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Minneapolis’ Urban Forest, 2021

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Abstract

A 2021 analysis of the urban forest in Minneapolis, Minnesota reveals that this area has an estimated 1.8 million live trees across all ownerships. The most common large diameter (11.0+ inches) tree species are hackberry, American elm, silver maple, bur oak, and honeylocust. Trees in Minneapolis are estimated to be currently storing about 228,000 tons of carbon (837,000 tons of carbon dioxide [CO_2]) valued at $38.9 million. In addition, it is estimated that these trees annually remove about 26,000 tons of CO_2 and about 774 tons of air pollution. Minneapolis' urban forest is estimated to reduce annual energy costs of residential buildings by $1.7 million. The overall compensatory value of the urban forest is estimated at $737.8 million. 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 Minneapolis.

Keywords: Urban FIA; UFIA: i-Tree; Minnesota, MN; My City's Trees; carbon; city; cities; tree volume and biomass; carbon sequestration; Urban Forest Inventory and Analysis; urban forest structure and health; urban forest trends; urban forest values; ecosystem services.

Cover photo: Trees frame the IDS tower and other iconic buildings of the Minneapolis skyline. Forest Service photo by Sjana Schanning.

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Minneapolis' Urban Forest, 2021

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Acknowledgments

The body of this report, apart from the introduction, background, and management implications sections, 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 format to allow for timely and accurate reporting for the many cities with Urban FIA data which will follow.

Critical plot selection, pre-field preparation, and data collection program work was done by James Blehm, Brian Gasper, Daniel Kaisershot, Kevin Nimerfro, Cassandra Olson, Kelly Peterson, Mitch Slater, and Paul Sowers. Field employees included Daniel August, Thom Bergstrom, Casey Cloeter, Chandler Johnson, Dan Kaisershot, Spencer Stehr, Aimee Stephens, and Brian Wall. These employees not only collect data, but also research land ownership, speak with owners to help them understand the program in order to gain permission to their land, and keep denied access rates as low as possible. Special thanks to the Information Management team for all their expertise in keeping these data organized and accessible.

Sincere gratitude goes to Philip Potyondy, sustainable forestry coordinator of the Minneapolis Park & Recreation Board, Chris Edgar, research associate professor, Department of Forest Resources, University of Minnesota, members of the Carbon Sequestration team and other staff at the Minneapolis Health Department, and Valerie McClannahan and Dennis Kepler of the Minnesota Department of Natural Resources, for their work in supporting urban forests and for the great questions, feedback, and local knowledge they provided as this report was prepared. Many thanks as well, to Thomas Goff, Benjamin Nurre, and Nancy Sonti, who reviewed this report and provided valuable feedback.

EXECUTIVE SUMMARY

People enjoy the shaded recreational trail along the shore of Lake Bde Maka Ska. Forest Service photo by Sjana Schanning.

The city of Minneapolis was sampled from 2017 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 36,783 acres), is estimated to contain 1.8 million live trees, 68.1 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 green ash, common buckthorn, American elm, northern white-cedar, and boxelder. The most common large-diameter tree species (11.0+ inches in diameter) are hackberry, American elm, silver maple, bur oak, and honeylocust. The most dominant species based on the number of trees and leaf area are green ash, American elm, hackberry, silver maple, and boxelder.

The land use class with the greatest number of trees is single family residential land (29.0 percent; 526,000 trees), which occupies 31.7 percent of the study area, highlighting the importance of engaging private landowners in managing the health and maintenance of the city's urban forest. Overall, 40.5 percent of trees are classified as growing in maintained areas such as lawns and manicured parks. Trees on public lands total 916,000 and account for 50.5 percent of the total live tree population. Trees on private lands total 898,000 and account for 49.5 percent of the population.

[1] See glossary for definition of bolded terms.

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

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 $737.8 million with the urban forest producing over $8.9 million in annual benefits (Table 1).

The tree species with the greatest estimated average percent dieback is common buckthorn (14.3 percent dieback) and the species with the greatest rot is Norway maple (4.4 percent rot). The most common urban specific damages affecting all tree species in the sampling area are bark inclusion (22.9 percent of trees) and conflict with crown (7.4 percent of trees).

Invasive plant species also threaten to alter forest composition and are found on 53.8 percent of the sampled plots; Norway maple was estimated to cover the largest area (658 acres) of any invasive plant species in the city. These natural and anthropogenic threats may affect the health and composition of Minneapolis' urban forest. Through better understanding of the benefits conferred by and potential threats to the urban forest, resource managers, arborists, and city planners can improve forest management, leading to healthier urban forests and more livable communities.

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

Feature	Estimate
Number of trees[a]	
Total live trees	1.8 million (413,706)[b]
Live saplings (1.0 to 4.9 inches in diameter)	1.2 million (379,000)[b]
Live trees (at least 5.0 inches in diameter)	579,000 (66,114)[b]
Standing dead saplings (1.0 to 4.9 inches in diameter)	112,000 (50,000)[b]
Standing dead trees (at least 5.0 inches in diameter)	15,000 (5,900)[b]
Most abundant species	
By number of live trees	green ash
By leaf area	hackberry
Ecosystem impacts and services	
VOC emissions	158 tons/year
Pollution removal	193 tons/year ($4 million/year)
Reduction in acute respiratory symptoms	453 cases/year ($40,000/year)
Avoided runoff	24.2 million cubic feet ($1.6 million/year)
Carbon storage[c]	228,000 tons ($38.9 million)
Carbon sequestration	7,100 tons/year ($1.2 million/year)
Net aboveground volume	12.2 million cubic feet
Reduced building energy use[c,d]	25,000 GJ/year ($1.7 million/year)
Reduced carbon emissions[c,d]	2,400 tons/year ($402,000/year)
Compensatory value	737.8 million

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.

Contents

BACKGROUND

Large trees shade the road and sidewalk as people gather outside a restaurant. Forest Service photo by Sjana Schanning.

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. This effort led to the development of the current FIA Strategic Plan (U.S. Forest Service 2016a) that includes a special focus on the nation's most populous cities.

In this report, the term "urban forest" describes all trees located in the city across both public and private ownerships, including planted trees along streets and boulevards, trees in parks and residential yards, remnant forest along railroads and riparian areas, small woodlots, and larger forested areas. FIA has partnered with the Forest Service's 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.

[3] See glossary for definition of bolded terms.

The Urban FIA program aims to provide continuously updated data on the status and health of urban forests across the nation to assist in informed decision making and management. Among other important datasets, including street tree inventories and satellite-based tree canopy calculations, the strength of the Urban FIA program is that it provides field based, on-the-ground measurements of a broad range of variables across all public and private land uses. Such data can be used for a wide range of purposes, such as comparing differences between publicly and privately managed lands, assessing species composition across various land uses to better assess where action might be needed, gaining insights on the impacts of (or need for) urban forest management policy changes, understanding where public outreach may be needed, and discovering areas where further research may be necessary.

The Urban FIA program is uniquely designed to assess change over time, and this first complete set of inventory data will serve as a baseline against which future Urban FIA data can be compared. This report provides estimates and an introduction to most of the metrics which can be evaluated using the Urban FIA data. Additional tools, described at the end of the Methods section, allow for further data analysis to meet the needs of urban foresters, residents, and city planners as they work together to manage their urban forests.

In January 2020, Minneapolis implemented a comprehensive city plan "Minneapolis 2040" which lays out goals including ensuring a high-quality physical environment, increased opportunities for access to natural amenities, resilience in the face of climate change, and a clean environment with clean water, air, and ecosystems (MDCPED 2019). To accomplish these goals, policies within the document provide actionable steps to guide work through 2040. A policy focused on improving tree canopy and urban forest lays out actions ranging from education and training for residents, to exploring incentives for tree planting and for preservation of existing trees. Supporting this plan, the Minneapolis Park & Recreation Board (MPRB), and the Sustainability, Healthy Homes and Environment Division of the City of Minneapolis Health Department, work to maintain and improve the urban forest to provide a healthy environment for residents and visitors.

The MPRB is tasked with the care of trees across public city properties including boulevards and parks, and with mitigation of high-risk trees on private property. Following the priorities and framework set by "Minneapolis 2040", their own document, "Parks for All: Minneapolis Park & Recreation Board Comprehensive Plan 2021–2036" directly guides their mission and work and brings a strengthened focus on equitable and sustainable organizational policies (MPRB 2021). Goals outlined in the plan, including strengthened ecological connections and an expanded health equity focus, while guiding the MPRB in their actions, including the way they manage public trees and greenspace and ways in which they apply practices laid out in local ordinances and the "2016 Minneapolis Urban Forest Policy" (MDCPED 2016).

With a focus on privately owned trees, the Sustainability, Healthy Homes and Environment Division of the City of Minneapolis Health Department oversees the City Trees program. This program began in 2006 to build the city's tree canopy by incentivizing private property owners to care for shade trees. The city hosts an annual low-cost tree sale for residents and offers affordable tree planting services for businesses, non-profits, and organizations. In the last 5 years, the City Trees program has emphasized work in low tree-canopy areas. The city of Minneapolis has two designated environmental justice communities, known as Green Zones. The City Trees program works to advance equity and increase tree canopy in these areas by prioritizing outreach in the Green Zones and offering free tree planting services for Green Zone property owners. Throughout Minneapolis, City Trees has planted over 25,000 trees on private property[4].

From 2017 through 2021, while the measurements for the Urban FIA data contained in this report were taking place, the City of Minneapolis continued ongoing, progressive actions to manage emerald ash borer. This invasive pest kills ash quickly, causing trees to rapidly shift from thriving yard trees to a liability. To reduce hazard risks, management practices in infested urban areas involves rapid removal of trees, often even before individual trees show signs of damage. Although the data in this report show green ash as the most abundant species (16.0 percent of the total live tree population), it is likely that many of the ash included in the study have died or were removed since measurement. During the 5 years of Urban FIA data collection, the Minneapolis Park and Recreation Board removed 21,941 ash trees from public land and condemned 12,628 on private land with requirements that they be removed within 60 days[5]. Although all ash are at risk, management efforts typically focus on trees greater than 5.0 inches in diameter due to their larger hazard risk. Of the 290,000 green ash estimated to be present across public and private lands in Minneapolis, nearly 90 percent of those (259,000) are saplings (trees 1.0–4.9 inch in diameter) and would receive little management attention. Due to the significant changes occurring in the ash population during the time the measurements for this study were occurring, the actual current number of live ash trees can be assumed to be much less. As the Urban FIA program continues to monitor changes in tree populations across Minneapolis, it will most certainly show significant declines in the number of live ash trees across the city. Although Urban FIA data was not yet available to assist with planning for necessary emerald ash borer management, the data provided through the program may help Minneapolis as they consider options and anticipate resource needs for future tree removals.

Along with actual changes that take place between measurement and reporting, it is also important to understand that estimates included here are based upon a sample made up of 197 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. 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. Due to the broad range of possible uses for the data, this report does not limit results to a minimum standard error threshold. 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.

As Minneapolis strives to meet the goals outlined in "Minneapolis 2040" and "Parks for All", the data provided through the Urban FIA program can provide quantifiable change over time to serve as necessary metrics by which to measure the success of current efforts and inform planners of future needs.

[4] Number of trees planted is provided by the City Trees program manager, Sydney Schaaf.

[5] Number of removed and condemned trees provided by Minneapolis Park & Recreation Board sustainable forestry coordinator, Philip Potyondy.

Methods

To evaluate the extent, composition, and benefits of Minneapolis' 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 this report (Baer et al. 2025), along with i-Tree Eco modeling software (Nowak 2024). This process established survey plots across Minneapolis and aims to revisit those plots every 5 years. Future reports can build on these data and consistently provide information on urban forest extent, diversity, health condition, and benefits. The first 5-year cycle of field measurements in Minneapolis was completed from 2017–2021. The sampling area was defined by the U.S. Census Bureau Designated Places boundary (highlighted in red in Fig. 1a). In total, the Urban FIA sample surveyed 197 plots[6] across the city's 36,783 acres within the designated sampling area in Minneapolis (Fig. 1b).

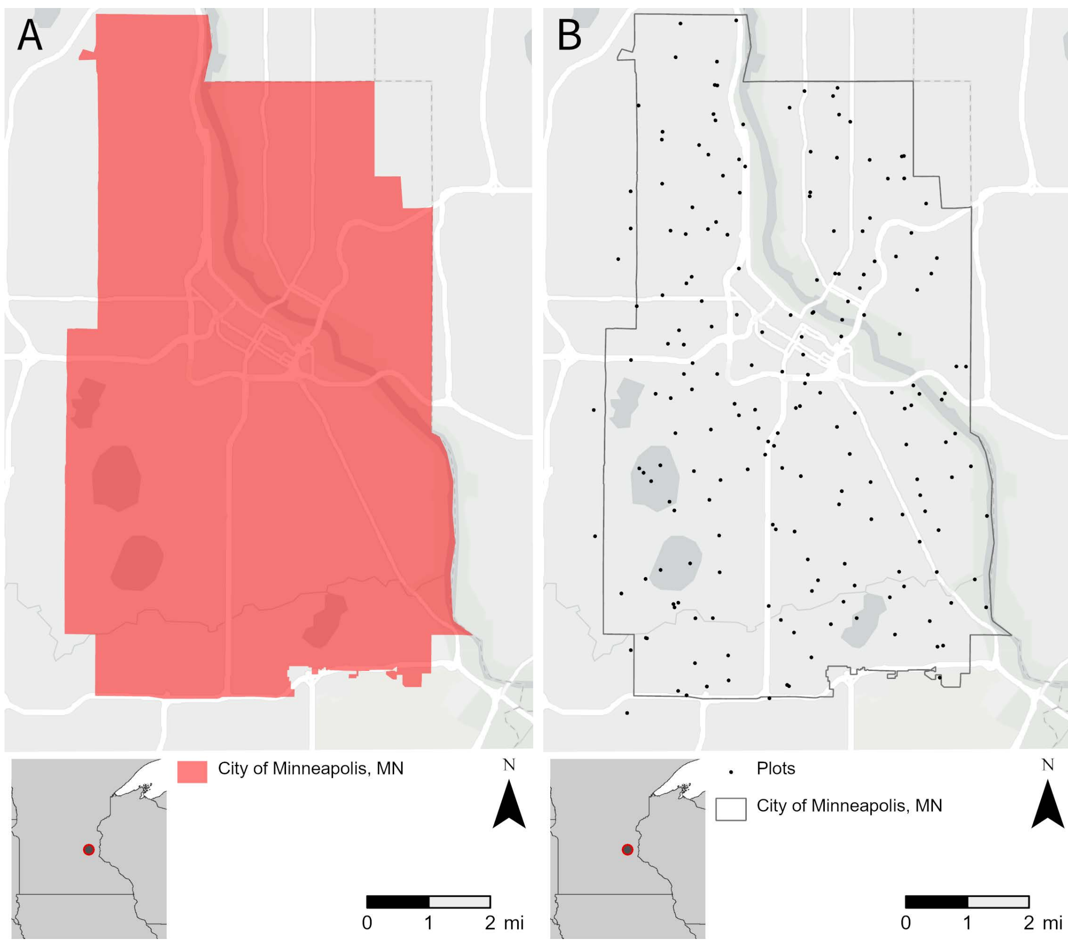

Figure 1.—Study area (A) and approximate plot locations (B) for the Urban Forest Inventory and Analysis (FIA) inventory, city of Minneapolis, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

[6] 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.

New methods were implemented in the inventory of Minneapolis' 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 the online supplement to this report (Baer et al. 2025) for more detailed information. Throughout this report trees refer to woody plant species listed in Appendix 3 and 3B of the Urban NRS Field Guide Version 7.1 (USDA Forest Service 2017) with **diameters** of at least 1.0-inch, and except where explicitly noted, results are given for live trees.

The collected data were analyzed using FIA methodology and i-Tree Eco modeling software outlined in Baer et al. (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.

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AREA AND COVER CHARACTERISTICS

Trees, lights, and the night sky are reflected in the water of the Peavey Plaza fountains. Forest Service photo by Sjana Schanning.

In 2010, Minnesota had 1,099,000 acres of urban land that covered 2.2 percent of the state area, and this urban area is projected to increase to 4.9 percent of the state by the year 2060 (Nowak and Greenfield 2018). Minneapolis is the largest city in Minnesota by population (383,000 residents with a population density of 7,088 per square mile in 2010) (U.S. Census Bureau 2024).

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 class group is developed-medium, followed by developed-low, developed-high, and developed-open/vegetation (Table 3). Figure 2 shows the distribution of landcover class groups across the city. Areas of developed-medium land cover are estimated to contain the greatest proportion (40.3 percent) of live trees in the sampling area of any land cover class group, followed by developed-low, developed-open/vegetation, and water land covers (28.4 percent, 27.6 percent, and 2.1 percent of the trees in the sampling area, respectively).

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

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

Source: Homer et al. 2015

See Appendix 1 for descriptions of each NLCD cover class

Table 3.—Sample area and count of plots within National Land Cover Database (NLCD) land cover class groups, city of Minneapolis, 2021

NLCD land cover class group	Area (acres)	Land (percent)	Plots (number)
Developed-medium	11,161	30	67
Developed-low	10,600	29	67
Developed-high	6,858	19	24
Developed-open/vegetation	6,070	17	29
Water	2,095	6	10
Total	**36,783**	**100**	**197**

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

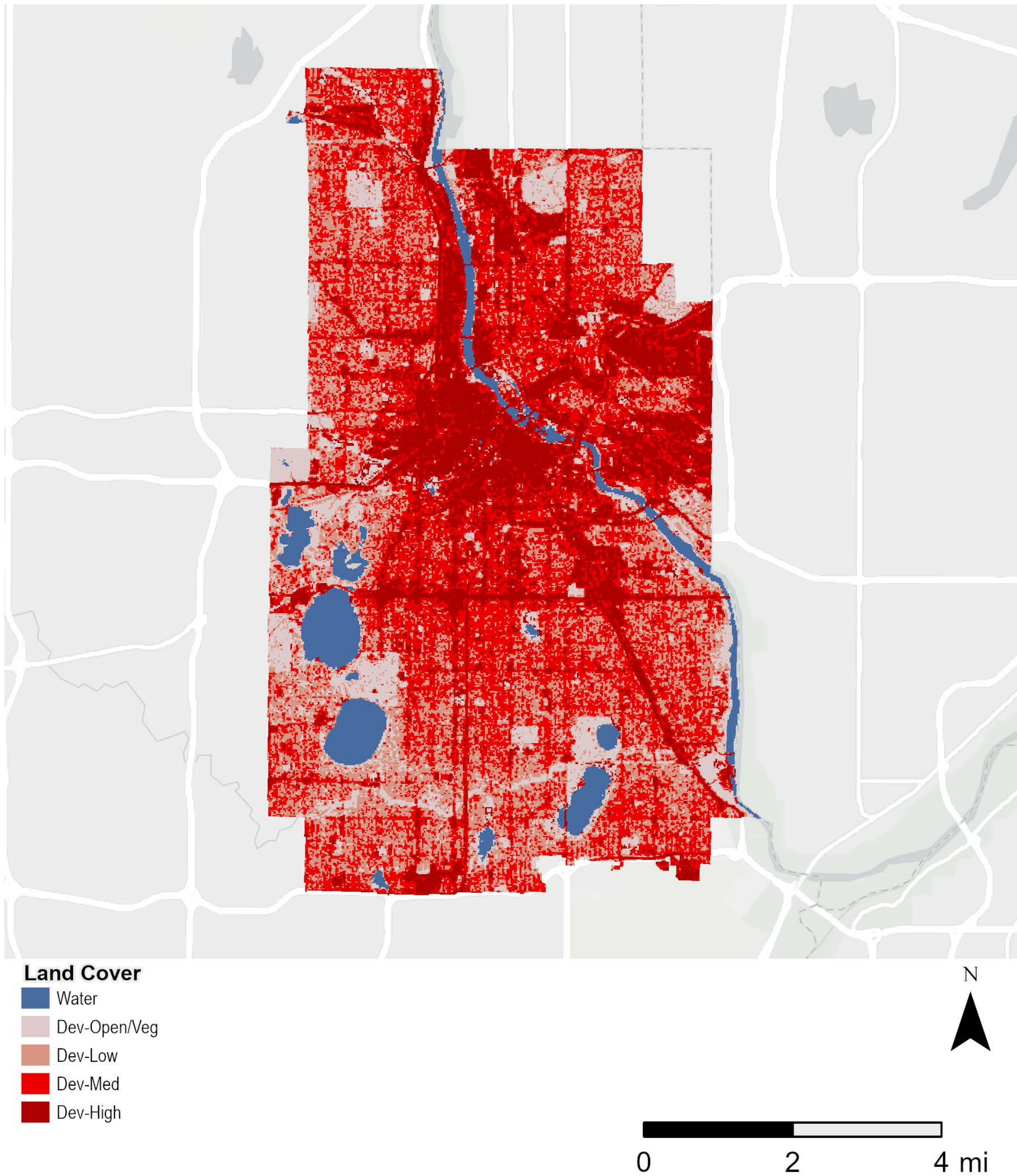

Figure 2.—Distribution of National Land Cover Database (NLCD; Homer et al. 2015) land cover class groups, city of Minneapolis, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

FIA Land Use

In addition to categorization according to NLCD land cover classes, plots were also classified in the field based on FIA land use classes (Table 4). There are often multiple land uses on a single plot. When this occurs, the area of each land use is mapped, and a percentage 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 Minneapolis.

Single-family residential (hereafter, residential) is the most prevalent land use class in Minneapolis, covering 31.7 percent of the city area (containing 29.0 percent of the city's trees), followed by **rights-of-way** (28.0 percent of the city area), commercial/industrial (13.6 percent), recreation/cemetery (12.6 percent), and multi-family residential (6.2 percent) (Table 5).

