
The Morton Arboretum®
THE CHAMPION of TREES
2020
Chicago Region Tree Census Report

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This summary provides key findings from the 2020 Chicago Region Tree Census, encompassing the seven-county Chicago area. For more information, please email treecensus2020@mortonarb.org.

Abstract

This report provides the results of the 2020 Chicago Region Tree Census, using an i-Tree Eco assessment, of the seven-county Chicago region: Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will counties, and the city of Chicago. Using methodology from the 2007 city of Chicago Urban Forest Effects (UFORE) model assessment and the 2010 Chicago region i-Tree assessment, 1,576 plots were resampled and analyzed to provide insights on a decade of structural and functional change in the regional forest. Further, values of select ecosystem benefits were analyzed and estimated. **The number of trees and shrubs increased from 157,142,000 in 2010 to 172,297,000 in 2020, representing more than 194 species. In 2020, the regional forest tree and shrub canopy cover was assessed to be 23%, an increase from 21% in 2010.** In general, canopy cover increased in six counties, but declined in the city of Chicago and McHenry County.

Forty-five percent of the tree species found in the region are considered invasive. The invasive small tree, European buckthorn (*Rhamnus cathartica*), has the highest importance value for the seven-county region. For the city of Chicago, silver maple (*Acer saccharinum*) has the highest importance value. Approximately 75% of the trees and shrubs are smaller than 6 inches in diameter at breast height (DBH). **The regional forest has an estimated replacement value of $45 billion and provides more than $416 million in annual ecosystem services.** Comparing 2010 and 2020, the replacement value of the regional forest has declined from $51 billion to $45 billion.

The 2020 tree census serves as a strategic guide for local and regional stakeholders to understand the current trends and make informed decisions on how to protect and improve the regional forest.

CHICAGO REGION FOREST FEATURES			TOTALS
Number of trees	Chicago	3,997,000	172,297,000
	Seven-County Region	168,300,000	
Tree and shrub canopy cover (i-Tree canopy)	Chicago	16%	23%
	Seven-County Region	26%	
Most common species of trees	Chicago	white mulberry, European buckthorn, tree of heaven	-
	Seven-County Region	European buckthorn, boxelder, black cherry	
Species with the most total leaf area	Chicago	silver maple, Norway maple, white ash	-
	Seven-County Region	European buckthorn, silver maple, black walnut	
Percentage of trees smaller than 6" (15.2 cm) diameter	Chicago	65%	75%
	Seven-County Region	76%	

CHICAGO REGION FOREST FEATURES *continued*			TOTALS
Pollution removal (tons/year)	Chicago	800	18,600
	Seven-County Region	17,800	
Pollution removal ($/year)	Chicago	$36,600,000	$191,600,000
	Seven-County Region	$155,000,000	
Carbon storage (tons)	Chicago	876,500	20,836,500
	Seven-County Region	19,960,000	
Carbon storage ($)	Chicago	$149,000,000	$3,549,000,000
	Seven-County Region	$3,400,000,000	
Carbon sequestration (tons)	Chicago	21,000	542,600
	Seven-County Region	521,600	
Carbon sequestration ($/year)	Chicago	$3,610,0000	$92,610,000
	Seven-County Region	$89,000,000	
Oxygen production (tons/year)	Chicago	23,000	648,800
	Seven- County Region	625,800	
Avoided runoff (cubic feet/year)	Chicago	65,000,000	1,490,000,000
	Seven-County Region	1,425,000,000	
Avoided runoff ($/year)	Chicago	$4,350,000	$99,650,000
	Seven-County Region	$95,300,000	
Building energy savings ($/year)	Chicago	$1,930,000	$32,430,000
	Seven-County Region	$30,500,000	
Carbon avoided (tons/year)	Chicago	1,800	58,800
	Seven-County Region	57,000	
Carbon avoided ($/year)	Chicago	$314,000	$10,094,000
	Seven-County Region	$9,780,000	
Replacement value ($)	Chicago	$2,050,000,000	$44,850,000,000
	Seven-County Region	$42,800,000,000	

Table 1: Summary of regional forest features, Chicago region, 2020.
Ton: short ton (U.S.) (2,000 lbs)
Monetary values are reported in U.S. dollars throughout the report except where noted. Pollution removal and avoided runoff estimates are reported for trees and shrubs. All other ecosystem service estimates are reported for trees. Figures are rounded from the i-Tree report.

Regional forest: The forest in the project area, which includes trees and shrubs in both urban and rural areas in the seven-county Chicago region and the city of Chicago.
Seven-county region: Suburban Cook (not including the city of Chicago), DuPage, Kane, Kendall, Lake, McHenry, and Will counties.

Background

Trees provide myriad benefits to people where they live and work, ranging from cleaning air and water, providing habitat to other organisms, improving mental and physical health, providing economic and ecosystem services, reducing flooding, and mitigating climate change through storing and sequestering carbon and reducing the urban heat island effect (Akbari et al. 2001, Berland et al. 2017, Brack 2002, Pandit et al. 2010, Turner-Skoff and Cavender 2019). Despite their importance as an asset in cities and suburban areas, many trees are negatively impacted due to the challenges of growing in a built environment (Cavender and Donnelly 2019). These challenges can include restricted root space, compacted soil, introduced nonnative insects and diseases, increased frequency and severity of storm events, converted land use, reduced investment in tree planting and care, among others (Figure 1, page 5). Understanding how regional forests change over time, especially in the number of trees, canopy and shrub cover, species diversity, and size of trees, is essential to making informed decisions to improve the regional forest and the benefits received.

This report represents more than a decade of information and research highlighting the current state of the regional forest, the ecosystem services and benefits it provides, and a review of the changes that have occurred.

In 2007, the first snapshot of the trees and shrubs growing in the city of Chicago was captured by the United States Forest Service's UFORE (Urban Forest Effects) model assessment (Fisher and Nowak 2010). Following this landmark study, in 2010 The Morton Arboretum and the USDA Forest Service completed the first tree census using an i-Tree Eco assessment of the trees in 1,331 plots found throughout the seven-county Chicago region (suburban Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will), providing a unique rural to urban gradient picture of the regional forest (Nowak et al. 2013).

In 2020, a follow-up tree census, using an i-Tree Eco assessment of the seven-county region and the city of Chicago, was conducted using methodology built from the 2007 and 2010 assessments. In the summer of 2020, 1,576 out of 1,600 randomized i-Tree Eco plots from the 2007 and 2010 tree assessments were surveyed. This included approximately 200 plots from each of the seven counties and 268 plots from the city of Chicago (Figure 2, page 6; Nowak et al. 2010, Nowak et al. 2013).

Informing the public of this work was vital to gaining access to as many plots as possible. In addition to press releases, social media posts, and other forms of digital communication, two rounds of informational postcards were mailed to each property owner. The multiple layers of communication played an important role in successfully accessing 98% of the assigned plots. Only 24 plots (less than 2%) were not surveyed because of inaccessibility or refused access by property owners. Such a high rate of reassessment provides valuable information on the dynamic nature of the regional forest.

Finally, this report ends with information on how to improve and strengthen the regional forest in terms of canopy cover, diversity, and number of trees. The comprehensiveness and spatial extent of the field data collection made for a highly useful assessment of the regional forest, and provides a basis for ongoing management and planning efforts now and in the years ahead. The 2020 tree census will serve as a strategic guide for local and regional stakeholders to make informed decisions on how to protect and improve the regional forest and the benefits received.

The Chicago Region

The Chicago region is the third-largest metropolitan region in the United States. This region includes an estimated 2,565,760 acres with more than 9 million residents in 284 municipalities. The region has a diverse landscape ranging from the highly urbanized city of Chicago (with its extensive transportation and infrastructure systems, protected open spaces, and areas dedicated to residential, industrial, business, and commercial uses) to predominantly residential areas of the surrounding suburban Cook, DuPage, and Lake counties, and agricultural land in Kane, Kendall, McHenry, and Will counties. These land-use classifications were determined by The Chicago Metropolitan Agency for Planning (CMAP).

The 1,600 randomized i-Tree Eco plots were distributed among the following four major land use types:

1. Residential (556 plots, 35% of area) includes single- and multiple-family dwellings.
2. Agriculture (453 plots, 28%) includes row crops, pastures, and nurseries.
3. Open space (310 plots, 19%) includes open land, water, and wetland:
    a. Open space (247 plots, 15%) includes forest preserves, parks, golf courses, private hunting clubs, and vacant forest and grassland.
    b. Water and wetland (63 plots, 4%) includes lakes, rivers, wetlands, and other open bodies of water.
4. Commercial and industrial, transportation and utilities, and institutional (CTI) (281 plots,18%):
    a. Commercial and industrial (128 plots, 8%) includes places of business, manufacturing, and industrial parks.
    b. Transportation and utilities (81 plots, 5%) includes major roads and highways, airports, and railroads.
    c. Institutional (72 plots, 5%) includes educational facilities, religious facilities, and cemeteries.

