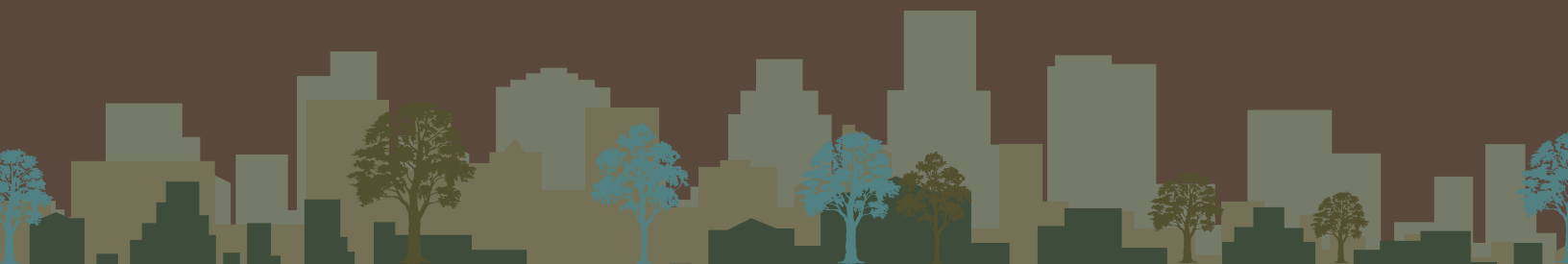




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Baltimore's Urban Forest, 2020



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Abstract

A 2020 analysis of the urban forest in Baltimore, Maryland reveals that this area has an estimated 1.9 million live trees across all ownerships. The most common tree species by number are tree of heaven, northern white-cedar, American elm, green ash, and Norway maple. The majority of trees are found on forest land (39.2 percent; 731,696 trees). Trees in Baltimore are estimated to store about 440,635 tons of carbon (1.6 million tons of carbon dioxide) valued at \$75.2 million. In addition, it is estimated that these trees remove about 15,200 tons of carbon per year (or 56,000 tons carbon dioxide per year, valued at \$2.6 million per year, an amount roughly equivalent to the annual emissions associated with 11,000 passenger vehicles or energy usage by 6,100 homes [[Greenhouse Gas Equivalencies Calculator](#), U.S. EPA 2020]) and about 347 tons of air pollution per year (valued at \$11.8 million per year). Baltimore's urban forest is estimated to reduce annual energy costs of residential buildings by \$7.2 million per year. The overall compensatory value of the urban forest is estimated at \$2.28 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 Baltimore. 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: A large London plane tree in front of Baltimore row houses. Courtesy photo by Sean O'Maille, Baltimore City Forestry Division.

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Baltimore's Urban Forest, 2020

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EXECUTIVE SUMMARY



A newly planted river birch tree and surrounding flower beds on a residential street. Courtesy photo by Zoe Gensheimer, Baltimore City Forestry Division.

The City of Baltimore was sampled in 2020 to assess the magnitude, composition, and value of its urban forest resource. The sampled area of the city (representing a total of 58,910 acres), is estimated to contain 1.9 million live trees, 43.6 percent of which are less than 5.0 inches in **diameter**¹. The most common tree species² at least 1.0 inch in diameter are tree of heaven, northern white-cedar, American elm, green ash, and Norway maple. The most common large-diameter tree species (11.0+ inches in diameter) are yellow-poplar, tree of heaven, white mulberry, white ash, and American elm. The most dominant species based on the number of trees and leaf area are tree of heaven, American elm, Norway maple, yellow-poplar, and white ash.

¹ See glossary for definition of bolded terms.

² Common and scientific names for all tree species observed in the 2020 Urban FIA inventory of Baltimore are reported in Appendix 2 (Table 32).



The majority of trees are found on **forest land** (39.2 percent; 731,696 trees). Overall, 43.5 percent of trees are classified as growing in maintained areas. Trees on public lands total 852,940 and account for 45.7 percent of the total live tree population. Trees on private lands total 1 million and account for 54.3 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 \$2.28 billion with the urban forest producing over \$26.1 million in annual benefits (Table 1).

The tree species with the greatest estimated average percent dieback is white ash (13.4 percent dieback) and the species with the greatest rot is boxelder (10.6 percent rot). The most common urban specific damages affecting all tree species in the sampling area are conflict with crown (11.9 percent of trees) and bark inclusion (5.1 percent of trees).

Invasive plant species also threaten to alter forest composition and are found on 32.7 percent of the sampled plots; Norway maple is estimated to cover the largest area (1,136 acres) of any invasive plant species in the city.

These natural and anthropogenic threats may affect the health and composition of Baltimore'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, City of Baltimore, 2020

Feature	Estimate
Number of trees ^a	
Total live trees	1.9 million (279,410) ^b
Live saplings (1.0 to 4.9 inches in diameter)	814,000 (247,000) ^b
Live trees (at least 5.0 inches in diameter)	1.1 million (108,699) ^b
Standing dead saplings (1.0 to 4.9 inches in diameter)	0 (0) ^b
Standing dead trees (at least 5.0 inches in diameter)	103,000 (30,000) ^b
Most abundant species	
By number of live trees	tree of heaven
By leaf area	yellow-poplar
Ecosystem impacts and services	
Avoided runoff	32.9 million cubic feet (\$2.2 million/year)
Carbon sequestration	15,000 tons/year (\$2.6 million/year)
Carbon storage ^c	441,000 tons (\$75.2 million)
Compensatory value	\$2.3 billion
Net aboveground volume	22.6 million cubic feet
Pollution removal	347 tons/year (\$11.8 million/year)
Reduced building energy use ^{c,d}	452,000 GJ/year (\$7.2 million/year)
Reduced carbon emissions ^{c,d}	14,000 tons/year (\$2.3 million/year)
Reduction in acute respiratory symptoms	803 cases/year (\$70,000/year)
VOC emissions	302 tons/year

Estimates are rounded.

VOC = volatile organic compound (a negative ecosystem impact). 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 5.0 inches in diameter.

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BACKGROUND



Baltimore's iconic park bench framed by Callery pear trees. USDA Forest Service photo by Nancy Sonti.

Urban forests offer a wide range of environmental, social, and public health benefits, such as wildlife habitat, aesthetic appeal, social cohesion, enhanced recreational opportunities, reduced air temperatures, improved water quality, mitigated air and noise pollution, and benefits to mental health and well-being. Since 1930, the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) program has provided information on the amount, status, and character of **forest land**³ 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.

³ See glossary for definition of bolded terms.



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 boulevards, 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 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.

Baltimore, Maryland has 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. One of the first cities to embark on UFIA data collection, Baltimore’s 7-year measurement cycle began during the 2014 field season and included plots scheduled for data collection through 2020, though data collection officially concluded during 2021 after delays due to COVID-19. Baltimore is home to the Baltimore Ecosystem Study, one of the first urban long-term ecological research sites supported by the National Science Foundation (Pickett et al. 2020), which contributed to the development of the Baltimore School of Urban Ecology (Grove et al. 2015). The Forest Service has had an urban field station located in Baltimore for over 25 years supporting these efforts, which remains central to the agency’s network of Urban Field Stations (USDA Forest Service 2023b).

The City’s [TreeBaltimore program](#) is a mayoral initiative established in 2007 that “strives to increase the urban tree canopy through the establishment, management and preservation of trees” (Baltimore City DRP 2007). TreeBaltimore staff provide trees and technical assistance to community groups and non-profit organizations, who in turn leverage their own capacity and fund-raising efforts to plant and maintain trees throughout the city. The program’s efforts are concentrated on increasing canopy on parkland, the public right-of-way, and private residential property. In addition, the Baltimore City Forestry Division’s Natural Areas Group works to preserve existing healthy forests on city parkland as a proactive and preventive measure to maintain the functions that these ecosystems actively provide. The Urban FIA inventory of Baltimore’s urban forest resource and the estimated values associated with this resource described in this report support these 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.

⁴ Common and scientific names for all tree species observed in the 2020 Urban FIA inventory of Baltimore are reported in Appendix 2 (Table 32).

Baltimore, Maryland is among the initial cohort of cities included in the Urban National Landowner Survey (UNLS), the urban counterpart to FIA's [National Woodland Owner Survey](#) (NWOS), and part of the UFIA portfolio. The UNLS is an effort to survey private owners of residential properties in cities and urban areas, to better understand who owns the urban forest and how these landowners use, value, and manage their urban trees and greenspaces. The UNLS was fielded within the boundaries of Baltimore City beginning in 2018 (Locke et al. 2025). During that initial survey cycle, 145 valid responses were collected, for a total cooperation rate of 19.1 percent. Analyses of this data shows that an estimated 295,000 private, residential ownerships own one or more properties in Baltimore City (standard error [SE] = 31,000 ownerships), with 87.0 percent of these ownerships residing on their property (SE = 4.0 percent). The most common structures on these properties are townhouses or duplexes (59.0 percent of ownerships, SE = 6.0 percent) and single-family detached homes (33.0 percent of ownership, SE = 5.0). At least 47.0 percent of residential ownerships have one or more trees on their land (SE = 6.0 percent), with 43.0 percent agreeing strongly that trees make their neighborhoods a “better place to live” (SE = 7.0 percent). Landscaping/tree care professionals; neighbors; employees at lawn and garden centers; and family and friends represent the most trusted sources of information on tree care for residential landowners in Baltimore City. Landowners’ biggest concerns about their trees include are branches damaging property; tree roots interfering with building foundations, and/or septic systems; and tree branches breaking and causing a power outage. The UNLS has continued to be implemented in Baltimore on an annual basis from 2019 onwards. More information on the UNLS can be found in Butler et al. 2025.

Providing accurate data describing Baltimore’s urban forest resources and landowners 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. Various city agencies have jurisdiction over Baltimore’s publicly owned forested areas. Given the limited capacity of these agencies, urban inventory data can support the development of evidence-based policies. Urban forest inventory data can be useful in helping managers address interrelated challenges such as flooding and drought stress related to climate change, and emerging risks from pests and pathogens such as beech leaf disease. Data describing Baltimore’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 Baltimore'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 [version 2 of the online supplement](#) (Baer et al. 2025) to this report, along with i-Tree Eco modeling software (Baer et al. 2025, www.itreetools.org, Nowak 2024). This process established survey plots across Baltimore 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 2014–2020 field seasons (extended to 2021 after COVID-19 delays), Baltimore's plots were visited on a 7-year measurement cycle where approximately 1/7 of the plots were visited each year. The sampling area was defined by the U.S. Census Bureau Designated Places boundary for Baltimore (highlighted in red in Fig. 1a). In total, the Urban FIA sample surveyed 208 plots across the city's 58,910 acres within the designated sampling area in Baltimore (Fig. 1).

New methods were implemented in the inventory of Baltimore'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. (2025) 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 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.

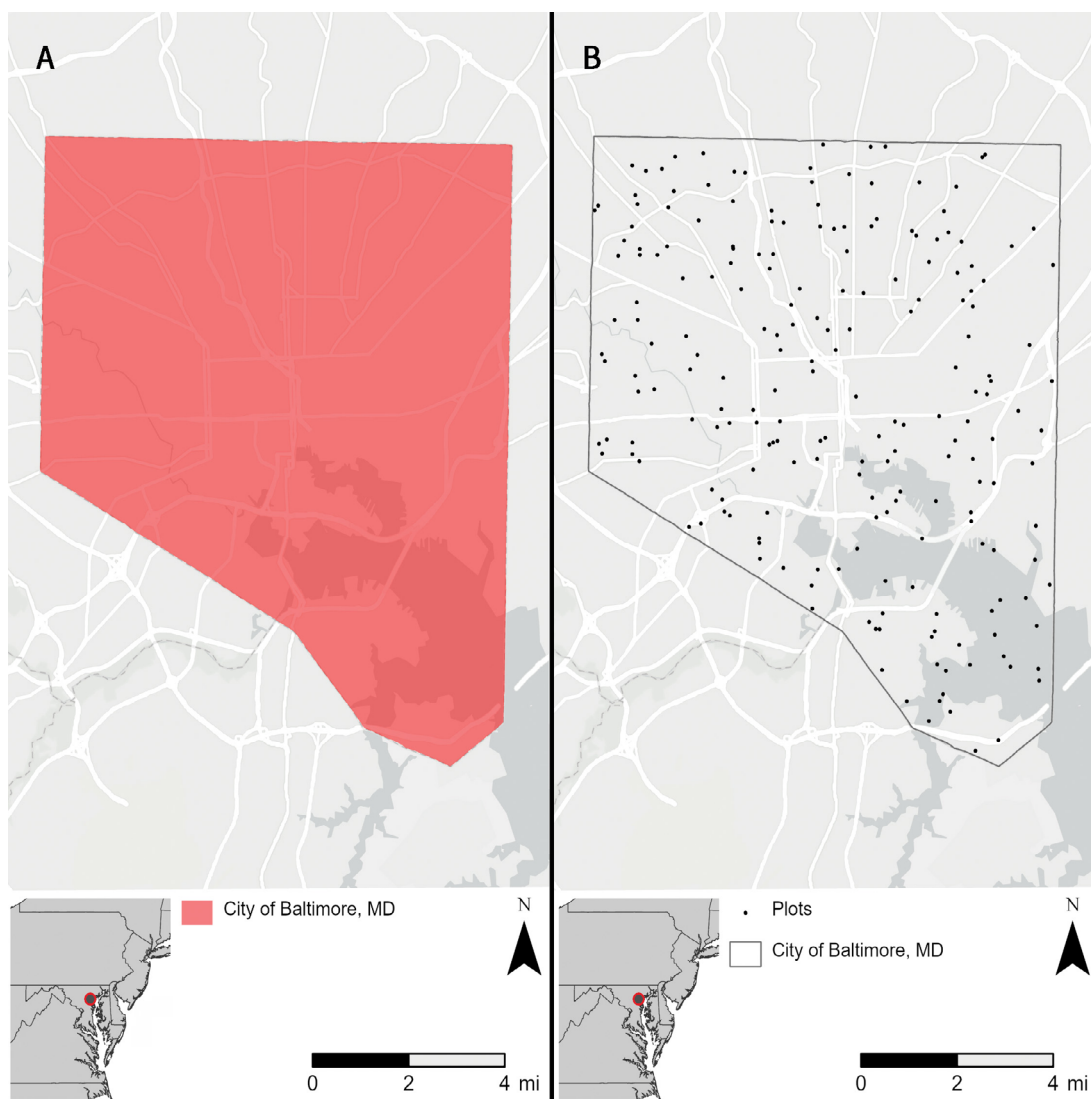


Figure 1.—Study area (A) and approximate plot locations (B) for the Urban Forest Inventory and Analysis (FIA) inventory, City of Baltimore, 2020. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

The collected data were analyzed using FIA methodology and i-Tree Eco modeling software outlined in Baer et al. (2025). Additional analyses were conducted using R Statistical software version 4.2.1 (R Core Development Team 2022), the dplyr package (Wickham et al. 2022), and Microsoft Excel. Figures presented in this report were generated with the ggplot2 package (Wickham 2016). 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.

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



A new tree planting in the median along U.S. Route 40. Courtesy photo by Zoe Gensheimer, Baltimore City Forestry Division.

According to the 2020 Census, 91.3 percent of the population in Maryland live within urban areas, which make up 18.2 percent (1.2 million acres) of the total state area. Baltimore is the largest city in Maryland by population with 602,000 residents and a population density of 7,000 people per square mile (U.S. Census Bureau 2020).



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).

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-high, and developed-open/vegetation (Table 3). Figure 2 shows the distribution of landcover classes across the city. Areas of forest/shrub land cover are estimated to contain the greatest proportion of trees in the sampling area of any land cover (39.0 percent), followed by developed-open/vegetation, developed-low, and developed-medium land covers (31.4 percent, 15.7, and 10.1 percent of the trees in the sampling area, respectively).

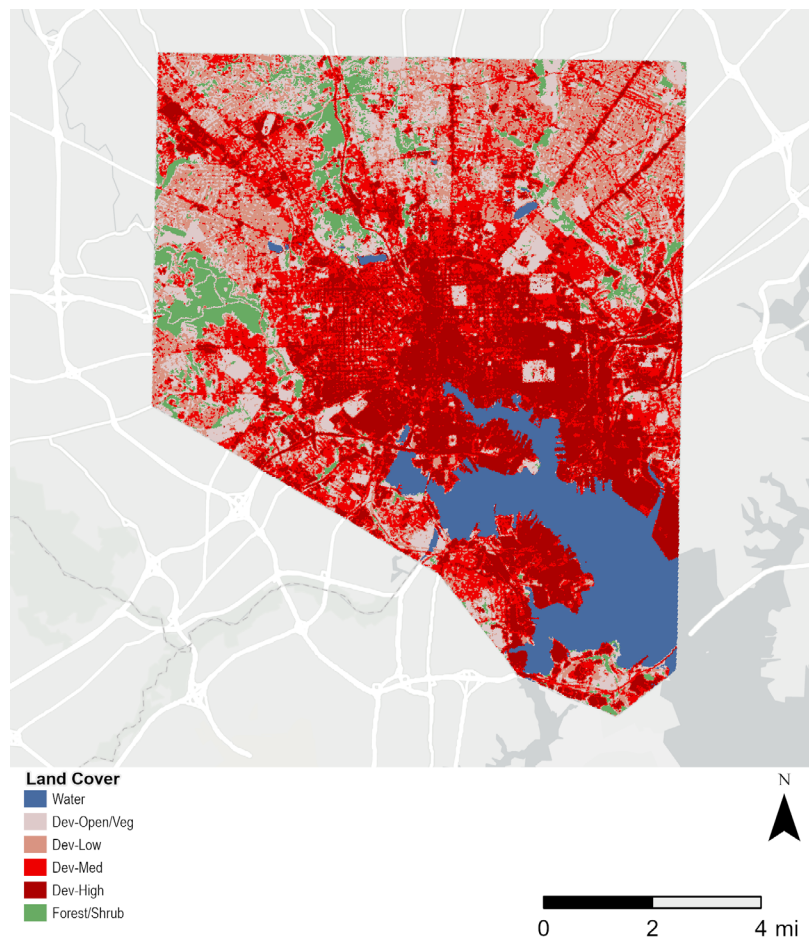


Figure 2.—Distribution of National Land Cover Database (NLCD; Homer et al. 2015) land cover classes, City of Baltimore, 2020. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Table 2.—National Land Cover Database (NLCD) land cover classes and subclasses, City of Baltimore, 2020

NLCD land cover	NLCD land cover subclasses
Dev-Open/Veg	Developed, Open Space and Grassland/Herbaceous and Pasture/ Hay and Cultivated Crops and Emergent Herbaceous Wetlands
Developed-low	Developed, Low Intensity
Developed-medium	Developed, Medium Intensity
Developed-high	Developed, High Intensity and Barren Land
Forest/Shrub	Deciduous Forest and Evergreen Forest and Mixed Forest and Shrub/Scrub and Woody Wetlands
Water	Open Water

Source: Homer et al. 2015.

Table 3.—Sample area and count of plots within National Land Cover Database (NLCD) land cover classes, City of Baltimore, 2020

NLCD land cover	Area (acres)	Land (percent)	Plots (number)
Forest/Shrub	3,730	6	13
Dev-Open/Veg	10,374	18	46
Developed-low	12,817	22	41
Developed-medium	13,590	23	43
Developed-high	11,811	20	41
Water	6,588	11	24
Total	58,910	100	208

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). There are often multiple land uses on a single plot. When this occurs, the area of each land use is mapped and a percent of the total plot area is assigned. These categories provide a specific look at how the land is being used by the local population in Baltimore.

Commercial/industrial is the most prevalent land use class in Baltimore, covering 24.3 percent of the city area (containing 7.0 percent of the city's trees), followed by **rights-of-way** (22.1 percent of the city area), residential (19.2 percent), water (11.4 percent), and multi-family residential (10.2 percent) (Table 5).

Table 4.—Forest Inventory and Analysis (FIA) land use classes and subclasses, City of Baltimore, 2020

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 plot counts within Forest Inventory and Analysis (FIA) land use classes, City of Baltimore, 2020

FIA land use	Area (acres)	Standard error (acres)	Land (percent)	Plots (number)
Forest land	3,721	799	6.3	13.5
Commercial/Industrial	14,306	1,477	24.3	48.9
Multi-family residential	6,014	1,084	10.2	20.4
Residential	11,288	1,335	19.2	41.9
Recreation/Cemetery	3,850	957	6.5	15.1
Rights-of-way	13,001	1,235	22.1	43.7
Water	6,731	117	11.4	24.5
Total	58,910	645	100.0	208.0

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

Tree, Shrub, and Ground Cover

Tree cover in Baltimore is estimated at 15.2 percent and shrub cover at 4.0 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 intervals by the Chesapeake Bay Conservancy (Chesapeake Bay Conservancy 2019).

Overall, tree cover ranges from 0.29 percent to 100 percent on plots where trees are present (Fig. 3a). Shrub cover on plots ranges from 0.25 percent to 75 percent on plots where shrubs are present (Fig. 3b). Average tree cover is highest on forest land (83.3 percent tree cover), residential (21.5 percent), and multi-family residential land uses (19.0 percent) (Table 6). Shrub cover is highest on forest land (23.9 percent shrub cover), residential (7.0 percent), and multi-family residential land uses (5.1 percent). Impervious cover is highest on rights-of-way (77.9 percent impervious cover), commercial/industrial (32.1 percent), and multi-family residential land uses (13.2 percent) (Table 6).

