An i-Tree Eco Analysis of the Chicago Region Urban Forest: Implications for the Future

Abstract

A 2010 i-Tree Eco analysis provides the first comprehensive assessment of the Chicago region urban forest. The analysis serves as a platform on which to develop strategies to sustain, enhance and improve environmental quality as well as human health and well-being. The Morton Arboretum undertook the assessment in collaboration with the US Forest Service during the summer of 2010. A total of 1,331,405 m^2 field plots, plus 745 plots measured in the City of Chicago in 2007, were analysed using the i-Tree Eco model, which quantifies forest structure, function and values. The regional forest includes all of the trees planted and naturally occurring throughout the region. There are an estimated 157,142,000 trees, ranging from 2.5 cm up to more than 125 cm in diameter at breast height (DBH), found from the core of the city to the agricultural areas on the periphery. A canopy composed of 161 species covers an average of 15.5% of the region. Slightly less than half (47%) of those trees are species native to Illinois. Analysis of the assessment provides useful insight into important trends such as losses to insects and diseases, the spread of invasive plants and the lack of adequate establishment of important species. These changes, plus land development and climate change, place the Chicago region urban forest in a 'transitional state'. The assessment seeks to inform approaches to urban forest management that will inspire citizens of the region to plant and protect trees and improve the vigour of the urban forest.

Introduction

The Morton Arboretum identified the need for an assessment of the Chicago region's urban forest as a first step in developing a comprehensive and integrated regional strategy for forest resource management. A regional assessment is critical given 1) the importance of trees and forests to the environment, human health and quality of life; 2) the diverse and dynamic character of the region's forest; 3) increasing threats from insects, disease, opportunistic species, climate change and land development and 4) the need to convey forest information and emerging threats and opportunities to a wide range of important stakeholders who affect, and are affected by, the regional forest.

Keywords:

canopy cover,
forest function,
forest structure,
invasive species,
tree size

Why i-Tree?

The i-Tree Urban Forest Assessment Model developed and supported by the USDA Forest Service Northern Research Station (Nowak *et al.*, 2008) was chosen for the assessment. The Morton Arboretum implemented the i-Tree model in partnership with the Forest Service, and collected field data throughout the seven county region outside of the Chicago city limits. Following i-Tree guidelines, the Forest Service entered that 2010 data, plus the 2007 Chicago i-Tree data (Fisher and Nowak, 2010; Nowak *et al.*, 2010), into the model along with local hourly weather and air pollution concentration data. The model generated a wide range of useful reports and website information on forest structure, functions and values that serve as the basis for this paper (Nowak *et al.*, 2013). Forest structure is a measure of the various physical attributes of the vegetation, including the number of trees, tree density, tree health, leaf area, biomass and species diversity. Forest functions, which are

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determined by the forest structure, include a wide range of environmental and ecosystem services such as air pollution removal and the cooling of summer air temperatures. Forest values are an estimate of the economic worth of forest functions.

How i-Tree Works

The assessment information was generated for the entire Chicago region (Figure 1) as well as individual counties (including the suburban part of Cook county), the City of Chicago and for specified land uses. The 2,076 on-the-ground plots were 405 m^2 in size and randomised within a grid across the entire landscape of each county (and suburban Cook) and the City of Chicago. Plot measurements, which included 9,731 planted and naturally occurring trees, were comprehensive and provided a wide-ranging characterisation of the entire regional forest. Trees can be found in fairly extensive woodlands and savannahs, around lakes and in river corridors, along streets and other rights of way, and in downtown, residential, commercial, industrial and institutional areas. Figure 2 provides a summary of the types of plot and tree data collected. This breadth and comprehensiveness of the data are the major strengths of an i-Tree assessment. The measurement of trees down to a minimum 2.5 cm diameter at breast height (DBH) provided useful information on invasive species as well as the trees that are likely to form the future forest. The equations or algorithms used to estimate forest structure and functions are science-based, peer-reviewed and have been used in hundreds of applications in the USA and internationally (Nowak *et al*., 2008). i-Tree Eco provides a complete assessment package that is supported by a well-qualified team of scientists and practitioners. Figures 3 and 4 provide a brief summary of the information on tree functions and values for the Chicago region generated by the model and their influence on the environment.