Ohio buckeye
(*Aesculus glabra*)

Built Environment

Built environment is the broad range of infrastructure created to support people living and working in cities. These spaces include residential neighborhoods, business districts, industrial parks, factories, transportation corridors, energy grids, forest preserves, water treatment plants, and a long list of other uses necessary for a comfortable existence. The built environment creates special challenges for trees and plants. Proper planning and management are crucial to ensure vegetation can thrive and provide the most benefits and services possible.

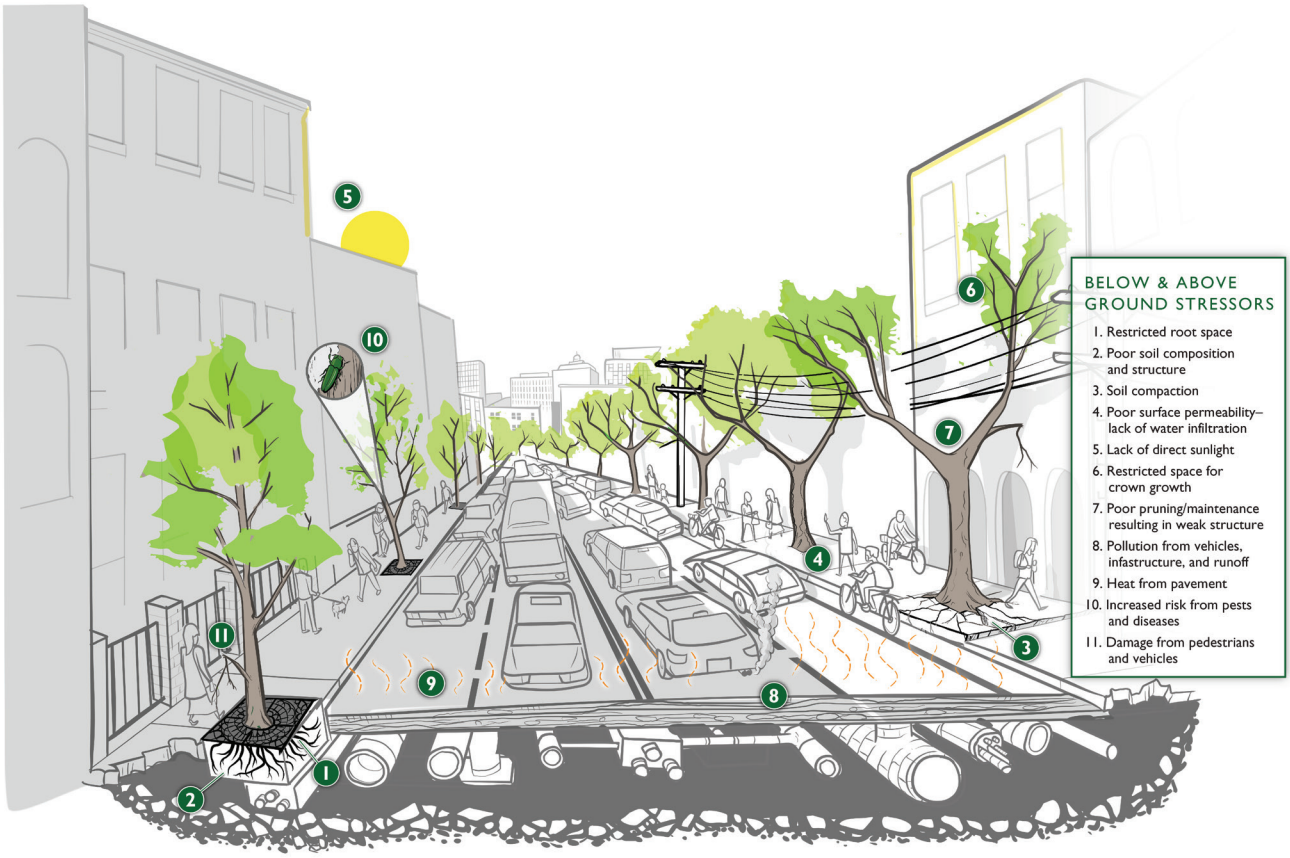


Figure 1: Trees face numerous challenges below and above ground in the built environment. These stressors can potentially limit their ability to survive and reach maturity (Figure from Cavender and Donnelly 2019).

Figure 2: Project area map. Sixteen hundred plots (approximately 200 plots from each of the seven counties and the city of Chicago) were assessed in 2020. Data from 1,576 out of the 1,600 plots were successfully updated.

Number of Trees

The region has an estimated 172,297,000 trees (stem count), a 12% increase from 157,142,000 in 2010. The seven-county region has an estimated 168,300,000 trees, and the city of Chicago has 3,997,000 trees. Kendall County has the lowest number of trees per acre (15), whereas Lake County has the highest number of trees per acre (149) (Table 2).

WHAT IS A TREE? WHAT IS A SHRUB?

For an i-Tree Eco project, shrubs are typically defined as woody plants with a diameter at breast height (DBH) less than 1 inch, whereas trees have a DBH greater than or equal to 1 inch. Woody plants that are not taller than 12 inches in height (e.g., seedlings) are considered herbaceous cover.

AREA	NUMBER OF TREES	AREA (ACRES)	TREES PER ACRE
Suburban Cook	44,590,000	462,000	73
DuPage	19,764,000	215,000	92
Kane	8,596,000	335,000	26
Kendall	2,991,000	206,000	15
Lake	44,726,000	300,000	149
McHenry	24,894,000	391,000	64
Will	21,592,000	544,000	40
City of Chicago	3,997,000	150,000	27

Table 2: Total number of trees, acreage, and average number of trees per acre in each of the seven counties of the Chicago region and the city of Chicago.

For the seven-county region, the top species in terms of the number of individual trees (stem count) are **European buckthorn** (*Rhamnus cathartica*), **boxelder** (*Acer negundo*), **black cherry** (*Prunus serotina*), and **Amur honeysuckle** (*Lonicera maackii*). Two of the top four species (European buckthorn and Amur honeysuckle) are invasive (Figure 3). The species with the highest stem count for the city of Chicago are **white mulberry** (*Morus alba*) and **European buckthorn** (Figure 4).

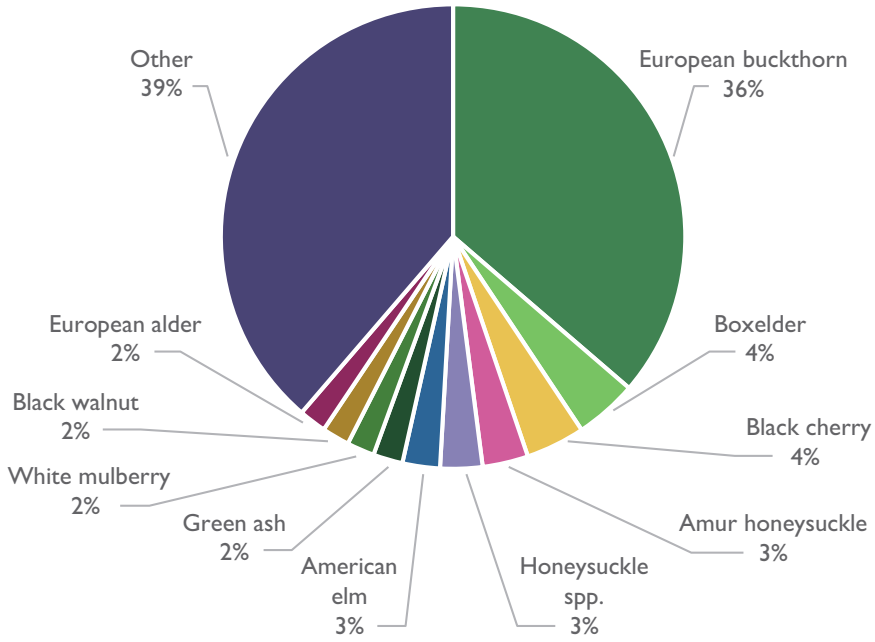


Figure 3: Top 10 species based on stem count in the seven-county Chicago region, shown with the percentage of the population.

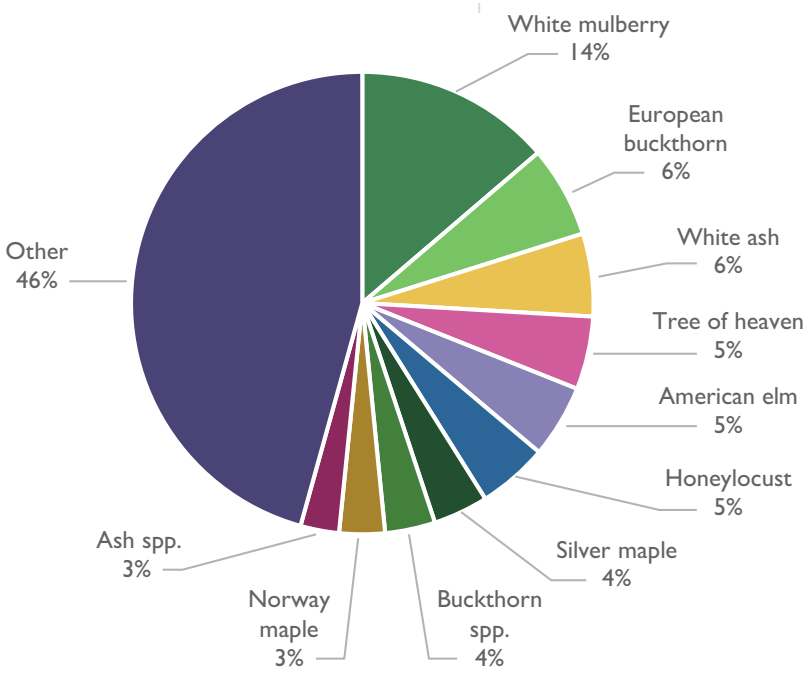


Figure 4: Top 10 species based on stem count in the city of Chicago, shown with the percentage of the population.