Table 6.—Average percent tree, shrub, and impervious cover by Forest Inventory and Analysis (FIA) land use classes, City of Baltimore, 2020

FIA land use	Tree (percent)	Shrub (percent)	Impervious (percent)
Forest land	83.3	23.9	0.8
Commercial/Industrial	6.0	1.4	32.1
Multi-family residential	19.0	5.1	13.2
Residential	21.5	7.0	9.5
Recreation/Cemetery	15.1	2.5	12.7
Rights-of-way	5.8	0.3	77.9
Water	0.0	0.0	0.0
Total	15.1	3.9	29.0
Total standard error	9.1	0.6	1.9

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

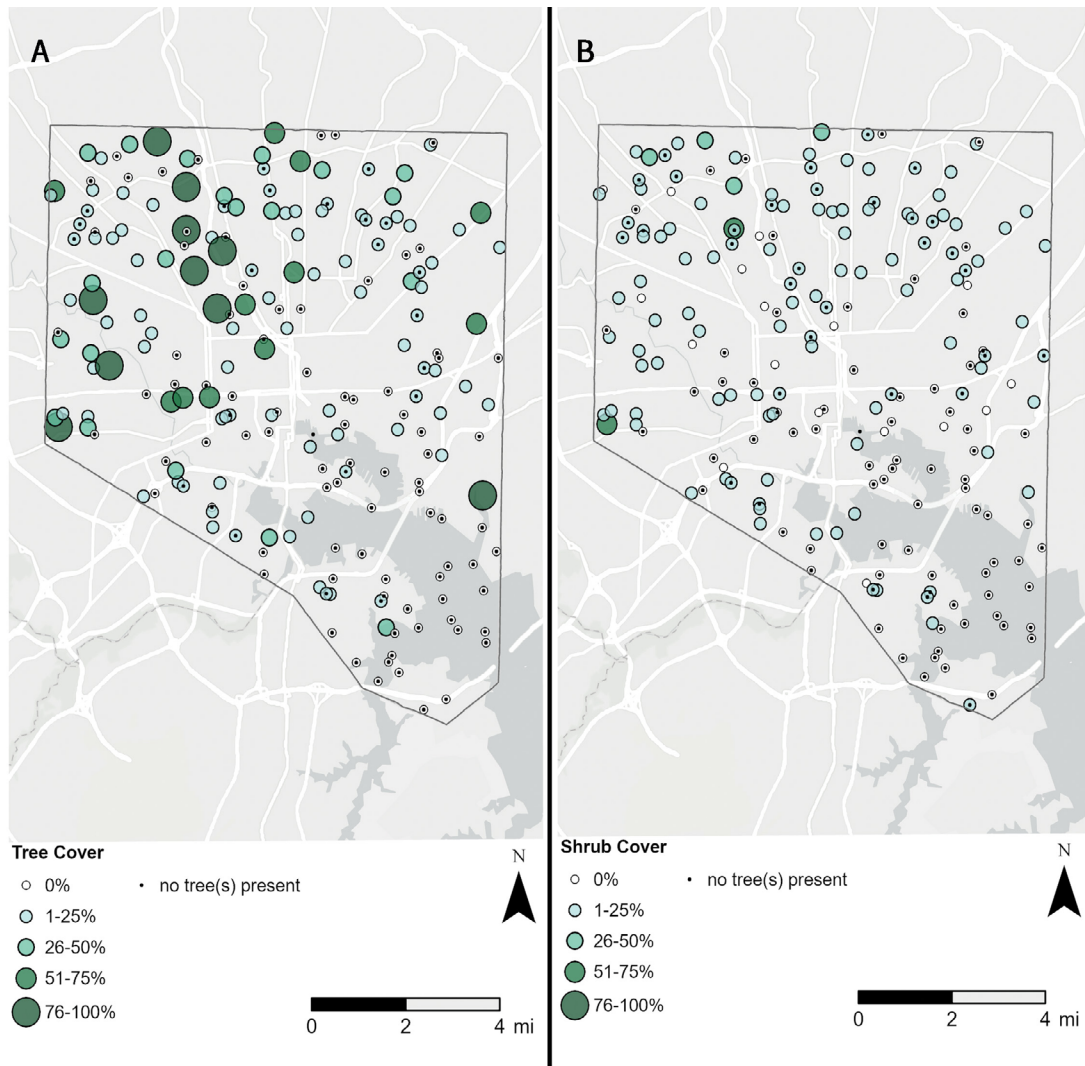


Figure 3.—Tree (A) and shrub (B) cover estimates for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, City of Baltimore, 2020. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Field crews categorized ground surface cover on each field plot according to five classes: (i) building, (ii) low vegetation (woody plants under 1 foot tall and all herbaceous plants), (iii) permeable (soil, leaf litter, mulch, gravel, etc.), (iv) impervious (non-building), or (v) water. Permeable and low vegetation ground covers account for 44.7 percent of all ground covers, while building and other impervious cover account for 44.3 percent (Figs. 4 and 5). An additional 11.0 percent of the city is classified as water. Please note that percentages may not add up to 100 percent due to rounding.

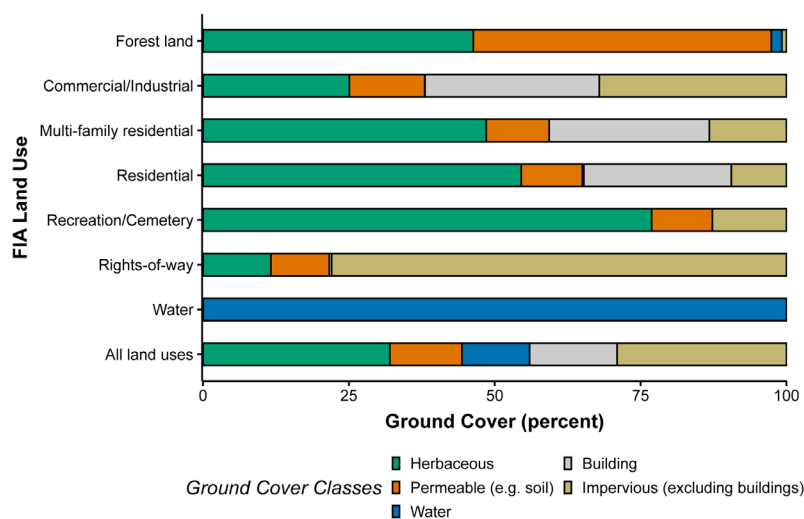


Figure 4.—Average ground cover (percent) by Forest Inventory and Analysis (FIA) land use classes, City of Baltimore, 2020.

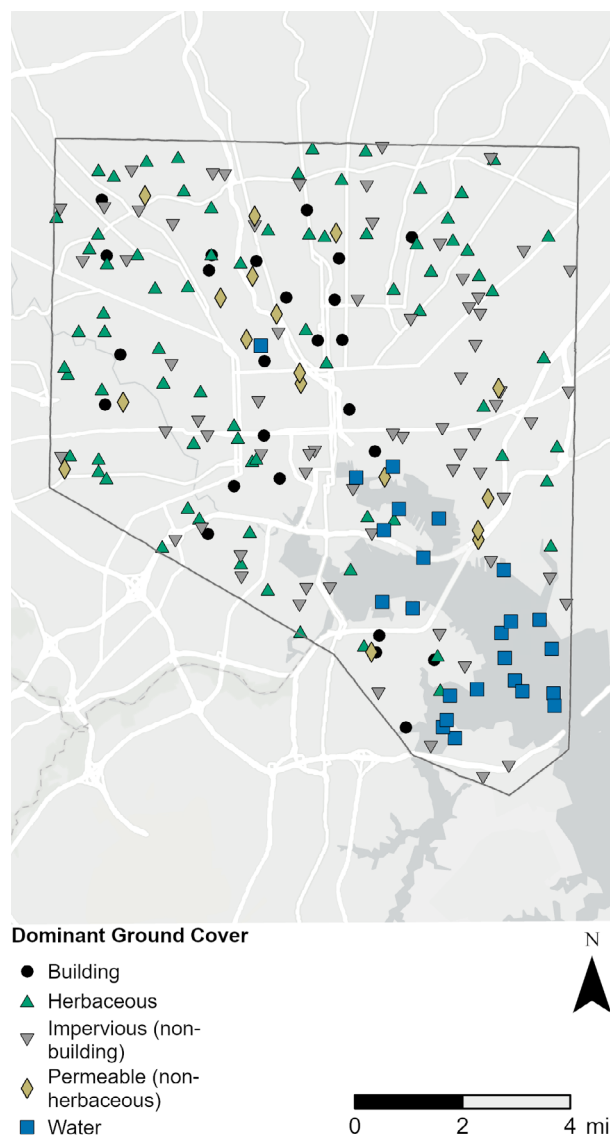


Figure 5.—Dominant ground cover for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, City of Baltimore, 2020. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Ownership

Plot ownership was divided into private, State and local government, Federal government, and unknown (water) classes. The most dominant ownership in Baltimore is private (49.8 percent), followed by State and local (38.1 percent), unknown (water) (11.4 percent) and Federal (0.7 percent) (Table 7). Percent tree cover is greatest in State and local (19.0 percent), followed by private (15.7 percent), and Federal (4.1 percent). In Baltimore, there are a total of 1 million trees (54.3 percent of the live tree population) on private lands, 847,060 trees (45.4 percent) on State and local land, and 5,879 trees (0.3 percent) on Federal lands (Table 7). Baltimore's sapling (trees 1.0–4.9 inches in diameter) population is mostly found on private lands (59.9 percent), followed by State and local lands (40.1 percent) (Table 7).

Table 7.—Number of live trees by ownership and diameter class, City of Baltimore, 2020

Ownership 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)	Area (acres)
Private	487,000	289,000	235,000	1,010,000	29,000
State and Local	326,000	273,000	247,000	847,000	22,000
Federal	0	3,900	2,000	5,900	420
Unknown (water)	0	0	0	0	6,700
Total	814,000	567,000	484,000	1,860,000	59,000

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

FOREST STRUCTURE



A red maple tree with fall color in a residential neighborhood. Courtesy photo by Frederic Chalfant, Baltimore City Forestry Division.

Number of Trees

Baltimore's urban forest has an estimated 1.9 million live trees and 103,000 standing dead trees. The number of trees varies by land use and diameter class. Most of the trees in Baltimore are located on forest land (39.2 percent, 731,696 trees) (Table 8). Overall, 43.6 percent of Baltimore's trees are saplings (1.0–4.9 inches in diameter), while the remaining 30.4 percent and 26.0 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 (39.0 percent) are found within the forest/shrub land cover class. The highest tree density (195.1 trees per acre) is found on the forest/shrub cover class (Table 9).



Table 8.—Number of live trees by Forest Inventory and Analysis (FIA) land use class and diameter class, City of Baltimore, 2020

FIA land use	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	318,000	233,000	180,000	732,000	198,000	197
Commercial/Industrial	0	73,000	57,000	130,000	38,000	9
Multi-family residential	26,000	49,000	56,000	131,000	51,000	22
Residential	410,000	148,000	126,000	684,000	221,000	61
Recreation/Cemetery	59,000	29,000	36,000	125,000	60,000	32
Rights-of-way	0	34,000	28,000	63,000	15,000	5
Water	0	0	0	0	0	0
Total	814,000	567,000	484,000	1,860,000	–	32
Total standard error	247,000	83,000	55,000	279,000	–	–

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

– = no value for cell

Table 9.—Number of live trees by National Land Cover Database (NLCD) land cover class and diameter class, City of Baltimore, 2020

NLCD land cover	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/Shrub	318,000	226,000	183,000	728,000	165,000	195
Dev-Open/Veg	327,000	134,000	125,000	586,000	196,000	57
Developed-low	123,000	95,000	76,000	293,000	99,000	23
Developed-medium	24,000	74,000	90,000	189,000	41,000	14
Developed-high	22,000	38,000	8,900	69,000	29,000	6
Water	0	0	0	0	0	0
Total	814,000	567,000	484,000	1,860,000	–	32
Total standard error	247,000	83,000	55,000	279,000	–	–

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

– = no value for cell

Species Composition

The 10 most common tree species by number account for 52.3 percent of all recorded live trees and are tree of heaven, northern white-cedar, American elm, green ash, Norway maple, black locust, American holly, American beech, Callery pear, and black cherry (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, making up 57.4 percent of the total, while large diameter trees make up only 15.6 percent of the total (Table 11; Fig. 7). When broken down into 2-inch diameter classes, many of the five most common species by number showed an abundance distribution similarly skewed toward smaller diameter trees (Fig. 8).

Table 10.—Urban forest tree species composition, City of Baltimore, 2020

Common name	Trees (number)	Percent	Common name	Trees (number)	Percent
tree of heaven	252,000	13.5	white ash	31,000	1.7
northern white-cedar	134,000	7.2	Japanese maple	31,000	1.7
American elm	121,000	6.5	silver maple	26,000	1.4
green ash	104,000	5.6	sassafras	25,000	1.3
Norway maple	74,000	4.0	overcup oak	25,000	1.3
black locust	65,000	3.5	willow oak	24,000	1.3
American holly	58,000	3.1	littleleaf linden	22,000	1.2
American beech	56,000	3.0	bitternut hickory	21,000	1.1
Callery pear	55,000	3.0	blue spruce	20,000	1.1
black cherry	54,000	2.9	Leyland cypress	17,000	0.9
slippery elm	53,000	2.8	yew spp.	17,000	0.9
white mulberry	53,000	2.8	American sycamore	16,000	0.8
boxelder	45,000	2.4	eastern white pine	15,000	0.8
yellow-poplar	42,000	2.2	northern red oak	14,000	0.8
red maple	38,000	2.0	mockernut hickory	12,000	0.7
Amur corktree	37,000	2.0	London planetree	12,000	0.6
sugar maple	36,000	1.9	white oak	11,000	0.6
Norway spruce	33,000	1.8	Japanese zelkova	9,500	0.5
sweetgum	32,000	1.7	Austrian pine	8,500	0.5

continued on next page

Table 10 (continued).

Common name	Trees (number)	Percent
buckeye, horsechestnut spp.	8,200	0.4
scarlet oak	8,200	0.4
honeylocust	7,900	0.4
black walnut	7,600	0.4
yellow buckeye	7,600	0.4
pin oak	6,900	0.4
Amur maple	6,900	0.4
sweet cherry	6,100	0.3
baldcypress	5,900	0.3
paper mulberry	5,900	0.3
pear spp.	5,300	0.3
flowering dogwood	5,300	0.3
eastern hemlock	4,800	0.3
blackgum	4,100	0.2
black willow	4,100	0.2
Freeman maple	4,000	0.2
Japanese cedar	4,000	0.2
eastern redcedar	3,900	0.2
Japanese pagoda tree	3,900	0.2
Silver linden	3,900	0.2
sawtooth oak	3,600	0.2
Siberian elm	3,300	0.2
mimosa, silktree	2,800	0.1
river birch	2,800	0.1

Common name	Trees (number)	Percent
apple spp.	2,800	0.1
eastern cottonwood	2,800	0.1
swamp chestnut oak	2,800	0.1
black oak	2,800	0.1
holly	2,800	0.1
dogwood spp.	2,100	0.1
chestnut oak	2,100	0.1
Scotch pine	2,000	0.1
northern catalpa	2,000	0.1
paulownia, empress-tree	2,000	0.1
Atlas cedar	2,000	0.1
eastern redbud	2,000	0.1
sour cherry	2,000	0.1
water oak	2,000	0.1
cherry plum	2,000	0.1
red mulberry	1,400	0.1
American basswood	1,400	0.1
European beech	1,400	0.1
Total	1,860,000	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, City of Baltimore, 2020

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)
tree of heaven	179,000	38,000	35,000	252,000
northern white-cedar	106,000	28,000	0	134,000
American elm	70,000	26,000	26,000	121,000
green ash	70,000	17,000	17,000	104,000
Norway maple	0	57,000	17,000	74,000
black locust	26,000	25,000	13,000	65,000
American holly	25,000	28,000	5,300	58,000
American beech	26,000	10,000	19,000	56,000
Callery pear	39,000	11,000	5,300	55,000
black cherry	17,000	22,000	15,000	54,000
Total	560,000	262,000	152,000	974,000

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

Standard errors for each estimate are reported in Appendix 2.

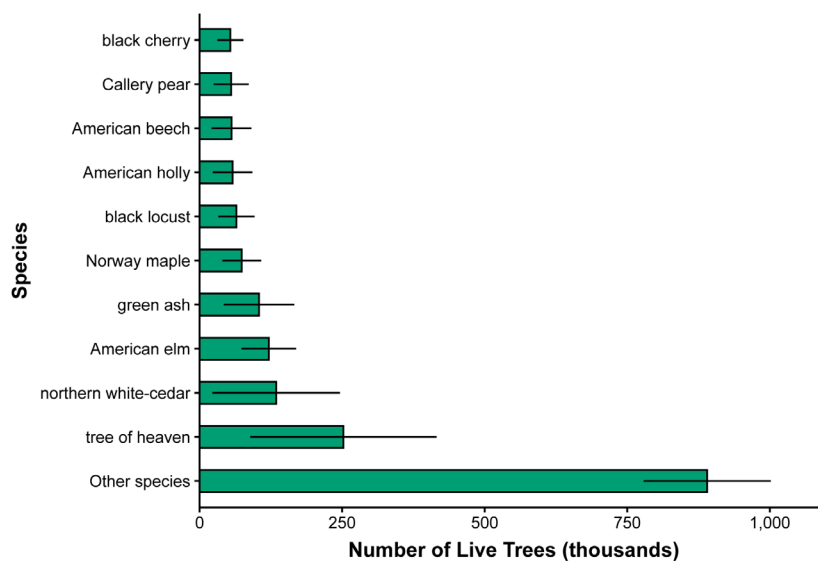


Figure 6.—The 10 most common tree species by number of trees, City of Baltimore, 2020. Other species is the total number of the other tree species in the inventory. Error bars represent 68 percent confidence intervals around the estimated means. Values in the bars represent the percent of each species in the population.

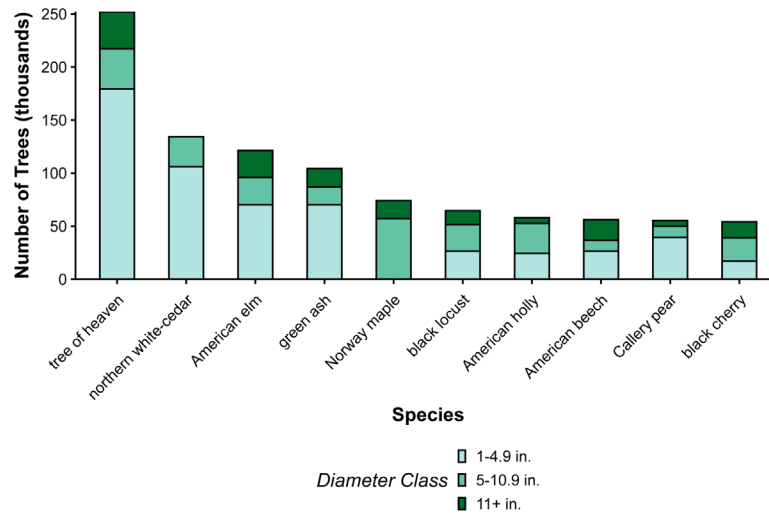


Figure 7.—The number of trees in each diameter class for the 10 most common tree species, City of Baltimore, 2020.

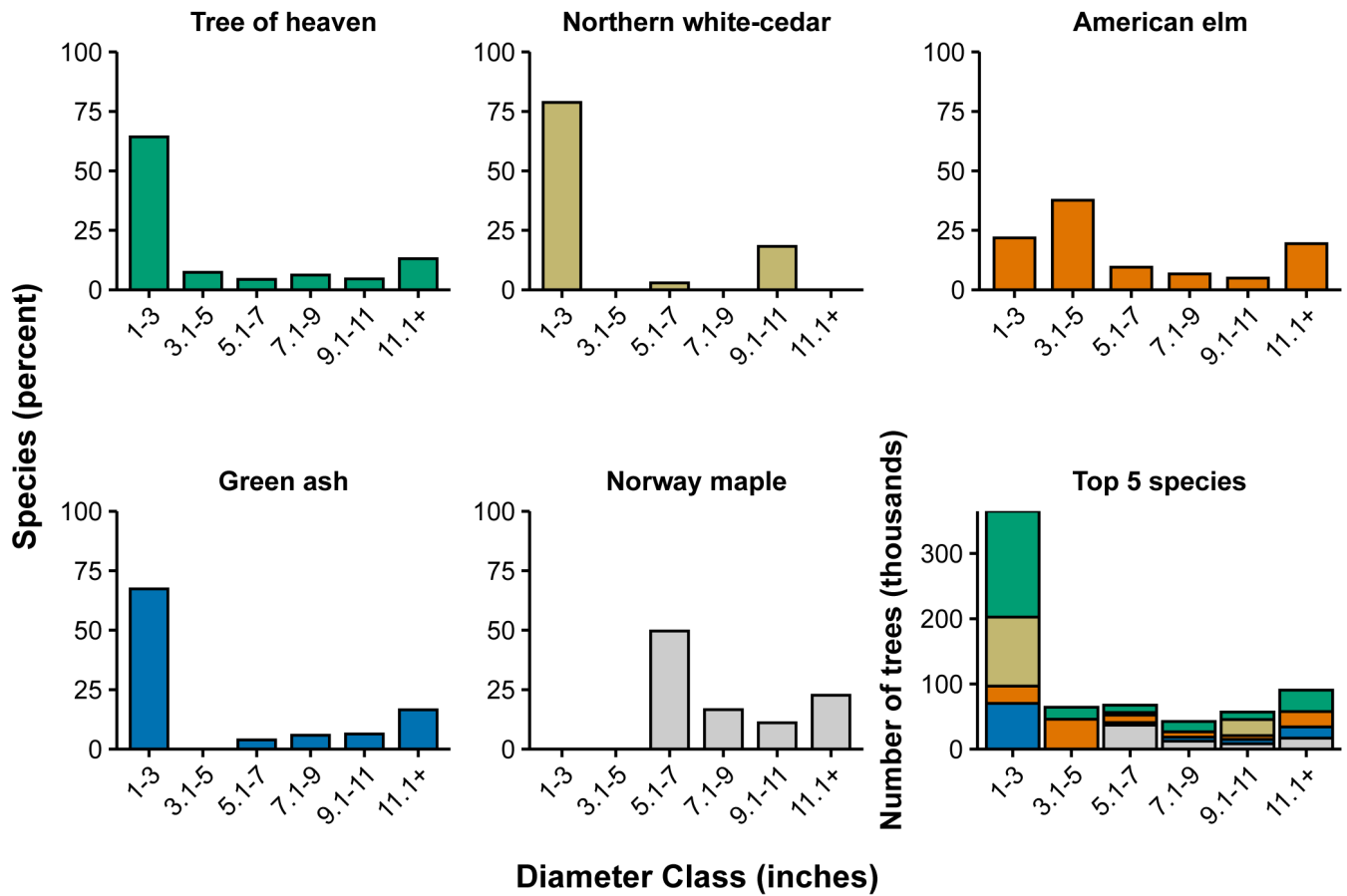


Figure 8.—Percentage of species population by diameter class for the five most common tree species, City of Baltimore, 2020.

The preceding table and figures highlight the most prominent species by number for all trees 1.0 inch in diameter and larger. As smaller diameter trees are generally more abundant per unit area, the overall species composition may be more reflective of the smaller diameter species when analyzing estimates based on number of trees. For this reason, it is also helpful to rank species according to other metrics such as the number of trees within various size classes, leaf area, importance value, volume, or biomass. The three most common species in terms of stem numbers in the smallest-diameter size classes (less than 5.0 inches in diameter) are tree of heaven, northern white-cedar, and American elm, together representing less than half (43.7 percent) of all live trees less than 5.0 inches in diameter (Table 12, Appendix 2). Norway maple, tree of heaven, and northern white-cedar are the most common species in intermediate diameter size classes, representing 21.8 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 tree of heaven, yellow-poplar, and white mulberry, which constitute 19.7 percent of live trees at least 11.0 inches in diameter (Table 12, Appendix 2).

Table 12.—The five most common tree species by diameter class, City of Baltimore, 2020

Diameter class (inches)	Common name	Trees (number)
1.0–4.9	tree of heaven	179,000
	northern white-cedar	106,000
	American elm	70,000
	green ash	70,000
	slippery elm	49,000
5.0–10.9	Norway maple	57,000
	tree of heaven	38,000
	northern white-cedar	28,000
	American holly	28,000
	white mulberry	27,000
11.0+	tree of heaven	35,000
	yellow-poplar	34,000
	white mulberry	26,000
	American elm	26,000
	white ash	25,000

Estimates are rounded.

In Baltimore, tree species composition on private land is dominated by tree of heaven (18.2 percent), northern white-cedar (13.3 percent), and American holly (5.7 percent) (Table 13). The most common tree species on public lands are green ash (10.0 percent), tree of heaven (8.0 percent), and American elm (8.0 percent) (Table 14). A total of 59 tree species are recorded on private lands, resulting in a **Shannon-Wiener diversity index** value of 3.2. The 46 species of trees recorded on public lands results in a Shannon-Wiener diversity index value of 3.3. 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 Urban FIA protocol. On private land, the top three genera with the greatest number of trees are tree of heaven (*Ailanthus* spp.), northern white-cedar (*Thuja* spp.), and maple (*Acer* spp.). On public land they are maple (*Acer* spp.), elm (*Ulmus* spp.), and ash (*Fraxinus* spp.) (Fig. 9). Species composition within NLCD land cover classes is detailed in Appendix 3 (Table 33).

