocust	3	32.8	0.0	0.0	0.0	0.0	0.0	0.0
mimosa, silktree	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0
mountain or Fraser magnolia	3	0.0	0.0	0.0	100.0	0.0	0.0	0.0

continued on next page

Table 36 (continued).

Common name	Sample (number)	Bark inclusion (percent)	Crown conflict (percent)	Excess mulch (percent)	Improper planting (percent)	Root conflict (percent)	Root/stem girdling (percent)	Topping/pruning (percent)
northern red oak	13	6.0	0.0	0.0	0.0	0.0	0.0	0.0
northern white-cedar	3	0.0	100.0	0.0	0.0	0.0	0.0	0.0
pin oak	8	50.5	0.0	0.0	21.4	63.8	0.0	0.0
red maple	44	0.7	0.0	0.0	14.1	1.7	0.0	3.1
river birch	8	72.4	0.0	0.0	0.0	0.0	0.0	0.0
scarlet oak	3	37.1	37.1	0.0	0.0	30.3	0.0	0.0
silver maple	10	30.8	8.7	0.0	0.0	9.4	0.0	10.7
slippery elm	6	16.7	16.7	0.0	66.7	0.0	0.0	0.0
southern magnolia	8	1.8	0.0	0.0	0.0	1.8	0.0	0.0
spruce spp.	1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
sugar maple	3	44.1	0.0	0.0	0.0	0.0	0.0	0.0
sweet cherry	2	0.0	0.0	0.0	56.3	0.0	0.0	0.0
tree of heaven	13	2.7	0.0	0.0	5.4	2.7	0.0	0.0
western redcedar	9	77.8	11.1	0.0	0.0	0.0	0.0	0.0
willow oak	7	75.5	31.6	0.0	19.3	24.5	0.0	12.3

Estimates are rounded.

APPENDIX 6 – LIST OF INVASIVE PLANT SPECIES

Table 37.—List of invasive plant species, Washington, DC, 2018

Scientific name	Common name	Scientific name	Common name
<i>Acer platanoides</i>	Norway maple	<i>Lonicera morrowii</i>	Morrow's honeysuckle
<i>Ailanthus altissima</i>	tree of heaven	<i>Lonicera tatarica</i>	Tatarian honeysuckle
<i>Albizia julibrissin</i>	mimosa, silktree	<i>Lonicera x bella</i>	showy fly honeysuckle
<i>Alliaria petiolata</i>	garlic mustard	<i>Lysimachia nummularia</i>	creeping jenny
<i>Berberis thunbergii</i>	Japanese barberry	<i>Lythrum salicaria</i>	purple loosestrife
<i>Berberis vulgaris</i>	common barberry	<i>Melaleuca quinquenervia</i>	melaleuca
<i>Celastrus orbiculatus</i>	Oriental bittersweet	<i>Melia azedarach</i>	chinaberry
<i>Centaurea stoebe ssp. micranthos</i>	spotted knapweed	<i>Microstegium vimineum</i>	Nepalese browntop
<i>Cirsium arvense</i>	Canada thistle	<i>Paulownia tomentosa</i>	paulownia, empress-tree
<i>Cirsium vulgare</i>	bull thistle	<i>Phalaris arundinacea</i>	reed canarygrass
<i>Cynanchum louiseae</i>	Louise's swallow-wort	<i>Phragmites australis</i>	common reed
<i>Cynanchum rossicum</i>	European swallow-wort	<i>Polygonum cuspidatum</i>	Japanese knotweed
<i>Elaeagnus angustifolia</i>	Russian-olive	<i>Polygonum sachalinense</i>	giant knotweed
<i>Elaeagnus umbellata</i>	autumn olive	<i>Polygonum x bohemicum</i>	Bohemian knotweed
<i>Euphorbia esula</i>	leafy spurge	<i>Rhamnus cathartica</i>	common buckthorn
<i>Frangula alnus</i>	glossy buckthorn	<i>Robinia pseudoacacia</i>	black locust
<i>Hedera helix</i>	English ivy	<i>Rosa multiflora</i>	multiflora rose
<i>Hesperis matronalis</i>	dames rocket	<i>Spiraea japonica</i>	Japanese meadowsweet
<i>Ligustrum vulgare</i>	European privet	<i>Tamarix ramosissima</i>	saltcedar
<i>Lonicera spp.</i>	honeysuckle	<i>Triadica sebifera</i>	Chinese tallowtree
<i>Lonicera japonica</i>	Japanese honeysuckle	<i>Ulmus pumila</i>	Siberian elm
<i>Lonicera maackii</i>	Amur honeysuckle	<i>Viburnum opulus</i>	European cranberrybush

