UFORE/i-Tree Eco Chicago article for *Illinois Trees*
Cherie LeBlanc Fisher and David Nowak
USDA Forest Service, Northern Research Station
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Title: UFORE (i-Tree Eco) Analysis of Chicago

Abstract: The USDA Forest Service and City of Chicago conducted a UFORE (now called i-Tree Eco) analysis of Chicago's urban forest in the summer of 2007. The UFORE (Urban FORest Effects) model developed by the Forest Service uses on-the-ground sampling data to understand the composition of an urban forest and calculate the forest's impacts on air pollution and energy use. UFORE Chicago involved visiting 750 tenth-acre (0.1 acre) plots randomly distributed across all land uses and the entire city. Over a 4-month period, three dedicated field crews collected data on every tree over 1 inch in diameter in every plot as well as more general plot information like ground cover and land use. The UFORE model used the sampling data to estimate that there are about 3,585,000 trees in Chicago. The most common species are white ash (6.0%), mulberry (5.2%), green ash (4.9%), and tree of heaven (4.7%), and 61% of all trees are less than 6 inches in diameter (dbh). Chicago's urban forest removes about 888 tons of air pollutants per year, removes about 25,200 tons of carbon per year, and currently stores a total of about 716,000 tons of carbon. Based on digital cover analysis completed in 2008, Chicago has about 17.2% tree cover.

What is UFORE/i-Tree Eco?

Municipal foresters and professional arborists know that trees bring value and benefits to urban communities, but these benefits can often be difficult to calculate and communicate. For example, trees can remove air pollutants – but how much air pollution and how does that translate into value for society?

USDA Forest Service scientists developed the UFORE (Urban FORest Effects) model (recently renamed i-Tree Eco) to answer these kinds of questions. Trained field workers collect field data from tenth-acre (0.1-acre) plots in the study area, which can be any geographic size including a neighborhood, university campus, city, county, or metropolitan area. The UFORE computer model uses the field data and other local data to analyze the trees' contribution to local ecosystem services. UFORE also estimates the compensatory value of the trees and the dollar value of the ecosystem services they provide. Analysis of the field data itself provides information about the composition and distribution of different tree species and size classes in the study area. The data can also be examined by land use, neighborhood, or other categories of interest.

UFORE Chicago

USDA Forest Service personnel supervised field data collection in Chicago in the summer and early fall of 2007. The City of Chicago Department of Environment initiated the project and

staff from the Chicago Park District, USDA Forest Service, Chicago's Bureau of Forestry, and WRD Environmental carried out the fieldwork. GreenCorps Chicago staff acted as technical advisors and logistics coordinators on the project as well.

UFORE Chicago's study plots

The original project design for Chicago called for data collection on 600 plots. Forest Service scientists divided the City of Chicago into 600 grid squares using a computer program; one tenth-acre (0.1 acre) plot was randomly located in each grid square. This meant that there were study plots throughout the city (including 20 plots within the boundaries of O'Hare International Airport).

The field crews completed the first 600 plots sooner than expected (in about seven weeks) and 150 more randomly located plots were subsequently added to the study. Data collection wrapped up in mid-October.

The Nuts 'n' Bolts of Data Collection

When they began the project, all field workers had tree identification experience and most had some fieldwork experience as well. They participated in two days of classroom and field training on collecting and recording UFORE data. Workers were paired together based on skills and experience to create three work crews of two people each. In the first few days of field collection, crews worked together and compared notes to continue the learning process. After that, crews worked independently and came together once a week for project meetings.

To find the plots on the ground, the crews received 8.5 x 11 inch maps of small sections of the city with about 10-12 plots per map. The City of Chicago provided high-resolution close-up aerial photos of each plot; these close-up aerials had street labels on them and were invaluable for locating each plot center and plot borders. The crews visited every plot on one map before moving on to the next map (i.e. the next section of the city).

Plot access was less of a problem than one might expect in a big city. The crews noted when a plot was inaccessible, worked to resolve the problem (for example, by contacting a business owner for permission to enter a fenced property), and returned to it at a later time (most often within a few days). They did not visit plots that were entirely in a lake or river but they visited every plot on land including those that fell on railroad tracks, roads, or the tops of buildings. For safety reasons, they did not have to actually stand on these types of plots, but they verified that there were no trees, collected non-tree data like land use, and took photos of the plot when possible.

UFORE uses a single data sheet for each plot. The front of the sheet includes sections for general plot data like plot number, street location, land use, percent tree cover, percent shrub cover, ground cover, plantable space (percent of plot), and reference points (compass direction and distance from plot center to 2 fixed objects like street lights or buildings). Data on every tree (1-inch minimum dbh) with a base at least 50% in the plot is recorded on the back of the sheet. Tree data includes species, tree height, crown height, dbh, crown width (north-south and east-

west), percent dieback, crown light exposure, and distance and compass direction to nearby residential buildings. There is also a box to check if it is a street tree.

