TREE CITY USA®
BULLETIN
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Understanding Tree Canopy Assessments

Urban tree canopy assessment is an important tool that can help communities gauge their environmental sustainability and plan for improvement. It is a complex subject and usually requires expert assistance, but it is well worth the effort and expense as urban forests are increasingly considered part of a city's infrastructure and a key component of sustainability.

It is true that death and taxes are the certainties of life but so is the inevitability of change. This is apparent in urban forestry as the field becomes more and more sophisticated. Gone are the days when community trees were only a thing of beauty and a source of shade for summertime relief. Today, trees are well-known for their practical and economical contributions, including energy reduction, stormwater runoff control, carbon sequestration, and improved public health. With this change in awareness has come the demise in most communities of simple "windshield surveys" and card files to collect data, evaluate the community forest, and perhaps determine planting needs.

Change has led to new tools and methods in urban forestry guided by research, innovation, and the availability of new technology. Urban tree canopy assessment is one such development, particularly the use of high-resolution aerial or satellite imagery that allows accurate assessments over large areas. This issue of Tree City USA Bulletin is not intended to be a how-to manual but rather a way to help the uninitiated gain a basic understanding of this relatively new and sophisticated tool and to get help implementing it in more communities.

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Some Canopy Assessment Basics

On tree boards and elsewhere in the urban forestry community, there are those who inherently understand and enjoy all things in the digital world. There are others who are new to these technological advances, including urban tree canopy assessment. For those in the latter group, here are some basics that might contribute to understanding this potentially valuable tool.

What is the Canopy?

The widely accepted definition of canopy in the context of urban forestry is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above.

Other cover features observable from above include soil/bare ground, water, grass and herbaceous plants, and such impervious objects such as roads, buildings, and parking lots. When quantified and taken together, all of these provide valuable information for future management.

A view from overhead provides a means to quantify tree cover, open spaces, and other land features.

TWO KINDS OF CANOPY ASSESSMENTS

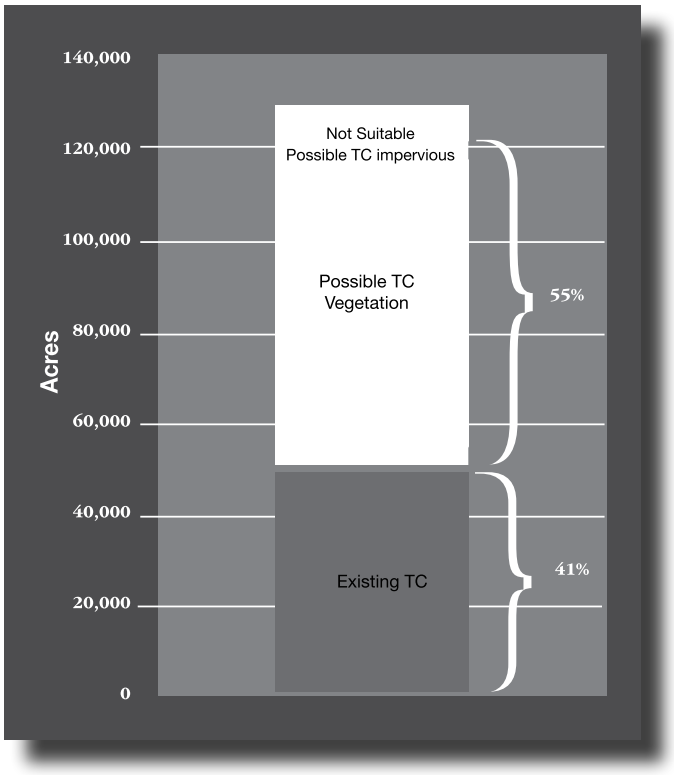
The two basic methods of assessing the community tree canopy are the "bottom-up approach" and the "top-down approach." The bottom-up approach means collecting field data much like in a traditional tree inventory — species, size, condition, etc. It provides details that can be translated into the value of ecoservices provided and into management planning. However, it is labor-intensive and does not map out the canopy or other land features. The top-down approach uses aerial or satellite images. It can cover either large or small geographic areas but is limited primarily to assessing quantity and distribution of trees or other land features. Sometimes, as in the examples on pages 6 and 7, the two methods are used together.

WHAT AN ASSESSMENT CAN PROVIDE

• TWO KINDS OF TREE COVER

Existing tree cover The tree canopy as it existed when the overhead image was made through aerial photo or satellite methods. This is usually done when trees are leafed out.

