Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Northern Research Station | Resource Bulletin NRS-146 | July 2026

Milwaukee's Urban Forest, 2021

Citation

Buckler, Dan; Schanning, Sjana; Herrick, Christina; Hoehn, Robert E., III; Jennings, Katie; Young, Alexander R. 2026. **Milwaukee's urban forest, 2021**. Resour. Bull. NRS-146. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 82 p. https://doi.org/10.2737/NRS-RB-146.

Abstract

Data collected from over 200 plots in Milwaukee, Wisconsin from 2015 through 2021 reveal that the city has an estimated 3.7 million live trees at least 1.0 inch in diameter across all ownerships. The most common tree species by number are common buckthorn, boxelder, and green ash, while those at least 5.0 inches in diameter are led by green ash, boxelder, and Norway maple. The largest number of trees (31.4 percent; 1.1 million trees) are found on forest land. Trees on public lands total 2.1 million and account for over 57 percent of all live trees. Trees at least 15.0 inches in diameter are only 7 percent of the population, but represent 48 percent of all trees' leaf area, which in turn produce many of the benefits of the urban forest. It is estimated that the urban forest produces over $12.6 million in annual benefits, while those trees represent a compensatory value of $1.24 billion. Buckthorn is the most common invasive species, covering 3.7 percent of the city's area, and ash trees overwhelmingly account for the city's dead trees (88 percent of the dead trees at least 5.0 inches in diameter). 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 Milwaukee. The analysis also provides a basis for monitoring changes in the urban forest over time.

Keywords

Urban FIA, Urban Forest Inventory and Analysis, UFIA, i-Tree, WI, Wisconsin, urban forest trends, urban forest values, My City's Trees, city, cities, tree volume and biomass, carbon sequestration, urban forest structure and health, ecosystem services

Cover photo: Street and yard trees on the west side of Milwaukee. The well-canopied Grant Boulevard in the center of the image is lined predominantly by honeylocust trees. Courtesy photo by Eric Tadsen, Tadsen Photography.

Published by:
U.S. Department of Agriculture
Forest Service
One Gifford Pinchot Drive
Madison, WI 53726
July 2026

Visit the Northern Research Station website at https://research.fs.usda.gov/nrs.

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Acknowledgments

The authors would like to thank the many individuals who contributed to the collection, processing, management, and analysis of Milwaukee's urban forest inventory data. The body of this report, with the exception of the introduction, background and management implications is the product of an automated template, developed through much collaboration, time, and effort by the authors of San Diego's Urban Forest, 2017. Their committed effort provides a consistent reporting format to allow for timely and accurate reporting for the many cities with Urban FIA data which will follow.

Plot selection and pre-field preparation work was done by James Blehm, Brian Gasper, Daniel Kaisershot, Kevin Nimerfro, Cassandra Olson, Kelly Peterson, Mitch Slater, and Paul Sowers. Data collectors included Thomas Davis, Devon DeRosso, Michael Duwe, Zachary Klessig, Peter Koehler, Paul Mueller, Pat Nelson, Cassandra Olson, Terry Schriber, Willard Smith, and Caleb Wolden. These employees not only collect data, but also research land ownership, manage landowner contact, and coordinate plot visits, keeping the occurrence of denied access plots very low through their quality, professional work. Mark Hatfield, Lucie Lepine, Katie Jennings, and Alex Young are invaluable for their expertise with the Universal National Information Management System (UNIMS) database. Special appreciation goes to Mark Majewsky, who took on the challenge of leading the Urban Forest Inventory and Analysis program from a concept to a growing nationwide program which currently monitors urban forests in 44 cities and across all urban areas of 26 states.

EXECUTIVE SUMMARY

Boxelder is one of the most common trees in Milwaukee. While many are found in unmaintained areas, these newly emerged boxelder leaves help shade the lawn at Milwaukee's Soldiers Home. Courtesy photo by Dan Buckler, Wisconsin Department of Natural Resources.

The city of Milwaukee was sampled from 2015 through 2021 to establish a baseline assessment of the magnitude, composition, and value of its urban forest resource. The sampled area of the city (representing a total of 61,953 acres), is estimated to contain 3.7 million live trees, 71.1 percent of which are less than 5.0 inches in **diameter**[1]. The most common tree species[2] at least 1.0-inch in diameter are common buckthorn, boxelder, green ash, and sugar maple. The most common large-diameter tree species (at least 11.0 inches in diameter) are Norway maple, green ash, boxelder, honeylocust, and mulberry. The most dominant species based on the number of trees and leaf area are common buckthorn, boxelder, green ash, sugar maple, and Norway maple.

[1] See glossary for definition of bolded terms.

[2] Common and scientific names for tree species observed in the 2021 Urban FIA inventory of Milwaukee are reported in Appendix 2.

The largest number of trees are found on **forest land** (31.4 percent; 1.1 million trees). Overall, 22.2 percent of trees are classified as growing in maintained areas. Trees on public lands total 2.1 million and account for 57.4 percent of the total live tree population. Trees on private lands total 1.6 million and account for 42.6 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 $1.24 billion with the urban forest producing over $12.6 million in annual benefits (Table 1).

Table 1.—Summary of urban forest estimates, city of Milwaukee, 2021

Feature	Estimate
Number of trees[a]	
Total live trees	3.7 million (857,540)[b]
Live saplings (1.0 to 4.9 inches in diameter)	2.6 million (775,000)[b]
Live trees (at least 5.0 inches in diameter)	1.1 million (148,423)[b]
Standing dead saplings (1.0 to 4.9 inches in diameter)	458,000 (226,000)[b]
Standing dead trees (at least 5.0 inches in diameter)	305,000 (116,000)[b]
Most abundant species	
By number of live trees	common buckthorn
By leaf area	Norway maple
Ecosystem impacts and services	
VOC emissions	196 tons/year
Pollution removal	333 tons/year ($5.3 million/year)
Reduction in acute respiratory symptoms	583 cases/year ($50,000/year)
Avoided runoff	13.5 million cubic feet ($901,000/year)
Carbon storage[c]	335,000 tons ($57.1 million)
Carbon sequestration	10,000 tons/year ($1.7 million/year)
Net aboveground volume	15.6 million cubic feet
Reduced building energy use[c,d]	215,000 GJ/year ($3.4 million/year)
Reduced carbon emissions[c,d]	6,500 tons/year ($1.2 million/year)
Compensatory value	$1.2 billion

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

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 [10^9] joules).

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

[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.

Invasive plant species also threaten to alter forest composition and are found on 57.1 percent of the sampled plots. Common buckthorn is estimated to cover the largest area (2,294 acres) of any invasive plant species in the city.

Both natural and anthropogenic threats may affect the health and composition of Milwaukee'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.

Contents

BACKGROUND

Milwaukee's distinct neighborhoods include Brady Street, first developed in the mid-19th-century. Courtesy photo by Eric Tadsen, Tadsen Photography.

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 (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, an effort that led to the development of an Urban FIA program (USDA Forest Service 2016). The goal of this program 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 information about the current state of Milwaukee's urban forest and the benefits it provides to the residents of the city.

[3] See glossary for definition of bolded terms.

In this report, the term "urban forest" describes all trees located in the city of Milwaukee 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.

Like all cities, the area now known as Milwaukee has experienced immense change to its natural environment. Survey records from the mid-19th-century, shortly after Milwaukee incorporated as a City in 1846, indicate that within its current borders were huge areas of forest dominated by sugar maple, American beech, basswood, and other hardwoods (WDNR 2017a). Punctuating that landscape were pockets of swamp conifers, lowland hardwoods, and marshes. Over the next century, population growth and land annexations transformed the area. By the 1960s, the current city borders were essentially in place, and much of what it contained was a profoundly altered environment. Now Milwaukee, with almost 578,000 people as of the 2020 Census (U.S. Census 2025), is the most populous city in Wisconsin, and the fifth most populous in the Midwest (Port Milwaukee 2020).

Given the large footprint of direct forest management responsibilities across road **rights-of-way** and parks, the municipal government plays a dominant role in the city's urban forest. Though the City first established a tree nursery in 1911, Milwaukee's forestry program wasn't established until 1918. For much of the past century, this forestry program has had a national reputation for proactive and progressive urban forest management.

The City of Milwaukee Forestry Services currently maintains a regular tree inventory of about 190,000 trees they manage along Milwaukee streets. Other entities in the city, such as Milwaukee County Parks and University of Wisconsin-Milwaukee, also have tree inventories. However, information on the city's trees outside of these spaces is sparse, despite making up most of the urban forest. The ongoing Urban FIA program will help reveal the entire city's urban forest and inform management decisions on both public and private lands.

The Urban FIA inventory is thus particularly useful in that it provides estimates of the urban forest across all ownerships and land uses. This approach can provide critical information beyond the detailed public tree inventories that many cities, including Milwaukee, have available. A close inspection of these data can help planners understand where improvements can be made and develop tree planting and conservation goals for the future. The data will also serve as a baseline against which the future results from continued monitoring can be compared. These comparisons will allow managers to assess rates of tree growth and mortality, as well as changes in species composition, health condition, and the corresponding changes in benefits associated with the urban forest. Effective monitoring allows for the development of data-driven management strategies to maximize the benefits of Milwaukee's urban forest while minimizing the cost associated with its maintenance.

When reviewing the estimates in this report, it is important to understand that they are based upon a sample made up of 210 randomly selected research plots. Some of these research plots have no trees present, while others are fully forested. Some tree species were found on many of these research plots while others were only found at a single site. Further details about protocols and plot design can be found in the Methods section of this paper and in additional referenced documents.

As with all sample-based estimates, standard error must be considered when assessing the data and its potential use. In general, broader estimates, such as the number of trees in the city, will have a smaller standard error than subsets of the data (e.g., the estimated count of a single species within a particular land use). Additionally, **seedling** and **sapling** counts occur on a smaller sample area than trees 5.0 inches in **diameter** and greater, and therefore typically have a larger standard error. A notable example of this in the Milwaukee data is Amur maple which was found on a single plot in the form of many saplings. From these data it is estimated that there are anywhere from 6,000 to 378,000 Amur maple saplings in the city, resulting in the midpoint estimate of 192,000.

Due to the broad range of possible uses for the data, ranging from strategic planning to the identification of needed additional research, this report does not limit results to a minimum standard error threshold. Throughout this report, tables provide standard errors for many, but not all estimates. To further explore the standard error of individual estimates, the Urban Forest Stats tool can be used or raw data can be downloaded from the Urban DataMart for independent calculations.

Methods

To evaluate the extent, composition, and benefits of Milwaukee'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 to Urban FIA city forest reports (Baer et al. 2025), along with i-Tree Eco modeling software (Nowak 2024). This process established survey plots across Milwaukee 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. Data for Milwaukee's first 7-year measurement cycle was collected from 2015 through 2021, hereafter referred to as the 2021 inventory. The sampling area was defined by the U.S. Census Bureau Designated Places boundary for Milwaukee (highlighted in red in Fig. 1a). In total, the Urban FIA sample surveyed 210 plots[4] across the city's 61,953 acres within the designated sampling area in Milwaukee (Fig. 1).

New methods were implemented in the inventory of Milwaukee'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 with diameters of at least 1.0-inch, and results are given for live trees.

[4] Information about the exact location of FIA plots is federally protected. Maps in this report use altered or "fuzzed" coordinates, available through the public Urban DataMart. This may cause plots to appear outside the study area. These maps are meant to provide a general overview, and the visual representation of the plot location does not reflect actual plot conditions.

Figure 1.—Study area (A) and approximate plot locations (B) for the Urban Forest Inventory and Analysis (FIA) inventory, city of Milwaukee, 2021. 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 document were created using ArcGIS® software by Esri (ArcGIS Pro version 2.9, Esri 2021). ArcGIS® is the intellectual property of Esri and used herein under license.

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

In addition to this report, information from this analysis is accessible via My City's Trees and Urban Forest Stats, online interactive tools that allow users to explore results and print data queries. Data tables are also available for download from FIA's Urban DataMart.

AREA AND COVER CHARACTERISTICS

Washington Park, on the west side, gives its name to the surrounding neighborhood. Though Milwaukee is the most populous city in Wisconsin, there are also many large parks. Courtesy photo by Bill McNee, Wisconsin Department of Natural Resources.

In 2010, Wisconsin had 1,204,000 acres of urban land that covered 3.5 percent of the state area, and this urban area is projected to increase to 9.2 percent by the year 2060 (Nowak and Greenfield 2018). Milwaukee is the largest city in Wisconsin by population (595,000 residents with a population density of 6,188 per square mile in 2010) (U.S. Census 2025).

Land Cover

The 2011 National Land Cover Database (NLCD 2011) land cover classes (Appendix 1) were used to analyze variability of the urban forest across the city (Homer et al. 2015; MRLC 2018). Plots were then categorized into land cover class groups as defined in Table 2.

The most prevalent land cover classification is developed-medium, followed by developed-low, developed-high, and developed-open (Table 3). Figure 2 shows the distribution of landcover class groups across the city. Areas of forest/vegetation land cover are estimated to contain the greatest proportion of trees in the sampling area of any land cover (30.3 percent), followed by developed-open, developed-medium, and developed-low land covers (28.7 percent, 23.6 percent, and 12.8 percent of the trees in the sampling area, respectively).

Table 2.—National Land Cover Database (NLCD) land cover class groups, city of Milwaukee, 2021

NLCD land cover class group	NLCD land cover classes
Water	Open water
Developed-open	Developed-open space
Developed-low	Developed-low intensity
Developed-medium	Developed-medium intensity
Developed-high	Developed-high intensity, and barren land
Forest/veg	Deciduous forest, woody wetlands, grassland/herbaceous, cultivated crops, evergreen forest, mixed forest, shrub/scrub, pasture/hay, and emergent herbaceous wetlands
Herb/crop	Grassland/herbaceous, pasture/hay, and cultivated crops

Source: Homer et al. 2015

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

Table 3.—Sample area and plot counts within National Land Cover Database (NLCD) land cover class groups, city of Milwaukee, 2021

NLCD land cover class group	Area (acres)	Land (percent)	Plots (number)
Developed-medium	21,769	35	69
Developed-low	19,502	31	74
Developed-high	10,130	16	35
Developed-open	5,894	10	18
Forest/vegetation	4,291	7	11
Water	328	1	2
Total	**61,953**	**100**	**210**

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

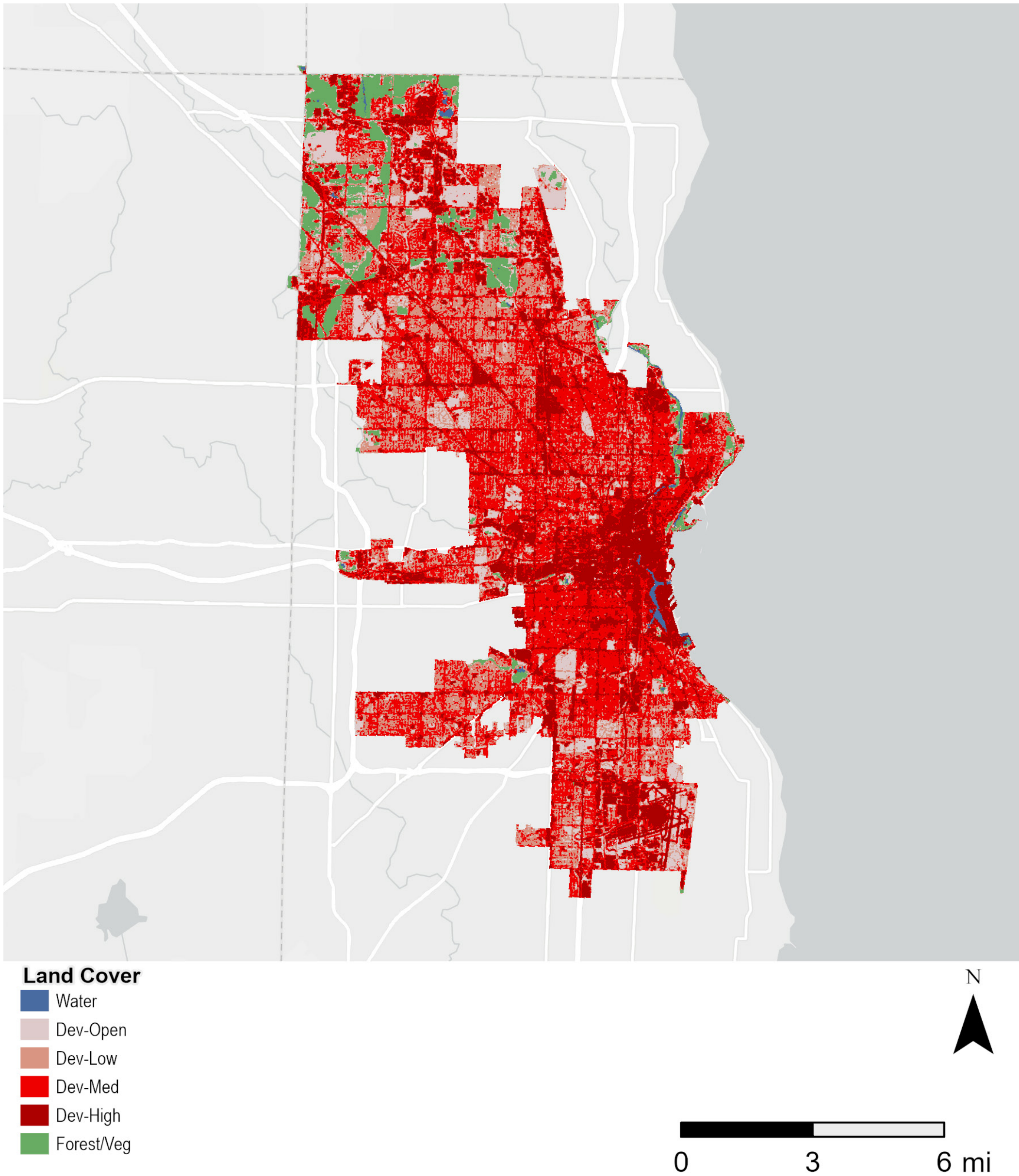

Figure 2.—Distribution of National Land Cover Database (NLCD; Homer et al. 2015) land cover class groups, city of Milwaukee, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

FIA Land Use

In addition to categorization according to NLCD land cover class groups, 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 Milwaukee.

Rights-of-way is the most prevalent land use class in Milwaukee, covering 26.3 percent of the city area (containing 14.8 percent of the city's trees), followed by commercial/industrial (25.3 percent of the city area), residential (23.4 percent), multi-family residential (10.2 percent), and recreation/cemetery (8.1 percent) (Table 5).

Table 4.—Forest Inventory and Analysis (FIA) land use classes and subclasses, city of Milwaukee, 2021

FIA land use class	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/chapparal	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 Milwaukee, 2021

FIA land use class	Area (acres)	Standard error (acres)	Land (percent)	Plots (number)
Forest land	3,709	744	6.0	10.1
Agriculture	102	108	0.2	0.4
Commercial/industrial	15,662	1,469	25.3	52.8
Multi-family residential	6,291	1,161	10.2	21.5
Residential	14,513	1,489	23.4	50.9
Recreation/cemetery	5,027	1,044	8.1	16.3
Rights-of-way	16,307	1,519	26.3	55.3
Water	344	48	0.6	2.8
Total	**61,953**	**456**	**100.0**	**210.0**

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

Tree, Shrub, and Ground Cover

On every Urban FIA plot visited, an overall tree canopy cover and shrub cover is visually estimated. These field plot estimates can have a relatively high degree of uncertainty due to the nature of tree cover data collection in the field and the effects of sample size. Many cities also have tree canopy estimates available which are derived from photo interpretation or light detection and ranging (LiDAR) technology which can provide high-resolution maps of vegetative cover and an overall, citywide estimate of canopy cover. Based on the Urban FIA evaluations, tree cover in Milwaukee is estimated at 17.4 percent and shrub cover at 4.4 percent. Multiple remote sensing projects, however, have estimated the city's canopy cover to be 23 to 26 percent (Milwaukee County 2022, WDNR 2017b).