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

FIA land use class	Area (acres)	Standard error (acres)	Land (percent)	Plots (number)
Forest land	736	364	2.0	4.0
Commercial/industrial	5,016	745	13.6	21.7
Multi-family residential	2,284	600	6.2	11.1
Residential	11,646	957	31.7	69.4
Recreation/cemetery	4,626	696	12.6	23.7
Rights-of-way	10,290	893	28.0	56.5
Water	2,184	196	5.9	10.6
Total	**36,783**	**371**	**100.0**	**197.0**

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

Tree, Shrub, and Ground Cover

On every plot visited, an overall tree canopy cover and shrub cover is estimated for each measured condition. The percent tree cover estimate includes the cover from all trees greater than 1.0-inch in diameter. The percent shrub cover includes cover from the remaining woody vegetation which is over one foot tall. These two estimates are taken independently and may overlap, for example where shrubs are growing underneath trees. Many cities also have tree canopy estimates 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. Although results from these aerial based methods often differ from the Urban FIA ground-based estimates by a few percent, the data gathered through Urban FIA estimates can provide additional, valuable information. The independently recorded tree and shrub cover estimates, for example, can indicate layered vegetation, which is not captured through other, aerial based methods. Urban FIA cover data can also be evaluated to better understand the amount and type of cover across individual FIA land uses.

Based on Urban FIA evaluations, tree cover in Minneapolis is estimated at 23.9 percent and shrub cover at 4.0 percent. The tree cover recorded on plots varied significantly across the city (Fig. 3a). Since overhanging tree canopy is included in the tree cover estimate, it is common to have tree cover reported even where there are no trees located within the plot area. A shrub cover of 25 percent or less was recorded most frequently and only four plots were recorded with a shrub cover higher than 25 percent (Fig. 3b) The highest shrub cover recorded was 60 percent. Average tree cover is highest on forest land (74.8 percent tree cover), followed by residential (33.9 percent), and recreation/cemetery land uses (27.1 percent) (Table 6). Shrub cover is highest on forest land (30.2 percent shrub cover), followed by residential (6.9 percent), and recreation/cemetery land uses (4.2 percent). Impervious cover is highest on rights-of-way (66.8 percent impervious cover), commercial/industrial (44.1 percent), and multi-family residential land uses (19.1 percent) (Table 6).

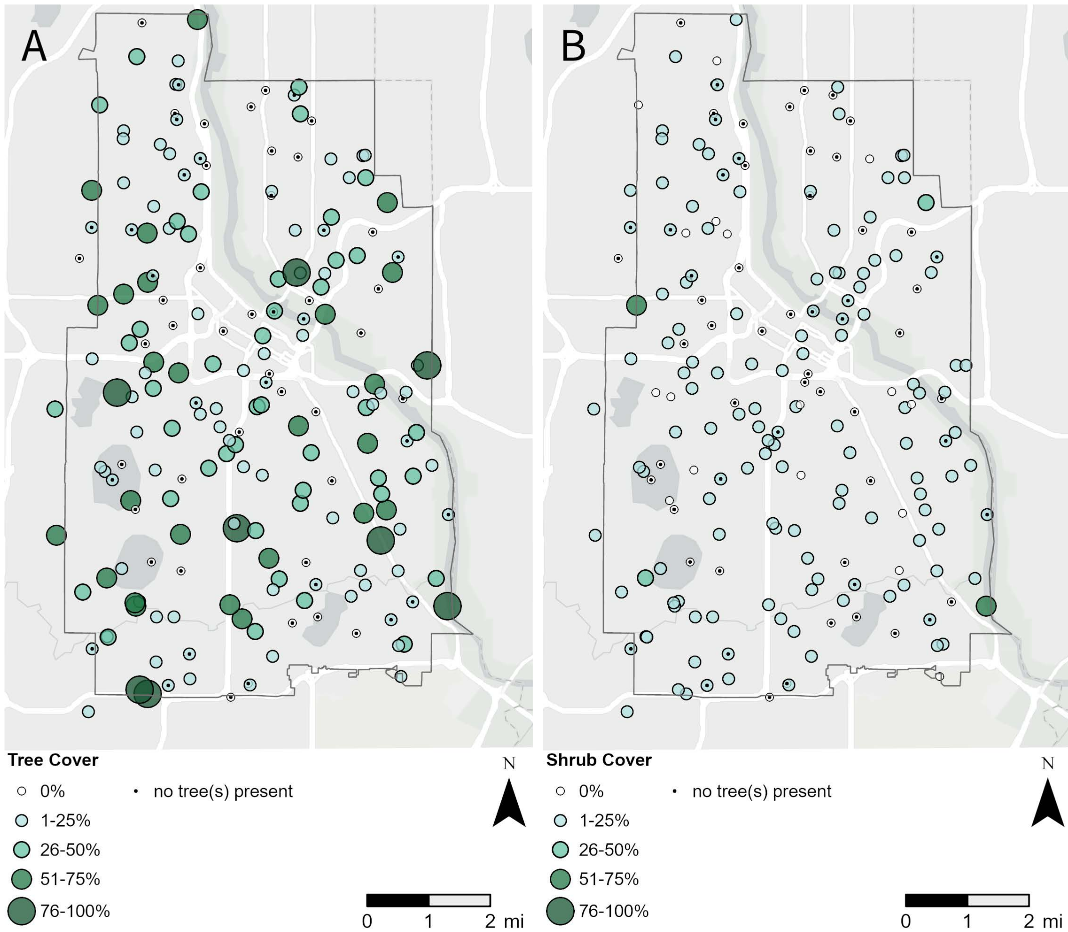

Figure 3.—Tree (A) and shrub (B) cover estimates for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, city of Minneapolis, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

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

FIA land use class	Tree (percent)	Shrub (percent)	Impervious (percent)
Forest land	74.8	30.2	0.2
Commercial/industrial	7.1	2.4	44.1
Multi-family residential	10.8	3.3	19.1
Residential	33.9	6.9	14.9
Recreation/cemetery	27.1	4.2	10.2
Rights-of-way	22.1	0.6	66.8
Water	6.7	0.6	1.0
Total	**23.9**	**4.0**	**32.0**
Total standard error	**6.9**	**0.6**	**1.8**

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

Field crews categorized ground surface cover on each field plot according to five classes: (i) building, (ii) low vegetation (woody plants under 1 foot tall and all herbaceous plants), (iii) permeable (soil, leaf litter, mulch, gravel, etc.), (iv) impervious (non-building), or (v) water. Permeable and low vegetation ground covers account for 46.3 percent of all ground covers in Minneapolis, while building and other impervious cover account for 47.7 percent (Figs. 4 and 5). An additional 5.9 percent of the city is classified as water.

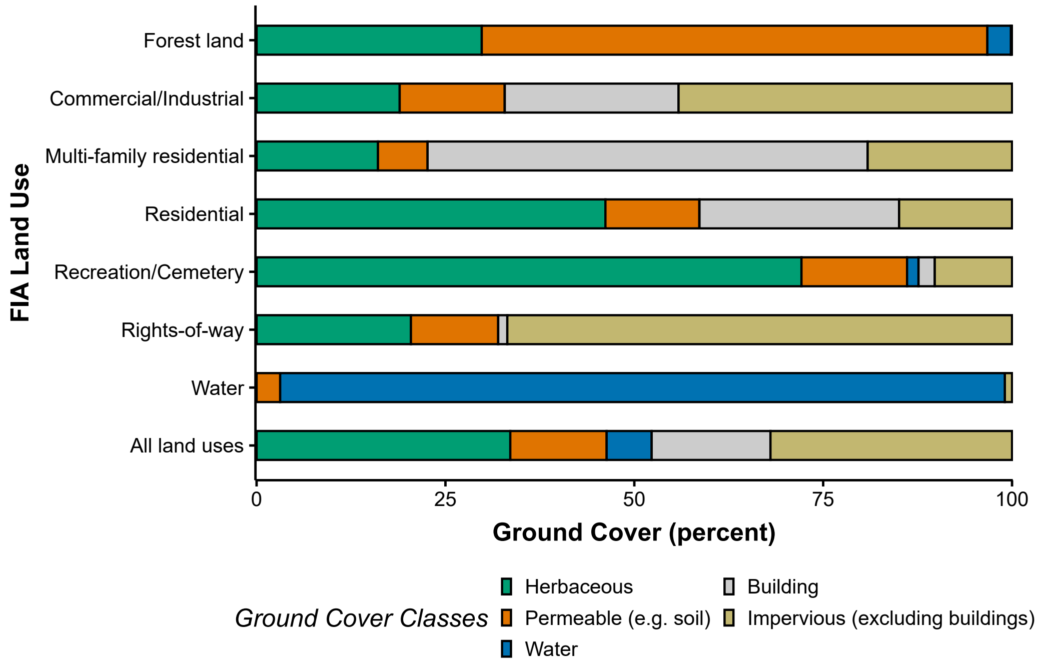

Figure 4.—Average ground cover by Forest Inventory and Analysis (FIA) land use class, city of Minneapolis, 2021.

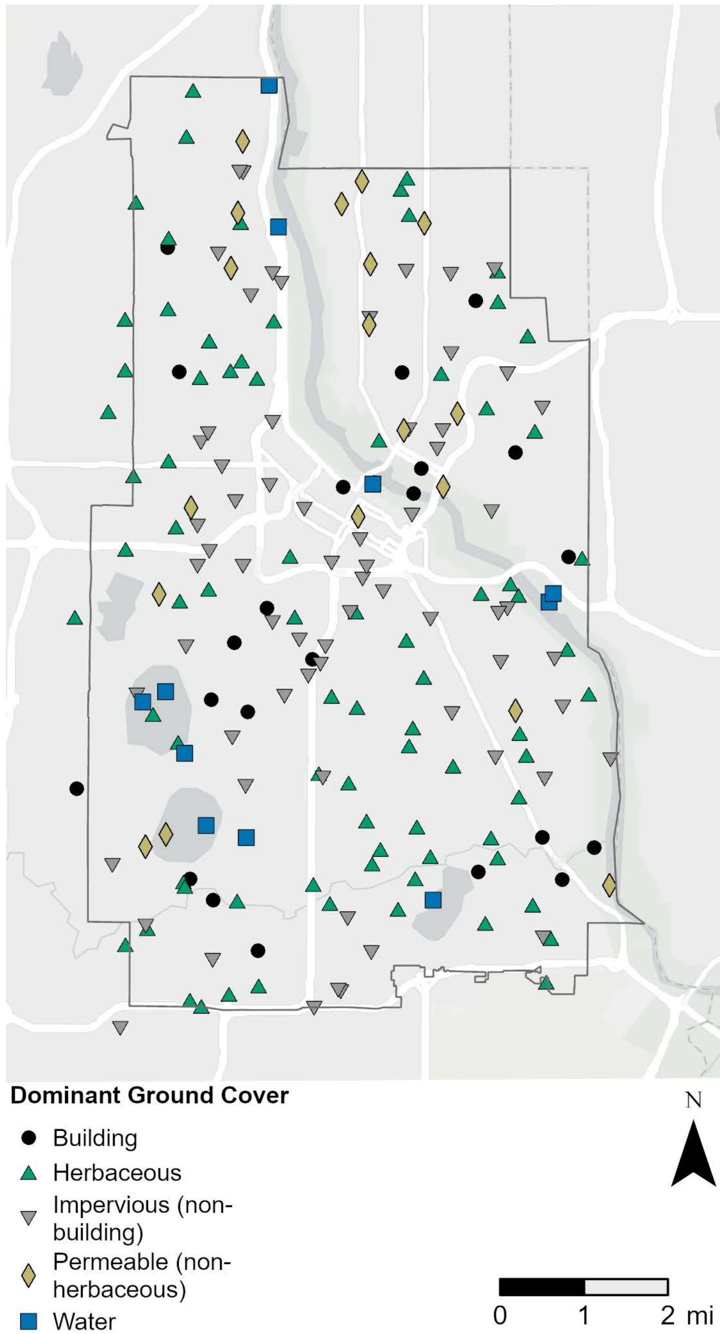

Figure 5.—Dominant ground cover for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, city of Minneapolis, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Ownership

Plot ownership was divided into private, State and local government, Federal government, and water classes (which are classified as unknown (water) due to varying water ownership regulations throughout the country). The most dominant ownership in Minneapolis is private (50.9 percent), followed by State and local (40.7 percent), unknown (water) (5.9 percent), and Federal (2.5 percent) (Table 7). Percent tree cover is greatest in private (26.3 percent), followed by State and local (24.7 percent), and unknown (water) (6.7 percent). In Minneapolis, there are a total of 898,000 trees (49.5 percent of the live tree population) on private lands, 848,000 trees (46.8 percent) on land managed by State and local government, and 67,000 trees (3.7 percent) within areas classified as unknown (water) (Table 7). Generally, trees within areas of ownership classified as unknown (water) stand on small islands within large bodies of water, such as the Mississippi River. Minneapolis' sapling (trees 1.0–4.9 inches in diameter) population is mostly found on private lands (48.9 percent), followed by State and local lands (47.9 percent), and unknown (water) lands (3.2 percent) (Table 7).

Table 7.—Number of live trees by ownership and size class, city of Minneapolis, 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)
Private	604,000	151,000	143,000	898,000	19,000
State and Local	591,000	132,000	126,000	848,000	15,000
Unknown (water)	40,000	21,000	6,300	67,000	2,200
Federal	0	1,000	0	1,000	920
Total	**1,230,000**	**304,000**	**275,000**	**1,810,000**	**37,000**

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

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FOREST STRUCTURE

A variety of trees, including conifers and hardwoods of different sizes, shapes, and colors, shade a house on a corner lot. Forest Service photo by Sjana Schanning.

Number of Trees

Minneapolis' urban forest has an estimated 1.8 million live trees and 126,000 standing dead trees. The number of trees varies by land use and diameter class. Nearly one-third of the trees in Minneapolis are located on residential land (29.0 percent, 526,000 trees) (Table 8). Overall, 68.1 percent of Minneapolis' trees are saplings, while the remaining 16.8 percent and 15.2 percent are medium trees (5.0–10.9 inches in diameter) and large trees (≥11.0 inches in diameter), respectively.

The greatest proportion of trees (40.3 percent) are found within the developed-medium land cover class group. The highest tree density (82.5 trees per acre) is found on the developed-open/vegetation cover class group (Table 9).

Table 8.—Number of live trees by Forest Inventory and Analysis (FIA) land use class and diameter class, city of Minneapolis, 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)	Total standard error (number)	Density no./ac
Forest land	361,000	56,000	21,000	438,000	242,000	594
Commercial/industrial	147,000	24,000	13,000	184,000	160,000	37
Multi-family residential	0	11,000	9,300	20,000	11,000	9
Residential	326,000	91,000	109,000	526,000	131,000	45
Recreation/cemetery	45,000	41,000	42,000	127,000	48,000	28
Rights-of-way	316,000	61,000	74,000	451,000	273,000	44
Water	40,000	21,000	6,300	67,000	71,000	31
Total	**1,230,000**	**304,000**	**275,000**	**1,810,000**	–	**49**
Total standard error	**379,000**	**51,000**	**24,000**	**414,000**	–	–

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

– = no value for cell.

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

NLCD and cover use 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)	Total standard error (number)	Density no./ac
Water	31,000	6,300	0	38,000	33,000	18
Developed-open/ vegetation	343,000	91,000	67,000	501,000	236,000	83
Developed-low	329,000	88,000	99,000	516,000	172,000	49
Developed-medium	531,000	107,000	92,000	730,000	291,000	65
Developed-high	0	12,000	17,000	29,000	11,000	4
Total	**1,230,000**	**304,000**	**275,000**	**1,810,000**	–	**49**
Total standard error	**379,000**	**51,000**	**24,000**	**414,000**	–	–

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

– = no value for cell.

Species Composition

The 10 most common tree species[7] by number account for 74.8 percent of all recorded live trees and are green ash, common buckthorn, American elm, northern white-cedar, boxelder, hackberry, silver maple, red mulberry, Siberian elm, and white mulberry (Table 10, Fig. 6). A breakdown of the estimated number of each recorded tree species by diameter classes is presented in Appendix 2. The relative abundance of the most common trees by species and diameter class are presented in Table 11 and Figures 7 and 8. Small diameter trees (saplings) are generally the most abundant of the three tree size classes for the 10 most common tree species, comprising 78.3 percent of the total, while large diameter trees comprise only 8.5 percent of the total (Table 11, Fig. 7). When broken down into 2-inch diameter classes, the top five most common species by number showed an abundance distribution similarly skewed toward smaller diameter trees (Fig. 8).

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

Common name	Trees (number)	Percent
green ash	290,000	16.0
common buckthorn	225,000	12.4
American elm	154,000	8.5
northern white-cedar	140,000	7.7
boxelder	136,000	7.5
hackberry	127,000	7.0
silver maple	83,000	4.6
red mulberry	74,000	4.1
Siberian elm	71,000	3.9
white mulberry	57,000	3.1
American basswood	36,000	2.0
apple spp.	27,000	1.5
western redcedar	27,000	1.5
bur oak	25,000	1.4
Norway maple	24,000	1.3
honeylocust	22,000	1.2
willow spp.	21,000	1.2
eastern cottonwood	20,000	1.1
sugar maple	20,000	1.1
white ash	19,000	1.1
littleleaf linden	19,000	1.0
slippery elm	18,000	1.0
Norway spruce	18,000	1.0
white oak	15,000	0.8
northern pin oak	14,000	0.8
Amur maple	14,000	0.8
American hornbeam, musclewood	13,000	0.7
blue spruce	12,000	0.6
white spruce	9,200	0.5
eastern redcedar	7,700	0.4
ginkgo, maidenhair tree	7,200	0.4
Freeman maple	6,400	0.4
chokecherry	5,500	0.3
Austrian pine	5,200	0.3
river birch	5,200	0.3
paper birch	5,200	0.3
black walnut	4,700	0.3
red maple	4,000	0.2
eastern white pine	3,700	0.2
Japanese tree lilac	3,400	0.2
pin oak	2,400	0.1
Ohio buckeye	2,300	0.1
weeping willow	2,100	0.1
pear spp.	2,100	0.1
pin cherry	2,100	0.1
northern red oak	2,000	0.1
common pear	2,000	0.1
swamp white oak	1,300	0.1
black locust	1,300	0.1
apricot	1,300	0.1
red pine	1,000	0.1
Scotch pine	1,000	0.1
northern catalpa	1,000	0.1
black oak	1,000	0.1
bitternut hickory	1,000	0.1
black ash	1,000	0.1
American mountain-ash	1,000	0.1
Japanese yew	1,000	0.1
Total	**1,810,000**	**100.0**

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

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

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

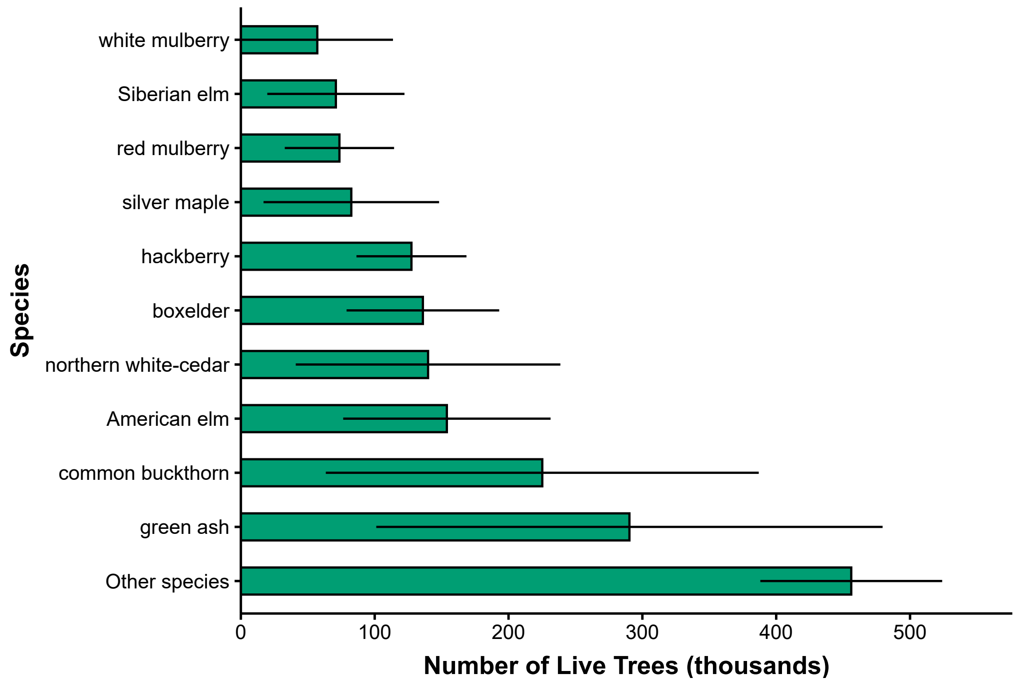


Figure 6.—The 10 most common tree species by number of trees, city of Minneapolis, 2021. Other species is the total number of all other tree species in the inventory. Error bars represent 68 percent confidence intervals around the estimated means.

Table 11.—Number of live trees by size class for the 10 most common tree species, city of Minneapolis, 2021

Species	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0 + in. diameter trees (number)	Total (number)
green ash	259,000	16,000	15,000	290,000
common buckthorn	205,000	20,000	0	225,000
American elm	105,000	27,000	22,000	154,000
northern white-cedar	130,000	5,100	5,200	140,000
boxelder	87,000	36,000	13,000	136,000
hackberry	71,000	29,000	28,000	127,000
silver maple	40,000	22,000	21,000	83,000
red mulberry	52,000	18,000	3,700	74,000
Siberian elm	62,000	3,700	5,700	71,000
white mulberry	53,000	1,700	2,300	57,000
Total	**1,060,000**	**179,000**	**116,000**	**1,360,000**

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

Standard errors for each estimate are reported in Appendix 2.