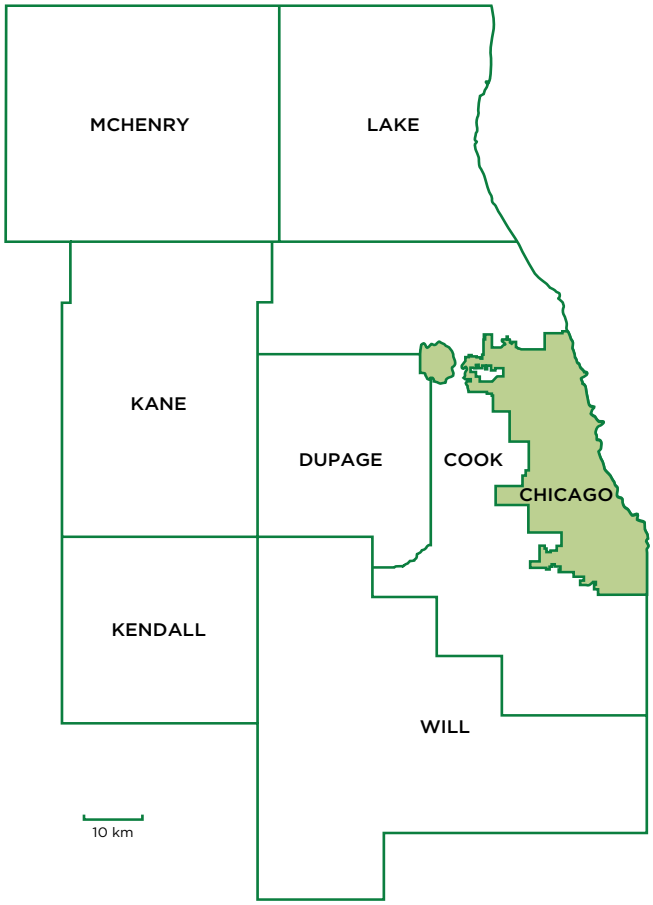

Figure 1: Map of the Chicago region showing the counties and the City of Chicago (10,383 km^2)

Plot information

- Land use
- Percentage tree canopy cover
- Percentage shrub cover
- Percentage plantable
- Percentage ground cover types

Tree parameters

- Species
- Stem diameter
- Total height
- Height to crown base
- Crown width
- Percentage foliage missing
- Percentage dieback
- Crown light exposure
- Distance and direction to building from trees

Figure 2: Field survey data collected for the i-Tree eco-assessment of the Chicago region

i-Tree Eco does not currently map the urban forest. The Arboretum is cooperating in the Urban Tree Canopy Study to generate this mapping. This collaborative effort amongst the US Forest Service, the University of Vermont and the Morton Arboretum is developing high-resolution aerial imagery using LIDAR and GIS. Together with i-Tree Eco, this will provide a science-based approach to direct urban forest planning and implementation across the region.

Total pollution removal: 18,080 tons/year ($137 million/year)

- Ozone (O_3): 7,904 tons/year ($71.9 million/year)
- Particulate matter less than 10 microns (PM_{10}): 5,549 tons/year ($33.1 million/year)
- Nitrogen dioxide (NO_2): 3,381 tons/year ($30.4 million/year)
- Sulphur dioxide (SO_2): 962 tons/year ($2.1 million/year)
- Carbon monoxide (CO): 280 tons/year ($357 thousand/ year)

Carbon storage: 16.9 million tons ($349 million)

Carbon sequestration: 677,000 tons/year ($14.0 million/year)

Building energy reduction: $44.0 million/year

Reduced carbon emissions: $1.3 million/year

Compensatory value: $51.2 billion

Emissions

- Volatile organic compound emissions: 10,864 metric tons/year

Figure 3: Estimated functions and values of the Chicago region's trees

The Chicago Region

The Chicago region includes some 10,383 km^2 (1,038,326 hectares) and nearly nine million residents. It is served by the Chicago Metropolitan Agency for Planning. It has a diverse landscape that is heavily affected by the City of Chicago, with its extensive residential and commercial areas, intricate system of infrastructure and protected open spaces. The county areas surrounding Chicago (Lake, DuPage and suburban Cook) are suburban, with extensive residential areas. The counties on the southern and western edges (Will, Kendall, Kane and McHenry) have substantial agricultural land. The population density ranges from 4,819 people/km^2 for the City of Chicago to 126 people/km^2 in Kendall County, which is highly agricultural (77% of the land use).

