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Des Moines, Iowa's Urban Forest, 2021

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Abstract

A 2021 analysis of the urban forest in Des Moines, Iowa, reveals that this area has an estimated 2.5 million live trees across all ownerships. The most common tree species by number are American elm, green ash, and boxelder. Trees in Des Moines are estimated to store about 466,000 tons of carbon (1.7 million tons of carbon dioxide [CO_2]) valued at $79.5 million. In addition, it is estimated that these trees remove about 12,000 tons of carbon per year (or 44,000 tons CO_2 per year, valued at $2.1 million, an amount roughly equivalent to the annual emissions associated with 8,700 passenger vehicles or energy usage by 4,800 homes [Greenhouse Gas Equivalencies Calculator, U.S. EPA 2020]) and about 382 tons of air pollution per year (valued at $4.0 million per year). Des Moines' urban forest is estimated to reduce annual energy costs of residential buildings by $825 thousand annually. The overall compensatory value of the urban forest is estimated at $1.3 billion. Compensatory value describes the replacement value of trees as a structural asset, which tends to increase with the size and health of the tree. The information presented in this report may be used to support urban forest management programs and to inform policy and planning to improve environmental quality and human health in Des Moines. The analysis also provides a basis for monitoring changes in the urban forest over time.

Keywords: Urban FIA; UFIA; i-Tree; Iowa; IA; 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 values; ecosystem services

Cover photo: Iowa State Capitol. Courtesy photo by Emma Hanigan, Iowa Department of Natural Resources.

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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 Casey Cloeter, Chandler Johnson, Daniel Kaisershot, Peter Koehler, Mark Majewsky, Mike Maki, Benjamin Nurre, Cassandra Olson, Dave Roth, Sjana Schanning, Willard Smith, and Brad Totten. These employees collected data, researched land ownership, skillfully managed landowner contact, and coordinated plot visits, keeping the occurrence of denied access plots to a minimum through their quality, professional work. Special thanks to Mark Hatfield and Lucie Lepine for their expert assistance with the Universal National Information Management System (UNIMS) database. Special thanks to Nancy Sonti and Janette Thompson, as well as all of the reviewers who graciously offered their valuable time to read draft versions of this report, asked great questions, and helped smooth out the edges.

EXECUTIVE SUMMARY

Fountain at Ewing Park. Courtesy photo by Emma Hanigan, Iowa Department of Natural Resources.

The 2021 Urban Forest Inventory and Analysis (Urban FIA) assessment of the City of Des Moines, Iowa includes estimates of the magnitude, composition, and value of its urban forest resource. The sampled area of the city (representing a total of 52,862 acres), is estimated to contain 2.5 million live trees, 55.0 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 American elm, green ash, boxelder, white mulberry, and hackberry. The most common large-diameter tree species (11.0+ inches in diameter) are silver maple, Siberian elm, eastern cottonwood, eastern white pine, and white mulberry. The most dominant species based on the number of trees and leaf area are silver maple, green ash, American elm, hackberry, and white mulberry.

[1] See glossary for definition of bolded terms.

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

The land use class with the greatest number of trees is **forest land** (51.5 percent; 1.3 million trees). Overall, 28.6 percent of trees are classified as growing in maintained areas. Trees on public lands total 558,000 and account for 22.3 percent of the total live tree population. Trees on private lands total 1.9 million and account for 77.7 percent of the population.

Urban forest ecosystem services are evaluated in terms of air pollution removal, carbon sequestration, reduction in stormwater runoff, and effects on residential building energy use and carbon emissions. The compensatory value of the urban forest (roughly equivalent to the replacement value of all trees in the urban forest) of Des Moines is estimated at $1.3 billion with the urban forest producing over $10 million in annual benefits (Table 1).

The tree species with the greatest estimated average percent dieback is boxelder (15.2 percent dieback) and the species with the greatest rot is Amur maple (10.3 percent rot). The most common urban specific damages affecting all tree species in the sampling area are bark inclusion (16.2 percent of trees) and conflict with crown (3.7 percent of trees).

Invasive plant species also threaten to alter Des Moines' urban forest composition. Invasive plant species are found on 48.0 percent of the sampled plots; Siberian elm is estimated to cover the largest area (622 acres) of any invasive plant species in the city. These natural and anthropogenic threats may affect the health and composition of Des Moines' urban forest. Through a better understanding of the benefits conferred by, and potential threats to the urban forest, resource managers, arborists, and city planners can improve forest management, leading to healthier urban forests and more livable communities.

Table 1.—Summary of urban forest estimates, Des Moines, Iowa, 2021

Feature	Estimate
Number of trees[a]	
Total live trees	2.5 million (419,913)[b]
Live saplings (1.0 to 4.9 inches in diameter)	1.4 million (377,000)[b]
Live trees (at least 5.0 inches in diameter)	1.1 million (114,444)[b]
Standing dead saplings (1.0 to 4.9 inches in diameter)	118,000 (63,000)[b]
Standing dead trees (at least 5.0 inches in diameter)	82,000 (20,000)[b]
Most abundant species	
By number of live trees	American elm
By leaf area	silver maple
Ecosystem Impacts and Services	
VOC emissions	343 tons/year
Pollution removal	382 tons/year ($4 million/year)
Reduction in acute respiratory symptoms	372 cases/year ($33,000/year)
Avoided runoff	40.8 million cubic feet ($2.7 million/year)
Carbon storage[c]	466,000 tons ($79.5 million)
Carbon sequestration	12,000 tons/year ($2.1 million/year)
Net aboveground volume	25.4 million cubic feet
Reduced building energy use[c, d, e]	-12,000 GJ/year ($825,000/year)
Reduced carbon emissions[c,d]	2,100 tons/year ($573,000/year)
Compensatory value	$1.3 billion

Estimates are rounded.

VOC = volatile organic compound (a negative ecosystem impact). Ton = short ton (U.S.) (2,000 lbs.). GJ = gigajoule (one billion [10^9] joules).

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

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

[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.

[e] Negative values indicate an increase in energy requirements.

Contents

BACKGROUND

Hilltop view of downtown Des Moines. Courtesy photo by Emma Hanigan, Iowa Department of Natural Resources.

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 (USDA Forest Service 2016a) which includes a special focus on the nation's most populous cities.

In this report, the term "urban forest" describes all trees located in the city across both public and private ownerships, including planted trees along streets and boulevards, trees in parks and residential yards, remnant forest along railroads and riparian areas, small woodlots, and larger forested areas. FIA has partnered with the Forest Service i-Tree team, which has a long tradition of conducting urban forest inventories and delivering data about urban forests and their associated ecosystem services. This combined national urban forest inventory effort leverages the strengths of both groups, drawing on the urban data processing and reporting strengths of the i-Tree program and FIA's strengths in quality, consistency, and comprehensiveness of data collection.

[3] See glossary for definition of bolded terms.

Urban FIA data were collected in Des Moines from 2015–2021 on research plots spread across various land uses and ownerships. In 2022, the remeasurement of that initial inventory began, and Des Moines, Iowa joined a growing list of U.S. cities that have completed a full inventory cycle under the Urban Forest Inventory and Analysis (Urban FIA or UFIA) program. This makes Urban FIA uniquely poised to assess change over time and this first inventory will serve as a baseline against which future data can be compared.

In 2020, the City of Des Moines with cooperation from the Iowa Department of Natural Resources, Iowa State University, and Drake University published "Trees in the Capitol City…Connecting the Dots: Urban Forest Master Plan for the City of Des Moines 2020" (City of Des Moines 2020). This comprehensive document utilized data from a citywide street tree inventory conducted between 2015 and 2017 to identify a goal of a 3 percent canopy increase by 2045, as well as the implementation of a cyclical pruning program as two items critical to the "future success of the urban tree canopy". The plan also outlines several individual emphasis areas categorized into the following four broad groups:

- Water—Stormwater and trees; climate change and trees; trees as green infrastructure; riparian zones and trees; street trees
- Nature—Wildlife and trees; bee pollinators and trees; resiliency and trees; big trees in the city; insects, disease and invasive plants
- Strategies—Large landowners; regional cooperation; urban wood utilization in the city; volunteerism, nonprofits and trees; recommended species; tree management plan
- People—Public opinion; environmental equity and trees; urban heat island and trees; trees and energy consumption; societal effects of trees, history of trees in Des Moines

Recommendations for the preceding emphasis areas include the following:

- Increase tree planting with a focus on species selection, diversity, and placement
- Identify other concerns and needs with additional surveys and studies
- Improve engagement with the public through outreach and education
- Invest in maintenance of existing trees to improve health and longevity

The tree inventory conducted by the city of Des Moines was a complete census of street trees and park trees in maintained portions of parks and cemeteries. Conversely, Urban FIA is a sample-based inventory that includes trees located across all ownerships and land uses. Many of the emphasis areas listed above are addressed in this report and the data from this ongoing inventory will provide an assessment to measure the progress being made toward the goals outlined in the city's Urban Forest Master Plan (City of Des Moines 2020).

Methods

To evaluate the extent, composition, and benefits of Des Moines' urban forest and establish a baseline for future monitoring, a sample-based inventory was conducted following Urban FIA monitoring methods and reporting tools described in the Urban FIA Northern Research Station (NRS) Field Guide Version 7.1 (USDA Forest Service 2017) and the online supplement to this report (Baer et al. 2025), along with i-Tree Eco modeling software (www.itreetools.org; Nowak 2024). This process established survey plots across Des Moines and aims to revisit those plots every 7 years. Future reports can build on these data and provide consistent information on urban forest extent, diversity, health condition, and benefits. The sampling area was defined by the U.S. Census Bureau Designated Places boundary for Des Moines (highlighted in red in Fig. 1a). In total, the Urban FIA sample surveyed 198 plots across the city's 52,862 acres within the designated sampling area in Des Moines (Fig. 1).

New methods were implemented in the inventory of the Des Moines urban forest to allow for flexibility in the estimation of tree characteristics for forked trees. In this inventory, all stems of forked trees are quantified and characterized as part of the same tree. All extrapolated estimates for forked trees are based on this approach except for estimates of tree merchantability and volume estimation. Refer to Baer et al. (2025) for more detailed information. Throughout this report, except where explicitly noted, trees refer to woody plant species listed in Appendix 3 and 3B of the NRS Field Guide Version 7.1 (USDA Forest Service 2017) with **diameters** of at least 1.0 inch, and results are given for live trees.

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) and Microsoft Excel; figures presented in this report were generated using the base, dplyr (Wickham et al. 2022), and ggplot2 (Wickham 2016) packages within the R Statistical Software platform, and Microsoft Excel. Maps throughout this document were created using ArcGIS® software by Esri (ArcGIS Pro version 2.9, Esri 2021). ArcGIS® is the intellectual property of Esri and 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, an online interactive tool that allows users to explore results and print data queries. Data tables are also available for download from FIA's Urban DataMart.

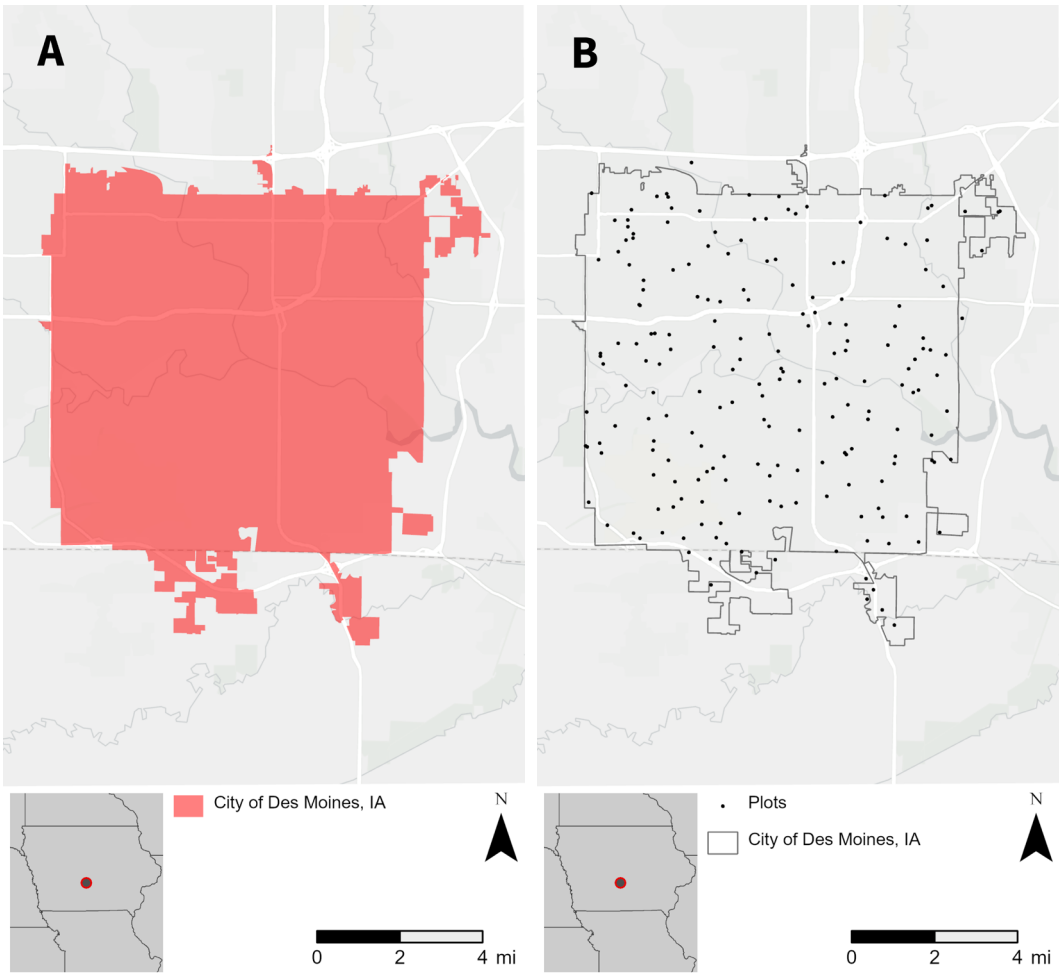

Figure 1.—Study area (A) and approximate plot locations (B) for the Urban Forest Inventory and Analysis (FIA) inventory, Des Moines, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

AREA AND COVER CHARACTERISTICS

Tree lined view of Polk Boulevard. Courtesy photo by Emma Hanigan, Iowa Department of Natural Resources.

In 2010, Iowa had 609,000 acres of urban land that covered 1.7 percent of the state area, and this urban area is projected to increase to 5.0 percent by the year 2060 (Nowak and Greenfield 2018). Des Moines is the largest city in Iowa by population with 203,000 residents and a population density of 2,516 per square mile (US Census 2020).

Land Cover

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

Land cover definitions are based on the 2011 National Land Cover Database (NLCD; Homer et al. 2015) and are described in Appendix 1. The most prevalent land cover classification in Des Moines is developed-low, followed by developed-open, herbaceous/crop, and developed-medium (Table 3). Figure 2 shows the distribution of landcover classes across the city. Areas of forest/shrub land cover are estimated to contain the greatest proportion of trees in the sampling area of any land cover (57.7 percent), followed by developed-low, developed-open and herbaceous/crop land covers (20.3 percent, 10.6 and 6.6 percent of the trees in the sampling area, respectively).

Table 2.—National Land Cover Database (NLCD) land cover class groups and subclasses, Des Moines, Iowa, 2021

NLCD land cover class group	NLCD land cover classes
Developed-high	Developed, High Intensity and Barren Land
Developed-low	Developed, Low Intensity
Developed-medium	Developed, Medium Intensity
Developed-open	Developed, Open Space
Forest/Shrub	Deciduous Forest and Mixed Forest and Woody Wetlands and Evergreen Forest and Shrub/Scrub
Herb/Crop	Pasture/Hay and Cultivated Crops and Grassland/Herbaceous and Emergent Herbaceous Wetlands
Water	Open Water

Source: Homer et al. 2015.

See Appendix 1 for descriptions of the NLCD land cover class groups.

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

NLCD land cover class group	Area (acres)	Land (percent)	Plots (number)
Developed-low	16,841	32	64
Developed-open	10,576	20	44
Herb/Crop	8,332	16	26
Developed-medium	6,596	12	25
Forest/Shrub	5,058	10	16
Developed-high	3,686	7	13
Water	1,773	3	10
Total	**52,862**	**100**	**198**

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

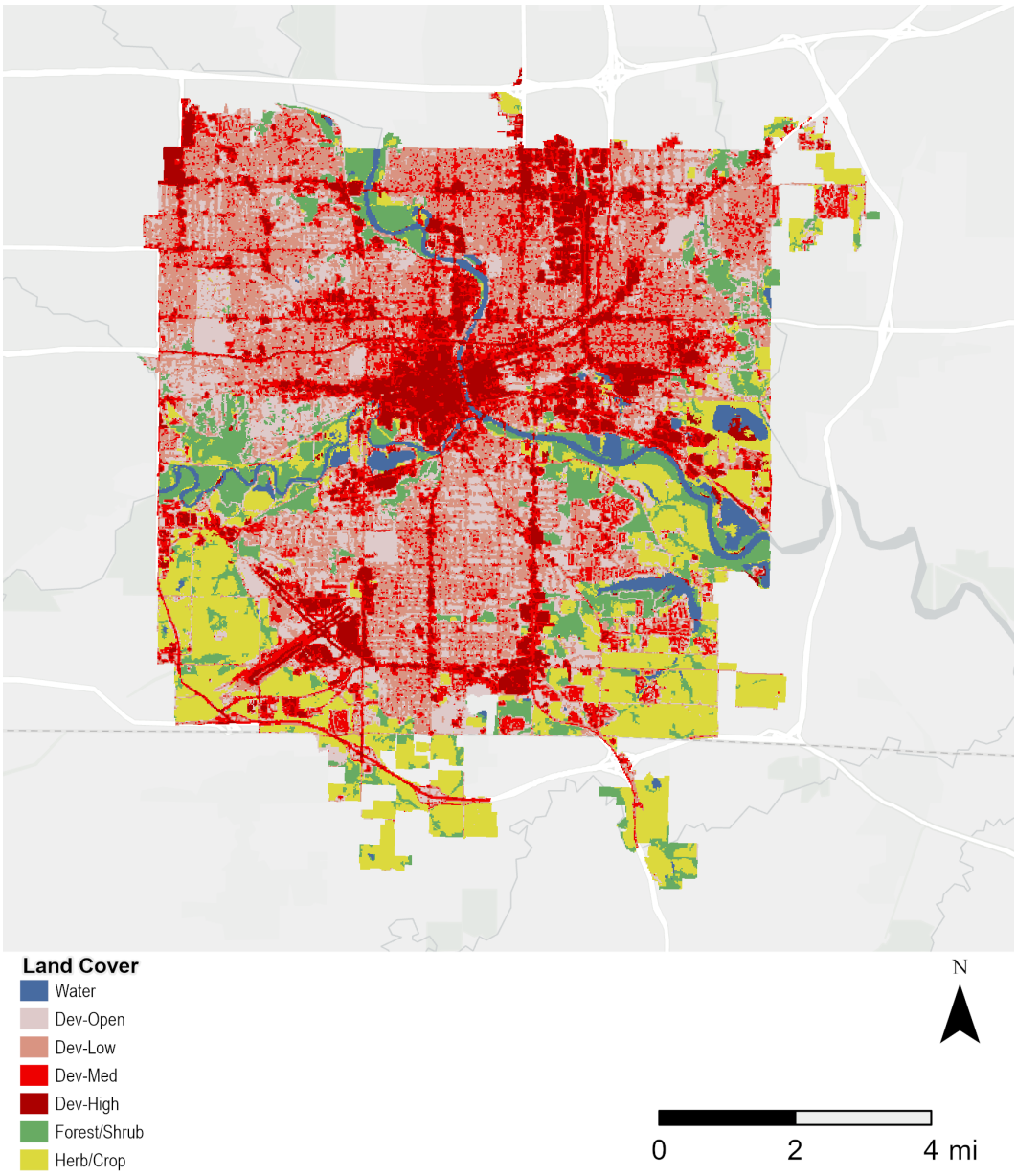

Figure 2.—Distribution of National Land Cover Database (NLCD; Homer et al. 2015) land cover class groups, Des Moines, Iowa, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

FIA Land Use

In addition to categorization according to NLCD land cover class groups, plots were also classified in the field based on FIA land use classes (Table 4). There are often multiple land uses on a single plot. When this occurs, the area of each land use is mapped, and a percent of the total plot area is assigned. These categories provide a specific look at how the land is being used by the local population in Des Moines.

Single-family residential (hereafter, residential) is the most prevalent land use class in Des Moines, covering 28.2 percent of the city area (containing 33.7 percent of the city's trees), followed by **rights-of-way** (17.9 percent of the city area), commercial/industrial (16.5 percent), agriculture (13.4 percent), and forest land (9.7 percent) (Table 5).

Table 4.—Forest Inventory and Analysis (FIA) land use classes and subclasses, Des Moines, Iowa, 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 count of plots within Forest Inventory and Analysis (FIA) land use classes in Des Moines, Iowa, 2021

FIA land use class	Area (acres)	Standard error (acres)	Land (percent)	Plots (number)
Residential	14,906	1,371	28.2	58.1
Rights-of-way	9,456	1,177	17.9	35.4
Commercial/Industrial	8,748	1,168	16.5	32.7
Agriculture	7,079	866	13.4	22.9
Forest land	5,112	827	9.7	17.1
Recreation/Cemetery	3,305	907	6.3	13.3
Water	2,217	404	4.2	11.1
Multi-family residential	1,404	569	2.7	5.4
Natural lands	637	420	1.2	2.0
Total	**52,862**	**492**	**100**	**198**

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

Tree, Shrub, and Ground Cover

Tree cover in Des Moines is estimated at 25.2 percent and shrub cover at 5.8 percent based on the urban forest inventory. Field plot estimates are used to evaluate tree cover and can have a relatively high degree of uncertainty due to the nature of tree cover data collection in the field and effects of sample size. Generally, better tree cover estimates can be derived from photointerpretation or high-resolution tree cover maps. For example, the Urban Forest Master Plan reports a 29 percent canopy cover in 2014 (City of Des Moines 2020).