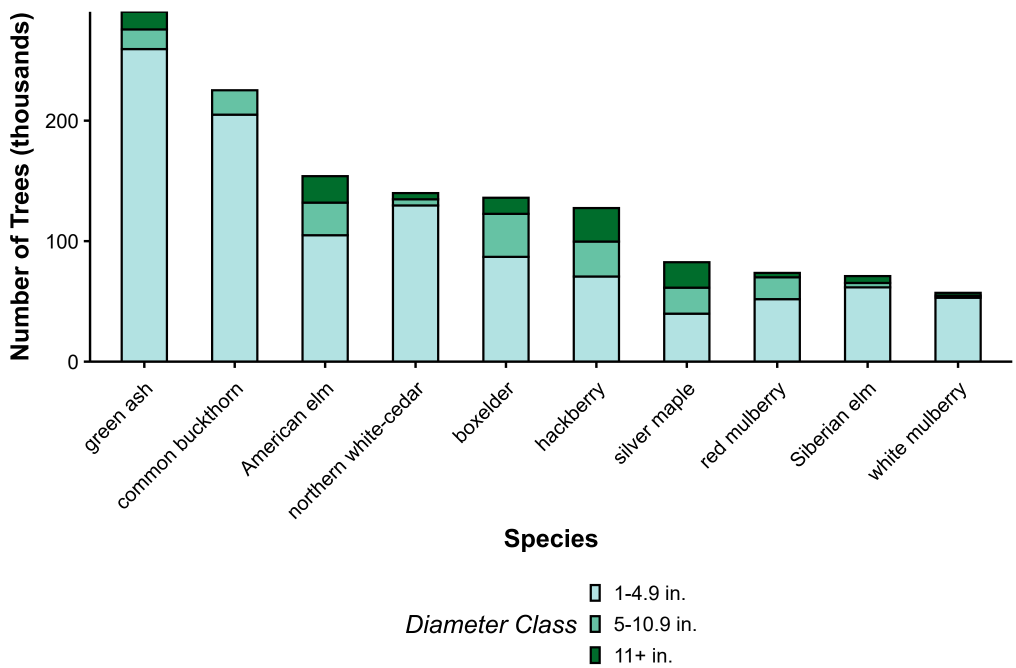


Figure 7.—Number of trees by size class for the 10 most common tree species, city of Minneapolis, 2021.

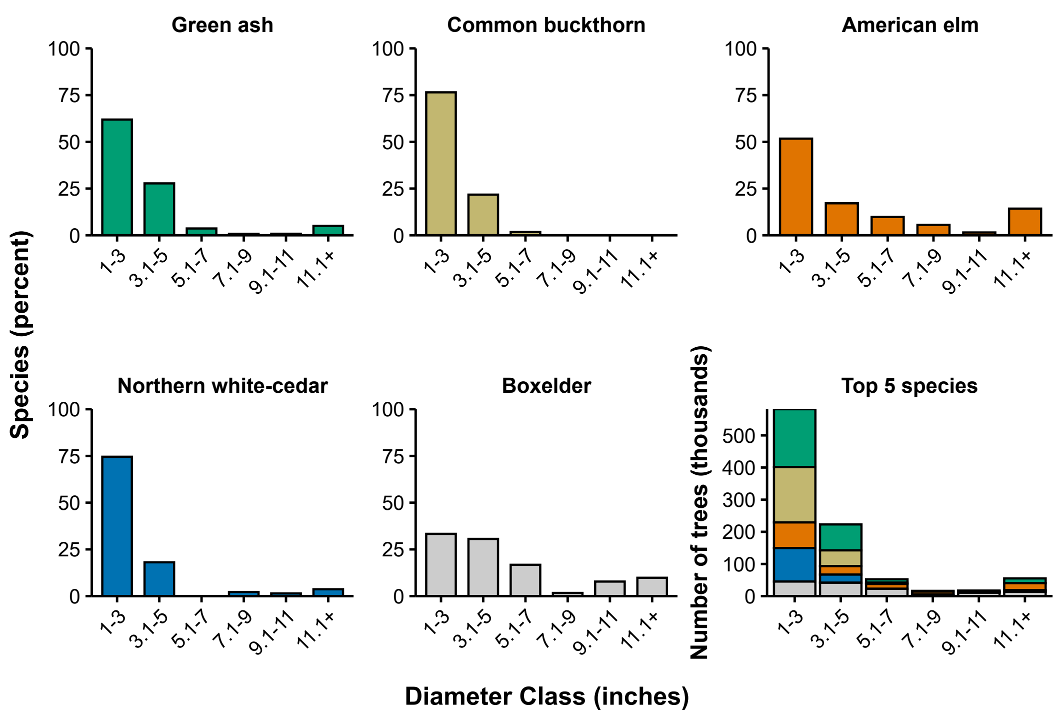


Figure 8.—Percentage of species population by diameter class for the five most common tree species, city of Minneapolis, 2021.

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 three most common species in terms of stem numbers in the smallest-diameter size classes (less than 5.0 inches in diameter) are green ash, common buckthorn, and northern white-cedar, together representing less than half (48.1 percent) of all live trees less than 5.0 inches in diameter (Table 12, Appendix 2). Boxelder, hackberry, and American elm are the top three most common species in intermediate diameter size classes, representing 30.1 percent of all live trees between 5.0 and 10.9 inches in diameter. The top three dominant species in the largest diameter classes, often the most recognizable component of the urban forest canopy, are hackberry, American elm, and silver maple, together comprising 25.8 percent of live trees at least 11.0 inches in diameter (Table 12, Appendix 2).

Table 12.—The most common tree species by size class, city of Minneapolis, 2021

Diameter class (inches)	Common name	Trees (number)
1.0–4.9	green ash	259,000
	common buckthorn	205,000
	northern white-cedar	130,000
	American elm	105,000
	boxelder	87,000
5.0–10.9	green ash	259,000
	common buckthorn	205,000
	northern white-cedar	130,000
	American elm	105,000
	boxelder	87,000
11.0+	hackberry	28,000
	American elm	22,000
	silver maple	21,000
	bur oak	19,000
	honeylocust	17,000

Estimates are rounded.

Standard errors for each estimate are reported in Appendix 2.

In Minneapolis, tree species composition on private land is dominated by green ash (24.6 percent), northern white-cedar (15.6 percent), and American elm (9.1 percent) (Table 13). The most common tree species on public lands are common buckthorn (24.3 percent), hackberry (9.8 percent), and boxelder (9.0 percent) (Table 14). A total of 51 tree species are recorded on private lands, resulting in a **Shannon-Wiener diversity index** value of 2.8. The 34 species of trees recorded on public lands results in a Shannon-Wiener diversity index value of 2.7. 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 private land, the top three genera with the greatest number of trees are ash (*Fraxinus*), northern white cedar (*Thuja*), and maple (*Acer*). On public land they are common buckthorn (*Rhamnus*), maple (*Acer*), and elm (*Ulmus*) (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 Minneapolis, 2021

Common name	Trees (percent)
green ash	24.6
northern white-cedar	15.6
American elm	9.1
white mulberry	6.2
boxelder	6.0
hackberry	4.2
red mulberry	4.2
apple spp.	3.0
western redcedar	3.0
Siberian elm	2.2
silver maple	2.1
white ash	2.1
Norway spruce	1.7
Amur maple	1.5
bur oak	1.4
blue spruce	1.3
eastern cottonwood	1.2
Norway maple	1.0
white spruce	1.0
honeylocust	0.9
chokecherry	0.6
river birch	0.6
paper birch	0.6
littleleaf linden	0.5
eastern redcedar	0.4
eastern white pine	0.4
Japanese tree lilac	0.4
sugar maple	0.4
black walnut	0.4
common buckthorn	0.3
pear spp.	0.2
Austrian pine	0.2
pin cherry	0.2
Freeman maple	0.2
northern red oak	0.2
common pear	0.2
swamp white oak	0.1
pin oak	0.1
black locust	0.1
apricot	0.1
red pine	0.1
Scotch pine	0.1
northern catalpa	0.1
black oak	0.1
weeping willow	0.1
American basswood	0.1
red maple	0.1
Ohio buckeye	0.1
northern pin oak	0.1
American mountain-ash	0.1
Japanese yew	0.1

Estimates are rounded.

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

Common name	Trees (percent)
common buckthorn	24.3
hackberry	9.8
boxelder	9.0
American elm	7.9
green ash	7.6
silver maple	6.9
Siberian elm	5.6
red mulberry	3.9
American basswood	3.8
willow spp.	2.3
slippery elm	2.0
sugar maple	1.8
Norway maple	1.7
white oak	1.6
littleleaf linden	1.6
honeylocust	1.5
American hornbeam, musclewood	1.4
northern pin oak	1.4
bur oak	1.3
eastern cottonwood	1.1
ginkgo, maidenhair tree	0.8
Freeman maple	0.5
eastern redcedar	0.4
Austrian pine	0.3
red maple	0.3
Norway spruce	0.3
white mulberry	0.2
Ohio buckeye	0.1
black walnut	0.1
pin oak	0.1
weeping willow	0.1
bitternut hickory	0.1
white ash	0.1
black ash	0.1

Estimates are rounded

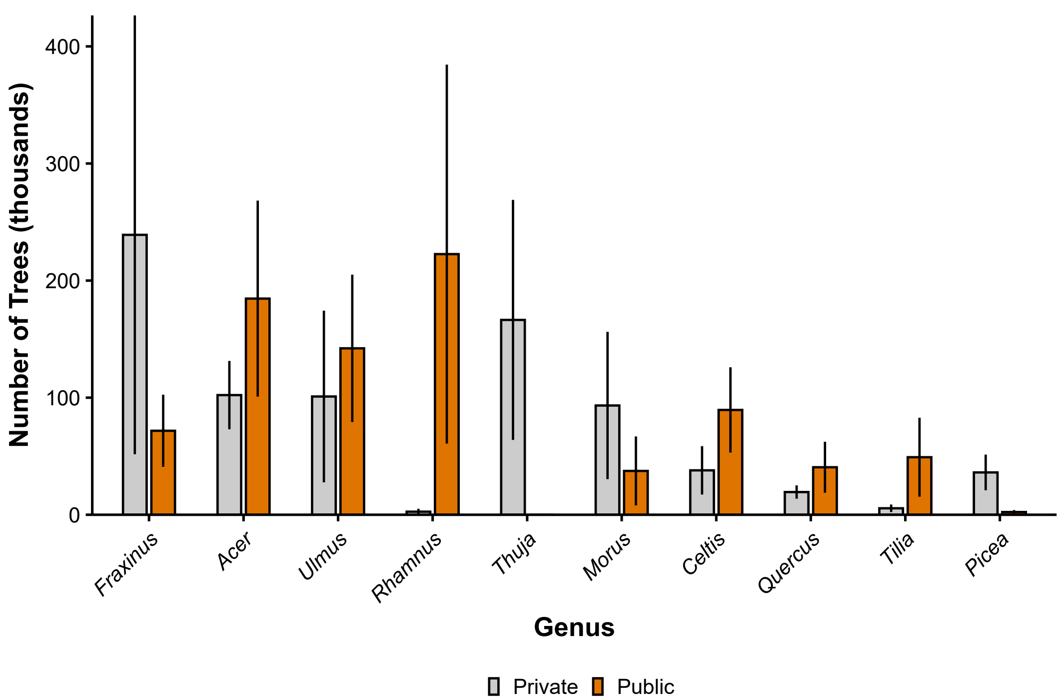


Figure 9.—The 10 most common genera within ownership classes, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Trees in Maintained Areas

Overall, 40.5 percent of trees in Minneapolis 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 Minneapolis, the most common tree species in maintained areas are northern white-cedar (18.6 percent of all trees in maintained areas), white mulberry (7.8 percent), and hackberry (5.5 percent) (Table 15). Appendix 4 lists the composition of tree species in maintained areas for the city of Minneapolis.

Table 15.—The 10 most common tree species in maintained areas, city of Minneapolis, 2021

Common name	Trees (number)	Percent of all trees in maintained areas
northern white-cedar	137,000	18.6
white mulberry	57,000	7.8
hackberry	41,000	5.5
red mulberry	41,000	5.5
American elm	34,000	4.6
green ash	32,000	4.4
western redcedar	27,000	3.6
apple spp.	26,000	3.5
Norway maple	24,000	3.3
honeylocust	22,000	3.0

Estimates are rounded.

Leaf Area

Leaf area is correlated with many ecosystem services provided by the urban forest. It is estimated as the surface area (on one side) of the leaves on a given tree or in an area. The proportion of total leaf area in the urban forest is greatest for trees 29.1+ inches in diameter (14.9 percent), followed by 19.1–21.0 inches in diameter (8.2 percent), and 9.1–11.0 inches in diameter (8 percent) (Fig. 10). In Minneapolis, leaf area is greatest in residential land uses (43.5 percent of total leaf area), followed by rights-of-way (22.6 percent), and recreation/cemetery land uses (13.7 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 13.3 in forest land use to 6.3 in rights-of-way (Fig. 11).

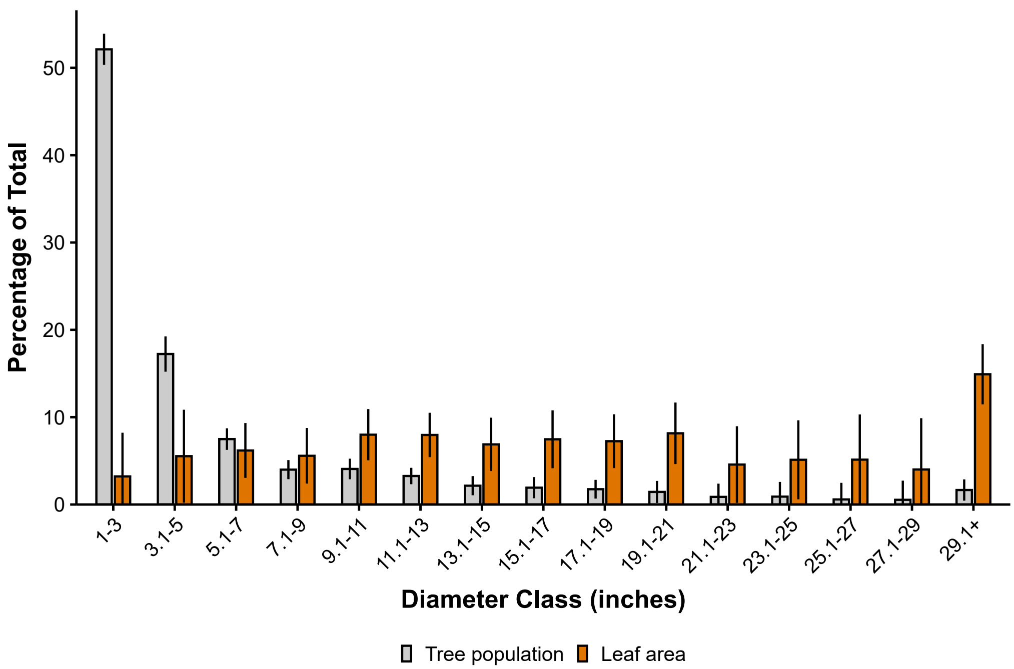


Figure 10.—Percentage of tree population and leaf area by 2-inch diameter class, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

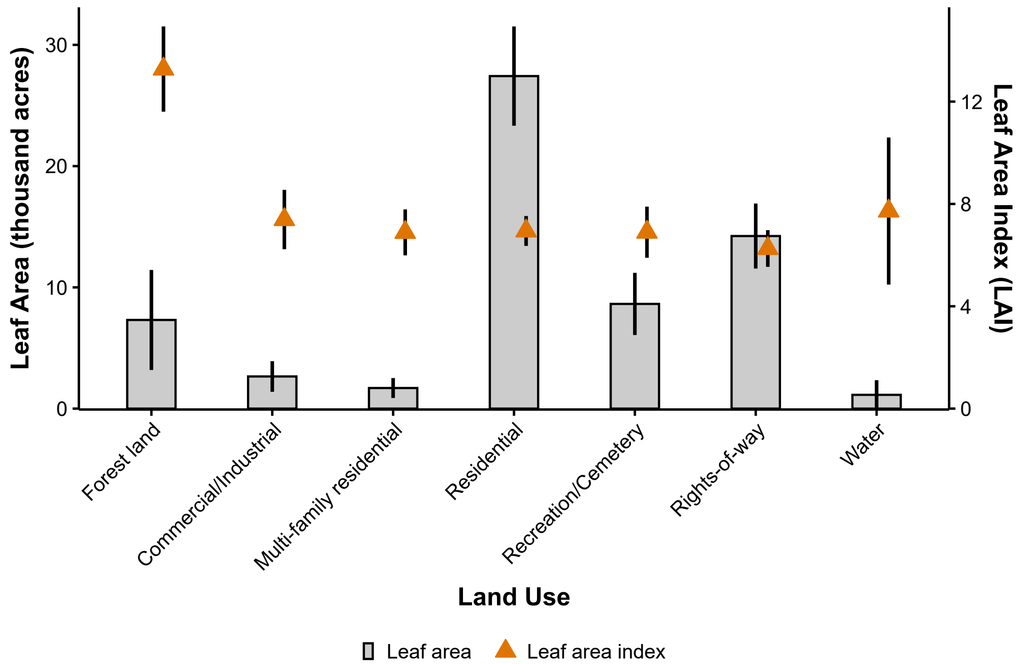


Figure 11.—Leaf area and leaf area index (LAI) by Forest Inventory and Analysis (FIA) land use class, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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 Minneapolis' urban forest with the greatest IVs are green ash (22.9), American elm (17.6), and hackberry (17.3) (Table 16).

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

Common name	Population (percent)	Leaf area (percent)	Importance value
green ash	16.0	6.9	22.9
American elm	8.5	9.1	17.6
hackberry	7.0	10.3	17.3
silver maple	4.6	10.0	14.6
boxelder	7.5	7.0	14.5
common buckthorn	12.4	0.7	13.1
northern white-cedar	7.7	1.3	9.0
bur oak	1.4	6.7	8.1
eastern cottonwood	1.1	5.6	6.7
red mulberry	4.1	1.9	6.0

Estimates are rounded.

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

VOLUME AND BIOMASS

The branches of a large oak tree stretch sideways creating an impressive canopy against the blue sky. Forest Service photo by Sjana Schanning.

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 Minneapolis, live trees at least 5.0 inches in diameter are estimated to contain 12.2 million cubic feet of net volume, of which 27.3 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 (US Census Bureau 2020), which would require approximately 14,500 board feet to construct. Thus, the net sawtimber volume of Minneapolis' urban forest is roughly equivalent to the amount of wood that would be needed to construct 1,883 median-sized homes. Silver maple contributes the greatest net cubic-foot volume at 15.4 percent of the city's total (Table 17). Silver maple contributes 22.5 percent of the total net board-foot sawtimber volume (Table 18). By diameter class, the greatest net cubic-foot volume (35.2 percent) is provided by trees 29.1 inches or greater in diameter (Fig. 12).

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

Common name	Net volume (cubic feet)	Standard error (cubic feet)	Net volume (percent)
silver maple	1,890,000	729,000	15.4
bur oak	1,530,000	643,000	12.5
American elm	1,450,000	485,000	11.8
eastern cottonwood	1,070,000	574,000	8.7
hackberry	887,000	268,000	7.3
sugar maple	631,000	343,000	5.2
littleleaf linden	477,000	214,000	3.9
green ash	459,000	141,000	3.8
Norway maple	450,000	193,000	3.7
honeylocust	387,000	148,000	3.2
Other species	3,010,000	450,000	24.6
Total	**12,230,000**	**1,410,000**	**100.0**

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

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

Table 18.—Net board-foot sawtimber volume for tree species with greatest net volume, city of Minneapolis, 2021

Common name	Net volume (board feet)	Standard error (board feet)	Net volume (percent)
silver maple	6,140,000	2,910,000	22.5
bur oak	5,310,000	2,500,000	19.4
eastern cottonwood	4,220,000	2,610,000	15.4
American elm	3,530,000	2,160,000	12.9
hackberry	1,720,000	902,000	6.3
green ash	1,690,000	796,000	6.2
pin oak	1,340,000	1,200,000	4.9
Siberian elm	500,000	318,000	1.8
eastern white pine	484,000	516,000	1.8
white spruce	423,000	281,000	1.5
Other species	1,960,000	658,000	7.2
Total	**27,310,000**	**5,690,000**	**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.

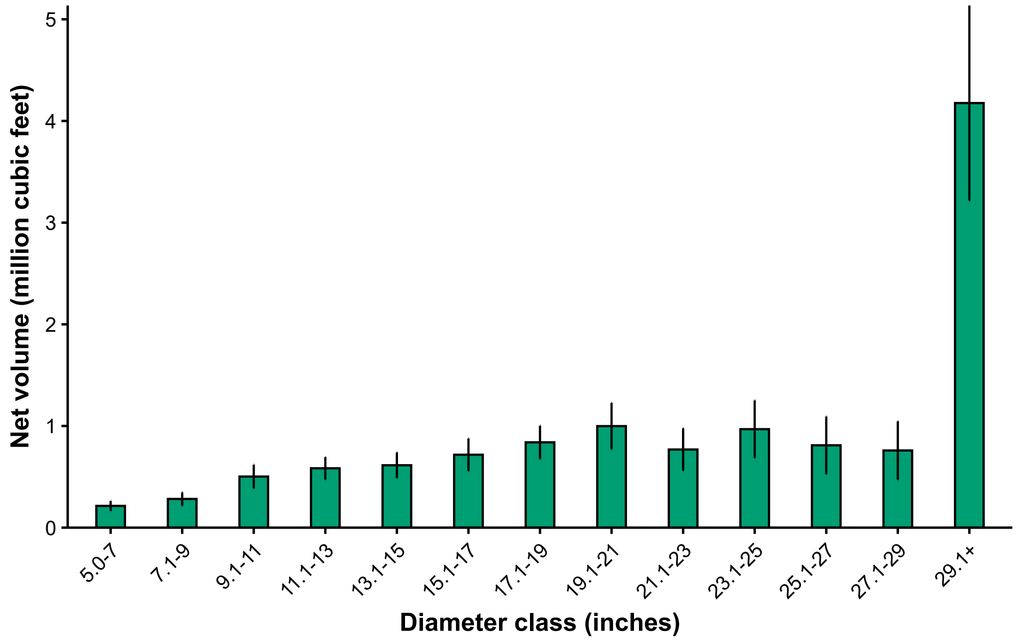


Figure 12.—Net cubic-foot volume by 2-inch diameter class, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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. Research is needed to develop metrics for evaluating urban wood waste 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

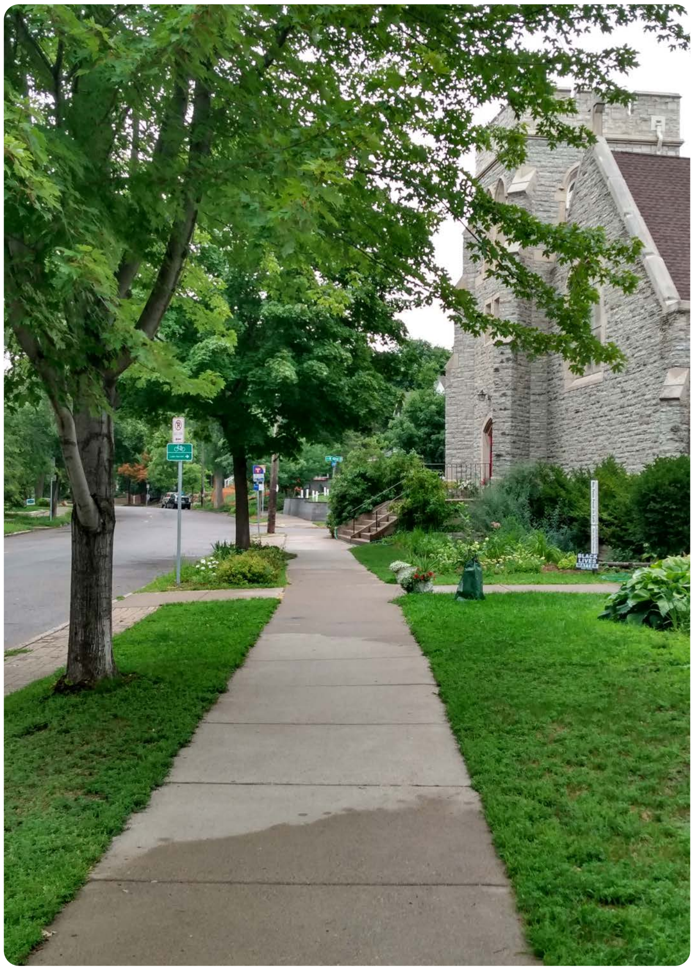
Like wood volume, tree biomass information is important in estimating both wood production and carbon storage. The overall aboveground biomass of all live trees in Minneapolis is estimated at 739,000 green tons, which includes the weight of its moisture content (Table 19). The amount of biomass stored by live trees in Minneapolis varies by species. The tree species with the greatest total aboveground biomass are silver maple (17.7 percent), American elm (15.9 percent), and bur oak (11.4 percent) (Table 19).