For assessment purposes, the region was divided into four major land use categories.

- **Residential (RES)** (751 plots, 30.1% of the region), includes areas with single and multiple family dwellings.
- **Agriculture (AGR)** (450 plots, 32.9%), includes row crops, pasture and nurseries.

Carbon (C) storage equivalent to:	■ amount of C emitted in the region in 120 days, or ■ annual C emissions from 10,128,000 traffic vehicles, or ■ annual C emissions from 5,085,400 single family homes
Carbon monoxide (CO) removal equivalent to:	■ annual CO emissions from 1,110 automobiles, or ■ annual CO emissions from 4,600 family homes
Nitrogen dioxide (NO_2) removal equivalent to:	■ annual NO_2 emissions from 213,500 automobiles, or ■ annual NO_2 emissions from 142,400 single family homes
Sulphur dioxide (SO_2) removals equivalent to:	■ annual SO_2 emissions from 1,406,600 automobiles, or ■ annual SO_2 emissions from 23,600 single family homes
Particulate matter less than 10 microns (PM_{10}) removal equivalent to:	■ annual PM_{10} emissions from 14,789,000 automobiles, or ■ annual PM_{10} emissions from 1,427,700 single family homes
Annual carbon (C) sequestration equivalent to:	■ amount of C emitted in region in 4.8 days, or ■ annual C emissions from 406,600 automobiles, or ■ annual C emissions from 204,200 single family homes

Figure 4: Functions provided by the Chicago region's trees

- **Open space (OPEN)** (419 plots, 23.0%), includes open land primarily for conservation, such as forest preserves, private hunting clubs, campgrounds, vacant forest and grassland, wetlands and open water such as lakes and rivers. Open water encompasses 20% of the area of the open space land use and 4.6% of the region.
- **Commercial/transportation/institutional (CTI)** (456 plots, 14.0%), is a group of less prevalent land uses. Commercial land use (57% of the CTI land use by area, 8.0% of the region) includes manufacturing, mining and industrial parks. Transportation land use (19% of the CTI land use by area, 2.7% of the region) includes major highways and associated facilities, aircraft transportation, communications and utilities and waste facilities. Institutional land use (24% of the CTI land use by area, 3.4% of the region) includes medical, educational, religious and government facilities.

The Forest

Trees and forests are an increasingly important component of the Chicago region. Some 157,142,000 trees provide canopy cover for 15.5% of the region. On average, there are some 148 trees/ha across the region, with many as small as 2.5 cm DBH. In many instances, trees and forests add an important vertical dimension to a relatively flat topography. The tree population is diverse, including some 161 species found in wide-ranging environments that extend from downtown Chicago across extensive residential and open space areas to agricultural areas on the region's periphery. There is also a wide range of tree diameters (Figure 5). Since trees were included down to 2.5 cm DBH, smaller trees predominate in the results, with a mean of 13.5 cm DBH and a median of 7.9 cm DBH, but also included trees greater than 127 cm DBH (burr oak, *Quercus macrocarpa* and silver maple, *Acer saccharinum*).

The highest tree density and percentage tree canopy cover occur in the suburban counties: Lake (277 trees/ha and 26% tree canopy cover), suburban Cook (230 trees/ha and 25% tree canopy cover) and DuPage (200 trees/ha and 27% tree canopy cover; Tables 1 and 2). Counties with extensive agricultural areas and the City of Chicago have lower tree densities and tree canopy cover.