Overall, tree cover ranges from 0.12 percent to 99 percent on plots where trees are present (Fig. 3a). Shrub cover on plots ranges from 0.39 percent to 85 percent on plots where shrubs are present (Fig. 3b). Average tree cover is highest on forest land (77.6 percent tree cover), residential (37.7 percent), and recreation/cemetery land uses (25.2 percent) (Table 6). Shrub cover is highest on forest land (30.3 percent shrub cover), agriculture (5.7 percent), and recreation/cemetery land uses (3.5 percent). Impervious cover is highest on rights-of-way (52.8 percent impervious cover), commercial/industrial (34.0 percent), and multi-family residential land uses (31.4 percent) (Table 6).

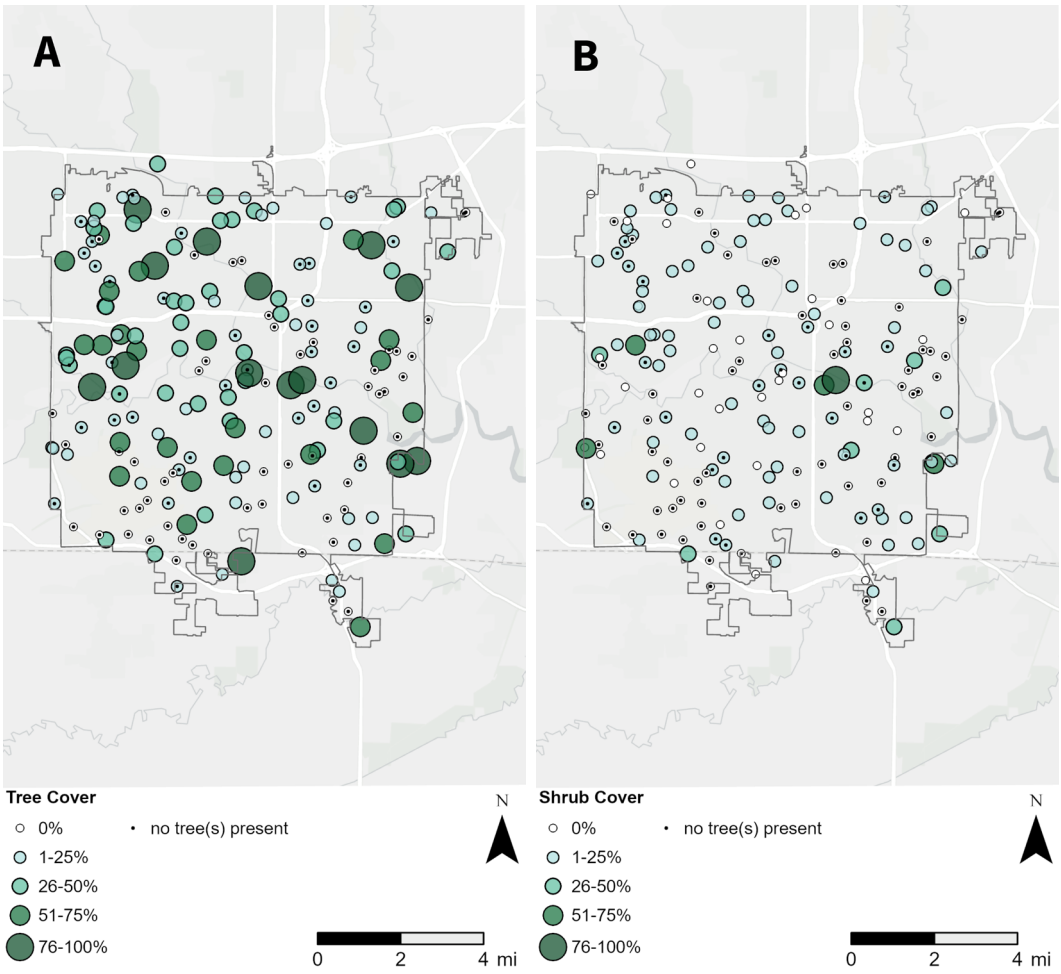

Figure 3.—Tree (A) and shrub (B) cover estimates for each Forest Inventory and Analysis (FIA) plot using approximate plot locations in Des Moines. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Table 6.—Average percent tree, shrub, and impervious cover by Forest Inventory and Analysis (FIA) land use class, Des Moines, Iowa, 2021

FIA land use class	Tree (percent)	Shrub (percent)	Impervious (percent)
Forest land	77.6	30.3	0.0
Agriculture	9.2	5.7	0.0
Commercial/Industrial	11.2	1.9	34.0
Multi-family residential	8.5	3.1	31.4
Residential	37.7	3.4	11.4
Recreation/Cemetery	25.2	3.5	6.9
Rights-of-way	10.4	3.0	52.8
Natural lands	0.5	0.0	0.0
Water	6.9	0.0	0.0
Total average	**25.2**	**5.8**	**19.6**
Total standard error	**6.7**	**0.9**	**1.5**

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 herbaceous ground covers account for 68.0 percent of all ground covers in Des Moines, while building and other impervious cover account for 27.2 percent (Figs. 4 and 5). An additional 4.8 percent of the city is classified as water.

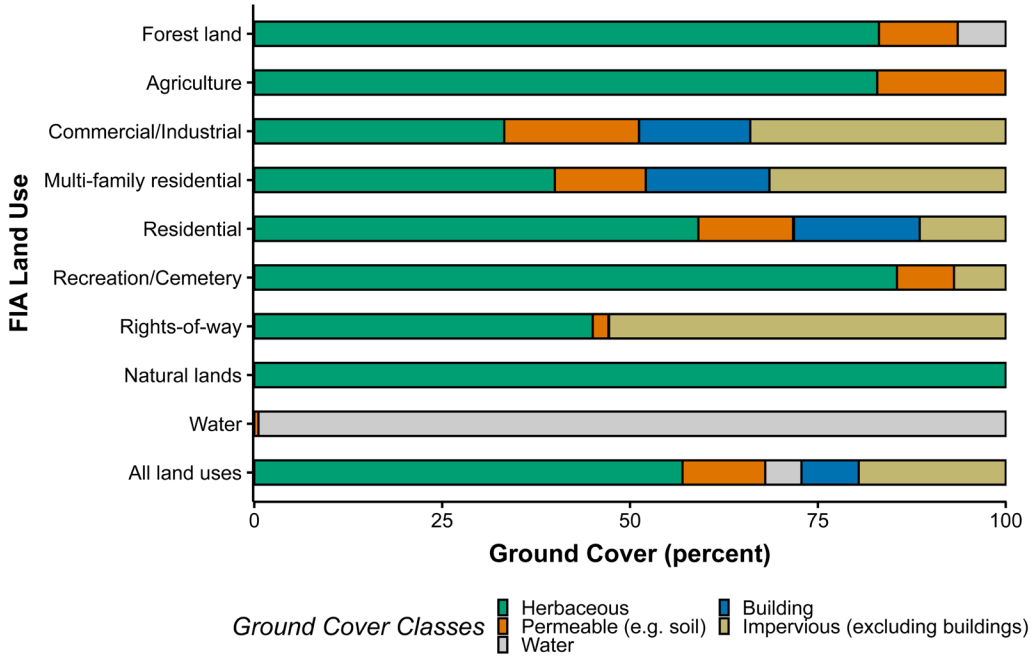

Figure 4.—Ground cover distribution by Forest Inventory and Analysis (FIA) land use class, Des Moines, Iowa, 2021.

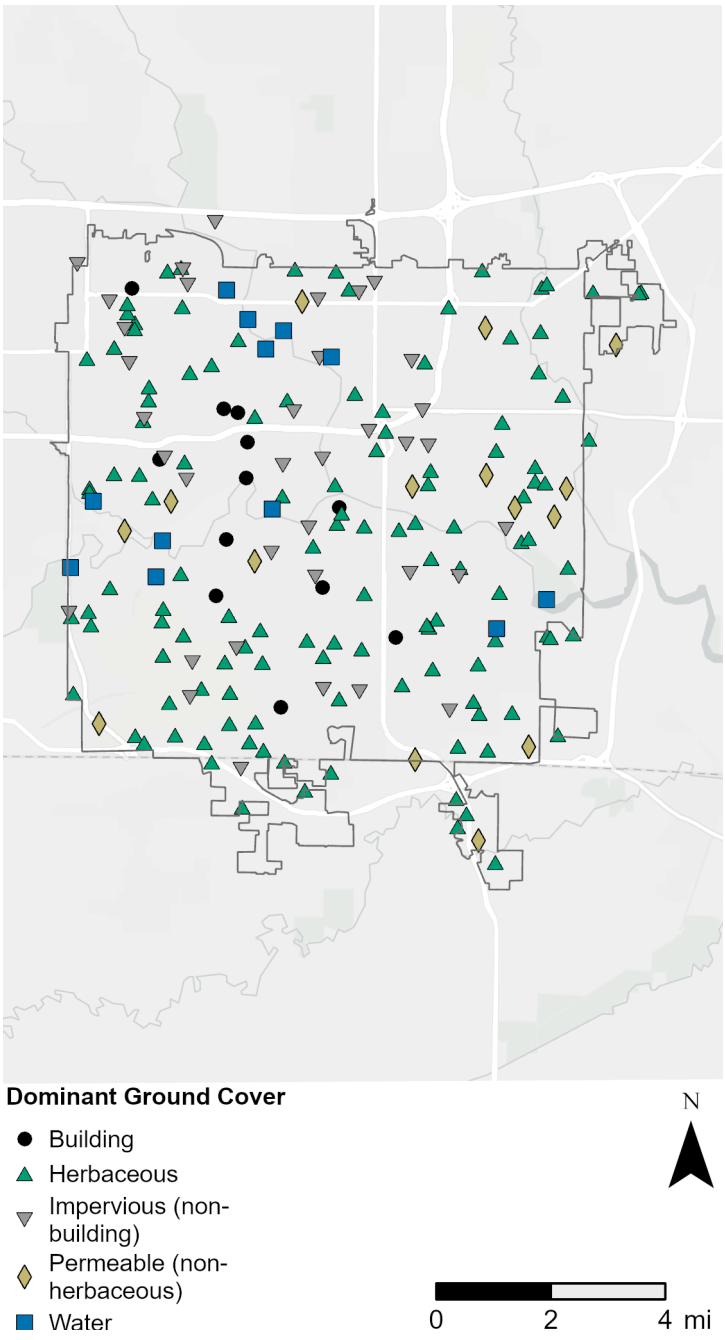

Figure 5.—Dominant ground cover for each Forest Inventory and Analysis (FIA) plotlocations, Des Moines, Iowa, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, ©OpenStreetMap contributors, and the GIS User Community.

Ownership

Plot ownership was divided into private, state and local government, federal government, and unknown (water) classes. The most dominant ownership in Des Moines is private (62.5 percent), followed by state and local (31.6 percent), unknown (water) (4.2 percent) and federal (1.7 percent) (Table 7). Percent tree cover is greatest in federal (57.1 percent), followed by private (27.8 percent), and state and local (20.6 percent). In Des Moines, there are a total of 1.9 million trees (77.7 percent of the live tree population) on private lands, 525,000 trees (21 percent) on state and local land, and 33,000 trees (1.3 percent) on federal lands (Table 7). Des Moines' sapling (trees 1.0–4.9 inches in diameter) population is mostly found on private lands (85.3 percent), followed by state and local lands (14.7 percent) (Table 7).

Table 7.—Number of live trees by ownership and diameter class, Des Moines, Iowa, 2021

Ownership class	1.0–4.9 in. diameter class (number)	5.0–10.9 in. diameter class (number)	11.0+ in. diameter class (number)	Total (number)	Area (acres)
Private	1,170,000	444,000	325,000	1,940,000	33,000
State and Local	202,000	174,000	149,000	525,000	17,000
Federal	0	13,000	20,000	33,000	920
Unknown (water)	0	0	0	0	2,200
Total	**1,370,000**	**631,000**	**494,000**	**2,500,000**	**53,000**

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

FOREST STRUCTURE

Greater Des Moines Botanical Garden as seen from the University Avenue bridge. Courtesy photo by Emma Hanigan, Iowa Department of Natural Resources.

Number of Trees

Des Moines' urban forest has an estimated 2.5 million live trees and 201,000 standing dead trees. The number of trees varies by land use and diameter class. Most of the trees in Des Moines are located on forest land (51.5 percent, 1.3 million trees) (Table 8). Overall, 55.0 percent of Des Moines' trees are saplings, while the remaining 25.3 percent and 19.8 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 (57.7 percent) are found within the forest/shrub land cover class. The highest tree density (285.0 trees per acre) is found on the forest/shrub cover class (Table 9).

Table 8.—Number of live trees by Forest Inventory and Analysis (FIA) land use class and diameter class, Des Moines, Iowa, 2021

FIA land use class	1.0–4.9 in. diameter class (number)	5.0–10.9 in. diameter class (number)	11.0+ in. diameter class (number)	Total (number)	Standard error (number)	Density (no./ac)
Forest land	735,000	344,000	208,000	1,290,000	320,000	252
Agriculture	71,000	66,000	11,000	148,000	100,000	21
Commercial/Industrial	0	29,000	35,000	63,000	19,000	7
Multi-family residential	0	0	1,700	1,700	1,700	1
Residential	507,000	135,000	200,000	842,000	328,000	56
Recreation/Cemetery	60,000	26,000	25,000	110,000	74,000	33
Rights-of-way	0	32,000	15,000	47,000	16,000	5
Natural lands	0	0	0	0	0	0
Water	0	0	0	0	0	0
Total	**1,370,000**	**631,000**	**494,000**	**2,500,000**	**–**	**47**
Total standard error	**377,000**	**84,000**	**52,000**	**420,000**	**–**	**–**

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, Des Moines, Iowa, 2021

NLCD land cover class group	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11.0+ in. diameter trees (number)	Total (number)	Standard error (number)	Density (no./ac)
Water	40,000	9,600	0	49,000	65,000	28
Developed-open	19,000	112,000	134,000	265,000	63,000	25
Developed-low	275,000	100,000	132,000	506,000	228,000	30
Developed-medium	20,000	14,000	11,000	45,000	23,000	7
Developed-high	0	14,000	12,000	26,000	13,000	7
Forest/Shrub	972,000	280,000	190,000	1,440,000	333,000	285
Herb/Crop	48,000	102,000	15,000	166,000	70,000	20
Total	**1,370,000**	**631,000**	**494,000**	**2,500,000**	**–**	**47**
Total standard error	**377,000**	**84,000**	**52,000**	**420,000**	**–**	**–**

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

– = no value for cell

Species Composition

The 10 most common tree species[4] by number account for 70 percent of all recorded live trees and are American elm, green ash, boxelder, white mulberry, hackberry, Siberian elm, red mulberry, silver maple, American basswood, and roughleaf dogwood (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, and are 64.4 percent of the total number of trees, while large diameter trees make up only 14.2 percent of the total number of trees (Table 11, Fig. 7). When broken down into 2-inch diameter classes, the top three most common species by number showed an abundance distribution similarly skewed toward smaller diameter trees (Fig. 8).

Table 10.—Urban forest tree species composition, Des Moines, Iowa, 2021

Common name	Trees (number)	Percent
American elm	309,000	12.4
green ash	288,000	11.5
boxelder	250,000	10.0
white mulberry	173,000	6.9
hackberry	153,000	6.1
Siberian elm	150,000	6.0
red mulberry	149,000	6.0
silver maple	133,000	5.3
American basswood	72,000	2.9
roughleaf dogwood	71,000	2.9
quaking aspen	63,000	2.5
black walnut	62,000	2.5
shagbark hickory	56,000	2.2
black cherry	50,000	2.0
eastern cottonwood	49,000	2.0
honeylocust	47,000	1.9
eastern white pine	43,000	1.7
white fir	36,000	1.4
apple spp.	33,000	1.3
northern catalpa	29,000	1.2
black locust	29,000	1.2
hawthorn spp.	26,000	1.0
northern red oak	25,000	1.0
common buckthorn	19,000	0.8
Amur maple	17,000	0.7
white oak	13,000	0.5
bur oak	13,000	0.5
eastern hemlock	9,100	0.4
black willow	8,500	0.3
eastern redbud	8,300	0.3
blue spruce	7,900	0.3
tree of heaven	7,000	0.3
eastern redcedar	7,000	0.3
river birch	6,800	0.3
littleleaf linden	6,400	0.3
Norway maple	6,100	0.2
bitternut hickory	5,300	0.2
white spruce	5,100	0.2
northern white-cedar	5,100	0.2
Callery pear	5,000	0.2
red maple	5,000	0.2
Freeman maple	4,800	0.2
pear spp.	4,700	0.2
white ash	4,700	0.2
black oak	4,600	0.2
ginkgo, maidenhair tree	3,400	0.1
common pear	3,200	0.1
pin oak	3,000	0.1
persimmon	3,000	0.1
swamp white oak	1,900	0.1
cherry and plum spp.	1,700	0.1
black maple	1,700	0.1
Kentucky coffeetree	1,700	0.1
Japanese flowering crab apple	1,700	0.1
Norway spruce	1,500	0.1
red pine	1,500	0.1
sugar maple	1,500	0.1
American plum	1,500	0.1
slippery elm	1,500	0.1
Total	**2,500,000**	**100.0**

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

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

[4] Common and scientific names for all species observed in the Urban FIA inventory of Des Moines are reported in Appendix 2.

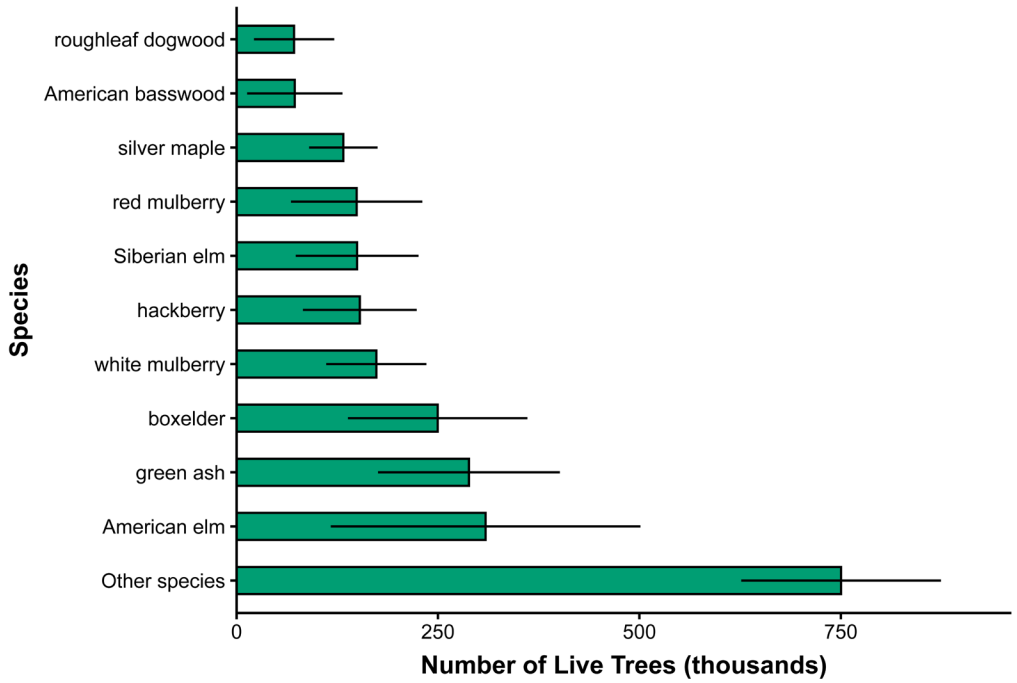

Figure 6.—The 10 most common tree species by number of trees, Des Moines, Iowa, 2021. Other species is the total number of all tree species in the inventory. Error bars represent 68 percent confidence intervals around the estimated means.

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

Common name	1.0–4.9 in. diameter class (number)	5.0–10.9 in. diameter class (number)	11.0+ in. diameter class (number)	Total (number)
American elm	250,000	48,000	11,000	309,000
green ash	227,000	36,000	25,000	288,000
boxelder	190,000	57,000	3,200	250,000
white mulberry	66,000	78,000	29,000	173,000
hackberry	95,000	43,000	15,000	153,000
Siberian elm	63,000	41,000	46,000	150,000
red mulberry	95,000	41,000	14,000	149,000
silver maple	21,000	19,000	92,000	133,000
American basswood	47,000	13,000	12,000	72,000
roughleaf dogwood	71,000	0	0	71,000
Total (number)	**1,130,000**	**375,000**	**248,000**	**1,750,000**

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

Standard errors for each estimate are reported in Appendix 2.