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

Common name	Biomass (green tons)	Standard error (green tons)	Biomass (percent)
silver maple	131,000	46,000	17.7
American elm	117,000	41,000	15.9
bur oak	84,000	35,000	11.4
hackberry	59,000	17,000	8.0
eastern cottonwood	41,000	22,000	5.5
sugar maple	32,000	18,000	4.3
boxelder	28,000	9,400	3.8
honeylocust	26,000	9,900	3.5
green ash	25,000	7,300	3.4
Norway maple	22,000	9,400	2.9
Other species	174,000	25,000	23.6
Total	**739,000**	**81,000**	**100.0**

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

URBAN FOREST VALUES



Trees create what might be called a “rainshadow” when their leaves block the rain from hitting the ground. In Minneapolis, trees are estimated to reduce surface water runoff by 181 million gallons annually. Forest Service photo by Sjana Schanning.

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 greenhouse gas 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 Minneapolis is greatest for O_3 (126.5 tons per year), followed by nitrogen dioxide (NO_2; 41.2 tons per year), sulfur dioxide (SO_2; 12.4 tons per year), particulate matter less than 2.5 microns ($PM_{2.5}$; 9.8 tons per year), and carbon monoxide (CO; 3.2 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 $PM_{2.5}$ ($3.1 million), followed by O_3 ($849,000), NO_2 ($34,000), CO ($4,300), and SO_2 ($2,900) (Table 20). It is estimated that trees in Minneapolis remove a total of 193 tons of air pollution per year with an associated value of $4 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 Minneapolis (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 453 fewer cases of acute respiratory symptoms per year with an associated value of over $40,000 (Table 20).

Trees in Minneapolis emit an estimated 158 tons of VOCs (62 tons of isoprene and 96 tons of monoterpenes) per year. Emissions vary among species based on species characteristics (e.g., some genera such as oaks are high isoprene emitters) and leaf biomass. *Quercus* spp. and *Populus* spp. contribute 64.8 percent of VOC emissions (Fig. 14). These VOCs are precursor chemicals to ozone formation.

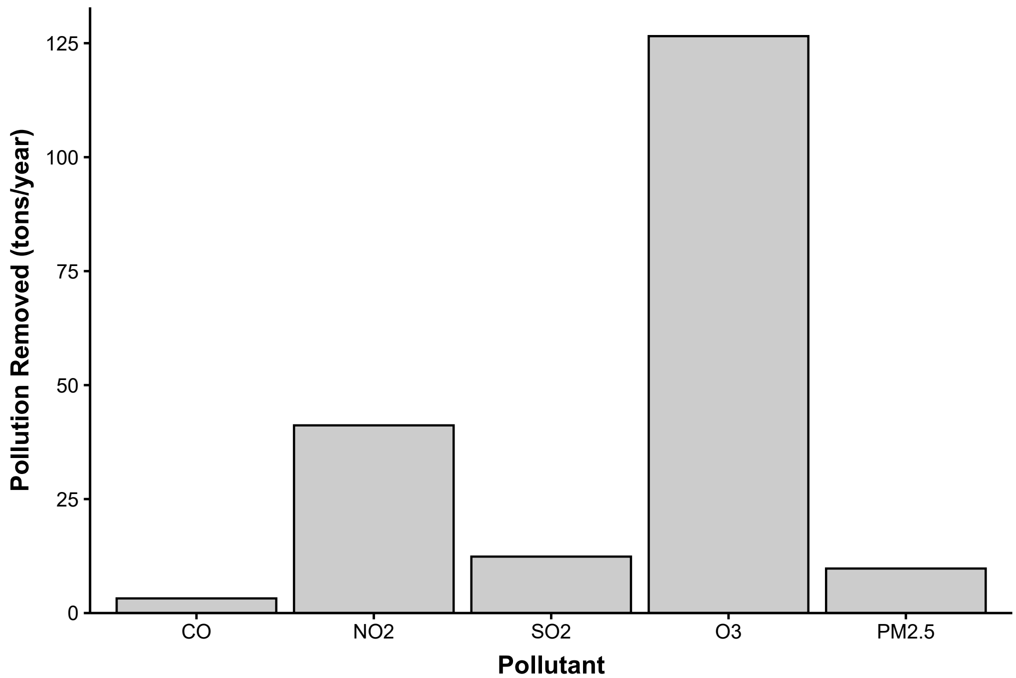


Figure 13.—Air pollution removal by trees, city of Minneapolis, 2021.

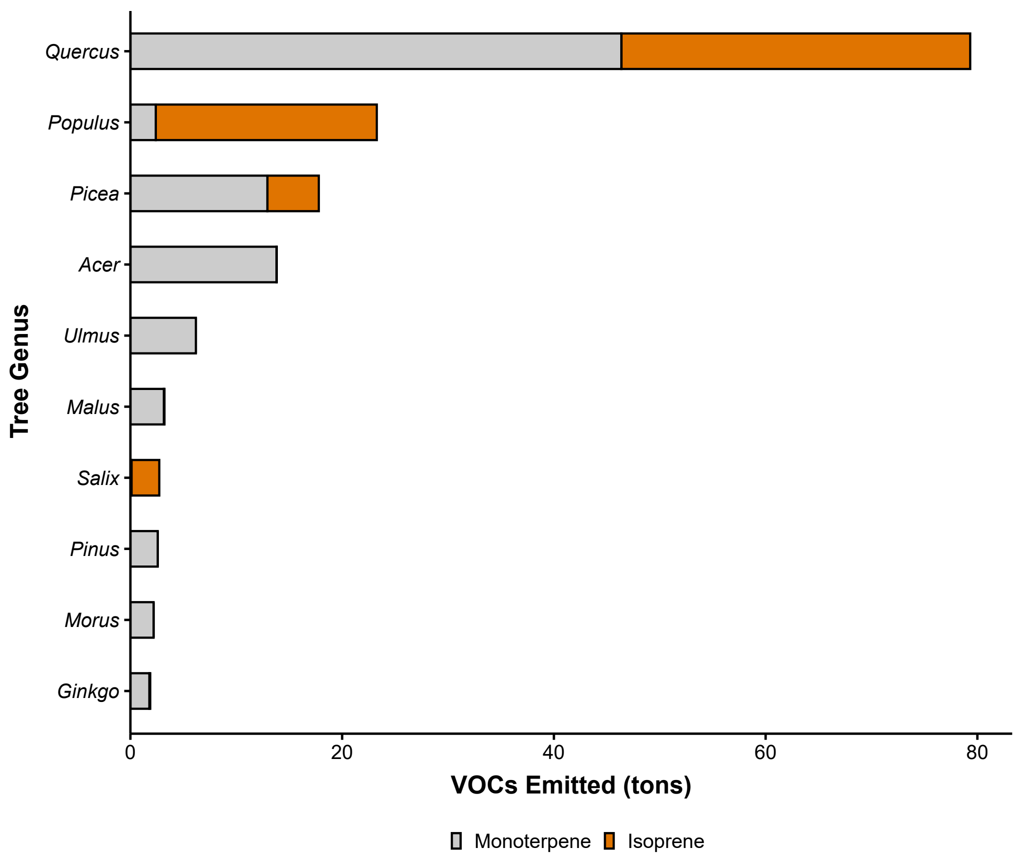


Figure 14.—Volatile organic compound (VOC) emissions by genus, city of Minneapolis, 2021.

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

	Nitrogen dioxide (NO_2)		Sulfur dioxide (SO_2)		Ozone (O_3)		Particulate matter ($PM_{2.5}$)	
Health effect	**Cases/year**	**$/year**	**Cases/year**	**$/year**	**Cases/year**	**$/year**	**Cases/year**	**$/year**
Acute bronchitis	–	–	–	–	–	–	0.2	19.5
Acute myocardial infarction	–	–	–	–	–	–	0.1	6,900
Acute respiratory symptoms	16.3	510	1.8	55.8	260	22,000	170	17,000
Asthma exacerbation	250	21,000	16.3	1,300	–	–	95.8	7,800
Chronic bronchitis	–	–	–	–	–	–	0.1	35,000
Emergency room visits	0.2	67.9	0.1	23.1	0.1	30.5	0.1	42.7
Hospital admissions	0.4	13,000	<0.1	1,500	0.2	5,600	–	–
Hospital admissions, cardiovascular	–	–	–	–	–	–	<0.1	1,400
Hospital admissions, respiratory	–	–	–	–	–	–	<0.1	730
Lower respiratory symptoms	–	–	–	–	–	–	2.6	140
Mortality	–	–	–	–	0.1	813,000	0.4	3,020,000
School loss days	–	–	–	–	74	7,300	–	–
Upper respiratory symptoms	–	–	–	–	–	–	2.2	98.7
Work loss days	–	–	–	–	–	–	29.7	5,600
Total	**260**	**34,000**	**18.1**	**2,900**	**340**	**849,000**	**310**	**3,100,000**

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

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

$PM_{2.5}$ = 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 Minneapolis are estimated to reduce runoff by 24 million cubic feet per year (181 million gallons annually), with an estimated value of $2 million/year based on a national average cost of stormwater control and treatment of $ 0.008936/gallon (Nowak 2024). Tree species with the greatest overall impact on runoff are hackberry, silver maple, and American elm due to their large leaf surface area (Fig. 15).

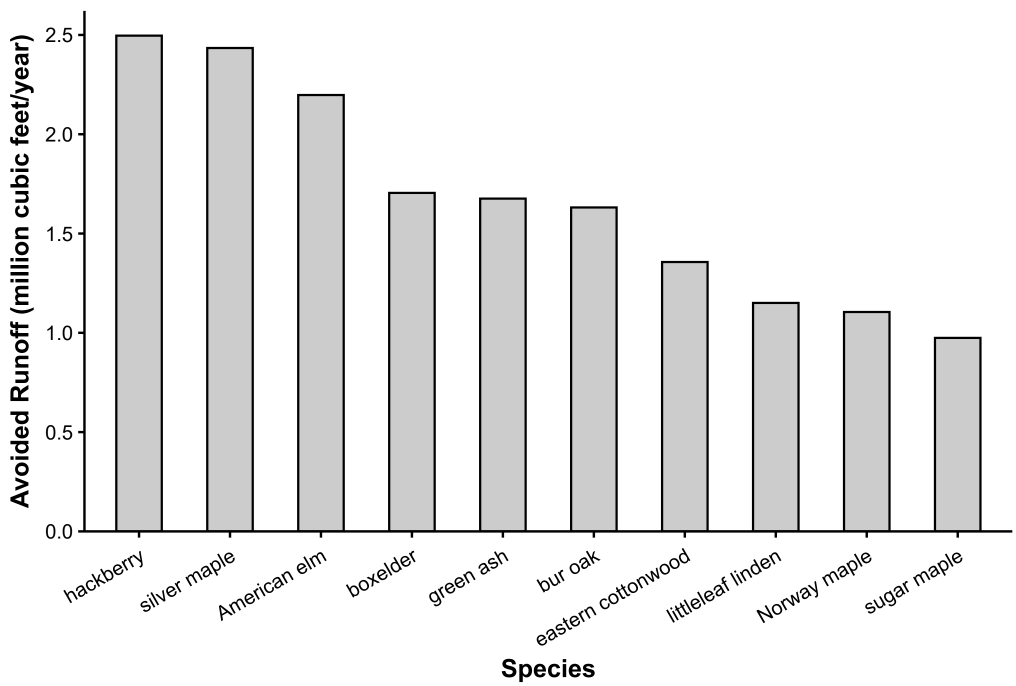


Figure 15.—Avoided runoff for the 10 tree species with the greatest leaf area, city of Minneapolis, 2021.

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 Minneapolis, interactions between buildings and trees 5.0 inches in diameter and greater are projected to annually decrease energy requirements by 25,000 gigajoules (GJ) during the heating and cooling seasons (an energy equivalent of 158,250 gallons of home heating fuel oil) (Table 21), with an annual savings in energy costs of $1.7 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 6,200 tons annually (1,700 tons of carbon; $402,000), equivalent to the burning of over 4.4 million pounds of coal or roughly 13,125 barrels of oil (Hong and Slatick 1994, U.S. EPA 2020).

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

Reduced energy use and emissions	Cooling	Heating	Total
Carbon avoided (tons)	2,400	-720	1,700
Energy savings (GJ)	54,000	-28,000	25,000

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

Negative values indicate an increase in energy requirements.

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 dead trees 5.0+ inches in diameter near residential buildings during heating and cooling seasons, city of Minneapolis, 2021

Reduced energy use and emissions	Cooling ($)	Heating ($)	Total ($)
Carbon avoided	571,000	-169,000	402,000
Energy effects	1,970,000	-244,000	1,720,000

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

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

Negative values indicate an increase in energy requirements.

Carbon Storage and Sequestration

Climate change is an issue of global concern that threatens vulnerable species and ecosystems (e.g., coral reefs, polar and coastal areas) along with food production, water resources, and human health (Intergovernmental Panel on Climate Change 2014). Reductions in the amount of energy required to heat or cool residential buildings described in the energy conservation section of this report lead to reduced 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 oven-dry 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. The combined above and below ground carbon stored in live and standing dead trees in Minneapolis is estimated to be 228,304 short tons (equivalent to 837,114 tons of CO_2) valued at $38.9 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 silver maple (17.8 percent), American elm (14.1 percent), and bur oak (11.5 percent) (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 Minneapolis, 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	99,000	13,000	280	112,000	20,000
Rights-of-way	40,000	5,400	19	46,000	9,900
Recreation/cemetery	32,000	4,900	14	37,000	12,000
Forest land	14,000	2,500	1,900	18,000	10,000
Commercial/industrial	5,200	900	0	6,100	2,600
Multi-family residential	4,800	570	0	5,400	2,700
Water	3,300	420	0	3,800	4,000
Total	**198,000**	**28,000**	**2,200**	**228,000**	–
Standard error	**22,000**	**3,000**	**1,400**	**25,000**	–

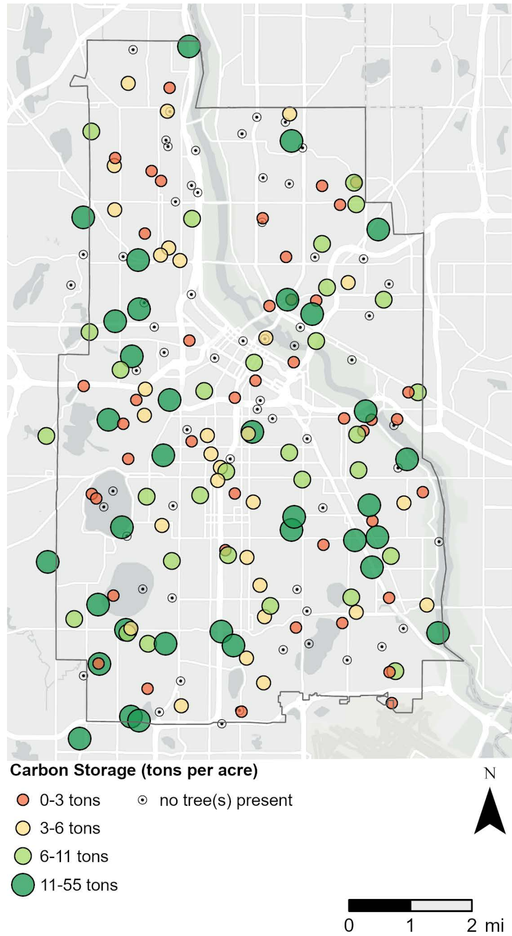


Figure 16.—Carbon storage per acre is shown for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, city of Minneapolis, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

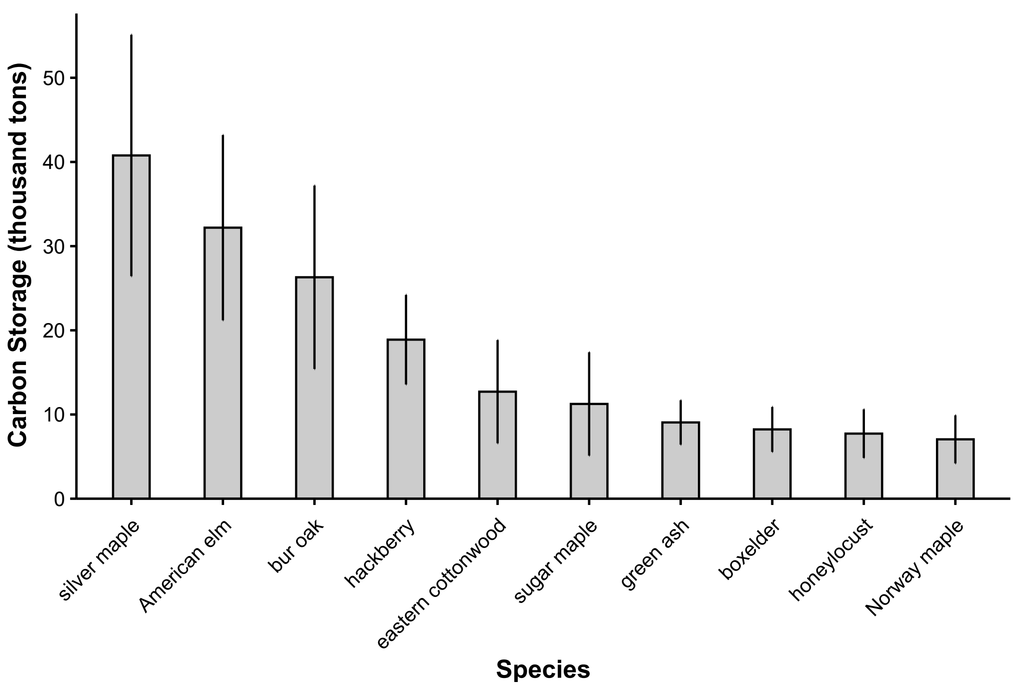


Figure 17.—Carbon storage for the 10 tree species with the greatest carbon storage, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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 Minneapolis is about 7,100 tons of carbon per year (26,000 tons per year of CO_2) with an associated value of $1.2 million per year, which is roughly equivalent to the annual emissions associated with 5,200 passenger vehicles or energy usage by 2,900 homes (U.S. EPA 2020). Silver maple is estimated to sequester the most carbon of all species in the urban forest (14 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.