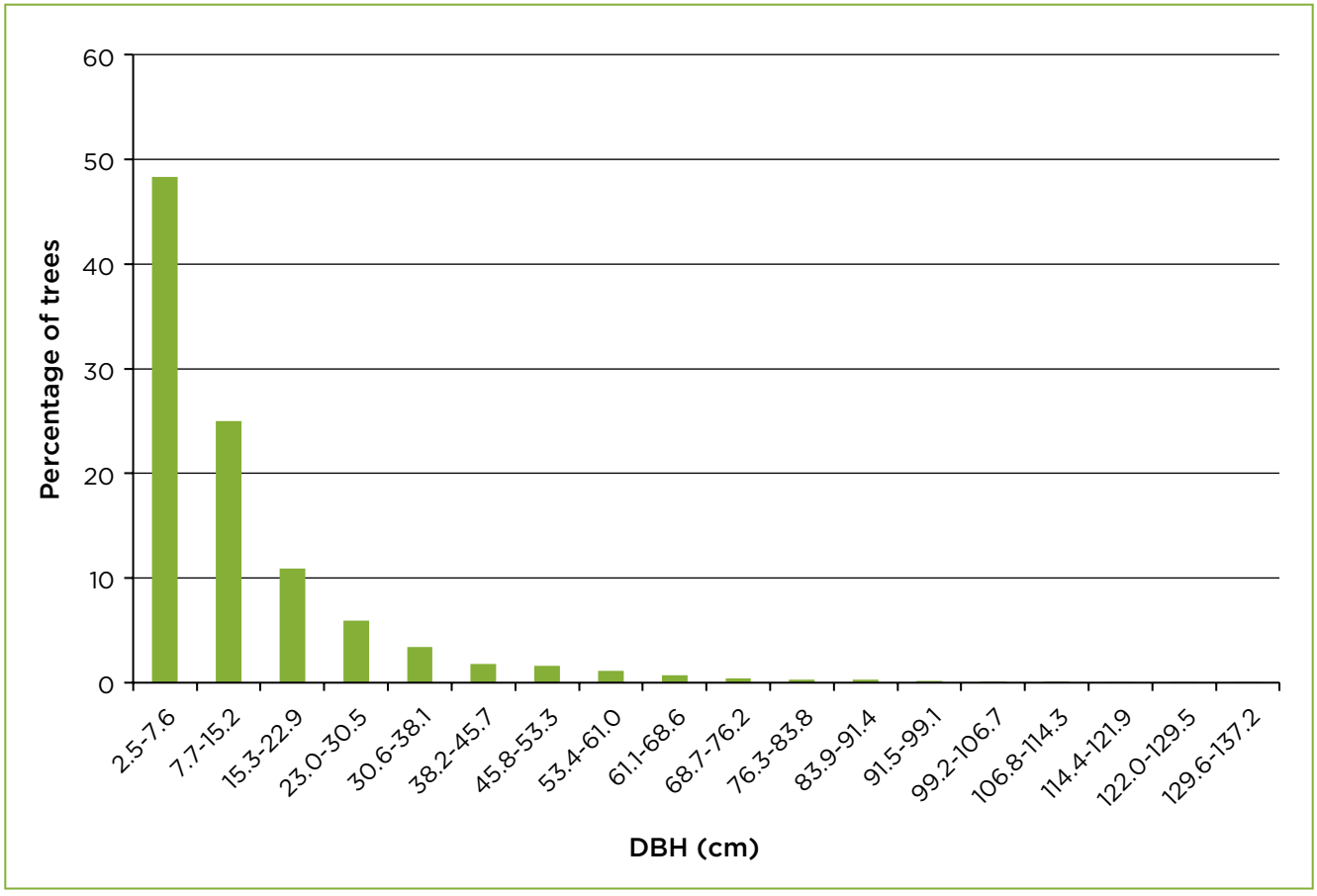

Figure 5: Diameters of the Chicago region's trees, 2010

Table 1: Trees per hectare in the Chicago region by area and land use, 2010

	AGR	CTI	OPEN	RES	ALL
Chicago		28	157	56	62
Suburban Cook	118	88	477	171	230
DuPage	49	174	267	184	200
Kane	5	11	198	158	74
Kendall	12	0	439	116	62
Lake	99	251	376	253	277
McHenry	39	35	329	217	141
Will	2	138	256	138	99

Table 2: Percentage tree canopy cover in the Chicago region by area and land use, 2010

	AGR	CTI	OPEN	RES	ALL
Chicago		8	28	27	19
Suburban Cook	10	10	38	26	25
DuPage	12	14	22	37	27
Kane	1	1	18	36	12
Kendall	2	0	39	17	7
Lake	13	17	26	33	26
McHenry	4	3	31	33	16
Will	1	12	30	21	13

The open space and residential land uses consistently have the highest tree density and percentage tree canopy cover in each county and the City of Chicago (Tables 1 and 2). The open space land use is often in some stage of transition to a forest cover from agriculture or other land uses, sometimes with assistance from tree planting in addition to natural regeneration. These areas, which include regionally significant forest preserves and conservation areas, also support significant remnant trees and forests. Substantial tree canopy cover in the residential land use is due in part to tree planting and care in residential environments, but also to homes in and near forested sites. Some residential areas and nearby forest preserves and river corridors have remnants of pre-settlement vegetation, for example, large oaks, that are highly visible in the landscape and prized by residents and visitors.