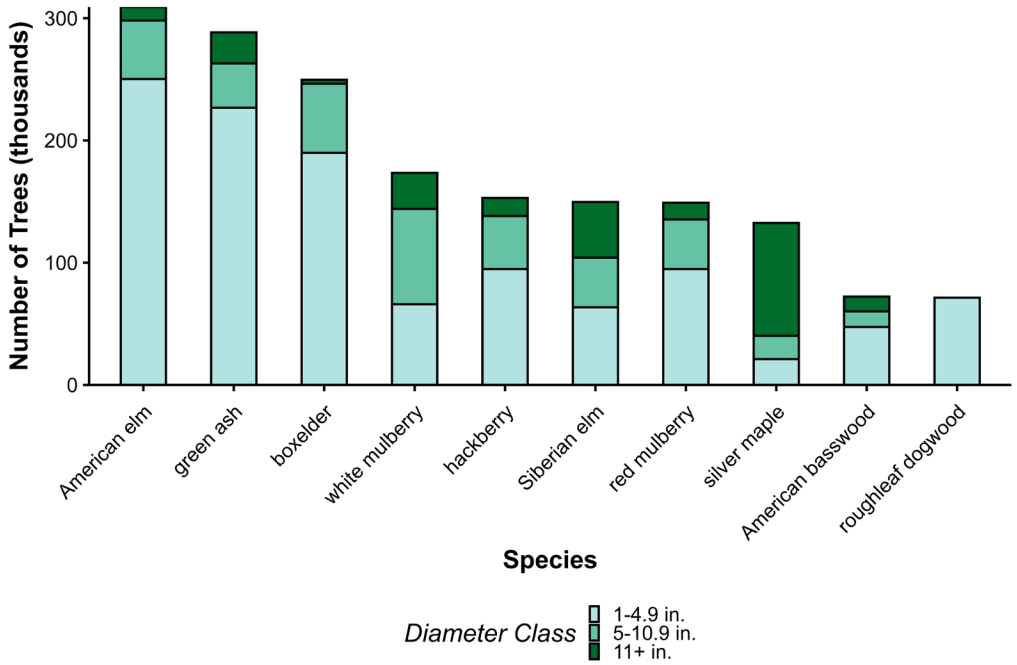

Figure 7.—Number of trees in each size class for the 10 most common tree species, Des Moines, Iowa, 2021.

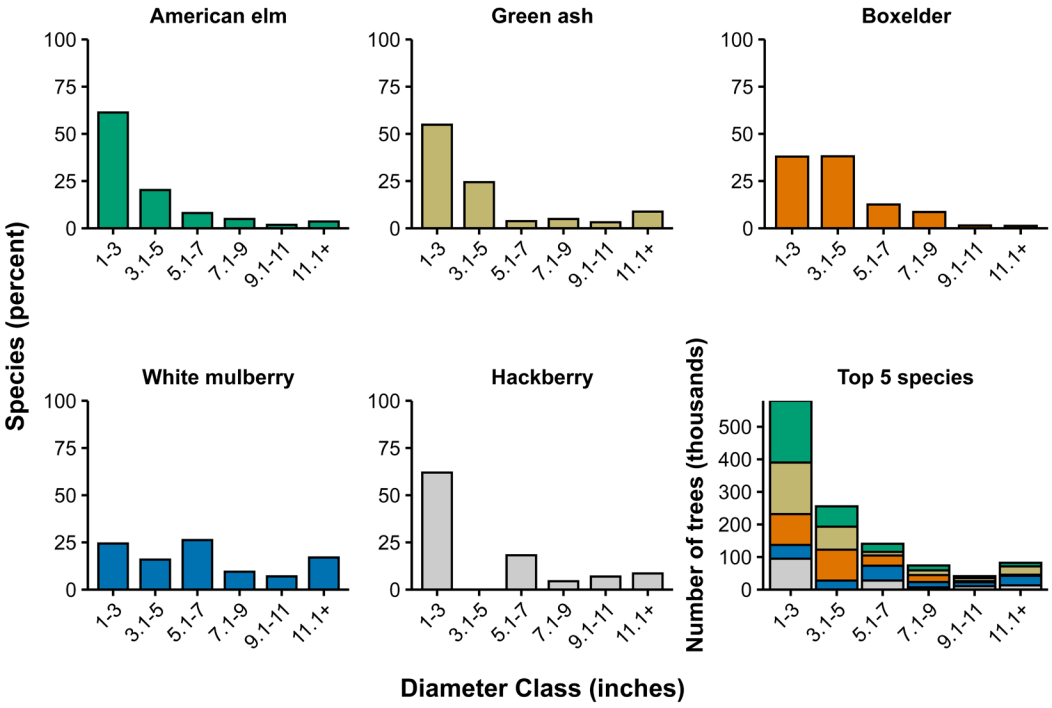

Figure 8.—Percentage of species population by diameter class for the five most common tree species, Des Moines, Iowa, 2021.

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 tree species in terms of stem numbers in the smallest-diameter size classes (less than 5.0 inches in diameter) are American elm, green ash, and boxelder, together representing nearly half (48.6 percent) of all live trees less than 5.0 inches in diameter (Table 12, Appendix 2). White mulberry, boxelder, and American elm are the most common species in intermediate diameter size classes, representing 28.9 percent of all live trees between 5.0 and 10.9 inches in diameter. Dominant species in the largest diameter classes, often the most recognizable component of the urban forest canopy, are silver maple, Siberian elm, and eastern cottonwood, which constitute 35.7 percent of live trees at least 11.0 inches in diameter (Table 12, Appendix 2).

Table 12.—The most common tree species by number of trees within each species by diameter class, Des Moines, Iowa, 2021

Diameter class (inches)	Common name	Trees (number)
1.0–4.9	American elm	250,000
	green ash	227,000
	boxelder	190,000
	hackberry	95,000
	red mulberry	95,000
5.0–10.9	white mulberry	78,000
	boxelder	57,000
	American elm	48,000
	hackberry	43,000
	Siberian elm	41,000
11.0 +	silver maple	92,000
	Siberian elm	46,000
	eastern cottonwood	39,000
	eastern white pine	31,000
	white mulberry	29,000

Estimates are rounded.

Standard errors for each estimate are reported in Appendix 2.

In Des Moines, tree species composition on private land is dominated by American elm (13.3 percent), green ash (12.7 percent), and boxelder (9.4 percent) (Table 13). The most common tree species on public lands are boxelder (12.1 percent), American basswood (11.8 percent), and American elm (9.0 percent) (Table 14). A total of 58 tree species are recorded on private lands, resulting in a **Shannon-Wiener diversity index** value of 3.1. The 23 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 abundance 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 elm (*Ulmus*), maple (*Acer*), and mulberry (*Morus*). On public land they are maple, elm, and basswood (*Tilia*) (Fig. 9). Species composition within NLCD land cover class groups is detailed in Appendix 3.

Table 13.—Species composition on private lands, Des Moines, Iowa, 2021

Common name	Trees (percent)
American elm	13.3
green ash	12.7
boxelder	9.4
red mulberry	7.5
hackberry	7.2
white mulberry	6.5
Siberian elm	5.3
silver maple	4.3
roughleaf dogwood	3.7
quaking aspen	3.3
shagbark hickory	2.9
black cherry	2.1
white fir	1.8
northern catalpa	1.5
black locust	1.5
hawthorn spp.	1.3
honeylocust	1.2
eastern white pine	1.1
black walnut	1.0
apple spp.	1.0
common buckthorn	1.0
northern red oak	0.9
Amur maple	0.9
eastern cottonwood	0.8
bur oak	0.6
eastern hemlock	0.5
white oak	0.5
eastern redbud	0.4
blue spruce	0.4
tree of heaven	0.4
river birch	0.3
American basswood	0.3
Norway maple	0.3
bitternut hickory	0.3
eastern redcedar	0.3
white spruce	0.3
northern white-cedar	0.3
Callery pear	0.3
red maple	0.3
pear spp.	0.2
black oak	0.2
black willow	0.2
common pear	0.2
Freeman maple	0.2
pin oak	0.2
persimmon	0.2
swamp white oak	0.1
cherry and plum spp.	0.1
black maple	0.1
Kentucky coffeetree	0.1
Japanese flowering crab apple	0.1
littleleaf linden	0.1
Norway spruce	0.1
red pine	0.1
sugar maple	0.1
white ash	0.1
American plum	0.1
slippery elm	0.1

Estimates are rounded.

Table 14.—Species composition on public lands, Des Moines, Iowa, 2021

Common name	Trees (percent)	Common name	Trees (percent)
boxelder	12.1	hackberry	2.3
American basswood	11.8	black cherry	1.7
American elm	9.0	northern red oak	1.3
silver maple	8.9	black willow	0.8
white mulberry	8.4	littleleaf linden	0.8
Siberian elm	8.4	white oak	0.6
black walnut	7.6	ginkgo, maidenhair tree	0.6
green ash	7.4	white ash	0.6
eastern cottonwood	6.0	red mulberry	0.5
honeylocust	4.1	eastern redcedar	0.3
eastern white pine	4.1	Freeman maple	0.3
apple spp.	2.4	Estimates are rounded	

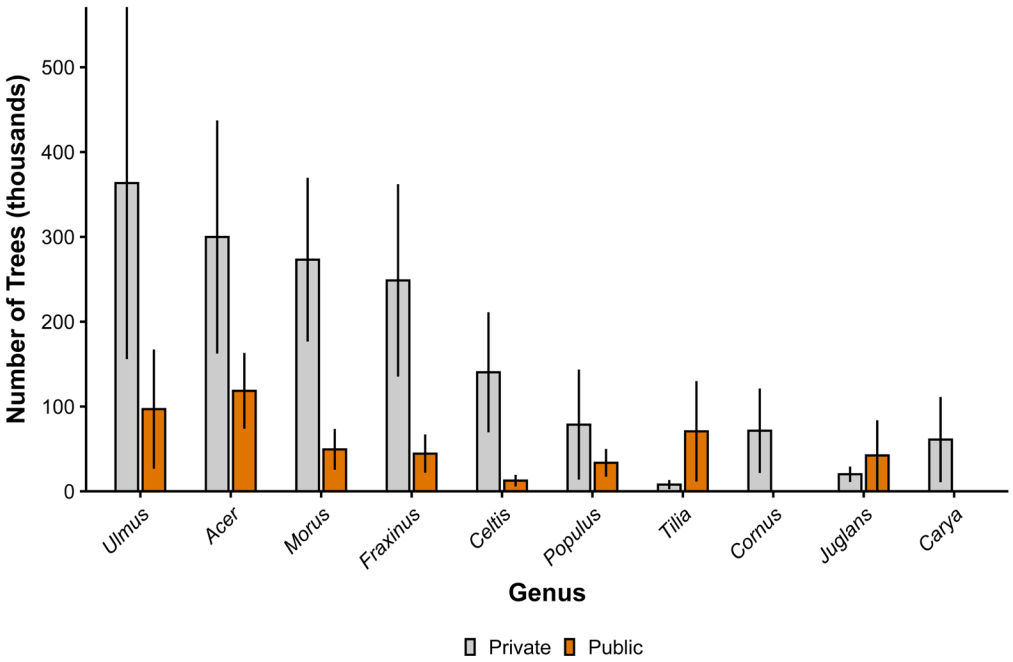

Figure 9.—The 10 most common genera by within ownership classes, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Maintained Area Trees

Overall, 28.6 percent of trees in Des Moines 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 Des Moines, the most common tree species in maintained areas are green ash (15.0 percent of all trees in maintained areas), Siberian elm (12.4 percent), and quaking aspen (8.9 percent) (Table 15, Appendix 4). Green ash and quaking aspen are both native to the State of Iowa while Siberian elm is an introduced species.

Table 15.—The 10 most common trees species in maintained areas, Des Moines, Iowa, 2021

Common name	Trees (number)	Percent of all trees in maintained areas
green ash	107,000	15.0
Siberian elm	89,000	12.4
quaking aspen	63,000	8.9
white mulberry	54,000	7.5
silver maple	53,000	7.4
apple spp.	33,000	4.6
honeylocust	30,000	4.2
hackberry	28,000	3.9
eastern white pine	27,000	3.7
common buckthorn	19,000	2.7

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 (18.6 percent), followed by 13.1-15.0 inches in diameter (7.9 percent), and 15.1–17.0 inches in diameter (7.5 percent) (Fig. 10). In Des Moines, leaf area is greatest in residential land uses (42 percent of total leaf area), followed by forest (41.8 percent), and recreation/cemetery land uses (5.1 percent) (Fig. 11).

Leaf area index (LAI) refers to a standardized measure of leaf surface area per unit of tree cover and is calculated as the total leaf area divided by the total ground area covered by tree canopies. Higher LAI values indicate a greater depth or layering of leaves in the tree canopy. As each land use class has a different amount of area covered by trees, LAI allows for standardized comparison of leaves per unit canopy area among land use classes (acres of leaves per acre of tree cover). The leaf area index in land uses with trees ranges from 12.4 in forest land use to 2.5 in rights-of-way (Fig. 11).

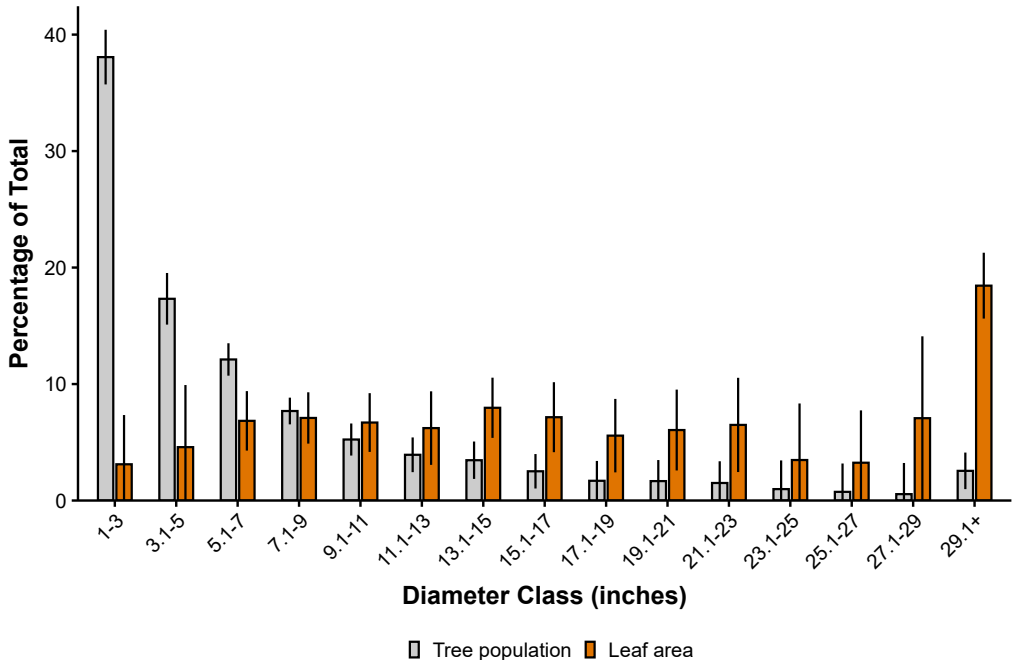

Figure 10.—Percentage of tree population and leaf area by 2-inch diameter class, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

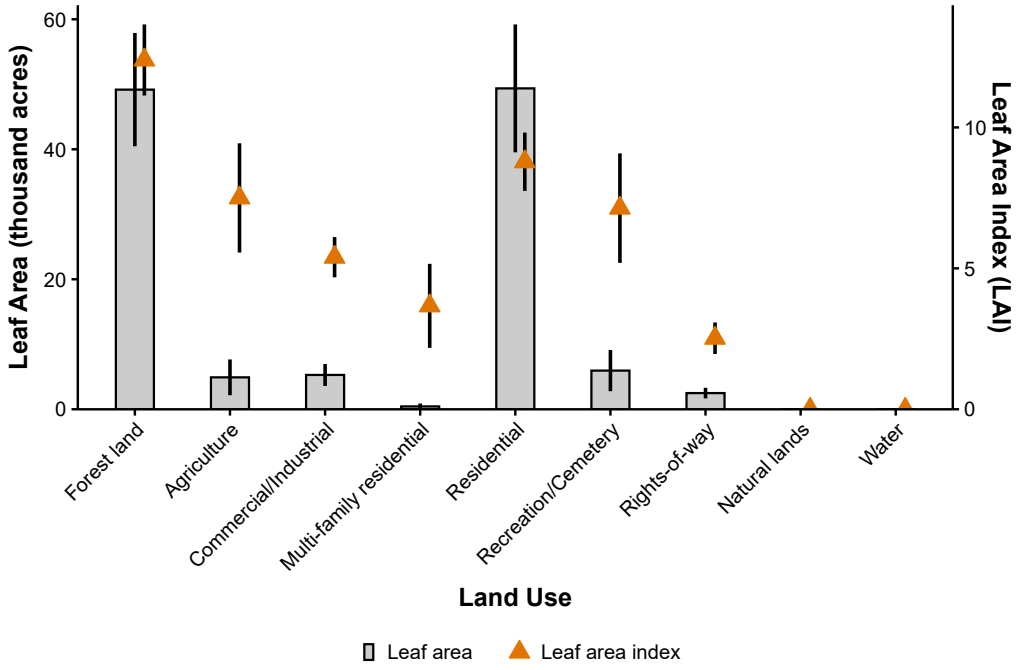

Figure 11.—Leaf area and leaf area index (LAI) by Forest Inventory and Analysis land use class, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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 Des Moines' urban forest with the greatest IVs are silver maple (26.6), green ash (19.5), and American elm (17.0) (Table 16).

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

Common name	Population (percent)	Leaf area (percent)	Importance value
silver maple	5.3	18.3	23.6
green ash	11.5	7.5	19.0
American elm	12.4	4.1	16.5
boxelder	10.0	2.8	12.8
white mulberry	6.9	4.7	11.7
Siberian elm	6.0	5.3	11.3
hackberry	6.1	5.1	11.2
red mulberry	6.0	2.9	8.9
eastern cottonwood	2.0	6.0	8.0
eastern white pine	1.7	6.1	7.9

Estimates are rounded.

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

VOLUME AND BIOMASS

Mature bur oaks in Ewing Park. Courtesy photo by Emma Hanigan, Iowa Department of Natural Resources.

Wood Volume and Value

Wood volume is a measure of the solid content of the tree stem and is used to estimate wood quantity. A detailed description of methods used to compute wood volume in terms of net cubic foot volume and **sawtimber volume** for this report is presented in Baer et al. (2025). Understanding the net volume of wood provided by a community's trees can serve a variety of purposes. From a management perspective, a thorough knowledge of wood volume can help predict potential storm damage and support planning for post-disaster recovery, including debris removal and cost. Volume data can also inform urban wood markets, which add value to traditional wood waste derived from tree removal, storm damage, and general tree maintenance. Such data can incentivize repurposing wood waste into traditional wood products such as lumber, handcrafted furniture, nature-based landscape supplies, and biofuel (e.g., Nowak et al. 2019).

In Des Moines, live trees at least 5.0 inches in diameter are estimated to contain 25.4 million cubic feet of net volume, of which 65.6 million board feet is sawtimber volume. To put this value in perspective, the median size of American homes constructed in 2019 was 2,301 square feet (U.S. Census Bureau 2020), which would require approximately 14,500 board feet to construct. Thus, the net sawtimber volume of Des Moines' urban forest is roughly equivalent to the amount of wood that would be needed to construct 4,526 median-sized homes. Silver maple contributes the greatest net cubic-foot volume at 27.5 percent of the city's total (Table 17). Silver maple contributes 29.7 percent of the total net **board-foot** sawtimber volume (Table 18). Aside from the high-end diameter class which includes all trees 29.1 inches in diameter and greater, the greatest net cubic volume is provided by trees 21.1 to 23 inches in diameter (Fig. 12).

Table 17.—Net cubic-foot volume for tree species with greatest net volume, Des Moines, Iowa, 2021

Common name	Net volume (cubic feet)	Standard error (cubic feet)	Net volume (percent)
eastern cottonwood	2,850,000	1,020,000	11.2
eastern white pine	1,640,000	1,150,000	6.5
bur oak	1,460,000	846,000	5.7
white oak	1,390,000	838,000	5.5
green ash	1,140,000	431,000	4.5
black walnut	1,050,000	547,000	4.1
Siberian elm	1,020,000	560,000	4.0
hackberry	864,000	323,000	3.4
white mulberry	673,000	243,000	2.6
Other species	6,350,000	1,050,000	25.0
Total	**25,430,000**	**2,990,000**	**100.0**

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

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

Table 18.—Net board-foot sawtimber volume for tree species with greatest net volume, Des Moines, Iowa, 2021

Common name	Net volume (board feet)	Standard error (board feet)	Net volume (percent)
silver maple	19,520,000	7,650,000	29.7
eastern cottonwood	11,830,000	4,810,000	18.0
eastern white pine	7,140,000	5,510,000	10.9
bur oak	4,150,000	2,610,000	6.3
white oak	4,130,000	2,840,000	6.3
green ash	3,490,000	2,260,000	5.3
black walnut	3,260,000	1,880,000	5.0
American basswood	2,300,000	1,650,000	3.5
northern red oak	1,270,000	1,060,000	1.9
northern catalpa	1,140,000	1,150,000	1.7
Other species	7,390,000	2,160,000	11.3
Total	**65,630,000**	**11,540,000**	**100.0**

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

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

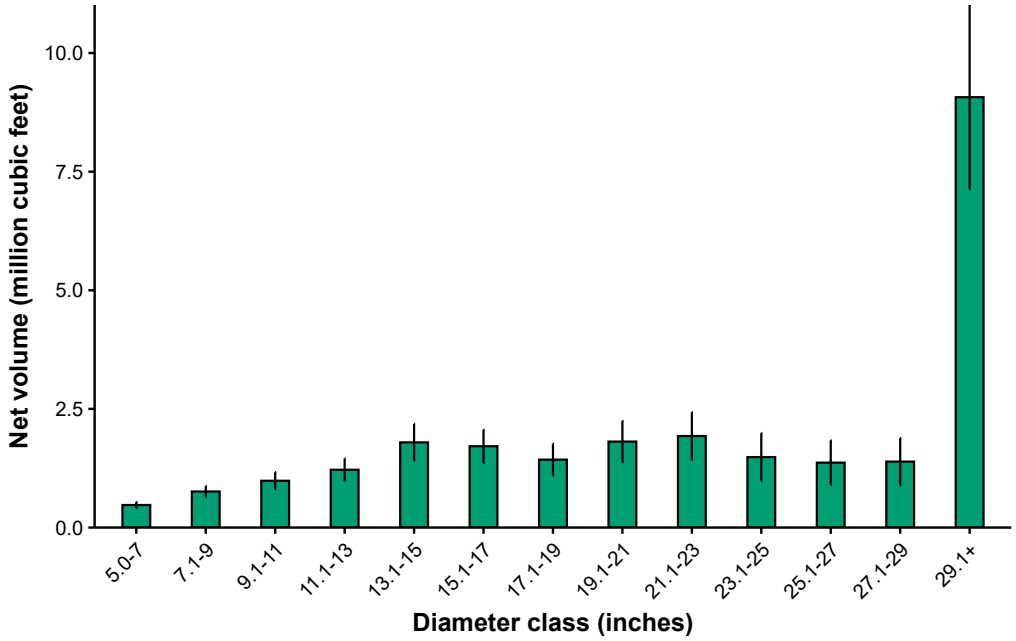

Figure 12.—Net cubic volume by tree diameter class, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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. Further research would allow for the development of metrics to evaluate the amount of urban wood waste available for specialty products. For example, many consumers of urban wood are interested in wood with grain character. Character wood that contains knots, insect damage and distorted grain is often highly desirable for specialty products, but these are the same 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 Des Moines is estimated at 1.5 million green tons, which includes the weight of its moisture content (Table 19). The amount of biomass stored by live trees in Des Moines varies by species. The tree species with the greatest total aboveground biomass are silver maple (29.4 percent), eastern cottonwood (7.3 percent), and white oak (5.5 percent) (Table 19).