Tree cover recorded on Urban FIA plots ranges from 0.59 percent to 95 percent where trees are present (Fig. 3a). Shrub cover on plots ranges from 0.17 percent to 93 percent on plots where shrubs are present (Fig. 3b). Average tree cover is highest on forest land (49.8 percent tree cover), recreation/cemetery (31.8 percent), and residential land uses (22.3 percent) (Table 6). Shrub cover is highest on forest land (26.0 percent shrub cover), residential (4.8 percent), and recreation/cemetery land uses (4.1 percent).

Field crews categorized ground surface cover on each field plot according to five classes: building, low vegetation (woody plants under 1 foot tall and all herbaceous plants), permeable (soil, leaf litter, mulch, gravel, etc.), impervious (non-building), or water. Across all land uses combined, permeable and low vegetation ground covers account for 48.7 percent of all ground covers, while building and other impervious cover account for 50.6 percent (Figs. 4 and 5). An additional 0.8 percent of the city is classified as water. Impervious cover is highest on rights-of-way (66.4 percent impervious cover), commercial/industrial (37.7 percent), and multi-family residential land uses (34.2 percent) (Figure 4).

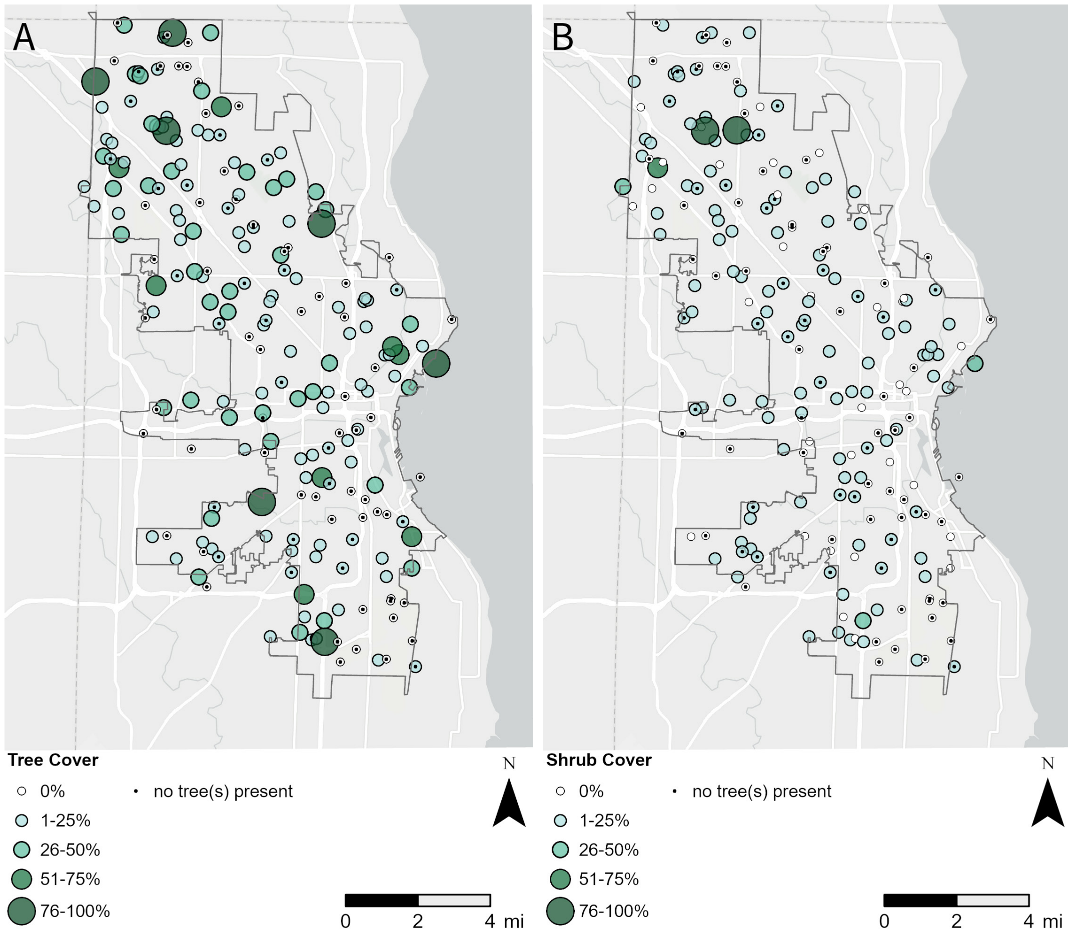

Figure 3.—Tree (A) and shrub (B) cover estimates for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, city of Milwaukee, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Table 6.—Average percent tree and shrub cover by Forest Inventory and Analysis (FIA) land use class, city of Milwaukee, 2021

FIA land use class	Tree (percent)	Shrub (percent)
Forest land	49.8	26.0
Agriculture	0.0	0.0
Commercial/industrial	4.5	2.4
Multi-family residential	10.3	1.7
Residential	22.3	4.8
Recreation/cemetery	31.8	4.1
Rights-of-way	16.8	2.1
Water	0.0	0.0
Total	**17.4**	**4.4**
Total standard error	**7.8**	**0.8**

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

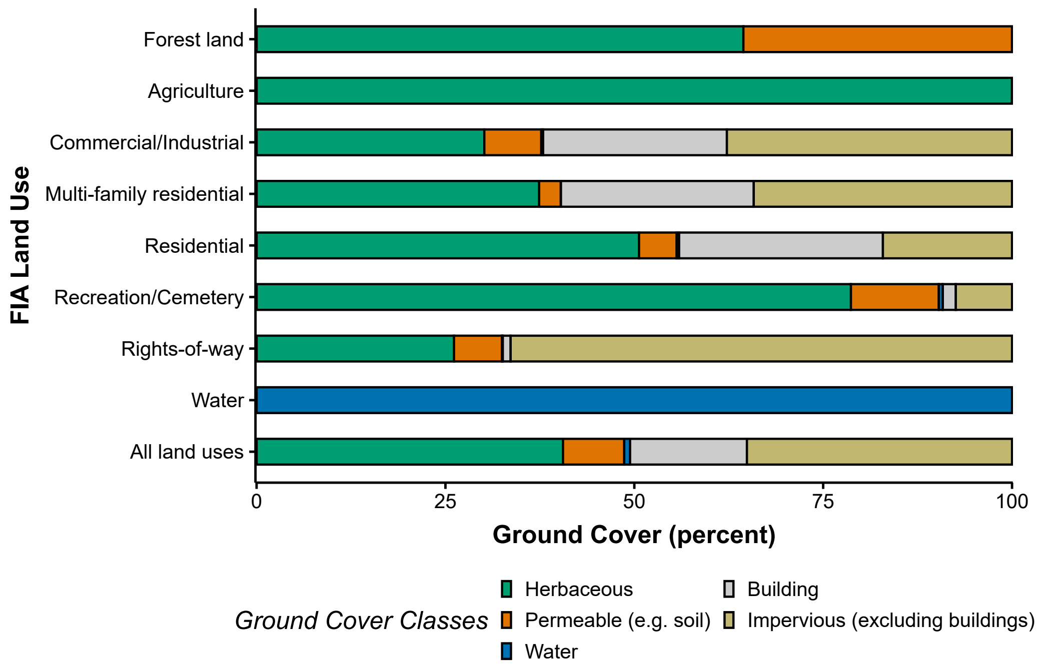

Figure 4.—Average ground cover by Forest Inventory and Analysis (FIA) land use class, city of Milwaukee, 2021.

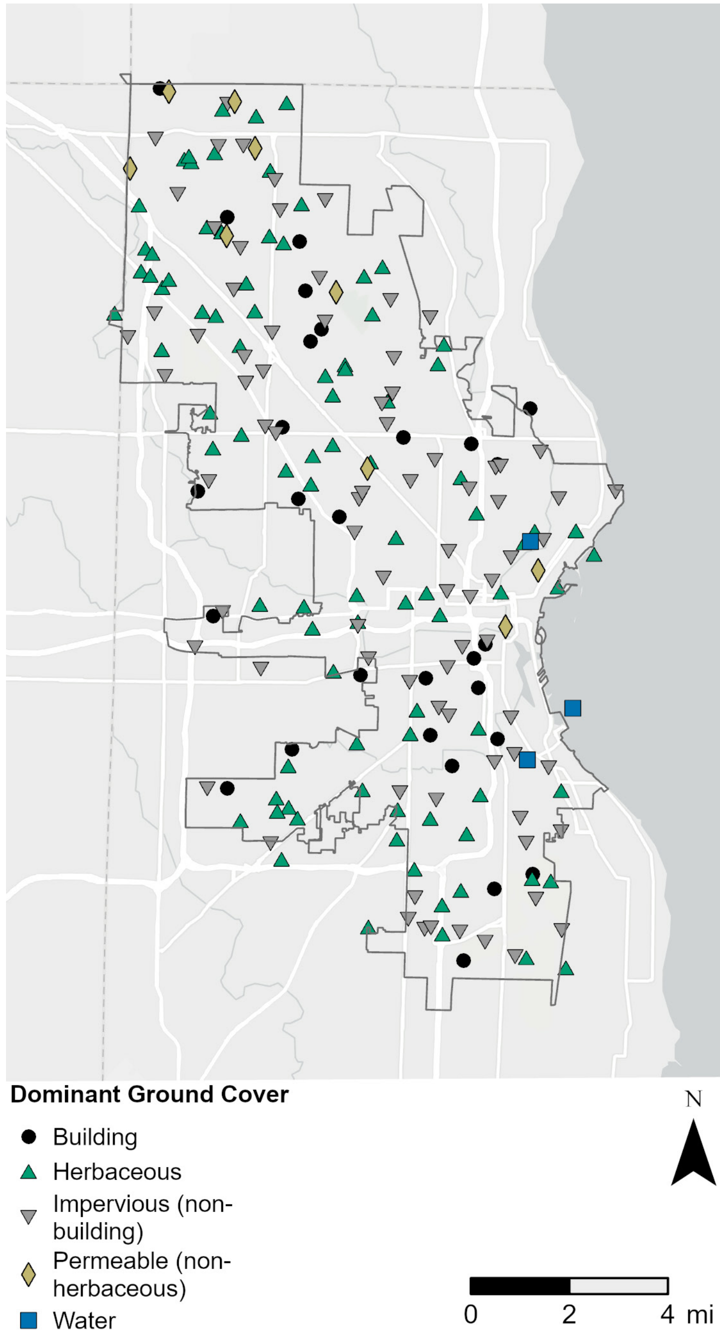

Figure 5.—Dominant ground cover for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, city of Milwaukee, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Ownership

Plot ownership was divided into private, state and local government, federal government, and unknown (water) classes. The most dominant ownership in Milwaukee is private (59.8 percent), followed by state and local (38.7 percent), federal (1.0 percent), and unknown (water) (0.6 percent) (Table 7). Percent tree canopy cover is greatest in federal (25.9 percent), followed by state and local (22.4 percent), and private (14.2 percent). In Milwaukee, there are a total of 2.1 million trees (56.6 percent of the live tree population) on state and local lands, 1.6 million trees (42.6 percent) on private land, and 30,000 trees (0.8 percent) on federal lands (Table 7). Milwaukee's sapling population is mostly found on state and local lands (56.7 percent), followed by private lands (43.3 percent), while the largest diameter classes (at least 11.0 inches in diameter) are mostly found on private lands (51.8 percent) (Table 7).

Table 7.—Number of trees by ownership and diameter class, city of Milwaukee, 2021

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)
State and local	1,470,000	415,000	181,000	2,070,000	24,000
Private	1,130,000	223,000	206,000	1,550,000	37,000
Federal	0	18,000	12,000	30,000	600
Unknown (water)	0	0	0	0	340
Total	**2,600,000**	**656,000**	**398,000**	**3,650,000**	**62,000**

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

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FOREST STRUCTURE

This American elm tree on Milwaukee's east side is one of the largest of its kind in the State according to the Wisconsin Department of Natural Resource's Champion Tree database. Courtesy photo by Dan Buckler, Wisconsin Department of Natural Resources.

Number of Trees

Milwaukee's urban forest has an estimated 3.7 million live trees and 764,000 standing dead trees. The number of trees varies by land use and diameter class. Nearly one-third of the trees in Milwaukee are located on FIA-defined forest land (31.4 percent, 1.1 million trees) (Table 8). Overall, 71.1 percent of Milwaukee's trees are saplings, while the remaining 18.0 percent and 10.9 percent are medium trees (5.0 to 10.9 inches in diameter) and large trees (at least 11.0 inches in diameter), respectively.

The greatest proportion of trees (30.3 percent) and the highest tree density (258 trees per acre) are found within the National Land Cover Database (NLCD) forest/vegetation land cover class group (Table 9).

Table 8.—Number of trees by Forest Inventory and Analysis (FIA) land use class and diameter class, city of Milwaukee, 2021

FIA land use class	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Standard error (number)	Density (no./ac)
Forest land	815,000	298,000	35,000	1,150,000	413,000	309
Commercial/industrial	345,000	42,000	34,000	421,000	214,000	27
Multi-family residential	41,000	55,000	34,000	131,000	57,000	21
Residential	330,000	107,000	133,000	571,000	191,000	39
Recreation/cemetery	687,000	78,000	75,000	841,000	655,000	167
Rights-of-way	379,000	76,000	86,000	541,000	308,000	33
Agriculture	0	0	0	0	0	0
Water	0	0	0	0	0	0
Total	**2,600,000**	**656,000**	**398,000**	**3,650,000**	–	**59**
Total standard error	**775,000**	**117,000**	**52,000**	**858,000**	–	–

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

– = no value for cell.

Table 9.—Number of trees by National Land Cover Database (NLCD) land cover class group and diameter class, city of Milwaukee, 2021

NLCD land cover class group	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 (no./ac)
Water	0	740	0	740	1,500	2
Developed-open	859,000	120,000	69,000	1,050,000	652,000	178
Developed-low	248,000	72,000	146,000	466,000	122,000	24
Developed-medium	599,000	147,000	117,000	864,000	355,000	40
Developed-high	131,000	26,000	8,800	167,000	138,000	16
Forest/vegetation	760,000	290,000	56,000	1,110,000	387,000	258
Herb/crop	215,000	81,000	33,000	328,000	183,000	49
Total	**2,600,000**	**656,000**	**398,000**	**3,650,000**	–	**59**
Total standard error	**775,000**	**117,000**	**52,000**	**858,000**	–	–

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

– = no value for cell.

Species Composition

The 10 most common tree species[5] by number account for 81.9 percent of all recorded live trees and are common buckthorn, boxelder, green ash, sugar maple, Amur maple, Norway maple, black locust, American elm, apple spp., and eastern cottonwood (Table 10, Fig. 6). Some species, including Amur maple, black locust, bur oak, tree of heaven, and Japanese yew, were found on only one to two plots each. A breakdown of the estimated number of each recorded tree species, as well as the estimate's error, is presented in Appendix 2. The relative abundance of the most common trees by species and diameter class are presented in Table 11 and Figures 7 and 8. Small diameter trees (saplings) are generally the most abundant of the three tree size classes for the 10 most common tree species, representing 82.1 percent of the total, while large diameter trees make up only 5.5 percent of the total (Table 11, Fig. 7). When broken down into 2-inch diameter classes, the five most common species by number showed an abundance distribution similarly skewed toward smaller diameter trees, though green ash shows a more even distribution across all size classes with a notable increase in the 11.0+ class (Fig. 8).

Table 10.—Urban forest tree species composition, city of Milwaukee, 2021

Common name	Trees (number)	Percent
common buckthorn	1,450,000	39.8
boxelder	416,000	11.4
green ash	278,000	7.6
sugar maple	223,000	6.1
Amur maple	192,000	5.2
Norway maple	124,000	3.4
black locust	91,000	2.5
American elm	88,000	2.4
apple spp.	64,000	1.8
eastern cottonwood	63,000	1.7
blue spruce	50,000	1.4
white mulberry	46,000	1.3
hawthorn spp.	41,000	1.1
northern red oak	40,000	1.1
silver maple	38,000	1.0
bur oak	36,000	1.0
red mulberry[a]	35,000	1.0
honeylocust	30,000	0.8
white spruce	29,000	0.8
tree of heaven	24,000	0.7
white oak	23,000	0.6
Siberian elm	23,000	0.6
black walnut	21,000	0.6
Japanese yew	21,000	0.6
eastern white pine	19,000	0.5
white ash	16,000	0.5
American basswood	14,000	0.4
littleleaf linden	14,000	0.4
northern white-cedar	14,000	0.4
Norway spruce	12,000	0.3
shagbark hickory	9,500	0.3
black cherry	9,400	0.3
hackberry	9,300	0.3
Callery pear	9,100	0.3
Douglas-fir	5,900	0.2
black maple	5,700	0.2
eastern redcedar	5,300	0.1
northern catalpa	5,300	0.1
Freeman maple	5,300	0.1
black willow	4,700	0.1
red pine	3,900	0.1
Japanese tree lilac	3,500	0.1
paper birch	3,300	0.1
Canada plum	3,300	0.1
balsam poplar	2,300	0.1
pin oak	2,300	0.1
slippery elm	2,000	0.1
Austrian pine	1,900	0.1
ginkgo, maidenhair tree	1,900	0.1
Kentucky coffeetree	1,900	0.1
chinkapin oak	1,900	0.1
horse chestnut	1,900	0.1
European beech	1,900	0.1
red maple	1,700	<0.1
Chinese magnolia	1,700	<0.1
Total	**3,650,000**	**100.0**

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

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

Amur maple, as well as tree of heaven and other species, were found on only one plot each in this category.

[a] Due to difficult identification, red mulberry may actually be white mulberry. These will be reassessed at plot remeasurement.

[5] Common and scientific names for tree species observed in the 2021 Urban FIA inventory of Milwaukee are reported in Appendix 2.

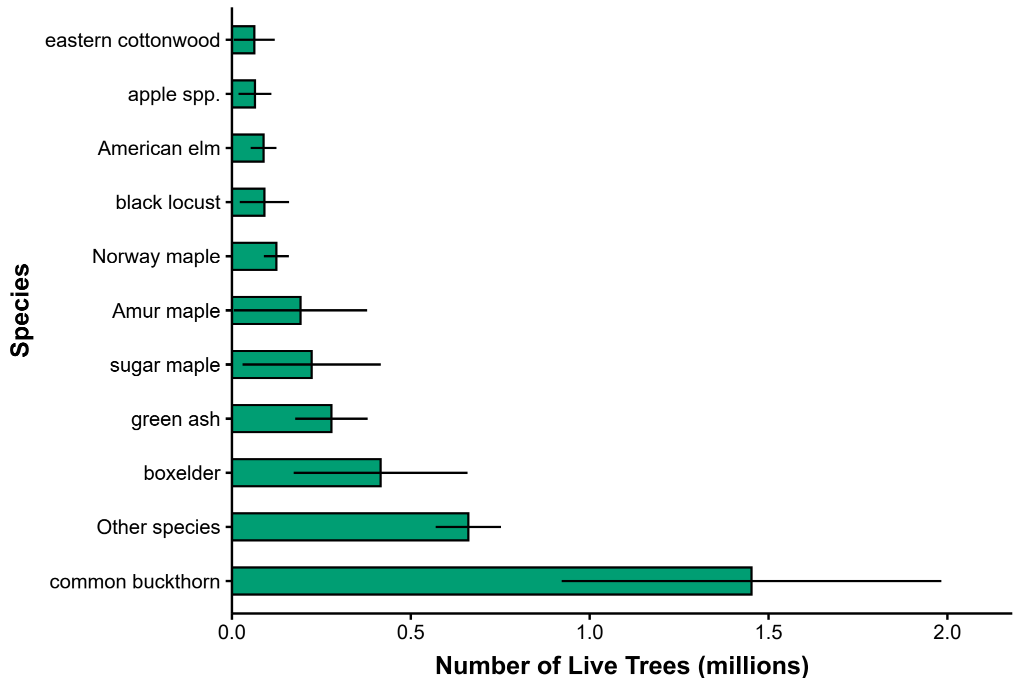

Figure 6.—The 10 most common tree species by number of trees, city of Milwaukee, 2021. Other species is the total for all other tree species in the inventory. Error bars represent 68 percent confidence intervals around the estimated means.