Across the region, the number of tree species, an indicator of forest diversity, is highest for the residential land use, followed by open space, with the exception of Kendall county (Table 3). The number of species in each of these land uses tends to be highest in the City of Chicago and surrounding suburban areas, demonstrating that a diverse urban forest is a significant component of this major urban area.

Table 3: Number of tree species in the Chicago region by area and land use, 2010

	AGR	CTI	OPEN	RES
Chicago		48	51	83
Cook	7	28	50	62
DuPage	3	34	39	77
Kane	6	6	26	57
Kendall	17	0	40	25
Lake	9	24	45	62
McHenry	23	4	39	45
Will	3	18	30	43

Less than half of the region's trees (47%) are species that are native to Illinois. Open space and residential areas have a greater percentage of native species than CTI and agricultural land, except for the City of Chicago and Will County (Table 4).

Table 4: Percentage of native tree species in the Chicago region by area and land use, 2010

	AGR	CTI	OPEN	RES
Chicago		55	59	45
Cook	15	25	45	43
DuPage	25	35	58	36
Kane	0	33	39	47
Kendall	22	0	75	73
Lake	25	22	39	53
McHenry	33	14	51	38
Will	12	84	73	45

Long-lived large trees 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 evapotranspirational cooling. Larger trees greater than 45.7 cm DBH (4.7% of all trees) can be found throughout the region, but compared with other areas the City of Chicago has

the highest percentage of trees greater than 45.7 cm DBH in the residential, open space and CTI land uses. The relatively large trees in the City of Chicago may reflect tree planting as a part of early settlement and the establishment of neighbourhoods, parks, forest preserves and other areas, as well as the preservation of remnant vegetation. Overall, across the region these larger trees make up a larger portion of the tree population in the residential (7.3%) land use than in open space, agricultural land and CTI. The large trees in these areas are also most likely due in part to tree planting in neighbourhoods at the time that they were established and in part to the preservation of remnant trees. Residential areas that were established 50 or more years ago may well support trees that have grown to 45.7 cm and larger in diameter.

Some 61 of the 161 species recorded had individuals with diameters in excess of 45.7 cm. These are the species that are likely to be especially prominent in local landscapes. The 10 species that account for the largest numbers of those large trees (Table 5) make up more than 70% of the region's trees greater than 45.7 cm DBH. Three oak species in that list account for nearly 30% of the regional total of trees greater than 45.7 cm DBH. Two of the species in the list, Norway maple (*Acer platanoides*) and Siberian elm (*Ulmus pumila*) are considered invasive (Center for Invasive Species and Ecosystem Health, 2010) and are less likely to be planted in the future. Green ash (*Fraxinus pennsylvanica*), which ranks seventh among the large trees, is likely to largely disappear from the landscape as a mature tree, along with other ash trees, in the next decade due to emerald ash borer (EAB, *Agrilus planipennis*). Ash trees remaining in the landscape in ten years are likely to be those that have been treated for EAB and young trees that have yet to be infested.

Pre-settlement vegetation has also influenced the regional forest. In a study that compared i-Tree Eco plots from 2010 with pre-settlement vegetation, Fahey *et al*. (2012) report that pre-settlement vegetation, which was 60-80% grassland with the remainder a savannah-woodland-forest gradient, was associated with the urban forest structure. Areas that were previously forest were more likely to currently have a higher native tree species dominance, tree canopy cover and structural complexity than areas that were previously prairie. Oaks, which dominated the pre-settlement forest areas, were strongly associated with pre-settlement forest areas and modern natural areas. Pre-settlement grassland and areas used for agriculture are more likely to currently have emergent vegetation rather than remnant vegetation. Studies of natural areas in the region have consistently shown a trend of decreasing oak dominance and an increase in other species such as maple (Fahey *et al*., 2012; Bowles *et al*., 2005).