Table 13.—Species composition on private lands, City of Baltimore, 2020

Common name	Trees (percent)	Common name	Trees (percent)	Common name	Trees (percent)
tree of heaven	18.2	sugar maple	1.2	black oak	0.3
northern white-cedar	13.3	yellow-poplar	1.2	holly	0.3
American holly	5.7	white ash	1.1	dogwood spp.	0.2
American elm	5.3	Norway maple	1.1	white oak	0.2
black cherry	3.7	Austrian pine	0.8	northern catalpa	0.2
white mulberry	3.7	pin oak	0.7	paulownia, empress-tree	0.2
black locust	3.7	northern red oak	0.6	Atlas cedar	0.2
Amur corktree	3.6	sweet cherry	0.6	eastern redbud	0.2
Japanese maple	3.1	baldcypress	0.6	sour cherry	0.2
Callery pear	3.1	paper mulberry	0.6	slippery elm	0.2
Norway spruce	3.0	boxelder	0.5	London planetree	0.2
sassafras	2.4	flowering dogwood	0.5	cherry plum	0.2
overcup oak	2.4	eastern hemlock	0.5	red mulberry	0.1
willow oak	2.4	black walnut	0.4	American basswood	0.1
blue spruce	2.0	Japanese cedar	0.4	Siberian elm	0.1
silver maple	2.0	eastern redcedar	0.4	Leyland cypress	0.1
green ash	1.9	sweetgum	0.3	European beech	0.1
yew spp.	1.7	river birch	0.3	pear spp.	0.1
red maple	1.5	apple spp.	0.3	littleleaf linden	0.1
eastern white pine	1.5	swamp chestnut oak	0.3		

Estimates are rounded.

Table 14.—Species composition on public lands, City of Baltimore, 2020

Common name	Trees (percent)	Common name	Trees (percent)	Common name	Trees (percent)
green ash	10.0	black cherry	1.9	blackgum	0.5
tree of heaven	8.0	Leyland cypress	1.9	black willow	0.5
American elm	8.0	American sycamore	1.8	Freeman maple	0.5
Norway maple	7.4	white mulberry	1.8	pear spp.	0.5
American beech	6.6	mockernut hickory	1.4	Japanese pagoda tree	0.5
slippery elm	6.0	London planetree	1.1	Silver linden	0.5
boxelder	4.7	Japanese zelkova	1.1	sawtooth oak	0.4
yellow-poplar	3.5	white oak	1.0	black walnut	0.4
sweetgum	3.3	buckeye, horsechestnut spp.	1.0	mimosa, silktree	0.3
black locust	3.2	scarlet oak	1.0	eastern cottonwood	0.3
Callery pear	2.9	northern red oak	1.0	Norway spruce	0.2
sugar maple	2.7	honeylocust	0.9	chestnut oak	0.2
red maple	2.6	yellow buckeye	0.9	Scotch pine	0.2
bitternut hickory	2.4	Amur maple	0.8	water oak	0.2
littleleaf linden	2.4	silver maple	0.7	Siberian elm	0.2
white ash	2.4				

Estimates are rounded.

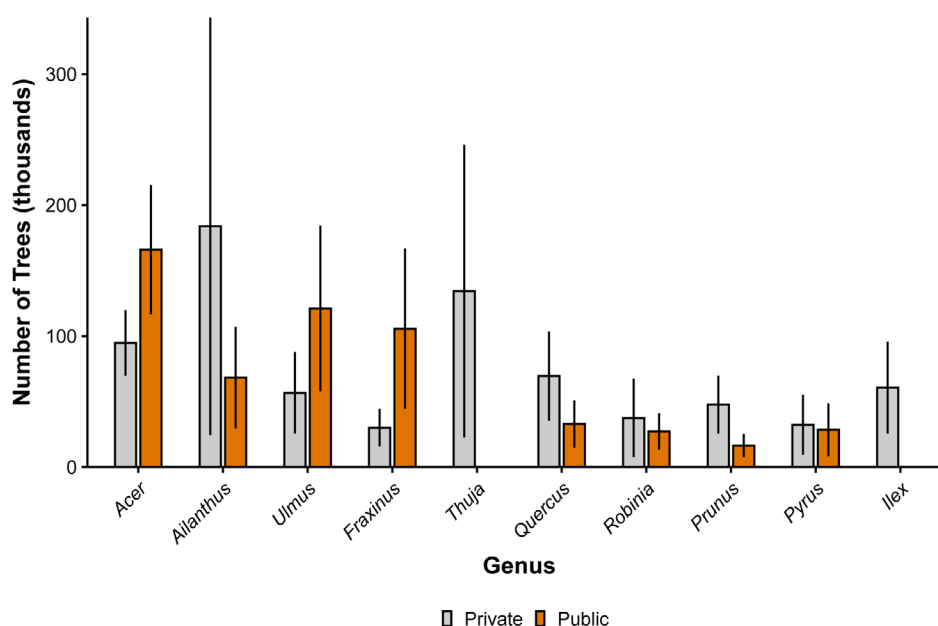


Figure 9.—The 10 most common genera within ownership classes, City of Baltimore, 2020. Error bars represent 68 percent confidence intervals around the estimated means.

Table 15.—The 10 most common tree species in maintained areas, City of Baltimore, 2020

Common name	Trees (number)	Percent of all trees in maintained areas
northern white-cedar	134,000	16.6
American holly	55,000	6.8
Callery pear	35,000	4.3
sugar maple	34,000	4.2
white mulberry	33,000	4.1
Japanese maple	31,000	3.9
Norway spruce	31,000	3.8
black cherry	25,000	3.0
overcup oak	25,000	3.0
willow oak	24,000	3.0

Estimates are rounded.

Trees in Maintained Areas

Overall, 43.5 percent of trees in Baltimore are found in maintained areas. Maintained areas are those which are regularly impacted by mowing, weeding, cutting, brush clearing, herbicide applications, etc. Examples of maintained areas include, but are not limited to, lawns, shrub and flower beds, **rights-of-way**, and manicured parks. However, a tree found in a maintained area has not necessarily received care. In Baltimore, the most common tree species in maintained areas are northern white-cedar (16.6 percent of all trees in maintained areas), American holly (6.8 percent), and Callery pear (4.3 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. The proportion of total leaf area in the urban forest is greatest for trees 29.1+ inches in diameter (20.6 percent), followed by 9.1–11.0 inches in diameter (9.0 percent), and 11.1–13.0 inches in diameter (8.0 percent) (Fig. 10). In Baltimore, leaf area is greatest in forest land uses (37.0 percent of total leaf area), followed by residential (31.9 percent), and commercial/industrial land uses (9 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 12.5 in forest land use to 7.1 in multi-family residential (Fig. 11).

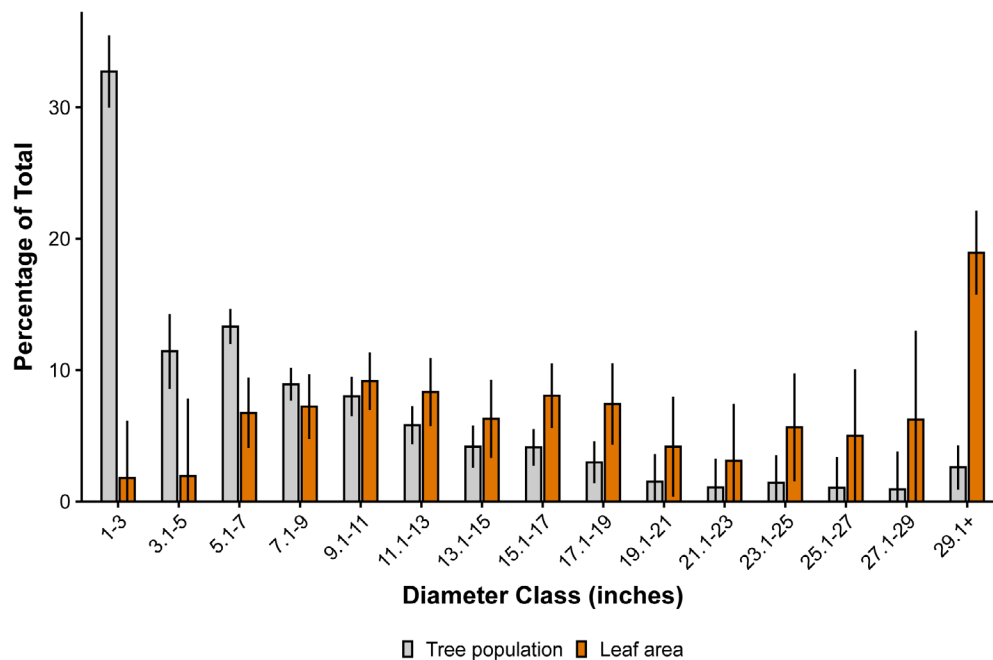


Figure 10.—Percentage of tree population and leaf area by 2-inch diameter class, City of Baltimore, 2020. Error bars represent 68 percent confidence intervals around the estimated means.

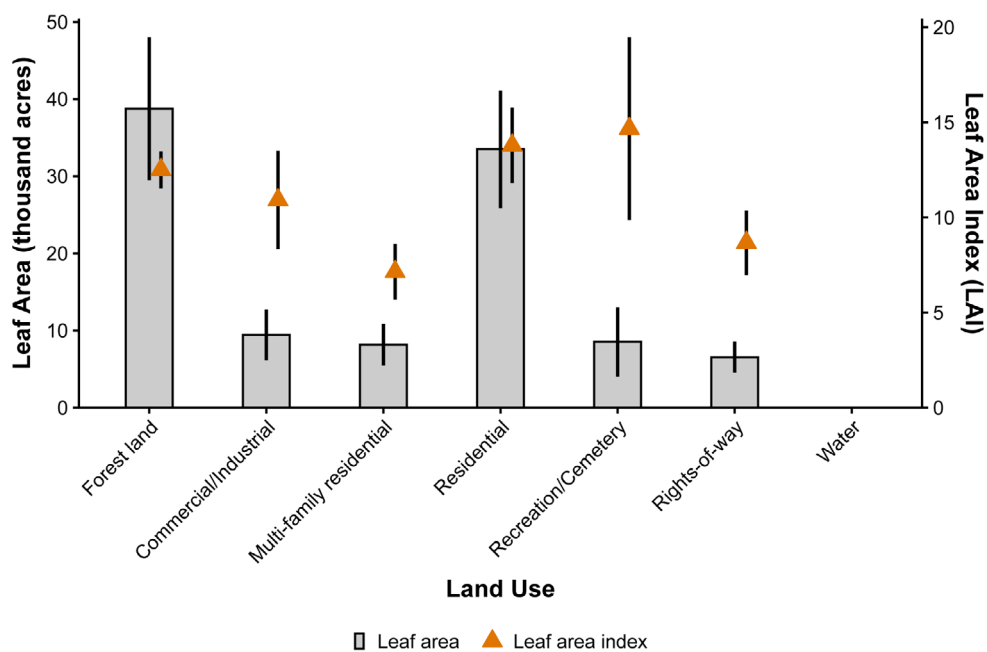


Figure 11.—Leaf area and leaf area index (LAI) by Forest Inventory and Analysis (FIA) land use classes, City of Baltimore, 2020. Error bars represent 68 percent confidence intervals around the estimated means.

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 Baltimore's urban forest with the greatest IVs are tree of heaven (19.6), American elm (11.3), and Norway maple (10.0) (Table 16).

Table 16.—Percent of total tree population represented by tree species with the highest importance value, City of Baltimore, 2020

Common name	Population (percent)	Leaf area (percent)	Importance value
tree of heaven	13.5	6.0	19.5
yellow-poplar	2.2	9.0	11.2
American elm	6.5	3.5	10.0
Norway maple	4.0	6.0	9.9
white ash	1.7	7.7	9.4
American beech	3.0	5.8	8.8
northern white-cedar	7.2	0.8	8.0
green ash	5.5	2.3	7.8
white mulberry	2.8	3.0	5.8
silver maple	1.4	4.2	5.6

Estimates are rounded.

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

VOLUME AND BIOMASS



A large sweetgum tree in Baltimore, Maryland. Courtesy photo by Zoe Gensheimer, Baltimore City 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. (2025). 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 Baltimore, live trees at least 5.0 inches in diameter are estimated to contain 22.6 million cubic feet of net volume, of which 100.1 million board feet is sawtimber volume. To put this value in perspective, the median size of American homes constructed in 2019 was 2,301 square feet (U.S. Census Bureau 2020), which would require approximately 14,500 board feet to construct. Thus, the net sawtimber volume of Baltimore's urban forest is roughly equivalent to the amount of wood that would be needed to construct 6,904 median-sized homes. Yellow-poplar contributes the greatest net cubic-foot volume at 17.7 percent of the city's total (Table 17). Yellow-poplar contributes 29.9 percent of the total net board-foot sawtimber volume (Table 18). By diameter class, the greatest net cubic volume is provided by trees 29.1 inches or greater in diameter (Fig. 12).

Table 17.—Net cubic-foot volume for tree species with greatest net volume, City of Baltimore, 2020

Common name	Net volume (cubic feet)	Standard error (cubic feet)	Net volume (percent)
yellow-poplar	4,000,000	1,270,000	17.7
white ash	2,330,000	1,000,000	10.3
white oak	1,630,000	1,040,000	7.2
American beech	1,070,000	738,000	4.7
silver maple	1,030,000	447,000	4.5
tree of heaven	983,000	420,000	4.3
pin oak	932,000	568,000	4.1
Norway spruce	850,000	556,000	3.8
white mulberry	698,000	285,000	3.1
sugar maple	605,000	284,000	2.7
Other species	8,520,000	1,150,000	37.6
Total	22,640,000	2,940,000	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, City of Baltimore, 2020

Common name	Net volume (board feet)	Standard error (board feet)	Net volume (percent)
yellow-poplar	29,890,000	9,570,000	29.9
white ash	14,130,000	6,450,000	14.1
white oak	12,940,000	8,280,000	12.9
American beech	6,690,000	5,270,000	6.7
pin oak	6,140,000	3,760,000	6.1
silver maple	3,440,000	2,290,000	3.4
northern red oak	2,700,000	1,530,000	2.7
black walnut	2,470,000	2,800,000	2.5
eastern white pine	2,340,000	2,240,000	2.3
littleleaf linden	2,300,000	2,600,000	2.3
Other species	17,050,000	3,980,000	17.0
Total	100,110,000	20,440,000	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.

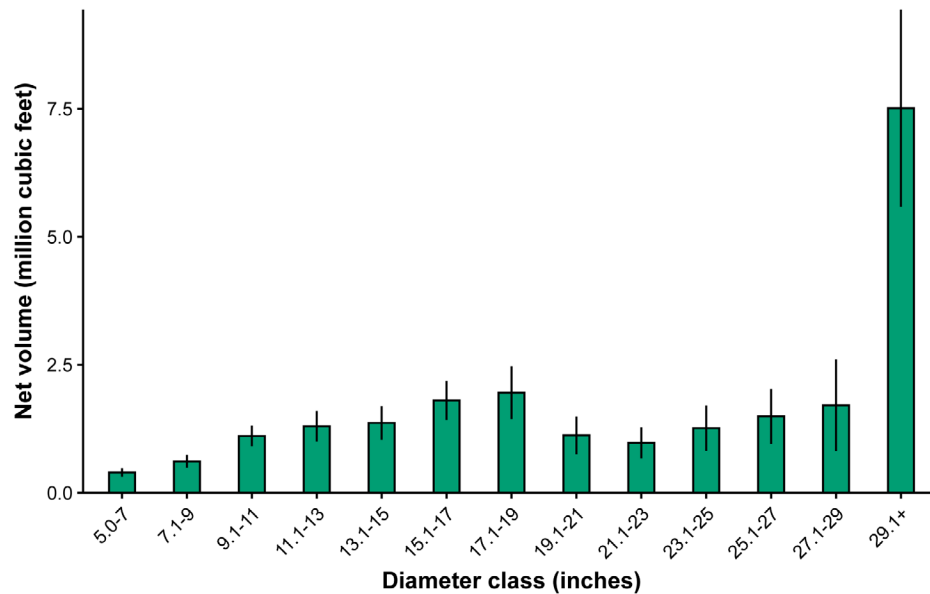


Figure 12.—Net cubic volume by tree diameter class, City of Baltimore, 2020.

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 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 Baltimore is estimated at 1.4 million green tons, which includes the weight of its moisture content (Table 19). The amount of biomass stored by live trees in Baltimore varies by species. The tree species with the greatest total aboveground biomass are yellow-poplar (15.3 percent), white oak (8.8 percent), and white ash (7.1 percent) (Table 19).

Table 19.—Aboveground biomass (green tons) for tree species with the greatest biomass, City of Baltimore, 2020

Common name	Biomass (green tons)	Standard error (green tons)	Biomass (percent)
yellow-poplar	213,000	67,000	15.3
white oak	122,000	79,000	8.8
white ash	98,000	39,000	7.1
silver maple	84,000	33,000	6.1
American beech	71,000	49,000	5.1
tree of heaven	65,000	28,000	4.7
white mulberry	64,000	26,000	4.6
pin oak	58,000	35,000	4.2
American elm	46,000	20,000	3.3
northern red oak	40,000	22,000	2.9
Other species	527,000	69,000	38.0
Total	1,390,000	176,000	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



A residential yard with large shade trees. USDA Forest Service photo by Nancy Sonti.

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 Baltimore is greatest for O_3 (259.3 tons per year), followed by nitrogen dioxide (NO_2 , 61.7 tons per year), particulate matter less than 2.5 microns ($PM_{2.5}$, 15.0 tons per year), sulfur dioxide (SO_2 , 8.7 tons per year), and carbon monoxide (CO; 2.6 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 2024). The estimated value associated with pollution removal is greatest for $PM_{2.5}$ (\$8.8 million), followed by O_3 (\$2.9 million), NO_2 (\$121,000), SO_2 (\$6,000), and CO (\$3,500) (Table 20). It is estimated that trees in Baltimore remove a total of 347 tons of air pollution per year with an associated value of \$11.8 million. More information about value calculations can be found in Baer et al. (2025).

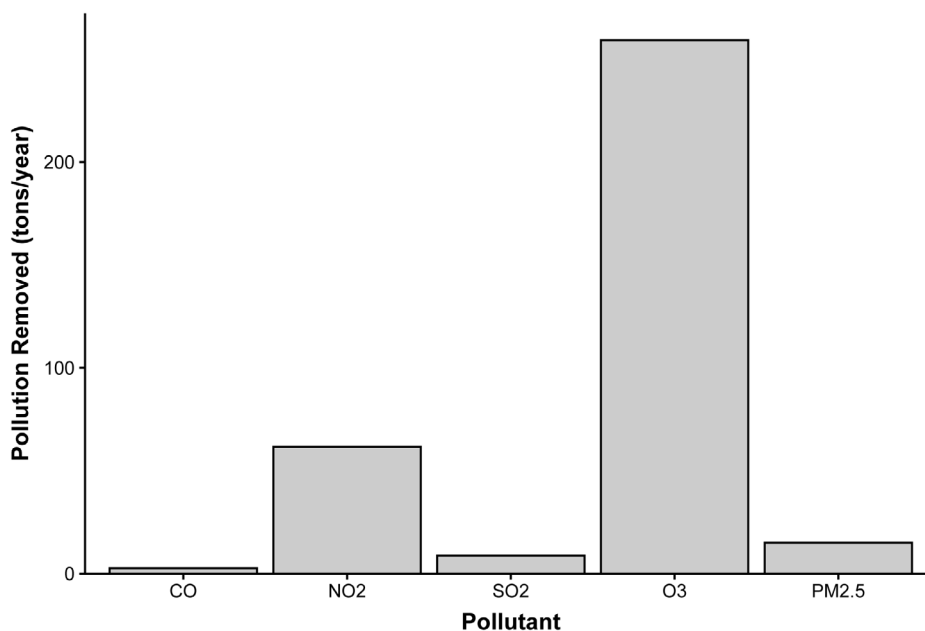


Figure 13.—Air pollution removal by trees, City of Baltimore, 2020.

Decreases in the concentration of various air pollutants due to removal by trees is expected to have a positive effect on human health in Baltimore (Nowak et al. 2014, U.S. EPA 2012). Using measured field data and pollution data from 2015, air quality improvements from trees produce numerous health benefits including an estimated 803 fewer cases of acute respiratory symptoms per year with an associated value of over \$70,000 (Table 20).

Trees in Baltimore emit an estimated 302 tons of VOCs (82 tons of isoprene and 220 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. *Quercus* (oak) and *Picea* (spruce) species contribute 69.6 percent of VOC emissions (Fig. 14). These VOCs are precursor chemicals to ozone formation.

Table 20.—Incidence (number of cases per year) and associated value (dollars per year) of avoided health effects from changes in pollution concentrations due to pollution removal by trees, City of Baltimore, 2020

Health effect	Nitrogen dioxide (NO ₂)		Sulfur dioxide (SO ₂)		Ozone (O ₃)		Particulate matter (PM _{2.5})	
	cases/year	\$/year	cases/year	\$/year	cases/year	\$/year	cases/year	\$/year
Acute Bronchitis	–	–	–	–	–	–	0.4	35.8
Acute Myocardial Infarction	–	–	–	–	–	–	0.2	16,000
Acute Respiratory Symptoms	33.7	1,100	1.6	50.9	500	43,000	270	26,000
Asthma Exacerbation	510	42,000	14.7	1,200	–	–	160	13,000
Chronic Bronchitis	–	–	–	–	–	–	0.2	60,000
Emergency Room Visits	1.7	720	0.3	110	0.8	350	1.1	440
Hospital Admissions	2.6	77,000	0.2	4,700	0.7	23,000	–	–
Hospital Admissions, Cardiovascular	–	–	–	–	–	–	0.2	7,000
Hospital Admissions, Respiratory	–	–	–	–	–	–	0.1	2,600
Lower Respiratory Symptoms	–	–	–	–	–	–	5.0	260
Mortality	–	–	–	–	0.4	2,810,000	1.1	8,620,000
School Loss Days	–	–	–	–	170	16,000	–	–
Upper Respiratory Symptoms	–	–	–	–	–	–	4.1	190
Work Loss Days	–	–	–	–	–	–	45.8	6,700
Total	540.0	121,000	16.7	6,000	670.0	2,890,000	480.0	8,750,000

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

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

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

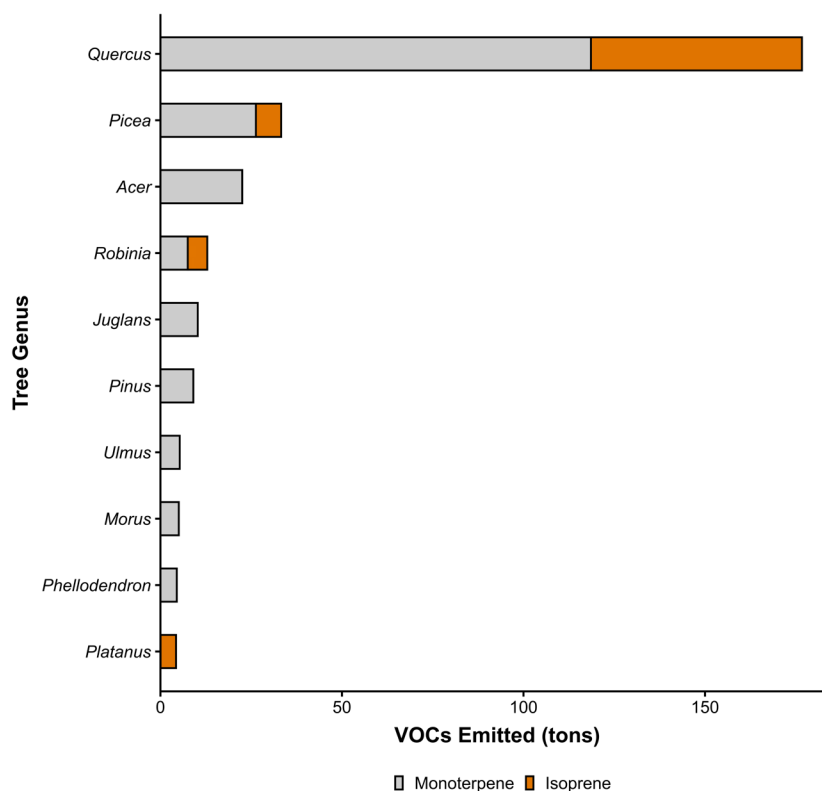


Figure 14.—Volatile organic compound (VOC) emissions by genus, City of Baltimore, 2020.

