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Assessing Urban Forest Structure: Summary and Conclusions

David J. Nowak

This special issue has presented data on several topics related to assessing urban forest structure. These topics include means to measure urban forest cover from aerial-based platforms (Walton et al. 2008), national and local ground-based assessments of urban forest structure and functions (Cumming et al. 2008; Nowak et al. 2008a), measurement of street tree environments through both sampling (McBride 2008) and 100% inventories (Jim 2008), evaluating urban forest structure and health in Shenyang, China (Ning et al. 2008), and the effect of plot and sample size on estimate precision (Nowak et al. 2008b). These papers provide insights to aid cities in assessing their urban forest resource.

In assessing an urban forest, there are several questions that need to be answered prior to conducting an assessment. These questions include: 1) What is the study area? – is it the entire urban forest (all trees) within a specific area (e.g., city or part of city) or is it just a street or park tree population? 2) Will all trees be measured (complete inventory) or will a sampling procedure be used? 3) Will aerial imagery and/or ground data be collected? and 4) What variables will be measured?

STUDY AREA

The boundary of the study area is a critical element that defines the scope of the assessment. Often street and/or park trees are measured due to their public ownership, high visibility, and relatively easy accessibility. Street and/or park tree assessments provide critical information for public urban forest management, but these public tree studies lack the comprehensive information that an urban forest assessment of an entire city can provide. As private land often dominates a city in terms of area, comprehensive assessments that include both public and private trees provide a means to develop more integrated and complete management plans to sustain the entire urban forest into the future.

SAMPLE VERSUS INVENTORY

Complete inventories provide the most precise and comprehensive data on the urban forest. Inventories also provide essential data for management by providing specific tree data with associated tree locations that can be mapped. Major drawbacks to complete inventories are the costs associated with the time and effort involved with measuring every tree and costs associated with keeping the inventory current. Unless conducting a street tree assessment or an assessment of a relatively small parcel of land, tree inventories can be impractical to establish and maintain.

Typically, sampling provides urban forest data at a lower cost than a complete inventory, but often lacks specific tree location information and provides only an estimate of urban forest data with varying degrees of precision. However, sampling is essential to provide cost-effective urban forest data over large areas. Various sampling designs have been detailed in this special issue, but most relate to forms of random sampling of a study area. Random sampling is a common technique for providing accurate estimates of the urban forest population. The number and size of plots used in random sampling can vary based on the specific study purposes, but will affect the precision of the urban forest estimate (Nowak et al. 2008b). The McBride (2008) article was an exception with regard to random sampling. Since random sampling produced plots with no trees, he opted to use an expert decision approach to select street plots that were believed to be characteristic of the city. This approach worked well in providing information on commonly used species, but cannot be used for statistical estimates of the tree population (McBride 2008).

AERIAL VERSUS GROUND-BASED MEASUREMENTS

Aerial-based information can provide relatively cost-effective data on urban cover types. This cover information can be sampled to provide general cover statistics with known standard errors, or it can be mapped to detail the location of various cover types. Aerial-based cover maps can be used with geographic information systems (GIS) to aid in urban forest management and integration with other city departments. These cover maps have varying degrees of accuracy depending upon resolution, image classification techniques, and quality control procedures used. In using cover map data, the user should be aware of the data accuracy.

Urban tree cover is one of the most basic and simple variables in assessing urban forests and is best obtained from aerial imagery. Aerial imagery can provide spatial information on current and potential locations of tree cover in two or three dimensions (e.g., LIDAR). However, aerial cover assessments cannot easily provide essential structural data needed for urban forest management (e.g., species composition, number of trees, diameter structure, tree health). The current best ways to obtain these data are through ground-based assessments where individual tree attributes are measured. An integration of aerial- and ground-based approaches will provide the most comprehensive data to improve urban forest management.

DATA VARIABLES

Before collecting field data for a ground-based assessment, a key decision is what variables to measure. Each variable will have an associated cost and, therefore, should be collected to fulfill the objectives of the assessment. Among the studies presented in this special issue, there are some consistently measured variables: species, diameter at breast height (dbh), tree height, location information (e.g., address, land use), and tree condition, which was often based on crown and other tree variables (e.g., trunk, roots). Other information commonly collected was crown width, height to base of live crown, tree and ground cover data, and information related to trees' proximity to buildings. Variables occasionally collected include tree damage, tree spacing, growing and plantable space, and visual diagrams of the site.