Table 5: Large trees in the Chicago region by species, 2010

Species	Percentage of all trees > 45.7 cm DBH	Percentage of all trees 2.5-7.6 cm DBH	Percentage of all trees
Silver maple (*Acer saccharinum*)	12.84	0.92	2.04
Burr oak (*Quercus macrocarpa*)	11.58	0.22	1.01
White oak (*Quercus alba*)	11.39	0.22	1.18
Eastern cottonwood (*Populus deltoides*)	8.26	0.87	1.40
Box elder (*Acer negundo*)	6.79	4.04	5.47
Northern red oak (*Quercus rubra*)	6.25	0.75	1.97
Green ash (*Fraxinus pennsylvanica*)	4.90	4.56	5.51
Honey locust (*Gleditsia triacanthos*)	3.36	0.27	0.63
Norway maple (*Acer platanoides*)	3.16	0.74	1.18
Siberian elm (*Ulmus pumila*)	2.95	0.70	1.43
Black walnut (*Juglans nigra*)	2.25	0.82	1.57
Sugar maple (*Acer saccharum*)	2.05	3.55	2.84
Willow (*Salix spp.*)	1.61	0.91	0.86
Red maple (*Acer rubrum*)	1.53	0.01	0.22
White ash (*Fraxinus americana*)	1.52	2.44	2.56
Black cherry (*Prunus serotina*)	1.47	3.33	4.93

Forces for Change

The assessment identified three important forces for change that are likely to play a major role in shaping the structure, function and values of the regional forest in the years ahead. These interrelated forces, which include insects and diseases, invasive trees and other plants and changes in forest structure, are outlined below.

Insects and Diseases

Insects and diseases can attack urban forests, potentially killing trees and reducing the health, value and sustainability of the forest. Each pest has different host trees, so the potential losses from individual pests differ. Twenty-nine exotic insects and diseases were evaluated in terms of their potential impact on the regional forest. Five pests pose the most serious threats based on the number of trees at risk of infestation. These are Asian longhorned beetle (ALB, *Anoplophora glabripennis*), gypsy moth (*Lymantria dispar*), EAB, oak wilt (*Ceratocystis fagacearum*), and Dutch elm disease (*Ophiostoma novo-ulmi)*. These pests currently exist or have existed in the Chicago region. ALB has been eradicated from the region, but could return. Note that the 41.6 million trees at risk of ALB infestation represent more than a quarter of the total number of trees in the Chicago region (Table 6).

The magnitude of the threat of loss from the five major pests varies by county and land use. The five pests collectively threaten many species that include all but three of the ten 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 considered Invasive.

It is likely that the expected loss of most of the 13 million ash trees to EAB over the next decade will bring profound changes across the regional forest. Ash trees are found in all of the land use categories, are common street trees and can reach a substantial size and be a key component of the landscape. The environmental impacts from the loss of the region's ash trees are likely to be high, given that ash trees have the highest total leaf surface area of all of the species recorded.

Invasive Trees

Invasive plant species are often characterised by their vigour, ability to adapt, reproductive capacity and lack of natural enemies. These factors enable them to displace native plants and threaten natural areas. The 17 tree species that are considered Invasive account for 38% of the region's tree population. Since the region's invasive species tend to be relatively small and reproduce rapidly, they presently make up more than half (52%) of the trees in the 2.5-7.6 cm DBH category and are prominent in all four land use categories (Table 7 (over)).

European buckthorn is the most common invasive species (73% of the invasive species) and also the most numerous individual tree in the region, accounting for 28% of all trees and 43% of trees in the 2.5-7.6 cm DBH category (Table 7). It is the most common tree in all of the land use categories, with its highest density of 101 trees/ha in the open space land use. It is not, however, the most common tree in all areas of the region, particularly the City of Chicago. Buckthorn also makes up a smaller proportion of the tree population in the rural counties of Kane, Kendall and Will, which form the southern and south-western borders of the region. The pattern of a decrease in buckthorn density from north to south may be due to the locations of its introduction.