Avoided Runoff

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

Urban trees can reduce surface runoff. Tree canopies intercept precipitation, while root systems promote infiltration and water storage in the soil. The amount of avoided runoff is less than the total amount intercepted because soils also absorb precipitation and thus reduce runoff in the absence of trees. The trees in Baltimore are estimated to reduce runoff by 33 million cubic feet per year (246 million gallons annually), with an estimated value of \$2 million per year based on a national average cost of stormwater control and treatment of \$0.008936 per gallon (Nowak 2024). Tree species with the greatest overall impact on runoff are yellow-poplar, white ash, and tree of heaven due to their large leaf surface area (Fig. 15).

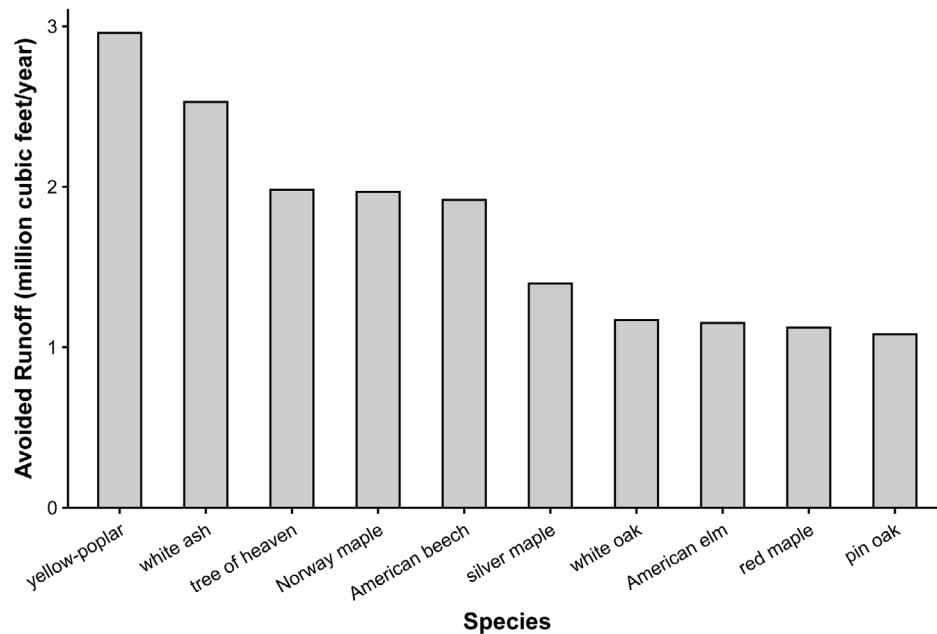


Figure 15.—Avoided runoff for tree species with greatest leaf area, City of Baltimore, 2020.

Energy Conservation

Trees can affect building energy use by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months (cooling season) and can either increase or decrease building energy use in the winter months (heating season), depending on the location of the trees around the building (Heisler 1986, Nowak et al. 2017). Estimates of tree effects on energy use are based on field measurements of the tree distance and directions to space-conditioned residential buildings (McPherson and Simpson 1999; Nowak et al. 2008; Nowak 2024; U.S. EIA 2012a, b; U.S. EIA 2014a, b, c).

In Baltimore, interactions between buildings and trees 5.0 inches in diameter and greater are projected to annually decrease energy requirements by 452,000 gigajoules (GJ) during the heating and cooling seasons (an energy equivalent of 2.9 million gallons of home heating fuel oil) (Table 21), with an annual savings in energy costs of \$7.2 million (Table 22). Savings in residential energy costs were calculated based on state average 2012 costs for natural gas (U.S. EIA 2014b), 2012/2013 heating season fuel oil costs (U.S. EIA 2012a, b), and 2012 costs of wood (U.S. EIA 2014a). Trees in the urban forest also are estimated to reduce carbon dioxide (CO₂) emissions from fossil-fuel-based power sources by 44,600 tons annually (12,200 tons of carbon; \$2,326,000), equivalent to the burning of over 31.2 million pounds of coal or roughly 94,179 barrels of oil (Hong and Slatick 1994, U.S. EPA 2020).

Table 21.—Annual energy savings (GJ or tons) due to trees 5.0+ inches in diameter near residential buildings, City of Baltimore, 2020

Reduced energy use and emissions	Cooling	Heating	Total
Carbon avoided (tons) ^a	1,600	11,000	12,000
Energy savings (GJ) ^b	58,000	395,000	452,000

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, City of Baltimore, 2020

Reduced energy use and emissions	Cooling (dollars)	Heating (dollars)	Total (dollars)
Carbon avoided	303,000	2,020,000	2,330,000
Energy effects	2,130,000	5,040,000	7,170,000

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). Although FIA volume and biomass models use species specific calculations, it is generally accepted that approximately half of the biomass in a tree is carbon (Westfall et al. 2024).

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 Baltimore store an estimated 440,635 tons of carbon (1.6 million tons of CO₂) valued at \$75.2 million (Table 23). Tree carbon values are based on the 2015 estimated social costs of carbon (\$170.60 per ton of carbon; Interagency Working Group on Social Cost of Carbon 2013, Intergovernmental Panel on Climate Change 2014). The social cost of carbon is a monetary value that encompasses the economic impact of increased carbon emissions on factors such as agricultural productivity, human health, and property damage. 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 white ash (Fig. 17).

Table 23.—Aboveground and belowground carbon in live and standing dead trees by Forest Inventory and Analysis (FIA) land use classes, City of Baltimore, 2020

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	149,000	24,000	9,000	182,000	51,000
Residential	114,000	18,000	400	132,000	29,000
Multi-family residential	35,000	4,900	150	40,000	13,000
Recreation/Cemetery	28,000	5,000	480	34,000	19,000
Commercial/Industrial	24,000	3,900	97	28,000	11,000
Rights-of-way	22,000	2,900	160	25,000	9,500
Total	372,000	58,000	10,000	441,000	–
Standard error	48,000	7,400	2,700	56,000	–

– = no value for cell

Figures 18 and 19 show the distribution of carbon storage and sequestration in trees by diameter class both as a proportion of the total amount of carbon stored and on a per tree basis.

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 Baltimore is about 15,200 tons of carbon per year (56,000 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 11,000 passenger vehicles or energy usage by 6,100 homes (U.S. EPA 2020). Yellow-poplar is estimated to sequester the most carbon of all species in the urban forest (11.7 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.

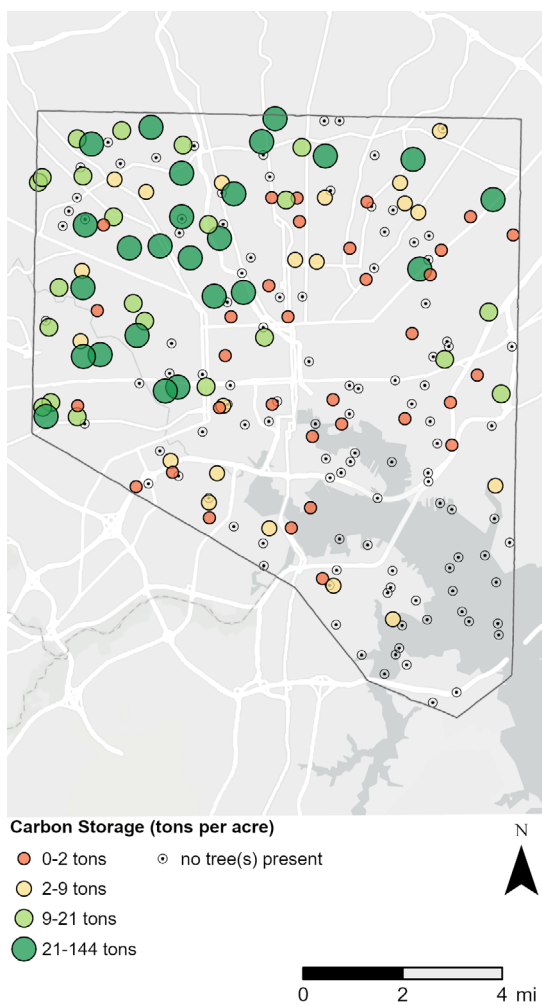


Figure 16.—Carbon storage per acre for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, City of Baltimore, 2020. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

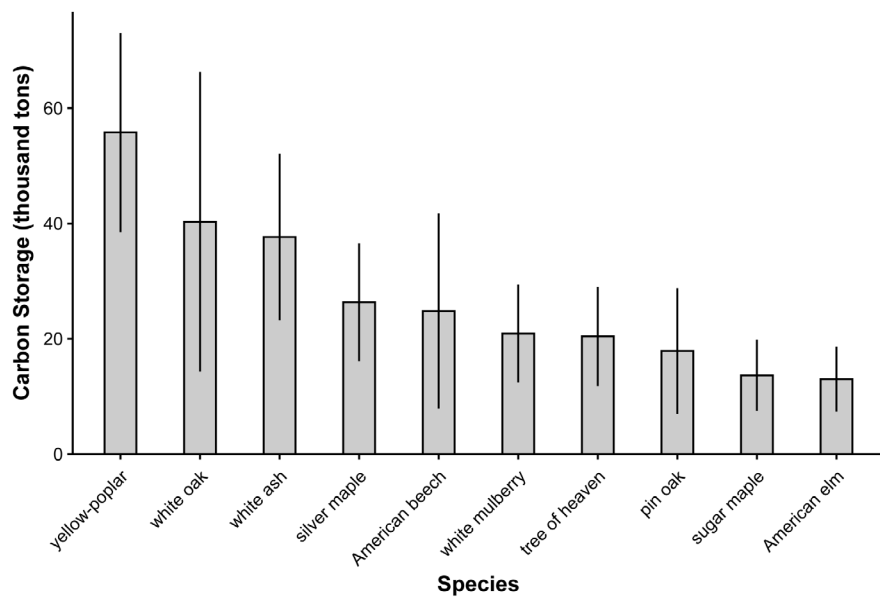


Figure 17.—Carbon storage for 10 tree species with the greatest carbon storage, City of Baltimore, 2020.

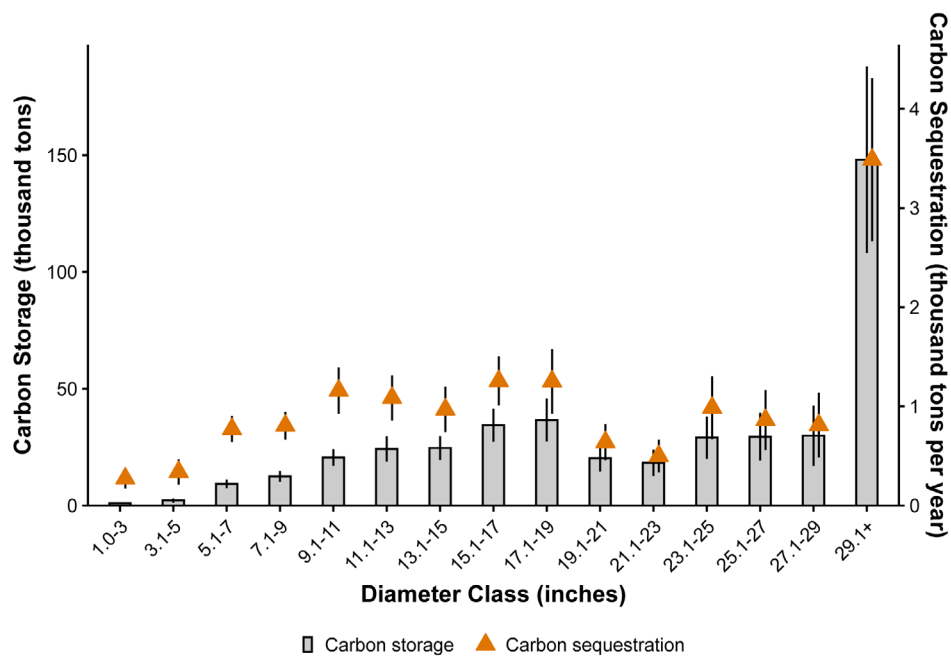


Figure 18.—Total carbon storage and sequestration by diameter class, City of Baltimore, 2020. Error bars represent 68 percent confidence intervals around the estimated means.

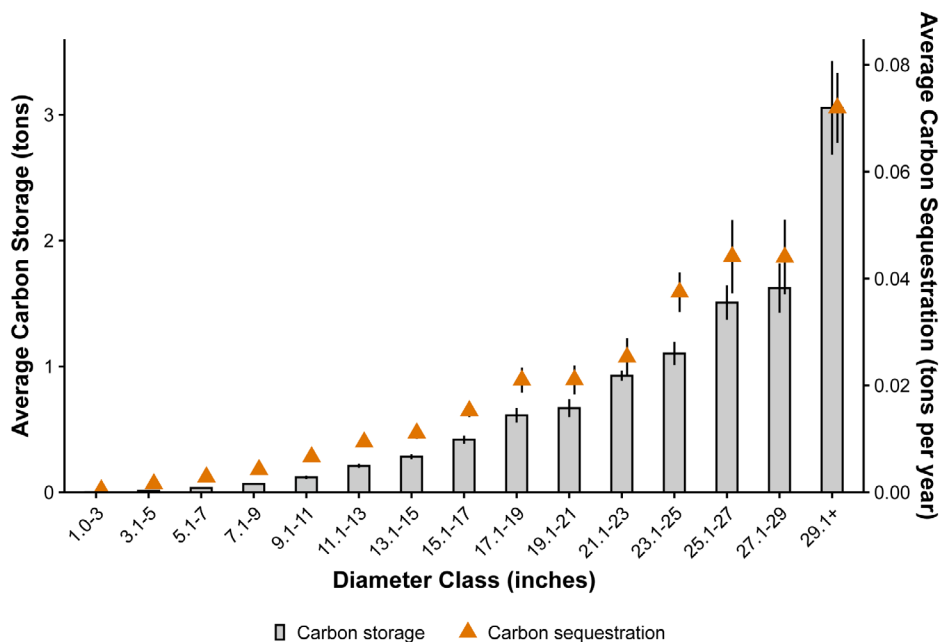


Figure 19.—Average per tree carbon storage and sequestration by diameter class, City of Baltimore, 2020. Error bars represent 68 percent confidence intervals around the estimated means.

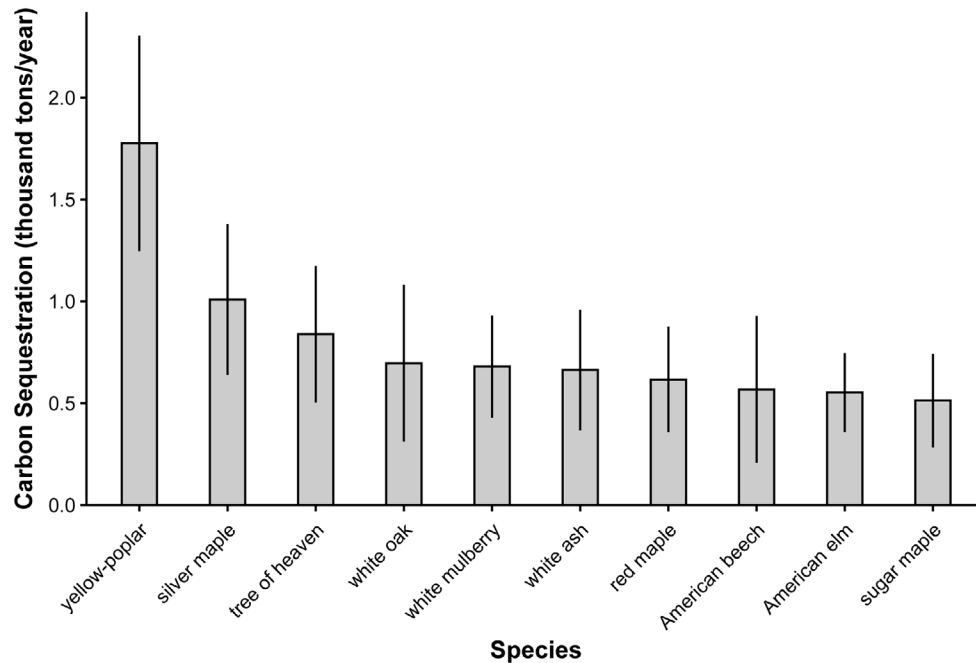


Figure 20.—Carbon sequestration for the 10 tree species with the greatest annual carbon sequestration, City of Baltimore, 2020.

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 (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 Baltimore is estimated to be about \$2.28 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 Baltimore are yellow-poplar, white mulberry, and white ash (Fig. 21). The mean compensatory value per acre for all surveyed plots in Baltimore is \$38,778; for the 47.6 percent of these plots that contain trees, the mean compensatory value per acre is \$81,500 (Fig. 22). However, compensatory value per acre is estimated to exceed \$124,000 for 25 plots in which the average tree diameter is 14.2 inches. The structural value of urban trees in Baltimore is a combination of their compensatory value (estimated at \$2.28 billion) and the value associated with carbon storage by the trees (estimated at \$75.2 million).

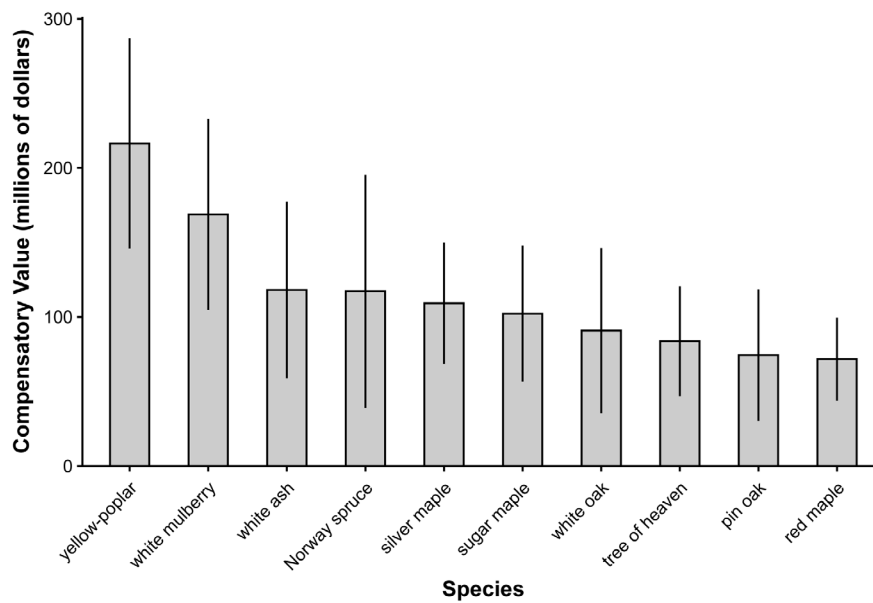


Figure 21.—The compensatory value for 10 of the highest value tree species, City of Baltimore, 2020.

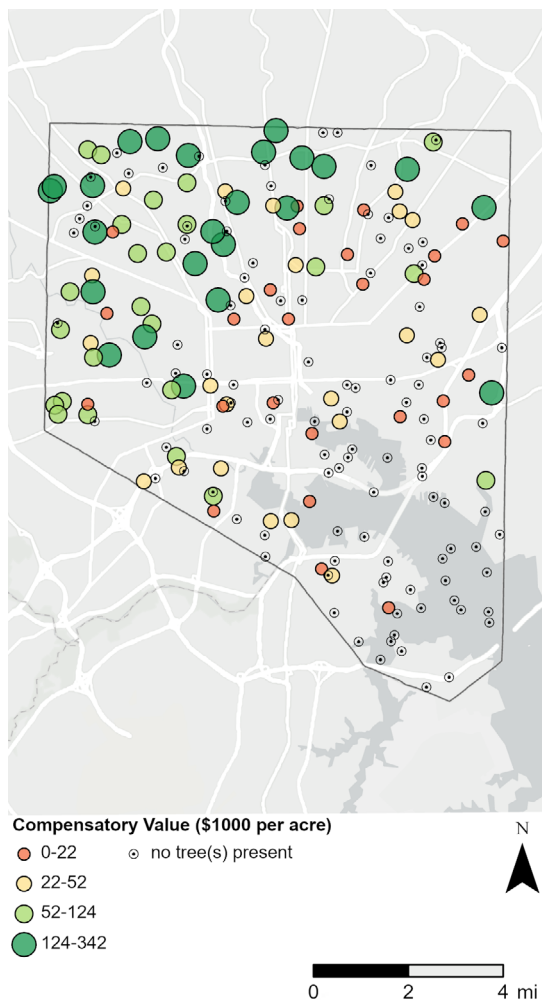


Figure 22.—Compensatory value per acre for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, City of Baltimore, 2020. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

URBAN FOREST HEALTH



A street tree with significant crown dieback. USDA Forest Service photo by Nancy Sonti.

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 Baltimore. 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 show evidence of dieback, white ash has the highest average dieback (13.4 percent) (Table 24). Approximately 12.2 percent of white ash displays greater than 25 percent crown dieback, indicating that this species may be threatened by insect, disease, or environmental stressors in Baltimore.

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 boxelder and red maple (Table 25).

Table 24.—Tree species with the greatest average dieback, City of Baltimore, 2020

Common name	Average dieback (percent)	Standard error (percent)	Trees with more than 25% dieback (percent)
white ash	13.4	12.9	12.2
white mulberry	9.7	3.5	6.3
green ash	7.6	7.1	7.2
Norway maple	5.1	3.4	0.0
silver maple	4.9	2.0	2.6
black locust	4.8	3.0	3.5
red maple	4.3	2.2	2.0
American elm	3.2	2.5	1.9
American holly	2.3	0.9	0.0
tree of heaven	2.2	1.6	0.0
sassafras	1.8	–	0.0
black cherry	1.6	0.8	0.0
American sycamore	1.3	0.2	0.0
sugar maple	1.1	0.9	0.0
boxelder	1.0	0.8	0.0
Callery pear	0.9	0.7	0.0
yellow-poplar	0.9	0.4	0.0
bitternut hickory	0.8	0.1	0.0
American beech	0.3	0.3	0.0
Norway spruce	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.

– = no value for cell

Table 25.—Tree species with the greatest average rot, City of Baltimore, 2020

Common name	Average rot (percent)	Standard error (percent)	Trees with more than 15% rot (percent)
boxelder	10.6	5.5	0.5
red maple	8.2	3.5	0.7
American beech	6.0	3.2	0.2
white mulberry	5.7	3.0	0.5
black cherry	5.2	2.4	0.4
sugar maple	3.3	1.0	0.1
black locust	3.2	1.1	0.0
silver maple	3.0	1.6	0.2
American holly	2.8	3.0	0.7
white ash	2.1	1.2	0.1
American elm	2.0	1.7	0.3
American sycamore	1.9	0.4	0.0
yellow-poplar	1.3	0.6	0.1
Norway maple	0.8	0.6	0.0
green ash	0.5	0.2	0.0
sassafras	0.5	0.0	0.0
bitternut hickory	0.3	0.0	0.0
tree of heaven	0.2	0.1	0.0
Norway spruce	0.2	0.2	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.