Table 11.—Number of trees by diameter class for the 10 most common tree species, city of Milwaukee, 2021

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)
common buckthorn	1,400,000	54,000	1,700	1,450,000
boxelder	290,000	98,000	28,000	416,000
green ash	146,000	90,000	42,000	278,000
sugar maple	175,000	44,000	3,600	223,000
Amur maple[a]	192,000	0	0	192,000
Norway maple	45,000	20,000	59,000	124,000
black locust	73,000	7,900	9,900	91,000
American elm	46,000	33,000	9,000	88,000
apple spp.	44,000	11,000	9,100	64,000
eastern cottonwood	49,000	9,900	3,600	63,000
Total	**2,460,000**	**368,000**	**166,000**	**2,990,000**

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

Standard errors for each estimate are reported in Appendix 2.

[a] Amur maple was found on only one plot in this category.

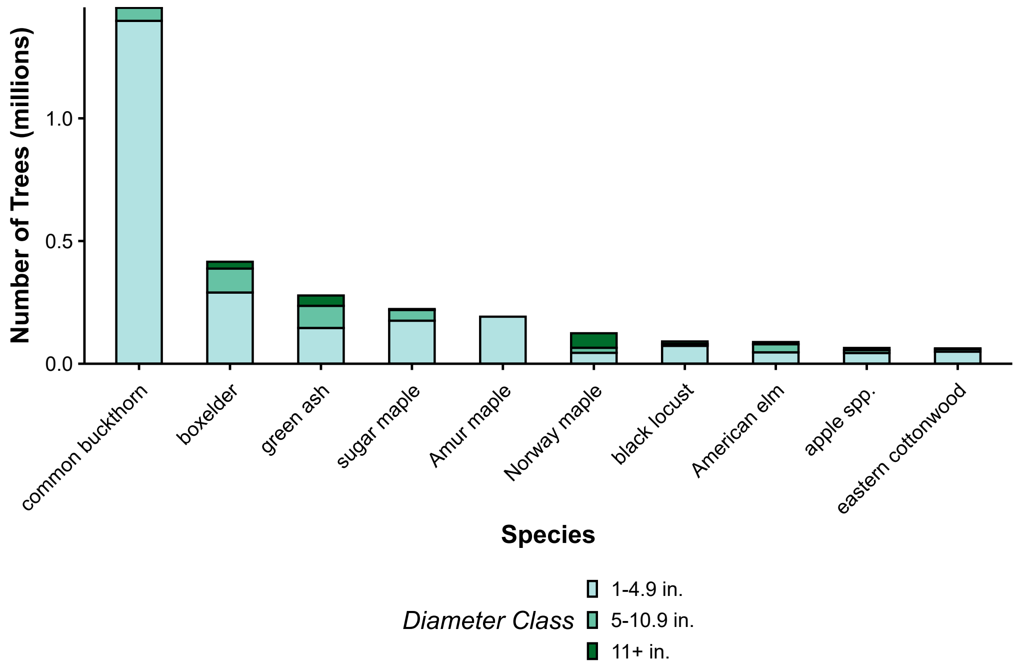

Figure 7.—The number of trees in each diameter class for the 10 most common tree species, city of Milwaukee, 2021.

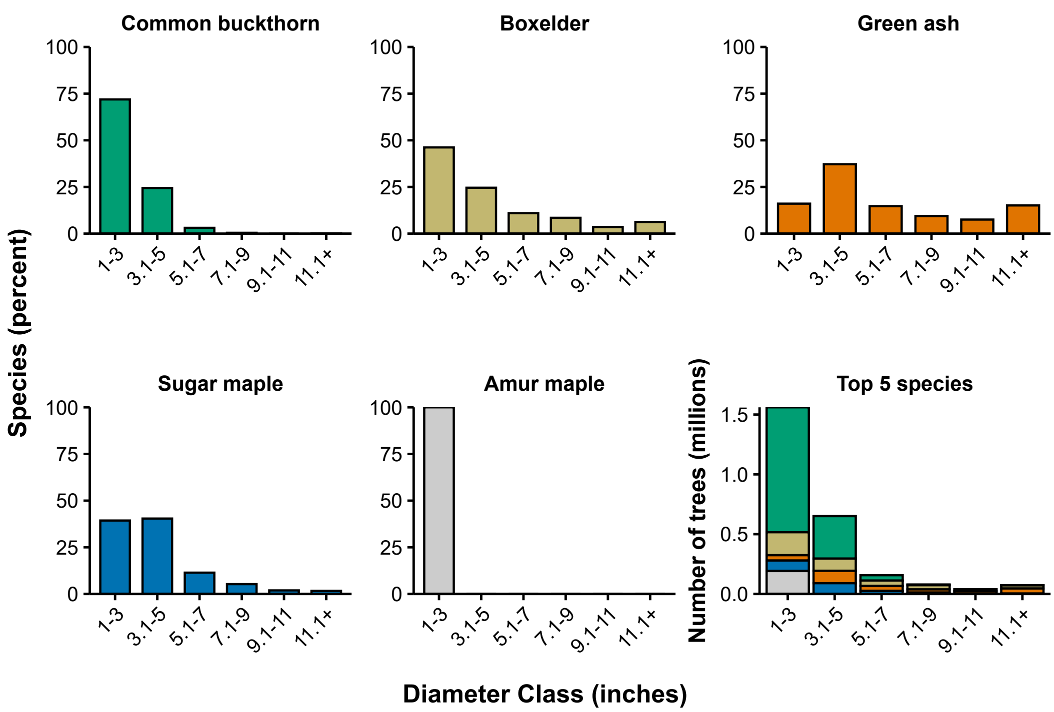

Figure 8.—Percentage of species population by diameter class for the five most common tree species, city of Milwaukee, 2021.

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 two most common species in terms of stem numbers in the smallest-diameter size classes (less than 5.0 inches in diameter) are common buckthorn and boxelder, together representing more than half (64.9 percent) of all live trees less than 5.0 inches in diameter (Table 12, Appendix 2). Boxelder, green ash, and common buckthorn are the most common species in intermediate diameter size classes, representing 36.8 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 Norway maple, green ash, and boxelder, which represent 32.4 percent of live trees at least 11.0 inches in diameter (Table 12, Appendix 2).

Table 12.—The five most common tree species by number of trees within each diameter class, city of Milwaukee, 2021

Diameter class (inches)	Common name	Trees (number)
1.0–4.9	common buckthorn	1,400,000
	boxelder	290,000
	Amur maple[a]	192,000
	sugar maple[a]	175,000
	green ash	146,000
5.0–10.9	boxelder	98,000
	green ash	90,000
	common buckthorn	54,000
	sugar maple	44,000
	northern red oak	35,000
11.0+	Norway maple	59,000
	green ash	42,000
	boxelder	28,000
	honeylocust	20,000
	red mulberry	18,000

Estimates are rounded.

Standard errors for each estimate are reported in Appendix 2.

[a] This species was found on only one plot in this category.

In Milwaukee, tree species composition on private land is dominated by common buckthorn (35.4 percent), Amur maple (12.3 percent), and green ash (9.6 percent) (Table 13). The most common tree species on public lands are common buckthorn (43.0 percent), boxelder (14.2 percent), and sugar maple (10.4 percent) (Table 14). A total of 46 tree species are recorded on private lands, resulting in a **Shannon-Wiener diversity index** value of 2.5. The 38 species of trees recorded on public lands results in a Shannon-Wiener diversity index value of 2.2. 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 2.0–3.5 within cities measured using Urban FIA protocol. On both private and public land, the three genera with the greatest number of trees are buckthorn (*Rhamnus*), maple (*Acer*), and ash (*Fraxinus*) (Fig. 9). Species composition within NLCD land cover class groups is detailed in Appendix 3.

Table 13.—Tree species composition on private lands, city of Milwaukee, 2021

Common name	Trees (percent)
common buckthorn	35.4
Amur maple	12.3
green ash	9.6
boxelder	7.6
eastern cottonwood	3.9
blue spruce	3.1
white mulberry	2.6
Norway maple	2.5
American elm	2.3
silver maple	2.1
red mulberry	2.0
tree of heaven	1.5
black locust	1.5
white oak	1.4
Japanese yew	1.3
black walnut	1.0
northern white-cedar	0.9
Norway spruce	0.8
honeylocust	0.7
apple spp.	0.7
Siberian elm	0.6
shagbark hickory	0.6
Callery pear	0.6
white ash	0.5
sugar maple	0.4
eastern redcedar	0.3
white spruce	0.3
northern catalpa	0.3
littleleaf linden	0.3
Scotch pine	0.2
Freeman maple	0.2
Japanese tree lilac	0.2
paper birch	0.2
Canada plum	0.2
balsam poplar	0.2
pin oak	0.2
black maple	0.1
red pine	0.1
ginkgo, maidenhair tree	0.1
horse chestnut	0.1
European beech	0.1
eastern white pine	0.1
red maple	0.1
hawthorn spp.	0.1
bur oak	0.1
Chinese magnolia	0.1

Estimates are rounded.

Amur maple, as well as tree of heaven, black locust, and other species, were found on only one plot each in this category.

Table 14.—Tree species composition on public lands, city of Milwaukee, 2021

Common name	Trees (percent)	Common name	Trees (percent)	Common name	Trees (percent)
common buckthorn	43.0	American basswood	0.7	English elm	0.2
boxelder	14.2	Siberian elm	0.6	red pine	0.1
sugar maple	10.4	black cherry	0.4	eastern cottonwood	0.1
green ash	6.1	hackberry	0.4	slippery elm	0.1
Norway maple	4.1	littleleaf linden	0.4	Austrian pine	0.1
black locust	3.2	white ash	0.4	Kentucky coffeetree	0.1
apple spp.	2.6	Douglas-fir	0.3	chinkapin oak	0.1
American elm	2.5	white mulberry	0.3	blue spruce	0.1
northern red oak	1.9	silver maple	0.3	white oak	0.1
hawthorn spp.	1.9	black walnut	0.2	Freeman maple	0.1
bur oak	1.6	black willow	0.2		
white spruce	1.1	red mulberry	0.2		
honeylocust	0.9	American sycamore	0.2		
eastern white pine	0.8	black maple	0.2		

Estimates are rounded.

Sugar maple, as well as black locust, bur oak, and other species, were found on only one plot each in this category.

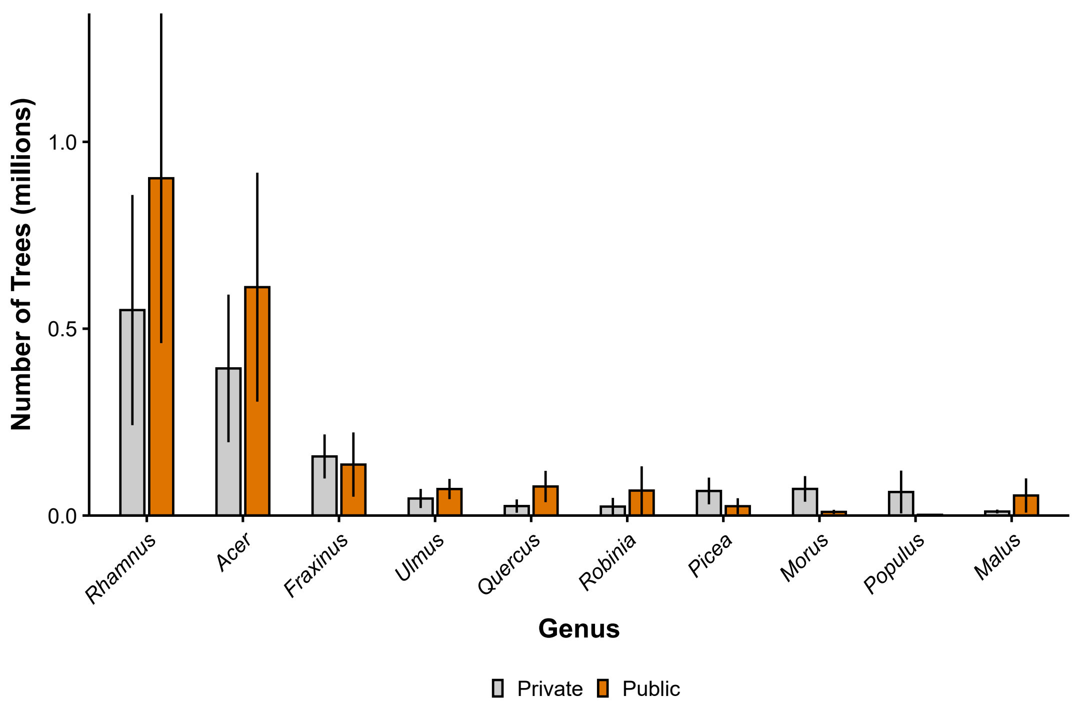

Figure 9.—The 10 most common tree genera within ownership classes, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Trees in Maintained Areas

Overall, 22.2 percent of trees in Milwaukee 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 Milwaukee, the most common tree species in maintained areas are Amur maple (23.6 percent of all trees in maintained areas), Norway maple (14.8 percent), and green ash (12.5 percent) (Table 15, Appendix 4).

Table 15.—The 10 most common tree species in maintained areas by number of trees, city of Milwaukee, 2021

Common name	Trees (number)	Percent of all trees in maintained areas
Amur maple	192,000	23.6
Norway maple	120,000	14.8
green ash	101,000	12.5
boxelder	37,000	4.6
silver maple	36,000	4.4
blue spruce	35,000	4.3
honeylocust	28,000	3.5
Japanese yew	21,000	2.6
American elm	20,000	2.4
eastern white pine	19,000	2.4

Estimates are rounded.

Amur maple and Japanese yew were found on only one plot each in this category.

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 3.1–5.0 inches in diameter (11.5 percent), followed by 15.1–17.0 inches in diameter (10.6 percent), and 5.1–7.0 inches in diameter (8.4 percent) (Fig. 10). In Milwaukee, leaf area is greatest in residential land uses (28.8 percent of total leaf area), followed by forest (23.3 percent), and recreation/cemetery land uses (20 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 11.7 in forest land use to 5.2 in rights-of-way (Fig. 11).

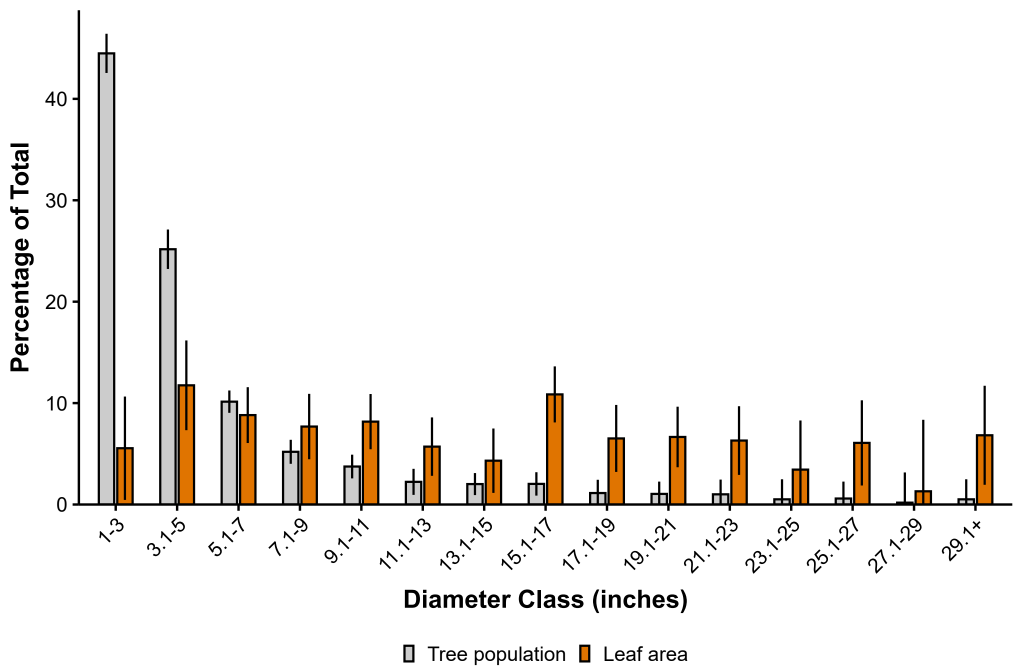

Figure 10.—Percentage of tree population and leaf area by 2-inch diameter class, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

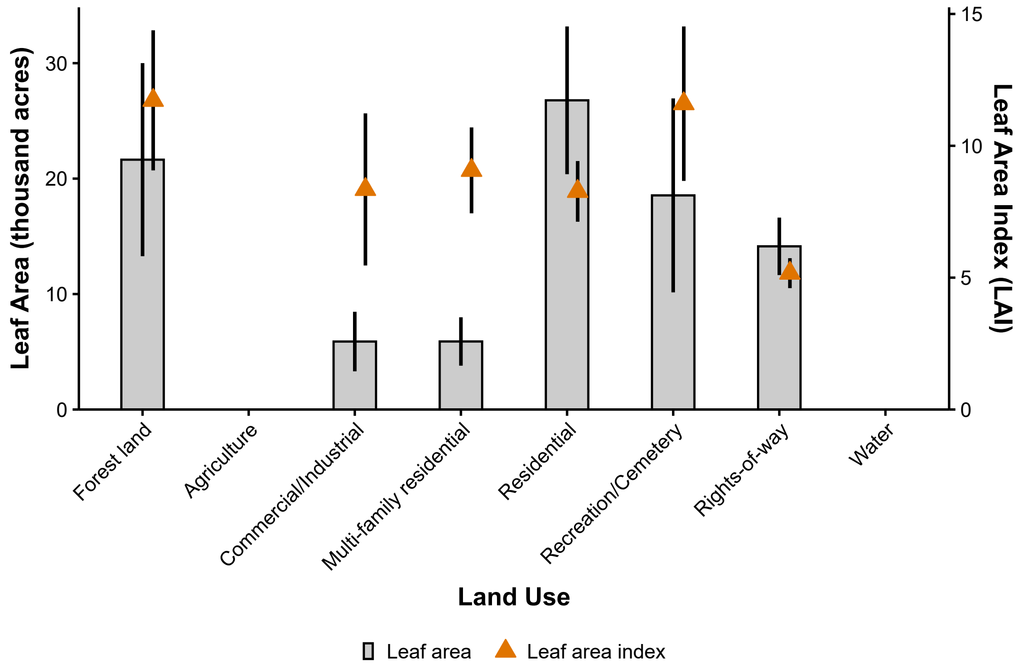

Figure 11.—Leaf area and leaf area index (LAI) by Forest Inventory and Analysis (FIA) land use class, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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 Milwaukee's urban forest with the greatest IVs are common buckthorn (47.3), boxelder (21.5), and green ash (15.3) (Table 16).

Table 16.—Percentage of total tree population represented by tree species with the highest importance value (IV), city of Milwaukee, 2021

Common name	Population (percent)	Leaf area (percent)	Importance value
common buckthorn	41.7	7.5	49.2
boxelder	11.9	10.1	22.0
green ash	8.0	7.7	15.7
sugar maple	6.4	7.7	14.1
Norway maple	3.6	10.3	13.9
silver maple	1.1	5.7	6.8
American elm	2.5	3.7	6.3
black locust	2.6	2.2	4.8
blue spruce	1.4	2.9	4.4
northern red oak	1.2	3.0	4.2

Estimates are rounded.