Quality Control/Quality Assurance

The UFORE guidelines recommend revisiting multiple plots to check for errors in data collection or trends in measurement errors (for example, one crew consistently mis-identifying a tree species or recording slightly higher dbh numbers than another crew). In the Chicago UFORE project, 100 (13%) of the 750 plots were randomly assigned to more than one crew; the crews knew about this reassignment, but they did not know which plots were involved.

Data from multi-surveyed plots were checked to help correct potential data collection issues. Fifty-seven of the 100 multi-surveyed plots had no or only minor data discrepancies. Minor discrepancies were reconciled in the database by the field supervisor – for example, if one crew estimated plot tree cover at 45% and another crew estimated 55%, the field supervisor averaged these to 50%. The field supervisor worked with the crews to re-check 43 plots in person, most often because crews had reported different numbers of trees in the plot. The most common problem was that locating plot center in a different place by just a few inches could cause trees on the edge of the plot to be included by one crew and excluded by another. The most common data mistake was mis-identification of a tree species by one crew. In a few cases, GreenCorps Chicago staff with extensive tree identification experience visited plots in person to verify tree species identifications. Crews that mis-identified tree species were re-trained on these species, and species mis-identifications were corrected in the database.

UFORE Chicago Results

The basic tree data identified in the UFORE fieldwork is very revealing. The most common species by numbers of individuals were white ash, mulberry, green ash, and tree of heaven (Table 1). About 61% of Chicago's trees have a dbh of less than 6 inches. The city's many large, older silver and Norway maples account for a very high percentage of the urban forest's total leaf area compared to the number of individuals. A digital cover analysis completed in 2008 estimated that Chicago has about 17.2% tree cover.

Latin Name	Common Name	Estimated Number of Trees	% of Population	% of total leaf area
Fraxinus americana	white ash	215,100	6.0	3.9
Morus species	mulberry	186,420	5.2	5.6
Fraxinus pennsylvanica	green ash	175,665	4.9	7.5
Ailanthus altissima	tree of heaven	168,495	4.7	2.6
Acer saccharinum	silver maple	164,910	4.6	12.5
Rhamnus cathartica	European buckthorn	161,325	4.5	0.7
Ulmus americana	American elm	161,325	4.5	3.9
Acer platanoides	Norway maple	143,400	4.0	11.4
Acer negundo	boxelder	125,475	3.5	1.3

Crataegus species	hawthorn	118,305	3.3	1.7
Gleditsia triacanthos	honeylocust	118,305	3.3	2.6
Populus deltoides	eastern cottonwood	114,720	3.2	6.0
Thuja occidentalis	northern white cedar	107,550	3.0	0.5
Rhamnus species	buckthorn	82,455	2.3	0.6
Acer saccharum	sugar maple	78,870	2.2	2.4

Table 1. The 15 most common tree species in Chicago

UFORE does a basic analysis of trees at risk from known pests and diseases. About 50% of Chicago's trees (over 1.8 million maples and other hardwood species) are vulnerable to the Asian longhorned beetle (ALB), which infested trees in one Chicago neighborhood in 1998. ALB was believed to be eradicated from the city by 2003 but a single beetle was found in a suburban town in 2008. Over 400,000 green, white, and black ash trees are under threat from the emerald ash borer, which was discovered in Chicago in 2008. Dutch elm disease is a potential threat to Chicago's 200,000 elm trees.

UFORE also estimates the urban forest's removal of air pollution by simulating pollutant removal using local pollution, weather, and field data. According to this analysis, Chicago's urban forest removes about 888 tons (U.S. tons, 2000 pounds) of pollutants per year including carbon monoxide (CO), nitrous dioxide (NO_2), ozone (O_3), particulate matter (PM_{10}), and sulfur dioxide (SO_2). This air pollution removal is valued at about $6,400,000 per year.

UFORE uses field data on tree species, size, condition, and distance to residential buildings to estimate the urban forest's impacts on residential energy use. Based on February 2009 energy cost averages for Illinois, Chicago's urban forest provides an estimated $360,000 of net savings per year for residential energy customers.

Finally, Chicago's UFORE analysis estimates that based on their species and size, the city's trees are storing a total of about 716,000 tons of carbon and sequestering an additional 25,200 tons of carbon per year. The total structural (compensatory) value of Chicago's urban forest is about $2.3 billion based on the valuation method used by the Council of Tree and Landscape Appraisers.

The full UFORE Chicago report contains additional data and analysis including information about Chicago park plots. The report is in press by the USDA Forest Service and is expected to be out by early 2010 (http://nrs.fs.fed.us/data/urban/).

More about the i-Tree Tools and Programs

The USDA Forest Service worked with numerous partner organizations to develop i-Tree Eco and additional modules including i-Tree Streets (formerly STRATUM), i-Tree Species (a species selection program), i-Tree Storm (formerly Storm Damage Assessment Protocol utility), and i-Tree Vue (a tree cover mapping and benefits projector). All of these programs are in the public domain and are available at www.itreetools.org.