Table 19.—Aboveground biomass for tree species with the most biomass, Des Moines, Iowa, 2021

Common name	Biomass (green tons)	Standard error (green tons)	Biomass (percent)
silver maple	436,000	116,000	29.7
eastern cottonwood	108,000	38,000	7.3
white oak	81,000	48,000	5.5
bur oak	76,000	43,000	5.2
hackberry	74,000	29,000	5.0
black walnut	63,000	32,000	4.3
Siberian elm	59,000	30,000	4.0
eastern white pine	58,000	39,000	3.9
green ash	56,000	19,000	3.8
white mulberry	54,000	19,000	3.7
Other species	404,000	64,000	27.5
Total	**1,470,000**	**162,000**	**100.0**

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

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

URBAN FOREST VALUES

Urban forest values can be quantified as functional or structural. Social and biophysical functional values, either positive (e.g., decreased energy use) or negative (e.g., increased energy use) are based on the annual functions the trees perform, including sequestering carbon, removing air pollutants, and influencing surrounding microclimates which affects the amount of energy used to heat or cool buildings. The urban 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 urban 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 based on existing leaf area, leaf biomass, or live tree conditions. However, standing dead trees do contribute to carbon storage and energy effects and are included in estimates for these values.

Air Pollution

Poor air quality is a common problem in urban areas. Air pollution can adversely affect human health through increased rates of pulmonary, cardiac, vascular, and neurological diseases and mortality (Pope et al. 2002), along with negatively impacting ecosystem processes and reducing visibility. Urban forests can improve air quality by directly removing pollutants from the air and reducing energy consumption by buildings, which consequently reduces air pollution emissions from power plants and other energy sources. While trees emit volatile organic compounds (VOCs) that can contribute to ozone (O_3) formation (Fehsenfeld et al. 1992, Karlik and Pittenger 2012), integrative studies have revealed that an increase in tree cover tends to reduce O_3 formation, although the extent to which this is the case depends upon species composition (Calfapietra et al. 2013; Manes et al. 2012; Nowak et al. 2000, 2006).

Pollution removal by the urban forest in Des Moines is greatest for O_3 (313.1 tons per year), followed by nitrogen dioxide (NO_2; 35.3 tons per year), particulate matter less than 2.5 microns ($PM_{2.5}$; 29.0 tons per year), carbon monoxide (CO; 4.0 tons per year), and sulfur dioxide (SO_2; 0.6 tons per year) (Fig. 13). The economic value of this pollution removed is estimated using i-Tree methodology in one of two ways, depending on the pollutant. The NO_2, SO_2, O_3, and $PM_{2.5}$, estimates are based on avoided health effects due to lower pollution concentrations. The CO, estimated value is based on the avoided externality costs of air pollution to society (Nowak 2024). The estimated value associated with pollution removal is greatest for $PM_{2.5}$ ($3.2 million), followed by O_3 ($833,000), NO_2 ($17,000), CO ($5,300), and SO_2 ($100) (Table 20). It is estimated that trees in Des Moines remove a total of 382 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 Des Moines (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 372 fewer cases of acute respiratory symptoms per year with an associated value of over $33,000 (Table 20).

Trees in Des Moines emit an estimated 343 tons of VOCs (119 tons of isoprene and 224 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* and *Populus* contribute 63.5 percent of VOC emissions (Fig. 14). These VOCs are precursor chemicals to ozone formation.

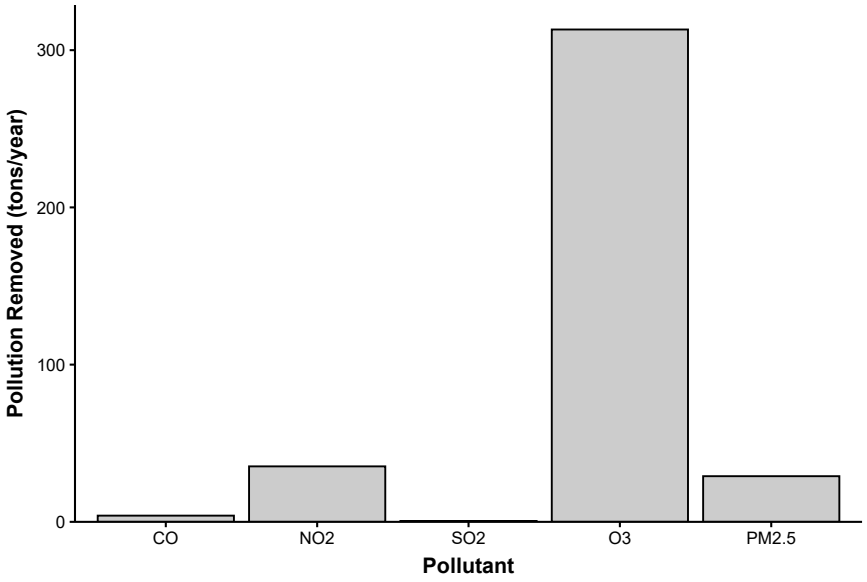

Figure 13.—Air pollution removal by trees, Des Moines, Iowa, 2021.

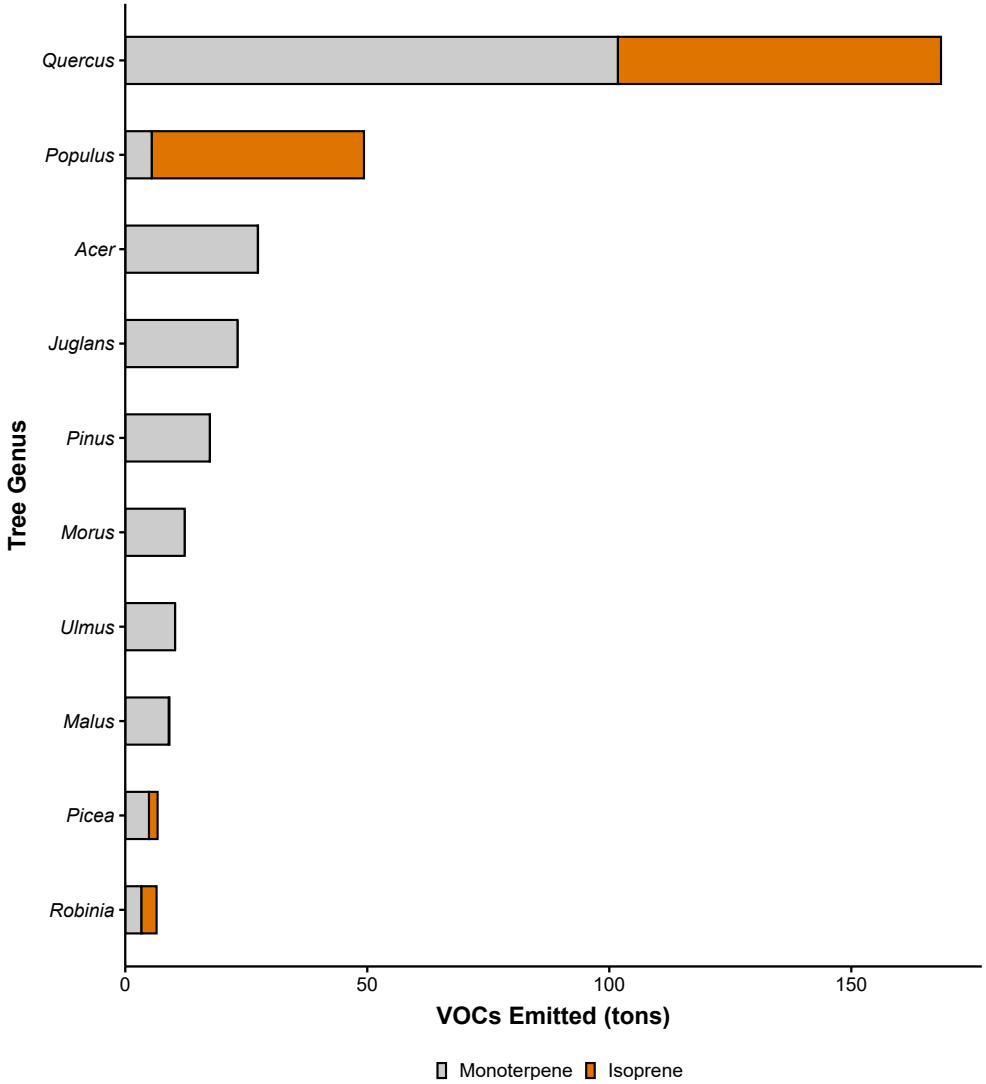

Figure 14.—Volatile organic compound (VOC) emissions by genus, Des Moines, Iowa, 2021.

Table 20.—Incidence and associated value of avoided health effects from changes in pollution concentrations due to pollution removal by trees in Des Moines' urban forest, 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	–	–	–	–	–	–	0.3	24.6
Acute Myocardial Infarction	–	–	–	–	–	–	0.1	8,100
Acute Respiratory Symptoms	7.7	240	<0.1	1.3	210	18,000	150	15,000
Asthma Exacerbation	110	9,400	0.4	30	–	–	120	9,800
Chronic Bronchitis	–	–	–	–	–	–	0.1	34,000
Upper Respiratory Symptoms	–	–	–	–	–	–	2.8	120
Lower Respiratory Symptoms	–	–	–	–	–	–	3.4	180
Mortality	–	–	–	–	0.1	798,000	0.4	3,110,000
Emergency Room Visits	0.1	28.9	<0.1	0.5	0.1	33.5	0.1	56.6
Hospital Admissions	0.2	6,900	<0.1	62.3	0.3	8,700	–	–
Hospital Admissions, Cardiovascular	–	–	–	–	–	–	<0.1	1,800
Hospital Admissions, Respiratory	–	–	–	–	–	–	<0.1	1,400
School Loss Days	–	–	–	–	87	8,500	–	–
Work Loss Days	–	–	–	–	–	–	25.9	4,300
Total	**120**	**17,000**	**0.4**	**93.9**	**300**	**833,000**	**300**	**3,180,000**

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 trees in Des Moines are estimated to reduce runoff by 41 million cubic feet per year (305 million gallons annually), with an estimated value of $3 million/year based on a national average cost of stormwater control and treatment of $0.008936/gallon (Baer et al. 2025). Tree species with the greatest overall impact on runoff are silver maple, green ash, and hackberry due to their large leaf surface area (Fig. 15).

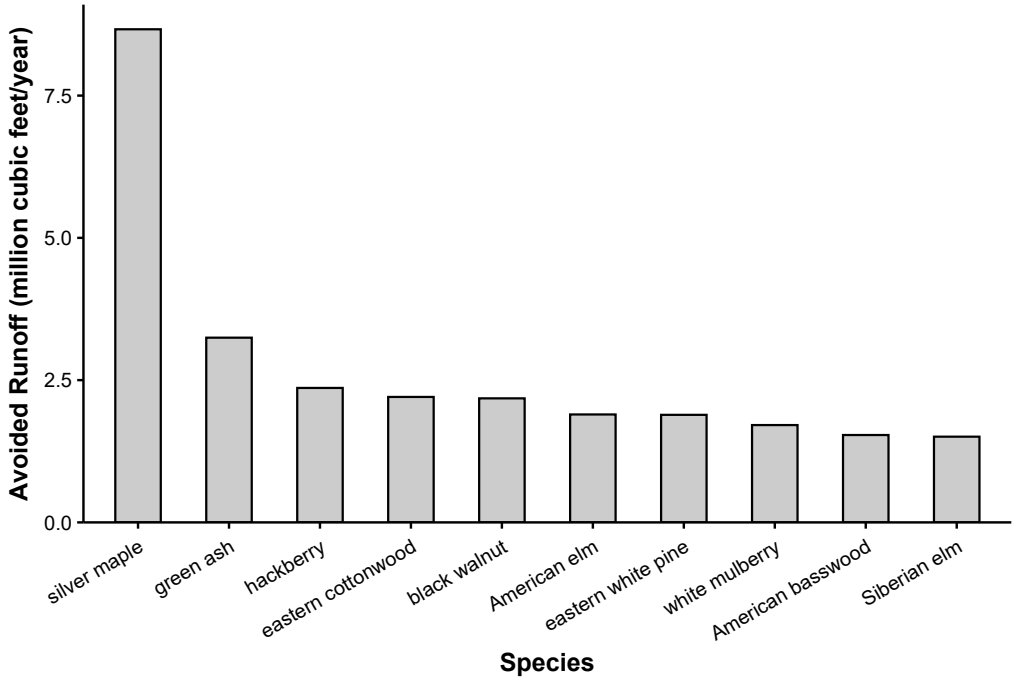

Figure 15.—Avoided runoff for tree species with the greatest leaf area, Des Moines, Iowa, 2021.

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. 2008a; Nowak 2024; U.S. EIA 2012a, b; U.S. EIA 2014a, b, c).

In Des Moines, interactions between buildings and trees 5.0 inches in diameter and greater are projected to annually increase energy requirements by 12,000 gigajoules (GJ) during the heating and cooling seasons (an energy equivalent of 76,000 gallons of home heating fuel oil) (Table 21), with an annual savings in energy costs of $825,000 (Table 22). Savings in residential energy costs were calculated based on state average 2012 costs for natural gas (U.S. EIA 2014b), 2012/2013 heating season fuel oil costs (U.S. EIA 2012a, b), and 2012 costs of wood (U.S. EIA 2014a). Trees in the urban forest also are estimated to reduce carbon dioxide (CO2) emissions from fossil-fuel-based power sources by 7,700 tons annually (2,100 tons of carbon; $573,000), equivalent to the burning of over 5.4 million pounds of coal or roughly 16,247 barrels of oil (Hong and Slatick 1994, U.S. EPA 2020). More information about value calculations can be found in Baer et al. 2025.

Table 21.—Annual energy savings due to trees 5.0+ inches in diameter near residential buildings during heating and cooling seasons, Des Moines, Iowa, 2021

Reduced energy use and emissions	Cooling	Heating	Total
Carbon avoided (tons)	3,500	-1,400	2,100
Energy savings (GJ)	36,000	-48,000	-12,000

Estimates are rounded.

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 trees 5.0+ inches in diameter near residential buildings during heating and cooling seasons, Des Moines, Iowa, 2021

Reduced energy use and emissions	Cooling ($)	Heating ($)	Total ($)
Carbon avoided	960,000	-387,000	573,000
Energy effects	1,280,000	-455,000	825,000

Estimates are rounded.

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 biomass in a tree is carbon (Westfall et al. 2024).

Carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose or are consumed in a fire event. Although tree maintenance practices (e.g., pruning) can contribute to carbon emissions, maintaining healthy trees helps to retain carbon stored in trees (Nowak et al. 2002b). Using removed trees for wood products is one way to help forestall carbon emissions related to wood decomposition. Wood from removed trees can also be used to produce energy (e.g., heat or cool buildings), helping to reduce fossil-fuel based carbon emissions. Trees in Des Moines store an estimated 466,000 tons of carbon (1.7 million tons of CO_2) valued at $79.5 million (Table 23). Tree carbon values are based on the 2015 estimated social costs of carbon which is $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 tree species that store the most carbon are silver maple, eastern cottonwood, and white oak (Fig. 17).

Table 23.—Aboveground and belowground carbon in live and standing dead trees by Forest Inventory and Analysis (FIA) land use class, Des Moines, Iowa, 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	199,000	26,000	880	226,000	41,000
Forest land	142,000	22,000	2,400	167,000	34,000
Recreation/Cemetery	26,000	4,300	0	30,000	17,000
Commercial/Industrial	16,000	2,300	270	18,000	7,800
Rights-of-way	11,000	1,200	0	12,000	6,400
Agriculture	6,800	1,100	1,400	9,400	5,600
Multi-family residential	3,300	520	0	3,800	3,900
Total	**403,000**	**58,000**	**5,000**	**466,000**	**–**
Standard Error	**46,000**	**6,200**	**1,300**	**52,000**	**–**

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

- = no value for cell.

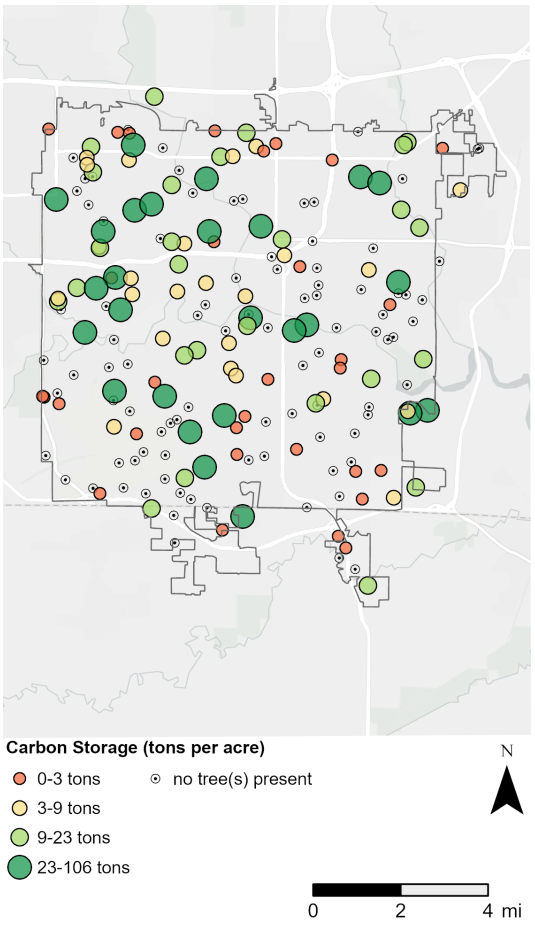

Figure 16.—Carbon storage per acre is shown for each Forest Inventory and Analysius (FIA) plot using approximate plot locations, Des Moines, Iowa, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

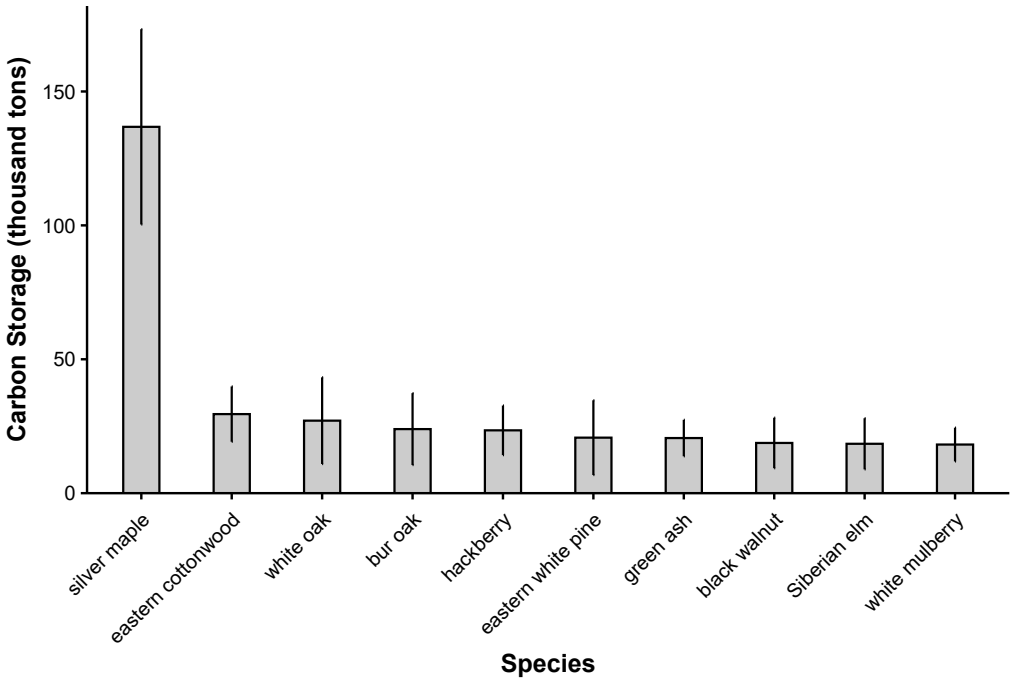

Figure 17.—Live and dead carbon storage for 10 tree species with the greatest carbon storage, Des Moines, Iowa 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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 Des Moines is about 12,000 tons of carbon per year (44,000 tons per year of CO_2) with an associated value of $2.1 million per year, which is roughly equivalent to the annual emissions associated with 8,700 passenger vehicles or energy usage by 4,800 homes (U.S. EPA 2020). Silver maple is estimated to sequester the most carbon of all species in the urban forest (23 percent of all sequestered carbon) (Fig. 20).

