A Guide to Assessing Urban Forests

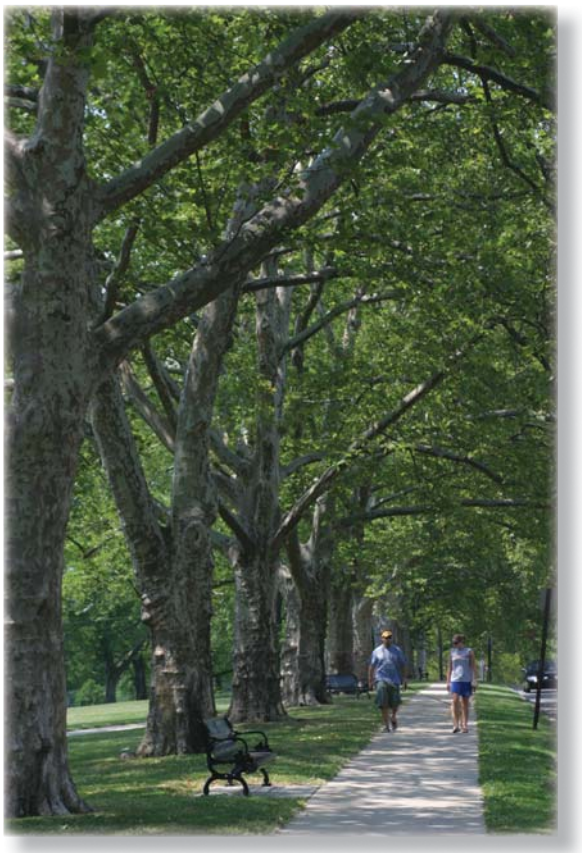
INTRODUCTION

Urban forests provide numerous ecosystem services. To quantify these services and guide management to sustain these services for future generations, the structure or composition of the forest must be assessed. There are two basic ways of assessing the structure or composition of the urban forest:

Bottom-up approach. Field-based assessments to measure the physical structure of the forest (e.g., species composition, number of trees)—typically used for strategic resource management or advocacy by connecting forest structure, functions and values with management costs, risks, and needs.

Top-down approach. Assessments of canopy cover using aerial or satellite images—used to determine amount and distribution of tree cover, potential planting space and other cover types.

These two approaches provide different types of urban forest information. The purpose of this guide is to outline the advantages, disadvantages and costs associated with various common assessment alternatives under these two approaches.



USDA United States Department of Agriculture

Forest Service

Northern Research Station

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THE BOTTOM-UP APPROACH: FIELD-BASED ASSESSMENTS

The bottom-up approach involves collecting field data on vegetation. It provides the most detailed information needed for urban forest management and to assess urban forest structure and its associated ecosystem services and values (Table 1). To aid in sampling or inventorying urban trees and forests, and for calculating their ecosystem services and values, the free i-Tree Eco and Streets models were developed (www.itreetools.org).

Advantages:

- Provides good estimates of basic forest information needed for management (e.g., number of trees and locations, species composition, tree sizes, tree health, risks)
- Provides estimates of numerous ecosystem services and their values
- Can be used for monitoring changes in forest composition and values

Disadvantages:

- Must collect accurate field data using technical metrics
- Cost of data collection

Cost:

Varies with size and scope of project. Volunteers, in-house crews and hired consultants have all been employed for collecting data. Hiring a consultant to carry out a typical i-Tree Eco sample of 200 plots could cost $40,000 at a contracted rate of $200 per plot. Costs would decrease with volunteers or student labor (e.g., $20,000 with students; even less with volunteers). Sampling intensity is determined by the user based on accuracy desired and resources available.

Accuracy:

Varies with sample size and accuracy of data collection; 200 one-tenth acre plots typically produces a relative standard error less than 15 percent for the total population estimate.

THE TOP-DOWN APPROACH: URBAN TREE CANOPY COVER ASSESSMENTS

There are three common top-down approaches for assessing urban tree canopy cover and all three methods will produce estimates of tree and other cover types in an area, but with differing resolution, costs, and accuracy. The three methods are:

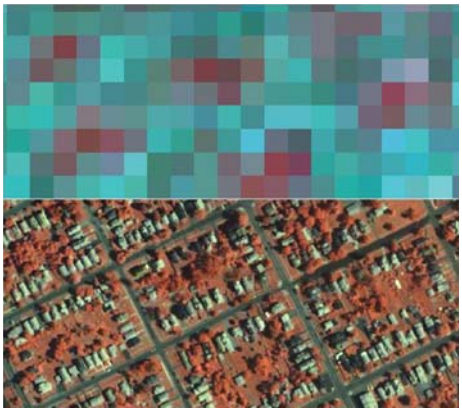
- NLCD analyses
- High-resolution image analyses
- Aerial photo interpretation

NLCD analyses

The National Land Cover Database (NLCD) has tree and impervious cover maps (30-m resolution) for the entire contiguous 48 states with percentage tree and percentage impervious cover estimated for each pixel. These maps and data are available for free and can be loaded into the free i-Tree Vue program to estimate tree cover and general ecosystem services.

Advantages

- Free
- Wall-to-wall coverage of lower 48 states
- Maps ecosystem services in addition to tree cover distribution



High resolution (below) vs. 30-m imagery.

Disadvantages

- Relatively course resolution (cannot see trees)
- Better suited for state or regional analyses rather than city scale or below
- Typically underestimates tree cover, on average, by about 10 percent. That is, if tree cover is 30 percent, NLCD tends to estimate 20 percent
- Data from circa 2001 (updated maps are being developed)

Cost:

Free

Accuracy:

Varies with mapping zone, but tends to underestimate tree cover by about 10 percent on average; user can adjust canopy cover percentage in individual pixels in i-Tree Vue to improve accuracy.