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 three 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 three damage agents were observed on a tree, the top three 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 vine damage are the most common causes of damage, affecting 17.3 and 9.5 percent of trees, respectively (Table 26).

Table 26.—Percentage of trees with observed damage, City of Baltimore, 2020

Damage type	Percent
Abiotic Damage	17.3
Boring Insects	9.5
Cankers	2.8
Competition	1.2
Decline Complexes/Dieback/Wilts	1.0
Foliage diseases	0.9
Human Activities	0.4
Root/Butt Diseases	0.3
Stem Decay	0.3
Wild Animals	0.2
Emerald Ash Borer	0.2
Imbedded objects	0.2
Vine damage	0.1
Wind	0.1
Other damages and symptoms	
Other damages and symptoms	4.0
Broken top	2.0
Dead top	1.4
Dieback	0.4

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:

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

Conflict with crown is the most common issue, occurring in 11.9 percent of trees. Bark inclusion and conflict with roots are the second and third most common urban specific infrastructure issues, occurring in 5.1 and 2.1 percent of trees, respectively (Fig. 23).

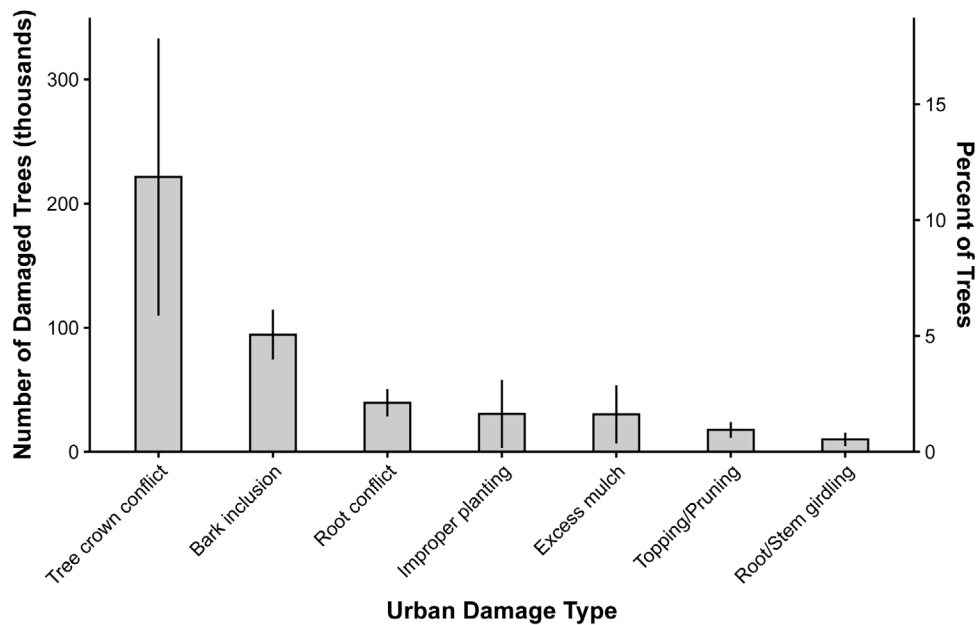


Figure 23.—Number and percentage of trees by urban infrastructure issue category, City of Baltimore, 2020. Error bars represent 68 percent confidence intervals around the estimated means.

Differences exist in the prevalence of these issues among the FIA-designated land uses and may further inform forest health and management priorities. In Baltimore, bark inclusion occurs in 36.4 percent of trees on rights-of-way land, conflict with roots in 33.0 percent of trees on rights-of-way land, and conflict with crown in 29.6 percent of trees on residential land.

Of species with a minimum sample size of 10 trees, the species with the greatest proportion of their population affected by urban-specific damages are tree of heaven (40.1 percent affected by conflict with crown) and white mulberry (27.0 percent affected by conflict with crown) (Table 27).

Table 27.—Percent of live trees identified with damage, maintenance, and site issues, City of Baltimore, 2020

Common name	Number of trees	Standard error	Bark inclusion (percent)	Crown conflict (percent)	Excess mulch (percent)	Improper planting (percent)	Root/stem girdling (percent)	Root conflict (percent)	Topping/pruning (percent)
American basswood	1,000	2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American beech	56,000	35,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American elm	121,000	48,000	6.5	2.8	0.0	0.0	0.0	3.2	0.0
American holly	58,000	35,000	2.4	8.1	0.0	3.0	0.0	0.0	2.4
American sycamore	16,000	16,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amur corktree	37,000	38,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amur maple	7,000	8,000	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Atlas cedar	2,000	2,000	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Austrian pine	9,000	7,000	0.0	16.2	0.0	0.0	0.0	0.0	0.0
Callery pear	55,000	31,000	19.3	3.6	0.0	0.0	5.0	0.0	0.0
European beech	1,000	2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Freeman maple	4,000	4,000	50.0	0.0	0.0	0.0	0.0	100.0	0.0
Japanese cedar	4,000	4,000	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Japanese maple	31,000	21,000	0.0	6.6	0.0	0.0	0.0	0.0	0.0
Japanese pagoda tree	4,000	3,000	0.0	0.0	0.0	0.0	50.0	0.0	0.0
Japanese zelkova	9,000	6,000	62.4	0.0	0.0	0.0	20.6	20.6	0.0
Leyland cypress	17,000	15,000	34.5	7.9	0.0	0.0	0.0	0.0	0.0
London planetree	12,000	7,000	0.0	0.0	0.0	0.0	0.0	31.0	0.0
Norway maple	74,000	34,000	2.7	4.6	0.0	0.0	0.0	2.7	0.0
Norway spruce	33,000	22,000	0.0	25.0	0.0	0.0	0.0	0.0	6.3
Scotch pine	2,000	2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Siberian elm	3,000	2,000	58.7	41.3	0.0	0.0	0.0	100.0	0.0
Silver linden	4,000	4,000	50.0	0.0	0.0	0.0	0.0	0.0	0.0
apple spp.	3,000	3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
baldcypress	6,000	6,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bitternut hickory	21,000	19,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black cherry	54,000	23,000	7.4	2.6	0.0	0.0	0.0	0.0	0.0
black locust	65,000	32,000	5.2	2.1	0.0	0.0	0.0	0.0	0.0
black oak	3,000	2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black walnut	8,000	4,000	0.0	36.4	0.0	0.0	0.0	0.0	0.0
black willow	4,000	4,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blackgum	4,000	3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 27 (continued).

Common name	Number of trees	Standard error	Bark inclusion (percent)	Crown conflict (percent)	Excess mulch (percent)	Improper planting (percent)	Root/stem girdling (percent)	Root conflict (percent)	Topping/pruning (percent)
blue spruce	20,000	20,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
boxelder	45,000	24,000	3.0	9.1	0.0	0.0	0.0	0.0	3.0
buckeye, horsechestnut spp.	8,000	8,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cherry plum	2,000	2,000	100.0	100.0	100.0	0.0	0.0	0.0	0.0
chestnut oak	2,000	2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dogwood spp.	2,000	2,000	0.0	100.0	0.0	0.0	0.0	0.0	0.0
eastern cottonwood	3,000	3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
eastern hemlock	5,000	4,000	0.0	29.0	0.0	0.0	0.0	0.0	0.0
eastern redbud	2,000	2,000	0.0	0.0	0.0	0.0	0.0	100.0	0.0
eastern redcedar	4,000	4,000	50.0	50.0	0.0	0.0	0.0	0.0	0.0
eastern white pine	15,000	12,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flowering dogwood	5,000	4,000	0.0	74.0	0.0	0.0	0.0	0.0	0.0
green ash	104,000	62,000	1.9	4.0	0.0	0.0	0.0	0.0	0.0
holly	3,000	3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
honeylocust	8,000	6,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
littleleaf linden	22,000	21,000	15.2	0.0	0.0	0.0	0.0	0.0	0.0
mimosa, silktree	3,000	3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mockernut hickory	12,000	11,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
northern catalpa	2,000	2,000	0.0	0.0	0.0	0.0	0.0	0.0	100.0
northern red oak	14,000	8,000	0.0	14.3	0.0	0.0	0.0	28.6	0.0
northern white-cedar	134,000	112,000	0.0	18.2	1.5	20.0	0.0	0.0	0.0
overcup oak	25,000	24,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
paper mulberry	6,000	6,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
paulownia, empress-tree	2,000	2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pear spp.	5,000	3,000	0.0	25.8	0.0	0.0	0.0	0.0	0.0
pin oak	7,000	4,000	0.0	20.0	0.0	0.0	0.0	40.0	0.0
red maple	38,000	14,000	13.1	0.0	0.0	0.0	5.2	10.5	0.0
red mulberry	1,000	2,000	0.0	100.0	0.0	0.0	0.0	0.0	0.0
river birch	3,000	3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sassafras	25,000	25,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sawtooth oak	4,000	4,000	0.0	0.0	0.0	0.0	0.0	50.0	0.0
scarlet oak	8,000	8,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
silver maple	26,000	10,000	15.9	18.4	0.0	8.0	0.0	0.0	5.3

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Table 27 (continued).

Common name	Number of trees	Standard error	Bark inclusion (percent)	Crown conflict (percent)	Excess mulch (percent)	Improper planting (percent)	Root/stem girdling (percent)	Root conflict (percent)	Topping/pruning (percent)
slippery elm	53,000	49,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sour cherry	2,000	2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sugar maple	36,000	24,000	5.6	3.9	0.0	0.0	3.9	9.5	0.0
swamp chestnut oak	3,000	3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sweet cherry	6,000	4,000	45.2	45.2	0.0	0.0	0.0	0.0	22.6
sweetgum	32,000	27,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tree of heaven	252,000	163,000	2.0	40.1	0.0	0.0	0.0	0.0	0.0
water oak	2,000	2,000	0.0	100.0	0.0	0.0	0.0	0.0	0.0
white ash	31,000	15,000	0.0	10.9	0.0	0.0	0.0	0.0	0.0
white mulberry	53,000	15,000	17.1	27.0	0.0	0.0	0.0	5.3	12.9
white oak	11,000	5,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
willow oak	24,000	23,000	0.0	0.0	100.0	0.0	0.0	0.0	0.0
yellow buckeye	8,000	7,000	27.3	0.0	0.0	0.0	0.0	0.0	0.0
yellow-poplar	42,000	11,000	0.0	9.8	0.0	0.0	0.0	0.0	3.3
yew spp.	17,000	20,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Estimates are rounded.

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 are found on 19 plots in Baltimore. Of the total live and dead tree population, 5.2 percent are estimated to be standing dead trees. The number of standing dead trees by species is shown in Table 28. The species that makes up 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 land, recreation/cemetery, and multi-family residential (Fig. 24). The majority of standing dead trees are observed on unmaintained land in forest land uses.

Table 28.—Number of trees classified as standing dead by species, City of Baltimore, 2020

Common name	Standing dead trees (number)	Standard error (number)	Percent of species
unknown dead hardwood	4,100	2,900	100.0
sassafras	19,000	19,000	42.9
white ash	21,000	14,000	39.6
black locust	16,000	9,700	19.6
white oak	2,100	2,100	16.0
black cherry	8,200	4,800	13.2
northern red oak	2,100	2,100	12.5
Leyland cypress	2,000	1,900	10.3
bitternut hickory	2,100	2,100	9.1
littleleaf linden	1,800	1,800	7.5
white mulberry	3,300	2,400	6.0
red maple	2,100	2,100	5.2
silver maple	1,400	1,600	5.0
American elm	6,200	4,600	4.8
boxelder	2,100	2,100	4.3
sweetgum	1,400	1,600	4.1
green ash	4,100	4,200	3.8
American beech	2,100	2,100	3.5
Norway maple	2,100	2,100	2.7
Callery pear	1,400	1,600	2.4
Total	103,000	30,000	5.2

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

Table 29.—Proportion of the total population of trees that are dead by species, City of Baltimore, 2020

Common name	Standing dead trees (percent)	Common name	Standing dead trees (percent)
white ash	20.0	bitternut hickory	2.0
sassafras	18.0	American beech	2.0
black locust	15.3	white oak	2.0
black cherry	8.0	northern red oak	2.0
American elm	6.0	Leyland cypress	1.9
green ash	4.0	littleleaf linden	1.7
unknown dead hardwood	3.9	silver maple	1.3
white mulberry	3.2	sweetgum	1.3
boxelder	2.0	Callery pear	1.3
red maple	2.0	Total	100.0
Norway maple	2.0		

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

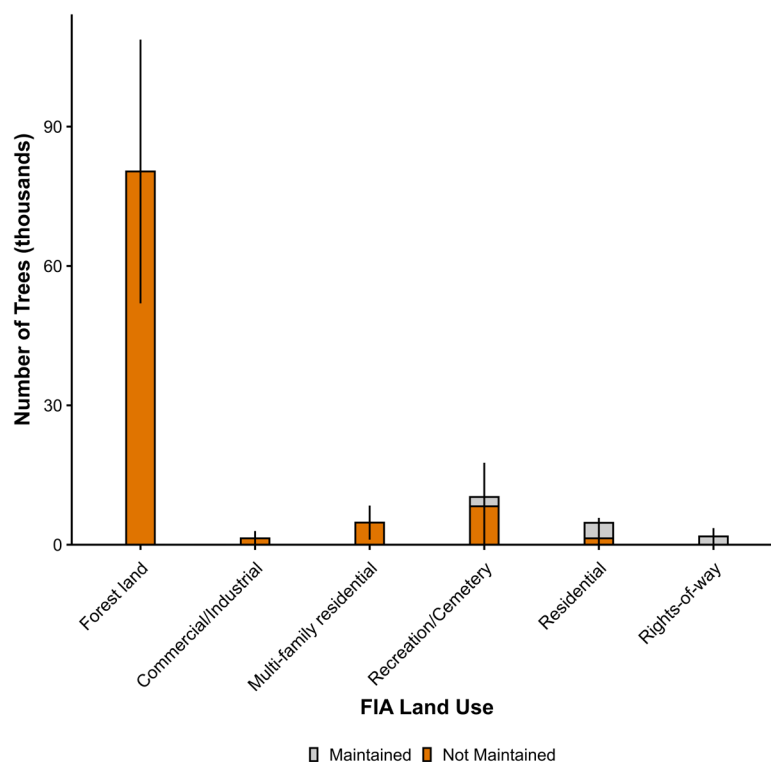


Figure 24.—Proportion of standing dead trees by Forest Inventory and Analysis (FIA) land use classes and maintenance status, City of Baltimore, 2020. Error bars represent 68 percent confidence intervals around the estimated means.

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. These factors may enable them to displace native plants and threaten natural areas (Davis 2009, Simberloff 2013). 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 Baltimore examined each plot for the presence of select invasive species based on the species list shown in Appendix 5 (Table 36). Of the 208 plots examined, invasive species were identified on 32.7 percent (68 plots).

Invasive species found in Baltimore 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, Norway maple (1,136 acres; 1.9 percent of the sampling area), English ivy (*Hedera helix*) (1,027 acres; 1.7 percent of the sampling area), and tree of heaven (972 acres; 1.7 percent of the sampling area) covered the largest 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 Baltimore are classified as trees, data on individual trees were collected in addition to descriptions of species cover on the plot. In Baltimore, invasive tree data were collected for tree of heaven, Norway maple, black locust, and Siberian elm. Taken together, these invasive trees are estimated to account for 21.1 percent of all live trees surveyed (estimated total trees: 394,219), and 14.4 percent of the total leaf area.

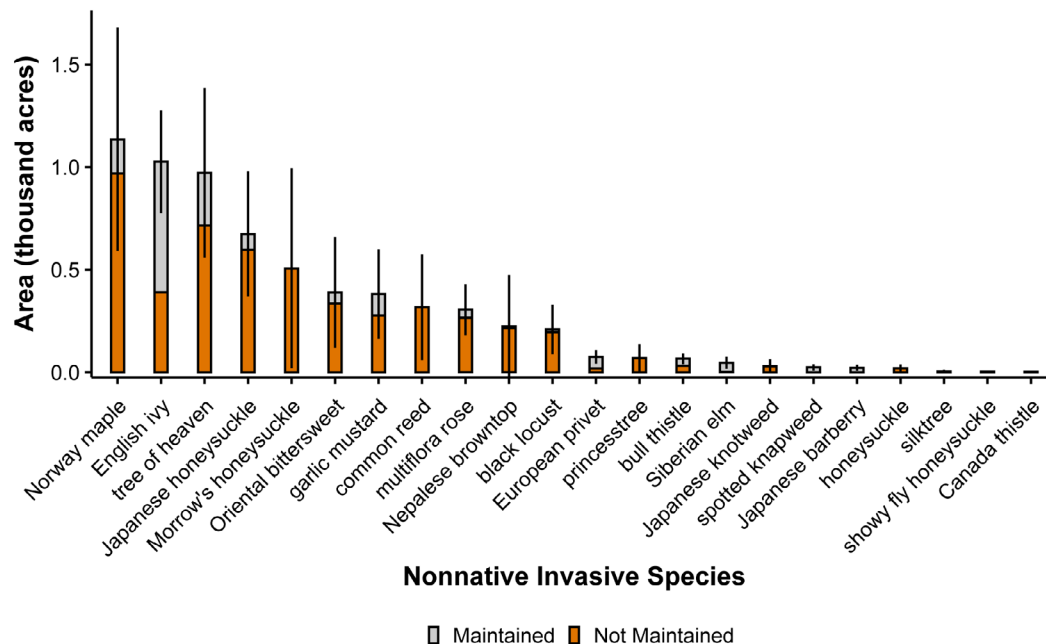


Figure 25.—Acres of non-native invasive species cover by species on maintained and unmaintained land, City of Baltimore, 2020. Error bars represent 68 percent confidence intervals around the estimated means.

Pests and Pathogens

Pathogens and insect pests can affect the health, sustainability, and benefits of urban forests. Identifying pathogens and pests of concern and their potential host-specific impacts allows managers to prioritize specific insects and diseases for monitoring and control measures. We evaluated 52 insects and diseases, along with their tree hosts in Baltimore, to quantify their potential impact on the urban forest (Table 30). The number of trees at risk (Figure 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. 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 2024, USDA Forest Service 2023) were used to determine the proximity of each pest to the area. For Baltimore, proximity was classified for insects and diseases in Baltimore City (county); within 250 miles of the county; between 250 and 750 miles of the county; or greater than 750 miles away. Since there are no pest range maps for Dutch elm disease (*Ophiostoma*

spp.) and chestnut blight (*Cryphonectria parasitica*), the ranges of these pests were based on known occurrence and the known host range, respectively (Nowak 2024). 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 6 (Table 37), each pest that could pose a risk to a tree species is scored as 4 points if it occurs within Baltimore City (county), 3 points if it occurs within 250 miles of Baltimore 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 Baltimore, but are not listed in this matrix, are not known to be hosts to any of the 52 insects and diseases evaluated. Appendix 6 also excludes the pests and diseases that were not a threat to any of the tree species sampled.

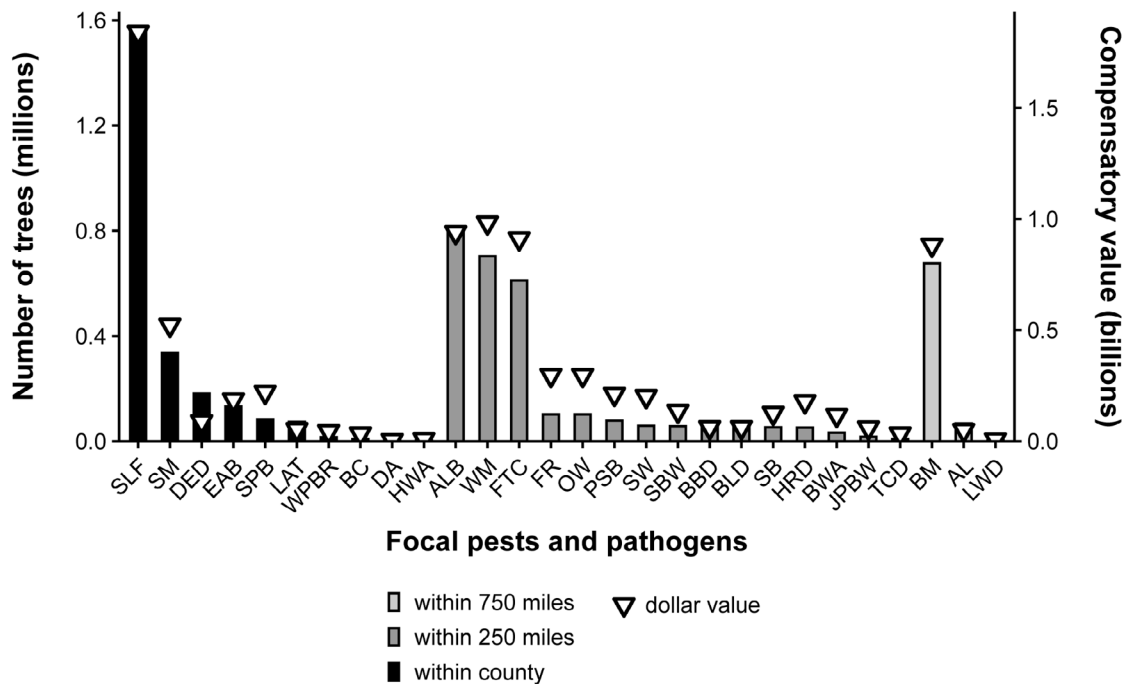


Figure 26.—Number of trees in City of Baltimore at risk due to pests and pathogens and their associated compensatory values. Pest abbreviations are presented in Table 30.

Table 30.—The number of host trees potentially at risk from various insects and diseases, City of Baltimore, 2020

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value (dollars)
within county	SLF	Spotted Lanternfly	<i>Lycorma delicatula</i>	1,554,552	83.4	1,840,110,690
	SM	Spongy Moth	<i>Lymantria dispar</i>	335,965	18.0	522,988,448
	DED	Dutch Elm Disease	<i>Ophiostoma ulmi</i>	181,687	9.7	89,112,970
	EAB	Emerald Ash Borer	<i>Agrilus planipennis</i>	133,682	7.2	186,678,662
	SPB	Southern Pine Beetle	<i>Dendroctonus frontalis</i>	83,409	4.5	221,432,010
	LAT	Large Aspen Tortrix	<i>Choristoneura conflictana</i>	73,700	4.0	53,471,177
	WPBR	White Pine Blister Rust	<i>Cronartium ribicola</i>	15,334	0.8	44,816,877
	BC	Butternut Canker	<i>Ophiognomonia clavignenti-juglandacearum</i>	7,576	0.4	33,934,182
	DA	Dogwood Anthracnose	<i>Discula destructiva</i>	7,359	0.4	4,582,535
within 250 miles	HWA	Hemlock Woolly Adelgid	<i>Adelges tsugae</i>	4,760	0.3	9,152,334
	ALB	Asian Longhorned Beetle	<i>Anoplophora glabripennis</i>	793,233	42.5	939,571,569
	WM	Winter Moth	<i>Operophtera brumata</i>	703,875	37.8	983,025,670
	FTC	Forest Tent Caterpillar	<i>Malacosoma disstria</i>	611,857	32.8	911,702,652
	FR	Fusiform Rust	<i>Cronartium quercuum</i> f. sp. <i>fusiforme</i>	102,259	5.5	297,298,924
	OW	Oak Wilt	<i>Bretziella fagacearum</i> (formerly <i>Ceratocystis fagacearum</i>)	102,259	5.5	297,298,924
	PSB	Pine Shoot Beetle	<i>Tomicus piniperda</i>	78,649	4.2	212,279,676
	SW	Sirex Wood Wasp	<i>Sirex noctilio</i>	58,682	3.1	202,478,591

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Table 30 (continued).