Importance value = population (%) + leaf area (%).

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VOLUME AND BIOMASS

Sugar maple, basswood, and green ash are common trees at Havenwoods State Forest on Milwaukee's north side. Despite occupying only 6 percent of Milwaukee's area, forest land makes up 26 percent of its urban forest biomass. Courtesy photo by Dan Buckler, Wisconsin Department of Natural Resources.

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 Milwaukee, live trees at least 5.0 inches in diameter are estimated to contain 15.6 million cubic feet of net volume, of which 25.5 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 Milwaukee's urban forest is roughly equivalent to the amount of wood that would be needed to construct 1,756 median-sized homes. Norway maple contributes the greatest net cubic-foot volume at 13.3 percent of the city's total (Table 17). White oak contributes 15.4 percent of the total net board-foot sawtimber volume (Table 18). The greatest net cubic-foot volume is provided by the largest trees which are represented in the 29.1 inches or greater class, which in the Milwaukee dataset includes trees up to 45.3 inches in diameter (Fig. 12).

Table 17.—Net cubic-foot volume for tree species with the greatest net volume, city of Milwaukee, 2021

Common name	Net volume (cubic feet)	Standard error (cubic feet)	Net volume (percent)
Norway maple	2,080,000	550,000	13.3
silver maple	1,350,000	604,000	8.6
green ash	1,230,000	602,000	7.9
white oak	875,000	762,000	5.6
boxelder	732,000	264,000	4.7
honeylocust	704,000	242,000	4.5
blue spruce	634,000	335,000	4.1
northern red oak	611,000	457,000	3.9
red mulberry	543,000	363,000	3.5
sugar maple	533,000	302,000	3.4
Other species	6,320,000	987,000	40.5
Total	**15,600,000**	**2,260,000**	**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 the greatest net volume, city of Milwaukee, 2021

Common name	Net volume (board feet)	Standard error (board feet)	Net volume (percent)
white oak	3,920,000	3,380,000	15.4
blue spruce	3,160,000	1,650,000	12.4
silver maple	2,260,000	2,400,000	8.9
eastern white pine	2,150,000	1,860,000	8.4
Norway spruce	1,920,000	2,040,000	7.6
eastern cottonwood	1,660,000	1,440,000	6.5
green ash	1,310,000	1,030,000	5.1
red pine	1,010,000	712,000	4.0
sugar maple	995,000	966,000	3.9
shagbark hickory	967,000	718,000	3.8
Other species	6,110,000	1,750,000	24.0
Total	**25,470,000**	**8,130,000**	**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.

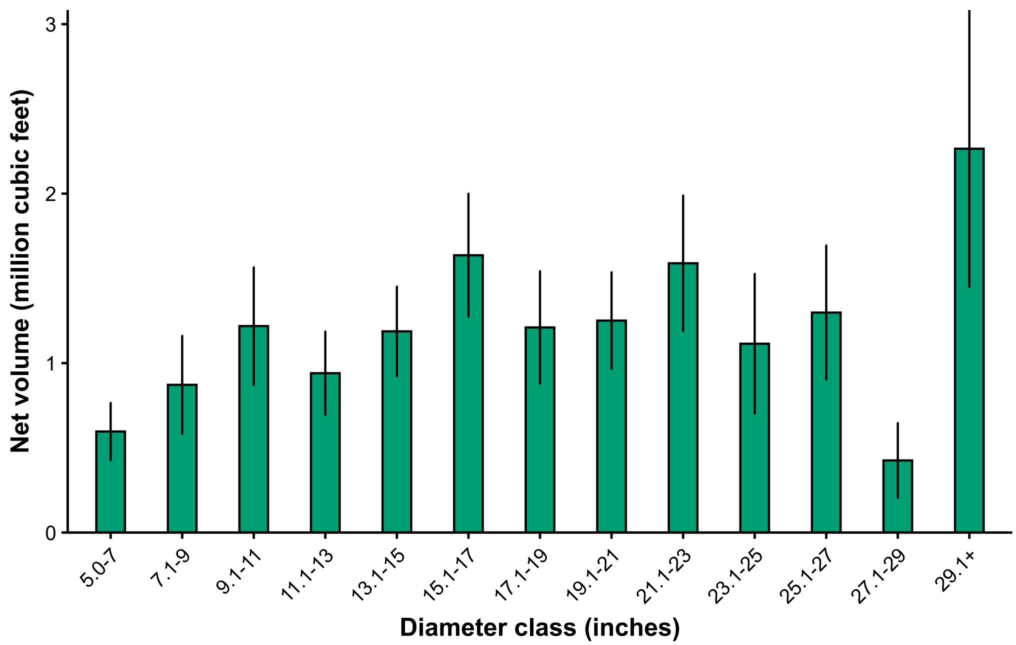

Figure 12.—Net cubic-foot volume by tree diameter class, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated values.

While sawtimber could potentially be derived from urban forests to provide economic value, the broader social-ecological value of this forest is derived from healthy trees. Healthy urban forests provide benefits that support environmental and human health and well-being and are valued at over $18 billion per year nationally (Nowak and Greenfield 2018). Harvesting healthy urban trees will reduce 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 Milwaukee is estimated at 903,000 green tons, which includes the weight of its moisture content (Table 19). The amount of biomass stored by live trees in Milwaukee varies by species. The tree species with the greatest total aboveground biomass are Norway maple (11.5 percent), silver maple (11.2 percent), and boxelder (6.5 percent) (Table 19).

Table 19.—Aboveground biomass for tree species with the greatest biomass, city of Milwaukee, 2021

Common name	Biomass (green tons)	Standard error (green tons)	Biomass (percent)
Norway maple	104,000	27,000	11.5
silver maple	101,000	43,000	11.2
boxelder	59,000	21,000	6.5
green ash	56,000	24,000	6.2
white oak	50,000	44,000	5.6
honeylocust	48,000	16,000	5.3
red mulberry	37,000	25,000	4.1
sugar maple	35,000	21,000	3.8
northern red oak	35,000	24,000	3.8
American elm	33,000	17,000	3.6
Other species	345,000	48,000	38.2
Total	**903,000**	**123,000**	**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

Many Milwaukee residents and visitors enjoy the city's parks and trails, like this one at Havenwoods State Forest on Milwaukee's north side. Courtesy photo by Angela Vickio, Wisconsin Department of Natural Resources.

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 affect 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 Removal

Poor air quality is a common problem in urban areas. Air pollution can adversely affect human health through increased rates of pulmonary, cardiac, vascular, and neurological diseases and mortality (Pope et al. 2002), along with negatively impacting ecosystem processes and reducing visibility. Urban forests can improve air quality by directly removing pollutants from the air and reducing energy consumption by buildings, which consequently reduces air pollution emissions from power plants and other energy sources. While trees emit volatile organic compounds (VOCs) that can contribute to ozone (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 Milwaukee is greatest for O_3 (256.6 tons per year), followed by nitrogen dioxide (NO_2; 49.2 tons per year), sulfur dioxide (SO_2; 12.0 tons per year), particulate matter less than 2.5 microns ($PM_{2.5}$; 11.2 tons per year), and carbon monoxide (CO; 3.8 tons per year) (Fig. 13). The economic value of this pollution removed is estimated using i-Tree methodology in one of two ways, depending on the pollutant. For NO_2, SO_2, O_3, and $PM_{2.5}$, estimates are based on avoided health effects due to lower pollution concentrations. For CO, the estimated value is based on the avoided externality costs of air pollution to society (Nowak 2024). The estimated value associated with pollution removal is greatest for $PM_{2.5}$ ($3.3 million), followed by O_3 ($2.0 million), NO_2 ($58,000), CO ($5,100), and SO_2 ($3,700) (Table 20). It is estimated that trees in Milwaukee remove a total of 333 tons of air pollution per year with an associated value of $5.3 million More information about value calculations can be found in Baer et al. (2025).

Decreases in the concentration of various air pollutants due to removal by trees is expected to have a positive effect on human health in Milwaukee (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 583 fewer cases of acute respiratory symptoms per year with an associated value of over $50,000 (Table 20).

Trees in Milwaukee emit an estimated 196 tons of VOCs (67 tons of isoprene and 129 tons of monoterpenes) per year. Emissions vary among species based on species characteristics (e.g., some genera such as oaks are high isoprene emitters) and leaf biomass. Oak (*Quercus*) and spruce (*Picea*) contribute 57.6 percent of VOC emissions (Fig. 14). These VOCs are precursor chemicals to ozone formation.

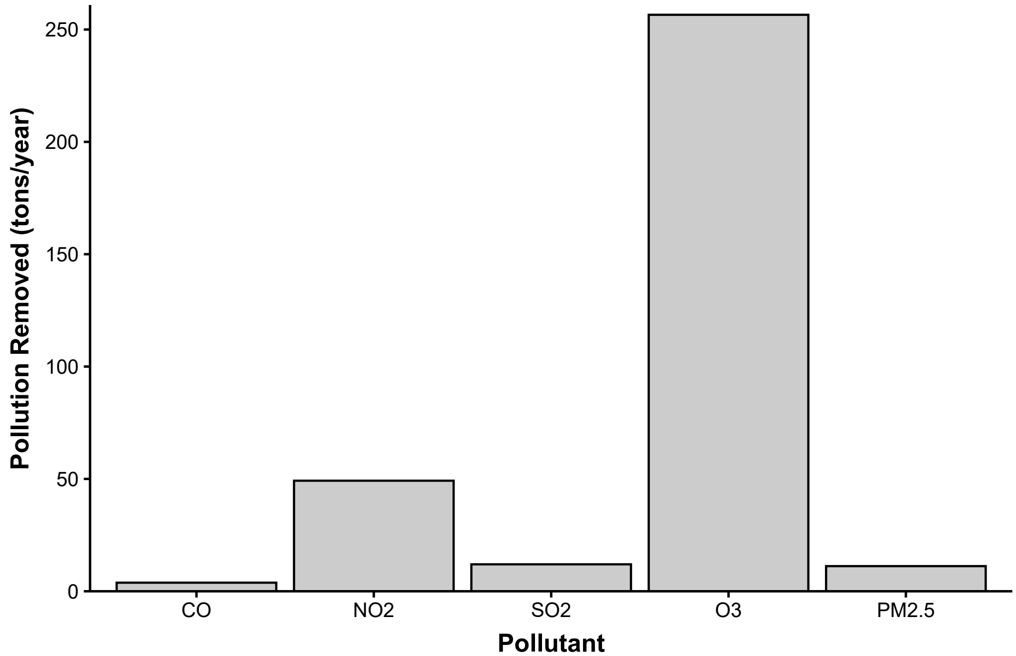

Figure 13.—Air pollution removal by trees, city of Milwaukee, 2021.

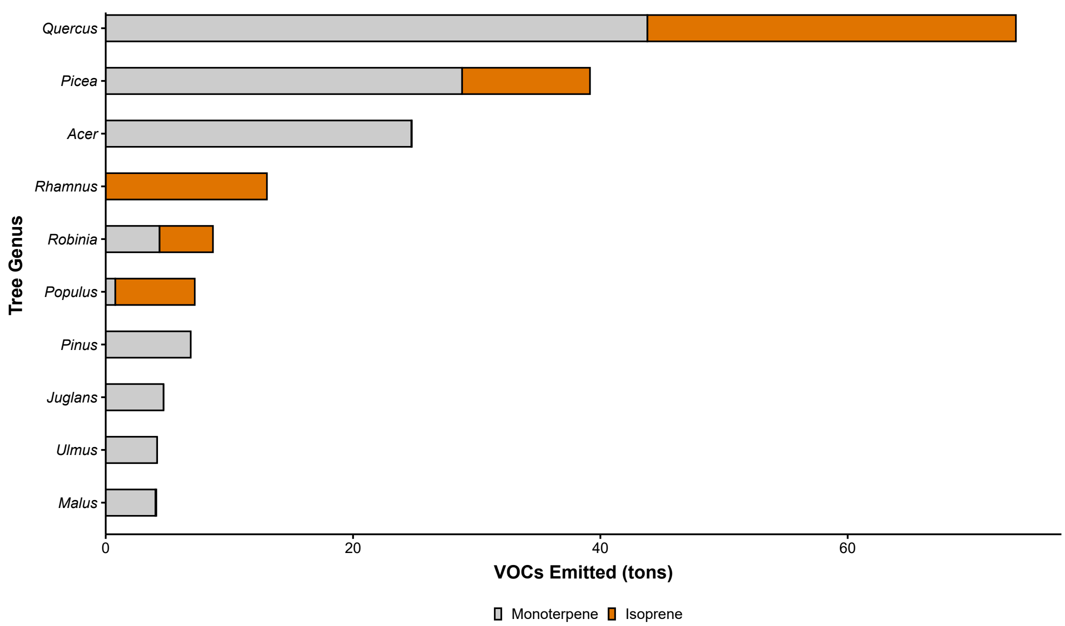

Figure 14.—Volatile organic compound (VOC) emissions by tree genus, city of Milwaukee, 2021.

Table 20.—Incidence and associated value of avoided health effects from changes in pollution concentrations due to pollution removal by trees, city of Milwaukee, 2021

	Nitrogen dioxide (NO_2)		Ozone (O_3)		Particulate matter ($PM_{2.5}$)		Sulfur dioxide (SO_2)	
Health effect	**Incidence (cases/year)**	**Associated value ($/year)**	**Incidence (cases/year)**	**Associated value ($/year)**	**Incidence (cases/year)**	**Associated value ($/year)**	**Incidence (cases/year)**	**Associated value ($/year)**
Acute bronchitis	–	–	–	–	0.3	24.5	–	–
Acute myocardial infarction	–	–	–	–	0.1	12,000	–	–
Acute respiratory symptoms	27.1	850	400	34,000	150	15,000	2.2	69.3
Asthma exacerbation	400	34,000	–	–	140	12,000	19.2	1,500
Chronic bronchitis	–	–	–	–	0.1	28,000	–	–
Emergency room visits	0.5	210	0.4	150	0.4	160	0.1	53.4
Hospital admissions	0.8	23,000	0.5	15,000	–	–	0.1	2,100
Hospital admissions, cardiovascular	–	–	–	–	<0.1	1,800	–	–
Hospital admissions, respiratory	–	–	–	–	<0.1	850	–	–
Lower respiratory symptoms	–	–	–	–	5.1	270	–	–
Mortality	–	–	0.2	1,900,000	0.4	3,240,000	–	–
School loss days	–	–	190	19,000	–	–	–	–
Upper respiratory symptoms	–	–	–	–	2.5	110	–	–
Work loss days	–	–	–	–	23.4	3,800	–	–
Total	**430**	**58,000**	**590**	**1,960,000**	**330**	**3,310,000**	**21.6**	**3,700**

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

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

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

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 Milwaukee are estimated to reduce runoff by 13 million cubic feet per year (101 million gallons annually), with an estimated value of $901,188 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 Norway maple, boxelder, and sugar maple due to their large leaf surface area (Fig. 15).

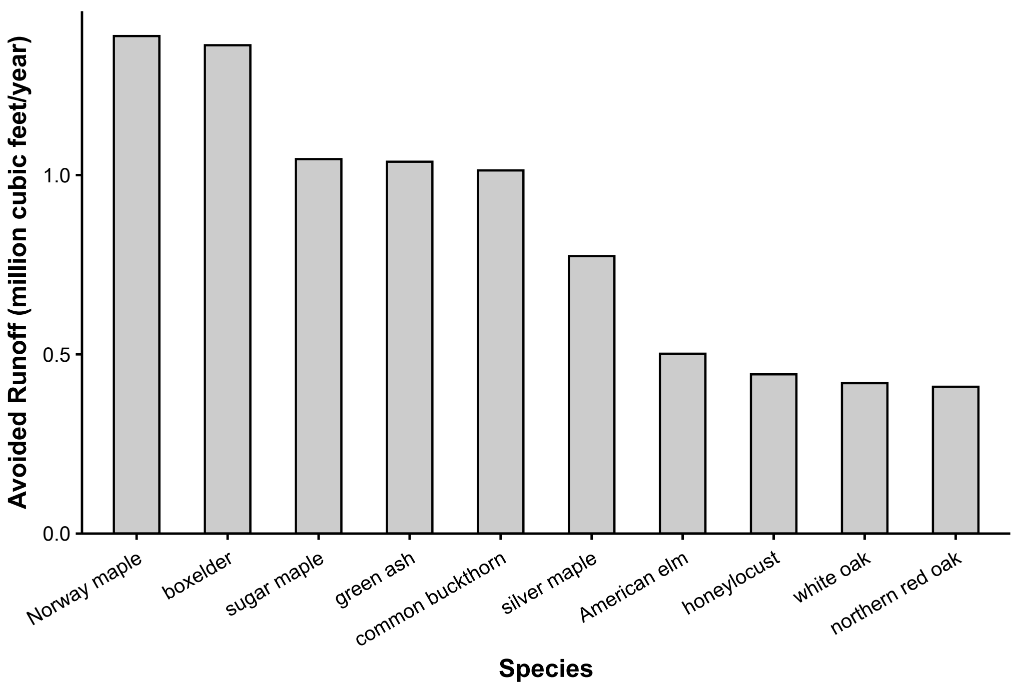

Figure 15.—Avoided runoff for the 10 tree species with the greatest leaf area, city of Milwaukee, 2021.

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 Milwaukee, interactions between buildings and trees 5.0 inches in diameter and greater are projected to annually decrease energy requirements by 215,000 gigajoules (GJ) during the heating and cooling seasons (an energy equivalent of 1.4 million gallons of home heating fuel oil) (Table 21), with an annual savings in energy costs of $3.4 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 2014c), 2012 residential electricity 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 (CO_2) emissions from fossil-fuel-based power sources by 23,900 tons annually (6,500 tons of carbon; $1,242,000), equivalent to the burning of over 16.7 million pounds of coal or roughly 50,462 barrels of oil (Hong and Slatick 1994, U.S. EPA 2020).

Table 21.—Annual energy savings due to live and standing dead trees 5.0+ inches in diameter near residential buildings during heating and cooling seasons, city of Milwaukee, 2021

Reduced energy use and emissions	Cooling	Heating	Total
Carbon avoided (tons)	2,100	4,400	6,500
Energy effects (GJ)	47,000	167,000	215,000

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

To convert carbon estimates to carbon dioxide, multiply carbon value by 3.667.

GJ = gigajoule (one billion [10^9] joules).

Table 22.—Annual monetary savings due to live and standing dead trees 5.0+ inches in diameter near residential buildings during heating and cooling seasons, city of Milwaukee, 2021

Reduced energy use and emissions	Cooling ($)	Heating ($)	Total ($)
Carbon avoided	403,000	840,000	1,240,000
Energy effects	1,950,000	1,480,000	3,430,000

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

Based on 2012 statewide energy costs (U.S. EIA 2012a, 2012b, 2014b, 2014c) and 2015 social cost of carbon (Interagency Working Group 2013, U.S. EPA 2015).

Carbon Storage and Sequestration

Climate change is an issue of global concern that threatens vulnerable species and ecosystems 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 CO_2 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 CO_2) 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 Milwaukee store an estimated 334,955 tons of carbon (1.2 million tons of CO_2) valued at $57.1 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 green ash, Norway maple, and silver maple (Fig. 17).

Table 23.—Aboveground and belowground carbon in live and standing dead trees by Forest Inventory and Analysis (FIA) land use class, city of Milwaukee, 2021

FIA land use class	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)
Residential	95,000	14,000	2000	110,000	30,000
Forest land	37,000	7,200	42000	86,000	25,000
Recreation/Cemetery	48,000	7,800	200	56,000	21,000
Rights-of-way	41,000	6,200	1100	48,000	10,000
Commercial/Industrial	15,000	2,200	440	18,000	7,700
Multi-family residential	14,000	2100	76	17,000	7,200
Agriculture	3,100	450	0	3,500	2,700
Total	**250,000**	**39,000**	**46,000**	**335,000**	**–**
Standard error	**35,000**	**5,800**	**14000**	**44,000**	**–**

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

– = no value for cell.