High-resolution land cover

With this approach, land cover features are extracted from high-resolution aerial or satellite imagery using automated techniques. This process yields a detailed map of tree and other cover types for a given area. This approach is used for Urban Tree Canopy (UTC) Assessments. For more information go to: http://www.nrs.fs.fed.us/urban/utc/

Advantages

- Produces accurate, high-resolution cover map
- Complete census of tree canopy locations
- Integrates well with GIS

Example of high-resolution land cover map.

- Allows the data to be summarized at a broad range of scales (e.g., parcel to watershed), enabling tree canopy to be related to a host of demographic, planning, and biophysical data
- Locates potentially available spaces to plant trees
- Can be used to monitor locations of cover change
- The source imagery needed for the mapping is available for the entire United States free of charge from the USDA

Disadvantages

- Can be costly if the data are low quality or incomplete
- Requires highly trained personnel along with specialized software
- Significant effort and time needed to produce quality maps
- Change analyses can locate false changes due to map inaccuracies
- Does not include ecosystem services reporting

Cost:

Variable depending upon available data. Development of city cover maps are on the order of $5,000 to 40,000+ depending upon size of city and availability of source data.

Accuracy:

Depends on the processor and available data, but is typically 90 percent accurate for tree cover. The incorporation of additional data, such as LiDAR, and/or the implementation of manual corrections can increase the accuracy to over 95 percent. Error matrix of map can detail actual accuracy of the map.

Photo-interpretation

Uses digital aerial images and a series of random points that are interpreted to determine the cover type at each point center. This process produces statistical estimates of cover with a known error of estimation. A free tool (i-Tree Canopy) can be used to photo-interpret cover across the globe using Google Maps™. Photo interpretation has been used for accuracy assessments of the other top-down methods.

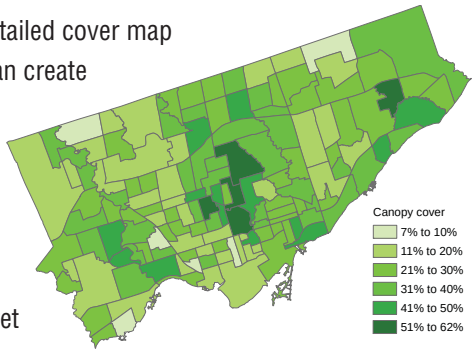
Advantages

- Low cost – most images can be acquired freely (e.g., Google Earth or from cities or counties)
- Cover assessment can be done quickly (e.g., available planting space, tree, impervious)
- Accuracy can be increased by adding more points and can be calculated quickly
- Can produce sub-area analyses and maps (e.g., tree cover by neighborhood)
- Multi-date paired imagery can be used to assess change

Photo-interpretation involves classifying randomly located points within preselected cover classes (e.g., tree, impervious, water).

Disadvantages

- Does not produce detailed cover map
- Photo-interpreters can create errors though misclassifications (training and quality checking are recommended)
- Leaf-off imagery can be difficult to interpret
- i-Tree Canopy interpretation limited to high quality Google images
- Poor image quality in some areas
- Resulting data cannot be summarized at multiple, user-defined scales



Neighborhood tree cover in Toronto, Canada, determined through photo-interpretation.

Cost:

At $10 per hour, cost is about 10 cents per point (e.g., 1,000 points = $100). Costs involve set up and interpretation time.

Accuracy:

A sample of 100 points will produce an estimate with a standard error of about 4.6 percent (assuming 30 percent canopy cover) and can be interpreted in about 1 hour. A sample of 1,000 points will produce an estimate with a standard error of about 1.4 percent (assuming 30 percent canopy cover).

Table 1.—Summary of features of four types of urban forest analyses

Urban Forest Attribute	i-Tree Eco[a]	i-Tree Vue[b]	i-Tree Canopy[c]	Cover Map (UTC)[d]
Cover				
Amount or percent tree cover	✓	✓	✓✓	✓
Specific locations and distribution of tree cover		✓		✓✓
Amount or percent potential planting space	✓	✓	✓✓	✓
Specific locations and distribution of plantable space		✓		✓✓
Maps of tree cover and plantable space		✓	✓	✓✓
Urban Forest Composition and Management				
Total number of trees / tree density	✓✓			
Species composition	✓✓			
Diameter / size distribution	✓✓			
Species diversity	✓✓			
Species importance values	✓✓			
Leaf area and biomass	✓✓			
Tree health	✓✓			
Native vs. exotic composition	✓✓			
Invasive trees	✓✓			
Risk to insects and diseases	✓✓			
Ground cover attributes	✓✓		✓	✓
Ecosystem Services and Values				
Air pollution removal / human health	✓✓	✓	✓*	✓*
Carbon storage and annual sequestration	✓✓	✓	✓*	✓*
Effects on building energy use	✓✓			
Rainfall interception	✓✓			
Structural value	✓✓			
Mapping of ecosystem services		✓✓	✓*	✓*
Monitoring				
Change in tree cover	✓		✓✓	✓
Locations of tree cover change				✓✓
Change in species composition, services and values	✓✓			

✓ - procedure calculates attribute
✓✓ - recommended procedure based on resolution, accuracy, and cost
✓* - broad estimates of services could be calculated based on procedures in i-Tree Vue
[a]i-Tree Eco – free program to assess ecosystem services and values from field data
[b]i-Tree Vue – free program that uses NLCD cover data to map cover and estimate ecosystem services
[c]i-Tree Canopy – free photo-interpretation tool to assess canopy cover and monitor change
[d]Cover map - high-resolution cover maps generated as part of a UTC assessment

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