Potential tree cover This is also called "possible tree cover." It is the area where tree canopy is absent but theoretically could be modified to accommodate tree cover. This includes areas such as open fields, yards, and bare planting strips along streets. Depending on the method of assessment used, this may also include impervious surfaces, excluding roads and buildings. It also excludes water surfaces.

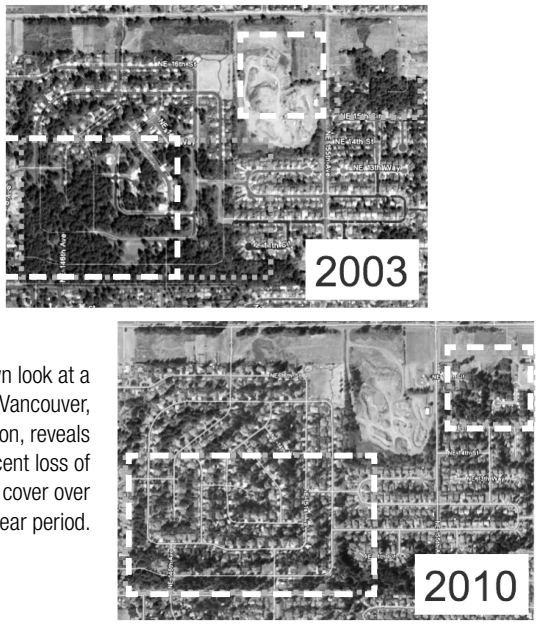


An example of tree canopy results.

• ACCURATE, DEFENDABLE DATA

A tree canopy assessment is useful in many ways and serves as a sign that the community truly cares about its trees and takes tree care and management seriously. An assessment provides valuable resource data useful for preparing:

- A guide to the preparation or updating of urban forestry master plans.
- A means to insert urban forestry and add value to a city's comprehensive plan, especially as a community strives for sustainability.
- Empirical data to prioritize investments and help persuade decision makers and those who set budgets.
- A way to illustrate disappearing tree resources if comparable images are available or, on a positive note, to show progress toward increasing tree cover with its associated benefits.



A top-down look at a section of Vancouver, Washington, reveals a 1.2 percent loss of tree canopy cover over a seven-year period.

SETTING GOALS

Perhaps the most important outcome of a tree canopy assessment is that it provides an opportunity to set specific tree-planting goals for a community. Comparing existing tree cover with specific goals (and adding target dates) provides an excellent guide for planning. Goals can be set in a number of ways depending on local needs, but here are three examples:

Comparison One study estimates that the national average of tree cover is 35 percent in urban areas. Atlanta, Georgia, can claim the highest — 48 percent.

An assessment in Washington, D.C., found the existing canopy to be 36 percent. The nonprofit tree care organization Casey Trees set a goal of 40 percent by 2032.

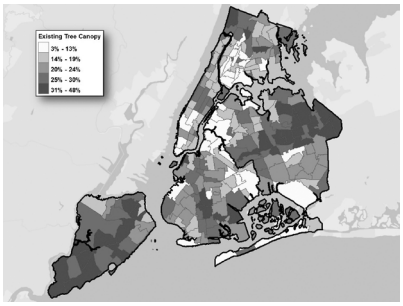
Economic/Environmental By integrating a top-down assessment method with a field-based method, such as i-Tree Eco or i-Tree Landscape, the ecoservice values of a community's trees can be determined. Scenarios for increased values can then be assessed.

For example, by increasing tree canopy cover in Boise, Idaho, by 5 percent, air pollution can be reduced by 25,802 pounds a year.

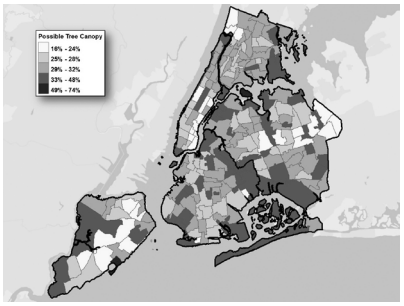
Social Justice Canopy assessment methods usually allow layers of data to be placed over tree canopy data. By breaking a city into districts or neighborhoods on a map and analyzing the data accordingly (e.g., using i-Tree Landscape), socio-economic conditions — such as underserved areas — can be taken into account when setting planting priorities.