Tree and Shrub Canopy Cover

As a part of this analysis, i-Tree canopy was used to estimate canopy cover across the region. These values were compared to a LiDAR-based assessment that was completed in 2010. The tree and shrub canopy cover increased from 2010 to 2020 in six of the seven counties (suburban Cook, DuPage, Kane, Kendall, Lake, and Will), while the tree and shrub canopy cover decreased in the city of Chicago and McHenry County. The tree and shrub canopy cover in the Chicago region is 23%, with the highest tree density and canopy cover in suburban counties (Table 3, page 10). This trend correlates with the approximately 10% increase in the estimated total number of trees from 2010 to 2020.

The 2010 tree census identified that the seven-county regional forest was going through a "state of transition" (Fahey et al. 2012), largely because of the significant loss of ash trees due to the emerald ash borer (EAB, *Agrilus planipennis*—more discussion on page 13), and therefore, the regional canopy cover of the seven-county region was expected to decrease. A possible explanation for the increase in the canopy cover in six of the counties could be due to suburban sprawl and conversion of agricultural lands. Over the past 10 years, a portion of agricultural land has been replaced with residential area, often with the addition of planted trees to make them more desirable places for people to live. During the past decades, these trees grew and became established, explaining in part the increased canopy cover. Additionally, the expansion of fast-growing pioneer species, such as the invasive European buckthorn, can also increase the canopy cover.

It is likely that the loss of mature ash trees contributed to the decline of canopy cover in the city of Chicago. Overall, the trees and shrubs have either not been replaced or if replaced, they have not grown in sufficiently to create a mature canopy.

> The tree and shrub canopy cover increased from 2010 to 2020 in six of the seven counties, while the tree and shrub cover decreased in the city of Chicago and in McHenry County.

The 2010 tree and shrub canopy cover shown was determined using a LiDAR-based land cover assessment that was completed by the University of Vermont's Spatial Analytics Lab and the USDA Forest Service. For 2020, it was estimated using 9,000 randomized points using the i-Tree Canopy tool.

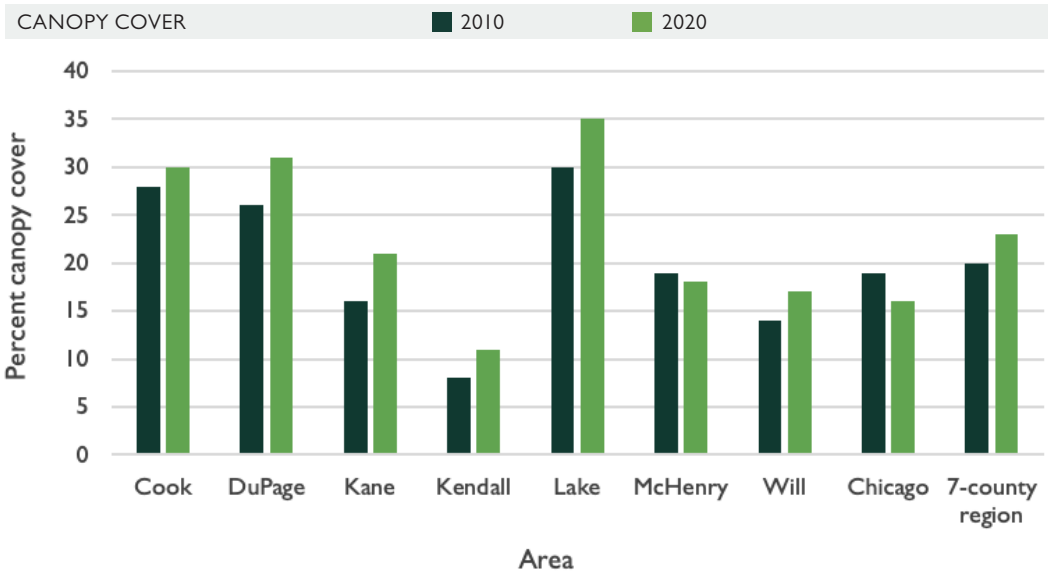
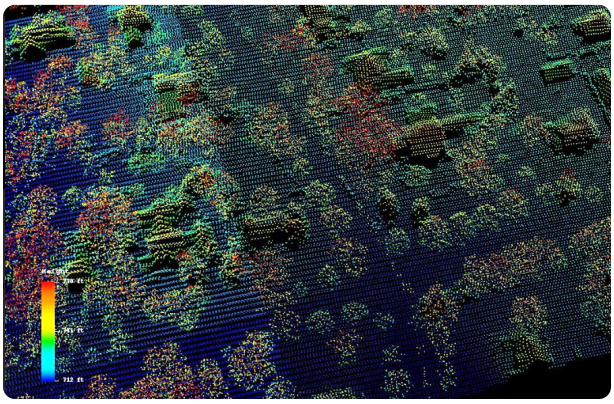


Figure 5: Comparison of tree and shrub canopy cover between 2010 and 2020.

AREA	2010 TREE AND SHRUB CANOPY COVER	2020 TREE AND SHRUB CANOPY COVER
Suburban Cook	29%	30%
DuPage	26%	31%
Kane	16%	21%
Kendall	9%	11%
Lake	30%	35%
McHenry	19%	18%
Will	14%	17%
City of Chicago	19%	16%
Whole region	21%	23%

Table 3: A comparison of the tree and shrub canopy of each of the seven counties, the city of Chicago, and the whole region. Tree and shrub canopy cover is highest in suburban counties.

Although the overall increase in canopy cover is encouraging, assessing the canopy quality would provide additional information in management of the regional forest. The Morton Arboretum is collaborating with the USDA Forest Service and the University of Vermont Spatial Analysis Lab to conduct an Urban Tree Canopy (UTC) Study of the region. The analysis of high-resolution images and LiDAR data will provide additional detailed accounting of the region's tree canopy, providing more information on the structure of the regional forest.



This LiDAR image shows heights of features in the landscape. These images can be used to identify where tree canopy, buildings, and other land surface features are located.

CANOPY INEQUITY

Tree and shrub canopy cover is not equitably distributed throughout the region, especially in the city of Chicago and portions of Cook County. Under-resourced communities often do not have the budget to plant and maintain trees. In order to have a more sustainable city and to maximize the benefits of trees, everyone needs to have access to green spaces with healthy and mature trees (CRTI Priority Map).

Forest Diversity

Through the 2020 assessment, 194 different tree species were recorded in the seven-county region, with 103 species in the city of Chicago. Of the 194 species, 37% are native to Illinois. Since these numbers were determined using the inventory of species in the sample plots, the diversity of the regional forest might actually be higher. Across the region, the number of tree species (an indicator of forest diversity) is generally highest for residential land use, followed by open space.

Comparing the species composition between 2010 and 2020, many of the top species remain the same. The most abundant species by stem count in the seven-county Chicago region is European buckthorn (*Rhamnus cathartica*), and white mulberry (*Morus alba*) for the city of Chicago (Figure 6; Figure 7, page 12). The genus maple (*Acer*) has strong representation in both the seven-county region and the city of Chicago, with three species on the top 10 species list: silver maple (*Acer saccharinum*), boxelder (*Acer negundo*), and Norway maple (*Acer platanoides*). Multiple invasive species also contribute to and lead the top 10 species lists: European buckthorn, black locust (*Robinia pseudoacacia*), tree of heaven (*Ailanthus altissima*), and Amur honeysuckle (*Lonicera maackii*).

Silver maple (*Acer saccharinum*)

Despite the impacts of Dutch elm disease, American elm (*Ulmus americana*) is a commonly found tree throughout the region. Although still on the top 10 list in the seven-county region, the relative abundance of green ash (*Fraxinus pennsylvanica*) has decreased drastically due to the removal and replacement of the green ash killed by the emerald ash borer (EAB). Ash management and treatment programs implemented by some regional municipalities have been effective in managing EAB and protecting the remaining ash population.

The regional forest comprises a variety of native and nonnative tree species typical of a built environment, influenced by a wide range of land-use classes, frequent disturbances, and introduction of species, especially from residential and commercial properties. Additionally, some nonnative species may have an advantage by being better adapted to growing in the harsh conditions of the built environment. Although a subset of nonnative species can become invasive and cause undesirable economic, social, or biological effects, nonnative species, if well selected, can add much needed biodiversity and ecosystem services to the region.