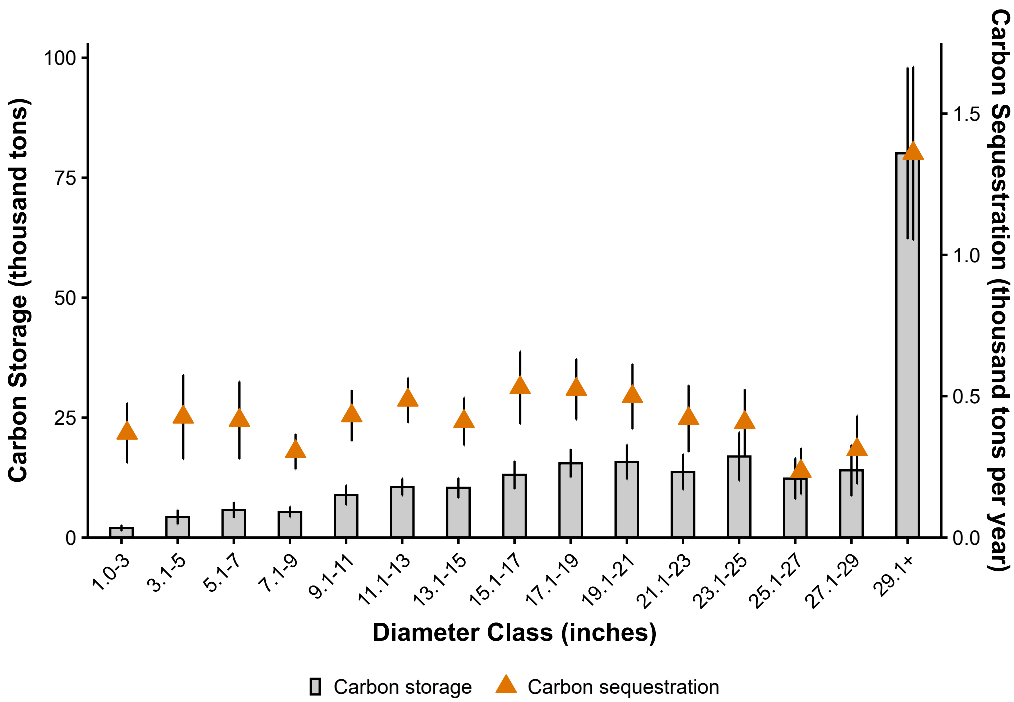


Figure 18.—Total carbon storage and sequestration by diameter class, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

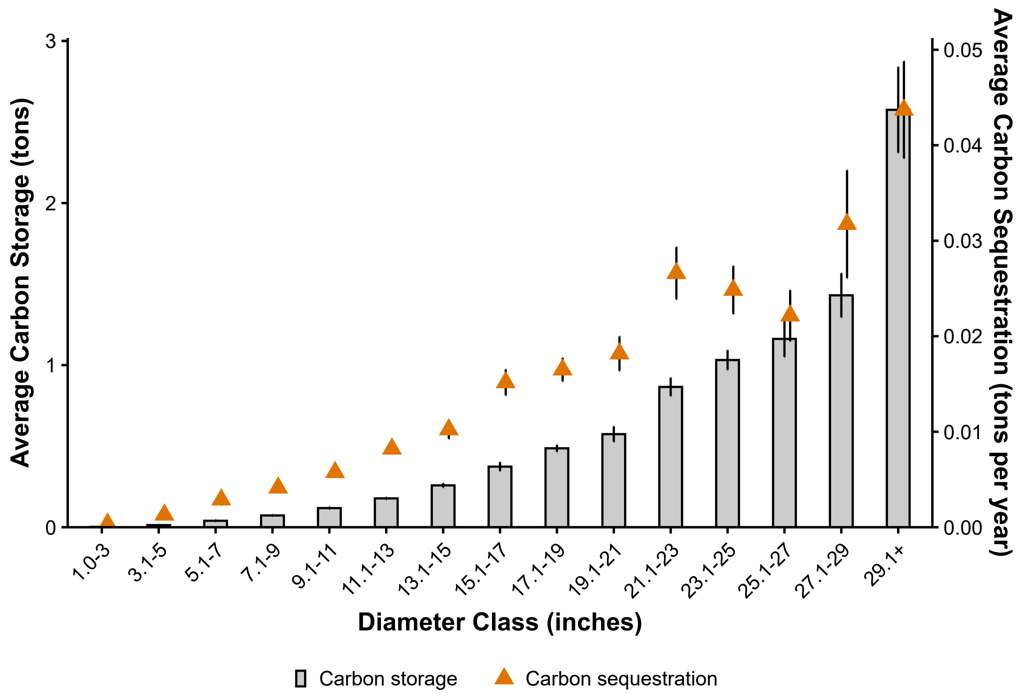


Figure 19.—Average per tree carbon storage and sequestration by diameter class, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

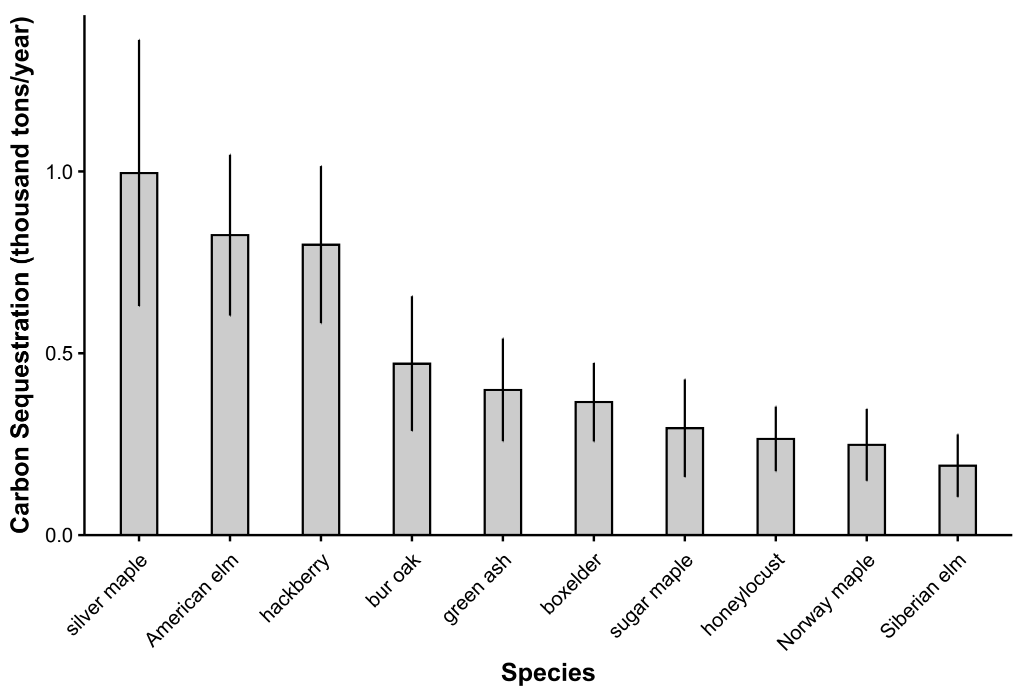


Figure 20.—Carbon sequestration for the 10 tree species with the greatest annual carbon sequestration, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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 (e.g., how much should one be compensated for the loss of the physical structure of the tree), 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 Minneapolis is estimated to be about $737.8 million. 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 Minneapolis are bur oak, American elm, and silver maple (Fig. 21). The mean compensatory value per acre for all surveyed plots in Minneapolis is $20,082; for the 69.0 percent of these plots that contain trees, the mean compensatory value per acre is $29,100 (Fig. 22). However, compensatory value per acre is estimated to exceed $37,000 for 34 plots in which the average tree diameter is 12.4 inches. The structural value of urban trees in Minneapolis is a combination of their compensatory value (estimated at $737.8 million) and the value associated with carbon storage by the trees (estimated at $38.9 million).

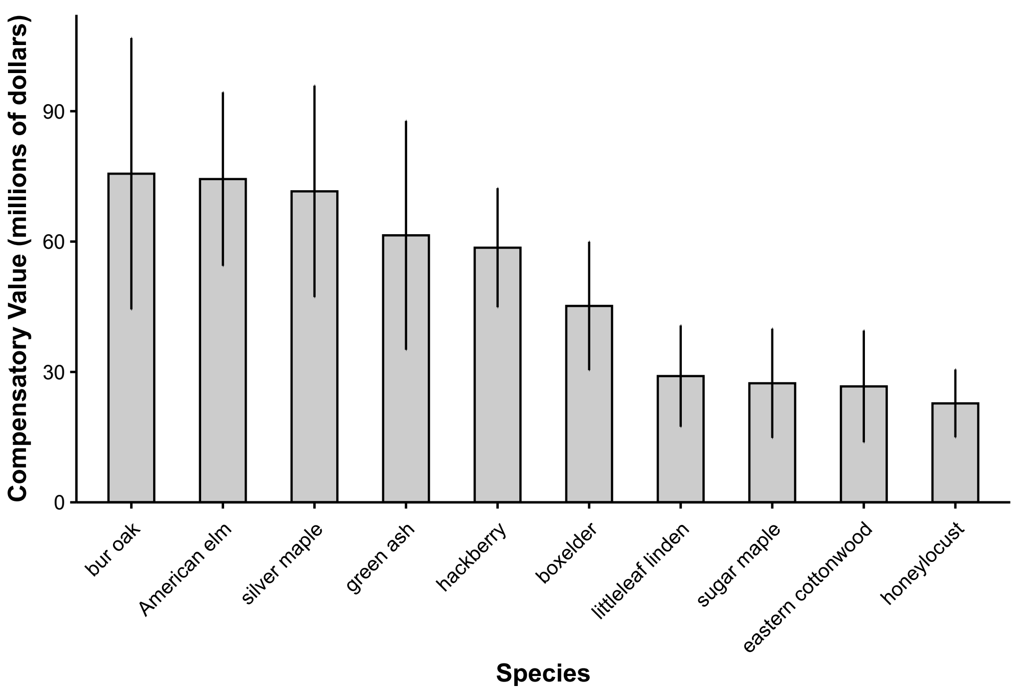


Figure 21.—The compensatory value for 10 of the highest value tree species, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

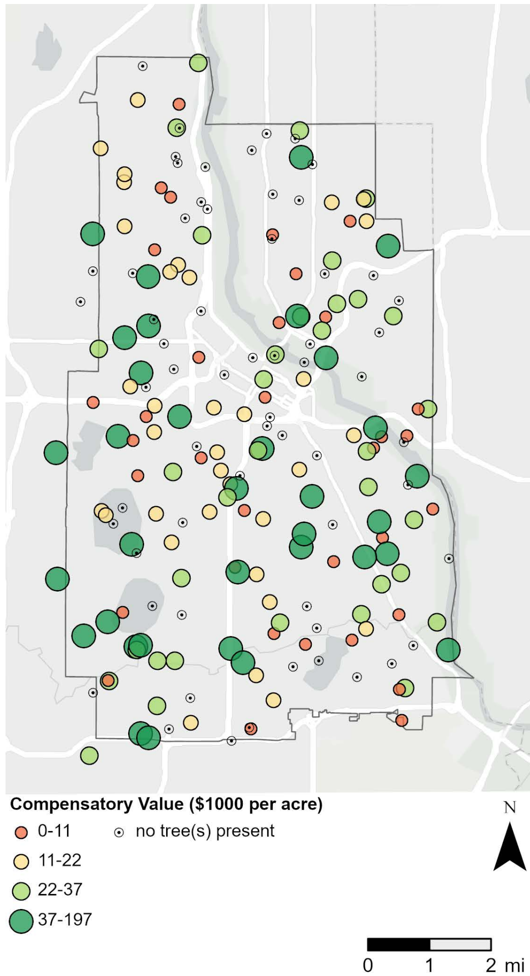


Figure 22.—Compensatory value per acre is shown for each Forest Inventory and Analysis (FIA) plot using approximate plot locations, city of Minneapolis, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

URBAN FOREST HEALTH

The leaves of a hackberry show signs of insect damage. Courtesy photo by Chris Edgar, Department of Forest Resources, University of Minnesota, Minneapolis, MN.

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 Minneapolis. 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, common buckthorn has the highest average dieback (14.3 percent) (Table 24). Approximately 14.0 percent of common buckthorn displays greater than 25 percent crown dieback, indicating that this species may be threatened by insect, disease, or environmental stressors in Minneapolis.

Table 24.—Tree species with the greatest average dieback, city of Minneapolis, 2021

Common name	Average dieback (percent)	Standard error (percent)	Trees with more than 25 percent dieback (percent)
common buckthorn	14.3	4.3	14.0
sugar maple	4.8	1.8	1.9
Norway maple	2.8	1.6	0.0
boxelder	2.4	0.8	0.4
littleleaf linden	2.1	1.1	0.0
silver maple	2.0	0.3	0.0
blue spruce	1.9	1.0	0.0
honeylocust	1.9	0.6	0.0
bur oak	1.2	0.5	0.0
apple spp.	1.0	1.0	0.0
Siberian elm	0.9	0.2	0.0
American elm	0.8	0.5	0.0
eastern cottonwood	0.7	0.6	0.0
hackberry	0.5	0.3	0.0
green ash	0.4	0.3	0.2
American basswood	0.2	0.0	0.0
red mulberry	0.2	0.2	0.0
northern white-cedar	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.

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 Norway maple and bur oak (Table 25).

Table 25.—Tree species with the greatest average rot, city of Minneapolis, 2021

Species	Average rot (percent)	Standard error (percent)	Trees with more than 15 percent rot (percent)
Norway maple	4.4	1.7	2.4
bur oak	3.8	2.2	1.5
boxelder	3.7	2.0	1.0
hackberry	3.7	2.2	1.4
littleleaf linden	2.8	1.1	0.0
American basswood	2.6	1.7	0.7
red mulberry	2.5	1.4	0.3
sugar maple	2.2	1.3	1.3
northern white-cedar	1.7	0.9	0.0
eastern cottonwood	1.5	1.4	1.0
American elm	1.2	0.6	0.1
silver maple	1.1	0.7	0.0
apple spp.	1.1	0.7	0.0
honeylocust	0.9	0.5	0.0
green ash	0.5	0.4	0.0
blue spruce	0.1	0.1	0.0

Estimates are rounded.

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

Rot is only measured on trees greater than or equal to 5.0+ 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 other damages and symptoms are the most common causes of damage, affecting 8.5 and 7.1 percent of trees, respectively (Table 26).

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

Damage type	Trees (percent)
Boring insects	0.2
Cankers	1.1
Competition	0.2
Decline complexes/dieback/wilts	0.1
Emerald ash borer	0.9
Flooding/high water	0.1
General diseases	0.2
General insects	0.1
Human activities	6.8
Imbedded objects	2.5
Lightning	0.1
Shoot borer	0.2
Stem decay	8.5
Sugar maple borer	0.1
Unknown	0.1
Vine damage	3.5
Wild animals	2.1
Wind	0.1
Other Damages and Symptoms	
Broken top	1.5
Dead top	0.7
Dieback	0.4
Other damages and symptoms	7.1

Estimates are rounded.

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

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

Bark inclusion is the most common issue, occurring in 22.9 percent of trees. Conflict with crown and topping/pruning are the second and third most common urban specific infrastructure issues, occurring in 7.4 and 3.7 percent of trees, respectively (Fig. 23). Differences exist in the prevalence of these issues among the FIA-designated land uses and may further inform forest health and management priorities. In Minneapolis, bark inclusion occurs in 59.6 percent of trees on commercial/industrial land, bark inclusion in 53.9 percent of trees on water land, and bark inclusion in 31.7 percent of trees on recreation/cemetery 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 apple spp. (73.1 percent affected by bark inclusion) and Siberian elm (52.6 percent affected by bark inclusion) (Table 27).

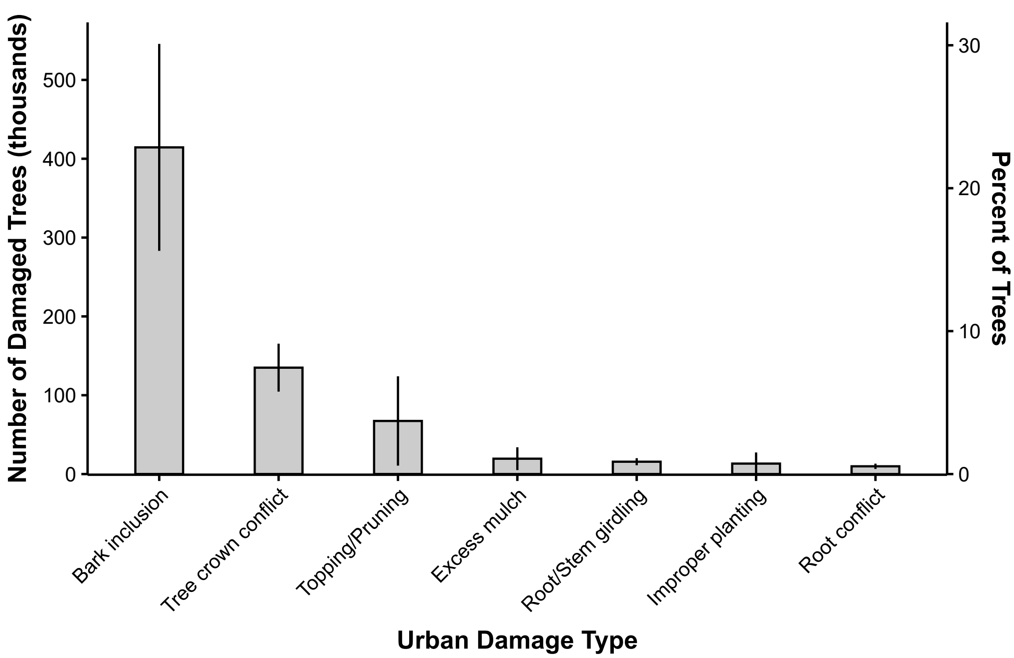


Figure 23.—Number and percent of trees by urban infrastructure issue category, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Table 27.—Percent of live trees identified with damage, maintenance, and site issues, city of Minneapolis, 2021

Species	Number of trees	Standard Error	Excess mulch (percent)	Root/ stem girdling (percent)	Bark inclusion (percent)	Topping/ pruning (percent)	Root conflict (percent)	Crown conflict (percent)	Improper planting (percent)
American basswood	35,800	33,300	0.0	0.0	44.6	0.0	2.8	8.7	0.0
American elm	153,900	77,500	8.6	0.7	16.1	0.0	0.0	6.5	0.0
apple spp.	27,000	14,600	0.0	0.0	73.1	3.9	0.0	15.5	49.0
blue spruce	11,700	4,400	0.0	0.0	8.9	0.0	0.0	8.6	0.0
boxelder	136,000	57,000	1.5	0.0	19.2	2.0	0.0	18.9	0.0
bur oak	25,000	10,400	0.0	5.2	22.6	4.0	0.0	13.3	0.0
common buckthorn	225,200	161,700	0.0	0.0	15.7	0.0	0.0	0.0	0.0
eastern cottonwood	20,100	12,100	0.0	0.0	5.2	0.0	5.2	15.6	0.0
green ash	290,300	189,200	0.4	0.0	2.5	0.0	0.5	1.8	0.0
hackberry	127,500	41,100	0.0	2.4	21.0	1.0	1.8	18.7	0.0
honeylocust	21,800	7,100	0.0	4.8	33.0	0.0	0.0	28.2	0.0
littleleaf linden	18,900	6,800	0.0	14.5	38.0	10.7	11.1	10.9	0.0
northern white-cedar	139,900	98,900	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Norway maple	24,400	8,400	4.3	4.1	50.2	0.0	0.0	20.9	0.0
red mulberry	73,700	40,800	0.0	0.0	46.1	0.0	0.0	4.9	0.0
Siberian elm	71,000	51,300	0.0	0.0	52.6	0.0	1.4	6.2	0.0
silver maple	82,500	65,600	1.2	2.5	52.1	1.2	1.3	14.0	0.0
sugar maple	19,800	6,600	0.0	11.9	38.0	5.3	0.0	20.5	0.0

This table includes only the live tree population.

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, infrastructure, or both 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 uses, caution is advised when interpreting forest health issues based on numbers of standing dead trees.

Standing dead trees were found on 10 plots in Minneapolis. Of the total live and dead tree population, 6.5 percent are estimated to be standing dead trees. The tree species with the highest percentage of standing dead trees are unknown maple (labeled as "maple spp." in tables because they were dead maple that could not be identified to species), pear spp., and apple spp. (Table 28). The species that comprises the largest proportion of the dead tree population is common buckthorn (Table 29). Land use classes with the highest estimated number of standing dead trees are forest land, residential, and rights-of-way (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 Minneapolis, 2021

Common name	Standing dead trees (number)	Standard error (number)	Percent of species
maple spp.	1,000	1,100	100.0
pear spp.	1,000	1,100	33.3
apple spp.	13,000	14,000	32.9
white mulberry	13,000	14,000	18.9
common buckthorn	38,000	35,000	14.4
hackberry	15,000	14,000	10.3
boxelder	13,000	14,000	8.9
green ash	27,000	20,000	8.6
white ash	1,300	1,300	6.3
eastern cottonwood	1,000	1,100	4.8
American elm	2,400	1,700	1.5
Total	**126,000**	**54,000**	**6.5**

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

Table 29.—Proportion of total dead tree population by species, city of Minneapolis, 2021

Common name	Standing dead trees (percent)
common buckthorn	30.0
green ash	21.5
hackberry	11.5
boxelder	10.5
apple spp.	10.5
white mulberry	10.5
American elm	1.9
white ash	1.0
maple spp.	0.8
pear spp.	0.8
eastern cottonwood	0.8
Total	**100.0**

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

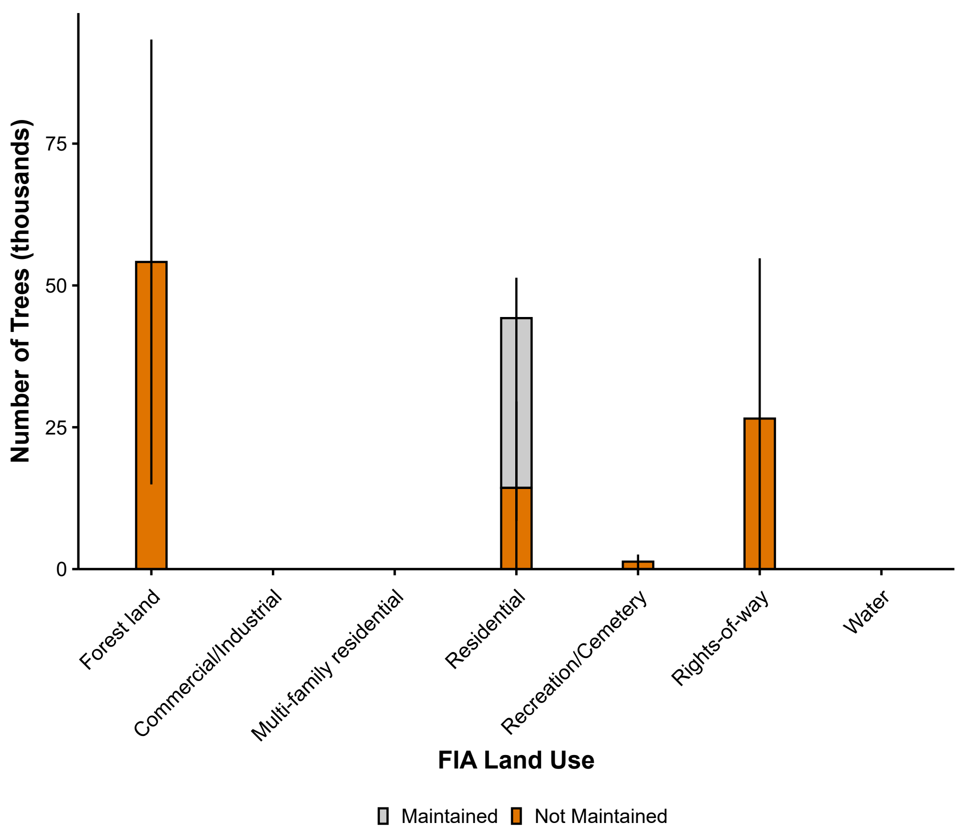


Figure 24.—Number of standing dead trees by Forest Inventory and Analysis (FIA) land use class on maintained and unmaintained land, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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. Urban FIA field crews in Minneapolis examined each plot for the presence of select invasive species based on the species list shown in Appendix 5. Of the 197 plots examined, invasive species were identified on 53.8 percent (106 plots).