Buckthorn is a small tree, with 95% of individuals less than 15.2 cm DBH and almost none greater than 30.5 cm DBH. This species is characterised by rapid growth and the formation of dense thickets that can form a barrier to the regeneration of native tree species such as oaks (Nowak, 2012; Fahey *et al*., 2012). This can have a significant impact on forest structure. The i-Tree plots recorded up to 2,272 buckthorn trees/ha. Nine per cent of the study plots

Table 6: Number and value of trees at risk from major pests in the Chicago region, 2010

Pest	At-risk Trees (millions $)	Compensatory Value (billions $)
Asian longhorned beetle (*Anoplophora glabripennis*)	41.6	17.4
Gypsy moth (*Lymantria dispar*)	17.7	18.5
Emerald ash borer (*Agrilus planipennis*)	12.7	4.2
Oak wilt (*Ceratocystis fagacearum*)	9.0	16.0
Dutch elm disease (*Ophiostoma novo*-ulmi)	8.2	1.6

Table 7: Species considered invasive as a percentage of all trees 2.4 to 7.6 cm DBH by land use in the Chicago region, 2010

Species	Land use category				
	ALL	AGR	CTI	OPEN	RES
European buckthorn (*Rhamnus cathartica*)	43.38	44.67	41.64	44.99	41.11
Amur honeysuckle (*Lonicera maackii*)	3.55	1.27	2.02	5.09	1.81
Tree-of-heaven (*Ailanthus altissima*)	1.17		9.33	0.01	0.29
Norway maple (*Acer platanoides*)	0.74		2.58	0.03	1.38
White mulberry (*Morus alba*)	0.72	0.94	1.03	0.40	1.11
Siberian elm (*Ulmus pumila*)	0.70	2.48	0.45	0.24	1.32
Glossy buckthorn (*Frangula alnus*)	0.50			0.88	0.10
Black locust (*Robinia pseudoacacia*)	0.46			0.63	0.40
Amur maple (*Acer ginnala*)	0.43		0.28	0.75	
Winged burningbush (*Euonymus alatus*)	0.15			0.14	0.26
Autumn olive (*Elaeagnus umbellate*)	0.11			0.21	
Callery pear (*Pyrus calleryana*)	0.04				0.14
Russian olive (*Elaeagnus angustifolia*)	0.02				0.06
Common privet (*Ligustrum vulgare*)	0.01				0.03
White poplar (*Populus alba*)	0.00			0.01	
Osage orange (*Maclura pomifera*)	0.00				
European filbert (*Corylus avellana*)	0.00				
All species	51.98	49.36	57.33	53.38	48.01

with buckthorn had a density greater than 1,235 buckthorn trees/ha, with 53% having a density of 25-257 buckthorn trees/ha. Buckthorn tolerates many soil and light conditions and reproduces rapidly from seeds dispersed by birds. In the 1930s, the nursery industry recognised its invasiveness and stopped its widespread sale, but it is still available for purchase.

More than a century after its introduction as an ornamental, buckthorn is most prevalent in the residential and open space land uses in suburban areas. The authors are not aware of any significant study of its geographic distribution over time, but a comparison of the present study with an assessment of trees in Cook and DuPage counties in 1994 (McPherson *et al*., 1994) offers some interesting comparisons. Between 1994 and 2010 there has been no increase in the number of buckthorn in the City of Chicago. However, during that same period, the number of buckthorn in suburban Cook and DuPage counties increased two and a half times. This leaves open the possibility of buckthorn increasing in extent if suburban development increases in the more rural areas of the Chicago region.

Dynamic Forest Structure

While the assessment is a snapshot of the regional forest at one point in time, it can provide a clue to the future forest, as much of that forest will emerge from the younger trees in the present forest. An analysis of species composition for trees of different sizes (a proxy for age) provides an indication of possible changes in the years ahead if the current trends continue. For example, burr oak is a prominent species among the large trees (trees greater than 45.7 cm DBH), but is far less common among the small diameter trees (2.5-7.6 cm DBH) that will make up the future forest (Table 5). This suggests that burr oak may not be as large a component of the region's urban forest in the years ahead.

Table 5 lists the 16 tree species with the largest percentage of the region's trees greater than 45.7 cm DBH. It also includes for each species the percentage of the region's trees that are 2.5-7.6 cm DBH as well as the percentage of all trees in the region. Thirteen of the 16 species in Table 5 have lower percentages of trees in the 2.5-7.6 cm DBH category than in the greater than 45.7 cm DBH category, suggesting that they may be a smaller component of the regional forest in the years ahead. Overall, the tree species with the highest proportion of the region's trees in the 2.5-7.6 cm DBH category tend to include prolific seeders, opportunistic species and invasive species. Perhaps some of them will make up an increased proportion of the region's trees in the years ahead. Green ash is unlikely to increase in number due to a major insect problem.