Species diversity is necessary to maintain a healthy and sustainable forest; this is especially important given the threats of climate change, and of insects and pathogens that target specific tree species.

Not all species provide the same type, or the same level, of benefits. Search hundreds of tree and plant profiles on the Arboretum's website to evaluate which trees to plant and where to maximize the diversity of the regional forest.

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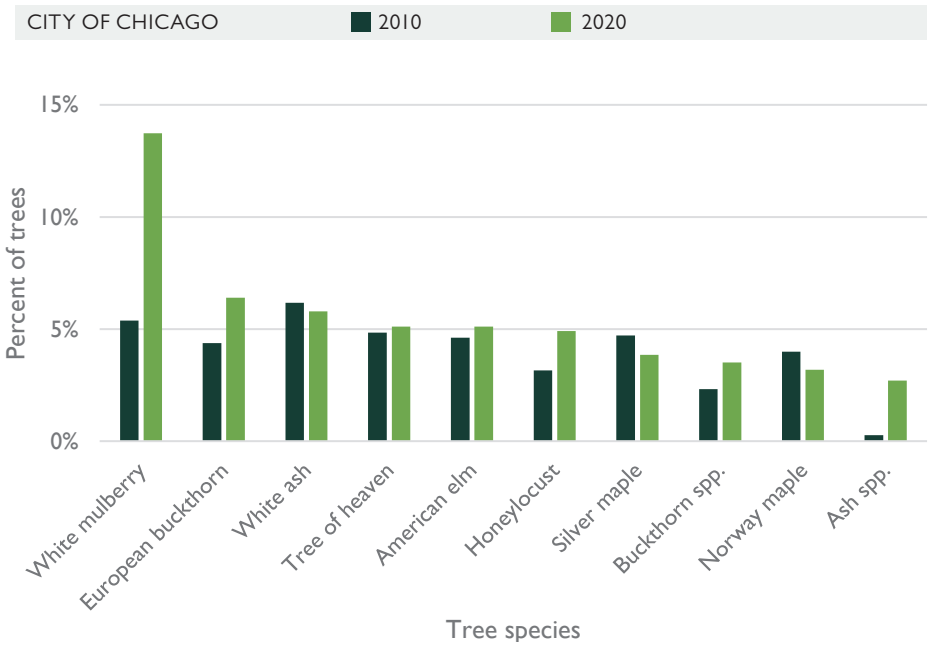


Figure 6: Population change of the top 10 species in the city of Chicago, 2010 and 2020.

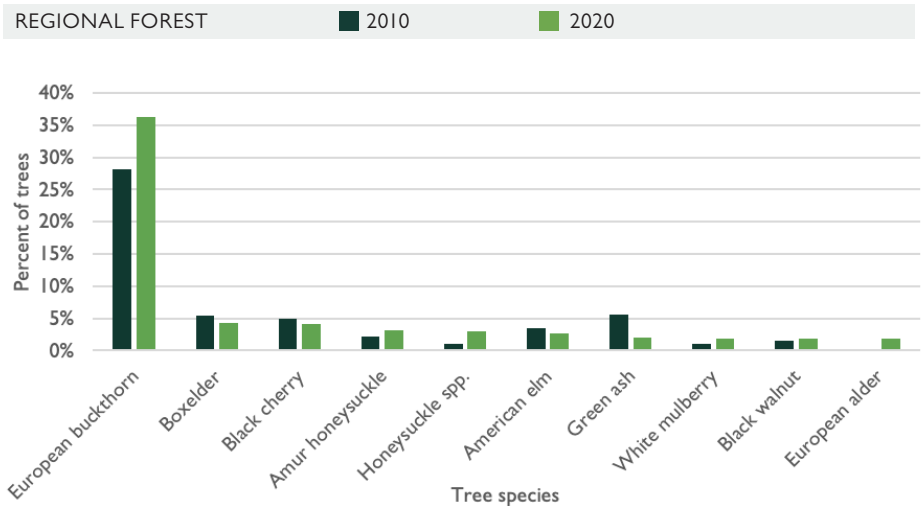


Figure 7: Population change of the top 10 species in the regional forest, 2010 and 2020.

Ash

In 2010, there were an estimated 13 million ash trees in the regional forest, including green ash (*Fraxinus pennsylvanica*), white ash (*Fraxinus americana*), black ash (*Fraxinus nigra*), and other ash species (*Fraxinus* spp.). In 2020, the estimated number of standing ash trees decreased by 46% to 7 million (Table 4). This loss is largely due to the removal of trees killed by the emerald ash borer (EAB). Over the past decade, the stem counts of green ash dropped from around 9 million to 4 million, and the number of white ash dropped from 4 million to less than 3 million.

Due to EAB control with insecticides in some neighborhoods, some ash trees from medium to larger size classes remain. Regardless, in 2020, about half of the ash trees were either in poor or declining health or dead, and a very small proportion are in excellent condition, particularly in comparison to 2010 (Figure 8, page 18).

Interestingly, the number of unidentified ash (*Fraxinus* spp.) stems increased from 10,000 in 2010 to 540,000 stems in 2020. Black ash increased in the regional forest from around 2,000 stems to 19,000 stems. This is likely due to prolific resprouting from the stumps of removed ash trees. Further assessments can provide additional clarity on this observation. Importantly, more than 30% of ash trees in the seven-county region are saplings, with a diameter of 3 inches or smaller, and only 13% of ash trees in the region have a diameter of 12 inches or larger. The ash population appears to be regenerating, but given the likely prevalence of the emerald ash borer, the chances that the trees will grow to maturity without intervention are unlikely. Additionally, many of these young ash trees are not growing in areas where they will be able to mature, especially if they are resprouts.

SPECIES	ESTIMATED NUMBER IN 2010	ESTIMATED NUMBER IN 2020	CHANGE IN ESTIMATE
Green ash (*Fraxinus pennsylvanica*)	8,657,000	3,456,000	-5,201,000
White ash (*Fraxinus americana*)	4,025,000	2,827,000	-1,198,000
Ash species *Fraxinus* spp.	10,000	540,000	530,000
Black ash (*Fraxinus nigra*)	2,000	19,000	17,000

Table 4: The differences in the estimated number of ash species in the seven-county region from 2010 to 2020. This change is largely due to the emerald ash borer.

White ash
(*Fraxinus americana*)

CONDITION OF ASH TREES IN THE CHICAGO REGION

SPECIES (COUNT)	CONDITION						
	EXCELLENT	GOOD	FAIR	POOR	CRITICAL	DYING	DEAD
Ash spp. (544,052)	0%	14%	2%	0%	0%	0%	84%
Black ash (18,552)	0%	0%	0%	12%	0%	0%	0%
Green ash (3,677,738)	3%	30%	12%	10%	6%	4%	37%
White ash (2,695,828)	2%	41%	11%	11%	4%	5%	29%

Table 5: The condition of the remaining ash population. An estimated 6.8 million ash trees are still standing in the region. However, this number includes 4 million standing dead trees and trees in decline.

Standing ash trees decreased by 46% to 7 million, with approximately 4 million either dead or in decline, leaving only 3 million healthy ash trees in the region.

Leaf Area and Importance Value

Leaf area is an important variable to understand, as many of the benefits that trees yield are directly related to the amount of healthy leaf surface area on the plant. Importance value (IV) is calculated by combining the gross leaf surface area of a species with its abundance in the overall population. The IV can be used to indicate the beneficial contributions of a particular species to the regional forest. A high importance value should not be the only variable considered when selecting trees to plant.

Ranging from 4% to 55% in different counties, European buckthorn (*Rhamnus cathartica*) is the most abundant tree species in the region (36% of all stems). It is an invasive, small, understory tree species, and has the most leaf area (10%) and the highest importance value for the seven-county region. Although significantly lower in abundance, larger trees such as the silver maple (*Acer saccharinum*) (9% of the leaf area, 2% of the population), black walnut (*Juglans nigra*) (7% of the leaf area, 2% of the population), and boxelder (*Acer negundo*) (6% of the leaf area, 4% of the total population) contribute significantly to the overall benefits of the region (Table 6, page 16).

In the city of Chicago, white mulberry (*Morus alba*) is the most abundant tree (14% of the population, 4% of the leaf area); however, silver maple (4% of the population, 16% of the leaf area) provides the most leaf area, and therefore, the most associated benefits (Table 7, page 17).

While European buckthorn has the highest importance value for the seven-county region, this metric must be considered holistically. European buckthorn is a highly invasive woody shrub that aggressively outcompetes other species, creates a monoculture, and reduces the biodiversity of an area. Further, through its dense canopy, it prevents the regeneration of native species, such as oaks, by reducing the amount of light that reaches the forest floor. Its high importance value for the region is alarming and signifies that management action must be taken to remove buckthorn throughout the region and replace it with more diverse and appropriate species. (See Healthy Hedges on page 26.)

The top two species with the highest importance value in the city of Chicago are silver maple and Norway maple (*Acer platanoides*), which highlights the need for increased diversity throughout the city because both of these species are susceptible to the Asian longhorned beetle and the spotted lanternfly (see page 27). If an infestation were to occur, Chicago has the potential to lose a significant amount of its canopy and the associated benefits that these trees provide.