APPENDIX 7 – RISK ASSOCIATED WITH VARIOUS INSECTS AND DISEASES

Table 38.—Potential risk associated with various insects and diseases, Washington, DC, 2018

Spp Rank	Cumulative risk weight	Common name	BC	DA	DED	EAB	GM	HWA	SPB	BLS	ALB	BBD	BLD	BWA	FR	FTC	HRD	JPBW	LWD	OW	PSB	SB	SBW	SLF	SW	TCD	WM	WPBR	DBC	AL	BM	MOB	MPB	POCRD	PSHB	SOD	WBBU	WSB	SI			
	31	Pin oak					4			4					3	3				3				3			3		3		2	1			1	1						
	31	Northern red oak					4			4					3	3				3				3			3		3		2	1			1	1						
	30	White oak					4			4					3	3				3				3			3		3		2	1			1							
	30	Scarlet oak					4			4					3	3				3				3			3		3		2	1			1							
	29	Swamp white oak					4			4					3	3				3				3			3		3		2	1										
	29	Northern pin oak					4			4					3	3				3				3			3		3		2	1										
	29	Willow oak					4			4					3	3				3				3			3		3		2	1										
	29	Chestnut oak					4			4					3	3				3				3			3		3		2	1										
	27	Sawtooth oak					4			4						3	3				3				3					3		2	1			1						
	25	Norway spruce								4					3			3				3	3	3		3								1				1	1			
	25	Eastern white pine							4							3	3	3			3	3	3		3	3			3										1			
	24	Chinese elm			4		4			4	3						3		3					3					3			2				1						
	23	American elm			4					4	3						3							3				3				2				1						
	22	Siberian elm			4					4	3						3							3				3				2										
	22	Slippery elm			4					4	3						3							3				3				2										
	21	Boxelder					4			4	3														3			3				2	1			1						
	19	Sugar maple								4	3						3							3			3					2	1									
	17	Sweet cherry									3						3							3			3				2	2	1									
	17	American basswood					4					3					3							3			3					2	2	1			1					
		16	Norway maple								4	3													3			3					2	1								
16		Red maple								4	3													3			3					2	1									
16		Silver maple								4	3													3			3					2	1									
16		River birch					4				3						3							3			3					2	1									
16		Green ash				4					3						3							3			3															
16		Black cherry									3						3							3			3															
15		Blue spruce							4													3	3	3							2	2						1	1			
14		Japanese maple									4	3													3							2	1				1					
14		Freeman maple									4	3													3							2	1				1					
14		Japanese flowering cherry										3					3								3							2	2				1					
	13	American beech					4					3	3											3																		
	13	Austrian pine							4								3					3			3																	
	13	Virginia pine							4								3					3				3																
	13	Sour Cherry									3						3							3							2	2										
	13	Yoshino flowering cherry									3						3							3							2	2										
	13	Gallery pear					4				3													3							2					1						
	11	Black walnut	4									3												3			3									1						
	11	spruce spp								4												3	3	3														1				
	11	Eastern hemlock						4		4														3																1		
	10	Amur maple									4	3																					2	2	1							
	10	Plum spp.									3						3														2	2										
	10	Littleleaf linden					4				3						3																									
	9	Sweetgum					4										3																				1				1	
	8	London plane								4	3																										1					
	8	American sycamore								4														3													1					
	7	Persian silk tree										3												3													1					
	7	Flowering dogwood		4																				3																		
	7	dogwood spp		4																				3																		
	7	White mulberry										3												3													1					
	7	Eastern hophornbeam					4																	3																		
	6	Sassafras																	3					3																		
	4	Tree of heaven																						3													1					
	4	Eastern red cedar																3																			1					
	4	Tulip tree																						3													1					
	4	Northern white cedar																						3												1						
	4	Japanese zelkova																						3													1					
	3	American hornbeam																						3																		
	3	Pignut hickory																						3																		
	3	Northern hackberry										3													3																	
	3	Black tupelo																						3																		
3	Royal paulownia																						3																			
3	Amur corktree																						3																			
3	Black locust																						3																			
	1	Northern catalpa																																			1					
	1	Hinoki cypress																																	1							
	1	Honeylocust																																			1					

See Table 30 for a key to the pest and pathogen abbreviations used in this table

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