Estimates of carbon storage and sequestration in developed and undeveloped land uses, along with evaluations of tree growth, removals, and mortality by ownership, can aid in assessing impacts of proposed land use changes and in developing climate change strategies and targets.

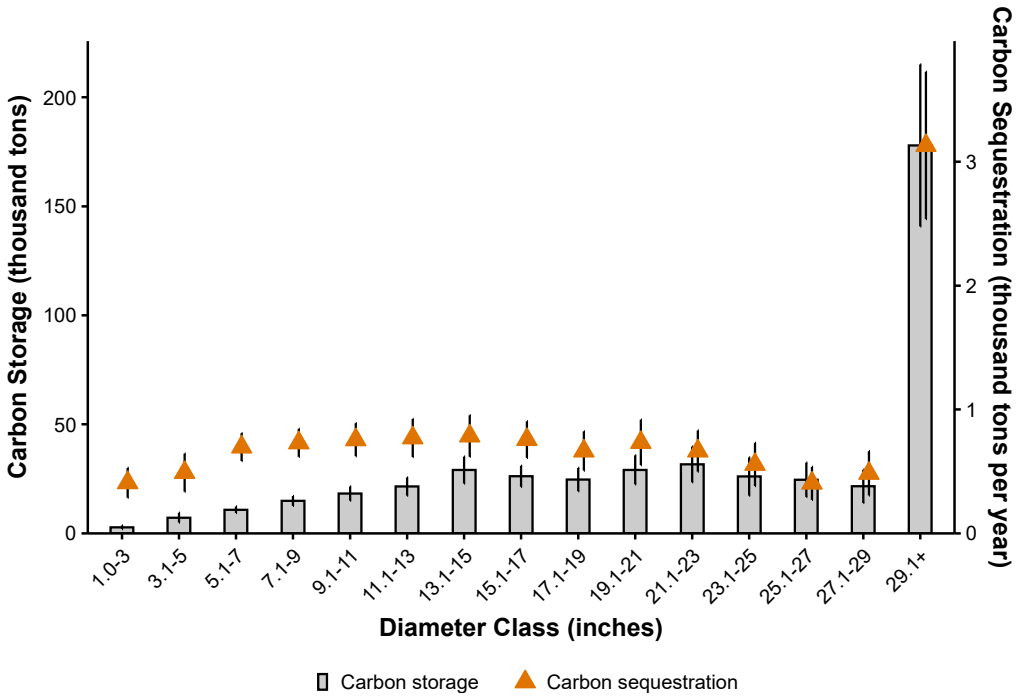

Figure 18.—Total live and dead carbon storage and sequestration by diameter class, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

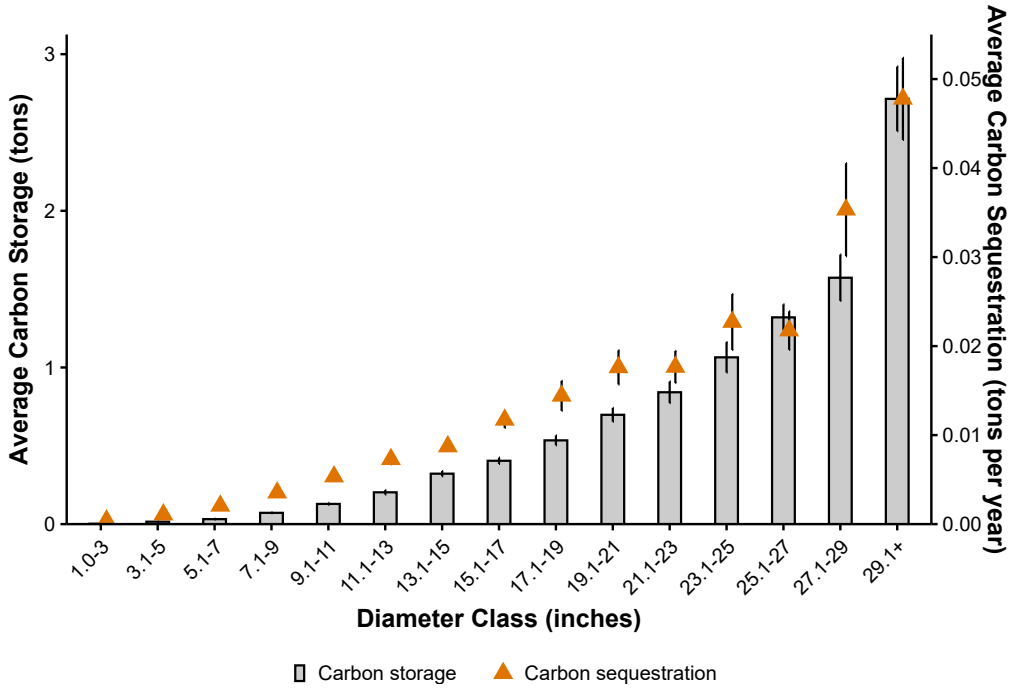

Figure 19.—Average per tree live and dead carbon storage and sequestration by diameter class, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

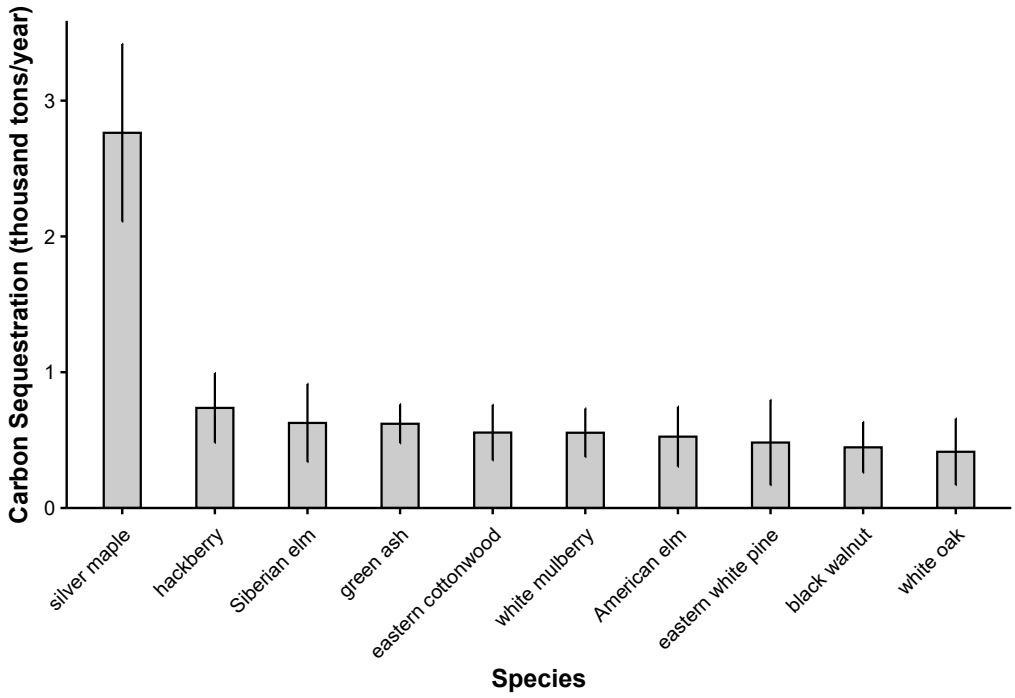

Figure 20.—Carbon sequestration for the 10 tree species with the greatest annul carbon sequestration, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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, non-native, or invasive. Additionally, invasive species can still contribute some ecosystem services. The compensatory value of the trees in Des Moines is estimated to be about $1.33 billion. This compensatory value is a function of the number, health, diameter, and species of all trees measured, as well as the land use in which they were encountered. The species with the largest compensatory values in Des Moines are eastern white pine, green ash, and white oak (Fig. 21). The mean compensatory value per acre for all surveyed plots in Des Moines is $25,000; for the 54.0 percent of these plots that contain trees, the mean compensatory value per acre is $46,000 (Fig. 22). However, compensatory value per acre is estimated to exceed $58,000 for 27 plots in which the average tree diameter is 15.8 inches. The structural value of urban trees in Des Moines is a combination of their compensatory value (estimated at $1.3 billion) and the value associated with carbon storage by the trees (estimated at $79.5 million).

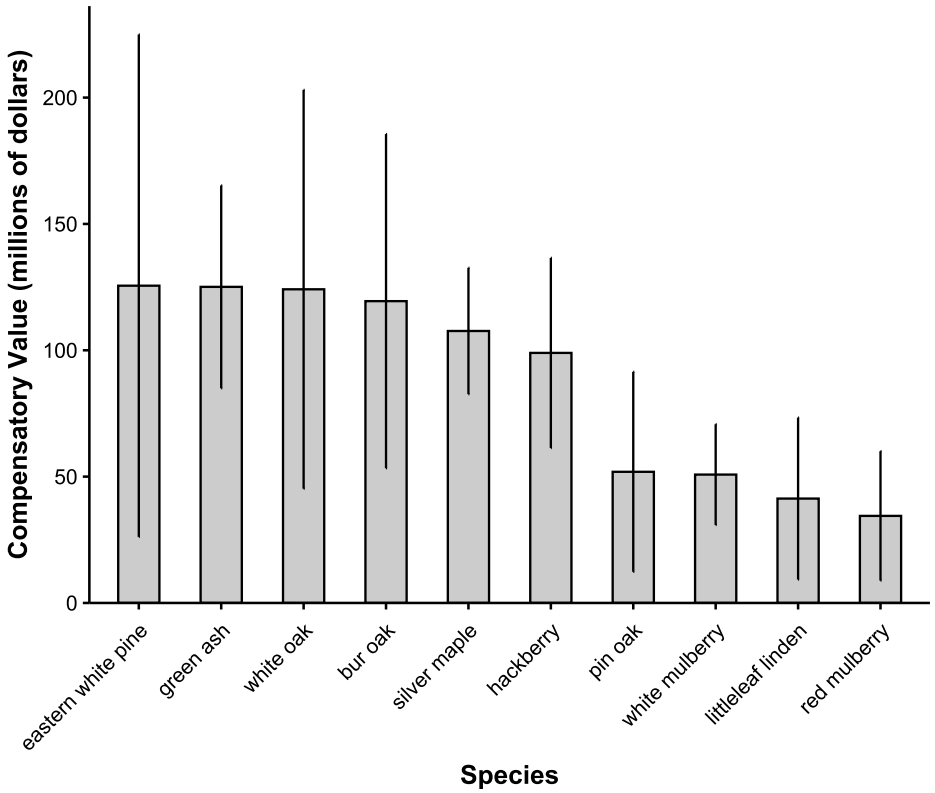

Figure 21.—The compensatory value for 10 of the highest value tree species, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

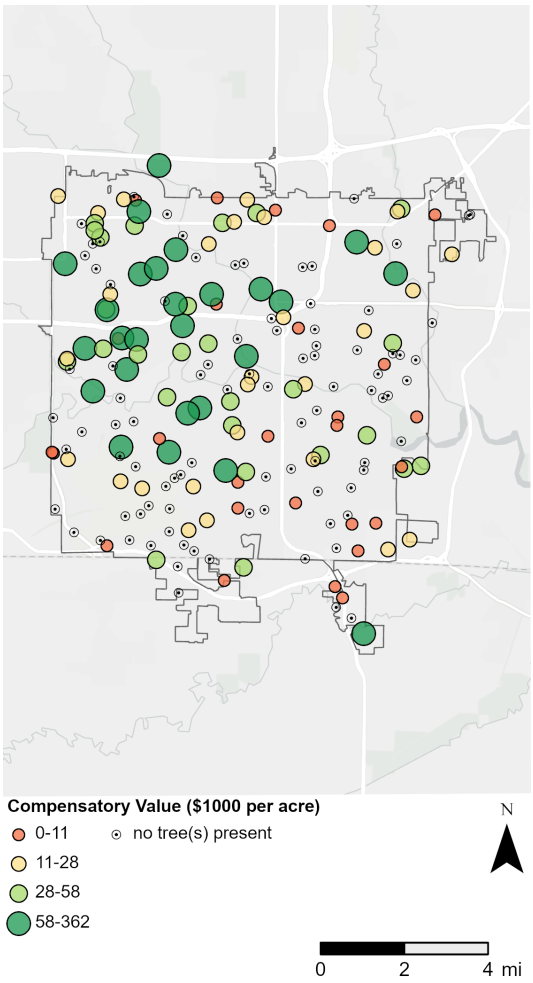

Figure 22.—Compensatory value per acre is shown for each Forest Inventory and Analysis (FIA) plot, using approximate plot locations, Des Moines, Iowa, 2021. The Light Gray Canvas basemap layer was provided by Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

URBAN FOREST HEALTH

Silver maple with large hollow cavity. Courtesy photo by Emma Hanigan, Iowa Department of Natural Resources.

A healthy urban forest provides greater benefits to society than an unhealthy one. This section highlights crown dieback, tree damages and rot, the number of standing dead trees, and the presence and prevalence of invasive plant species as indicators of urban forest health in Des Moines. 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, boxelder has the highest average dieback (15.2 percent) (Table 24). Approximately 12.3 percent of white mulberry displays greater than 25 percent crown dieback, indicating that this species may be threatened by insect, disease, or environmental stressors in Des Moines.

Table 24.—Tree species with the greatest average dieback, Des Moines, Iowa, 2021

Common name	Average dieback (percent)	Standard error (percent)	Trees with more than 25% dieback (percent)
boxelder	15.2	8.4	11.4
white mulberry	13.2	7.2	12.3
Siberian elm	5.3	2.8	3.6
apple spp.	5.3	2.3	4.4
American elm	5.2	0.7	2.7
eastern cottonwood	4.7	2.6	4.1
red mulberry	4.3	0.9	2.1
silver maple	3.1	1.6	0.8
American basswood	2.9	0.3	2.6
black locust	2.5	0.0	0.0
Amur maple	2.4	1.1	0.0
eastern white pine	1.7	1.5	0.0
green ash	1.3	0.8	0.4
black cherry	0.9	0.7	0.0
hackberry	0.4	0.2	0.0
northern red oak	0.4	0.3	0.0
honeylocust	0.3	0.3	0.0
black walnut	0.2	0.2	0.0
white fir	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 potentially hazardous trees in urban areas. The percent of the main stem that is **rotten or cull** between 1 foot above the ground and approximately 4.0-inch top diameter outside of bark was recorded for all trees at least 5.0 inches in diameter. Of species with a minimum sample size of 10 trees, the species with the highest average rotten/cull amounts are Amur maple and white mulberry (Table 25).

Table 25.—Tree species with the greatest average rot, Des Moines, Iowa, 2021

Common name	Average rot (percent)	Standard error (percent)	Trees with more than 15% rot (percent)
Amur maple	10.3	4.6	8.9
white mulberry	8.6	4.3	5.2
apple spp.	3.7	1.5	1.9
Siberian elm	3.5	3.1	1.9
red mulberry	2.7	0.7	0.4
boxelder	2.7	0.6	0.3
hackberry	2.7	1.8	0.9
silver maple	1.7	0.5	0.2
green ash	1.2	0.5	0.1
black locust	0.9	–	0.0
American basswood	0.9	0.3	0.0
eastern cottonwood	0.6	0.3	0.0
northern red oak	0.4	0.3	0.0
black cherry	0.1	0.1	0.0
American elm	0.1	0.1	0.0
black walnut	0.1	0.1	0.0
honeylocust	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 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 3 damage agents were recorded per tree; each recorded agent was required to meet a minimum severity threshold (e.g., 20 percent of the foliage affected). If more than 3 damage agents were observed on a tree, the top 3 were prioritized according to their ability to: (1) prevent the tree from surviving more than 1 to 2 years, (2) reduce the tree's growth in the near term, and (3) negatively affect a tree's marketable wood products. The full list of potential damage agents is presented in the Urban FIA NRS Field Guide Version 7.1 (USDA Forest Service 2017). Stem decay and imbedded objects are the most common causes of damage, affecting 13.6 and 7.8 percent of trees, respectively (Table 26).

Table 26.—Percentage of trees with observed damage, Des Moines, Iowa, 2021

Damage type	Trees (percent)
Cankers	0.4
Chemical	1.1
Decline complexes/dieback/wilts	0.8
Defoliators	0.1
Dutch elm disease	0.2
Foliage diseases	0.1
General diseases	0.1
General insects	3.1
Human activities	2.8
Imbedded objects	7.8
Lightning	0.2
Parasitic/epiphytic plants	1.0
Shoot borer	1.2
Stem decay	13.6
Stem rusts	0.4
Vine damage	4.8
Wild animals	1.0
Wind	2.9
Other damages and symptoms	
Broken top	0.4
Dead top	5.8
Dieback	3.8
Other damages and symptoms	4.0

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 16.2 percent of trees. Conflict with crown and topping/pruning are the second and third most common urban specific infrastructure issues, occurring in 3.7 and 0.9 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 Des Moines, bark inclusion occurs in 44.6 percent of trees on commercial/industrial land, bark inclusion in 29.8 percent of trees on rights-of-way land, and conflict with crown in 28.1 percent of trees on rights-of-way land.

Of those 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. (65.2 percent affected by bark inclusion) and Amur maple (50.0 percent affected by topping/pruning) (Table 27).

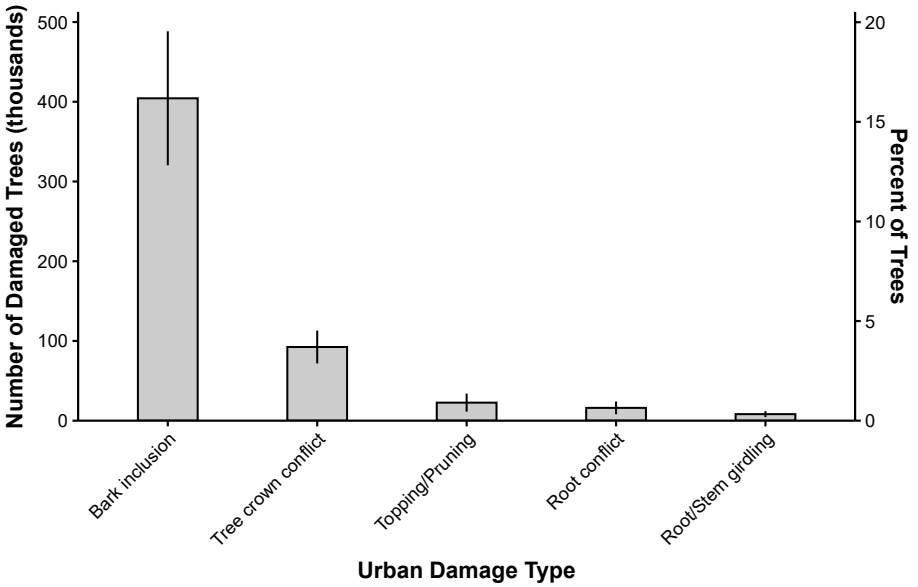

Figure 23.—Number and percent of trees by urban infrastructure issue category, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Table 27.—Number of host trees potentially at risk from various damage, maintenance, and site issues, Des Moines, Iowa, 2021

Common name	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	72,200	59,200	0.0	0.0	4.7	0.0	0.0	0.0	0.0
American elm	309,100	192,200	0.0	0.0	4.9	0.0	0.0	0.0	0.0
Amur maple	17,100	12,600	0.0	10.0	0.0	50.0	0.0	0.0	0.0
apple spp.	33,200	13,700	0.0	5.1	65.2	0.0	0.0	45.3	0.0
black cherry	49,800	24,400	0.0	0.0	15.5	0.0	0.0	0.0	0.0
black locust	28,900	26,800	0.0	0.0	46.7	0.0	0.0	0.0	0.0
black walnut	62,400	42,300	0.0	0.0	1.7	0.0	0.0	2.7	0.0
boxelder	249,600	111,400	0.0	0.0	14.2	0.7	0.0	0.6	0.0
eastern cottonwood	48,800	18,200	0.0	0.0	11.7	0.0	15.9	0.0	0.0
eastern white pine	43,300	27,100	0.0	0.0	10.5	0.0	0.0	19.1	0.0
green ash	288,400	112,800	0.0	0.6	2.3	0.5	0.5	2.8	0.0
hackberry	153,000	70,600	0.0	1.0	8.8	0.0	1.1	2.1	0.0
honeylocust	47,000	24,600	0.0	0.0	3.6	0.0	0.0	0.0	0.0
northern red oak	25,400	13,300	0.0	0.0	6.7	0.0	0.0	26.7	0.0
red mulberry	149,100	81,500	0.0	0.0	28.2	1.1	0.0	4.5	0.0
Siberian elm	149,700	76,200	0.0	0.0	33.1	4.1	0.0	1.1	0.0
silver maple	132,600	42,500	0.0	0.0	34.4	0.0	1.3	6.2	0.0
white fir	35,900	38,200	0.0	0.0	0.0	0.0	0.0	0.0	0.0
white mulberry	173,500	62,100	0.0	0.0	49.0	0.0	0.0	1.0	0.0

Estimates are rounded.