Tree species with larger canopy, such as maples, provide more benefits than European buckthorn, an invasive, small understory species.

TOP 10 SPECIES BY LEAF AREA IN THE REGION

SPECIES	LEAF AREA	PERCENTAGE OF TOTAL TREES	IMPORTANCE VALUE (IV)
European buckthorn (*Rhamnus cathartica*)	10%	36%	46%
Silver maple (*Acer saccharinum*)	9%	2%	10%
Black walnut (*Juglans nigra*)	7%	2%	9%
Boxelder (*Acer negundo*)	6%	4%	10%
Cottonwood (*Populus*)	6%	2%	7%
Bur oak (*Quercus macrocarpa*)	4%	1%	6%
Black cherry (*Prunus serotina*)	4%	4%	9%
Red oak (*Quercus rubra*)	4%	2%	6%
American elm (*Ulmus americana*)	4%	3%	7%
Norway maple (*Acer platanoides*)	3%	1%	4%

Table 6: Top 10 species by leaf area in the seven-county Chicago region.

TOP 10 SPECIES BY LEAF AREA IN CHICAGO

SPECIES	LEAF AREA	POPULATION	IMPORTANCE VALUE (IV)
Silver maple (*Acer saccharinum*)	16%	4%	19%
Norway maple (*Acer platanoides*)	11%	3%	14%
White ash (*Fraxinus americana*)	7%	6%	13%
American elm (*Ulmus americana*)	6%	5%	11%
Honeylocust (*Gleditsia triacanthos*)	6%	5%	11%
Mulberry species (*Morus*)	5%	2%	8%
Basswood (*Tilia americana*)	5%	2%	7%
White mulberry (*Morus alba*)	4%	14%	18%
Cottonwood (*Populus*)	4%	1%	5%
Tree of heaven (*Ailanthus altissima*)	4%	5%	9%

Table 7: Top 10 species by leaf area in the city of Chicago.

Forest Structure

In this assessment, tree measurement started from 1 inch DBH and above to provide useful information on small understory species, as well as data on the trees that are likely to form the canopy of the future forest. The structure of the Chicago region forest is dominated by smaller trees.

Approximately 75% of the population is less than 6 inches in DBH. In the city of Chicago, 66% of the population is less than 6 inches DBH. While the percentage is highly skewed to the smaller DBH classes, many of these trees are European buckthorn, which will never enter the larger DBH classes (Figure 8).

WHAT IS FOREST STRUCTURE?

Forest structure is a measure of the various physical attributes of the vegetation, including the number of trees, biomass, tree density, canopy condition, leaf area, and species diversity. A sustainable and functional urban forest should have a structure that includes large, mature trees to provide the widest range of environmental benefits and younger trees to eventually replace the large, mature trees as they reach mortality.

> The structure of the Chicago region forest is dominated by smaller trees.

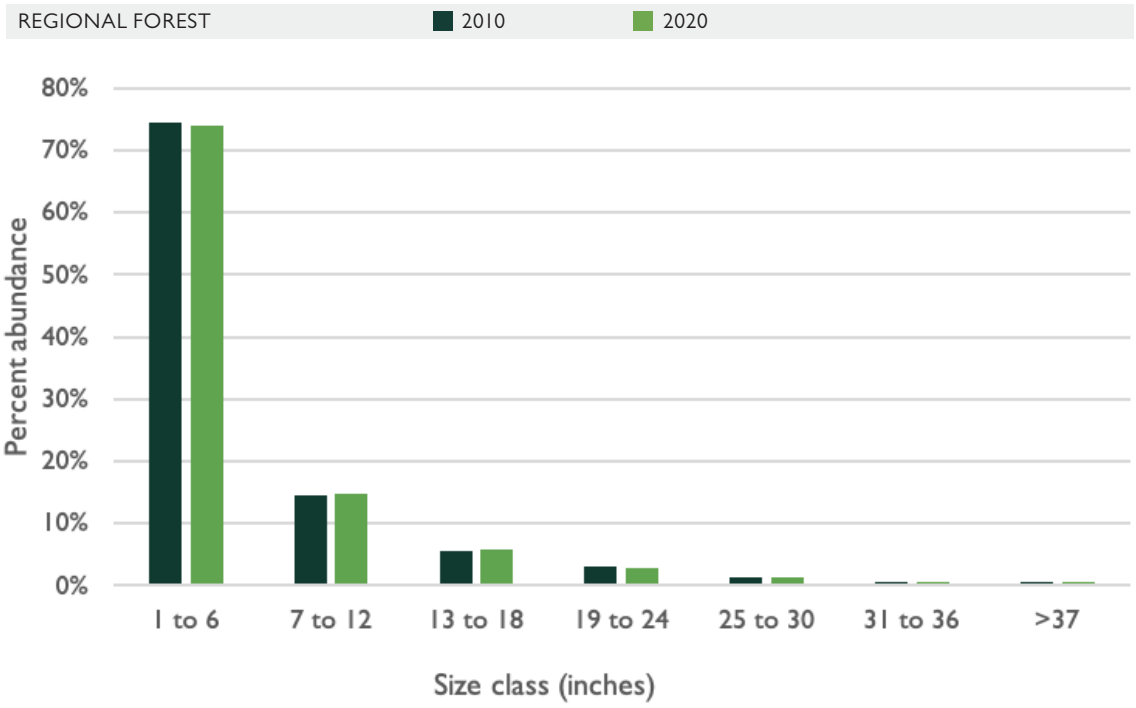


Figure 8: Comparison of size classes distribution between 2010 and 2020, showing a stable distribution of size classes in the regional forest. The distribution over these two decades remains skewed to smaller size classes, demonstrating the need to manage and support tree species that are able to grow into larger size classes in the future.

Larger trees, with greater than 18 inches DBH (5% percent of all trees in 2020), are found throughout the region. The city had the highest percentage of trees greater than 18 inches in residential, open space, and CTI (commercial/transportation/institutional) land use. The relatively large trees in the city may reflect preservation of remnant vegetation, tree planting as a part of early settlement, and the establishment of green spaces in neighborhoods, such as parks and forest preserves (Watson et al. 2013).

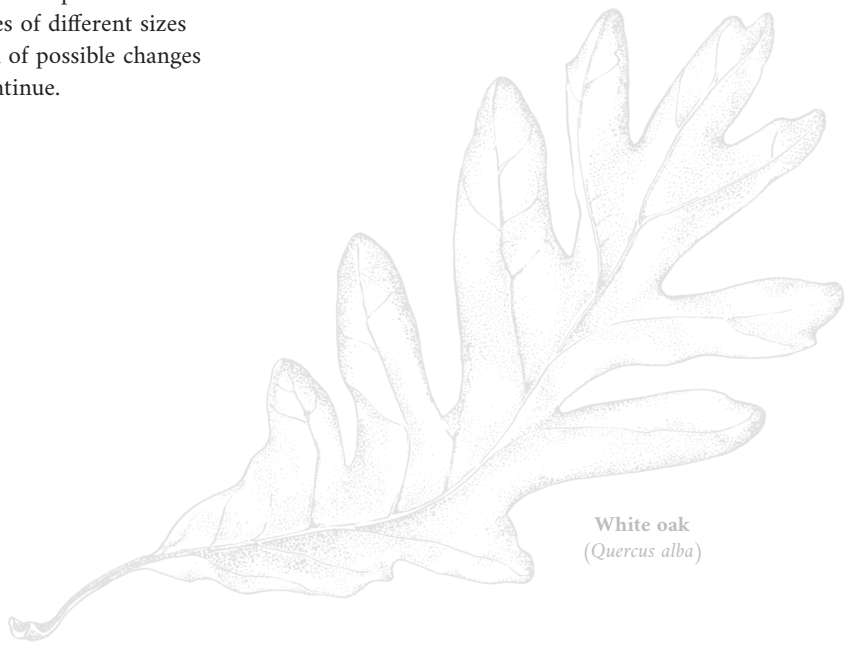
In the seven-county region, larger trees, with 18 inches DBH or larger, are more likely to be found on residential property than any other land classification. Large trees in these areas are also most likely due to tree plantings when neighborhoods were being established more than 50 years ago, as well as the preservation of remnant trees. Further, people are more likely to be connected to trees that are found on residential land, taking more ownership in tree care, and ultimately influencing the trees' ability to reach maturity.

Both the 2010 and 2020 tree censuses are snapshots of the regional forest at one point in time. These snapshots can provide a clue to the future forest, since much of that forest will emerge from younger trees in the present forest. Analysis of species composition for trees of different sizes (proxy for ages) provides an indication of possible changes in the years ahead if current trends continue.