Studies in other cities also suggest prospects for a dynamic forest structure that includes opportunistic, invasive and exotic species. In a study of tree planting and natural regeneration in 14 North American cities, including the City of Chicago, Nowak (2012) reported that two in three existing trees in cities are the result of natural regeneration and one from planting. In the City of Chicago, some 55% of the trees are the result of natural regeneration, including 96% in transportation areas, 88% in vacant areas and 83% in parks. In Baltimore and Syracuse, which were re-sampled to estimate the proportion of new trees that were planted, natural regeneration was found to dominate the influx of new trees. One in twenty of the newly established trees in Baltimore were planted, as were 1 in 12 in Syracuse. In Baltimore, 58% of new trees are native species and in Syracuse 35% of new trees are native species. In Syracuse, 52% of the new trees were classified as invasive, as were 13% of the new trees in Baltimore. Buckthorn dominated regeneration in Syracuse.

These findings suggest good prospects for opportunistic species, including exotics. In a finding that echoes that of Fahey *et al*. (2012), Nowak (2012) reports that "without tree planting and management the urban forest composition in Syracuse will likely shift to more pioneer or invasive tree species in the near term. As these species typically are smaller and have shorter life spans, the ability of city systems to sustain larger, long-term tree species may require human intervention through tree planting and maintenance. In addition, the invasive characteristics of some of these species pose problems associated with spreading into surrounding landscapes, displacing native species and altering local ecosystems (e.g., Pimental *et al*., 2000)".

The spread of invasive species, the loss of important native species to insects and disease and the inadequate establishment of important species continue to be significant issues concerning the future of the regional forest. An analysis that compared the present forest to the pre-settlement forest led researchers at the Morton Arboretum (Fahey *et al*., 2012) to characterise the regional forest as being 'in transition'. With smaller size classes dominated by exotic or opportunistic tree species, they outline the possibility of smaller stature trees making up the future forest structure and reducing the environmental benefits provided. They further point out the possibility of the reduced vitality, sustainability and resiliency of the emerging forest, including the reduced ability to adapt to climate change and exotics.

Summary

The i-Tree assessment has helped to characterise the extent, location, character, functions and values of the Chicago region's forest. The important findings include the extent of the tree canopy cover over the region across diverse areas and land uses, and the size and species of trees found throughout the region. The species information is helpful in assessing the risks from significant species-specific threats such as EAB, and in identifying the extent of invasive tree species. Determining tree size by species, as a proxy for age, makes it possible to project how the species composition of the regional forest is likely to change in the years ahead. The estimates of tree canopy cover provide useful information on the extent and influence of the forest on urban and urbanising environments across the regional landscape. The estimates of tree functions and values give a comprehensive assessment of the significant environmental benefits provided by the region's trees and forests, which include air pollution removal, carbon storage, carbon sequestration, building energy reduction and reduced carbon emissions. Overall, the assessment illustrates the current status of and important trends in the regional forest, and conveys the importance of trees to a range of constituents who may not principally value or work with trees, but depend on the services they provide.

The comprehensiveness and large spatial extent of the field data collection made for a highly useful assessment of the region's forest, and provides a basis for ongoing management/planning efforts as well as those that may well be needed in the years ahead. Information on the structure and functions of the regional forest can be used to inform forest management programmes and help integrate forests into programmes to improve environmental quality. This will lead to enhanced human health and well-being. The assessment also provides a benchmark for evaluating future trends, the influence of future threats to the forest and the outcomes of management programmes, such as tree planting initiatives, on the urban forest. The information provided by the assessment can help get the attention and involvement of a number of important groups who influence or are influenced by the region's forest.

Future Efforts

To sustain and enhance the forest and the benefits it contributes amidst the major challenges outlined above, a comprehensive and integrated management strategy must be developed and implemented across the region. This assessment is an important step towards the development of that strategy.

i-Tree Eco is designed to be replicated in the years ahead to help identify trends in forest structure, function and values. With continuing support from the USDA Forest Service, the Morton Arboretum plans to replicate the 2010 i-Tree Eco assessment in 2020 to assess ongoing changes and help plan for and guide future efforts to inspire the citizens of the region to plant and protect trees and improve the vigour of the urban forest.

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