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value (dollars)
within 250 miles (cont.)	SBW	Spruce Budworm	<i>Choristoneura freemani</i>	57,544	3.1	136,188,104
	BBD	Beech Bark Disease	<i>Cryptococcus fagisuga/Neonectria</i> spp. complex	57,438	3.1	62,471,412
	BLD	Beech Leaf Disease	<i>Litylenchus crenatae</i> ssp. <i>mccannii</i>	57,438	3.1	62,471,412
	SB	Spruce Beetle	<i>Dendroctonus rufipennis</i>	52,784	2.8	127,035,770
	HRD	Heterobasidion Root Disease	<i>Heterobasidion annosum</i>	52,070	2.8	178,646,715
	BWA	Balsam Woolly Adelgid	<i>Adelges piceae</i>	32,817	1.8	117,234,684
	JPBW	Jack Pine Budworm	<i>Choristoneura pinus</i>	17,336	0.9	61,090,395
within 750 miles	TCD	Thousand Canker Disease	<i>Geosmithia morbida</i>	7,576	0.4	33,934,182
	BM	Browntail Moth	<i>Euproctis chrysorrhoea</i>	676,532	36.3	883,328,376
	AL	Aspen Leafminer	<i>Phyllocnistis populiella</i>	68,186	3.7	50,050,614
	LWD	Laurel Wilt	<i>Raffaelea lauricola</i>	24,734	1.3	7,997,388
	PSHB	Polyphagous Shot Hole Borer	<i>Euwallacea fornicatus</i>	761,473	40.8	1,015,206,400
	MOB	Mediterranean Oak Borer	<i>Xyleborus monographus</i>	370,581	19.9	706,835,091
	POCRD	Port-Orford-Cedar Root Disease	<i>Phytophthora lateralis</i>	134,392	7.2	25,394,489
farther than 750 miles	WSB	Western Spruce Budworm	<i>Choristoneura occidentalis</i>	54,787	2.9	143,309,288
	WBBU	Western Blackheaded Budworm	<i>Acleris gloverana</i>	52,784	2.8	127,035,770
	MPB	Mountain Pine Beetle	<i>Dendroctonus ponderosae</i>	34,819	1.9	133,508,203
	SOD	Sudden Oak Death	<i>Phytophthora ramorum</i>	22,700	1.2	111,807,338

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Table 30 (continued).

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value (dollars)
within county	ARD	Armillaria Root Disease	<i>Armillaria</i> spp.	0	NA	NA
	CB	Chestnut Blight	<i>Cryphonectria parasitica</i>	0	NA	NA
within 250 miles	RPS	Red Pine Scale	<i>Matsucoccus matsumarae</i>	0	NA	NA
within 750 miles	BOB	Bur Oak Blight	<i>Tubakia iowensis</i>	0	NA	NA
farther than 750 miles	ARCA	Aspen Running Canker	<i>Neodothiora populina</i>	0	NA	NA
	BSRD	Black Stain Root Disease	<i>Leptographium wagneri</i>	0	NA	NA
	DFB	Douglas-Fir Beetle	<i>Dendroctonus pseudotsugae</i>	0	NA	NA
	DBSR	Douglas-fir Black Stain Root Disease	<i>Leptographium wagneri</i> var. <i>pseudotsugae</i>	0	NA	NA
	FE	Fir Engraver	<i>Scolytus ventralis</i>	0	NA	NA
	GSOB	Goldspotted Oak Borer	<i>Agrilus auroguttatus</i>	0	NA	NA
	HS	Hemlock Sawfly	<i>Neodiprion tsugae</i>	0	NA	NA
	JPB	Jeffrey Pine Beetle	<i>Dendroctonus jeffreyi</i>	0	NA	NA
	NSE	Northern Spruce Engraver	<i>Ips perturbatus</i>	0	NA	NA
	PBSR	Pine Black Stain Root Disease	<i>Leptographium wagneri</i>	0	NA	NA
	SFM	Subalpine Fir Mortality	NA – multiple pests	0	NA	NA
	WFNPM	Western Five-Needle Pine Mortality	NA – multiple pests	0	NA	NA
	WPB	Western Pine Beetle	<i>Dendroctonus brevicornis</i>	0	NA	NA

Estimates are rounded.

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MANAGEMENT IMPLICATIONS



A residential yard tree covered in invasive vines. USDA Forest Service photo by Nancy Sonti.

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. Associated results from the UNLS provide data on private landownership, including landowner activities, practices, and objectives. These comparisons will allow managers to assess mortality and growth rates, as well as monitor changes in species composition, the distribution of size classes, and the benefits associated with the urban forest. Effective long-term monitoring allows for the formulation of data-driven management strategies to optimize the benefits of Baltimore's urban forest while minimizing maintenance costs. This inventory is complementary to other monitoring efforts being conducted by the City's Forestry Division, particularly on publicly-owned parkland and in the public right-of-way.



For example, Baltimore completed a full street tree inventory in 2018 that is publicly available and has provided insight into citywide patterns of tree diversity, condition, and stocking (Baltimore City DRP 2007; Fleming et al., in press). In addition, other inventories are designed to capture specific subsets of Baltimore's urban forest such as forest patches (e.g., Baker et al. 2025). Analysis of these inventories over time can provide insight into the effectiveness of tree planting and preservation policies.

Urban FIA data supports the objectives of the Forestry Division's Natural Areas Group to conduct data-driven, equitable, conservation planning. Between 2019 and 2023, the Forestry Division actively managed 243 acres of forested natural areas to inhibit the spread and establishment of non-native invasive vegetation, while protecting and returning native plant stock to the landscape. The Forestry Division aims to enroll an annual average of 70 acres of forested natural areas on public parkland into active restoration, in order to conserve the estimated 945 acres of top priority stands by 2035. By mid-2024, 75 percent of the key natural areas on public parkland will have associated ecological inventories and assessments, to further inform future management. Urban FIA data and remeasurements will complement these monitoring efforts and the ultimate goals of maximizing ecological function and habitat value for community health and well-being.

Baltimore's residents face impacts of climate change and economic decline. While trees may not solve these issues, a healthy urban forest can mitigate the urban heat island and help absorb stormwater from increasingly extreme flooding events. TreeBaltimore and partners like Baltimore Tree Trust and Blue Water Baltimore have worked for over a decade to increase tree canopy throughout the city, even as many cities are seeing a decline in urban tree canopy cover (Nowak and Greenfield 2012, USDA Forest Service 2023). Identifying priority areas for the enhancement or maintenance of tree growth, survival, and cover may assist Baltimore City in managing the benefits of urban forests. Tree density and its benefits are highly variable among NLCD land cover classes in Baltimore, with density ranging from only 0 and 6 trees per acre in water and developed-high land covers, respectively, to 195 trees per acre in the forest/shrub land cover class (Table 9). Similarly, there are differences in tree species composition across land uses. Tree of heaven, northern white-cedar, and American holly are the most abundant species on residential land, while green ash, tree of heaven, and American elm are most common on forest land (Table 34 of 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, Baltimore City 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.

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 within and among cities (Nowak 2012). The majority of trees that make up Baltimore's urban forest are the result of natural recruitment, and UFIA estimates suggest that 28.0 percent of trees in the city are planted rather than naturally occurring. Planted trees may be native or introduced; the northern white-cedar is native to parts of Maryland and is the most common tree in Baltimore's inventory recorded as planted rather than naturally occurring. Northern white-cedar (or *arborvitae*) is not native to the Baltimore region specifically, but cultivars of northern white-cedar, other *Thuja* species, and closely related genera are widely planted in the landscape, often for screening purposes. The highest percentages of planted trees are found in rights-of-way and commercial/industrial land uses (92 and 66 percent, respectively), whereas no inventoried forest trees are planted. Baltimore City's Urban Forestry Division 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 (*Agrilus planipennis*) and Dutch elm disease.

Baltimore, Maryland had a tree canopy cover of 28.7 percent at the time of the inventory (assessed using remotely sensed imagery and LiDAR data from 2015) with a goal to increase canopy cover to 40 percent by 2037 (City of Baltimore 2019). As part of the City's commitment to care for the natural world, they strive to foster the connection between people and nature while strengthening communities (City of Baltimore 2019). The Baltimore Sustainability Plan includes tree planting as part of neighborhood improvement, as it is an important element of neighborhood beautification and provides other benefits such as addressing noise pollution. As part of their efforts to expand, preserve and improve the urban forest, TreeBaltimore and partner organizations strive to increase urban tree canopy across public and private lands, and prioritizes tree plantings in neighborhoods with the fewest trees, helping to address critical public health issues (City of Baltimore 2019). Action items include expanding tree pits, increasing tree diversity, and engaging more residents and local organizations in tree planting, particularly in neighborhoods with the fewest trees.

Meeting Baltimore'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 majority of Baltimore's trees occur on residential and other private lands (Table 7). Based on the Urban National Landowner Survey (UNLS) it is estimated that about 25 percent of owners removed trees in the past 5 years, and only about 25 percent of those replaced them (Locke et al. 2025). About 19 percent of all residential owners are estimated to have planted trees in the last 5 years (Locke et al. 2025). Finally, residential owners remain largely unaware of programs that reduce the costs associated with planting new trees or caring for existing trees (73 percent not at all aware), and only about 6 percent of owners have used local programs that provide free trees in the previous 5 years (Locke et al. 2025).

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 Baltimore Tree Trust and Blue Water Baltimore, 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. About half of Baltimore's residential landowners agree or strongly agree that they are physically able to plant new trees, about 54 percent agree or strongly agree that they know who to ask for help with planting, and about 58 percent agree or strongly agree that their communities should invest more in tree planting (Locke et al. 2025).

Urban FIA can support Baltimore'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.

According to a recent analysis from the Chesapeake Bay Program, Baltimore City achieved a net gain of 81 acres of tree cover on developed and developing lands between 2013 and 2018 (USDA Forest Service 2023). Baltimore City is one of only 26 out of the 207 jurisdictions in the Chesapeake Bay watershed that reported a net increase in tree canopy during that time period (Bouffard 2023). About 65 percent of Baltimore City's gain in tree canopy occurred over impervious surfaces, suggesting that tree planting efforts alongside streets and sidewalks have been very effective in increasing overall canopy cover in the city. These plantings can provide shade and cooling, improve air quality, and reduce the extent to which heated runoff is entering waterways. As an umbrella organization for many local community groups involved with planting and maintaining tree canopy in the city, TreeBaltimore helps target these street tree planting efforts to the neighborhoods that need

trees the most. Although Baltimore City had a net gain of tree canopy cover during the time period of the Chesapeake Bay Program analysis, there was a loss of 139 acres of tree cover. This loss is likely due to a combination of development and a gradual decline in the health of mature trees, particularly oaks. Repeated inventories may help provide insight about the nature of canopy loss across different land uses and ownerships over time. However, there has been recent progress towards stronger forest and tree protection laws in Baltimore. For example, a recent ordinance amending Forest and Tree Conservation provisions of Baltimore City Code now requires review of any disturbance of 5,000 square feet of forest and compliance with an approved Forest Conservation Plan (City of Baltimore 2020). Such efforts contribute to conservation of existing trees and forest patches. In addition, an administrative bill has been approved by the Health, Environment, and Technology committee for the Council's consideration (City of Baltimore 2023). Upon passage, the law would require approval for any tree removal on land owned by Baltimore City Department of Recreation & Parks, as well as mitigation for any approved removals. By codifying this policy, Baltimore City will strengthen the agency's ability to protect and reforest these public green spaces.

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). 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 (Liebhold 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 economic impacts of invasive wood borers such as the emerald ash borer caused over \$11 billion 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 Baltimore inventory, likely reflecting years of emerald ash borer infestation (Wheeler 2015). Since 2015, Baltimore City's Forestry Division has been treating over 350 specimen ash trees with insecticide injections throughout the city's parks and public rights-of-way. In 2018, it was estimated that 13 percent of all trees over 10 feet tall in the city's largest forested park (Gwynns Falls/Leakin Park) were white or green ash (City of Baltimore 2017). Dutch elm disease is another common pathogen that

occurs throughout Baltimore and is managed by the City's Forestry Division. In 2018, it was estimated that 10 percent of trees in Gwynns Falls/Leakin Park over 10 feet tall were American elms. While no fungicide treatments are active, the Forestry Division will expedite removals of elms with advanced symptoms of Dutch elm disease, refrain from pruning elms during the growing season, and is planting disease-resistant or tolerant elm cultivars. About 8 percent of Baltimore residential landowners mitigate the risks to trees by treating trees for pests and diseases (Locke et al. 2025).

The greatest threats to Baltimore's urban forest posed by pests and pathogens include spotted lanternfly (SLF; *Lycorma delicatula*), Asian longhorned beetle (ALB; *Anoplophora glabripennis*), winter moth (WM; *Operophtera brumata*), and polyphagous shot hole borer (PSHB; *Euwallacea fornicates*) (Fig. 26, Table 30). Asian longhorned beetle poses a threat to a significant proportion of trees in Baltimore given that its hosts include two of the most commonly occurring genera in Baltimore, *Acer* (maple) and *Ulmus* (elm), which account for approximately 24 percent of the trees in the urban forest (Appendix 2). 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).

A recently introduced invasive species, spotted lanternfly, is identified as having the greatest compensatory impact (Fig. 26, Table 30), due to its large range of hosts 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. However, the impacts of spotted lanternfly on urban tree and forest health does not appear to be significant (Hoover et al. 2023), and at this point it is only considered an urban nuisance pest in Baltimore.

American beech is a common tree in Baltimore and is threatened by two different disease complexes: beech bark disease and beech leaf disease. Beech leaf disease, caused by the nematode *Litylenchus crenatae* ssp. *mccannii*, is an emerging disease in the Northeast and symptoms include dark banding in between leaf veins and abnormal leaf texture and shape, while impacts contribute to widespread tree mortality (Ewing et al. 2019). Beech bark disease 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). Baltimore's forest species composition may be dramatically altered in the future if these diseases cause American beech to disappear from the city's forested landscape.

There are some pest species not yet included in the Urban FIA analysis that are being closely watched by Baltimore City's Forestry Division. For example, elm zigzag sawfly (*Aproceros leucopoda*) is a non-native insect that originated in eastern Asia and is now invasive in Europe and North America. The elm zigzag sawfly has been found in Maryland and surrounding states and significant defoliation of elm host plants has been seen in some locations. Caterpillars of the elm zigzag sawfly feed on slippery elm, winged elm (*Ulmus alata*), American elm, Siberian elm, English elm (*U. minor* 'Atinia'), lacebark elm (*U. parvifolia*), and hybrid elms (*U. spp.*). Entire leaves can be completely defoliated, and heavily infested trees can suffer partial or complete defoliation. The impact of this new invasive insect in the United States is not currently fully understood (Simisky and Keleher 2023). Vascular wilt (*Verticillium spp.*) is another issue of growing concern, as it is impacting regional nursery stock and affecting the supply of *Acer* (maple), *Cersis* (redbud), and *Cornus* (dogwood) species to urban areas including Baltimore (Virginia Cooperative Extension 2023).

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. Baltimore is highly vulnerable to coastal storms, flooding, extreme heat, high winds, and winter storms (City of Baltimore 2019). Combined with a projected rise in sea level, these hazards will continue to cause damage to the city's urban forest. Baltimore also experiences the "urban heat island" effect, described by the 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 Baltimore 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 Baltimore City 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., Baltimore Sustainability Plan, Baltimore Green Network Plan, Climate Action Plan). 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 Baltimore's urban forest (Table 16), which means that it contributes significantly to cooling the city

and also prevents the greatest amount of stormwater runoff (Fig. 15). The species with the next highest value for both leaf area and avoided runoff is white ash, a species that has rapidly declined due to the invasive emerald ash borer. In order to maintain important ecosystem services, ash trees will need to be replaced with comparable tree canopy.

Climate impacts are not distributed equally across Baltimore. Recent analysis has shown that areas targeted for systematic disinvestment in the past have higher temperatures today (Wilson 2020). The city's Urban FIA data summarized by urban heat island class can be found on the My City's Trees application, and shows that Baltimore's hottest neighborhoods have the fewest trees per person. 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 the City's Climate Action Plan, Baltimore's urban forest also has an important role to play in counteracting climate change via carbon sequestration (City of Baltimore 2012). Sixty-eight percent of carbon stored by the city's trees is found on forest land and residential land combined (Table 23). By species, yellow-poplar contributes most to carbon storage, followed by white oak and white ash (Fig. 17). These same species also contain the largest net board-foot sawtimber volume (Table 18). Baltimore's Forestry Division has noted a recent increase in reports of rapid decline of white oak trees throughout the mid-Atlantic region. This trend, along with the loss of white ash trees to emerald ash borer would have significant implications for climate mitigation, in addition to other ecosystem services. However, the Baltimore's innovative Camp Small project is helping to address this issue. Camp Small repurposes City wood waste from fallen trees by diverting it from landfills and incineration while reducing expenses and creating jobs through the production of locally-sourced wood products (City of Baltimore 2019).

An analysis of the climate change vulnerability of Baltimore's tree species reveals that most of the top species recorded in the Urban FIA inventory have "good" capability to cope or persist with climate change based on predicted changes in suitable habitat, species adaptability, and abundance within the region (NIACS 2021). However, black locust, slippery elm, and American beech have only "fair" capability to cope or persist with climate change and make up a significant portion of Baltimore's urban forest (3.5 percent, 3 percent, and 3 percent respectively). Urban forest managers may want to think about transitioning sites dominated by these species to more climate-adapted species that will continue to provide critical ecosystem services into the future.

Native, Introduced, and Invasive species in Baltimore

The majority of Baltimore's trees are native to the area. Thirteen of the top twenty live tree species recorded by Urban FIA crews in the city are native to Baltimore and surrounding counties, while the remaining seven are introduced species. Tree of heaven, northern white-cedar, and Norway maple represent 13.5, 7.2, and 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 33 of Appendix 3).

Norway maple makes up a greater proportion of trees found on public land than on private land, while tree of heaven is more prevalent in the population of trees on private land, and northern white-cedar was only found on privately owned land in Baltimore (Tables 13 and 14). Tree of heaven and Norway maple are included in the Northern Research Station FIA's invasive species list, as well as Siberian elm, black locust, silktree, and paulownia. However, the Baltimore City Forestry Division does not consider black locust to be invasive, and does consider Amur corktree, Amur maple, Callery pear, Japanese maple, paper mulberry, paulownia, sawtooth oak, and white mulberry to be invasive tree species. Baltimore's Urban Forestry Division encourages removal of invasive tree species through its Weed Warriors program, where local environmental stewards are trained in non-native invasive plant management for enhancing native ecosystems. The City also has a goal to actively manage 75 percent of forests and trees by 2030, which would help address the spread of invasive trees and other vegetation (City of Baltimore 2019). Callery pear was found to be one of the most common species in Baltimore's maintained areas, due in part to misguided overplanting of this species for many decades before it was recognized to be invasive. It is important to note that most introduced species tallied in Baltimore's inventory are not invasive. These may be ornamental species planted on developed land (e.g., cherry plum) or species known to thrive as street trees in difficult planting conditions (e.g., Japanese zelkova). Major cities such as Baltimore can also be home to unusual trees found in gardens and arboreta (e.g., Scots pine). The prevalence of both native and non-native early successional species found in Baltimore's inventory (e.g., tree of heaven, black cherry, slippery elm, black locust, white mulberry) may reflect the large amount of vacant and undeveloped land in Baltimore (Locke et al. 2023), which can occur across different land ownerships and uses.

Native species recorded in Baltimore's inventory with the greatest number of stems include American elm, green ash, black locust, and American holly, which represent 6.5, 5.5, 3.5, and 3.1 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, species like American elm and red maple are prevalent

in both forest/scrub and developed land uses. In contrast, sassafras and hickory species are typically found in the forest and not frequently planted. Baltimore City recognizes the importance of native species in providing a diverse, resilient urban forest by aiming to plant native tree species on sites outside the public right-of-way and by highlighting native tree species on the approved street tree species list, requiring that large planting areas be composed of at least half native trees (City of Baltimore 2018). Maryland's Tree Solutions Now Act of 2021 recently mandated the planting of five million native trees across the state by 2031, with 500,000 of those trees planted in underserved urban areas, which includes many Baltimore neighborhoods (Maryland DNR 2023). Efforts like this are sure to change the species composition of Baltimore's urban forest and the balance of native versus introduced trees for decades to come.

Baltimore also contains a large amount of forest land managed by the city's Department of Recreation & Parks as well as numerous public and private landowners across thousands of individual property parcels (Bowers et al. 2020; Sonti et al., 2025). These forested natural areas serve as important cultural and ecological resources supporting biodiversity and critical ecosystem services throughout the city. Nearly 100 species of birds have been spotted in and near Baltimore's waterways, as well as in the city's forested areas (City of Baltimore 2019). Native tree species from the *Quercus* (oak), *Prunus* (cherry), and *Ilex* (holly) genera are important food sources for local wildlife across public and private lands (Fig. 9). The City's 2019 Sustainability Plan identifies strategies and actions for increasing "restoration, creation, and maintenance of habitat for native species on public and private land; [ensuring] it is done in culturally competent ways with early and frequent engagement" (City of Baltimore 2019). This includes the goal of completing Forest Management Plans for the largest forested parks, with an emphasis on choosing a diversity of trees, plants, and shrubs that support pollinators and wildlife through the seasons.

Baltimore's efforts to conserve habitat also include removal of invasive plant species across the city's forested natural areas. In addition to the invasive tree species described above, English ivy, honeysuckle species, and Oriental bittersweet are some of the most prevalent invasive plant species recorded in the inventory (Fig. 25). English ivy is found across maintained and unmaintained urban areas and often escapes from landscaped sites to threaten forest canopy health and prevent regeneration in the understory, while the other top invaders are more often found in unmaintained areas of the city. Tracking the spread of these species will be important in limiting their impacts on natural ecosystems throughout Baltimore.

CONCLUSIONS



A residential neighborhood with healthy street trees. USDA Forest Service photo by Nancy Sonti.

Baltimore's urban forest contributes to the city's environmental, economic, and societal well-being. Throughout the city, an estimated 1.9 million trees, representing 81 species, provide tree canopy cover and associated ecosystem services to Baltimore 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 2037 (City of Baltimore 2019). 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, Troy et al. 2012).



There are several forces that may impact Baltimore's 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 continued urban development.

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 Baltimore will be re-measured 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 and ecosystem services for future generations. In the future, change analyses can be used to evaluate the success of Baltimore's urban forest management programs.

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GLOSSARY OF TERMS

Board-foot: A unit of measure indication the amount of wood contained in an unfinished board 1.0 foot wide, 1.0 foot long, and 1.0 inch thick.

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 total diameter for the tree. Woodland diameters are measured at the ground line or at the stem(s) root collar (d.r.c.), whichever is higher. Timber species are listed in Appendix 2 (USDA Forest Service 2017). There were no woodland species measured in Baltimore during the 2020 inventory.

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 a 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 forest 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 non-native 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 invasive plant species used in this inventory protocol is presented in Appendix 5 (Table 36).

Rights-of-way: Developed lands including improved and/or maintained roads, railways, power or gas line clearings, and maintained canals (USDA Forest Service 2017).

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, 2017).

Sawtimber: A live tree of commercial species containing at least a 12-foot sawlog or two noncontiguous sawlogs 8.0 feet or longer and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d.b.h. Hardwoods must be at least 11.0 inches d.b.h. (USDA Forest Service 2016b).

Sawtimber volume: Net volume of the sawlog portion of live sawtimber in board feet, International 1/4-inch Rule (unless specified otherwise), from stump to a minimum 7.0 inches top diameter outside bark for softwoods and a minimum 9.0 inches top diameter outside bark for hardwoods (USDA Forest Service 2016b).