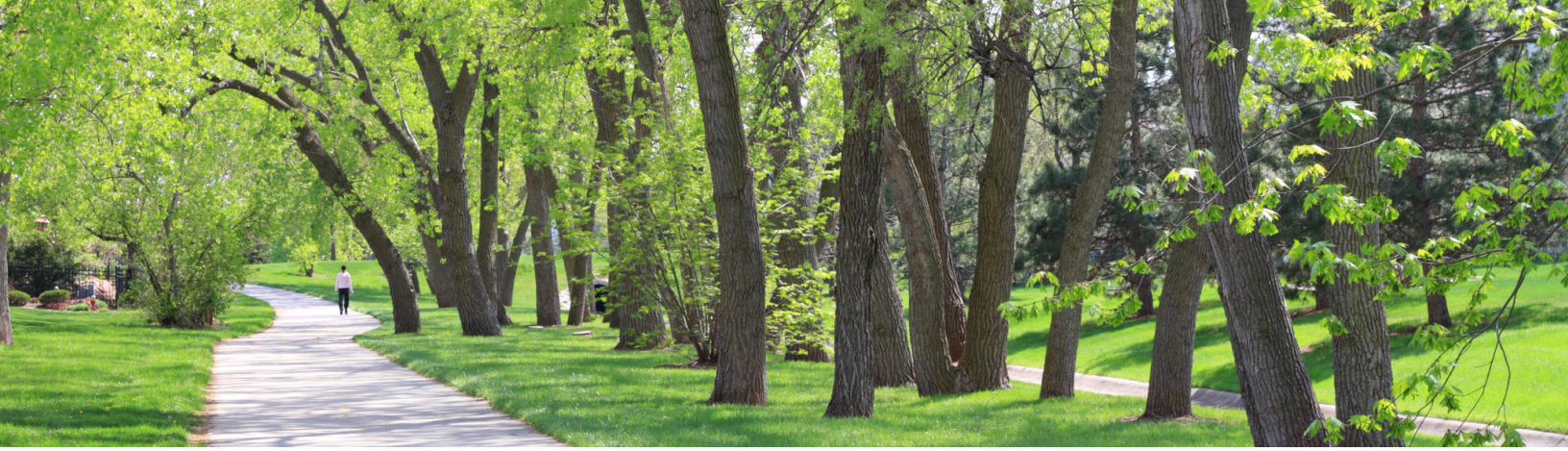
A compelling example in the seven-county region is the bur oak (*Quercus macrocarpa*). Bur oak is a prominent species among large trees (greater than 18 inches DBH); but the tree is far less common among the small diameter trees that will make up the future forest. This finding suggests that bur oak may not be as large a component of the regional forest in the years ahead.

MORE CANOPY, MORE BENEFITS

Long-lived large trees with large canopies are essential elements in a healthy, vigorous urban forest, given their especially high potential to sequester carbon, remove air pollution, and moderate high summer temperatures through shading and evapotranspiration cooling.



White oak
(*Quercus alba*)



Forest functions, which are determined by forest structure, include a wide range of environmental and ecosystem services such as air pollution removal and cooler summer air temperatures. The economic benefits described in the following section are conservative estimates for the regional forest, since many of the services provided by urban trees are still being researched and are not yet quantified or valued by i-Tree Eco.

Removing Air Pollution

VALUE: $192 MILLION PER YEAR

Poor air quality is a common problem in many urban areas. Ozone and particulate matter are the two forms of air pollution that have the greatest impact on human health and can cause premature death, heart attacks, irregular heartbeat, asthma attacks, and irritation of the lungs that can cause coughing or difficulty breathing (Environmental Protection Agency 2020). In addition to the impact on human health, poor air quality can also affect ecosystem processes.

Thoughtfully planted, healthy trees can help improve air quality by reducing air temperature, directly removing pollutants from the air and trapping them on leaf surfaces, and by reducing energy consumption in buildings. Reducing energy consumption consequently reduces air pollutant emissions from the power sources. Pollution removal by trees and shrubs in the Chicago region was estimated using field data and recent available pollution and weather data.

It is important to note that although a number of tree species can produce the volatile organic compounds (VOCs) that lead to ozone production in the atmosphere, the i-Tree Eco software accounts for both reduction and production of VOCs within its algorithms. While at a site-specific level some trees may cause VOC disservices, the overall effect of the region's trees reduces the production of ozone through evaporative cooling.

> Trees and shrubs remove an estimated 18,600 tons of air pollution: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter less than 2.5 microns (PM2.5), and sulfur dioxide (SO_2) per year, with an associated value of $192 million.

Storing and Sequestering Carbon

VALUE: $4 BILLION IN CARBON STORAGE; $93 MILLION IN CARBON SEQUESTRATION PER YEAR

The Chicago Metropolitan Agency for Planning (CMAP) ON TO 2050 comprehensive plan highlights climate change and greenhouse gas emissions (GHGs) as important issues facing the region. GHGs, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), trap and retain heat in the atmosphere, leading to warmer temperatures and more frequent and intense storm events. Carbon dioxide is a major greenhouse gas, and the region's transportation activities account for more than half of the carbon dioxide emissions in Illinois.

Trees reduce the amount of carbon in the atmosphere by sequestering it in new growth every year. The amount of carbon sequestered annually is increased with the size and health of the trees. Gross sequestration by the region's trees is about 543,000 tons of carbon per year, with an associated value of $93 million.

CARBON STORAGE PROCESS

Carbon dioxide is sequestered in tree trunks, branches, leaves, and roots during photosynthesis. The amount of carbon that can be stored is directly related to the size of the tree—larger trees store more carbon.

STORAGE VS. SEQUESTRATION

Carbon storage: The estimated amount of carbon currently held in tree tissue such as roots, stem, and branches.

Carbon sequestration: The estimated amount of carbon removed annually by trees.

As a tree grows, it stores carbon by holding it in its accumulated tissue. As a tree dies and decays, it releases the stored carbon back into the atmosphere. Carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose. Maintaining trees to keep them healthy will keep the carbon stored in trees longer, but activities such as pruning, removal, wood chipping, and prescribed burns can also contribute to carbon emissions (Nowak and Crane 2002).

Trees in the regional forest store an estimated 20 million tons of carbon. The value of storing this carbon is estimated to be around $4 billion. Of the species sampled, silver maple (*Acer saccharinum*) stores the most carbon (approximately 11% of the total carbon stored). Having the highest stem count, European buckthorn (*Rhamnus cathartica*) sequesters the most annually (approximately 9% of all sequestered carbon).

Mitigating Runoff

VALUE: $100 MILLION PER YEAR

The ON TO 2050 comprehensive plan for the Chicago region noted that the region's infrastructure is aging and insufficient for today's needs. Due to the changing climate, the intensity and frequency of storm events have increased in the region. These events can produce more rain than the region's stormwater systems were designed to handle—leading to overtaxed systems and flooding.

Trees intercept rainfall in their canopies during storm events. This intercepted rainfall evaporates from leaves or slowly soaks into the ground, reducing, cooling, and slowing stormwater runoff and lessening erosion. Underground tree root growth and decomposition help to increase the amount of water the soil can retain, allowing for greater absorption of stormwater.

STORMWATER INTERCEPTION

Trees and shrubs are beneficial in reducing surface runoff. The canopies can intercept precipitation, whereas the root systems promote infiltration and storage in the soil. In many metropolitan areas, especially areas with a large extent of impervious surfaces, surface runoff can be a cause for concern by carrying pollution to streams, wetlands, rivers, lakes, and oceans.

Based on the data from local weather stations, the trees and shrubs in the region help to reduce runoff by an estimated 1.5 billion cubic feet per year, with an associated value of around $100 million.

Reducing Energy Consumption

VALUE: $32 MILLION PER YEAR

A properly planted tree can reduce building energy consumption in the summer and/or winter months. Shade from large, healthy trees that are properly cared for lowers city and building temperatures by reducing the amount of sunlight that is absorbed and stored by impervious surfaces (e.g., roads, buildings, sidewalks), while their leaves release water vapor (transpiration) to cool the surrounding area. Trees also can block cold winter winds. The estimated impact of trees on energy use is calculated using field measurements of the distance and location of the tree to residential buildings (McPherson and Simpson 1999). Trees in the regional forest are estimated to reduce energy-related costs from residential buildings by $32 million annually. They provide an additional $10 million in value by reducing the amount of carbon released by fossil fuel–based power plants (a reduction of 58,800 tons of carbon emissions).

Trees in the regional forest are estimated to reduce energy-related costs from residential buildings by $32 million annually.

Structural Value

TOTAL STRUCTURAL VALUE: $49 BILLION

The regional forest has a structural value based on the trees themselves. The value includes the cost of replacing the trees with similar trees, and the value of the carbon they store. The cost of replacing the entire Chicago region forest is estimated at $45 billion, and the value of the carbon stored in the region's trees is estimated at $4 billion.

Comparing 2010 and 2020, the replacement value of the regional forest has declined from $51 billion to $45 billion (Table 8). Since the structural value is correlated to the number and size of healthy trees, the loss of approximately 6 million ash trees has greatly impacted the structural value.