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

Standing Dead

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

Standing dead trees are found on 18 plots in Des Moines. Of the total live and dead tree population, 7.4 percent are estimated to be standing dead trees. The tree species with the highest percentage of standing dead trees are northern red oak, roughleaf dogwood, and tree of heaven (Table 28). The species representing the largest proportion of the dead tree population is American elm (Table 29). Land uses with the highest estimated number of standing dead trees are forest land, residential, and agriculture (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, Des Moines, Iowa, 2021

Common name	Standing dead trees (number)	Standard error (number)	Percent of species
northern red oak	26,000	22,000	50.2
roughleaf dogwood	47,000	45,000	39.9
tree of heaven	3,000	3,200	30.2
eastern redcedar	1,700	1,700	19.5
black cherry	11,000	9,100	18.1
eastern redbud	1,700	1,700	16.9
American elm	63,000	44,000	16.8
black locust	3,900	3,600	11.8
apple spp.	3,000	3,200	8.4
silver maple	7,600	4,900	5.4
boxelder	13,000	9,400	5.1
Siberian elm	7,600	5,500	4.8
honeylocust	1,900	1,800	3.9
white mulberry	6,800	4,100	3.8
eastern cottonwood	1,900	1,800	3.8
green ash	1,700	1,700	0.6
Total	**201,000**	**66,000**	**7.4**

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

Table 29.—Proportion of the total population of trees that are dead by species, Des Moines, Iowa, 2021

Common name	Standing dead trees (percent)
American elm	31.2
roughleaf dogwood	23.6
northern red oak	12.7
boxelder	6.6
black cherry	5.5
silver maple	3.8
Siberian elm	3.8
white mulberry	3.4
black locust	1.9
tree of heaven	1.5
apple spp.	1.5
honeylocust	0.9
eastern cottonwood	0.9
green ash	0.8
eastern redcedar	0.8
eastern redbud	0.8
Total	**100.0**

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

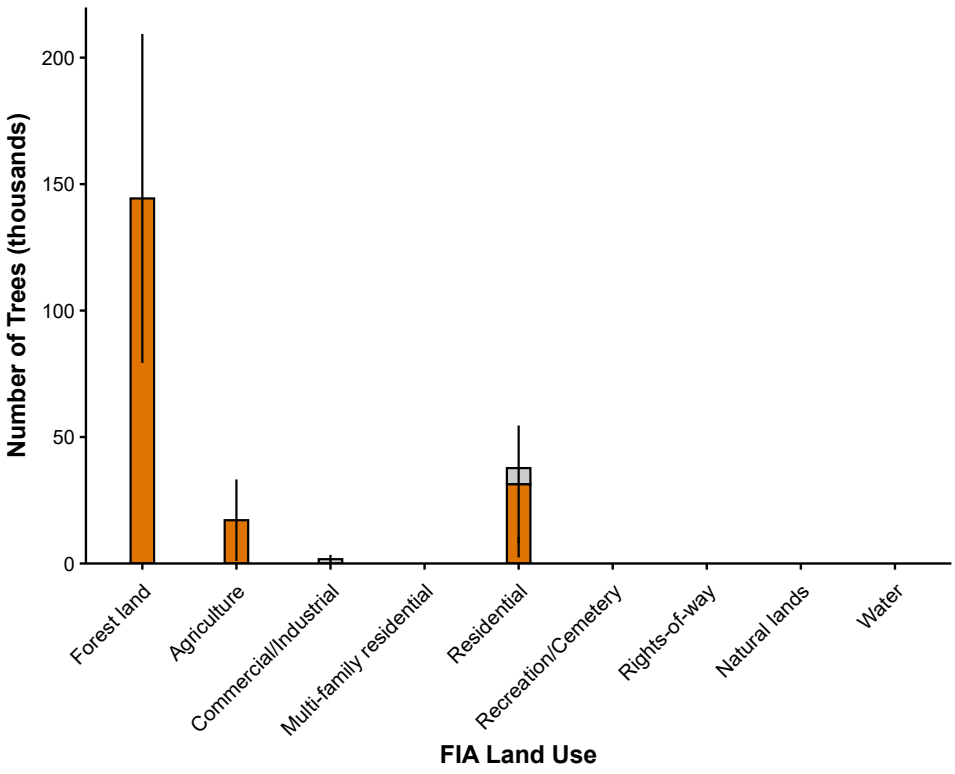

Figure 24.—Proportion of standing dead trees by Forest Inventory and Analysis (FIA) land use class and maintenance status, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

Invasive Plant Species

Invasive plant species are often noted for their vigor, ability to adapt to novel environments, high reproduction capacity, and lack of natural enemies. These factors may enable them to displace native plants and threaten natural areas (Davis 2009; Simberloff 2013). Important considerations for invasive plant control efforts include weighing short- and long-term trade-offs in terms of ecosystem services provided or disrupted by invasive species. The removal of invasive species and loss of ecosystem services they provide may lead to a subsequent need to increase the abundance of desirable species to offset these losses. Field crews in Des Moines examined each plot for the presence of select invasive species based on the species list shown in Appendix 5. Of the 198 plots examined, invasive species were identified on 48.0 percent (95 plots).

Invasive species found in Des Moines 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, Siberian elm (622 acres; 1.2 percent of the sampling area), garlic mustard (474 acres; 0.9 percent of the sampling area), and Amur honeysuckle (372 acres; 0.7 percent of the sampling area) cover the largest area. Of particular concern is the potential for these and other invasive species to spread beyond their current distribution into the surrounding landscape, potentially displacing native species and altering local ecosystems (Pimentel et al. 2000).

Additional measurements are recorded in the field for most tree species. As some of the species on the invasive plants list for Des Moines are classified as trees, data on individual trees were collected in addition to descriptions of species cover on the plot. In Des Moines, tree data were collected for Norway maple, Siberian elm, black locust, common buckthorn, and tree of heaven. Taken together, these invasive trees are estimated to account for 8.4 percent of all live trees surveyed (estimated total trees: 211,000), and 6.0 percent of the total leaf area.

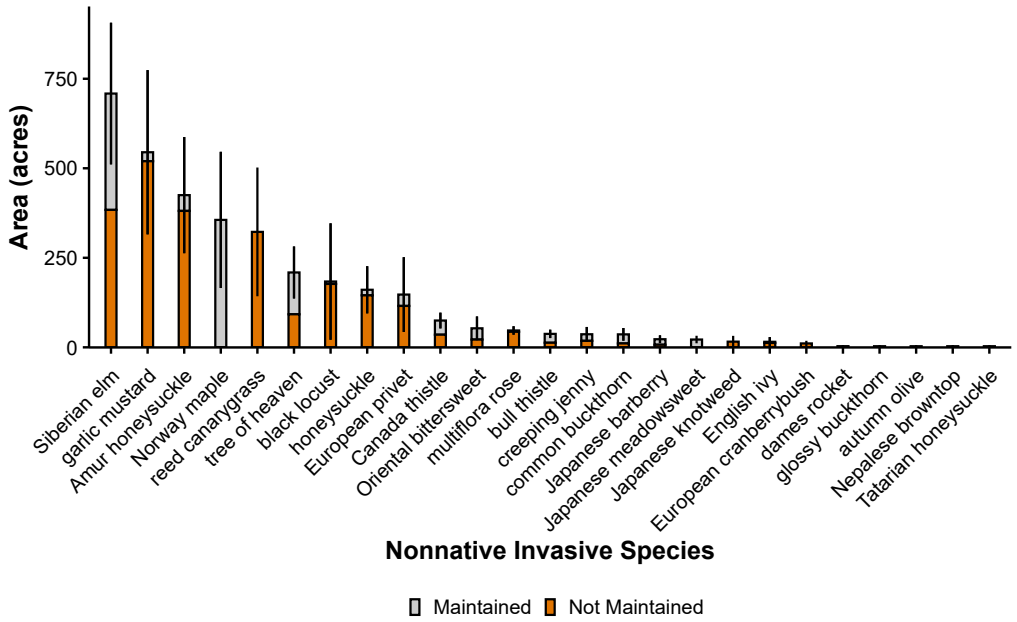

Figure 25.—Area of non-native invasive plant species cover by species on maintained and unmaintained land, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

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, along with their tree hosts in Des Moines, 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 and/or infection. As FIA crews did not attribute tree damage or mortality to specific pests or pathogens, it was not possible to identify what portion of each host tree's population was directly at risk from or affected by the focal pests and pathogens. Pest range maps (USDA Forest Service 2023; Nowak 2024) were used to determine the proximity of each pest to the area. For Des Moines, proximity was classified for insects and diseases in Polk and Warren counties; within 250 miles of these counties; between 250 and 750 miles of the counties; or greater than 750 miles away. Since there are no range maps for Dutch elm disease and chestnut blight, the ranges of these pathogens 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 Polk and Warren counties, 3 points if occurs within 250 miles of the counties, 2 points if it occurs within 750 miles of the counties, and 1 point if it is not present within 750 miles of the counties. 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 Des Moines, but are not listed in this matrix, are not known to be hosts to any of the 53 insects and diseases evaluated. Appendix 6 also excludes the pests and diseases that were not a threat to any of the tree species sampled.

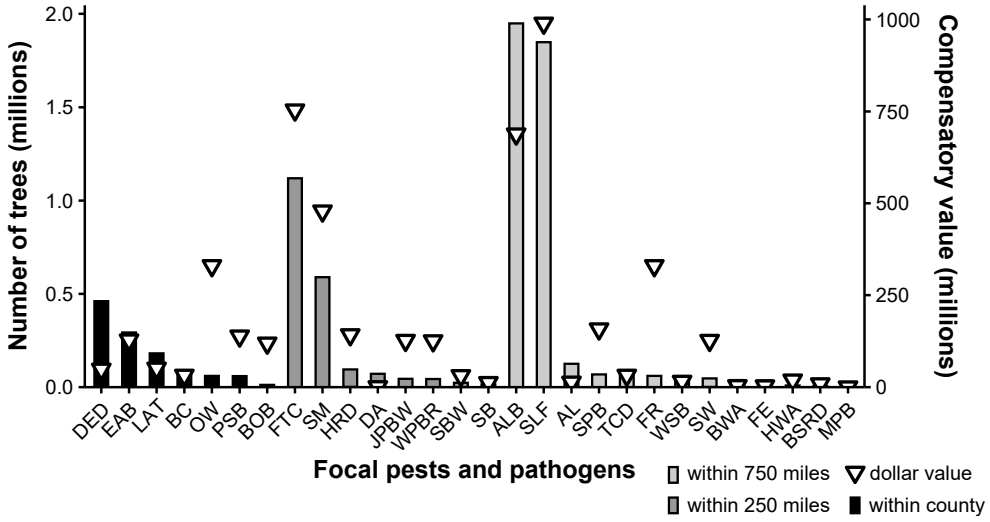

Figure 26.—Number of trees at risk due to pests and pathogens and their associated compensatory values. Pest abbreviations are presented in Table 30.

Table 30.—Potential risk associated with various insects and diseases, Des Moines, Iowa, 2021

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value ($)
within county	DED	Dutch Elm Disease	*Ophiostoma ulmi*	460,304	18.4	48,552,204
	EAB	Emerald Ash Borer	*Agrilus planipennis*	293,102	11.7	127,780,026
	LAT	Large Aspen Tortrix	*Choristoneura conflictana*	180,532	7.2	51,337,099
	BC	Butternut Canker	*Ophiognomonia clavigignenti-juglandacearum*	62,403	2.5	32,144,417
	OW	Oak Wilt	*Bretziella fagacearum*	60,093	2.4	330,230,926
	PSB	Pine Shoot Beetle	*Tomicus piniperda*	59,321	2.4	139,011,070
	BOB	Bur Oak Blight	*Tubakia iowensis*	12,506	0.5	119,442,376
within 250 miles	FTC	Forest Tent Caterpillar	*Malacosoma disstria*	1,118,976	44.8	753,690,771
	SM	Spongy Moth	*Lymantria dispar*	589,338	23.6	478,664,974
	HRD	Heterobasidion Root Disease	*Heterobasidion annosum*	94,260	3.8	142,276,551
	DA	Dogwood Anthracnose	*Discula destructiva*	71,422	2.9	902,929
	JPBW	Jack Pine Budworm	*Choristoneura pinus*	44,787	1.8	126,765,032
	WPBR	White Pine Blister Rust	*Cronartium ribicola*	43,266	1.7	125,557,885
	SBW	Spruce Budworm	*Choristoneura freemani*	23,661	0.9	31,184,841
	SB	Spruce Beetle	*Dendroctonus rufipennis*	14,534	0.6	12,246,038
within 750 miles	ALB	Asian Longhorned Beetle	*Anoplophora glabripennis*	1,949,527	78.0	688,158,546
	SLF	Spotted Lanternfly	*Lycorma delicatula*	1,848,550	74.0	989,600,386
	AL	Aspen Leafminer	*Phyllocnistis populiella*	124,994	5.0	13,377,410
	SPB	Southern Pine Beetle	*Dendroctonus frontalis*	68,448	2.7	157,949,873
	TCD	Thousand Canker Disease	*Geosmithia morbida*	62,403	2.5	32,144,417
	FR	Fusiform Rust	*Cronartium quercuum* f. sp. *fusiforme*	60,093	2.4	330,230,926
	WSB	Western Spruce Budworm	*Choristoneura occidentalis*	50,417	2.0	15,460,545
	SW	Sirex Wood Wasp	*Sirex noctilio*	46,309	1.9	127,045,068
	BWA	Balsam Woolly Adelgid	*Adelges piceae*	37,405	1.5	3,494,543
	FE	Fir Engraver	*Scolytus ventralis*	35,883	1.4	3,214,507
	HWA	Hemlock Woolly Adelgid	*Adelges tsugae*	9,127	0.4	18,938,803
	BSRD	Black Stain Root Disease	*Leptographium wageneri*	5,070	0.2	9,021,425
	MPB	Mountain Pine Beetle	*Dendroctonus ponderosae*	1,521	0.1	280,036
farther than 750 miles	WM	Winter Moth	*Operophtera brumata*	1,461,034	58.5	740,498,622
	PSHB	Polyphagous Shot Hole Borer	*Euwallacea fornicatus*	1,088,728	43.6	503,130,115

Continued on next page

Table 30. (continued)—Potential risk associated with various insects and diseases, Des Moines, Iowa, 2021

Proximity (miles)	Abbreviation	Common name	Scientific name	Trees at risk (number)	Proportion of all trees (percent)	Compensatory value ($)
	BM	Browntail Moth	*Euproctis chrysorrhoea*	1,048,070	41.9	608,290,977
	MOB	Mediterranean Oak Borer	*Xyleborus monographus*	478,381	19.1	512,804,323
	ARCA	Aspen Running Canker	*Neodothiora populina*	63,450	2.5	1,447,133
	WBBU	Western Blackheaded Budworm	*Acleris gloverana*	50,417	2.0	15,460,545
	SOD	Sudden Oak Death	*Phytophthora ramorum*	28,401	1.1	77,771,415
	NSE	Northern Spruce Engraver	*Ips perturbatus*	5,070	0.2	9,021,425
	POCRD	Port-Orford-Cedar Root Disease	*Phytophthora lateralis*	5,070	0.2	2,398,176
	RPS	Red Pine Scale	*Matsucoccus matsumarae*	1,521	0.1	1,207,147
within county	ARD	Armillaria Root Disease	*Armillaria* spp.	0	–	–
within 250 miles	BBD	Beech Bark Disease	*Cryptococcus fagisuga/Neonectria* spp. complex	0	–	–
within 750 miles	BLD	Beech Leaf Disease	*Litylenchus crenatae* ssp. *mccannii*	0	–	–
	CB	Chestnut Blight	*Cryphonectria parasitica*	0	–	–
	DBSR	Douglas-fir Black Stain Root Disease	*Leptographium wageneri* var. *pseudotsugae*	0	–	–
	DFB	Douglas-Fir Beetle	*Dendroctonus pseudotsugae*	0	–	–
	LWD	Laurel Wilt	*Raffaelea lauricola*	0	–	–
	SFM	Subalpine Fir Mortality	NA – multiple pests	0	–	–
	WBB	Western Balsam Bark Beetle	*Dryocoetes confusus*	0	–	–
	WFNPM	Western Five-Needle Pine Mortality	NA – multiple pests	0	–	–
	WPB	Western Pine Beetle	*Dendroctonus brevicomis*	0	–	–
farther than 750 miles	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*	0	–	–

Estimates are rounded.

– = no value for cell

MANAGEMENT IMPLICATIONS

Sculpture and trees at Cowles Commons. Courtesy photo by Emma Hanigan, Iowa Department of Natural Resources.

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

Energy Conservation

The presence of trees and their orientation in relation to residential buildings can have a large impact on the amount of energy savings they provide. On hot days, trees can lower localized temperatures through evaporative cooling, and a tree on the sunny side of a house can provide shade, thereby reducing the energy necessary to cool the home. In the winter, trees can reduce the amount of energy needed to heat homes by blocking cold winds. Alternatively, conifer trees (which do not lose their leaves in the winter) on the south and southwest side of houses may also increase heating requirements in the winter by shading homes from warming sun.

In Des Moines, trees are estimated to cause an overall increase in the amount of energy used annually. Although Des Moines' trees provide significant energy savings by reducing cooling needed during the summer months, this is currently outweighed during winter months by other, less strategically placed trees, which cause increased energy requirements to heat homes. However, Des Moines' trees do still have a positive impact on overall energy costs, saving homeowners an estimated $825,000 annually. This savings is due to the higher cost of the electricity used for summer cooling relative to the cost of fuels typically used for winter heating.

Current building energy use models take only residential buildings into account, and further research would allow a deeper understanding of the impacts on commercial or other building types. Educate residents was listed as a recommendation in both the Urban Heat Island and Trees and Energy Use and Trees sections of the Urban Forest Master Plan (City of Des Moines 2020). Providing information to homeowners about the impact of various tree species and planting locations on energy requirements and costs can help inform their decisions about planting and removing trees on their own property.

Invasive Trees

Each plot is assessed for the presence and cover of 40 invasive plant species (39 species and one undifferentiated genus) (Appendix 5). While this list was developed at the regional level it is by no means comprehensive. For many states there are non-native species that are widely considered invasive or have invasive tendencies but are not on the list currently. However, some of these species are inventoried tree species and we can use those data to infer something about their presence/absence.

White mulberry was introduced from China during colonial times and has since become naturalized throughout much of the eastern United States. It commonly invades disturbed areas such as old fields, forest edges, and urban lots and therefore has the potential to displace native tree and shrub species (USDA 2023). White mulberry is the fourth most common tree in Des Moines by number with a population of 173,000 trees primarily located on forest (58 percent) and residential (35 percent) land. Although these trees are commonly found in residential areas, only 1 percent are planted, suggesting that they were not intentionally selected as ornamental trees but rather a result of natural seeding. Due to its invasive tendencies, fruitless cultivars are preferred for landscape plantings. This species is found on the "do not plant" list of the "City of Des Moines Recommended Tree Species" (City of Des Moines 2023).

Callery pear is a widely planted non-native tree that has the potential to spread rapidly. In addition to its invasive nature, it is highly prone to bark inclusion which makes it susceptible to damage during wind and ice storms (Missouri Department of Conservation 2023). Callery pear is also listed on the "do not plant" list of the "City of Des Moines Recommended Tree Species" (City of Des Moines 2023). Although Callery pear was not frequently encountered in the first inventory of Des Moines, it is certainly a species to watch for in the coming years.

Insect and Disease Impacts

Although tree damage and mortality were not attributed to specific pests or pathogens during the 2021 Des Moines urban forest inventory, tree species that are common in the city are known to be susceptible to threats that are well established in the state (Potter and Paschke 2022).

Emerald ash borer (EAB, *Agrilus planipennis*) is an invasive wood boring beetle that kills ash trees by tunneling under their bark and disrupting the flow of water and nutrients (Iowa Department of Natural Resources 2018a). Green ash is the second most numerous tree species in Des Moines, with an estimated population of 288,000 and is known to be highly vulnerable to EAB (Herms and McCullough 2014). The City of Des Moines is actively removing ash trees from rights-of-way and city parks. A majority (79 percent) of green ash are less than 5.0 inches in diameter, suggesting that many mature trees may have already died or been removed. However, 37 percent are in maintained areas so there may be a need for continued tree removal for years to come.

Dutch elm disease is an invasive fungal pathogen, spread by bark beetles, that kills native elm trees (University of Minnesota 2023). American elm is the most common tree in Des Moines by number with an estimated population of 309,000 or 12.4 percent of all trees. Like green ash, an overwhelming majority (81 percent) of these trees are less than 5.0 inches in diameter. However, unlike green ash, American elm trees are rarely found in maintained areas. This suggests there may be a lesser impact to property owners in terms of tree removal and replacement.

Bur oak blight (*Tubakia iowensis*) is a fungal disease that affects bur oak, and to a lesser degree swamp white oak, causing severe defoliation which can lead to tree mortality (Goerndt et al. 2022). Infected trees typically have v-shaped discoloration of leaves and browning of veins (Iowa Department of Natural Resources 2018). Bur oak is one of the most common trees in Iowa forest land (Goff et al. 2022) but was less commonly observed in the Des Moines urban forest inventory with an estimated population of 13,000 trees. Maintaining a diversity of species across the city provides the best defense against existing and emerging forest health threats. Additionally, oak trees provide important wildlife habitat to numerous species (Missouri Department of Conservation 2024).

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CONCLUSIONS

State capital from tree-lined Locust Street.
Courtesy photo, Iowa Department of Natural Resources.

The urban forest of Des Moines contributes to the city's environmental, economic, and societal well-being. Throughout the city, an estimated 2.5 million trees, representing 59 species, provide an estimated tree canopy cover of 25.2 percent. These trees provide a wide range of important environmental benefits including air pollution removal, reduced carbon emissions, carbon storage and sequestration, savings in energy costs, stormwater capture, and many others.

There are several forces that may impact Des Moines' urban forest structure, health, and the environmental benefits provided to the city's residents in the future. These include insect and disease impacts, aging and loss of larger trees, the spread 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 changes over time. The plots measured in Des Moines will be re-measured on a 7-year cycle as part of the continuing Urban FIA program. Future analyses of the city's urban 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 Des Moines. 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 Table 32 of Appendix 2 (USDA Forest Service 2017). There were no woodland species measured in the 2021 Des Moines, Iowa inventory.