Invasive species found in Minneapolis are presented in Figure 25. Beyond noting simple presence or absence, crews noted the percentage of the plot area covered by the invasive species, allowing for the estimation of total area covered by each species within the city (Bechtold and Scott 2005). These estimated areas may offer insights into which species are having the greatest impact in the city. Of the invasive species recorded, Norway maple (658 acres; 1.8 percent of the sampling area), common buckthorn (522 acres; 1.4 percent of the sampling area), and Siberian elm (324 acres; 0.9 percent of the sampling area) covered the largest area. Of particular concern is the potential for these and other invasive species to spread beyond their current distribution into the surrounding landscape, potentially displacing native species and altering local ecosystems (Pimentel et al. 2000).

Additional measurements are recorded in the field for most tree species. As some of the species on the invasive plants list for Minneapolis are classified as trees, data on individual trees were collected in addition to descriptions of species cover on the plot. In Minneapolis, tree data were collected for black locust, common buckthorn, Norway maple, and Siberian elm. Taken together, these invasive trees are estimated to account for 17.8 percent of all live trees surveyed (estimated total trees: 321,889), and 7.3 percent of the total leaf area.

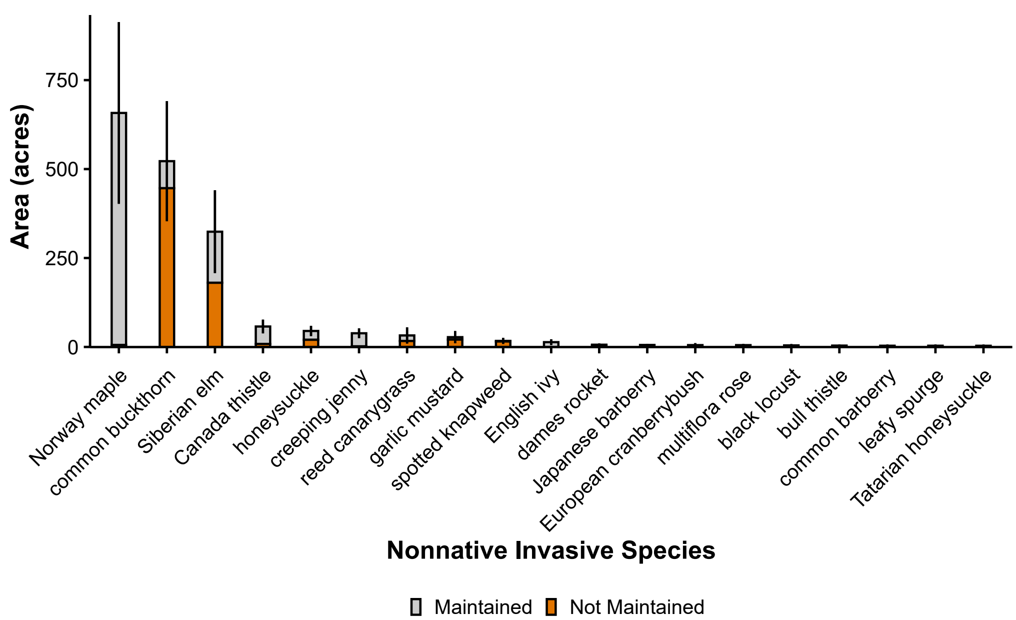


Figure 25.—Acres of nonnative invasive species cover by species on maintained and unmaintained land, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Pests and Pathogens

Pathogens and insect pests can affect the health, sustainability, and benefits of urban forests. Identifying pathogens and pests of concern and their potential host-specific impacts allows managers to prioritize specific insects and diseases for monitoring and control measures. We evaluated 53 insects and diseases[8], along with their tree hosts in Minneapolis, to quantify their potential impact on the urban forest (Table 30). The number of trees at risk (Figure 26) reflects all the known host tree species that could experience damage or mortality either directly or indirectly due to the pest or pathogen and does not necessarily include only trees that are known to be directly at risk of attack, infection, or both. As FIA crews did not attribute tree damage or mortality to specific pests or pathogens, it was not possible to identify what portion of each host tree's population was directly at risk from or affected by the focal pests and pathogens. Pest range maps (Nowak 2024, USDA Forest Service 2023) were used to determine the proximity of each pest to the area. For Minneapolis, proximity was classified for insects and diseases in Hennepin County; within 250 miles of the county; between 250 and 750 miles of the county; or greater than 750 miles away. Since there are no pest range maps for Dutch elm disease and chestnut blight, the ranges of these pests were based on known occurrence and the known host range, respectively (Nowak 2024). Proximity data for insects and diseases, along with the numbers of trees potentially affected and their compensatory values, are illustrated in Table 30.

Based on the host tree species for each pest and the current range of the pest, it is possible to estimate the risk faced by each tree species sampled in the urban forest to attack by each of these insects or diseases and assign each tree species a relative risk weight. In Appendix 6, each pest that could pose a risk to a tree species is scored as 4 points if it occurs within the Hennepin county, 3 points if occurs within 250 miles of the county, 2 points if it occurs within 750 miles of the county, and 1 point if it is not present within 750 miles of the county. These values are summed across each row to determine the relative risk weight for each tree species recorded in the city.

Tree species that were sampled in Minneapolis, but are not listed in the Appendix 6 matrix, are not known to be hosts to any of the 53 insects and diseases evaluated. The matrix also excludes the pests and diseases that were not a threat to any of the tree species sampled.

[8] Common and scientific names for pests and pathogens evaluated during the 2021 Urban FIA inventory of Minneapolis are in Table 30.

Table 30.—The number of host trees potentially at risk from various insects and diseases, city of Minneapolis, 2021

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value ($)
within county	FTC	Forest Tent Caterpillar	*Malacosoma disstria*	761,645	42.0	390,651,857
	EAB	Emerald Ash Borer	*Agrilus planipennis*	310,814	17.1	71,328,795
	DED	Dutch Elm Disease	*Ophiostoma novo-ulmi*	243,134	13.4	98,870,589
	LAT	Large Aspen Tortrix	*Choristoneura conflictana*	62,294	3.4	40,569,253
	OW	Oak Wilt	*Bretziella fagacearum*	59,975	3.3	103,253,442
	PSB	Pine Shoot Beetle	*Tomicus piniperda*	49,419	2.7	25,108,990
	SBW	Spruce Budworm	*Choristoneura fumiferana*	38,479	2.1	18,928,682
	ARD	Armillaria Root Disease	*Armillaria* spp.	26,534	1.5	3,873,237
	BOB	Bur Oak Blight	*Tubakia iowensis*	25,009	1.4	75,616,507
	BC	Butternut Canker	*Sirococcus clavigignenti juglandacearum*	4,673	0.3	5,826,582
within 250 miles	SM	Spongy Moth	*Lymantria dispar*	337,520	18.6	240,610,228
	HRD	Heterobasidion Root Disease	*Heterobasidion irregulare/occidentale*	65,701	3.6	20,808,162
	SB	Spruce Beetle	*Dendroctonus rufipennis*	38,479	2.1	18,928,682
	AL	Aspen Leafminer	*Phyllocnistis populiella*	31,864	1.8	8,132,702
	JPBW	Jack Pine Budworm	*Choristoneura pinus*	5,753	0.3	2,882,179
	WPBR	White Pine Blister Rust	*Cronartium ribicola*	3,664	0.2	2,173,308
within 750 miles	ALB	Asian Longhorned Beetle	*Anoplophora glabripennis*	1,228,889	67.8	513,263,941
	SLF	Spotted Lanternfly	*Lycorma delicatula*	1,207,886	66.6	519,379,731
	FR	Fusiform Rust	*Cronartium quercuum* f. sp. *Fusiforme*	59,975	3.3	103,253,442
	SPB	Southern Pine Beetle	*Dendroctonus frontalis*	49,419	2.7	25,108,990
	WSB	Western Spruce Budworm	*Choristoneura occidentalis*	39,524	2.2	19,383,027
	SW	Sirex Wood Wasp	*Sirex noctilio*	28,578	1.6	10,847,183
	MPB	Mountain Pine Beetle	*Dendroctonus ponderosae*	18,683	1.0	5,121,220
	BWA	Balsam Woolly Adelgid	*Adelges piceae*	17,639	1.0	4,666,875
	BSRD	Black Stain Root Disease	*Leptographium wageneri*	9,153	0.5	5,920,305
	TCD	Thousand Canker Disease	*Geosmithia morbida*	4,673	0.3	5,826,582
farther than 750 miles	WM	Winter Moth	*Operophtera brumata*	955,457	52.7	492,300,208
	BM	Browntail Moth	Euproctis chrysorrhoea	658,036	36.3	400,290,155
	PSHB	Polyphagous Shot Hole Borer	*Euwallacea* nov. sp.	468,392	25.8	275,760,043
	MOB	Mediterranean Oak Borer	*Xyleborus monographus*	346,777	19.1	280,002,859

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Table 30. (Continued)—The number of host trees potentially at risk from various insects and diseases, city of Minneapolis, 2021

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value ($)
farther than 750 miles (cont.)	POCRD	Port-Orford-Cedar Root Disease	*Phytophthora lateralis*	139,877	7.7	19,948,134
	WBBU	Western Blackheaded Budworm	*Acleris gloverana*	38,479	2.1	18,928,682
	NSE	Northern Spruce Engraver	*Ips perturbatus*	9,153	0.5	5,920,305
	SOD	Sudden Oak Death	Phytophthora ramorum	4,372	0.2	12,100,258
	RPS	Red Pine Scale	*Matsucoccus resinosae*	1,045	0.1	254,526
within 250 miles	BBD	Beech Bark Disease	*Neonectria faginata*	0	–	–
	BLD	Beech Leaf Disease	*Litylenchus crenatae mccannii*	0	–	–
	CB	Chestnut Blight	*Cryphonectria parasitica*	0	–	–
	DA	Dogwood Anthracnose	*Discula destructiva*	0	–	–
	DFB	Douglas-Fir Beetle	*Dendroctonus pseudotsugae*	0	–	–
	DBSR	Douglas-fir Black Stain Root Disease	*Leptographium wageneri* var. *pseudotsugae*	0	–	–
	FE	Fir Engraver	*Scolytus ventralis*	0	–	–
	HWA	Hemlock Woolly Adelgid	*Adelges tsugae*	0	–	–
	LWD	Laurel Wilt	*Raffaelea lauricola*	0	–	–
	SFM	Subalpine Fir Mortality	NA-multiple pests	0	–	–
	WFNPM	Western Five-Needle Pine Mortality	NA-multiple pests	0	–	–
	WBB	Western Balsam Bark Beetle	*Dryocoetes confusus*	0	–	–
	WPB	Western Pine Beetle	*Dendroctonus brevicomis*	0	–	–
farther than 750 miles	ARCA	Aspen Running Canker	*Neodothiora populina*	0	–	–
	GSOB	Goldspotted Oak Borer	Agrilus auroguttatus	0	–	–
	HS	Hemlock Sawfly	Neodiprion tsugae	0	–	–
	JPB	Jeffrey Pine Beetle	Dendroctonus jeffreyi	0	–	–
	PBSR	Pine Black Stain Root Disease	Leptographium wageneri var. ponderosum	0	–	–

Estimates are rounded.

-= no value for cell.

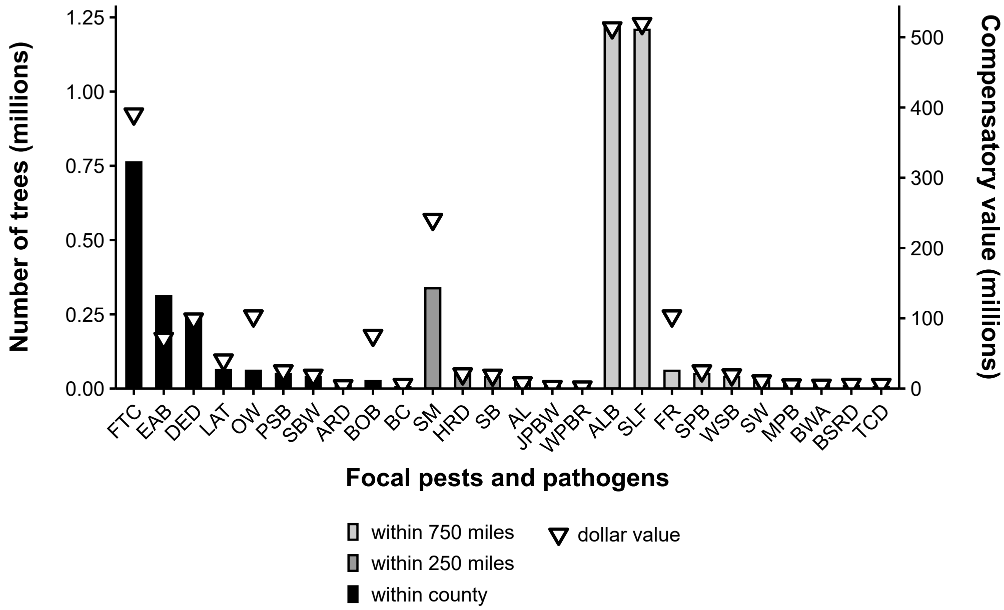

Figure 26.—Number of trees at risk due to pests and pathogens and their associated compensatory values, city of Minneapolis, 2021. Pest abbreviations are presented in Table 30.

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MANAGEMENT IMPLICATIONS

The branches of large deciduous trees in the public right-of-way arch over the sidewalk and road creating shade for nearby houses, pedestrians and drivers, while smaller conifers, planted on private land, provide shade and privacy for residents. Forest Service photo by Sjana Schanning.

The primary goal of Urban FIA is to provide an accurate estimate of the composition, distribution, health, and values of urban forests to aid in sustainable urban forest management and planning. This report presents information about the current state of the Minneapolis urban forest and the benefits it provides to residents of the city. 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 to understand the status and trends of resources across different ownerships. These comparisons will allow managers to assess rates of tree growth and mortality, as well as changes in species composition, the distribution of size classes, and the 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 Minneapolis' urban forest while minimizing the cost associated with its maintenance.

Forest Lands of Minneapolis

Although forested areas make up only 2.0 percent (736 acres) of the sample area in Minneapolis, these areas hold more than 13 percent of all trees 5.0 inches in diameter or greater. These forest lands serve as important stopover sites for migrating birds (Matthews and Rodewald 2010) and as habitat for a variety of plants and animals. They provide enhanced storm water runoff reduction benefits and have been shown to be as much as 10 degrees cooler than landscaped areas with tree cover (Crown et al. 2023). With proper care and attention, they can be a place of respite and physical activity for city residents and can improve the general well-being of the surrounding community.

Although all forested lands sampled included a mix of native tree species, they also all had common buckthorn present in seedling, sapling, or tree form. Common buckthorn is listed as a restricted noxious weed in Minnesota and within the state it is illegal to import, sell or transport (MDA 2024). Despite this, its ability for prolific seed production and stump sprouting has led it to become the most prolific tree species in the forested areas of Minneapolis. Nearly all (99 percent) of common buckthorn saplings and trees are found on public land and 84 percent grow within forest lands.

Due to buckthorn's dense, thicketed regeneration, it has the ability to dominate ecosystems and displace native species, altering forest conditions, and threatening natural succession. Its heavy presence in forested areas, with cover ranging from 3–55 percent, suggests that these areas are at risk for reduced regeneration of native trees and the benefits that they provide. Much of the buckthorn cover present was from seedlings, which may indicate encroachments into previously unaffected areas, or may reflect ongoing efforts by local government to eradicate the species through the removal of larger stems. This is an ongoing process which often requires many years of effort due to regeneration from seed and stump sprouts. Other invasive plant species present in forested areas within the city are Canada thistle, reed canary grass, Norway maple, honeysuckle, garlic mustard, and white mulberry.

Planted Trees

For every tree recorded within the Urban FIA program, data collection staff indicate whether indicators suggest the tree was planted, grew naturally, or whether it is too difficult to identify their origin. In Minneapolis, it is estimated that nearly 30 percent (536,647) of the live trees are planted, two-thirds (1,199,518) established through natural regeneration with the rest (77,051) unknown. Of the planted trees, nearly half (260,446) are saplings, 20 percent (108,991) are in the 5.0–10.9 inch diameter range with the rest (167,210) having a diameter of 11.0 inches or greater. Of planted saplings, northern white-cedar (often known as arborvitae when used in urban settings) make up nearly half of the population (49.7 percent of all planted saplings) and are all found on private lands. Of planted trees 11.0 inches in diameter and greater, hackberry (13.0 percent), honeylocust (9.9 percent), and littleleaf linden (9.4 percent) are the top three species by count.

As may be expected, differences in the composition of planted trees exist between public and privately owned lands. On privately owned lands the most populous species are northern white-cedar, western redcedar (both frequently called arborvitae), and apple species, and nearly 60 percent (221,868) of the planted trees are saplings. On public lands, where comprehensive urban forestry plans typically guide planting efforts, American elm, hackberry, and sugar maple are the top three most frequently encountered planted trees. Only 30 percent (51,844) of all public planted trees are saplings and nearly 50 percent (84,769) are trees over 11.0 inches in diameter.

Norway maple is the fourth most frequently encountered planted tree on public lands. It is a popular non-native landscape tree that has been widely planted as an urban street tree in many cities across the United States. It spreads by seeds which can disperse into nearby forestlands and eventually outcompete native trees and understory plants. Although the Minnesota Department of Natural Resources (MN DNR) has not included it in the list of invasive plants to be treated or controlled, in 2020 the Minnesota Department of Agriculture added it to the list of "specially regulated plants" which "have the potential to cause harm in non-controlled environments" (MDA 2024). This listing requires that, when sold, the trees must be labeled to indicate appropriate planting locations to reduce the risk of impacts on natural landscapes. In Minneapolis, all Norway maple recorded within the Urban FIA data had been planted and were located in maintained areas. The species makes up 4.4 percent of all planted trees (estimated 24,354 trees i.e., 1.3 percent of total population) and trees are located primarily in rights-of-ways, often planted along streets and in boulevards (62.1 percent of all Norway maple), followed by residential lands (22.2 percent), and then commercial lands (7.1 percent). By count 62.3 percent of the species is found on public lands and 37.7 percent on private lands. It is notable that all Norway maple recorded were greater than 5.0 inches in diameter suggesting that education about the potential risk of spreading has been effective in reducing more recent plantings. Also of note is that no Norway maple trees were recorded in forested areas (although some seedlings were encountered in forested areas), providing hope that impacts from this species on forested areas might be minimized through continued outreach, education, and close attention to species choices during planting.

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.

Planning Resource Allocation

City planners and urban foresters depend on data to prioritize the allocation of resources. Programs aimed toward public outreach and increasing tree canopy cover use information about where trees are currently located and where space for additional planting is available. By considering the data available through the Urban FIA results, such as current planting trends, surface cover evaluations, tree canopy cover measurements, and number of trees per acre, planners can get a better idea about what areas to prioritize for outreach and planting.

Upon further investigation of surface covers within the sample area in Minneapolis, the multi-family housing land use was found to have the least amount of permeable and vegetated ground cover, with an average 77 percent of this land consisting of buildings and other impervious cover. This is higher than both rights-of-ways (68 percent) and commercial areas (67 percent). Tree canopy cover reported from on-the-ground assessments made during data collection is estimated to be 10.8 percent in multi-family housing, which is a third that of single-family residential areas (33.9 percent), and half as much as that on rights-of-ways (22.1 percent). When considering tree counts, multi-family housing areas also showed the lowest density of trees, with only 9 per acre. By comparison, single-family residential lands averaged 45 trees per acre. No saplings were recorded within multi-family residential areas, which may indicate a shortage of young trees available to replace older trees as they age and are removed. This may be an area for further investigation to better understand whether multi-family residential areas should receive increased attention for outreach and planting efforts. Due to ownership dynamics on many multi-family housing properties, this may be an especially challenging type of property on which to influence change, but with generally higher density of residents in these areas, increased canopy cover here could create positive impacts for even more Minneapolis residents.

Wood Use Planning and Durable Carbon Storage

As mentioned earlier in the report, Minneapolis trees contain 739,000 green tons of live, aboveground biomass and provide temporary storage of 198,000 tons of carbon. While alive, these trees provide the ample benefits discussed in this report, and with proper planning in place, can contribute continued value even after they die and must be removed. When trees die and begin to decay, the carbon that they have sequestered and stored over their lifetime begins to be released. If wood from those dead trees can be converted to durable products, that carbon remains locked away for decades, or even centuries beyond the life of the tree (Skog 2008, Ippolito et al. 2012). Standard lumber is a commonly used durable wood product, and other products can expand the volume of wood that is diverted from waste streams. Thermally modified wood uses heat to improve dimensional stability of wood and reduce water sorption which can slow decay of the resulting wood product and may increase the range of species available for exterior use (Zelinka et al. 2022). Biochar, another example of a durable wood product, is an organic material that has been combusted in the absence of oxygen and has a growing market as a soil amendment and additive in concrete and other construction materials (Amonette et al. 2021).

In 2022 the Partnership on Waste & Energy commissioned a report to evaluate current and potential wood waste flows and to plan for the continued influx of tree removals due to emerald ash borer (Cambium Carbon 2022). This report indicated that approximately 67 percent of metro area wood waste is currently chipped and used by District Energy for heat and electricity production with the majority of the remaining wood turned to mulch and compost, and only 1 percent milled to lumber. In an effort to strengthen wood waste utilization pathways and increase the proportion of wood converted to durable products, the Partnership on Waste & Energy provided a 2022 grant to help a local business scale up its reclamation and production of urban wood into lumber. In 2024, the City of Minneapolis committed to the development of an industrial yard and pyrolyzer which will be used to produce biochar (Du 2024).