Functional Value

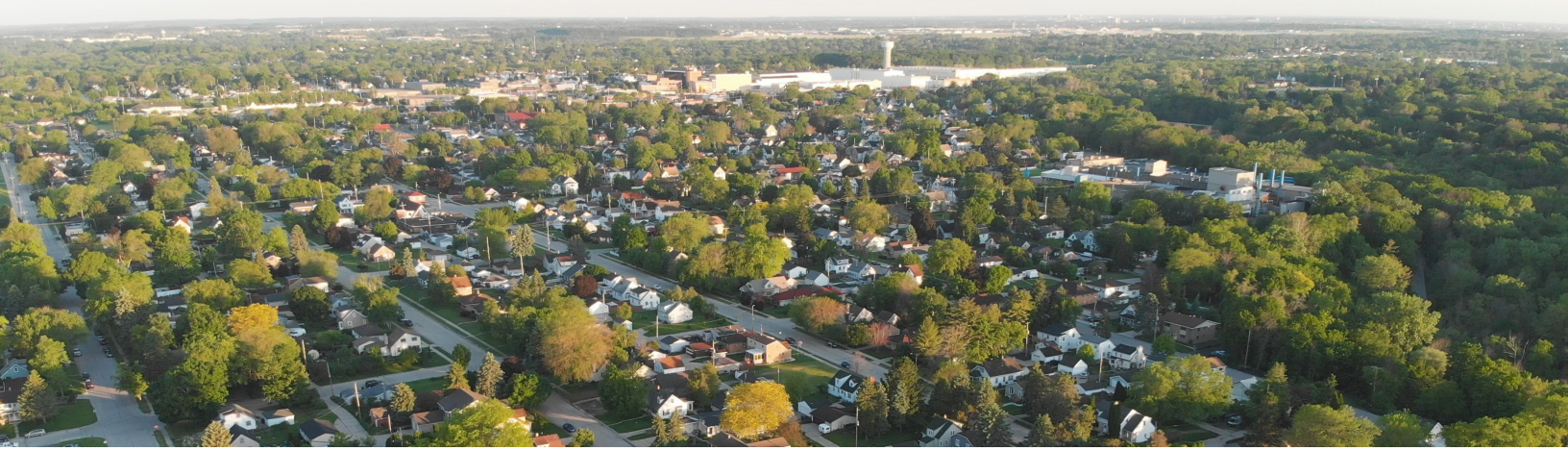
ANNUAL FUNCTIONAL VALUE: $416 MILLION

The functional value of regional forest is based on the myriad ecosystem services performed by trees (e.g., carbon sequestration, avoided runoff, pollution removal, reduced energy costs). Only a fraction of the value of these services is captured in this report, but a minimum estimate of the functional value of the Chicago region forest is more than $416 million annually.

The structural and functional values of a regional forest tend to increase with the number and size of healthy trees (Nowak et al. 2002). Through proper management, regional structural and functional forest values can appreciate over time. However, the values and benefits can decrease if the canopy becomes unhealthy or if the trees are mismanaged.

Total Structural Value	Replacement value: $45 billion
	Carbon storage: $4 billion
Annual Functional Value	Carbon sequestration: $93 million
	Avoided runoff: $100 million
	Pollution removal: $192 million
	Energy costs and carbon emission value: $32 million

Table 8: Estimated structural and functional values of the seven-county regional forest in 2020.



Dynamic Regional Forest

As the third-largest metropolitan area in the United States, the Chicago region is vibrant and dynamic. It is a major transportation and distribution hub with high national and international traffic connections. This extensive network creates unique management issues, particularly as grey infrastructure and brownfield sites are not actively managed for benefit or function. Hence, they can be areas where invasive species can establish. Largely, though, the greatest contributors to change in the regional forest are the consequences of connectivity: the spread of woody invasive species, as well as pests and diseases. The transportation network leads to the expansion of range, and lack of management often supports spontaneous regeneration by naturalized species.

Invasive Woody Species

Invasive plant species are often characterized by their vigor, acclimation, reproductive capacity, and lack of natural enemies. Invasives often thrive in areas of high disturbance and in harsh growing conditions. As seen in the 2010 and 2020 tree censuses, the regional forest continues to be dominated by exotic, invasive species—specifically European buckthorn (*Rhamnus Cathartica*) and Amur honeysuckle (*Lonicera maackii*) (Nowak 2013). This is likely due to the connectivity of the region, its wide variety of land use classes, lack of environmental management of transportation corridors, introduction of nonnatives in residential communities, and the harsh growing conditions in urban and suburban settings, among other reasons. In fact, the 2020 census found that these two species now make up more than 42% of the region's trees.

Invasive species can greatly impact the biodiversity of a region, as well as the forest structure and function. To have a healthy and sustainable regional forest, there needs to be a special emphasis on removing these invasive woody species and replacing them with a diverse selection of woody plants. This is critical for the future of the seven-county region of Chicago.

European buckthorn and Amur honeysuckle make up more than 42% of the region's trees.

TOP INVASIVE SPECIES IN THE REGION

SPECIES	STEM COUNT IN 2010	STEM COUNT IN 2020	CHANGE IN STEM COUNT
European buckthorn (*Rhamnus cathartica*)	44,866,000	63,382,000	18,516,000
Amur honeysuckle (*Lonicera maackii*)	4,930,000	10,539,000	5,609,000
Black locust (*Robinia pseudoacacia*)	2,972,000	2,270,000	-702,000
Tree of heaven (*Ailanthus altissima*)	1,831,000	978,000	-853,000
Russian olive (*Elaeagnus angustifolia*)	283,000	505,000	222,000
Callery pear (*Pyrus calleryana*)	258,000	495,000	237,000
Burning bush (*Euonymus alatus*)	149,000	143,000	-6,000
Privet (*Ligustrum sinense*)	37,000	113,000	76,000

Table 9: Top invasive species in the seven-county Chicago region in 2010 and 2020.

Healthy Hedges

Woody invasive plants, such as European buckthorn (*Rhamnus cathartica*) or Eurasian bush honeysuckles (*Lonicera* spp.), form dense thickets and reproduce aggressively, shading out other plants and disrupting ecosystems. In woodlands, they can completely replace young trees and understory plants, including native wildflowers. The formation of dense thickets can prevent regeneration of native tree species, such as oaks (Fahey et al. 2015), which can have a significant impact on forest structure. Buckthorn also causes long-lasting damage to the soil and wildlife habitat where it grows.

Unfortunately, these woody invasive plants are also commonly found in residential landscaping, sometimes serving the function as hedges. They can be replaced with species highlighted in the Healthy Hedges program, an initiative of the Chicago Region Trees Initiative to reduce the damage caused by invasive woody plants.

European buckthorn (*Rhamnus cathartica*)

Amur honeysuckle (*Lonicera maackii*)

Image credit : Allyson Frederick, Lake County Forest Preserve District

Pests and Diseases

Pests and diseases can cause considerable damage and mortality to healthy trees—negatively impacting the structure, function, resilience, and benefits that the regional forest provides. Globalization and increased transportation connectivity have led to an increased spread of nonnative insects and diseases, extending beyond the typical range for many. The regional forest is familiar with the devastating effects of tree pests, as the emerald ash borer has killed millions of ash trees in the region (see Ash section, page 13).

The 2020 tree census identified insects and diseases that have the potential to impact, or have impacted, the regional forest. These include the European gypsy moth (EGM, *Lymantria dispar*), emerald ash borer (EAB, *Agrilus planipennis*), Asian longhorned beetle (ALB, *Anoplophora glabripennis*), spotted lanternfly (SLF, *Lycorma delicatula*), sudden oak death (SOD), and thousand cankers disease (TCD). The magnitude of the threat of loss from the five major pests varies by county and land use. These pests collectively threaten many species, including all but three of the 10 most common tree species; the exceptions being European buckthorn (*Rhamnus cathartica*), black cherry (*Prunus serotina*), and Amur honeysuckle (*Lonicera maackii*). Of these three species, only black cherry is not on the Illinois Invasive Species List. Invasive trees, such as Amur honeysuckle and European buckthorn, have a strong adaptive capacity with little to no host risk for invasive insects and pathogens.

Native trees such as maples (*Acer* spp.), elms (*Ulmus* spp.), and oaks (*Quercus* spp.) are prone to stress with changing climate patterns. Wetter springs followed by drier, drought-like conditions in late summer can stress trees and make them more vulnerable to invasions from the two-lined chestnut borer and to diseases such as hypoxylon canker, oak wilt, bur oak blight, and Dutch elm disease. Insects and diseases impacting oaks (*Quercus* spp.) are a major concern to the native oak ecosystem.

Emerald ash borer
(EAB, *Agrilus planipennis*)

Spotted lanternfly
(SLF, *Lycorma delicatula*)

European gypsy moth
(EGM, *Lymantria dispar*)

PESTS AND DISEASES						
TREE GENUS	LEAF AREA	EUROPEAN GYPSY MOTH	ASIAN LONGHORNED BEETLE*	SPOTTED LANTERNFLY*	THOUSAND CANKERS DISEASE*	SUDDEN OAK DEATH*
Maple (*Acer*)	22%		X	X		
Oak (*Quercus*)	13%	X		X		X
Buckthorn (*Rhamnus*)	10%					
Elm (*Ulmus*)	7%		X			
Walnut (*Juglans*)	7%			X	X	
Poplar (*Populas*)	6%	X		X		
Cherry (*Prunus*)	5%	X				
Mulberry (*Morus*)	4%					
Locust (*Robinia*)	3%	X				
Spruce (*Picea*)	2%					

Table 10: Tree genera and respective leaf area percentages potentially at risk in the seven-county Chicago region.
*Insect or disease not currently established in Illinois.