Forest/forest land/forested area: Land that has at least 10 percent crown cover by live trees or land formerly having such tree cover, and is not currently developed for a nonforest use. The minimum area for classification as forest land is 1 acre and 120 feet in width. Unimproved roads and trails, streams and other bodies of water, or natural clearings in forested areas shall be included within surrounding forest conditions, if <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 Table 36.

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

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

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

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

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

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

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

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

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

APPENDIX 1 – LAND COVER DESCRIPTIONS

Table 31.—National Land Cover Database (NLCD) land cover class descriptions, Des Moines, Iowa, 2021

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

Source: Homer et al. 2015

APPENDIX 2 – TREE SPECIES COMPOSITION

Table 32.—List of all live tree species and their characteristics, Des Moines, Iowa, 2021

Genus	Species	Common name	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total (percent)	Total SE (number)	Average diameter (in.)
Abies	*concolor*	white fir	0	36,000	0	36,000	1.4	38,000	5.9
Acer	*ginnala*	Amur maple	0	6,800	10,000	17,000	0.7	13,000	9.9
Acer	*negundo*	boxelder	190,000	57,000	3,200	250,000	10.0	111,000	4.2
Acer	*nigrum*	black maple	0	1,700	0	1,700	0.1	1,700	7.3
Acer	*platanoides*	Norway maple[a]	0	1,500	4,600	6,100	0.2	3,900	20.3
Acer	*rubrum*	red maple	0	1,600	3,400	5,000	0.2	2,900	14.2
Acer	*saccharinum*	silver maple	21,000	19,000	92,000	133,000	5.3	42,000	17.7
Acer	*saccharum*	sugar maple	0	0	1,500	1,500	0.1	1,600	21.6
Acer	*x freemanii*	Freeman maple	0	4,800	0	4,800	0.2	4,900	6.4
Ailanthus	*altissima*	tree of heaven[a]	0	3,400	3,600	7,000	0.3	4,300	12.6
Betula	*nigra*	river birch	0	0	6,800	6,800	0.3	5,400	17.0
Carya	*cordiformis*	bitternut hickory	0	1,500	3,800	5,300	0.2	3,900	11.1
Carya	*ovata*	shagbark hickory	47,000	1,900	6,400	56,000	2.2	47,000	3.6
Catalpa	*speciosa*	northern catalpa	24,000	1,900	3,600	29,000	1.2	26,000	7.0
Celtis	*occidentalis*	hackberry	95,000	43,000	15,000	153,000	6.1	71,000	5.2
Cercis	*canadensis*	eastern redbud	0	8,300	0	8,300	0.3	7,000	7.4
Cornus	*drummondii*	roughleaf dogwood	71,000	0	0	71,000	2.9	50,000	2.2
Crataegus	spp.	hawthorn spp.	24,000	1,900	0	26,000	1.0	24,000	1.7
Diospyros	*kaki*	persimmon	0	3,000	0	3,000	0.1	3,200	6.0
Fraxinus	*americana*	white ash	0	4,700	0	4,700	0.2	3,600	7.9
Fraxinus	*pennsylvanica*	green ash	227,000	36,000	25,000	288,000	11.5	113,000	4.8
Ginkgo	*biloba*	ginkgo, maidenhair tree	0	0	3,400	3,400	0.1	3,400	22.8
Gleditsia	*triacanthos*	honeylocust	20,000	13,000	14,000	47,000	1.9	25,000	7.8
Gymnocladus	*dioicus*	Kentucky coffeetree	0	0	1,700	1,700	0.1	1,700	44.9
Juglans	*nigra*	black walnut	27,000	14,000	22,000	62,000	2.5	42,000	9.5
Juniperus	*virginiana*	eastern redcedar	0	7,000	0	7,000	0.3	4,200	6.9
Malus	*floribunda*	Japanese flowering crab apple	0	1,700	0	1,700	0.1	1,700	8.6
Malus	spp.	apple spp.	0	20,000	13,000	33,000	1.3	14,000	9.6
Morus	*alba*	white mulberry	66,000	78,000	29,000	173,000	6.9	62,000	6.8
Morus	*rubra*	red mulberry	95,000	41,000	14,000	149,000	6.0	81,000	5.8
Picea	*abies*	Norway spruce	0	1,500	0	1,500	0.1	1,600	5.7

Continued on next page

Table 32. (continued)—List of all live tree species and their characteristics, Des Moines, Iowa, 2021

Genus	Species	Common name	1.0–4.9 in. diameter trees (number)	5.0–10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total (percent)	Total SE (number)	Average diameter (in.)
Picea	*glauca*	white spruce	0	1,700	3,400	5,100	0.2	2,900	14.5
Picea	*pungens*	blue spruce	0	7,900	0	7,900	0.3	5,400	7.2
Pinus	*resinosa*	red pine	0	1,500	0	1,500	0.1	1,600	9.2
Pinus	*strobus*	eastern white pine	0	13,000	31,000	43,000	1.7	27,000	16.8
Populus	*deltoides*	eastern cottonwood	0	10,000	39,000	49,000	2.0	18,000	18.0
Populus	*tremuloides*	quaking aspen	63,000	0	0	63,000	2.5	64,000	3.2
Prunus	*americana*	American plum	0	1,500	0	1,500	0.1	1,600	6.2
Prunus	*serotina*	black cherry	24,000	23,000	3,000	50,000	2.0	24,000	6.0
Prunus	*spp.*	cherry and plum spp.	0	0	1,700	1,700	0.1	1,700	11.3
Pyrus	*calleryana*	Callery pear	0	3,400	1,600	5,000	0.2	3,800	11.0
Pyrus	*communis*	common pear	0	3,200	0	3,200	0.1	2,400	5.9
Pyrus	spp.	pear spp.	0	4,700	0	4,700	0.2	3,700	7.1
Quercus	*alba*	white oak	0	0	13,000	13,000	0.5	8,600	28.8
Quercus	*bicolor*	swamp white oak	0	1,900	0	1,900	0.1	1,800	8.4
Quercus	*macrocarpa*	bur oak	0	0	13,000	13,000	0.5	8,600	31.3
Quercus	*palustris*	pin oak	0	0	3,000	3,000	0.1	2,300	42.0
Quercus	*rubra*	northern red oak	0	16,000	9,100	25,000	1.0	13,000	11.0
Quercus	*velutina*	black oak	0	3,000	1,500	4,600	0.2	3,600	11.9
Rhamnus	*cathartica*	common buckthorn[a]	19,000	0	0	19,000	0.8	20,000	1.8
Robinia	*pseudoacacia*	black locust[a]	0	17,000	12,000	29,000	1.2	27,000	10.1
Salix	*nigra*	black willow	0	4,700	3,800	8,500	0.3	5,100	12.8
Thuja	*occidentalis*	northern white-cedar	0	5,100	0	5,100	0.2	5,100	8.3
Tilia	*americana*	American basswood	47,000	13,000	12,000	72,000	2.9	59,000	5.0
Tilia	*cordata*	littleleaf linden	0	0	6,400	6,400	0.3	4,000	23.1
Tsuga	*canadensis*	eastern hemlock	0	0	9,100	9,100	0.4	9,700	14.9
Ulmus	*americana*	American elm	250,000	48,000	11,000	309,000	12.4	192,000	3.7
Ulmus	*pumila*	Siberian elm[a]	63,000	41,000	46,000	150,000	6.0	76,000	7.5
Ulmus	*rubra*	slippery elm	0	1,500	0	1,500	0.1	1,600	5.2
Total			**1,370,000**	**631,000**	**494,000**	**2,500,000**	**100.0**	**420,000**	**7.1**

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

Continued on next page

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

[a] Tree species included on the list of invasive plants monitored during the inventory of Des Moines, 2021 (see Appendix 5).

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

Table 33.—Estimates of total number of trees, basal area, and average diameter by aggregated National Land Cover Database (NLCD) land cover class, Des Moines, Iowa, 2021

NLCD land cover class group	Common name	Trees (number)	Basal area[a] (square feet/acre)	Average diameter[b] (inches)
Developed-High	Amur maple	17,066	2.6	9.9
	Callery pear	3,413	0.5	10.3
	cherry and plum spp.	1,707	0.3	11.3
	common pear	1,707	< 0.1	6.0
	white mulberry	1,707	0.3	10.4
Developed-Low	American basswood	5,070	0.3	12.5
	apple spp.	27,038	0.9	9.9
	black maple	1,690	< 0.1	7.3
	black walnut	3,380	0.3	16.7
	black willow	1,690	< 0.1	9.1
	blue spruce	3,380	< 0.1	8.0
	boxelder	10,139	0.2	8.0
	bur oak	3,380	1.5	37.0
	eastern cottonwood	8,449	0.5	12.6
	eastern redbud	6,760	0.1	7.8
	eastern redcedar	5,070	< 0.1	7.4
	eastern white pine	6,760	0.7	14.4
	ginkgo, maidenhair tree	3,380	0.6	22.8
	green ash	93,049	1.8	3.4
	hackberry	21,968	1.4	11.3
	honeylocust	10,139	0.8	15.0
	Japanese flowering crab apple	1,690	< 0.1	8.6
	Kentucky coffeetree	1,690	1.1	44.9
	littleleaf linden	1,690	0.1	16.3
	northern catalpa	1,690	0.8	37.1
	northern red oak	10,139	0.5	10.8
	northern white-cedar	5,070	0.1	8.3
	pear spp.	1,690	< 0.1	8.5
	quaking aspen	63,450	0.2	3.2
	red maple	3,380	0.3	16.9
	red mulberry	13,519	1.2	15.9
	river birch	6,760	0.7	17.0
	shagbark hickory	3,380	0.4	19.3
	Siberian elm	73,589	0.8	3.7
	silver maple	46,498	9.0	18.1

Estimates are rounded

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

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

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

NLCD land cover class group	Common name	Trees (number)	Basal area[a] (square feet/acre)	Average diameter[b] (inches)
Developed-Low (cont.)	tree of heaven	1,690	0.2	19.5
	white mulberry	52,439	0.8	4.0
	white oak	1,690	1.1	44.9
	white spruce	5,070	0.4	14.5
Developed-Medium	apple spp.	1,588	< 0.1	6.1
	Callery pear	1,588	0.2	12.4
	Freeman maple	4,763	0.2	6.4
	green ash	7,939	1.6	14.7
	honeylocust	19,779	< 0.1	1.5
	littleleaf linden	3,176	2.2	28.8
	red maple	1,588	< 0.1	8.6
	silver maple	1,588	1.9	38.4
	white ash	3,176	0.2	8.7
Developed-Open	American basswood	4,563	0.4	12.7
	American elm	1,521	0.2	14.5
	American plum	1,521	< 0.1	6.2
	apple spp.	4,563	0.2	9.0
	bitternut hickory	1,521	< 0.1	7.3
	black cherry	3,042	0.3	13.6
	black oak	4,563	0.4	11.9
	black walnut	16,732	2.3	15.2
	black willow	3,042	< 0.1	5.8
	blue spruce	4,563	0.1	6.6
	boxelder	7,606	0.4	9.2
	bur oak	9,127	4.4	29.2
	common buckthorn	19,151	< 0.1	1.8
	common pear	1,521	< 0.1	5.8
	eastern cottonwood	6,084	0.3	9.0
	eastern hemlock	9,127	1.1	14.9
	eastern redbud	1,521	< 0.1	5.7
	eastern white pine	36,507	6.3	17.2
	green ash	6,084	1.4	20.1
	hackberry	7,606	2.6	23.8
	littleleaf linden	1,521	0.3	18.8
	Norway maple	6,084	1.5	20.3
	Norway spruce	1,521	< 0.1	5.7
	pear spp.	3,042	< 0.1	6.3
	persimmon	3,042	< 0.1	6.0
	pin oak	3,042	2.8	42.0

Estimates are rounded

Continued on next page

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

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

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

NLCD land cover class group	Common name	Trees (number)	Basal area[a] (square feet/acre)	Average diameter[b] (inches)
Developed-Open (cont.)	red mulberry	1,521	< 0.1	6.3
	red pine	1,521	< 0.1	9.2
	shagbark hickory	3,042	0.3	13.5
	Siberian elm	19,774	2.0	13.0
	silver maple	4,563	1.7	26.0
	slippery elm	1,521	< 0.1	5.2
	sugar maple	1,521	0.4	21.6
	tree of heaven	1,521	< 0.1	9.0
	white ash	1,521	< 0.1	6.3
	white fir	35,883	0.6	5.9
	white mulberry	15,211	1.1	11.8
	white oak	9,127	3.6	27.4
Forest/Shrub	American basswood	62,617	3.0	3.8
	American elm	290,254	7.2	3.5
	bitternut hickory	3,805	0.7	12.7
	black cherry	31,308	0.9	4.9
	black walnut	9,512	3.1	16.3
	black willow	3,805	1.6	20.0
	boxelder	198,231	3.5	3.7
	eastern cottonwood	34,244	18.0	20.9
	green ash	178,338	6.3	4.5
	hackberry	119,526	1.9	2.8
	hawthorn spp.	25,601	0.1	1.7
	honeylocust	17,122	2.5	10.9
	northern catalpa	27,503	0.9	5.1
	northern red oak	15,220	2.6	11.2
	red mulberry	123,331	3.3	4.5
	roughleaf dogwood	47,397	0.2	1.8
	shagbark hickory	49,299	0.3	1.9
	Siberian elm	51,366	7.0	10.8
	silver maple	79,903	28.1	16.6
	swamp white oak	1,902	0.1	8.4
	tree of heaven	3,805	0.5	10.9
	white mulberry	65,553	5.6	7.5
	white oak	1,902	0.9	21.5
Herbaceous/Crop	American elm	1,929	< 0.1	7.2
	black cherry	15,429	0.5	6.8
	black locust	28,930	2.1	10.1
	black walnut	1,929	0.1	9.1

Estimates are rounded

Continued on next page

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

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

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

NLCD land cover class group	Common name	Trees (number)	Basal area[a] (square feet/acre)	Average diameter[b] (inches)
Herbaceous/Crop (cont.)	boxelder	33,668	0.6	5.2
	eastern redcedar	1,929	< 0.1	5.6
	green ash	1,929	< 0.1	6.2
	hackberry	3,857	< 0.1	5.2
	red mulberry	9,643	0.3	7.2
	roughleaf dogwood	24,025	0.1	2.9
	Siberian elm	3,857	0.2	8.6
	white mulberry	38,573	1.6	7.3
Water	American elm	15,425	1.2	5.0
	black walnut	30,850	1.5	3.5
	green ash	1,067	0.2	8.6
	red mulberry	1,067	0.4	10.5
	Siberian elm	1,067	< 0.1	5.4

Estimates are rounded

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

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

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

FIA land use class	Common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Forest land	American basswood	62,617	3	3.8
	American elm	280,768	6	3.4
	black cherry	13,396	0.9	7.5
	black locust	28,930	3.5	10.1
	black walnut	13,313	4.5	17
	black willow	5,495	1.8	16.7
	blue spruce	4,563	0.2	6.6
	boxelder	196,442	3.7	3.9
	eastern cottonwood	39,314	19.5	20.4
	eastern redcedar	1,929	< 0.1	5.6
	eastern white pine	12,169	4.9	19.3
	green ash	97,756	2.9	4.5
	hackberry	13,317	0.8	7.1
	hawthorn spp.	25,601	0.1	1.7
	honeylocust	15,220	2.4	11.6
	northern red oak	5,707	1.7	15.5
	red mulberry	124,852	3.3	4.5
	roughleaf dogwood	71,422	0.4	2.2
	Siberian elm	51,366	6.9	10.8
	silver maple	79,903	27.8	16.6
	tree of heaven	3,805	0.5	10.9
	white fir	35,883	1.3	5.9
	white mulberry	101,481	8.1	7.5
	white oak	1,902	0.9	21.5
Agriculture	American elm	11,415	0.9	8.7
	black cherry	7,715	0.2	6.1
	boxelder	35,244	0.5	4
	eastern cottonwood	9,464	0.5	7.7
	green ash	9,512	1.6	13.5
	hackberry	55,007	0.4	2.4
	honeylocust	1,902	< 0.1	5.2
	red mulberry	9,643	0.4	7.2
	Siberian elm	8,013	0.4	8.2
Commercial/Industrial	American basswood	3,380	0.3	12.1
	American elm	1,521	0.2	14.5
	Amur maple	17,066	1.1	9.9
	apple spp.	8,449	0.6	10.6
	black maple	1,690	< 0.1	7.3
	Callery pear	5,001	0.4	11
	cherry and plum spp.	1,707	0.1	11.3
	common pear	1,707	< 0.1	6

Estimates are rounded

Continued on next page

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

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

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

FIA land use class	Common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Commercial/Industrial (cont.)	eastern redcedar	1,690	< 0.1	9.4
	green ash	6,351	1.2	16.7
	hackberry	1,521	< 0.1	6
	honeylocust	6,760	1	14.7
	northern red oak	1,690	0.4	20
	white mulberry	3,228	0.3	11.9
	white oak	1,690	2.1	44.9
Multi-family residential	bur oak	1,690	8.4	35.8
Residential	American basswood	6,253	0.4	12.9
	American plum	1,521	< 0.1	6.2
	apple spp.	11,390	0.4	9.5
	bitternut hickory	5,326	0.3	11.1
	black cherry	26,741	0.3	5.1
	black oak	4,563	0.3	11.9
	black walnut	16,311	1.5	14.7
	blue spruce	3,380	< 0.1	8
	boxelder	9,508	0.3	8.6
	bur oak	9,295	2.7	27.8
	common buckthorn	19,151	< 0.1	1.8
	common pear	1,521	< 0.1	5.8
	eastern hemlock	9,127	0.8	14.9
	eastern redbud	8,281	0.2	7.4
	eastern redcedar	3,380	< 0.1	6.4
	eastern white pine	8,281	0.9	13.2
	Freeman maple	3,176	< 0.1	5.6
	green ash	172,131	3.4	4
	hackberry	76,044	2.5	5.7
	Japanese flowering crab apple	1,690	< 0.1	8.6
	Kentucky coffeetree	1,690	1.2	44.9
	littleleaf linden	3,211	0.4	17.5
	northern catalpa	29,193	1.2	7
	northern red oak	17,962	0.5	8.8
	northern white-cedar	5,070	0.1	8.3
	Norway maple	6,084	1.1	20.3
	Norway spruce	1,521	< 0.1	5.7
	pear spp.	4,732	< 0.1	7.1
	persimmon	3,042	< 0.1	6
	pin oak	1,521	0.9	39.6
	quaking aspen	63,450	0.3	3.2
	red maple	4,968	0.4	14.2
	red mulberry	13,519	1.4	15.9

Estimates are rounded

Continued on next page

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

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

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

FIA land use class	Common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Residential (cont.)	red pine	1,521	< 0.1	9.2
	river birch	6,760	0.8	17
	shagbark hickory	55,721	0.8	3.6
	Siberian elm	87,279	2.2	5.6
	silver maple	52,649	12.3	19.4
	slippery elm	1,521	< 0.1	5.2
	sugar maple	1,521	0.3	21.6
	swamp white oak	1,902	< 0.1	8.4
	tree of heaven	3,211	0.3	14.5
	white ash	1,521	< 0.1	6.3
	white mulberry	61,059	1.5	5.4
	white oak	9,127	2.6	27.4
	white spruce	5,070	0.4	14.5
Recreation/Cemetery	American elm	15,425	0.6	5
	apple spp.	8,449	0.8	7.4
	black walnut	30,850	0.8	3.5
	bur oak	1,521	5.8	47.9
	eastern white pine	22,817	12.3	16.8
	green ash	2,655	0.3	7.5
	hackberry	1,521	1.1	20.8
	honeylocust	23,158	1.4	3.6
	pin oak	1,521	4.9	44.3
	red mulberry	1,067	0.2	10.5
	Siberian elm	1,067	< 0.1	5.4
Rights-of-way	apple spp.	4,901	0.4	11.8
	black cherry	1,929	< 0.1	8
	black walnut	1,929	< 0.1	9.1
	black willow	3,042	< 0.1	5.8
	boxelder	8,449	0.4	8.5
	Freeman maple	1,588	< 0.1	7.9
	ginkgo, maidenhair tree	3,380	1	22.8
	hackberry	5,547	1.5	15.2
	littleleaf linden	3,176	1.5	28.8
	Siberian elm	1,929	< 0.1	8.1
	white ash	3,176	0.1	8.7
	white mulberry	7,715	0.2	6.1

Estimates are rounded

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

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

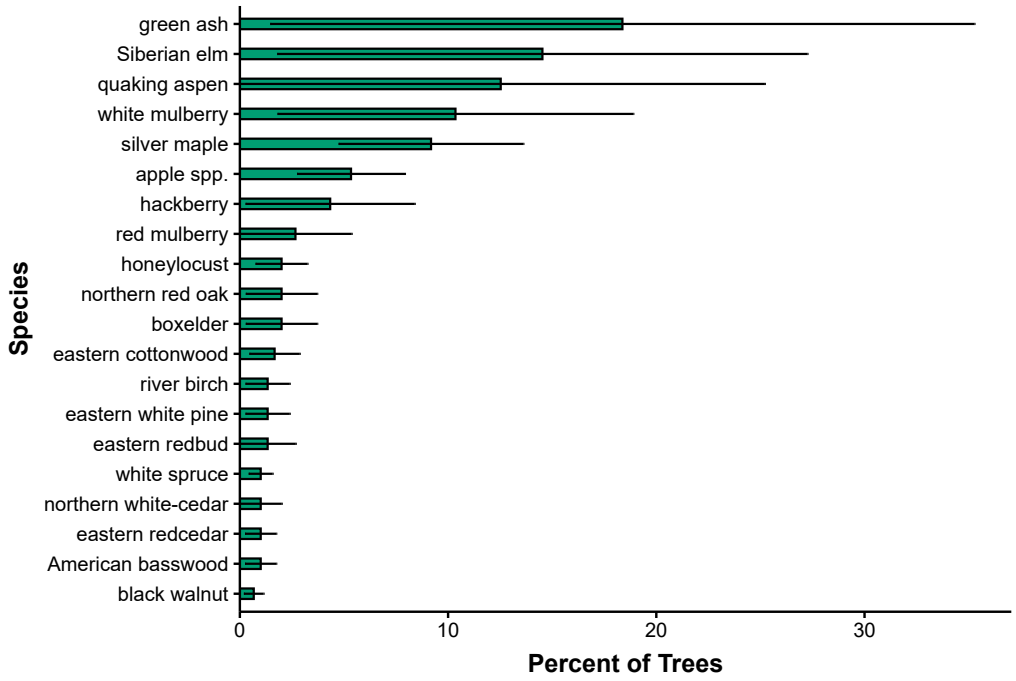

Figure 27.—Percent of the total tree population for up to 20 of the most common tree species observed in the developed-low National Land Cover Database (NLCD) land cover class group, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