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 FIA-designated forest land that is dominated by woodland species (Dooley 2019).

Woodland Species: FIA 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 2017). This difference in typical form induce 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 class descriptions

NLCD land cover class	NLCD code	NLCD land cover description
Open water	11	Areas of open water generally with less than 25 percent of vegetation or soil.
Perennial ice/snow	12	Areas characterized by a perennial cover of ice and/or snow, generally greater than 25 percent of total cover.
Developed-open space	21	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed-low intensity	22	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 percent to 49 percent of total cover. These areas most commonly include single-family housing units.
Developed-medium intensity	23	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 percent to 79 percent of the total cover. These areas most commonly include single-family housing units.
Developed-high intensity	24	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 percent to 100 percent of the total cover.
Barren land (rock/sand/clay)	31	Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.
Deciduous forest	41	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen forest	42	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed forest	43	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

continued on next page

Table 31 (continued).

NLCD land cover class	NLCD code	NLCD land cover description
Dwarf scrub	51	Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20 percent of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
Shrub/Scrub	52	Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Grassland/Herbaceous	71	Areas dominated by graminoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Sedge/Herbaceous	72	Alaska only areas dominated by sedges and forbs, generally greater than 80 percent of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
Lichens	73	Alaska only areas dominated by fruticose or foliose lichens generally greater than 80 percent of total vegetation.
Moss	74	Alaska only areas dominated by mosses, generally greater than 80 percent of total vegetation.
Pasture/Hay	81	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Cultivated crops	82	Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Woody wetlands	90	Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent herbaceous wetlands	95	Areas where perennial herbaceous vegetation accounts for greater than 80% 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, City of Baltimore, 2020

Genus	Species	Common name	1–4.9 in. diameter trees (number)	5–10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (in.)
<i>Acer</i>	<i>ginnala</i>	Amur maple	0	6,900	0	6,900	0.4	7,800	5.9
<i>Acer</i>	<i>negundo</i>	boxelder	17,000	18,000	10,000	45,000	2.4	24,000	8.0
<i>Acer</i>	<i>palmatum</i>	Japanese maple	17,000	14,000	0	31,000	1.7	21,000	5.2
<i>Acer</i>	<i>platanooides</i>	Norway maple	0	57,000	17,000	74,000	4.0	34,000	8.5
<i>Acer</i>	<i>rubrum</i>	red maple	0	24,000	14,000	38,000	2.0	14,000	11.4
<i>Acer</i>	<i>saccharinum</i>	silver maple	0	6,900	19,000	26,000	1.4	10,000	19.6
<i>Acer</i>	<i>saccharum</i>	sugar maple	17,000	3,600	15,000	36,000	1.9	24,000	10.0
<i>Acer</i>	<i>x freemanii</i>	Freeman maple	0	0	4,000	4,000	0.2	3,800	22.4
<i>Aesculus</i>	<i>flava</i>	yellow buckeye	0	5,500	2,100	7,600	0.4	6,500	7.2
<i>Aesculus</i>	spp.	buckeye, horsechestnut spp.	0	8,200	0	8,200	0.4	8,500	9.0
<i>Ailanthus</i>	<i>altissima</i>	tree of heaven ^a	179,000	38,000	35,000	252,000	13.5	163,000	4.8
<i>Albizia</i>	<i>julibrissin</i>	mimosa, silk tree	0	2,800	0	2,800	0.1	3,100	5.3
<i>Betula</i>	<i>nigra</i>	river birch	0	2,800	0	2,800	0.1	3,100	5.4
<i>Broussonetia</i>	<i>papyrifera</i>	paper mulberry	0	5,900	0	5,900	0.3	5,600	6.1
<i>Carya</i>	<i>alba</i>	mockernut hickory	0	8,200	4,100	12,000	0.7	11,000	9.5
<i>Carya</i>	<i>cordiformis</i>	bitternut hickory	0	12,000	8,200	21,000	1.1	19,000	9.6
<i>Catalpa</i>	<i>speciosa</i>	northern catalpa	0	2,000	0	2,000	0.1	1,900	6.1
<i>Cedrus</i>	<i>atlantica</i>	Atlas cedar	0	0	2,000	2,000	0.1	1,900	11.3
<i>Cercis</i>	<i>canadensis</i>	eastern redbud	0	0	2,000	2,000	0.1	1,900	12.3
<i>Cornus</i>	<i>florida</i>	flowering dogwood	0	5,300	0	5,300	0.3	4,100	5.4
<i>Cornus</i>	spp.	dogwood spp.	0	2,100	0	2,100	0.1	2,100	8.6
<i>Cryptomeria</i>	<i>japonica</i>	Japanese cedar	0	0	4,000	4,000	0.2	3,800	17.6
<i>Cupressocyparis</i>	<i>leylandii</i>	Leyland cypress	0	2,000	15,000	17,000	0.9	15,000	13.5
<i>Fagus</i>	<i>grandifolia</i>	American beech	26,000	10,000	19,000	56,000	3.0	35,000	8.9
<i>Fagus</i>	<i>sylvatica</i>	European beech	0	1,400	0	1,400	0.1	1,600	7.9
<i>Fraxinus</i>	<i>americana</i>	white ash	0	6,100	25,000	31,000	1.7	15,000	20.2
<i>Fraxinus</i>	<i>pennsylvanica</i>	green ash	70,000	17,000	17,000	104,000	5.6	62,000	5.3
<i>Gleditsia</i>	<i>triacanthos</i>	honeylocust	0	3,900	4,000	7,900	0.4	6,000	10.6
<i>Ilex</i>	<i>opaca</i>	American holly	25,000	28,000	5,300	58,000	3.1	35,000	6.1

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Table 32 (continued).

Genus	Species	Common name	1–4.9 in. diameter trees (number)	5–10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (in.)
<i>Ilex</i>	spp.	holly	0	2,800	0	2,800	0.1	3,100	5.3
<i>Juglans</i>	<i>nigra</i>	black walnut	0	3,400	4,100	7,600	0.4	4,300	16.4
<i>Juniperus</i>	<i>virginiana</i>	eastern redcedar	0	0	3,900	3,900	0.2	3,700	16.9
<i>Liquidambar</i>	<i>styraciflua</i>	sweetgum	26,000	3,300	2,100	32,000	1.7	27,000	2.8
<i>Liriodendron</i>	<i>tulipifera</i>	yellow-poplar	0	7,600	34,000	42,000	2.2	11,000	22.4
<i>Malus</i>	spp.	apple spp.	0	0	2,800	2,800	0.1	3,100	14.0
<i>Morus</i>	<i>alba</i>	white mulberry	0	27,000	26,000	53,000	2.8	15,000	14.0
<i>Morus</i>	<i>rubra</i>	red mulberry	0	1,400	0	1,400	0.1	1,600	9.1
<i>Nyssa</i>	<i>sylvatica</i>	blackgum	0	4,100	0	4,100	0.2	2,900	8.2
<i>Paulownia</i>	<i>tomentosa</i>	paulownia, empress-tree	0	2,000	0	2,000	0.1	1,900	5.0
<i>Phellodendron</i>	<i>amurense</i>	Amur corktree	26,000	6,200	4,100	37,000	2.0	38,000	3.9
<i>Picea</i>	<i>abies</i>	Norway spruce	0	8,200	25,000	33,000	1.8	22,000	13.8
<i>Picea</i>	<i>pungens</i>	blue spruce	17,000	1,400	1,400	20,000	1.1	20,000	5.5
<i>Pinus</i>	<i>nigra</i>	Austrian pine	0	1,800	6,700	8,500	0.5	7,300	13.1
<i>Pinus</i>	<i>strobus</i>	eastern white pine	0	3,600	12,000	15,000	0.8	12,000	14.8
<i>Pinus</i>	<i>sylvestris</i>	Scotch pine	0	0	2,000	2,000	0.1	1,900	26.3
<i>Platanus</i>	<i>hybrida</i>	London planetree	0	9,600	2,000	12,000	0.6	7,000	8.7
<i>Platanus</i>	<i>occidentalis</i>	American sycamore	0	10,000	5,500	16,000	0.8	16,000	9.7
<i>Populus</i>	<i>deltoides</i>	eastern cottonwood	0	1,400	1,400	2,800	0.1	3,100	13.1
<i>Prunus</i>	<i>avium</i>	sweet cherry	0	6,100	0	6,100	0.3	3,900	7.0
<i>Prunus</i>	<i>cerasifera</i>	cherry plum	0	2,000	0	2,000	0.1	1,900	10.6
<i>Prunus</i>	<i>cerasus</i>	sour cherry	0	0	2,000	2,000	0.1	1,900	11.1
<i>Prunus</i>	<i>serotina</i>	black cherry	17,000	22,000	15,000	54,000	2.9	23,000	7.6
<i>Pyrus</i>	<i>calleryana</i>	Callery pear	39,000	11,000	5,300	55,000	3.0	31,000	4.9
<i>Pyrus</i>	spp.	pear spp.	0	3,300	2,000	5,300	0.3	3,100	9.6
<i>Quercus</i>	<i>acutissima</i>	sawtooth oak	0	0	3,600	3,600	0.2	3,600	14.4
<i>Quercus</i>	<i>alba</i>	white oak	0	2,100	8,700	11,000	0.6	5,000	28.7
<i>Quercus</i>	<i>coccinea</i>	scarlet oak	0	4,100	4,100	8,200	0.4	8,500	12.7
<i>Quercus</i>	<i>lyrata</i>	overcup oak	25,000	0	0	25,000	1.3	24,000	3.2

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Table 32 (continued).

Genus	Species	Common name	1–4.9 in. diameter trees (number)	5–10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (in.)
<i>Quercus</i>	<i>michauxii</i>	swamp chestnut oak	0	0	2,800	2,800	0.1	3,100	21.8
<i>Quercus</i>	<i>nigra</i>	water oak	0	0	2,000	2,000	0.1	1,900	25.9
<i>Quercus</i>	<i>palustris</i>	pin oak	0	0	6,900	6,900	0.4	4,000	28.6
<i>Quercus</i>	<i>phellos</i>	willow oak	24,000	0	0	24,000	1.3	23,000	3.4
<i>Quercus</i>	<i>prinus</i>	chestnut oak	0	0	2,100	2,100	0.1	2,100	15.5
<i>Quercus</i>	<i>rubra</i>	northern red oak	0	6,200	8,200	14,000	0.8	8,000	14.9
<i>Quercus</i>	<i>velutina</i>	black oak	0	1,400	1,400	2,800	0.1	2,200	23.6
<i>Robinia</i>	<i>pseudocacia</i>	black locust ^a	26,000	25,000	13,000	65,000	3.5	32,000	7.5
<i>Salix</i>	<i>nigra</i>	black willow	0	0	4,100	4,100	0.2	4,200	13.2
<i>Sassafras</i>	<i>albidum</i>	sassafras	0	25,000	0	25,000	1.3	25,000	7.8
<i>Styphnolobium</i>	<i>japonicum</i>	Japanese pagoda tree	0	0	3,900	3,900	0.2	2,600	12.7
<i>Taxodium</i>	<i>distichum</i>	baldcypress	0	2,000	3,900	5,900	0.3	5,600	11.5
<i>Taxus</i>	spp.	yew spp.	17,000	0	0	17,000	0.9	20,000	4.6
<i>Thuja</i>	<i>occidentalis</i>	northern white-cedar	106,000	28,000	0	134,000	7.2	112,000	3.5
<i>Tilia</i>	<i>americana</i>	American basswood	0	0	1,400	1,400	0.1	1,600	34.5
<i>Tilia</i>	<i>cordata</i>	littleleaf linden	17,000	2,000	2,800	22,000	1.2	21,000	6.5
<i>Tilia</i>	<i>tomentosa</i>	Silver linden	0	2,000	2,000	3,900	0.2	3,700	16.4
<i>Tsuga</i>	<i>canadensis</i>	eastern hemlock	0	2,000	2,800	4,800	0.3	3,700	11.8
<i>Ulmus</i>	<i>americana</i>	American elm	70,000	26,000	26,000	121,000	6.5	48,000	6.3
<i>Ulmus</i>	<i>pumila</i>	Siberian elm	0	0	3,300	3,300	0.2	2,400	18.3
<i>Ulmus</i>	<i>rubra</i>	slippery elm	49,000	2,000	2,000	53,000	2.8	49,000	1.9
<i>Zelkova</i>	<i>serrata</i>	Japanese zelkova	0	9,500	0	9,500	0.5	5,500	7.6
Total			814,000	567,000	484,000	1,860,000	100.0	279,000	8.1

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

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

^a Invasive species.

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

Table 33.—Estimates of total number of trees, basal area (square feet per acre), and average diameter by aggregated National Land Cover Database (NLCD) land cover classes, City of Baltimore, 2020

Land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Developed-High	Austrian pine	7,150	0.6	13.1
	Callery pear	22,136	< 0.1	2.0
	Japanese zelkova	3,575	< 0.1	7.6
	London planetree	3,575	0.1	9.1
	eastern white pine	3,575	< 0.1	6.0
	red maple	5,362	0.2	8.2
	sawtooth oak	3,575	0.3	14.4
	sugar maple	3,575	< 0.1	6.8
	tree of heaven	7,150	0.2	6.9
	white mulberry	8,937	0.2	7.5
Developed-Low	American elm	2,003	< 0.1	7.0
	American holly	36,530	0.6	5.5
	Atlas cedar	2,003	0.1	11.3
	Callery pear	10,013	0.5	9.9
	Freeman maple	4,005	0.9	22.4
	Japanese cedar	4,005	0.6	17.6
	Japanese maple	12,015	0.3	7.6
	Japanese zelkova	2,003	< 0.1	9.9
	Leyland cypress	16,020	1.3	13.5
	London planetree	6,008	0.2	7.7
	Norway maple	10,013	0.7	12.0
	Norway spruce	6,008	0.8	16.0
	Scotch pine	2,003	0.6	26.3
	black cherry	6,008	0.8	17.9
	black locust	8,010	0.3	8.3
	boxelder	2,003	< 0.1	9.0
	eastern hemlock	2,003	< 0.1	10.1
	northern catalpa	2,003	< 0.1	6.1
	northern white-cedar	26,518	1.1	9.8
	overcup oak	24,515	0.1	3.2
	paulownia, empress-tree	2,003	< 0.1	5.0
	pear spp.	2,003	0.2	13.3

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Table 33 (continued).

Land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Developed-Low (cont.)	red maple	4,005	1.2	26.8
	silver maple	8,010	3.3	30.3
	slippery elm	51,033	< 0.1	1.5
	sugar maple	2,003	0.5	24.8
	tree of heaven	32,525	1.1	6.3
	white ash	2,003	< 0.1	7.3
	white mulberry	6,008	1.5	23.7
Developed-Medium	American elm	17,638	1.5	13.5
	American holly	11,759	0.2	6.7
	American sycamore	1,960	< 0.1	7.0
	Callery pear	1,960	0.2	17.0
	Japanese pagoda tree	3,920	0.3	12.7
	Japanese zelkova	3,920	< 0.1	6.3
	London planetree	1,960	< 0.1	11.2
	Norway maple	5,879	0.4	12.4
	Siberian elm	1,960	0.1	11.7
	Silver linden	3,920	0.5	16.4
	baldcypress	5,879	0.3	11.5
	black cherry	1,960	< 0.1	5.7
	black locust	1,960	< 0.1	10.0
	cherry plum	1,960	< 0.1	10.6
	eastern redbud	1,960	0.1	12.3
	eastern redcedar	3,920	0.5	16.9
	eastern white pine	11,759	1.5	17.5
	flowering dogwood	3,920	< 0.1	5.6
	green ash	7,839	0.3	8.9
	honeylocust	5,879	0.2	9.9
	littleleaf linden	1,960	< 0.1	8.2
	northern white-cedar	1,960	< 0.1	5.7
	paper mulberry	5,879	< 0.1	6.1
	pear spp.	1,960	< 0.1	8.2
	red maple	7,839	0.4	10.7
	slippery elm	1,960	0.1	13.5
	sour cherry	1,960	< 0.1	11.1
	sugar maple	5,879	0.7	16.8
	sweet cherry	1,960	< 0.1	7.0
	sweetgum	1,960	< 0.1	8.7

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Table 33 (continued).

Land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Developed-Medium (cont.)	tree of heaven	15,678	1.4	14.1
	water oak	1,960	0.5	25.9
	white ash	1,960	0.9	33.7
	white mulberry	5,879	0.6	13.8
	white oak	3,920	2.3	37.9
	willow oak	24,267	0.1	3.4
Developed-Open/Vegetation	American basswood	1,379	0.9	34.5
	American beech	11,029	2.6	18.9
	American elm	24,103	0.5	5.4
	American holly	9,651	0.3	7.6
	American sycamore	13,787	0.8	10.0
	Amur maple	6,893	0.1	5.9
	Austrian pine	1,379	0.1	13.1
	Callery pear	21,346	0.3	4.5
	European beech	1,379	< 0.1	7.9
	Japanese maple	17,210	< 0.1	2.9
	Leyland cypress	1,379	0.1	13.9
	Norway maple	2,757	0.5	18.7
	Norway spruce	4,136	0.6	17.1
	Siberian elm	1,379	0.6	27.8
	apple spp.	2,757	0.3	14.0
	black cherry	21,346	0.4	3.6
	black locust	9,651	0.7	11.0
	black oak	2,757	1.0	23.6
	black walnut	5,515	1.5	20.5
	blue spruce	19,967	0.3	5.5
	boxelder	26,861	0.7	6.1
	eastern cottonwood	2,757	0.3	13.1
	eastern hemlock	2,757	0.2	13.1
	flowering dogwood	1,379	< 0.1	5.1
	green ash	39,269	2.7	8.7
	holly	2,757	< 0.1	5.3
	littleleaf linden	19,967	1.9	6.3
	mimosa, silktree	2,757	< 0.1	5.3
	pear spp.	1,379	< 0.1	6.1
	pin oak	6,893	3.2	28.6
	red maple	4,136	0.1	6.9
	red mulberry	1,379	< 0.1	9.1

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Table 33 (continued).

Land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Developed-Open/Vegetation (cont.)	river birch	2,757	< 0.1	5.4
	silver maple	17,923	2.4	14.8
	sugar maple	24,103	2.2	7.6
	swamp chestnut oak	2,757	0.7	21.8
	sweet cherry	4,136	0.1	6.9
	sweetgum	1,379	< 0.1	10.9
	tree of heaven	182,463	1.4	2.8
	white ash	2,757	1.5	31.9
	white mulberry	23,438	3.9	15.4
	white oak	2,757	2.3	39.1
	yellow buckeye	1,379	< 0.1	5.2
	yellow-poplar	11,029	4.1	22.1
	yew spp.	17,210	0.2	4.6
Forest/Shrub	American beech	45,029	5.9	6.5
	American elm	77,692	4.7	4.9
	Amur corktree	36,785	2.1	3.9
	Japanese maple	2,061	0.4	10.9
	Norway maple	55,335	4.2	6.9
	Norway spruce	22,673	5.7	12.6
	bitternut hickory	20,612	3.1	9.6
	black cherry	24,734	3.1	8.7
	black locust	45,029	5.1	6.6
	black walnut	2,061	< 0.1	5.2
	black willow	4,122	1.1	13.2
	blackgum	4,122	0.4	8.2
	boxelder	16,490	4.2	10.9
	buckeye, horsechestnut spp.	8,245	1.0	9.0
	chestnut oak	2,061	0.7	15.5
	dogwood spp.	2,061	0.2	8.6
	green ash	57,080	1.7	2.5
	honeylocust	2,061	0.5	12.5
	mockernut hickory	12,367	1.9	9.5
	northern red oak	14,428	5.5	14.9
	northern white-cedar	105,914	0.6	1.9
	red maple	16,490	2.7	10.1
	sassafras	24,734	2.3	7.8

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Table 33 (continued).

Land cover	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Forest/Shrub (cont.)	scarlet oak	8,245	2.1	12.7
	sweetgum	28,540	0.7	2.0
	tree of heaven	14,428	6.6	15.4
	white ash	24,734	14.7	18.8
	white mulberry	8,245	1.4	10.2
	white oak	4,122	1.2	13.0
	yellow buckeye	6,184	0.6	7.7
	yellow-poplar	30,918	24.5	22.5

Estimates are rounded.

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

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

Table 34.—Estimates of total number of trees, basal area, and average diameter by Forest Inventory and Analysis (FIA) land use classes, City of Baltimore, 2020

Land use	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Forest land	American beech	51,923	11.4	8.5
	American elm	62,239	4.6	5.9
	American sycamore	13,787	2.2	10.0
	Amur corktree	36,785	2.1	3.9
	Callery pear	19,170	1.1	4.6
	Norway maple	61,343	4.8	7.0
	Norway spruce	2,061	0.2	7.6
	bitternut hickory	20,612	3.1	9.6
	black cherry	22,572	3.1	9.0
	black locust	17,186	3.7	10.9
	black walnut	3,440	0.7	9.9
	black willow	4,122	1.1	13.2
	blackgum	4,122	0.4	8.2
	boxelder	39,838	5.1	7.3
	buckeye, horsechestnut spp.	8,245	1.0	9.0
	chestnut oak	2,061	0.7	15.5
	eastern cottonwood	2,757	0.7	13.1
	green ash	72,228	0.4	1.8
	honeylocust	2,061	0.5	12.5
	mimosa, silktree	2,757	0.1	5.3
	mockernut hickory	12,367	1.9	9.5
	northern red oak	8,245	3.1	15.0
	paulownia, empress-tree	2,003	< 0.1	5.0
	red maple	16,490	2.7	10.1
	sassafras	24,734	2.3	7.8
	scarlet oak	8,245	2.1	12.7
	slippery elm	51,033	0.3	1.5
	sugar maple	1,379	2.2	32.7
	sweetgum	28,540	0.7	2.0
	tree of heaven	64,164	10.8	7.6
	white ash	16,490	9.2	18.7
	white mulberry	9,623	1.5	9.8
	white oak	6,778	10.5	31.0
	yellow buckeye	6,184	0.6	7.7
	yellow-poplar	26,113	20.0	21.7

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Table 34 (continued).

Land use	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Commercial/Industrial	American elm	5,879	0.1	7.9
	Austrian pine	7,150	0.5	13.1
	Callery pear	4,005	< 0.1	7.4
	London planetree	1,960	< 0.1	11.2
	Norway spruce	20,612	1.4	13.1
	Siberian elm	1,960	0.1	11.7
	baldcypress	5,879	0.3	11.5
	black cherry	2,757	0.3	15.6
	black locust	1,379	< 0.1	12.9
	boxelder	1,379	< 0.1	10.0
	eastern white pine	3,575	< 0.1	6.0
	green ash	7,839	0.2	8.9
	honeylocust	5,879	0.2	9.9
	paper mulberry	5,879	< 0.1	6.1
	pear spp.	2,003	0.1	13.3
	red maple	12,039	0.2	7.2
	sour cherry	1,960	< 0.1	11.1
	sugar maple	5,879	0.6	16.8
	swamp chestnut oak	2,757	0.5	21.8
	sweetgum	3,338	0.1	9.6
	tree of heaven	6,332	0.2	8.2
	white ash	2,003	< 0.1	7.3
	white mulberry	16,324	1.6	13.7
	yellow-poplar	1,379	1.1	44.7
Multi-family residential	American elm	42,301	3.2	6.0
	American holly	9,799	0.3	5.7
	Atlas cedar	2,003	0.2	11.3
	Japanese maple	4,005	0.2	6.6
	Norway maple	1,960	0.2	11.2
	Norway spruce	2,003	0.7	19.8
	black cherry	2,061	< 0.1	5.8
	black locust	15,586	2.2	11.2
	eastern redbud	1,960	0.3	12.3
	eastern white pine	11,759	3.3	17.5
	green ash	11,029	2.8	15.1
	pin oak	1,379	0.5	19.2

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Table 34 (continued).