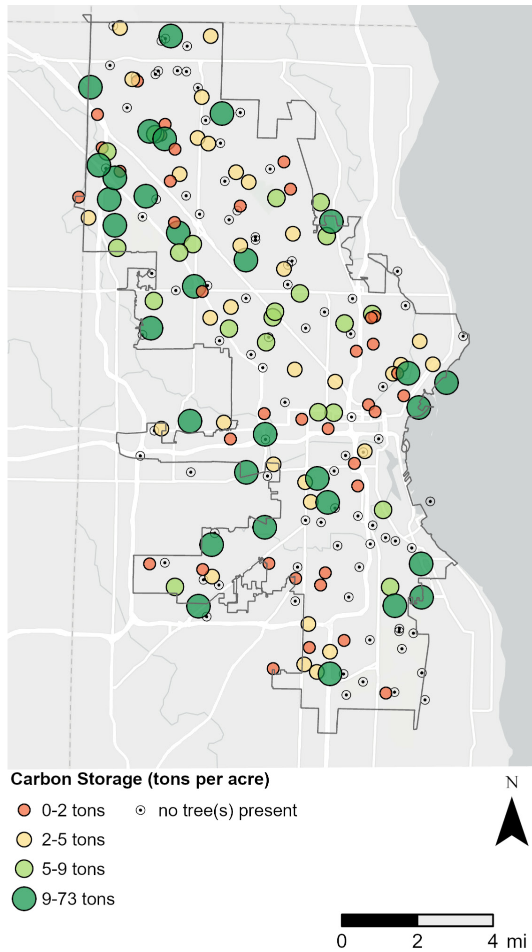

Figure 16.—Carbon storage per acre is shown for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, city of Milwaukee, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

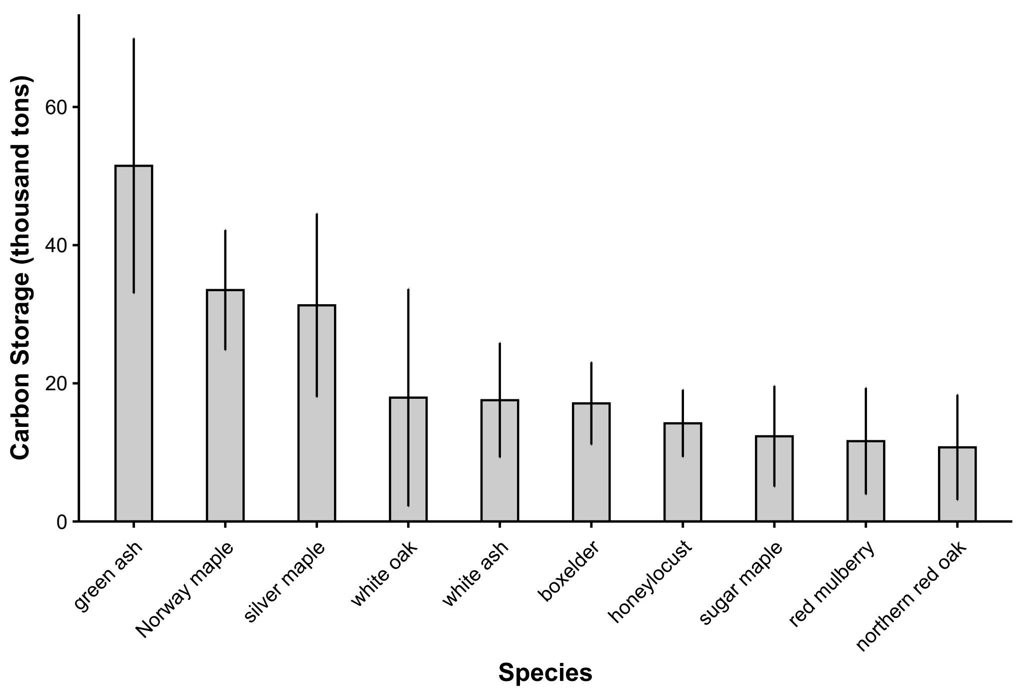

Figure 17.—Live and dead carbon storage for the 10 tree species with the greatest carbon storage, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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 Milwaukee is about 10,200 tons of carbon per year (37,000 tons per year of CO_2) with an associated value of $1.7 million per year, which is roughly equivalent to the annual emissions associated with 7,300 passenger vehicles or energy usage by 4,100 homes (U.S. EPA 2020). Norway maple is estimated to sequester the most carbon of all species in the urban forest (12.8 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.

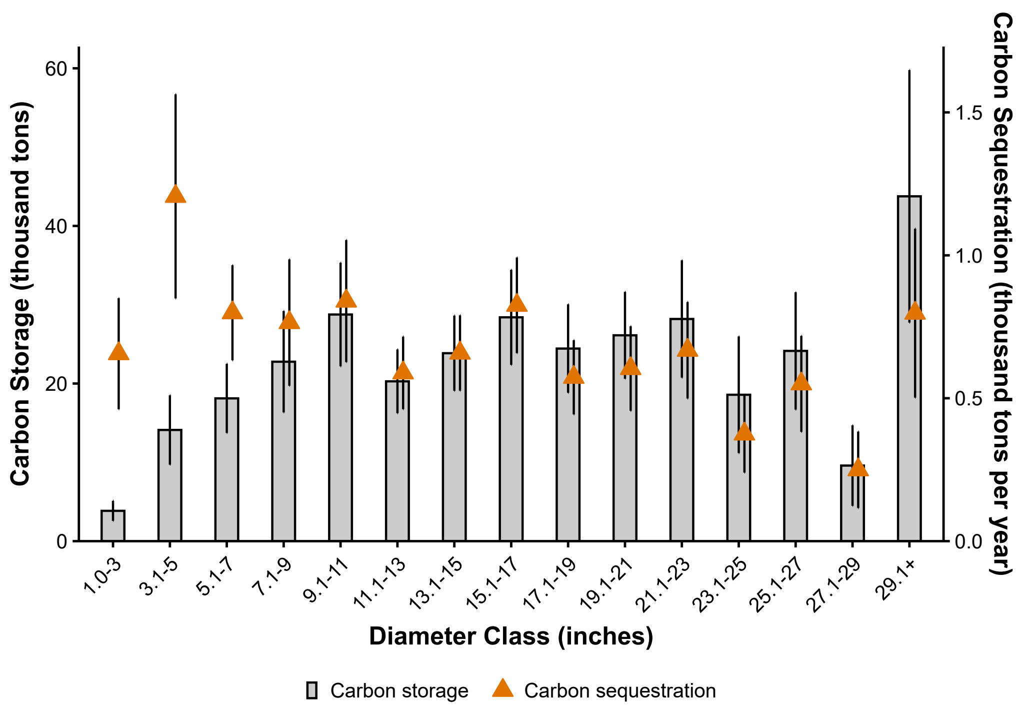

Figure 18.—Total live and dead carbon storage and sequestration by diameter class, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

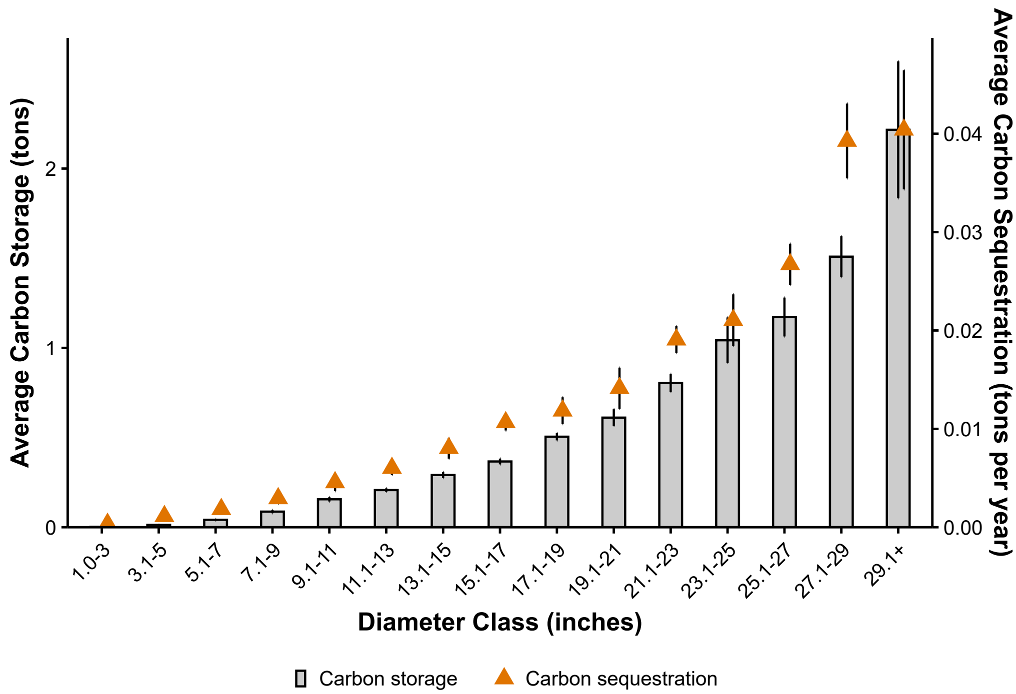

Figure 19.—Average per tree live and dead carbon storage and sequestration by diameter class, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

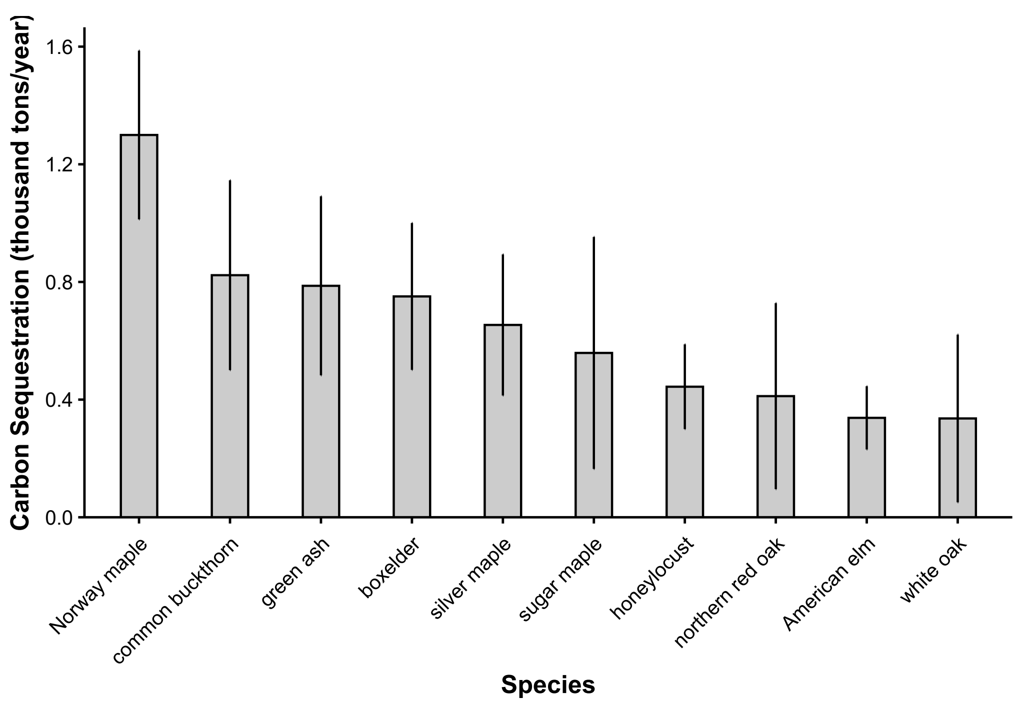

Figure 20.—Carbon sequestration for the 10 tree species with the greatest annual carbon sequestration, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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, nonnative, or invasive. Additionally, invasive species can still contribute some ecosystem services.

The compensatory value of the trees in Milwaukee is estimated to be about $1.24 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 Milwaukee are Norway maple, green ash, and honeylocust (Fig. 21). The mean compensatory value per acre for all surveyed plots in Milwaukee is $19,118; for the 56.7 percent of these plots that contain trees, the mean compensatory value per acre is $33,700 (Fig. 22). The structural value of urban trees in Milwaukee is a combination of their compensatory value (estimated at $1.24 billion) and the value associated with carbon storage by the trees (estimated at $57.1 million).

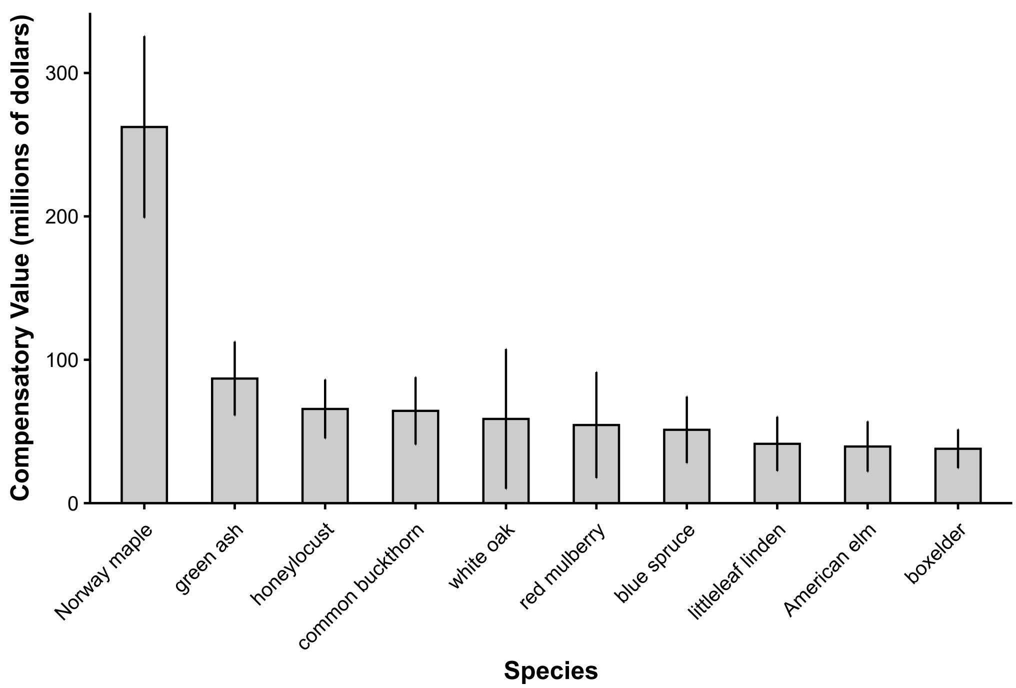

Figure 21.—The 10 tree species with the greatest compensatory value, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

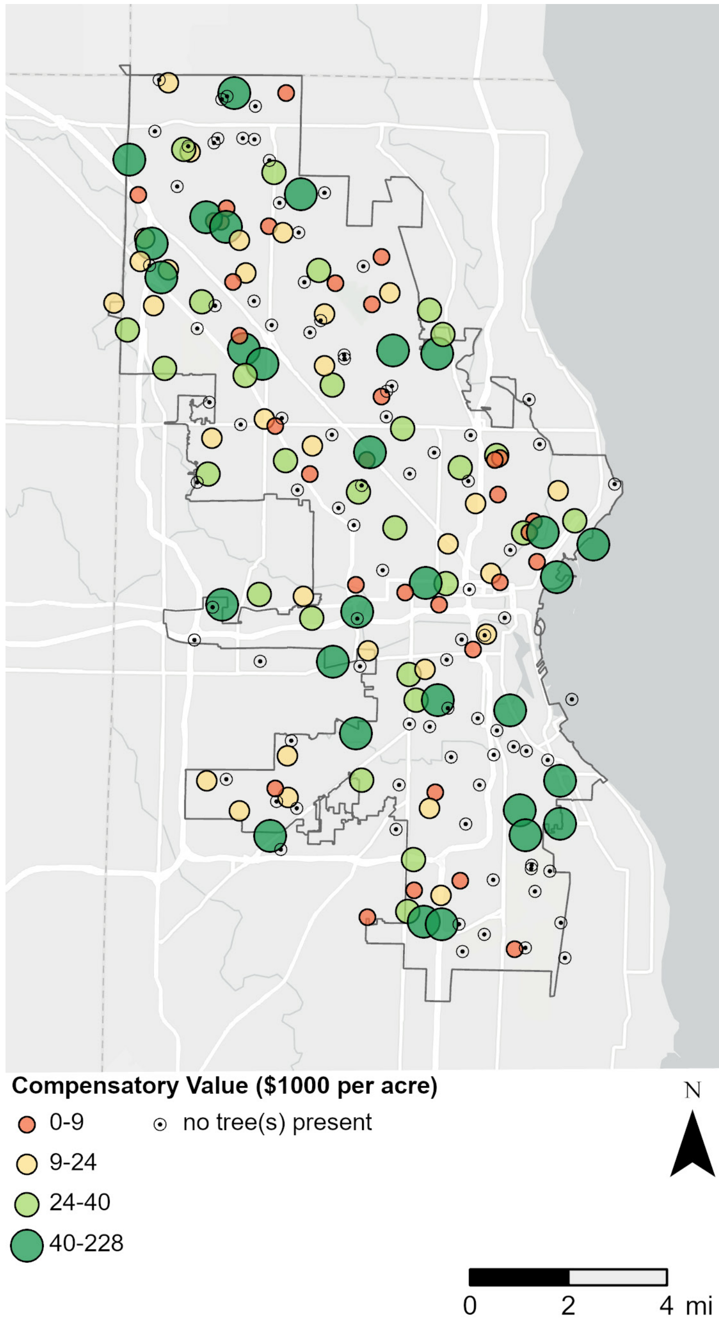

Figure 22.—Compensatory value per acre for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, city of Milwaukee, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

URBAN FOREST HEALTH

Spongy moth is an invasive pest present in many parts of Wisconsin, including Milwaukee. Caterpillars feed on over 300 tree species across the country, though outbreaks of large population increases occur in some areas every 10 to 12 years. Urban FIA data could be used to identify trees potentially impacted by pests and diseases. Courtesy photo by Dan Buckler, Wisconsin Department of Natural Resources.

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 Milwaukee. 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, Siberian elm has the highest average dieback (19.0 percent) (Table 24). Approximately 16.6 percent of Siberian elm displays greater than 25 percent crown dieback, indicating that this species may be threatened by insect, disease, or environmental stressors in Milwaukee.

Table 24.—The 10 tree species with the greatest average dieback, city of Milwaukee, 2021

Common name	Average dieback (percent)	Standard error (percent)	Trees with more than 25 % dieback (percent)
Siberian elm	19.0	12.3	16.6
apple spp.	8.7	1.1	2.2
white oak	8.1	1.9	5.8
green ash	7.9	2.7	4.4
red mulberry	5.7	0.9	2.5
common buckthorn	2.1	1.0	0.5
honeylocust	1.7	0.4	0.0
boxelder	1.6	1.1	1.3
sugar maple	1.5	0.0	0.0
Norway maple	1.2	0.5	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.

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 mulberry and boxelder (Table 25).

Table 25.—The 10 tree species with the greatest average rot, city of Milwaukee, 2021

Common name	Average rot (percent)	Standard error (percent)	Trees with more than 15 % rot (percent)
red mulberry	3.6	0.6	0.0
boxelder	2.5	1.1	0.4
apple spp.	2.5	0.6	0.4
Norway maple	2.0	0.4	0.2
green ash	1.9	1.4	0.7
white oak	1.5	0.4	0.0
silver maple	1.2	0.8	0.0
Siberian elm	0.9	0.6	0.0
black walnut	0.4	0.2	0.0
common buckthorn	0.3	0.3	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 at least 5.0 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 human activities are the most common causes of damage, affecting 15.5 and 6.4 percent of trees, respectively (Table 26).