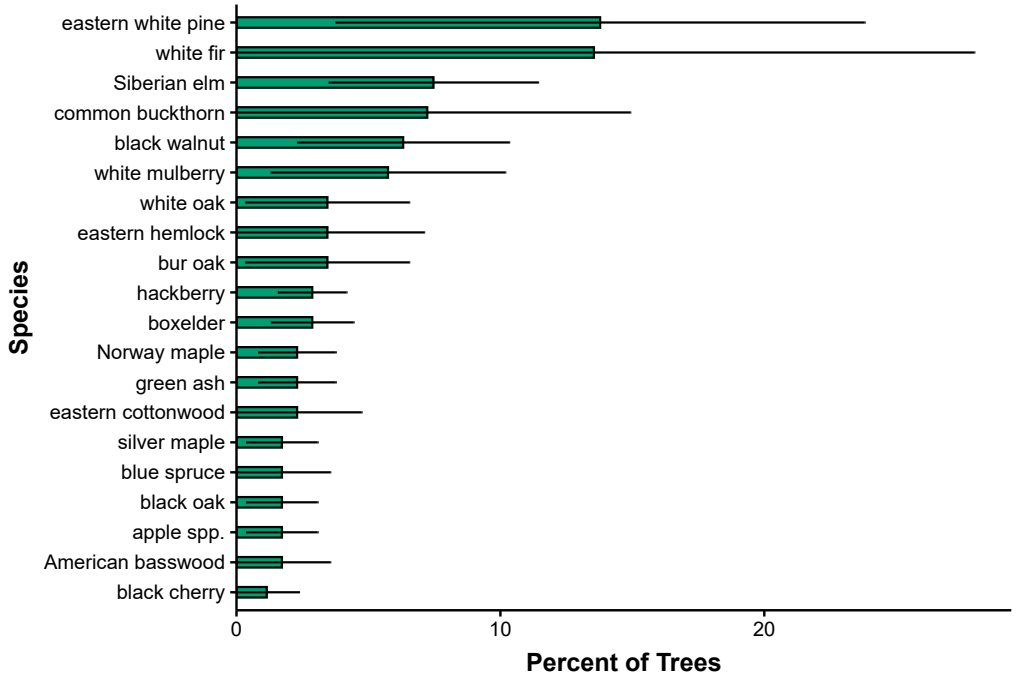

Figure 28.—Percent of the total tree population for up to 20 of the most common tree species observed in the developed-open National Land Cover Database (NLCD) land cover class group, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

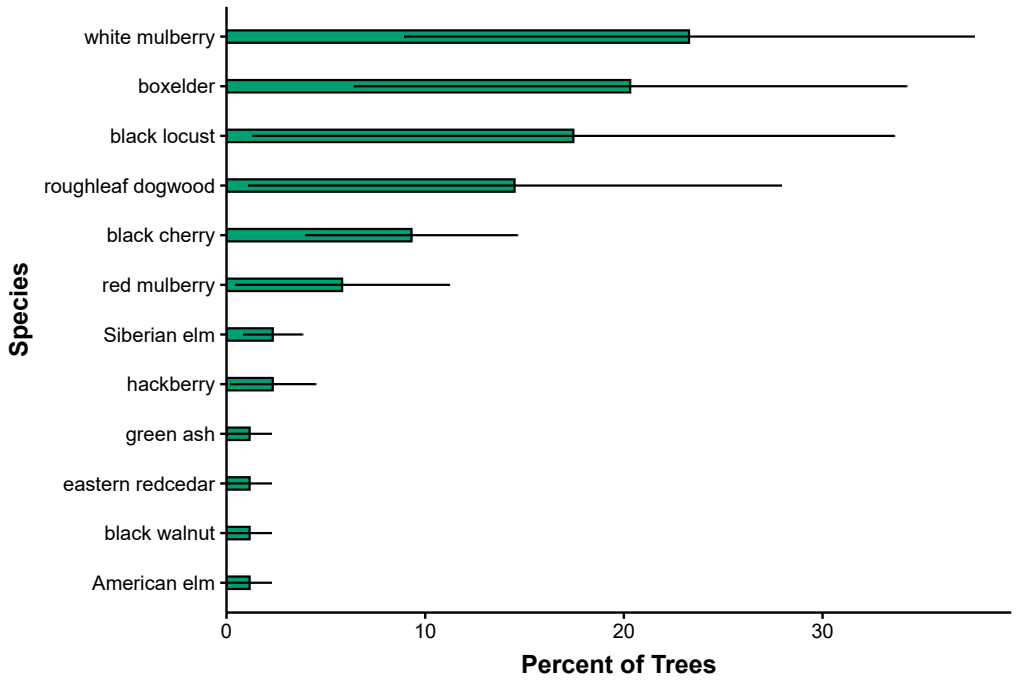

Figure 29.—Percentage of total tree population for up to 20 of the most common tree species observed in the crop/herbaceous National Land Cover Database (NLCD) land cover class group, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

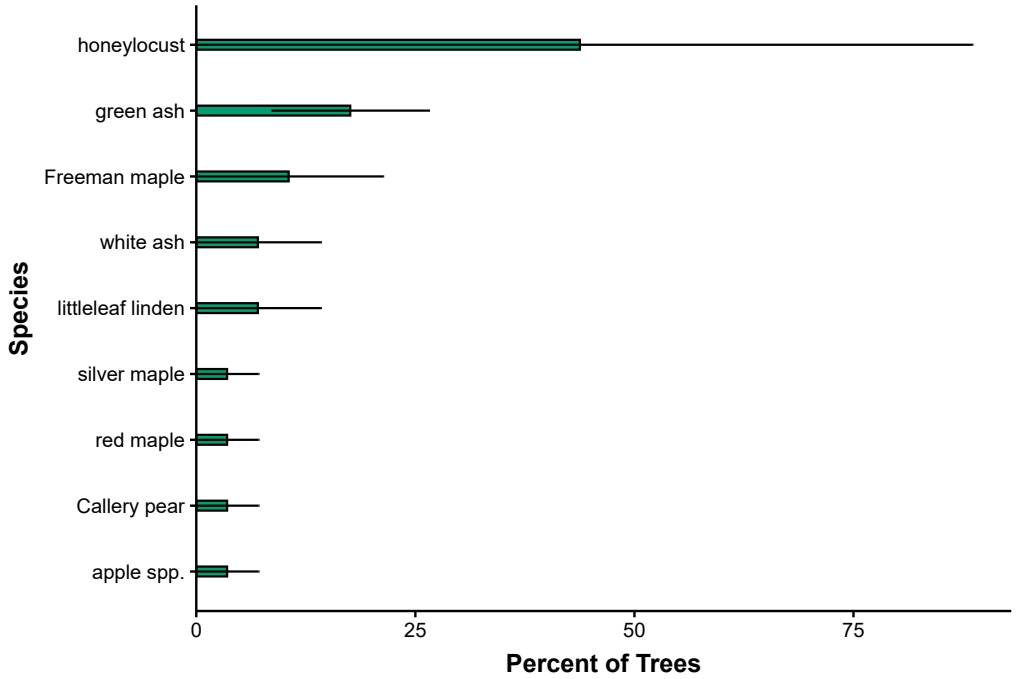

Figure 30.—Percent of the total tree population for up to 20 of the most common tree species observed in the developed-medium National Land Cover Database (NLCD) land cover class group, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

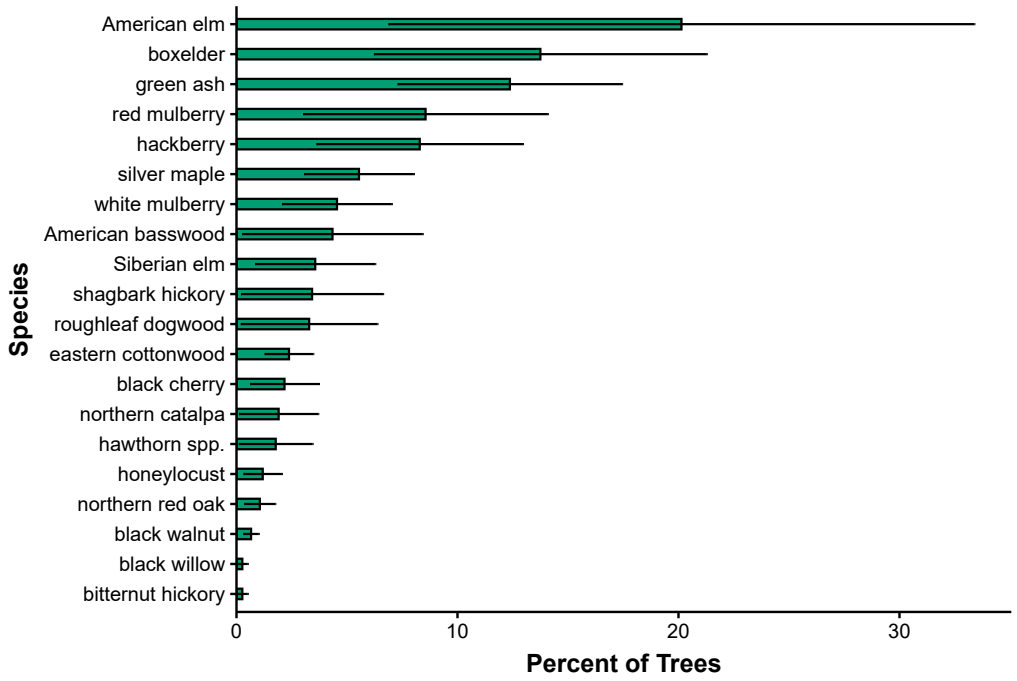

Figure 31.—Percent of the total tree population for up to 20 of the most common tree species observed in the forest/shrub National Land Cover Database (NLCD) land cover class group, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

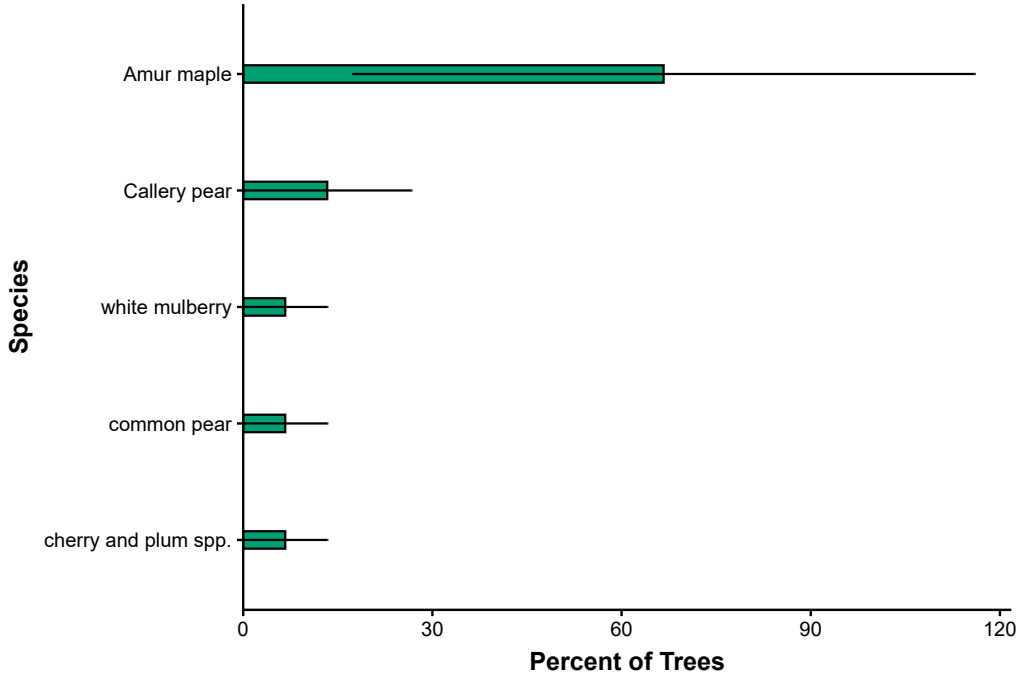

Figure 32.—Percent of the total tree population for up to 20 of the most common tree species observed in the developed-high National Land Cover Database (NLCD) land cover class group, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

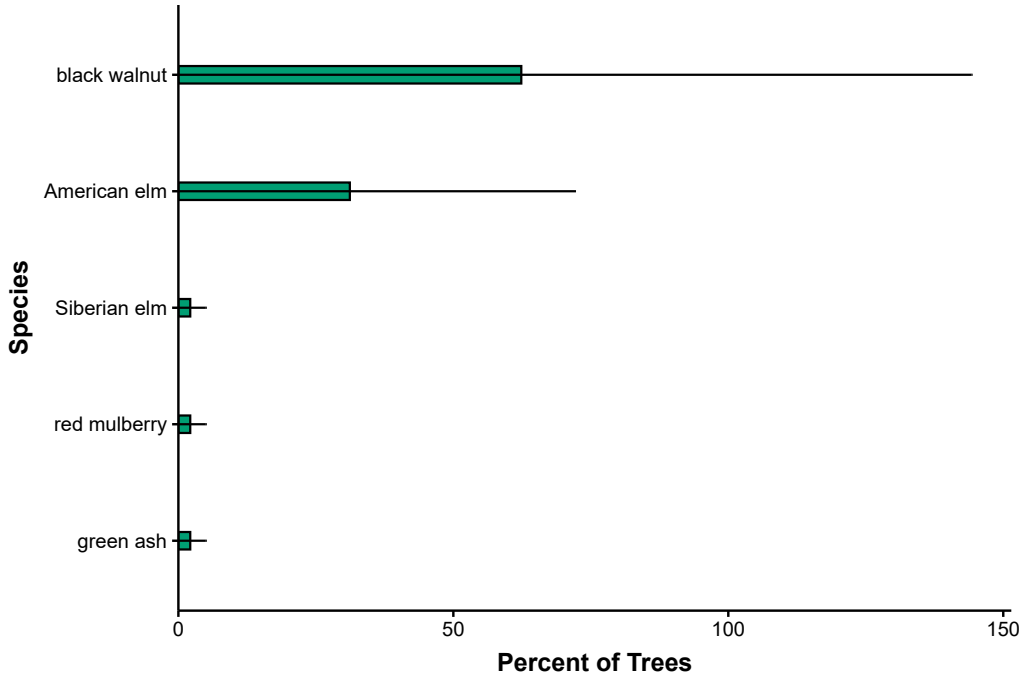

Figure 33.—Percent of total tree population for up to 20 of the most common tree species observed in the water National Land Cover Database (NLCD) land cover class group, Des Moines, Iowa, 2021. Error bars represent 68 percent confidence intervals around the estimated means.

APPENDIX 4 – SPECIES COMPOSITION IN MAINTAINED AREAS

Table 35.—Tree species composition in maintained areas, Des Moines, Iowa, 2021

Common name	Number of trees
green ash	107,000
Siberian elm	89,000
quaking aspen	63,000
white mulberry	54,000
silver maple	53,000
apple spp.	33,000
honeylocust	30,000
hackberry	28,000
eastern white pine	27,000
common buckthorn	19,000
Amur maple	17,000
red mulberry	14,000
bur oak	13,000
boxelder	11,000
white oak	11,000
northern red oak	10,000
American basswood	9,600
black walnut	9,500
eastern hemlock	9,100
river birch	6,800
eastern redbud	6,800
shagbark hickory	6,400
littleleaf linden	6,400
Norway maple	6,100
eastern redcedar	5,100
white spruce	5,100
northern white-cedar	5,100
Callery pear	5,000
red maple	5,000
Freeman maple	4,800
pear spp.	4,700
blue spruce	3,400
ginkgo, maidenhair tree	3,400
common pear	3,200
white ash	3,200
pin oak	3,000
black oak	3,000
black willow	3,000
persimmon	3,000
cherry and plum spp.	1,700
black maple	1,700
tree of heaven	1,700
northern catalpa	1,700
Kentucky coffeetree	1,700
Japanese flowering crab apple	1,700
Norway spruce	1,500
sugar maple	1,500
bitternut hickory	1,500
American plum	1,500

Estimates are rounded

APPENDIX 5 – LIST OF INVASIVE PLANT SPECIES

Table 36.—Invasive plant species list used in the inventory protocol for Des Moines, Iowa, 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 ssp. *micranthos*	spotted knapweed
Cirsium arvense	Canada thistle
Cirsium vulgare	bull thistle
Cynanchum louiseae	Louise's swallow-wort
Cynanchum rossicum	European swallow-wort
Elaeagnus angustifolia	Russian olive
Elaeagnus umbellata	autumn olive
Euphorbia esula	leafy spurge
Frangula alnus	glossy buckthorn
Hedera helix	English ivy
Hesperis matronalis	dames rocket
Ligustrum vulgare	European privet
Lonicera spp.	honeysuckle
Lonicera japonica	Japanese honeysuckle
Lonicera maackii	Amur honeysuckle
Lonicera morrowii	Morrow's honeysuckle
Lonicera tatarica	Tatarian honeysuckle
Lonicera x bella	showy fly honeysuckle
Lysimachia nummularia	creeping jenny
Lythrum salicaria	purple loosestrife
Melaleuca quinquenervia	melaleuca
Melia azedarach	Chinaberrytree
Microstegium vimineum	Nepalese browntop
Paulownia tomentosa	paulownia
Phalaris arundinacea	reed canarygrass
Phragmites australis	common reed
Polygonum cuspidatum	Japanese knotweed
Polygonum sachalinense	giant knotweed
Polygonum x bohemicum	Bohemian knotweed
Rhamnus cathartica	common buckthorn
Robinia pseudoacacia	black locust
Rosa multiflora	multiflora rose
Spiraea japonica	Japanese meadowsweet
Tamarix ramosissima	saltcedar
Triadica sebifera	Chinese tallow
Ulmus pumila	Siberian elm
Viburnum opulus	European cranberrybush

APPENDIX 6 – TREE SPECIES' PEST RISK SCORE

Table 37.—List of invasive plant species inventoried in Des Moines, Iowa, 2021

Common name	Cumulative score	DED	EAB	LAT	BC	OW	PSB	BOB	FTC	SM	HRD	DA	JPBW	WPBR	SBW	SB	ALB	SLF	AL	SPB	TCD	FR	WSB	SW	BWA	FE	HWA	BSRD	MPB	WM	PSHB	BM	MOB	ARCA	WBBU	SOD	NSE	POCRD	RPS
Norway spruce	24						4				3				3	3				2			2	2	2				2						1				
bur oak	22					4		4	3	3								2				2								1	1	1	1						
eastern white pine	22						4		3		3		3	3				2		2				2															
white spruce	21						4				3				3	3				2			2					2						1		1		
northern red oak	19					4			3	3								2				2								1	1	1	1			1			
pin oak	19					4			3	3								2				2								1	1	1	1			1			
black willow	18			4					3	3							2	2	2											1		1						
red pine	18						4		3		3		3							2				2															1
white oak	18					4			3	3								2				2								1	1	1	1						
black oak	17					4			3	3								2				2								1		1	1						
quaking aspen	17			4					3	3							2		2											1	1			1					
swamp white oak	17					4			3	3								2				2								1		1	1						
black cherry	15			4					3								2	2	2											1		1							
blue spruce	15						4								3	3				2			2												1				
river birch	15			4					3	3							2	2												1									
American elm	14	4							3								2	2												1	1	1							
American plum	13			4					3								2		2											1		1							
eastern cottonwood	13			4					3	3							2													1									
Siberian elm	13	4							3								2	2												1		1							
slippery elm	13	4							3								2	2												1		1							
American basswood	12								3	3							2	2												1	1								
green ash	12		4						3								2	2												1									
cherry and plum spp.	12			4					3								2		2													1							
boxelder	11									3							2	2												1	1	1	1						
sugar maple	10								3								2	2												1		1	1						
white ash	10		4						3									2												1									
white fir	10										3												2		2	2									1				
black walnut	9				4													2			2									1									
Callery pear	9									3							2	2													1	1							
Japanese flowering crab apple	9									3							2	2													1	1							
apple spp.	8									3							2	2														1							
common pear	8									3							2	2														1							
littleleaf linden	8								3	3							2																						
pear spp.	8									3							2	2														1							
eastern hemlock	7														3					2							2											
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						
black maple	5																2													1		1	1						
roughleaf dogwood	5											3						2																					
white mulberry	5																2	2													1								
Amur maple	4																2															1	1						
eastern redcedar	4										3																				1							
hawthorn spp.	3									3																													
persimmon	3																	2													1								
northern white-cedar	3																	2																				1	
tree of heaven	3																	2													1								
black locust	2																	2																					
hackberry	2																2																						
red mulberry	2																2																						
shagbark hickory	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.

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