In general, the data variables can be summarized into five categories: 1) location, 2) tree species and dimension, 3) tree condition, 4) site characteristics and conditions, and 5) associated cover type information (e.g., ground cover, shrubs, buildings). Of these categories, location, tree species and dimensions, and tree condition are commonly collected in assessing urban forest structure. Location information is required to relocate the trees and as a record of the data collection procedure. Tree species, dimensions, and condition are basic attributes to quantify the urban forest structure; these are variables that can be directly recorded for a tree. Aggregation of individual tree information allows for quantification of urban forest population attributes (e.g., total number of trees, species composition). This basic individual tree information is also important in quantifying ecosystem services and values, and is essential to develop appropriate management plans to sustain urban forest cover and health.

Site characteristics and conditions often are collected for street trees to assess current and potential planting sites to aid in tree management. Associated cover type information can be collected to help assess other cover types that are part of the urban ecosystem and to help quantify the interactions among cover types to aid in management or the quantification of ecosystem services (e.g., energy conservation). All of these variables aid in understanding urban forest structure and can aid in urban forest management. The decision on what variables are actually collected depends upon the local objectives of the data collection.

INTERNATIONAL STANDARDIZATION OF URBAN FOREST DATA COLLECTION

Standardizing field data collection could provide significant gains in facilitating data collection and analyzing information for urban forest management. Exclusive of inventories, many studies use some sort of random plot design to collect field data on the urban forest. These studies often collect core variables related to location, species, tree dimensions, and tree condition. Development of international standards related to urban forest sampling and core variables (e.g., standard species codes) could greatly assist urban forestry globally. By adhering to standard methods of urban forest data collection, various programs can be developed and shared internationally to aid in data collection, analysis, reporting, and management.

The i-Tree software (www.itreetools.org) is a suite of programs that is currently attempting to standardize data collection and analysis of urban forest samples and inventories. Core variables would be required, but standardized supplemental variables could also be added to aid in analysis or management depending on the user's desires. For example, detailed standardized tree damage variables or site characteristic variables could be developed as supplemental variables for analysis. Standardized analysis and reporting of data could also be developed.

Groups interested in the international aspects of urban forestry, such as the International Society of Arboriculture (ISA) and the International Union of Forestry Research Organizations (IUFRO), could work toward developing international standards for urban forest data collection and analysis. These new standards could relate to plot design and distribution (e.g., random versus stratified random sampling, plot sizes), analysis and reporting methods, and core data standards. These standards should link with existing forest measurement standards (e.g., U.S. Forest Service Forest Inventory and Analysis standards) (Cumming et al. 2008) to help ensure integration with other forest programs. To facilitate the development of standards, the ISA, IUFRO, and scientists from the Research and Development branch of the U.S. Forest Service will be approaching the Society of Municipal Arborists, the European Arboricultural Council, and other international organizations within the urban forestry network to stimulate interest in and establishment of international urban forest data standards.

Once standards are established, new programs and tools could be developed to help urban foresters across the world in collecting, analyzing, and reporting on their urban forests. The use of standards would be optional, but entities that choose to use the standards and associated tools would be afforded a relatively low-cost means to quantify and monitor their resource and compare data among other urban areas throughout the world. The use of urban forest data and analysis standards could also be used to help develop minimum standards or goals for urban forest structure (e.g., tree cover, tree density, species diversity) and a means to monitor attainment of these standards.

Given current technology, international standards could be disseminated to help move urban forest management to a forefront in many local to international arenas. These new standards could advance integration of urban forestry within regional, national, and international programs (e.g., climate change programs), aid in long-term monitoring of urban forests, facilitate urban forest management to improve urban forest cover and health, and consequently enhance environmental quality and human health in urban areas.

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David J. Nowak
Northern Research Station
USDA Forest Service
SUNY-ESF
5 Moon Library
1 Forestry Drive
Syracuse, NY 13210, U.S.
dnowak@fs.fed.us