ASIAN LONGHORNED BEETLE

The Asian longhorned beetle (ALB, *Anoplophora glabripennis*) is an invasive beetle that attacks live, healthy trees. This beetle was found in the city of Chicago in 1998 and eradicated in 2008 (Chicago Asian Longhorned Beetle Eradication Program). However, ALB is still active in Ohio, Massachusetts, New York, and South Carolina, and remains a potential threat across the Midwest. In addition to actively monitoring for signs and symptoms of ALB, focusing on tree diversity and developing a rapid response plan is vital to preventing the establishment and spread of this highly invasive tree pest. Currently in the region, 38% of the leaf area is considered to be a susceptible host for ALB. In the city of Chicago, 53% of the leaf area is considered to be a susceptible host for ALB.

Education, scouting, and monitoring of these and other emerging threats are crucial to the health of the regional forest.

Asian longhorned beetle (ALB)

Summary

The 2020 Chicago Region Tree Census provides information on the extent, location, character, functions, and values of the seven-county Chicago region forest. This report also evaluates how the forest has changed over the past decade. There are positive trends for the regional forest. The regional canopy has increased in both the number of trees (from 157 million to 172 million) and the canopy cover (from 21% to 23%). Through air pollution removal, carbon storage, carbon sequestration, building energy reduction, and reduced carbon emission, the 172 million trees provide $416 million in annual benefits to the people who live and work in this region. Although the overall replacement value has declined since 2010, from $51 billion to $45 billion, the regional forest remains an extremely valuable asset.

This report highlights areas where the regional forest can improve. While the canopy cover has increased, more than 42% of the trees found in this area are considered invasive. Additionally, approximately 75% of the tree and shrub population is smaller than 6 inches DBH. Despite the high number of ash trees dying due to the emerald ash borer infestation, there is considerable regeneration of young ash trees. Their fate will be clearer in future analyses. The regional forest would be improved with an increase in its diversity of species and size classes to ensure resilience against nonnative insects and diseases, and rapidly changing climate.

This report uses the best scientific tools available to capture a snapshot in time of the region's forest. By understanding the key issues that impact the trees and regional forest, stakeholders can prioritize resources and efforts to make the area greener, healthier, and more beautiful for the people who live and work there. Replicating the methodology every 10 years will provide a benchmark for evaluating future trends, the influence of future threats to the forest, and the outcomes of management programs, such as tree planting initiatives, on the regional forest.

Although the overall replacement value has declined since 2010, from $51 billion to $45 billion, the regional forest remains an extremely valuable asset.

Future Efforts

Trees are critical green infrastructure. They are essential infrastructure for the quality of life across the Chicago region. CMAP has projected that the population of the region will increase to 11 million by 2050. As the region continues to grow in population, attention and resources need to be applied to planting the right trees correctly in the right place, and caring for them properly so they can grow to their full potential and provide the most benefits possible.

As outlined in the Chicago Region Trees Initiative Master Plan 2050 (CRTI Master Plan 2019), the regional forest has several key areas that need to be addressed to improve its functional and structural value: increased diversity of both species and size classes, improved regular care and management to promote healthy growth, and reduced threats (such as pests and diseases). The Master Plan recommends that the regional canopy be evaluated every 10 years to understand the dynamics of the regional forest and to identify potential threats and areas that need to be improved.

Given the current state of the regional forest, future work needs to focus on:

- Increased awareness
- Improved planting and tree care
- Increased diversity
- Improved policies
- Engaged residents

Increased Awareness

The residents of the region need a clear understanding of the vital role trees play in their communities, and the vast social, health, economic, and ecosystem benefits they provide. Awareness is the first step to supporting informed advocacy and action. Everyone has a role in improving the regional forest.

Improved Tree Planting and Care

Improved knowledgeable tree care is needed to ensure trees are planted and cared for correctly, so they can thrive and provide the most benefits and services possible. Given that trees planted in the built environment often have high turnover and mortality rates, the right tree needs to be planted correctly with adequate soil and root space, in the right place, and given the right care afterward in order to maximize resources and reduce failures. This includes watering during droughts, implementing regular pruning cycles to improve tree structure, reducing damage to trees and people from storms, and finally, increasing watchfulness for potential pests and pathogens. As larger trees provide more benefits to the region and well-maintained trees are safer and healthier, municipal budgets must include tree care from trained arborists to truly support the regional forest. By treating trees and tree care as an investment, the value of the regional forest can appreciate over time.

Increased Diversity

The regional forest needs greater diversity of tree species and size classes to be resilient to a changing climate, as well as to pests and diseases. Landowners and individuals need to work to remove woody invasive species and replace them with diverse tree and shrub species, or to support the regeneration of native species. Species that are closely related are more likely to be impacted by the same pests and diseases.

The Morton Arboretum recommends that communities follow the 5:10:15 rule when planting trees and shrubs: no more than 5% of trees should be of the same species; no more than 10% should be from the same genus; and no more than 15% should be from the same family. Resources, such as the searchable tree and plant profiles on the Arboretum's website, can help people select diverse trees based on site conditions. People need to not only manage trees so that they can mature, but also plant or allow regeneration so that the canopy is composed of a variety of stages. Diversity of both species and size are important for a healthy regional forest.

Improved Policies

In order to improve the regional forest, residents need to advocate for trees by creating, implementing, and improving tree policies on public and private land throughout the region. Strong policies are needed to guide development and practices to preserve established trees and remnant forest ecosystems. Trees need to be valued and supported by municipalities as a critical infrastructure in the built environment. They need to be resourced, managed, and valued with the same commitment as other forms of infrastructure.

Engaged Residents

The residents of the region need to advocate for tree plantings and care equitably throughout the region. In order to maximize the benefits of trees and ensure a sustainable city of the future, the tree canopy in under-resourced communities needs to improve. These communities often experience poor air and water quality, increased heat, high crime rates, increased health risk, and low percentage of tree canopy.

To improve the health and expand the canopy of Chicago's regional forest, every person living and working in the Chicago region has a role to play—from watering neighborhood trees, to looking for and reporting pests and diseases, to planting diverse trees and shrubs when possible. All people, of all ages, are needed to advocate for and to take action on behalf of the regional forest.

Acknowledgments

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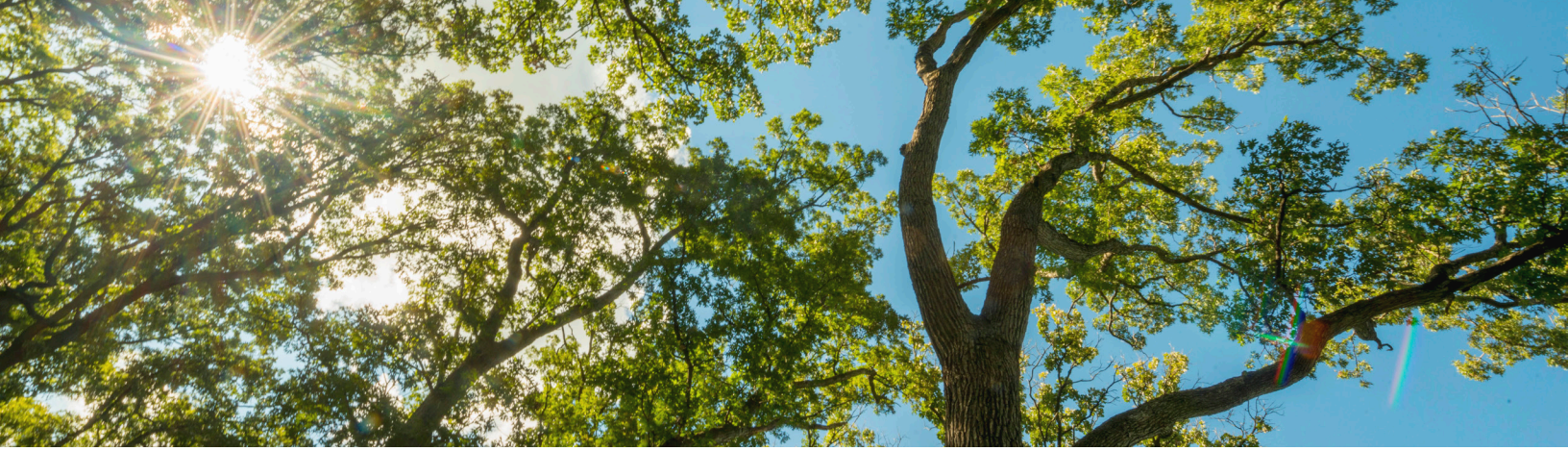

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Mission

The mission of The Morton Arboretum
is to collect and study trees, shrubs, and other plants from around the world,
to display them across naturally beautiful landscapes for people to study and enjoy,
and to learn how to grow them in ways that enhance our environment.
Our goal is to encourage the planting and conservation of trees
and other plants for a greener, healthier, and more beautiful world.

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