Land use	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Multi-family residential (cont.)	red maple	1,379	< 0.1	8.1
	silver maple	5,384	5.0	29.4
	tree of heaven	4,136	0.4	9.8
	water oak	1,960	1.2	25.9
	white ash	4,122	0.3	9.6
	white mulberry	4,136	0.3	8.9
	white oak	2,061	0.1	7.7
	yellow-poplar	2,061	0.6	18.6
Residential	American basswood	1,379	0.8	34.5
	American elm	11,016	0.4	8.5
	American holly	48,141	1.1	6.2
	Austrian pine	1,379	0.1	13.1
	Callery pear	26,896	0.5	4.1
	European beech	1,379	< 0.1	7.9
	Japanese cedar	4,005	0.6	17.6
	Japanese maple	27,281	0.5	5.0
	Leyland cypress	1,379	0.1	13.9
	Norway maple	8,679	1.1	15.7
	Norway spruce	8,141	1.1	15.6
	Siberian elm	1,379	0.5	27.8
	apple spp.	2,757	0.3	14.0
	black cherry	26,657	1.0	5.7
	black locust	28,540	0.1	3.1
	black oak	2,757	1.0	23.6
	black walnut	4,136	1.2	21.7
	blue spruce	19,967	0.3	5.5
	boxelder	4,136	0.4	14.0
	cherry plum	1,960	0.1	10.6
	dogwood spp.	2,061	< 0.1	8.6
	eastern hemlock	4,760	0.3	11.8
	eastern redcedar	3,920	0.5	16.9
	flowering dogwood	5,298	< 0.1	5.4
	green ash	2,061	0.5	21.5
	holly	2,757	< 0.1	5.3
	littleleaf linden	1,379	1.1	39.8

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Table 34 (continued).

Land use	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Residential (cont.)	northern catalpa	2,003	< 0.1	6.1
	northern red oak	6,184	0.8	14.7
	northern white-cedar	134,392	1.5	3.5
	pear spp.	1,379	< 0.1	6.1
	pin oak	5,515	2.7	31.0
	red maple	2,003	0.6	24.4
	red mulberry	1,379	< 0.1	9.1
	river birch	2,757	< 0.1	5.4
	silver maple	14,411	2.1	15.5
	slippery elm	1,960	0.2	13.5
	sugar maple	4,954	0.4	10.9
	sweet cherry	6,096	0.2	7.0
	tree of heaven	169,321	2.4	3.4
	white ash	6,880	3.0	29.9
	white mulberry	21,045	3.3	15.9
	willow oak	24,267	0.1	3.4
	yellow-poplar	8,258	3.5	29.0
	yew spp.	17,210	0.2	4.6
Recreation/Cemetery	American beech	4,136	1.6	14.2
	Amur maple	6,893	0.3	5.9
	Callery pear	1,379	0.1	7.5
	Leyland cypress	16,020	4.4	13.5
	Scotch pine	2,003	2.0	26.3
	black locust	1,960	0.3	10.0
	green ash	11,029	2.9	13.0
	littleleaf linden	18,589	2.0	3.8
	overcup oak	24,515	0.4	3.2
	silver maple	4,136	1.9	18.1
	sugar maple	19,967	1.1	3.2
	tree of heaven	4,717	0.2	5.9
	white ash	1,960	3.2	33.7
	white oak	1,960	5.1	42.8
	yellow buckeye	1,379	< 0.1	5.2
	yellow-poplar	4,136	0.4	8.2

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Table 34 (continued).

Land use	Common name	Trees (number)	Basal area ^a (square feet/acre)	Average diameter ^b (inches)
Rights-of-way	American sycamore	1,960	< 0.1	7.0
	Callery pear	4,005	0.1	8.3
	Freeman maple	4,005	0.9	22.4
	Japanese pagoda tree	3,920	0.3	12.7
	Japanese zelkova	9,497	0.2	7.6
	London planetree	9,582	0.3	8.2
	Norway maple	2,003	0.3	18.8
	Silver linden	3,920	0.5	16.4
	littleleaf linden	1,960	< 0.1	8.2
	pear spp.	1,960	< 0.1	8.2
	red maple	5,922	1.1	19.7
	sawtooth oak	3,575	0.3	14.4
	silver maple	2,003	0.5	25.1
	sugar maple	3,381	1.1	27.5
	tree of heaven	3,575	< 0.1	6.6
	white mulberry	1,379	0.7	34.2

Estimates are rounded.

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

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

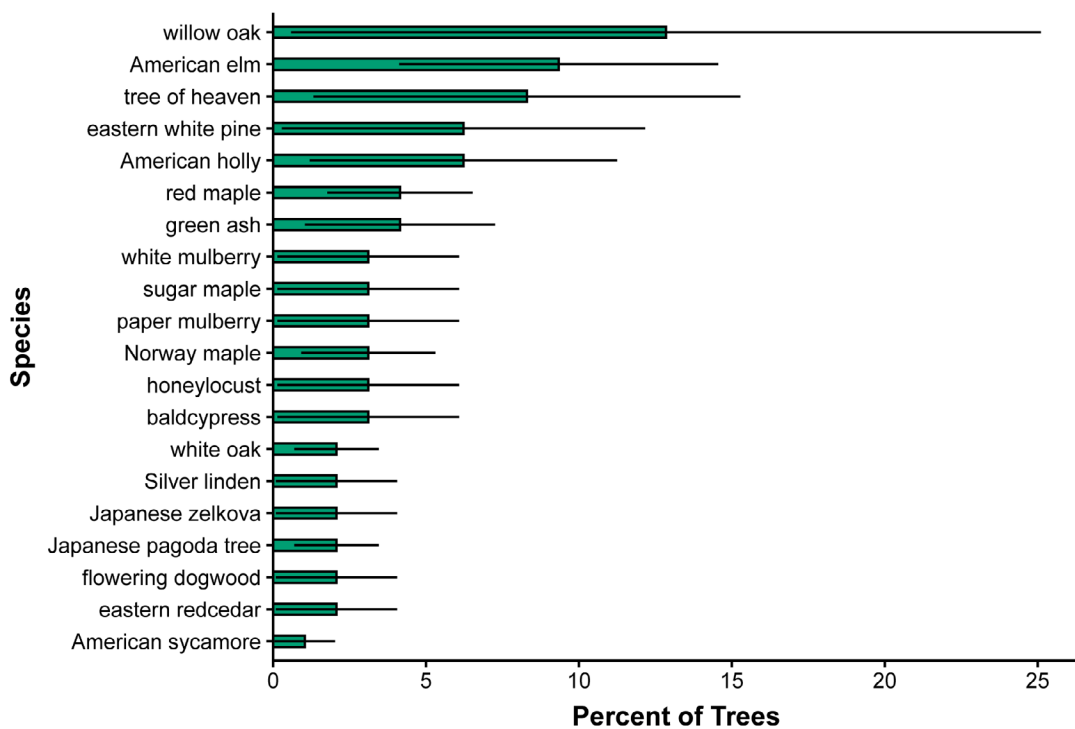


Figure 27.—Percent of the total tree population for up to 20 of the most common tree species observed in the Developed-medium National Land Cover Database (NLCD) land cover classes, City of Baltimore, 2020.

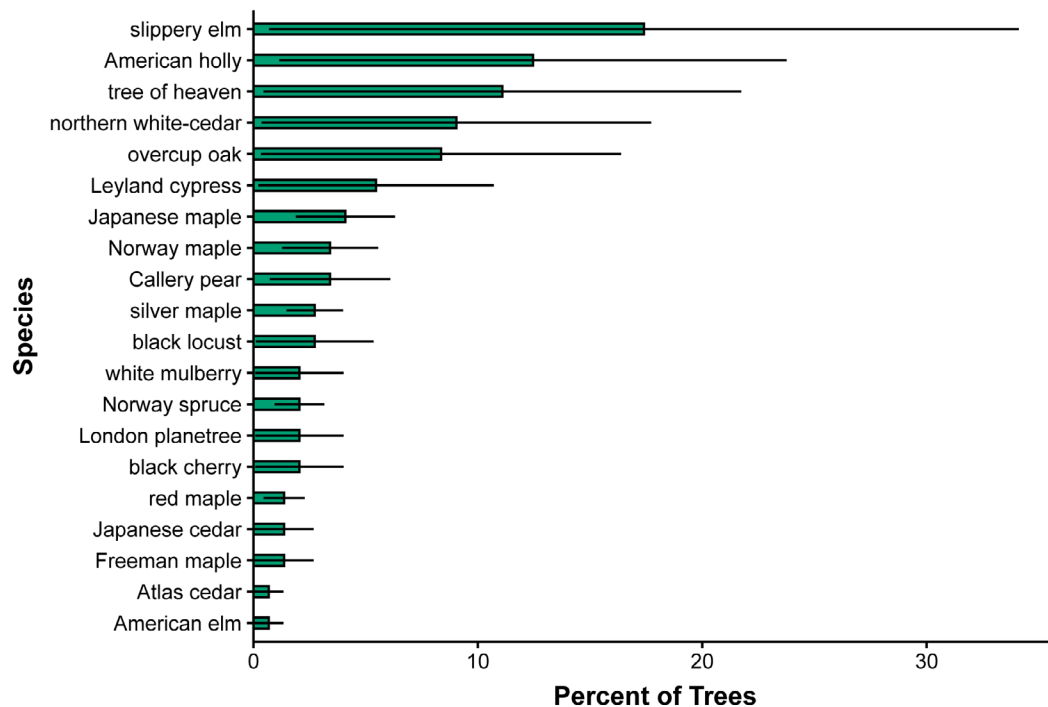


Figure 28.—Percent of the total tree population for up to 20 of the most common tree species observed in the Developed-low National Land Cover Database (NLCD) land cover classes, City of Baltimore, 2020.

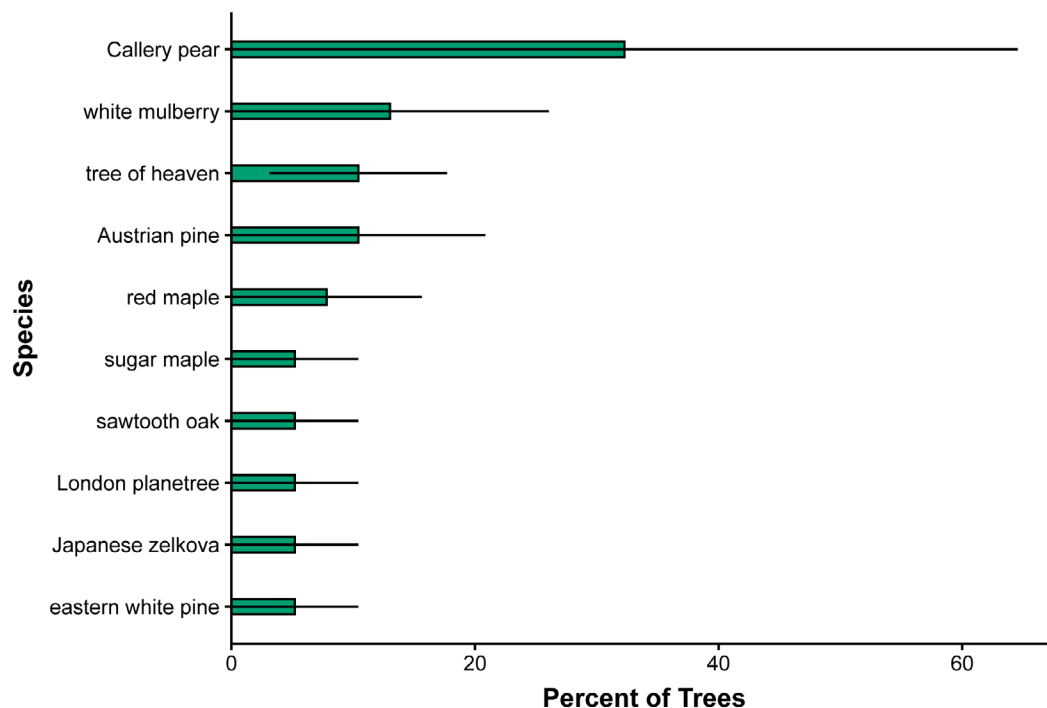


Figure 29.—Percent of the total tree population for up to 20 of the most common tree species observed in the Developed-high National Land Cover Database (NLCD) land cover classes, City of Baltimore, 2020.

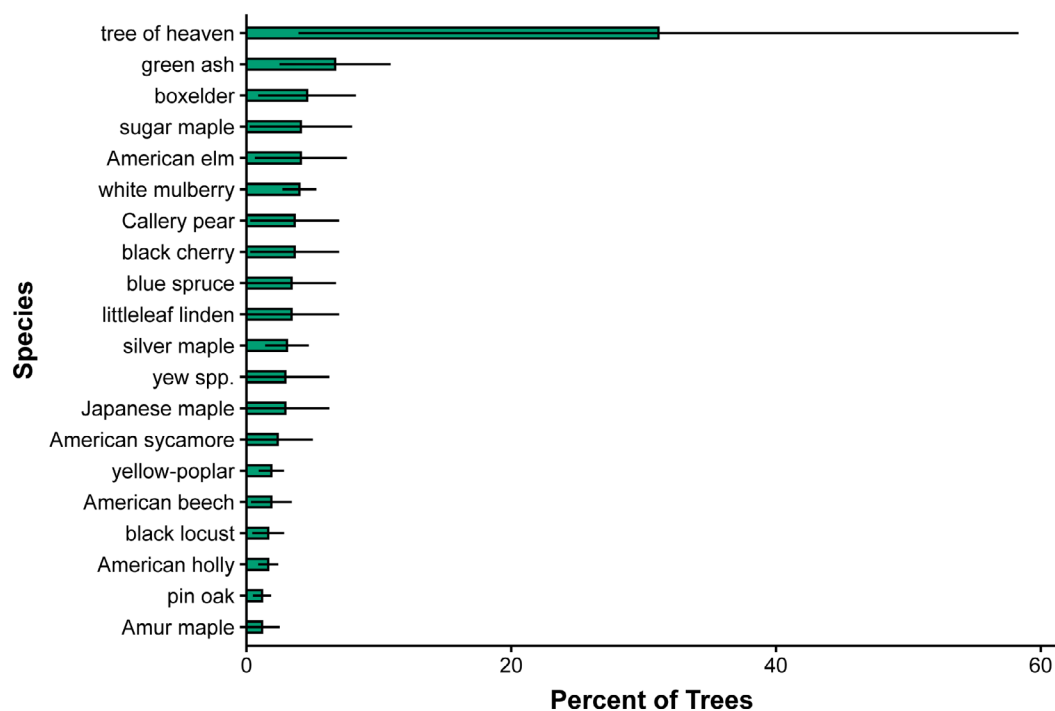


Figure 30.—Percent of the total tree population for up to twenty of the most common tree species observed in the Dev-Open/Veg National Land Cover Database (NLCD) land cover classes, City of Baltimore, 2020.

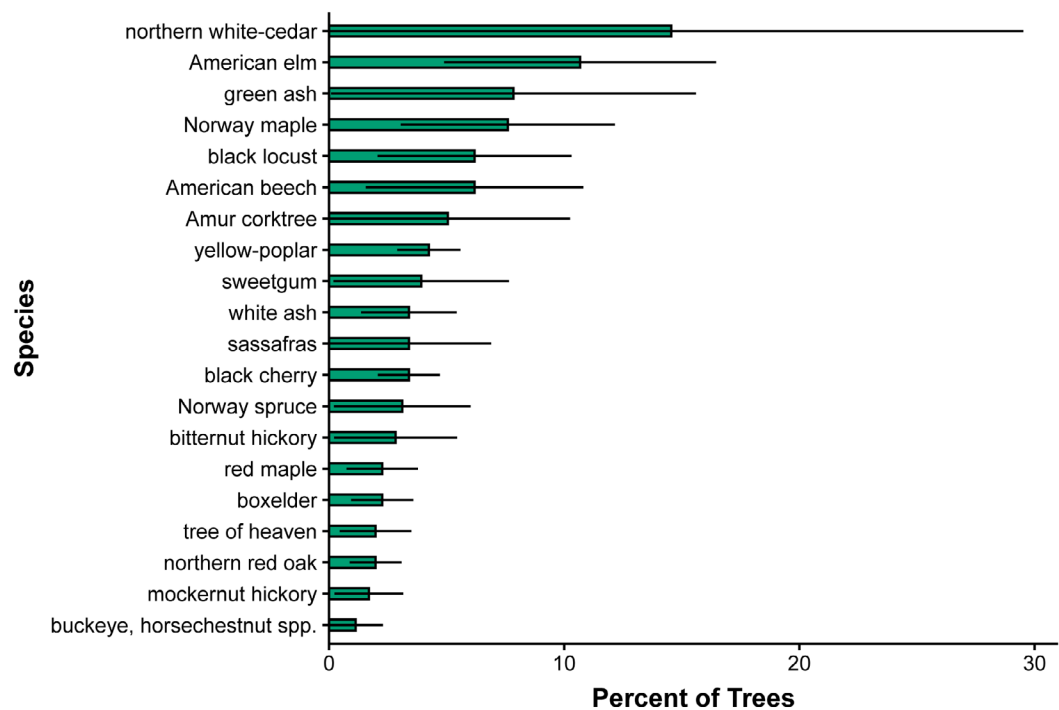


Figure 31.—Percent of the total tree population for up to 20 of the most common tree species observed in the Forest/Shrub National Land Cover Database (NLCD) land cover classes, City of Baltimore, 2020.

APPENDIX 4 – SPECIES COMPOSITION IN MAINTAINED AREAS

Table 35.—Species composition in maintained areas, City of Baltimore, 2020

Common name	Number of trees	Common name	Number of trees
northern white-cedar	134,000	flowering dogwood	5,300
American holly	55,000	eastern hemlock	4,800
Callery pear	35,000	American beech	4,100
sugar maple	34,000	Freeman maple	4,000
white mulberry	33,000	Japanese cedar	4,000
Japanese maple	31,000	eastern redcedar	3,900
Norway spruce	31,000	Japanese pagoda tree	3,900
black cherry	25,000	Silver linden	3,900
overcup oak	25,000	sawtooth oak	3,600
willow oak	24,000	Siberian elm	3,300
silver maple	23,000	river birch	2,800
American elm	23,000	black walnut	2,800
littleleaf linden	22,000	apple spp.	2,800
green ash	22,000	holly	2,800
tree of heaven	21,000	dogwood spp.	2,100
blue spruce	20,000	Scotch pine	2,000
red maple	19,000	northern catalpa	2,000
Leyland cypress	17,000	Atlas cedar	2,000
yew spp.	17,000	eastern redbud	2,000
eastern white pine	15,000	sweetgum	2,000
London planetree	12,000	American sycamore	2,000
Norway maple	11,000	sour cherry	2,000
yellow-poplar	10,000	white oak	2,000
Japanese zelkova	9,500	water oak	2,000
white ash	8,800	slippery elm	2,000
Austrian pine	7,100	cherry plum	2,000
pin oak	6,900	yellow buckeye	1,400
northern red oak	6,200	red mulberry	1,400
sweet cherry	6,100	black oak	1,400
baldcypress	5,900	black locust	1,400
honeylocust	5,900	American basswood	1,400
paper mulberry	5,900	European beech	1,400
pear spp.	5,300		

Estimates are rounded.

APPENDIX 5 – LIST OF INVASIVE PLANT SPECIES

Table 36.—Invasive species list used in the inventory protocol for City of Baltimore, 2020

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>	Chinaberrytree
<i>Centaurea stoebe</i> ssp. <i>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 tallow
<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 6 – RISK ASSOCIATED WITH VARIOUS INSECTS AND DISEASES

Table 37.—Potential risk to trees associated with various insects and diseases, City of Baltimore, 2020

Common name	Cumulative risk weight	SLF	SM	DED	EAB	SPB	LAT	WPBR	BC	DA	HWA	ALB	WM	FTC	FR	OW	PSB	SW	SBW	BBD	BLD	SB	HRD	BWA	JPBW	TCD	BM	AL	LWD	PSHB	MOB	POCRD	WSB	WBBU	MPB	SOD	
eastern white pine	27	4				4		4						3			3	3					3			3											
black willow	25	4	4				4					3	3	3														2	2								
northern red oak	25	4	4										3	3	3	3												2			1	1				1	
Norway spruce	25					4											3	3	3				3	3	3								1	1	1		
pin oak	25	4	4										3	3	3	3												2			1	1				1	
scarlet oak	24	4	4										3	3	3	3												2			1	1					
white oak	24	4	4										3	3	3	3												2			1	1					
black oak	23	4	4										3	3	3	3												2				1					
chestnut oak	23	4	4										3	3	3	3												2				1					
overcup oak	23	4	4										3	3	3	3												2				1					
swamp chestnut oak	23	4	4										3	3	3	3												2				1					
water oak	23	4	4										3	3	3	3												2				1					
willow oak	23	4	4										3	3	3	3												2				1					
sweet cherry	22	4					4					3	3	3														2				1					
black cherry	21	4					4					3	3	3														2	2								
river birch	21	4	4				4					3	3	3																							
sawtooth oak	21	4	4												3	3												2			1	1					
American elm	20	4		4								3	3	3														2			1						
Siberian elm	19	4		4								3	3	3														2									
slippery elm	19	4		4								3	3	3														2									
American basswood	18	4	4									3	3	3														2			1						
boxelder	18	4	4									3	3															2				1	1				
Scotch pine	18					4											3	3								3								1	1		
sour cherry	18	4					4					3		3														2	2							1	
eastern cottonwood	17		4				4					3	3	3																							
green ash	17	4			4							3	3	3																							
sugar maple	16	4										3	3	3														2				1					
blue spruce	15					4											3		3															1	1		
American beech	14	4	4																	3	3																
Callery pear	14	4	4									3																2			1						
cherry plum	14						4					3		3														2	2								
white ash	14	4			4								3	3	3																						
apple spp.	13	4	4									3																2									
Austrian pine	13					4									3		3	3																			
Norway maple	13	4										3	3															2				1					
pear spp.	13	4	4									3																2									
red maple	13	4										3	3															2				1					
silver maple	13	4										3	3															2				1					
black walnut	12	4							4																	3											
eastern hemlock	11					4					4								3																		
Freeman maple	11	4										3																2			1	1					
Japanese maple	11	4										3																2			1	1					
littleleaf linden	10		4									3		3																							
Silver linden	10		4									3		3																							
European beech	9																			3	3									1	1					1	
dogwood spp.	8	4								4																											
flowering dogwood	8	4								4																											
London planetree	8	4										3																			1						
mimosa, silktree	8	4										3																			1						
sweetgum	8		4											3																	1						
white mulberry	8	4										3																			1						
Amur maple	6											3																2				1					
sassafras	6	4																												2							
American sycamore	5	4																																			
Japanese zelkova	5	4																																			
northern white-cedar	5	4																															1				
Japanese pagoda tree	5	4																														1					
paper mulberry	5	4																														1					
tree of heaven	5	4																														1					
yellow-poplar	5	4																														1					
Amur corktree	4	4																																			
black locust	4	4																																			
blackgum	4	4																																			
eastern redcedar	4																					3									1						
paulownia, empress-tree	4	4																																			
buckeye, horsechestnut spp.	3											3																									
red mulberry	3											3																									
yellow buckeye	3											3																									
Atlas cedar	1																															1					
baldcypress	1																															1					
honeylocust	1																															1					
northern catalpa	1																															1					

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

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