An understanding of the species, size, health, and general form of standing live and dead trees can help anticipate needs and plan for hazard mitigation and wood reclamation once trees need to be removed. The data can help with decision making for new businesses interested in entering and diversifying the urban wood market. Urban FIA estimates that the city currently has 27.3 million net board-feet of sawtimber volume held in standing trees. Knowing what species will be available for lumber, other wood products, pyrolysis, and chipping allows proper equipment to be procured to provide the highest value and carbon retention products. If logs from removed urban trees are to be used, arborists must be trained to assess, fell, and process trees appropriately. Tree size influences what equipment is needed to process and transport the wood. Managing the full cycle of urban forestry from planting, to maintenance, to removal and processing requires long-term planning, for which data are critical.

CONCLUSION

A park bench awaits the next passerby looking for a place to rest and enjoy the view. Courtesy photo by Chris Edgar, Department of Forest Resources, University of Minnesota, Minneapolis, MN.

Minneapolis' urban forest contributes to the city's environmental, economic, and societal well-being. Throughout the city, tree canopy cover is provided by an estimated 1.8 million trees, representing 59 species. These trees provide a wide range of important environmental benefits including air pollution removal, reduced carbon emissions, carbon storage and sequestration, reduced energy use for buildings, stormwater capture, and many others.

There are several forces that may impact Minneapolis' 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 Minneapolis will be re-measured on a 5-year cycle as part of the continuing Urban FIA program. Future analyses of the city's forest can be used to determine the role that natural and human forces play in shaping forest structure and composition.

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

Diameter: For timber species, diameter is measured at breast height (d.b.h.), which is usually measured at 4.5 feet above the ground line on the uphill side of the tree. For woodland species, if the tree has multiple stems, the diameter of each is taken and combined to establish total diameter for the tree. Woodland diameters are measured at the ground line or at the stem(s) root collar (d.r.c.), whichever is higher. Timber tree species are listed in Appendix 2 (USDA Forest Service 2017). There were no woodland species sampled in the 2021 Urban FIA inventory of Minneapolis.

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 2016b).

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

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

Rotten or cull: Missing or rotten main stem or large branch volume caused by agents including cankers, punky knots, hollow sounding stems, or embedded metal in the wood (USDA Forest Service 2016b, 2017).

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

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

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

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

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

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

Woodland species: FIA classifies all tree species into either woodland or timber categories. Woodland species are typically small, slow-growing trees characterized by a multi-stemmed growth form; timber species generally grow from a single central stem (USDA Forest Service 2017). This difference in typical form induces some differences in data collection and calculation, such as how diameters are determined (see Diameter definition). There were no woodland species sampled in the 2021 Urban FIA inventory of Minneapolis.

APPENDIX 1 – LAND COVER DESCRIPTION

Table 31.—National Land Cover Database (NLCD) land cover class descriptions, city of Minneapolis, 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% 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% of total cover.
Deciduous forest	41	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% 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% of total vegetation cover. More than 75% 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% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% 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% 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% 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% 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% 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% of total vegetation.
Moss	74	Alaska only areas dominated by mosses, generally greater than 80% 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% 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% of total vegetation. This class also includes all land being actively tilled.
Woody wetlands	90	Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent herbaceous wetlands	95	Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Source: Homer et al. 2015

APPENDIX 2 – TREE SPECIES COMPOSITION

Table 32.—List of all live tree species and their characteristics, city of Minneapolis, 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	13,000	1,000	0	14,000	0.8	15,000	4.0
Acer	*negundo*	boxelder	87,000	36,000	13,000	136,000	7.5	57,000	5.4
Acer	*platanoides*	Norway maple[a]	0	9,200	15,000	24,000	1.3	8,400	13.6
Acer	*rubrum*	red maple	0	3,000	1,000	4,000	0.2	2,200	10.3
Acer	*saccharinum*	silver maple	40,000	22,000	21,000	83,000	4.6	66,000	10.2
Acer	*saccharum*	sugar maple	0	8,400	11,000	20,000	1.1	6,600	15.4
Acer	*x freemanii*	Freeman maple	0	4,400	2,000	6,400	0.4	2,700	9.7
Aesculus	*glabra*	Ohio buckeye	0	0	2,300	2,300	0.1	1,700	15.3
Betula	*nigra*	river birch	0	4,100	1,000	5,200	0.3	4,000	10.3
Betula	*papyrifera*	paper birch	0	4,100	1,000	5,200	0.3	2,900	8.6
Carpinus	*caroliniana*	American hornbeam, musclewood	13,000	0	0	13,000	0.7	14,000	1.1
Carya	*cordiformis*	bitternut hickory	0	1,000	0	1,000	0.1	1,100	8.0
Catalpa	*speciosa*	northern catalpa	0	0	1,000	1,000	0.1	1,100	25.6
Celtis	*occidentalis*	hackberry	71,000	29,000	28,000	127,000	7	41,000	6.8
Fraxinus	*americana*	white ash	13,000	3,100	3,100	19,000	1.1	19,000	6.4
Fraxinus	*nigra*	black ash	0	1,000	0	1,000	0.1	1,100	5.5
Fraxinus	*pennsylvanica*	green ash	259,000	16,000	15,000	290,000	16	189,000	3.3
Ginkgo	*biloba*	ginkgo, maidenhair tree	0	1,000	6,200	7,200	0.4	4,800	14.8
Gleditsia	*triacanthos*	honeylocust	0	5,200	17,000	22,000	1.2	7,100	14.7
Juglans	nigra	black walnut	0	1,300	3,400	4,700	0.3	2,300	15.3
Juniperus	*virginiana*	eastern redcedar	0	5,000	2,600	7,700	0.4	3,500	10.1
Malus	spp.	apple spp.	13,000	13,000	1,000	27,000	1.5	15,000	5.2
Morus	*alba*	white mulberry	53,000	1,700	2,300	57,000	3.1	57,000	3.0
Morus	*rubra*	red mulberry	52,000	18,000	3,700	74,000	4.1	41,000	3.3
Picea	*abies*	Norway spruce	13,000	2,100	2,300	18,000	1.0	14,000	5.3
Picea	*glauca*	white spruce	0	3,000	6,100	9,200	0.5	3,600	12.6
Picea	*pungens*	blue spruce	0	6,200	5,500	12,000	0.6	4,400	12.4
Pinus	*nigra*	Austrian pine	0	3,100	2,100	5,200	0.3	3,700	13.7
Pinus	*resinosa*	red pine	0	1,000	0	1,000	0.1	1,100	5.4
Pinus	*strobus*	eastern white pine	0	2,600	1,000	3,700	0.2	2,700	10.6

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Table 32. (continued)—List of all live tree species and their characteristics, city of Minneapolis, 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.)
Pinus	sylvestris	Scotch pine	0	1,000	0	1,000	0.1	1,100	10.4
Populus	*deltoides*	eastern cottonwood	0	5,200	15,000	20,000	1.1	12,000	16.8
Prunus	*armeniaca*	apricot	0	1,300	0	1,300	0.1	1,300	5.1
Prunus	*pensylvanica*	pin cherry	0	2,100	0	2,100	0.1	1,600	7.4
Prunus	*virginiana*	chokecherry	0	5,500	0	5,500	0.3	4,600	6.9
Pyrus	*communis*	common pear	0	1,000	1,000	2,000	0.1	2,200	13.7
Pyrus	spp.	pear spp.	0	0	2,100	2,100	0.1	2,200	11.9
Quercus	*alba*	white oak	13,000	0	1,300	15,000	0.8	14,000	5.0
Quercus	*bicolor*	swamp white oak	0	1,300	0	1,300	0.1	1,300	7.9
Quercus	*ellipsoidalis*	northern pin oak	13,000	0	1,000	14,000	0.8	14,000	3.9
Quercus	*macrocarpa*	bur oak	0	6,100	19,000	25,000	1.4	10,000	22.0
Quercus	*palustris*	pin oak	0	0	2,400	2,400	0.1	1,700	26.2
Quercus	*rubra*	northern red oak	0	0	2,000	2,000	0.1	1,500	18.6
Quercus	*velutina*	black oak	0	0	1,000	1,000	0.1	1,100	17.6
Rhamnus	*cathartica*	common buckthorn[a]	205,000	20,000	0	225,000	12.4	162,000	2.1
Robinia	*pseudoacacia*	black locust[a]	0	1,300	0	1,300	0.1	1,300	10.5
Salix	spp.	willow spp.	16,000	1,000	4,200	21,000	1.2	16,000	5.3
Salix	*x sepulcralis*	weeping willow	0	0	2,100	2,100	0.1	1,600	18.7
Sorbus	*americana*	American mountain-ash	0	0	1,000	1,000	0.1	1,100	11.6
Syringa	*reticulata*	Japanese tree lilac	0	3,400	0	3,400	0.2	2,800	6.2
Taxus	*cuspidata*	Japanese yew	0	1,000	0	1,000	0.1	1,100	5.8
Thuja	*occidentalis*	northern white-cedar	130,000	5,100	5,200	140,000	7.7	99,000	2.5
Thuja	*plicata*	western redcedar	27,000	0	0	27,000	1.5	28,000	2.9
Tilia	*americana*	American basswood	25,000	6,100	4,400	36,000	2.0	33,000	4.9
Tilia	*cordata*	littleleaf linden	0	3,100	16,000	19,000	1.0	6,800	17.0
Ulmus	*americana*	American elm	105,000	27,000	22,000	154,000	8.5	77,000	5.7
Ulmus	*pumila*	Siberian elm[a]	62,000	3,700	5,700	71,000	3.9	51,000	3.8
Ulmus	*rubra*	slippery elm	13,000	3,500	2,000	18,000	1.0	14,000	3.8
Total			**1,230,000**	**304,000**	**275,000**	**1,810,000**	**100.0**	**414,000**	**5.6**

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 Minneapolis (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 Minneapolis, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Developed-high	American elm	3,439	1.4	18.4
	Japanese tree lilac	3,439	0.1	6.2
	Norway maple	1,720	0.2	12.6
	blue spruce	3,439	1.2	20.3
	boxelder	3,439	0.5	12.1
	eastern redcedar	1,720	< 0.1	7.1
	green ash	1,720	0.3	14.1
	hackberry	3,439	0.6	14.9
	littleleaf linden	3,439	0.7	16.2
	white mulberry	1,720	< 0.1	7.1
	white spruce	1,720	0.1	9.3
Developed-low	American basswood	31,362	0.3	2.7
	American elm	36,405	2.1	6.7
	American hornbeam, musclewood	12,655	< 0.1	1.1
	American mountain-ash	1,009	< 0.1	11.6
	Amur maple	13,664	0.1	4.0
	Austrian pine	1,009	0.2	20.2
	Freeman maple	4,034	0.3	11.1
	Japanese yew	1,009	< 0.1	5.8
	Norway maple	17,146	2.1	14.8
	Norway spruce	2,017	0.1	10.7
	Ohio buckeye	1,009	0.1	17.0
	Siberian elm	14,673	0.3	4.6
	apple spp.	3,026	0.1	9.0
	bitternut hickory	1,009	< 0.1	8.0
	black ash	1,009	< 0.1	5.5
	black walnut	1,009	0.1	16.6
	blue spruce	3,026	0.2	11.7
	boxelder	57,129	1.2	5.4
	bur oak	10,086	2.2	17.2
	common buckthorn	25,311	< 0.1	1.6
	common pear	2,017	0.2	13.7
	eastern redcedar	2,017	0.1	9.9
	ginkgo, maidenhair tree	3,026	0.2	10.8

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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 Minneapolis, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Developed-low (cont.)	green ash	33,379	1.1	4.7
	hackberry	58,138	2.4	6.0
	honeylocust	11,095	1.5	16.0
	littleleaf linden	7,060	0.8	14.5
	northern pin oak	13,664	0.7	3.9
	northern red oak	2,017	0.4	18.6
	northern white-cedar	68,320	0.6	3.2
	paper birch	2,017	0.1	10.2
	pin cherry	1,009	< 0.1	6.5
	red maple	4,034	0.2	10.3
	red mulberry	29,345	0.1	2.1
	river birch	2,017	0.2	12.7
	silver maple	9,077	3.9	27.3
	slippery elm	15,681	0.3	3.2
	sugar maple	7,060	0.7	11.2
	white ash	2,017	0.8	28.0
	white mulberry	1,009	0.1	14.5
	white spruce	4,034	0.4	14.3
Developed-medium	American basswood	3,134	0.5	16.3
	American elm	93,180	2.6	3.6
	Austrian pine	4,178	0.3	12.1
	Freeman maple	1,045	< 0.1	10.1
	Norway maple	4,178	0.1	8.4
	Norway spruce	14,311	< 0.1	3.2
	Scotch pine	1,045	< 0.1	10.4
	Siberian elm	2,089	0.2	12.6
	apple spp.	22,667	0.3	4.6
	black oak	1,045	0.2	17.6
	black walnut	1,045	0.2	18.9
	blue spruce	5,223	0.2	7.7
	boxelder	4,178	0.4	10.9
	bur oak	3,134	0.3	11.8
	chokecherry	4,178	0.1	7.2
	eastern cottonwood	13,579	2.4	15.7
	eastern white pine	1,045	0.2	20.9
	ginkgo, maidenhair tree	4,178	0.6	17.6
	green ash	195,138	1.9	3.2
	hackberry	13,579	1.2	12.6

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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 Minneapolis, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Developed-medium (cont.)	honeylocust	9,401	0.7	12.0
	littleleaf linden	8,356	1.7	19.4
	northern catalpa	1,045	0.3	25.6
	northern white-cedar	71,557	0.4	1.9
	paper birch	3,134	< 0.1	7.7
	pear spp.	2,089	0.1	11.9
	pin cherry	1,045	< 0.1	8.2
	pin oak	1,045	0.1	14.3
	red mulberry	39,068	0.4	3.2
	red pine	1,045	< 0.1	5.4
	river birch	3,134	0.1	8.8
	silver maple	70,824	4.0	7.4
	sugar maple	6,267	0.6	12.8
	weeping willow	2,089	0.4	18.7
	western redcedar	26,534	0.1	2.9
	white ash	17,445	0.2	3.9
	white mulberry	53,068	0.1	2.3
	white oak	13,267	< 0.1	3.0
	white spruce	2,089	0.2	13.2
	willow spp.	5,223	0.5	14.3
Developed-open/vegetation	American basswood	1,310	1.0	29.6
	American elm	19,649	3.6	11.9
	Freeman maple	1,310	< 0.1	5.3
	Norway maple	1,310	0.3	16.9
	Norway spruce	1,310	0.5	19.7
	Ohio buckeye	1,310	0.2	14.0
	Siberian elm	54,236	1.2	3.2
	apple spp.	1,310	< 0.1	6.5
	apricot	1,310	< 0.1	5.1
	black locust	1,310	0.1	10.5
	black walnut	2,620	0.6	13.3
	boxelder	71,265	2.6	4.8
	bur oak	11,789	9.0	28.9
	chokecherry	1,310	< 0.1	5.9
	common buckthorn	199,916	1.1	2.1
	eastern cottonwood	6,550	2.3	18.9
	eastern redcedar	3,930	0.5	11.6
	eastern white pine	2,620	< 0.1	6.5

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 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 Minneapolis, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Developed-open/vegetation (cont.)	green ash	43,144	1.2	3.2
	hackberry	52,313	2.3	5.7
	honeylocust	1,310	0.6	22.5
	pin oak	1,310	1.5	35.7
	red mulberry	5,240	0.5	10.0
	silver maple	2,620	1.8	27.5
	sugar maple	5,240	3.4	26.7
	swamp white oak	1,310	< 0.1	7.9
	white mulberry	1,310	0.3	16.0
	white oak	1,310	0.7	24.9
	white spruce	1,310	0.1	10.5
Water	American elm	1,261	0.1	6.0
	green ash	16,962	0.2	1.6
	slippery elm	2,521	0.4	7.6
	sugar maple	1,261	< 0.1	5.5
	willow spp.	15,702	0.2	2.3

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 Minneapolis, 2021

FIA land use class	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Forest land	American basswood	30,354	3.6	2.5
	American elm	46,023	13.2	5.6
	bitternut hickory	1,009	0.5	8
	black ash	1,009	0.2	5.5
	boxelder	29,789	12.5	6.6
	bur oak	7,060	11.2	13.5
	common buckthorn	189,943	5.9	1.8
	eastern cottonwood	6,550	19.2	18.9
	green ash	32,567	1.3	1.6
	hackberry	53,039	12.9	4.5
	red mulberry	26,319	0.5	1.4
	slippery elm	12,655	0.1	1.1
	sugar maple	1,261	0.3	5.5
Commercial/industrial	American elm	1,045	< 0.1	5.8
	blue spruce	3,439	1.6	20.3
	boxelder	53,746	1.3	3.4
	common buckthorn	32,664	0.5	3
	eastern redcedar	1,009	0.1	10.1
	green ash	18,052	0.4	2.3
	hackberry	19,430	0.5	3.7
	honeylocust	1,009	0.3	15.5
	Norway maple	1,720	0.3	12.6
	Siberian elm	51,616	0.6	2.7
Multi-family residential	apple spp.	1,045	0.1	7.7
	common pear	2,017	1	13.7
	eastern redcedar	1,720	0.2	7.1
	Freeman maple	1,045	0.3	10.1
	hackberry	2,728	1.8	16
	honeylocust	1,045	0.5	14.3
	Japanese tree lilac	3,439	0.3	6.2
	littleleaf linden	3,439	2.2	16.2
	Norway maple	1,045	0.2	8.1
	silver maple	1,045	1.9	27.8
	white spruce	1,720	0.4	9.3
Residential	American basswood	1,045	< 0.1	6.5
	American elm	10,832	2.5	18.2
	American mountain-ash	1,009	< 0.1	11.6
	Amur maple	13,664	0.1	4
	apple spp.	25,959	0.4	5.1

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

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 Minneapolis, 2021

FIA land use class	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Residential (cont.)	apricot	1,310	< 0.1	5.1
	Austrian pine	2,053	0.4	19.8
	black oak	1,045	0.2	17.6
	black walnut	3,363	0.3	12.8
	blue spruce	8,248	0.4	9.2
	boxelder	27,751	1	7.6
	bur oak	11,399	4.1	25
	chokecherry	5,488	0.1	6.9
	eastern cottonwood	1,045	1	44.2
	eastern redcedar	1,310	< 0.1	10.9
	eastern white pine	3,664	0.3	10.6
	Freeman maple	1,009	< 0.1	6.4
	green ash	22,789	1.6	9.7
	hackberry	22,106	1.3	7.7
	honeylocust	4,070	0.4	13.5
	Japanese yew	1,009	< 0.1	5.8
	littleleaf linden	1,045	0.3	25.7
	northern catalpa	1,045	0.3	25.6
	northern pin oak	1,009	0.6	35.6
	northern red oak	2,017	0.3	18.6
	northern white-cedar	138,832	0.9	2.5
	Norway maple	5,416	0.5	12.9
	Norway spruce	2,053	< 0.1	8.7
	Ohio buckeye	1,009	0.1	17
	paper birch	5,151	0.2	8.6
	pear spp.	2,089	0.1	11.9
	pin cherry	2,053	< 0.1	7.4
	red maple	1,009	< 0.1	14.4
	red mulberry	35,614	0.5	3.4
	river birch	5,151	0.3	10.3
	Scotch pine	1,045	< 0.1	10.4
	Siberian elm	19,381	0.8	6.8
	silver maple	19,009	7	26.2
	sugar maple	2,053	0.6	24.4
	swamp white oak	1,310	< 0.1	7.9
	weeping willow	2,089	0.3	18.7
	western redcedar	26,534	0.1	2.9
	white ash	18,454	0.6	5.2
	white mulberry	55,386	0.4	2.8

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

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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 Minneapolis, 2021

FIA land use class	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Residential (cont.)	white spruce	7,433	0.6	13.3
Recreation/cemetery	American basswood	1,310	1.4	29.6
	American elm	5,753	2	16.3
	black locust	1,310	0.2	10.5
	black walnut	1,310	0.7	21.6
	boxelder	5,947	0.9	10.3
	bur oak	6,550	5.3	26.1
	common buckthorn	2,620	0.1	6.6
	eastern cottonwood	2,089	1	20.2
	eastern redcedar	2,620	0.4	11.9
	Freeman maple	1,310	< 0.1	5.3
	ginkgo, maidenhair tree	1,009	< 0.1	6.2
	green ash	24,570	0.9	3.7
	hackberry	20,162	3.1	10.2
	honeylocust	1,310	0.8	22.5
	Norway maple	1,045	0.1	9.6
	Norway spruce	15,585	0.9	4.8
	Ohio buckeye	1,310	0.3	14
	pin oak	1,310	2	35.7
	red mulberry	1,310	0.1	9.2
	slippery elm	5,547	0.8	10.1
	sugar maple	6,284	4.5	23.5
	white oak	1,310	1	24.9
	willow spp.	15,702	< 0.1	2.3
Rights-of-way	American basswood	3,098	0.6	17.7
	American elm	90,281	3.4	3.7
	American hornbeam, musclewood	12,655	< 0.1	1.1
	Austrian pine	3,134	0.2	9.6
	boxelder	18,779	0.5	4.6
	eastern cottonwood	10,445	1.1	12.0
	eastern redcedar	1,009	< 0.1	9.7
	Freeman maple	3,026	0.3	12.6
	ginkgo, maidenhair tree	6,195	0.9	16.2
	green ash	192,365	1.6	2.9
	hackberry	10,004	1.1	13.4
	honeylocust	14,372	1.7	14.3
	littleleaf linden	14,372	2.3	16.5
	northern pin oak	12,655	< 0.1	1.4

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

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 Minneapolis, 2021

FIA land use class	Common name	Trees (number)	Basal area (sq ft per ac)	Average diameter (inches)
Rights-of-way (cont.)	northern white-cedar	1,045	< 0.1	8.4
	Norway maple	15,129	1.9	14.7
	pin oak	1,045	0.1	14.3
	red maple	3,026	0.1	8.9
	red mulberry	10,409	0.3	6.8
	red pine	1,045	< 0.1	5.4
	silver maple	1,045	0.1	13.7
	sugar maple	10,230	0.6	9.9
	white ash	1,009	0.4	27.6
	white mulberry	1,720	< 0.1	7.1
	white oak	13,267	< 0.1	3.0
Water	silver maple	61,424	4.7	4.9
	willow spp.	5,223	2.8	14.3

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

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.).