Table 26.—Percentage of trees with observed damage by damage type, city of Milwaukee, 2021

Damage type	Trees (percent)
Boring insects	0.1
Cankers	0.5
Decline complexes/dieback/wilts	0.1
Emerald ash borer	4.1
Foliage diseases	0.1
Human activities	6.4
Imbedded objects	4.6
Nectria canker	1.3
Snow/ice	0.8
Stem decay	15.5
Sugar maple borer	0.1
Vine damage	0.6
Wild animals	0.7
Wind	0.1
Other damages and symptoms	
Broken top	0.1
Dead top	3.0
Dieback	0.6
Foliage discoloration	<0.1
Other damages and symptoms	4.2

Estimates are rounded.

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

- **bark inclusion,**
- **conflict with crown,**
- **conflict with roots,**
- **excessive mulch,**
- **improper planting,**
- **root/stem girdling, and**
- **topping/pruning.**

Bark inclusion is the most common issue, occurring in 25.6 percent of trees. Conflict with crown and topping/pruning are the second and third most common urban specific infrastructure issues, occurring in 8.2 and 4.7 percent of trees, respectively (Fig. 23).

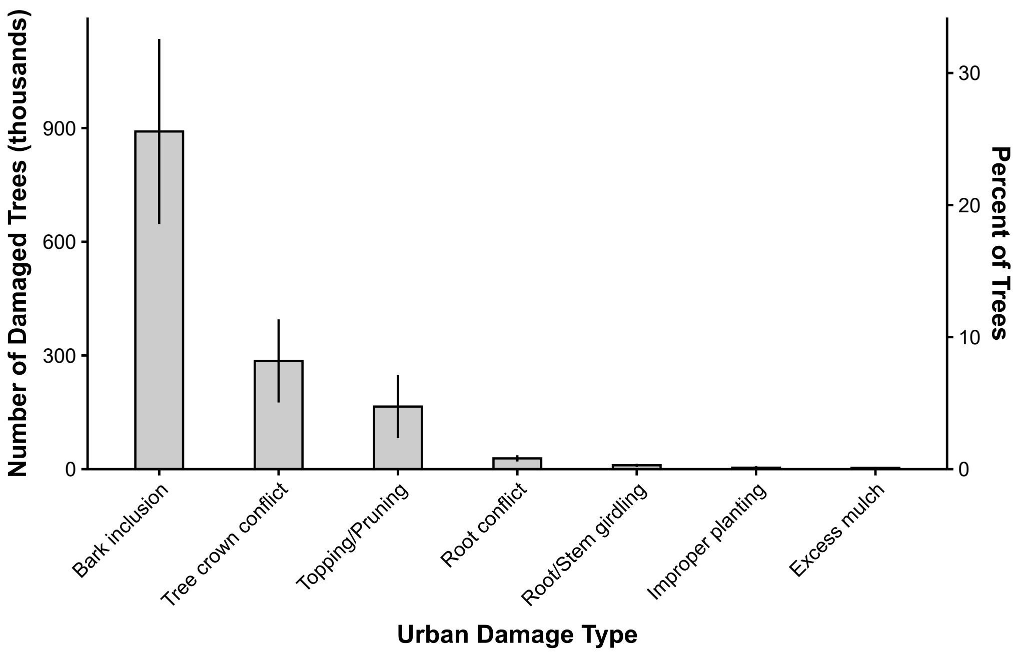

Figure 23.—Number and percentage of trees by urban infrastructure issue category, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Differences exist in the prevalence of these issues among the FIA-designated land uses and may further inform forest health and management priorities. In Milwaukee, bark inclusion occurs in 43.3 percent of trees on multi-family residential land, conflict with crown in 38.5 percent of trees on residential land, and bark inclusion in 36.4 percent of trees on forest 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 Siberian elm (100.0 percent affected by bark inclusion) and red mulberry (87.8 percent affected by bark inclusion) (Table 27).

Table 27.—Percentage of trees identified with damage, maintenance, and site issues, city of Milwaukee, 2021

Common name	Number of trees	Standard error	Bark inclusion (percent)	Crown conflict (percent)	Excess mulch (percent)	Improper planting (percent)	Root conflict (percent)	Root/ stem girdling (percent)	Topping/ pruning (percent)
American elm	88,400	36,000	11.4	12.2	0.0	0.0	1.9	0.0	0.0
apple spp.	64,400	45,900	84.7	6.0	0.0	0.0	0.0	0.0	3.0
black locust	90,800	68,900	30.7	0.0	0.0	0.0	0.0	0.0	0.0
black walnut	20,800	8,500	27.2	18.5	0.0	0.0	0.0	0.0	0.0
blue spruce	50,000	29,100	0.0	7.7	0.0	0.0	0.0	0.0	0.0
boxelder	415,600	243,000	11.4	2.5	0.0	0.0	0.0	0.0	19.6
common buckthorn	1,452,400	530,700	31.0	5.7	0.0	0.0	0.0	0.0	1.4
eastern white pine	19,400	17,300	0.0	0.0	0.0	0.0	0.0	0.0	0.0
green ash	278,100	101,300	19.8	20.7	0.0	1.0	0.6	0.0	7.4
honeylocust	29,800	10,000	5.6	23.2	0.0	0.0	11.2	0.0	18.7
northern red oak	40,200	31,800	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Norway maple	124,200	35,000	19.5	25.1	1.5	0.0	5.8	5.6	0.0
red mulberry	35,300	23,800	87.8	15.6	0.0	0.0	0.0	0.0	11.0
Siberian elm	22,600	12,800	100.0	0.0	0.0	0.0	0.0	0.0	0.0
silver maple	37,800	22,600	22.7	27.1	0.0	0.0	5.1	0.0	0.0
sugar maple	222,900	193,200	1.6	0.0	0.0	0.0	0.0	0.0	0.0
white mulberry	45,700	25,300	30.9	0.0	0.0	0.0	0.0	0.0	7.8
white oak	23,000	17,500	15.6	7.2	0.0	0.0	0.0	0.0	0.0
white spruce	28,600	21,300	5.8	6.7	0.0	0.0	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.

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 25 plots in Milwaukee. Of the total live and dead tree population, 17.3 percent are estimated to be standing dead trees. The tree species with the highest percentage of standing dead trees are weeping willow (*Salix babylonica*), white ash, and green ash (Table 28). The only weeping willow encountered during the 2021 Urban FIA inventory of Milwaukee was dead. The species that makes up the largest proportion of the dead tree population is green ash (Table 29). Land uses with the highest estimated number of standing dead trees are forest land, residential, and commercial/industrial (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 Milwaukee, 2021

Common name	Standing dead trees (number)	Standard error (number)	Percent of species
weeping willow	1,900	1,900	100.0
white ash	116,000	88,000	87.6
green ash	294,000	163,000	51.4
Canada plum	3,300	3,500	50.0
sugar maple	117,000	105,000	34.4
Scotch pine	1,900	1,900	33.3
eastern cottonwood	25,000	24,000	28.2
white oak	3,900	3,800	14.6
Norway spruce	1,900	1,900	13.6
red mulberry	4,300	2,800	10.9
common buckthorn	175,000	113,000	10.8
American elm	8,600	3,900	8.9
Siberian elm	1,800	1,800	7.2
blue spruce	3,300	3,500	6.2
apple spp.	1,700	1,800	2.5
boxelder	3,600	2,600	0.9
Total	**764,000**	**280,000**	**17.3**

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

Table 29.—Proportion of the total population of trees that are standing dead by species, city of Milwaukee, 2021

Common name	Standing dead trees (percent)
green ash	38.5
common buckthorn	23.0
sugar maple	15.3
white ash	15.2
eastern cottonwood	3.2
American elm	1.1
red mulberry	0.6
white oak	0.5
boxelder	0.5
blue spruce	0.4
Canada plum	0.4
Norway spruce	0.3
Scotch pine	0.3
weeping willow	0.3
Siberian elm	0.2
apple spp.	0.2
Total	**100.0**

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

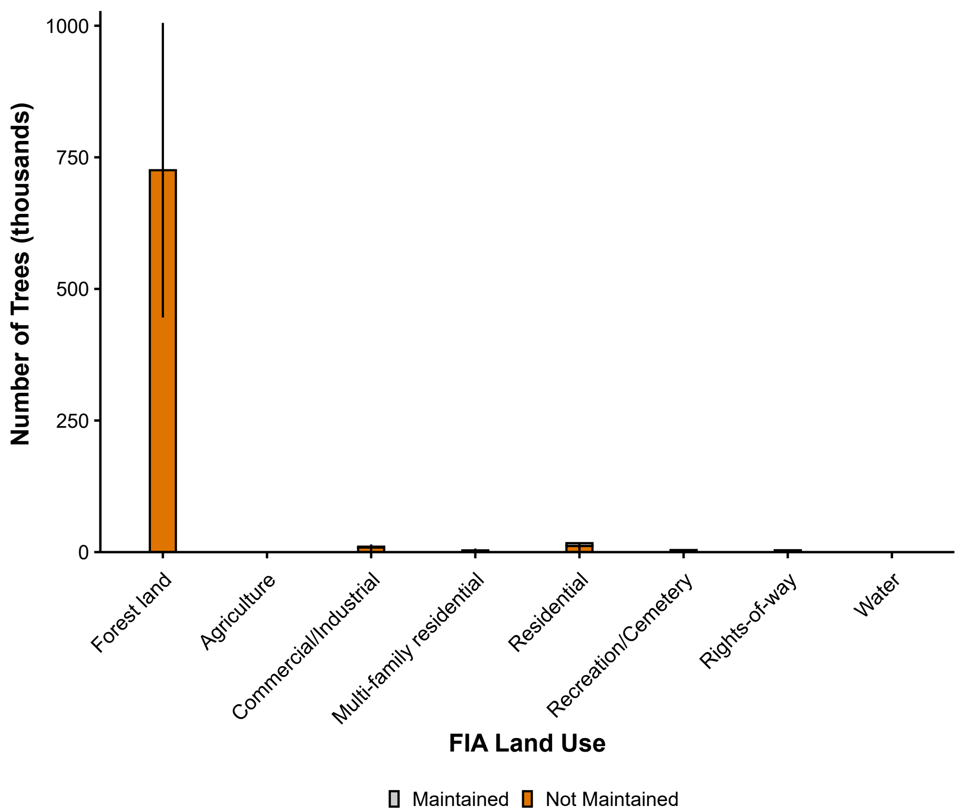

Figure 24.—Number of standing dead trees by Forest Inventory and Analysis (FIA) land use class on maintained and unmaintained land, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Invasive Plant Species

Invasive plant species are often noted for their vigor, ability to adapt to novel environments, high reproduction capacity, and lack of natural enemies. These factors may enable them to displace native plants and threaten natural areas (Davis 2009, Simberloff 2013). 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 Milwaukee examined each plot for the presence of select invasive species based on the species list shown in Appendix 5. Of the 210 plots examined, invasive plant species were identified on 57.1 percent (120 plots).

Invasive species found in Milwaukee 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, common buckthorn (2,294 acres; 3.7 percent of the sampling area), Norway maple[6] (1,895 acres; 3.1 percent of the sampling area), and reed canarygrass (1,376 acres; 2.2 percent of the sampling area) cover 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 Milwaukee are classified as trees, data on individual trees were collected in addition to descriptions of species cover on the plot. In Milwaukee, tree data were collected for black locust, common buckthorn, Norway maple, Siberian elm, and tree of heaven. Taken together, these invasive trees are estimated to account for 46.9 percent of all live trees surveyed (estimated total live trees: 1.7 million), and 22.4 percent of the total leaf area.

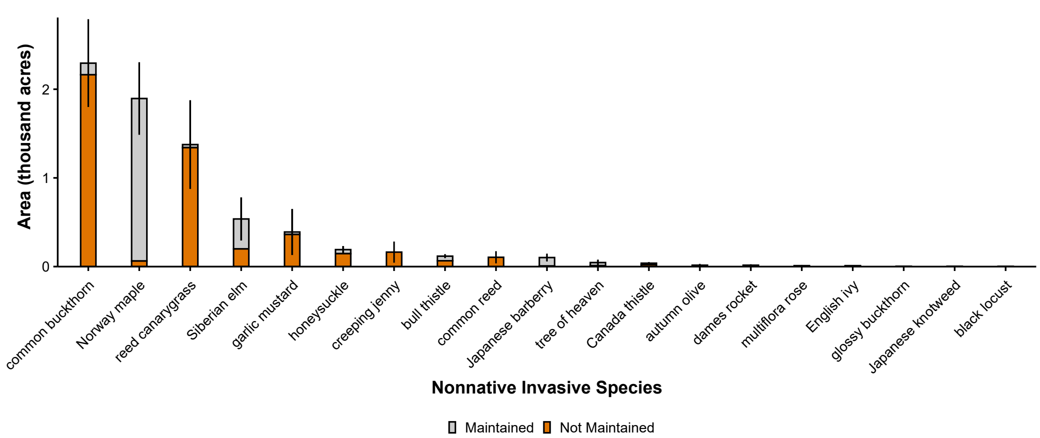

Figure 25.—Acres of nonnative invasive species cover by species on maintained and unmaintained land, city of Milwaukee, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

[6] Norway maple is not listed as a regulated invasive species by the State of Wisconsin (WDNR 2024a).

Pests and Pathogens

Pathogens and insect pests can affect the health, sustainability, and benefits of urban forests. Identifying pathogens and pests[7] of concern and their potential host-specific impacts allows managers to prioritize specific insects and diseases for monitoring and control measures. Using an i-Tree Eco analysis of the effects of 53 potential insects and diseases (Nowak 2024, Appendix 6), we evaluated the data to quantify the possible impact on the Milwaukee urban forest based on the number of host tree species and pest or pathogen proximity. Pest range maps (Nowak 2024, USDA Forest Service 2023) were used to determine the proximity of each pest and disease to Milwaukee and Waukesha Counties. Pests and pathogens of note which are already present include spongy moth (734,000 trees at risk), emerald ash borer (295,000 trees at risk), Dutch elm disease (117,000 trees at risk), and oak wilt (103,000 trees at risk). 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 is currently impacted by these pests and pathogens.

[7] Common and scientific names for pests and pathogens evaluated for the 2021 Urban FIA inventory of Milwaukee are in Appendix 6.

MANAGEMENT IMPLICATIONS

Boxelder trees are present in many unmaintained or lightly maintained parts of Milwaukee, including in this industrial area of Milwaukee's south side. Courtesy photo by Dan Buckler, Wisconsin Department of Natural Resources.

Urban trees are important and dynamic parts of Milwaukee's character and its infrastructure. After sites are revisited, data from this project can help identify trends in the urban forest, and managers can better determine appropriate interventions or strategies. Though at this stage these data offer a "snapshot" in time; insights and implications can be gleaned for the future of Milwaukee's trees. Some of these management implications include:

- The abundance of maple trees exposes the urban forest to risk.
- The high number of common buckthorn, particularly on forest land and other unmaintained spaces, present a challenge to regeneration of desired species.
- A focus on preserving large trees could help maintain the outsized benefits that they provide to communities.

Species Diversity

An important consideration in urban forestry is species diversity. Forests with more species variety and greater species evenness are more resilient to future disturbances, whether storms, pests, or climate change. Some planting rules are generally accepted in the urban forestry world as ideals for public, maintained trees, such as those along streets or in high-use areas of parks. For example, the "30-20-10" planting rule or the Wisconsin Department of Natural Resource's more aggressive "20-10-5" rule provide guidelines for how much of a managed tree population should be composed of any individual family, genus, or species, respectively (Kendal et al. 2014, WDNR 2016). These were created to discourage dependence on a few types of trees in order to avoid catastrophic losses like those seen with Dutch elm disease and emerald ash borer. While there are no widely accepted diversity rules for the entire urban forest, assessing species diversity is an important way to project future problems.

While common buckthorn has the highest number of stems in the 2021 Urban FIA inventory of Milwaukee, its small stature means that it does not currently dominate the urban canopy. However, this could change as larger, overstory trees die. The population of trees at least 5.0 inches in diameter, typically provide much more canopy, and this assemblage is highly represented by the ash and maple genera (Appendix 2).

The City of Milwaukee's emerald ash borer management program for street trees has been a tremendous success in retaining many ash trees along city managed rights-of-way (almost 26,000 ash trees remained on city streets as of 2024) (WDNR 2024b), preserving the benefits that those trees provide. By regular pesticide injections and a gradual reduction of the ash population, the City has been able to significantly reduce the impact of emerald ash borer on the streetscapes of Milwaukee.

Unfortunately, observers throughout the city may easily note that most untreated ash trees in Milwaukee are now dead or dying. A whopping 88 percent of the city's dead trees at least 5.0 inches in diameter are estimated to be ash trees. Indeed, over 60 percent of the ash trees at least 5.0 inches in diameter were dead when these plots were established during the 2021 Urban FIA inventory. As these plots are revisited, that number will likely approach 100 percent.

As much as the city's ash trees have been devastated by the emerald ash borer, the potential impact to Milwaukee's urban forest is greater should the maple genus also be threatened by a serious pest or pathogen. There are high numbers of maple trees (including boxelder) across all ownerships (at least three of the 10 most numerous species on both public and private lands) and size classes (at least two of the five most numerous species in each size class) (Tables 12, 13, and 14). In maintained areas, four of the top five species are maple, with green ash as the other, and maple trees account for 49 percent of all trees in maintained areas (with 28 percent of those at least 5.0 inches in diameter). For additional context, 21 percent of trees in Madison at least 5.0 inches are maples (Buckler et al., in press), 25 percent in Minneapolis (Schanning et al. 2026), 33 percent in Chicago (Schanning et al. 2025), and 18 percent in Des Moines (Goff et al. 2026). According to its own municipal street tree inventory, Milwaukee also has a high number of maple street trees, totaling almost 44 percent of the street tree population as of 2023 (WDNR 2024b).

Although no serious threats are currently detected, given these data, the future use of maples in planting regimes should be carefully considered. Maintaining the existing trees and the benefits they provide is critical, while also planning and planting for a more diverse future population.

As the planting of other species expands, close tracking and monitoring will allow managers to assess their success and potential in Milwaukee, especially non-traditional, marginally hardy, and experimental species. For example, the City of Milwaukee maintains a municipal nursery with up to 20,000 trees. It continues to experiment with new species and cultivars such as shingle oak (*Quercus imbricaria*), yellow-poplar (*Liriodendron tulipifera*), and dawn redwood (*Metasequoia glyptostroboides*) to improve the long-term sustainability of the urban forest.

Planting

Recruitment of new trees into the urban forest can result from both natural regeneration and intentional planting. Every tree measured on Urban FIA plots is assigned a code to indicate whether it was planted, is natural regeneration, or whether the origin is unknown. Since the number and size distribution of planted trees reflect intentional human effort toward development of the urban forest, close attention to these tree populations can provide information about how local interest, education, policy, and funding impact planting efforts over time.

On Milwaukee's nonforest lands, 27 percent of saplings and trees are planted. Of planted trees at least 5.0 inches across all ownerships, Norway maple is the most common, representing 23 percent of these trees. Honeylocust, blue spruce, green ash, and littleleaf linden are the next most common. On public land, the top five most frequently encountered planted trees (at least 5.0 inches in diameter) are Norway maple, honeylocust, green ash, American elm, and littleleaf linden. In contrast, across private land, blue spruce, Norway maple, apple species, Norway spruce, and silver maple are the most prevalent planted species. Across public and private ownership, 54 percent of all planted tree species are saplings, 16 percent are trees 5.0 to 11.0 inches in diameter, and 30 percent are trees with diameters 11.0 inches or greater.