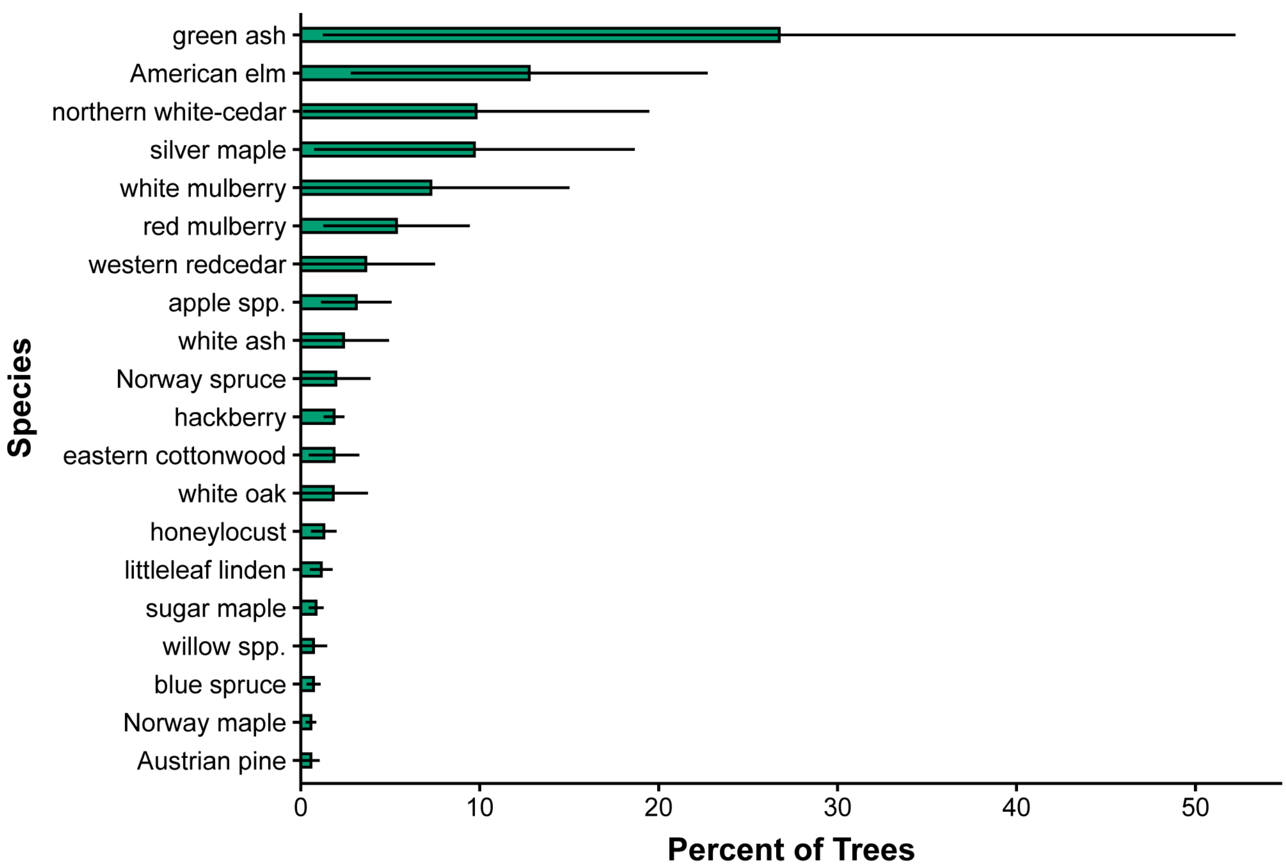

Figure 27.—Percent of the total tree population for up to 20 of the most common tree species observed in the developed-medium National Land Cover Database (NLCD) land cover class group, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

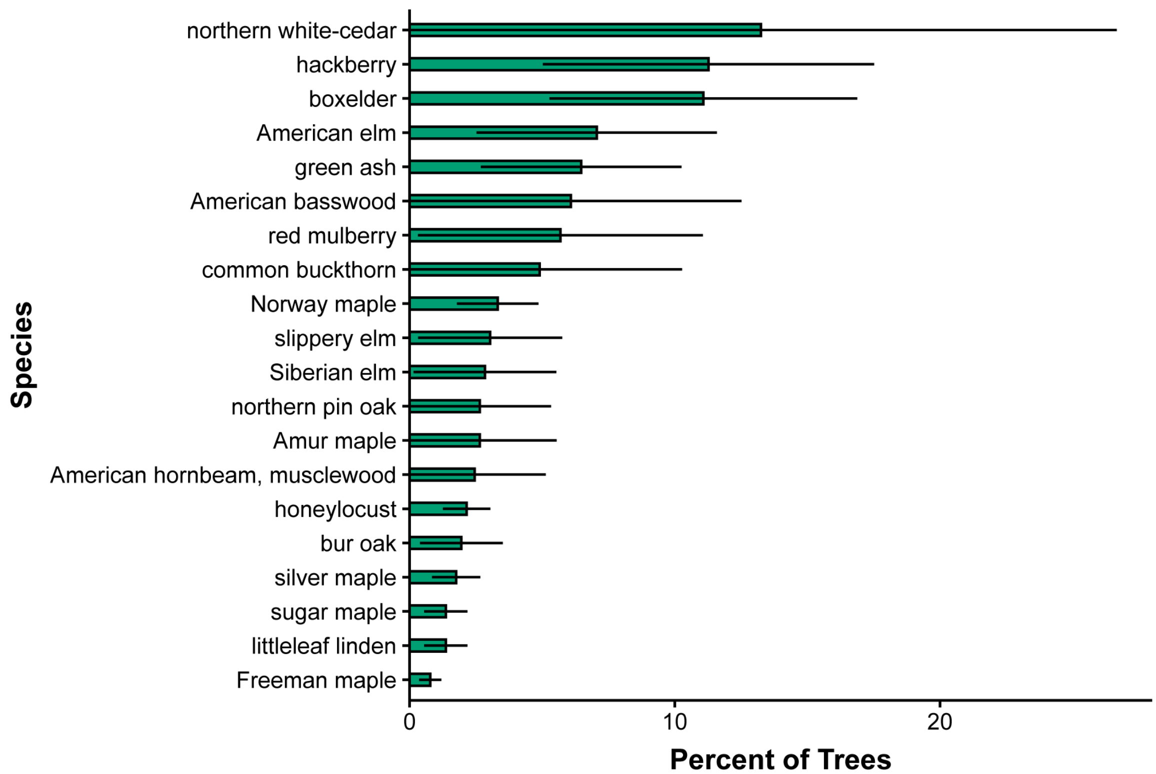

Figure 28.—Percent of the total tree population for up to 20 of the most common tree species observed in the developed-low National Land Cover Database (NLCD) land cover class group, city of Minneapolis, 2021.Error bars represent 68 percent confidence intervals around the estimated means.

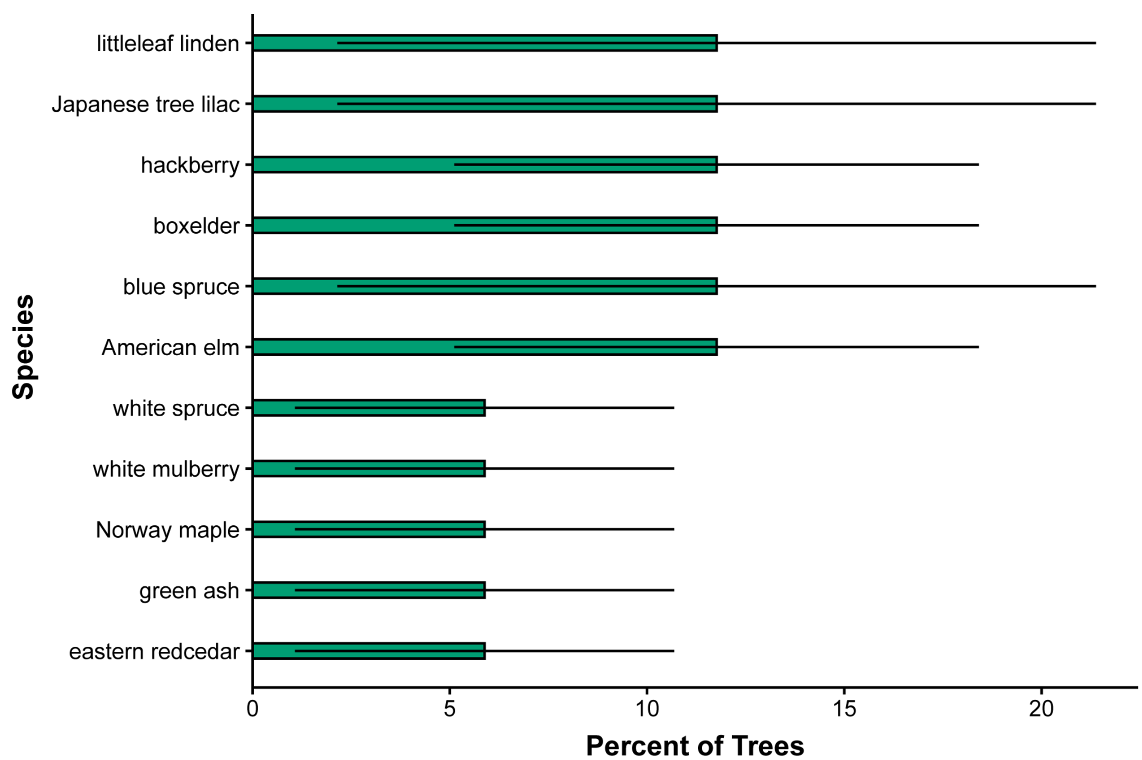

Figure 29.—Percentage of total tree population for up to 20 of the most common tree species observed in the developed-high National Land Cover Database (NLCD) land cover class group, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

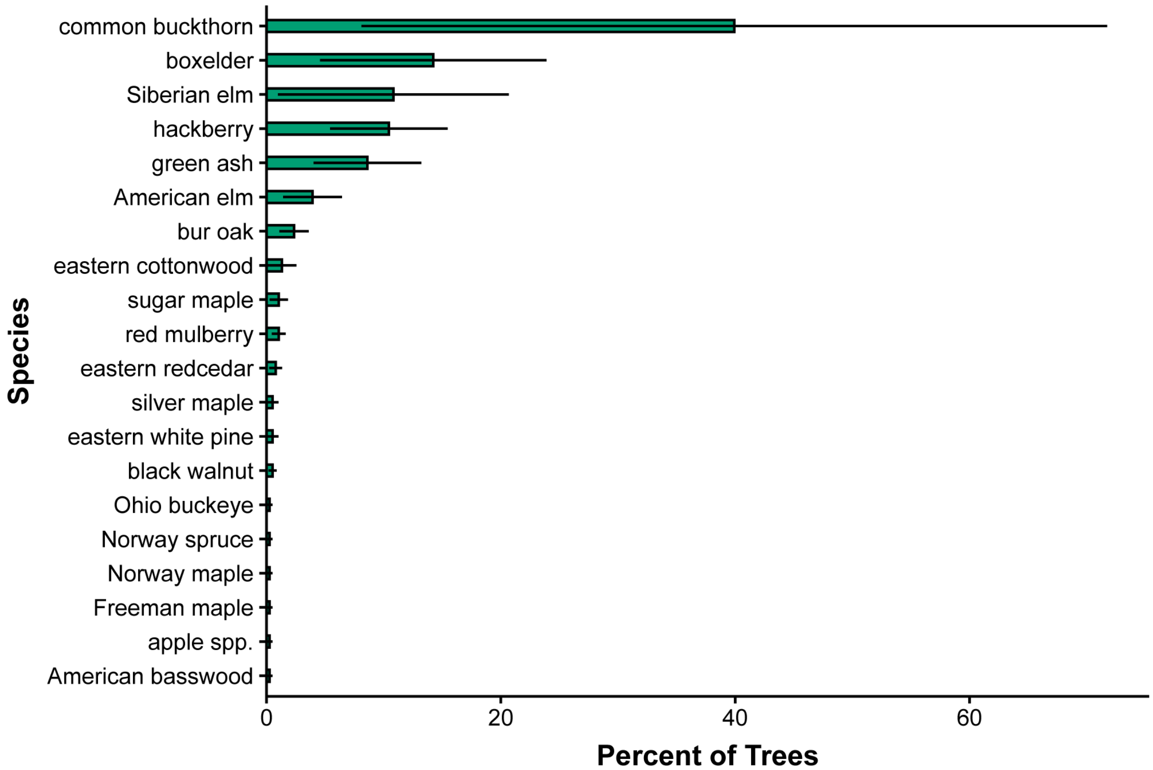

Figure 30.—Percent of the total tree population for up to 20 of the most common tree species observed in the developed-open/vegetation National Land Cover Database (NLCD) land cover class group, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

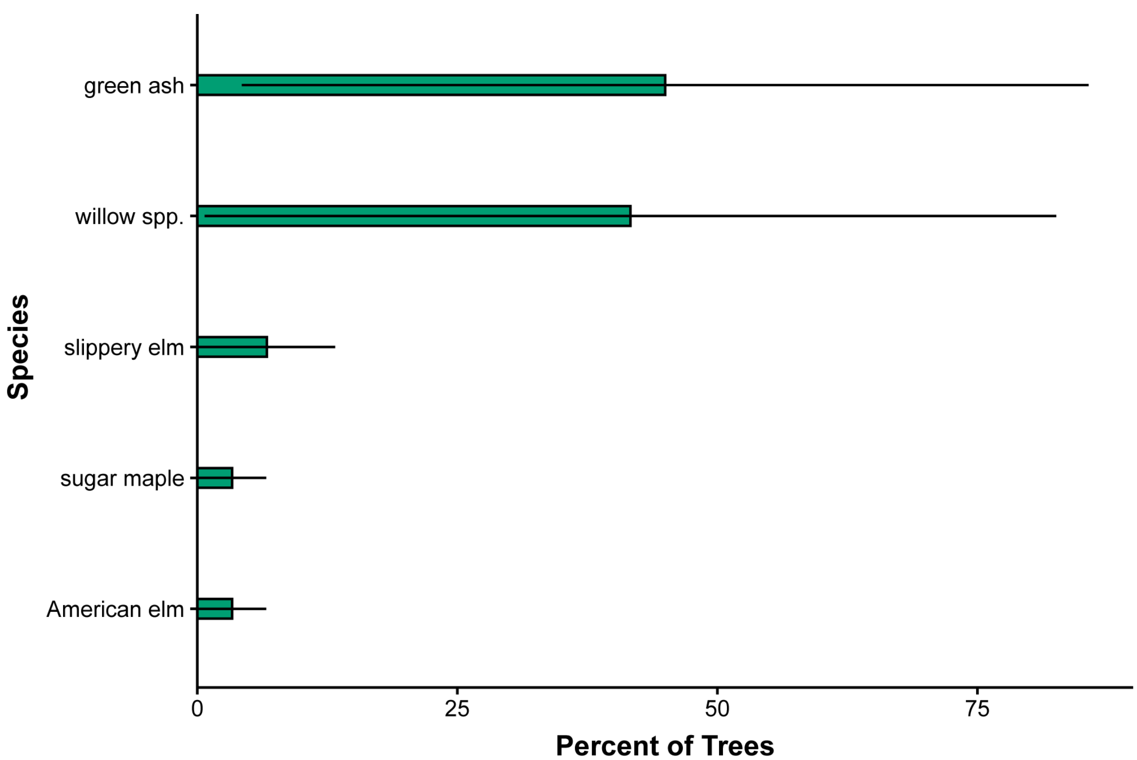

Figure 31.—Percent of the total tree population for up to 20 of the most common tree species observed in the water National Land Cover Database (NLCD) land cover class group, city of Minneapolis, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

APPENDIX 4 – SPECIES COMPOSITION IN MAINTAINED AREAS

Table 35.—Species composition in maintained areas, city of Minneapolis, 2021

Common name	Number of trees
northern white-cedar	137,000
white mulberry	57,000
hackberry	41,000
red mulberry	41,000
American elm	34,000
green ash	32,000
western redcedar	27,000
apple spp.	26,000
Norway maple	24,000
honeylocust	22,000
silver maple	19,000
littleleaf linden	19,000
sugar maple	19,000
bur oak	18,000
Norway spruce	18,000
boxelder	18,000
Siberian elm	17,000
white oak	15,000
Amur maple	14,000
American hornbeam, musclewood	13,000
northern pin oak	13,000
blue spruce	12,000
white spruce	9,200
eastern redcedar	7,700
ginkgo, maidenhair tree	7,200
Freeman maple	6,400
slippery elm	5,500
chokecherry	5,500
Austrian pine	5,200
river birch	5,200
paper birch	5,200
American basswood	4,400
eastern cottonwood	4,200
red maple	4,000
black walnut	3,700
Japanese tree lilac	3,400
eastern white pine	2,600
pin oak	2,400
Ohio buckeye	2,300
pear spp.	2,100
pin cherry	2,100
white ash	2,000
northern red oak	2,000
common pear	2,000
swamp white oak	1,300
apricot	1,300
red pine	1,000
northern catalpa	1,000
black oak	1,000
weeping willow	1,000
American mountain-ash	1,000
Japanese yew	1,000

Estimates are rounded.

APPENDIX 5 – LIST OF INVASIVE PLANT SPECIES

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

Scientific name	Common name
Acer platanoides	Norway maple
Ailanthus altissima	tree of heaven
Albizia julibrissin	mimosa
Alliaria petiolata	garlic mustard
Berberis thunbergii	Japanese barberry
Berberis vulgaris	common barberry
Celastrus orbiculatus	Oriental bittersweet
Centaurea stoebe spp. *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 x bella	showy fly honeysuckle
Lonicera japonica	Japanese honeysuckle
Lonicera morrowii	Morrow’s honeysuckle
Lonicera	honeysuckle
Lonicera tatarica	Tatarian honeysuckle
Lysimachia nummularia	creeping jenny
Lythrum salicaria	purple loosestrife
Melia azedarach	Chinaberrytree
Melaleuca quinquenervia	melaleuca
Microstegium vimineum	Nepalese browntop
Phalaris arundinacea	reed canarygrass
Phragmites australis	common reed
Polygonum cuspidatum	Japanese knotweed
Polygonum sachalinense	giant knotweed
Rhamnus cathartica	common buckthorn
Rosa multiflora	multiflora rose
Robinia pseudoacacia	black locust
Spiraea japonica	Japanese meadowsweet
Tamarix ramosissima	saltcedar
Triadica sebifera	Chinese tallow
Ulmus pumila	Siberian elm
Viburnum opulus	European cranberrybush
Lonicera maackii	Amur honeysuckle
Paulownia tomentosa	paulownia
Polygonum x bohemicum	Bohemian knotweed

APPENDIX 6 – RISK ASSOCIATED WITH VARIOUS INSECTS AND DISEASES

Table 37.—Tree species pest risk score from various insects and diseases, city of Minneapolis, 2021

Common name	Cumulative score	FTC	EAB	DED	LAT	OW	PSB	SBW	ARD	BOB	BC	SM	HRD	SB	AL	JPBW	WPBR	ALB	SLF	FR	SPB	WSB	SW	MPB	BWA	BSRD	TCD	WM	BM	PSHB	MOB	POCRD	WBBU	NSE	SOD	RPS
Norway spruce	25						4	4					3	3							2	2	2	2	2								1			
bur oak	23	4				4				4		3							2	2								1	1	1	1					
eastern white pine	23	4					4						3			3	3		2		2		2													
white spruce	22						4	4					3	3							2	2				2							1	1		
northern red oak	20	4				4						3							2	2								1	1	1	1				1	
pin oak	20	4				4						3							2	2								1	1	1	1				1	
apricot	19	4			4							3			3			2	2										1							
red pine	19	4					4						3			3					2		2													1
Scotch pine	19	4					4									3					2	2	2	2												
weeping willow	19	4			4							3			3			2	2										1							
white oak	19	4				4						3							2	2								1	1	1	1					
willow spp.	19	4			4							3			3			2	2										1							
black oak	18	4				4						3							2	2								1	1		1					
northern pin oak	18	4				4						3							2	2								1	1		1					
swamp white oak	18	4				4						3							2	2								1	1		1					
paper birch	17	4			4							3						2	2									1	1							
blue spruce	16						4	4						3							2	2											1			
river birch	16	4			4							3						2	2									1								
American elm	15	4		4														2	2									1	1	1						
chokecherry	15	4			4										3			2										1	1							
pin cherry	15	4			4										3			2										1	1							
eastern cottonwood	14	4			4							3						2										1								
Siberian elm	14	4		4														2	2									1	1							
slippery elm	14	4		4														2	2									1	1							
American basswood	13	4										3						2	2									1		1						
green ash	13	4	4															2	2									1								
Austrian pine	12	4					4														2		2													
black ash	11	4	4																2									1								
boxelder	11											3						2	2									1	1	1	1					
sugar maple	11	4																2	2									1	1		1					
white ash	11	4	4																2									1								
black walnut	9										4								2								2			1						
littleleaf linden	9	4										3						2																		
apple spp.	8											3						2	2										1							
common pear	8											3						2	2										1							
pear spp.	8											3						2	2										1							
Freeman maple	7																	2	2										1	1	1					
Norway maple	7																	2	2									1	1		1					
red maple	7																	2	2									1	1		1					
silver maple	7																	2	2									1	1		1					
western redcedar	7								4				3																							
white mulberry	5																	2	2											1						
American mountain-ash	4											3																1								
Amur maple	4																	2											1		1					
eastern redcedar	4												3																	1						
northern white-cedar	3																		2													1				
American hornbeam, musclewood	2																		2																	
black locust	2																		2																	
hackberry	2																	2																		
Ohio buckeye	2																	2																		
red mulberry	2																	2																		
honeylocust	1																													1						
northern catalpa	1																													1						

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

Each pest that could pose a risk to a tree species is scored as 4 points if it occurs within Hennepin County, 3 points if occurs within 250 miles of the county, 2 points if it occurs within 750 miles of the county, and 1 point if it is not present within 750 miles of the county.

Northern Research Station
https://research.fs.usda.gov/nrs