As city foresters and local organizations work to manage and build the Milwaukee urban forest, it will be useful to understand how the preferences and practices of private landowners differ from those of public land managers. City foresters looking to diversify the tree canopy will benefit from a clear understanding of what species are already heavily planted on private lands. Efforts aimed at increasing tree planting on private lands can take into consideration what species have been most popular. Providing outreach materials which recommend alternative species, while highlighting similar growth patterns or benefits to those more well known, popular species may encourage landowners to move beyond the species with which they are most familiar.

Buckthorn and Tomorrow's Urban Forest

While bigger trees loom larger in our collective impression of the urban forest, the invasive common buckthorn dominates the 1.0 to 5.0 inch size class, and is significantly represented in the 5.0 to 11.0 inch class as well (Table 12). It also has, by far, the most seedlings estimated in this study (32 million of the 40.5 million estimated total).

Because of its sheer quantity and its competitive advantages (e.g., it holds its leaves longer than native species, colonizes land rapidly), the invasive common buckthorn threatens the regeneration of desired species and puts the ecological function of some areas in jeopardy, especially forest land. Of the more than 2,000 acres of buckthorn cover, more than 80 percent is on forest land or recreational/cemetery spaces. Likewise, 64 percent of buckthorn stems are in forest land or recreational/cemetery land uses. It is these more unmaintained spaces, and the native species within them, that are most at threat. Native species overwhelmingly found in forest land relative to other land uses include sugar maple, cottonwood, bur oak, red oak, and basswood.

Despite ongoing management efforts, common buckthorn is not going to be eliminated. However, without continued management, buckthorn may threaten the regeneration of uncommon native trees in the remaining natural areas in Milwaukee. Management on small lots may also be effective given the low totals on private residential parcels.

Pest and Pathogen Impacts

The introductions of Dutch elm disease and emerald ash borer have made the urban forestry community, and many others beyond it, painfully aware of the cultural and ecological trauma that pests and pathogens can wreak. And given the ongoing issues with species diversity, future insects or diseases invading Milwaukee have the potential to cause massive amounts of damage.

Although 13 insects and diseases were noted as already present in Milwaukee County (of the 53 assessed) (Appendix 6), not all the pest species are equally damaging. For example, emerald ash borer is a devastating insect, while pine shoot beetle is mostly a pest of current or abandoned Christmas tree farms. Spongy moth can be a significant damage agent periodically, while Dutch elm disease continues to impact untreated elm trees.

Of those other damage agents within the county, oak wilt is present and is always a concern but should be manageable with the right protocols (e.g., oak pruning moratoriums). Other listed pests and diseases currently in Milwaukee County could cause local damage or mortality on low vigor trees but are not expected to be major damage agents. Two wood-boring insects not included in the i-Tree Eco analysis are nonetheless present in Milwaukee: twolined chestnut borer (*Agrilus bilineatus*; attacks oak trees) and bronze birch borer (*A. anxius*; attacks birch trees). These have the potential to cause damage when trees are already stressed by drought, construction, disease, or other problems.

Of course, change can come fast. With a globalized economy and changing climate, new pests and diseases can be introduced and spread quickly. An urban forest that is diversified across public and private lands will be more resilient against the potential damage of these pests and pathogens.

Maximizing Benefits

When considering benefits of trees assessed in the i-Tree protocol, bigger is almost always better. Larger diameter trees tend to have more volume, greater heights, wider canopies, and more leaf area. These all play a role in producing societal benefits. Silver maple, white oak, and northern red oak are among the trees with the highest carbon storage or volume in the 2021 Urban FIA inventory of Milwaukee (Table 17, Fig. 17). Despite not being in the 10 most common species in the city, these species play significant roles in volume and carbon storage because many of them are large. Protective measures and proactive maintenance can help ensure that these larger trees remain in the landscape.

A major reason why common buckthorn is such a threat is that it could prevent the regeneration of species that play much greater ecological or functional roles. For example, despite having the most stems in the city, 11 other tree species store more carbon than buckthorn. When considering the carbon storage by crown area, 56 tree species (of the 58 live tree species sampled in the 2021 inventory) store more carbon per acre of crown than common buckthorn. Similarly, the potential leaf area coverage per acre of crown is much larger for other species. While common buckthorn is estimated to have about 2 acres of leaf area for every acre of crown, several species have a leaf area to crown area ratio nearly five times that, and 56 species have a larger ratio than common buckthorn. Leaf area is the dominant variable in ecosystem services such as air pollution removal and stormwater reduction so species that tend to have more of it play outsized roles in the benefits the urban forest provides to society.

Though much of the discussion around the impact of trees on energy savings has focused on the summer, Urban FIA results show that trees in Milwaukee play a larger role reducing the energy footprint of buildings in the winter (Table 21). This makes sense given how much longer buildings are heated than cooled through a year in Wisconsin. Despite the longer use of heating, however, the monetary benefit of trees is greater in the summer (Table 22) due to the use of coal to produce electricity for most air conditioning, while heating uses cheaper oil.

One of the benefits of Urban FIA data is to help project tree decline and mortality, which can be used to help predict availability of urban wood. Utilizing urban wood can reroute trees from waste streams toward higher use products. Milwaukee's urban tree removals generate significant biomass. Expanding urban wood utilization programs can provide economic and environmental benefits by repurposing removed trees for construction, furniture, or biomass energy. As the Urban FIA plots are revisited, pairing tree health data and sawtimber volume could offer meaningful predictions of urban wood availability.

Land Use Opportunities

The commercial/industrial land use makes up 25.3 percent of Milwaukee's area but has a low tree density of 27 trees an acre, even fewer than rights-of-way (Table 5, Table 8). Despite having a high amount of impervious surface in these areas, the huge scale of commercial/industrial land creates an opportunity for tree planting (Table 6). There may be policy incentives, for example through business improvement districts, that could encourage tree planting in these spaces.

Likewise, while it is no surprise that rights-of-way are predominantly covered by impervious surfaces, the low density of trees on this land use nonetheless suggests the potential for increased tree cover through improved streetscaping.

Private land represents 60 percent of the city's land area yet contains only 42 percent of its trees. This discrepancy could present an opportunity to encourage tree planting and maintenance on private property.

Ecological Role

The ecological role of trees is not significantly explored in this project, however, they are of great importance. Forest land has relatively higher woody vegetation coverage (49.8 percent tree canopy, 26 percent shrub/seedling cover) and thus has a fair amount of structural diversity that could support different wildlife species. While shrub species were not identified in this study, the fact that almost 92 percent of the seedlings in forest land were common buckthorn implies that much of the shrub/seedling understory could indeed be buckthorn. The percentage of shrub cover in forest land ranked far ahead of the next highest ranking land use, residential, which had a shrub cover of 4.8 percent (with a 22.3 percent tree canopy cover). Though the relatively low shrub cover is expected in most developed spaces, it also presents an opportunity to introduce more shrubs and structural diversity across the city.

Plot data was processed through i-Tree Eco's Avian Habitat Suitability model, which produced a unitless value for eight different bird species indicating the suitability of habitat (Lerman et al. 2014). A score of 0, for example, indicated unsuitable habitat (i.e., the likelihood that a species is not present) while a score of 1 indicated that conditions likely exist to support the species. In addition to producing an overall suitability index value for the entire city (Table 30), the model was also applied to each NLCD land cover class (Appendix 1). Forest areas had the highest average score and were likely to contain more favorable conditions for five of the eight species (black-capped chickadee, northern cardinal, red-bellied woodpecker, scarlet tanager, and wood thrush). Baltimore oriole scored highest in mid- and lightly-developed spaces due to its preference for large, well-spaced trees. Most land cover classes were equally accommodating to the American robin, befitting its reputation as an excellent generalist. The final species studied, the European starling, was more likely to be found in developed spaces.

Scarlet tanager and wood thrush had the lowest overall suitability score, due to their requirement for dense canopy and sensitivity to forest fragmentation. The supplementary material in Lerman et al. (2014) can provide insights into how habitat could be improved for individual bird species.

Table 30.—The overall suitability index values for eight bird species across all National Land Cover Database (NLCD) land cover classes using i-Tree Eco's Avian Habitat Suitability model, city of Milwaukee, 2021

Scientific name	Common name	Suitability index
Turdus migratorius	American robin	0.42
Cardinalis cardinalis	northern cardinal	0.22
Icterus galbula	Baltimore oriole	0.20
Poecile atricapillus	black-capped chickadee	0.16
Sturnus vulgaris	European starling	0.14
Melanerpes carolinus	red-bellied woodpecker	0.11
Hylocichla mustelina	wood thrush	0.02
Piranga olivacea	scarlet tanager	0.01

CONCLUSIONS

Canada goldenrod (*Solidago canadensis*) gives way to forest land at Havenwoods State Forest on Milwaukee's north side. Courtesy photo by Bill McNee, Wisconsin Department of Natural Resources.

Milwaukee's urban forest contributes to the city's environmental, economic, and societal well-being. Throughout the city, an estimated 3.7 million trees, representing 59 species, 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.

There are several forces that may impact Milwaukee'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 growth of the human population.

This analysis provides a baseline for future monitoring. While data from this report capture attributes of the current urban forest resource and associated ecosystem services and values, future monitoring will identify how the forest is changing over time. The plots measured in Milwaukee will be remeasured 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 and online tools to inform long-term management plans and policies to sustain a healthy urban tree population and ecosystem services for future generations. Planning and management of the urban forest resource can help sustain vital ecosystem services and values for current and future generations in Milwaukee. Additionally, these data and results can be used for expanded educational outreach and resources for private property owners to foster an improved understanding of the importance of urban trees and their management. In the future, change analyses can be used to evaluate the success of urban forest management programs.

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GLOSSARY OF TERMS

Definitions

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.

Bark inclusion: Bark inclusions are a sign of weak branch unions and are places where branches are not strongly attached to the tree. A weak union occurs when two or more branches grow so closely together that bark grows between the branches and inside the union. This ingrown, or included, bark does not have the structural strength of wood, and the union can become very weak. The inside bark may also act as a wedge and force the branch union to split apart. Trees with a tendency to form upright branches, such as elm and maple, often produce weak branch unions (USDA Forest Service 2017).

Conflict with roots: Damage to infrastructure such as sidewalks, driveways, roads, or other hardscapes directly caused by roots. Tree roots grow under sidewalks and asphalt. They do this in many instances because that is where the soil oxygen and moisture are located. Conflicts with curbs, driveways, or roads are all considered conflicts with roots (USDA Forest Service 2017).

Conflict with tree crown: Conflict with tree crown occurs when tree branches, foliage, or bole are within 5 feet of utility wires of any type, including drop lines that extend from the main line to a building. Conflict with overhead wires can cause problems for both trees and wires, creating maintenance problems and hazard situations (USDA Forest Service 2017).

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 (USDA Forest Service 2017). Timber species are listed in Appendix 2. There were no woodland tree species sampled in the 2021 Urban FIA inventory of Milwaukee.

Excessive mulch: Excessive mulch is defined as mulch piled high around the stem to a depth greater than 3 inches and covering the root flare at the base of the trunk. Over mulching of landscape plants, sometimes to the extent of creating mountainous mulch “volcanoes”, can result in disease or death of the tree. Mulch can take the form of many different materials and is not limited to wood chips (USDA Forest Service 2017).

Improper planting: Improper planting occurs when burlap, twine, or root ball wire not removed prior to planting, or when the tree root flare is buried (USDA Forest Service 2017).

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 <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 2023a).

Invasive species: A nonnative species whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112, 1999). A list of invasive plant species used in this inventory protocol is presented in Appendix 5.

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 2017, 2023a).

Sapling: Live trees 1.0 to 4.9 inches (2.5-12.5 cm) in diameter (d.b.h./d.r.c.) (USDA Forest Service 2023a).

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 2023a).

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 2023a).

Seedlings: Live tree species smaller than 1.0-inch (2.5 cm) d.b.h./d.r.c. that are at least 6 inches (15.2 cm) in height for softwoods and 12-inches (30.5 cm) in height for hardwoods (USDA Forest Service 2023a).

Severe topping or poor pruning: A tree is considered to have been severely topped when it has been reduced to a single "pole" due to severe over pruning and branch removal. Topping is the cutting of branches to stubs, or, if 25 percent or more at the main stem has been cut to reduce tree height. Topping usually results in a profusion of shoots rendering the tree more susceptible to wind damage. Poor pruning techniques include leaving stubs outside the branch collar or cutting into the branch collar. A tree with proper pruning may still maintain the look and shape of the tree, only it is shorter (USDA Forest Service 2017).

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).

Stem girdling: Stem girdling occurs when roots begin to grow around the main stem of the tree and cut off or restrict the movement of water, plant nutrients, and stored food reserves. Certain trees are more prone to this problem than others. Lindens, magnolias, pines, and maples (other than silver maple) are susceptible to root girdling (USDA Forest Service 2017).

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). There were no woodland tree species sampled in the 2021 Urban FIA inventory of Milwaukee.

APPENDIX 1 – LAND COVER DESCRIPTIONS

Table 31.—National Land Cover Database (NLCD) land cover class descriptions, city of Milwaukee, 2021

NLCD land cover class	NLCD code	Land cover description
Open water	11	Areas of open water generally with less than 25 percent of vegetation or soil.
Perennial ice/snow	12	Areas characterized by a perennial cover of ice and/or snow, generally greater than 25 percent of total cover.
Developed-open space	21	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed-low intensity	22	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 percent to 49 percent of total cover. These areas most commonly include single-family housing units.
Developed-medium intensity	23	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 percent to 79 percent of the total cover. These areas most commonly include single-family housing units.
Developed-high intensity	24	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 percent to 100 percent of the total cover.
Barren land (rock/sand/clay)	31	Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.
Deciduous forest	41	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen forest	42	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed forest	43	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Dwarf scrub	51	Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20 percent of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
Shrub/scrub	52	Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Grassland/herbaceous	71	Areas dominated by graminoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Sedge/herbaceous	72	Alaska only areas dominated by sedges and forbs, generally greater than 80 percent of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
Lichens	73	Alaska only areas dominated by fruticose or foliose lichens generally greater than 80 percent of total vegetation.
Moss	74	Alaska only areas dominated by mosses, generally greater than 80 percent of total vegetation.
Pasture/hay	81	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Cultivated crops	82	Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Woody wetlands	90	Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent herbaceous wetlands	95	Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Source: Homer et al. 2015

APPENDIX 2 – TREE SPECIES COMPOSITION

Table 32.—List of live tree species and their characteristics, city of Milwaukee, 2021

Genus	Species	Common name	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (in.)
Acer	*ginnala*	Amur maple	192,000	-	-	192,000	5.2	186,000	1.9
Acer	*negundo*	boxelder	290,000	98,000	28,000	416,000	11.4	243,000	4.5
Acer	*nigrum*	black maple	-	-	5,700	5,700	0.2	3,200	19.6
Acer	*platanoides*	Norway maple[a]	45,000	20,000	59,000	124,000	3.4	35,000	11.9
Acer	*rubrum*	red maple	-	1,700	-	1,700	0.0	1,800	7.7
Acer	*saccharinum*	silver maple	21,000	3,600	14,000	38,000	1.0	23,000	13.5
Acer	*saccharum*	sugar maple	175,000	44,000	3,600	223,000	6.1	193,000	4.1
Acer	*x freemanii*	Freeman maple	-	3,300	1,900	5,300	0.1	3,100	9.1
Aesculus	*hippocastanum*	horse chestnut	-	-	1,900	1,900	0.1	1,900	26.0
Ailanthus	*altissima*	tree of heaven[a]	-	24,000	-	24,000	0.7	23,000	5.3
Betula	*papyrifera*	paper birch	-	3,300	-	3,300	0.1	3,500	10.5
Carya	*ovata*	shagbark hickory	-	2,000	7,500	9,500	0.3	6,300	16.0
Catalpa	*speciosa*	northern catalpa	-	-	5,300	5,300	0.1	4,000	26.2
Celtis	*occidentalis*	hackberry	-	1,900	7,300	9,300	0.3	4,800	15.5
Crataegus	spp.	hawthorn spp.	25,000	16,000	-	41,000	1.1	25,000	4.7
Fagus	*sylvatica*	European beech	-	-	1,900	1,900	0.1	1,900	26.2
Fraxinus	*americana*	white ash	-	8,100	8,300	16,000	0.5	10,000	13.8
Fraxinus	*pennsylvanica*	green ash	146,000	90,000	42,000	278,000	7.6	101,000	6.3
Ginkgo	*biloba*	ginkgo, maidenhair tree	-	1,900	-	1,900	0.1	1,900	5.8
Gleditsia	*triacanthos*	honeylocust	-	9,700	20,000	30,000	0.8	10,000	15.6
Gymnocladus	*dioicus*	Kentucky coffeetree	-	1,900	-	1,900	0.1	1,900	7.2
Juglans	*nigra*	black walnut	-	10,000	10,000	21,000	0.6	8,500	10.3
Juniperus	*virginiana*	eastern redcedar	-	1,700	3,600	5,300	0.1	3,100	11.9
Magnolia	*x soulangiana*	Chinese magnolia	-	-	1,700	1,700	0.0	1,800	13.5
Malus	spp.	apple spp.	44,000	11,000	9,100	64,000	1.8	46,000	4.8
Morus	*alba*	white mulberry	22,000	24,000	-	46,000	1.3	25,000	4.4
Morus	*rubra*	red mulberry	-	18,000	18,000	35,000	1.0	24,000	13.1
Picea	*abies*	Norway spruce	-	2,000	10,000	12,000	0.3	9,200	16.5

Continued on next page

Table 32. (continued)—List of live tree species and their characteristics, city of Milwaukee, 2021

Genus	Species	Common name	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Total (percent)	Total standard error (number)	Average diameter (in.)
Picea	*glauca*	white spruce	-	22,000	7,000	29,000	0.8	21,000	9.3
Picea	*pungens*	blue spruce	24,000	12,000	14,000	50,000	1.4	29,000	9.3
Pinus	*nigra*	Austrian pine	-	1,900	-	1,900	0.1	1,900	5.3
Pinus	*resinosa*	red pine	-	-	3,900	3,900	0.1	2,700	18.5
Pinus	*strobus*	eastern white pine	-	5,900	13,000	19,000	0.5	17,000	12.9
Pinus	*sylvestris*	Scotch pine	-	-	3,800	3,800	0.1	3,700	13.2
Platanus	*occidentalis*	American sycamore	-	-	3,800	3,800	0.1	2,600	23.8
Populus	*balsamifera*	balsam poplar	-	-	2,300	2,300	0.1	2,100	22.1
Populus	*deltoides*	eastern cottonwood	49,000	9,900	3,600	63,000	1.7	57,000	3.6
Prunus	*nigra*	Canada plum	-	3,300	-	3,300	0.1	3,500	5.9
Prunus	*serotina*	black cherry	-	9,400	-	9,400	0.3	6,500	7.1
Pseudotsuga	*menziesii*	Douglas-fir	-	-	5,900	5,900	0.2	5,700	14.6
Pyrus	*calleryana*	Callery pear	-	3,500	5,600	9,100	0.3	5,500	11.8
Quercus	*alba*	white oak	-	7,500	15,000	23,000	0.6	17,000	16.2
Quercus	*macrocarpa*	bur oak	29,000	4,700	1,700	36,000	1.0	30,000	5.0
Quercus	*muehlenbergii*	chinkapin oak	-	1,900	-	1,900	0.1	1,900	5.4
Quercus	*palustris*	pin oak	-	-	2,300	2,300	0.1	2,100	12.7
Quercus	*rubra*	northern red oak	-	35,000	5,700	40,000	1.1	32,000	9.8
Rhamnus	*cathartica*	common buckthorn[a]	1,400,000	54,000	1,700	1,450,000	39.8	531,000	2.1
Robinia	*pseudoacacia*	black locusta	73,000	7,900	9,900	91,000	2.5	69,000	4.9
Salix	*nigra*	black willow	-	2,300	2,300	4,700	0.1	4,200	13.4
Syringa	*reticulata*	Japanese tree lilac	-	3,500	-	3,500	0.1	3,600	5.2
Taxus	*cuspidata*	Japanese yew	21,000	-	-	21,000	0.6	22,000	2.3
Thuja	*occidentalis*	northern white-cedar	-	12,000	1,700	14,000	0.4	6,000	10.1
Tilia	*americana*	American basswood	-	14,000	-	14,000	0.4	13,000	6.8
Tilia	*cordata*	littleleaf linden	-	1,700	12,000	14,000	0.4	5,500	16.9
Ulmus	*americana*	American elm	46,000	33,000	9,000	88,000	2.4	36,000	6.2
Ulmus	*procera*	English elm	-	-	3,600	3,600	0.1	2,600	13.3
Ulmus	*pumila*	Siberian elm[a]	-	13,000	9,800	23,000	0.6	13,000	12.0
Ulmus	*rubra*	slippery elm	-	2,000	-	2,000	0.1	1,900	6.4
Total			**2,600,000**	**656,000**	**398,000**	**3,650,000**	**100.0**	**858,000**	**4.9**

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

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

[a] Tree species included on the list of invasive plants monitored during the 2021 Urban FIA inventory of Milwaukee (see Appendix 5).

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

Table 33.—Estimates of total number of trees, basal area, and average diameter by National Land Cover Database (NLCD) land cover class group, city of Milwaukee, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Developed-high	American elm	23,661	< 0.1	2.3
	apple spp.	47,323	0.2	2.4
	black maple	1,763	0.1	11.0
	boxelder	1,763	0.4	19.5
	Callery pear	5,289	0.3	8.9
	common buckthorn	21,898	< 0.1	1.1
	green ash	30,714	0.7	5.8
	honeylocust	7,053	0.2	6.9
	Japanese tree lilac	3,526	< 0.1	5.2
	white ash	1,763	< 0.1	8.0
	white mulberry	21,898	< 0.1	1.7
Developed-low	American elm	14,977	1.0	13.0
	apple spp.	3,328	0.2	16.0
	black walnut	3,328	< 0.1	9.1
	blue spruce	18,306	0.9	12.3
	boxelder	27,343	0.6	5.0
	bur oak	1,664	0.2	20.6
	Canada plum	3,328	< 0.1	5.9
	Chinese magnolia	1,664	< 0.1	13.5
	common buckthorn	127,446	0.2	2.1
	eastern cottonwood	1,664	0.1	15.4
	eastern redcedar	3,328	0.1	10.1
	eastern white pine	1,664	< 0.1	14.0
	English elm	1,664	< 0.1	11.9
	Freeman maple	3,328	< 0.1	6.4
	green ash	51,357	0.8	5.5
	hackberry	4,992	0.4	17.5
	hawthorn spp.	1,664	< 0.1	5.0
	honeylocust	9,985	1.1	19.0
	Japanese yew	20,686	< 0.1	2.3
	littleleaf linden	9,985	0.8	16.8
	northern catalpa	3,328	0.4	19.4
	northern red oak	4,992	0.3	13.3
	northern white-cedar	11,649	0.4	10.5
	Norway maple	53,969	3.2	12.2
	Norway spruce	8,321	0.8	18.1

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Estimates are rounded.

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

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

Table 33. (continued)—Estimates of total number of trees, basal area, and average diameter by National Land Cover Database (NLCD) land cover class group, city of Milwaukee, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Developed-low (cont.)	paper birch	3,328	0.1	10.5
	red maple	1,664	< 0.1	7.7
	red mulberry	1,664	0.5	33.2
	shagbark hickory	1,664	0.1	17.5
	Siberian elm	1,664	0.1	17.9
	silver maple	33,999	3.4	13.2
	sugar maple	1,664	0.3	23.5
	white ash	9,985	1.0	18.1
	white mulberry	8,321	0.1	6.6
	white oak	3,328	0.2	13.6
	white spruce	4,992	0.3	13.4
Developed-medium	American elm	11,541	0.1	6.0
	American sycamore	3,847	0.5	23.8
	Amur maple	191,729	0.2	1.9
	apple spp.	3,847	0.2	13.7
	Austrian pine	1,924	< 0.1	5.3
	black locust	23,966	< 0.1	1.3
	black maple	1,924	0.1	17.2
	black walnut	5,771	0.2	11.7
	blue spruce	31,660	0.7	7.6
	boxelder	77,825	1.8	7.5
	Callery pear	3,847	0.2	15.8
	chinkapin oak	1,924	< 0.1	5.4
	common buckthorn	287,594	< 0.1	1.1
	English elm	1,924	0.1	14.5
	European beech	1,924	0.3	26.2
	Freeman maple	1,924	< 0.1	13.7
	ginkgo, maidenhair tree	1,924	< 0.1	5.8
	green ash	47,048	0.7	6.0
	hackberry	1,924	< 0.1	10.5
	hawthorn spp.	7,694	< 0.1	6.2
	honeylocust	7,694	0.5	15.8
	horse chestnut	1,924	0.3	26.0
	Kentucky coffeetree	1,924	< 0.1	7.2
	littleleaf linden	3,847	0.3	17.2
	northern catalpa	1,924	0.7	38.0
	northern white-cedar	1,924	< 0.1	7.8
	Norway maple	64,360	2.9	11.3
	Norway spruce	1,924	0.2	19.8

Estimates are rounded.

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

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

Table 33. (continued)—Estimates of total number of trees, basal area, and average diameter by National Land Cover Database (NLCD) land cover class group, city of Milwaukee, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Developed-medium (cont.)	red mulberry	3,847	< 0.1	6.9
	red pine	1,924	0.1	17.6
	Scotch pine	3,847	0.2	13.2
	shagbark hickory	1,924	0.2	20.1
	Siberian elm	11,541	0.4	11.5
	silver maple	3,847	0.4	16.1
	sugar maple	1,924	< 0.1	10.0
	tree of heaven	23,966	0.2	5.3
	white mulberry	9,618	0.1	6.5
	white oak	1,924	< 0.1	8.2
	white spruce	1,924	< 0.1	5.2
Developed-open	American elm	26,520	0.6	4.8
	apple spp.	9,854	0.8	9.4
	black locust	66,834	4.3	6.2
	black maple	1,971	1.6	29.7
	boxelder	271,108	2.8	3.1
	common buckthorn	470,370	2.0	2.0
	Douglas-fir	5,912	1.2	14.6
	eastern cottonwood	60,922	2.1	3.3
	eastern redcedar	1,971	0.4	15.0
	eastern white pine	17,737	2.8	12.8
	green ash	17,737	2.4	11.0
	hawthorn spp.	24,549	0.3	3.9
	honeylocust	1,971	0.5	17.1
	Norway maple	5,912	2.4	16.8
	Norway spruce	1,971	< 0.1	6.6
	red mulberry	3,941	0.4	9.6
	red pine	1,971	0.7	19.3
	shagbark hickory	5,912	1.2	14.3
	slippery elm	1,971	< 0.1	6.4
	sugar maple	3,941	1.3	16.0
	white mulberry	5,912	0.4	7.9
	white oak	17,737	5.6	17.6
	white spruce	21,678	1.6	8.7
Forest/vegetation	American basswood	14,085	0.8	6.8
	American elm	11,737	1.2	8.6
	balsam poplar	2,347	1.5	22.1
	black cherry	9,390	0.7	7.1
	black walnut	11,737	1.8	9.9

Estimates are rounded.

Continued on next page

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

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

Table 33. (continued)—Estimates of total number of trees, basal area, and average diameter by National Land Cover Database (NLCD) land cover class group, city of Milwaukee, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Forest/vegetation (cont.)	black willow	4,695	1.1	13.4
	boxelder	37,559	2.7	7.3
	bur oak	33,936	0.8	4.3
	common buckthorn	545,127	7.2	2.9
	green ash	131,254	8.3	6.3
	hackberry	2,347	0.7	15.2
	hawthorn spp.	7,042	0.3	5.8
	honeylocust	2,347	2.3	27.8
	northern red oak	35,212	4.0	9.4
	pin oak	2,347	0.5	12.7
	red mulberry	25,822	6.8	13.3
	Siberian elm	9,390	2.4	11.7
	sugar maple	215,356	4.5	3.7
	white ash	4,695	0.3	6.8
Water	honeylocust	736	0.4	6.1

Estimates are rounded.

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

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

Table 34.—Estimates of total number of trees, basal area, and average diameter by Forest Inventory and Analysis (FIA) land use class, city of Milwaukee, 2021

FIA land use class	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Forest land	American basswood	14,085	1.0	6.8
	American elm	13,708	1.5	8.2
	black cherry	9,390	0.8	7.1
	black walnut	4,695	1.0	11.8
	black willow	4,695	1.3	13.4
	boxelder	62,108	3.4	5.5
	bur oak	33,936	0.9	4.3
	common buckthorn	534,377	8.8	3.0
	eastern cottonwood	58,951	0.7	2.3
	green ash	102,853	9.6	7.3
	hackberry	2,347	0.8	15.2
	hawthorn spp.	31,591	0.9	4.3
	northern red oak	35,212	4.7	9.4
	Norway spruce	1,971	0.1	6.6
	Siberian elm	9,390	2.8	11.7
	slippery elm	1,971	0.1	6.4
	sugar maple	215,356	5.2	3.7
	white ash	4,695	0.3	6.8
	white mulberry	5,912	0.6	7.9
Commercial/industrial	American elm	26,891	0.1	3.0
	Amur maple	191,729	0.3	1.9
	Austrian pine	1,924	< 0.1	5.3
	boxelder	42,782	1.8	7.4
	Callery pear	9,136	0.5	11.8
	common buckthorn	63,271	0.1	2.0
	eastern white pine	1,664	0.1	14.0
	Freeman maple	1,924	0.1	13.7
	ginkgo, maidenhair tree	1,924	< 0.1	5.8
	green ash	25,585	0.2	4.7
	hawthorn spp.	1,664	< 0.1	5.0
	honeylocust	8,976	0.2	7.1
	Japanese tree lilac	3,526	< 0.1	5.2
	Norway maple	1,924	< 0.1	6.0
	Norway spruce	8,321	0.9	18.1
	red pine	1,924	0.2	17.6
	sugar maple	1,924	< 0.1	10.0
	white mulberry	25,745	< 0.1	2.5

Estimates are rounded.

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

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

Table 34. (continued)—Estimates of total number of trees, basal area, and average diameter by Forest Inventory and Analysis (FIA) land use class, city of Milwaukee, 2021

FIA land use class	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Multi-family residential	apple spp.	3,526	0.2	9.0
	blue spruce	1,924	0.4	15.3
	boxelder	37,739	2.3	6.0
	Canada plum	3,328	< 0.1	5.9
	green ash	29,785	1.0	4.4
	honeylocust	736	< 0.1	6.1
	littleleaf linden	1,924	0.4	14.9
	northern catalpa	5,252	3.5	26.2
	Norway maple	4,992	1.6	19.2
	Siberian elm	9,618	1.5	12.4
	tree of heaven	23,966	0.6	5.3
	white mulberry	8,321	0.3	6.6
Residential	American elm	9,099	0.4	9.3
	apple spp.	7,175	0.6	14.7
	balsam poplar	2,347	0.4	22.1
	black walnut	16,141	0.7	9.8
	blue spruce	46,378	2.0	9.1
	boxelder	9,146	0.3	8.4
	bur oak	1,664	0.3	20.6
	Chinese magnolia	1,664	0.1	13.5
	common buckthorn	174,411	0.2	1.4
	eastern cottonwood	1,664	0.1	15.4
	eastern redcedar	1,664	< 0.1	6.2
	European beech	1,924	0.5	26.2
	Freeman maple	1,664	< 0.1	6.0
	green ash	90,295	0.8	4.4
	honeylocust	6,916	1.1	19.9
	horse chestnut	1,924	0.5	26.0
	Japanese yew	20,686	< 0.1	2.3
	littleleaf linden	3,328	0.5	18.6
	northern white-cedar	11,908	0.4	8.8
	Norway maple	27,909	0.6	6.3
	Norway spruce	1,924	0.3	19.8
	paper birch	3,328	0.1	10.5
	pin oak	2,347	0.1	12.7
	red maple	1,664	< 0.1	7.7
	red mulberry	31,333	2.8	13.5

Estimates are rounded.

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

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

Table 34. (continued)—Estimates of total number of trees, basal area, and average diameter by Forest Inventory and Analysis (FIA) land use class, city of Milwaukee, 2021

FIA land use class	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Residential (cont.)	Scotch pine	3,847	0.3	13.2
	shagbark hickory	9,500	1.0	16.0
	silver maple	32,595	4.5	13.2
	sugar maple	5,606	0.9	18.2
	white ash	8,321	1.0	17.2
	white mulberry	5,771	< 0.1	6.3
	white oak	21,324	2.6	17.0
	white spruce	5,252	0.3	10.6
Recreation/cemetery	American elm	24,549	0.6	4.7
	apple spp.	9,854	1.0	9.4
	black locust	66,834	5.0	6.2
	black maple	1,971	1.9	29.7
	blue spruce	1,664	< 0.1	6.7
	boxelder	244,589	3.0	3.1
	common buckthorn	392,782	2.1	2.0
	Douglas-fir	5,912	1.4	14.6
	eastern cottonwood	1,971	2.0	30.5
	eastern redcedar	3,635	0.8	14.5
	eastern white pine	17,737	3.3	12.8
	green ash	13,182	3.4	14.0
	hackberry	1,664	0.3	13.6
	honeylocust	6,242	3.6	22.6
	northern red oak	4,992	1.2	13.3
	northern white-cedar	1,664	0.7	19.5
	Norway maple	8,934	6.1	23.1
	red mulberry	3,941	0.4	9.6
	red pine	1,971	0.8	19.3
	silver maple	3,328	1.7	21.3
	white spruce	23,342	2.2	9.0
Rights-of-way	American elm	14,190	0.9	10.8
	American sycamore	3,847	0.7	23.8
	apple spp.	43,797	< 0.1	1.9
	black locust	23,966	< 0.1	1.3
	black maple	3,687	0.3	14.2
	boxelder	19,235	0.4	7.8
	chinkapin oak	1,924	< 0.1	5.4
	common buckthorn	287,594	0.1	1.1
	English elm	3,588	0.2	13.3
	Freeman maple	1,664	< 0.1	6.8

Estimates are rounded.

Continued on next page

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

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

Table 34. (continued)—Estimates of total number of trees, basal area, and average diameter by Forest Inventory and Analysis (FIA) land use class, city of Milwaukee, 2021

FIA land use class	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Rights-of-way (cont.)	green ash	16,411	0.8	11.3
	hackberry	5,252	0.5	16.2
	hawthorn spp.	7,694	0.1	6.2
	honeylocust	6,916	0.7	16.9
	Kentucky coffeetree	1,924	< 0.1	7.2
	littleleaf linden	8,580	0.8	16.8
	Norway maple	80,483	5.5	12.4
	Siberian elm	3,588	0.2	11.9
	silver maple	1,924	< 0.1	5.6
	white ash	3,427	0.3	15.2
	white oak	1,664	< 0.1	5.8

Estimates are rounded.

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

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

APPENDIX 4 – SPECIES COMPOSITION IN MAINTAINED AREAS

Table 35.—Tree species composition in maintained areas, city of Milwaukee, 2021

Common name	Number of trees
Amur maple	192,000
Norway maple	120,000
green ash	101,000
boxelder	37,000
silver maple	36,000
blue spruce	35,000
honeylocust	28,000
Japanese yew	21,000
American elm	20,000
eastern white pine	19,000
littleleaf linden	14,000
northern white-cedar	14,000
white ash	12,000
Siberian elm	11,000
white spruce	11,000
apple spp.	11,000
Norway spruce	10,000
Callery pear	9,100
white mulberry	8,300
hawthorn spp.	7,700
hackberry	6,900
Douglas-fir	5,900
black maple	5,700
red mulberry	5,500
white oak	5,300
Freeman maple	5,300
northern red oak	5,000
Scotch pine	3,800
American sycamore	3,800
eastern redcedar	3,600
sugar maple	3,600
shagbark hickory	3,600
English elm	3,600
Japanese tree lilac	3,500
paper birch	3,300
northern catalpa	3,300
Canada plum	3,300
pin oak	2,300
red pine	1,900
ginkgo, maidenhair tree	1,900
chinkapin oak	1,900
horse chestnut	1,900
European beech	1,900
red maple	1,700
eastern cottonwood	1,700
bur oak	1,700
Chinese magnolia	1,700

Estimates are rounded.

APPENDIX 5 – LIST OF INVASIVE PLANT SPECIES

Table 36.—Invasive species list used in the Urban FIA inventory protocol, city of Milwaukee, 2021

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

APPENDIX 6 – LIST OF PESTS AND PATHOGENS

Table 37.—List of pests and pathogens assessed in the Urban FIA inventory protocol, city of Milwaukee, 2021

Scientific name	Common name
Acleris gloverana	western blackheaded budworm
Adelges piceae	balsam woolly adelgid
Adelges tsugae	hemlock woolly adelgid[a]
Agrilus auroguttatus	goldspotted oak borer[a]
Agrilus planipennis	emerald ash borer
Anoplophora glabripennis	Asian longhorned beetle
Armillaria spp.	Armillaria root disease
Bretziella fagacearum	oak wilt
Choristoneura conflictana	large aspen tortrix
Choristoneura fumiferana	spruce budworm
Choristoneura occidentalis	western spruce budworm
Choristoneura pinus	jack pine budworm
Cronartium quercuum f. sp. *Fusiforme*	fusiform rust
Cronartium ribicola	white pine blister rust
Cryphonectria parasitica	chestnut blight[a]
Dendroctonus brevicomis	western pine beetle[a]
Dendroctonus frontalis	southern pine beetle
Dendroctonus jeffreyi	Jeffrey pine beetle[a]
Dendroctonus ponderosae	mountain pine beetle
Dendroctonus pseudotsugae	Douglas-fir beetle
Dendroctonus rufipennis	spruce beetle
Discula destructiva	dogwood anthracnose[a]
Dryocoetes confusus	western balsam bark beetle[a]
Euproctis chrysorrhoea	browntail moth
Euwallacea nov. sp.	polyphagous shot hole borer
Geosmithia morbida	thousand canker disease
Heterobasidion irregulare/occidentale	Heterobasidion root disease
Ips perturbatus	northern spruce engraver
Leptographium wageneri	black stain root disease
Leptographium wageneri var. *ponderosum*	pine black stain root disease[a]
Leptographium wageneri var. *pseudotsugae*	Douglas-fir black stain root disease
Litylenchus crenatae mccannii	beech leaf disease
Lycorma delicatula	spotted lanternfly
Lymantria dispar	spongy moth
Malacosoma disstria	forest tent caterpillar
Matsucoccus resinosae	red pine scale
NA - multiple pests	subalpine fir mortality[a]
NA - multiple pests	western five-needle pine mortality[a]
Neodiprion tsugae	hemlock sawfly[a]
Neodothiora populina	aspen running canker[a]
Neonectria faginata	beech bark disease
Operophtera brumata	winter moth
Ophiostoma novo-ulmi	Dutch elm disease
Phyllocnistis populiella	aspen leafminer
Phytophthora lateralis	Port-Orford-cedar root disease
Phytophthora ramorum	sudden oak death
Raffaelea lauricola	laurel wilt[a]
Scolytus ventralis	fir engraver
Sirex noctilio	sirex wood wasp
Sirococcus clavigignenti juglandacearum	butternut canker
Tomicus piniperda	pine shoot beetle
Tubakia iowensis	bur oak blight
Xyleborus monographus	Mediterranean oak borer

[a] The pest or pathogen does not pose a risk to the tree species sampled in the 2021 Urban FIA inventory of Milwaukee.

Northern Research Station
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