Without setting goals as a result of a tree canopy assessment, the activity is little more than an academic exercise. Instead, results should be put to good use; setting goals is the way to do this. The results — and goals — represent a golden opportunity for publicity and public education about the benefits of the existing canopy and the potential for more, including economic benefits for all residents. Formal adoption of the goals (improved water quality, reduced energy consumption, improved environment in an underserved neighborhood, etc.) is the ideal. The actual planting goal to achieve the increase in canopy cover by a certain date can be incorporated into comprehensive plans, ordinances, or otherwise instituted.

Existing Tree Canopy



Possible Tree Canopy



Tree canopy data combined with GIS mapping techniques can be used by volunteer organizations, neighborhood associations, and urban foresters to set planting priorities where trees can best help serve social needs. The power of GIS as an analysis tool can also be used to determine strategic locations, such as where to plant to maximize shade or gain other environmental benefits.

Some Methods of Canopy Assessment

The tools available for estimating urban tree canopy are so numerous and ever-evolving that it is necessary to discuss with an expert the method that best matches your needs and budget. Here are a few methods that have been used by communities in recent years.

i-Tree Tools

A growing number of free i-Tree applications are available thanks to the U.S. Forest Service and its cooperators. The following three are particularly valuable for urban tree canopy assessments.

i-Tree Canopy is notable for being relatively quick and probably the easiest way to determine land cover types that are statistically accurate. Users can define the area of interest, such as a neighborhood or city limits, and whatever cover types are of interest. The program lays random points over Google aerial photos (500 to 1,000 points are suggested) and then zooms in on each sample point. Next, you select the cover types contained in each point, choosing from your pre-defined list.

This assessment provides a summary of tree cover in the community and an estimate of air pollution reduction and atmospheric carbon captured. This tool allows managers to set canopy goals and, with repeated use, will show progress over time — or the undesirable opposite. However, i-Tree Canopy does not map the canopy or tell you where the planting spaces are located.

i-Tree Eco is more involved and labor-intensive. It uses data collected in the field either from tree inventories or sample plots and combines it with local hourly air pollution and meteorological data. This results in detailed information such as species, size class distribution, and, by using a central computing engine based on scientific equations, environmental and economic benefits. Charts and tables can also be easily generated.

i-Tree Landscape is a relatively new tool that provides even more information. It is pre-loaded with land cover data and census demographics, allowing the user to create maps of communities of all sizes and summarize information within those boundaries. The website for this tool states that this "is not designed to replace other assessment tools, but augments them by allowing users to quickly show where the tree canopy is, estimate the services trees provide, and prioritize stewardship efforts based on U.S. Census demographic data. In less than 10 minutes, users can identify locations of interest and begin to explore the challenges and opportunities facing their urban forests. These outputs can help justify further assessment projects or natural resource management actions, such as undertaking an i-Tree Eco assessment or a more detailed urban tree canopy analysis."

The purpose of urban tree canopy assessments is to improve and expand community forests and make more scenes like this possible in neighborhoods of all economic levels.

HIGH-RESOLUTION AERIAL IMAGERY

There are a number of ways to use existing aerial images to delineate tree cover in a community. Sometimes the National Land Cover Database is recommended because it is free, easily available, and provides complete coverage of the lower 48 states. However, its image resolution is rather coarse, and tree canopies in communities are often underestimated. If used, it could be updated with correction factors developed by the U.S. Forest Service. The National Agricultural Imaging Program may be a better source since it provides images with crisper resolution. These images can either be interpreted manually or used with feature extraction software. Using a GIS program, such as ArcMap, is another method that is often used.

REMOTE SENSING

These more sophisticated geospatial methods are either passive (detecting naturally emitted or reflected radiation) or active (energy is sent earthward and measured as it is reflected back). The latter methods are the most expensive, but they provide extreme details that are important in larger urban areas.

LIDAR (Light Detection and Ranging) are images taken from an airplane that result from reflected light and emitted energy in the form of a laser. The big advantage of LIDAR is that it can "see" through building shadows. It also has the ability to sense small changes in elevation, thereby detecting small, recently planted trees and differentiating between objects such as trees and shrubs or buildings and parking lots.

Building shadows obscure trees in this urban aerial image. The use of LIDAR cuts through the shadows and significantly increases the accuracy of urban tree canopy mapping and assessment.

Multispectral imagery is another useful but expensive tool. It can be a very high-resolution type of remote sensing that detects energy wavelengths, including infrared, and creates digital maps. It can detect leaf pigments and help distinguish forest types in natural areas. In Milwaukee, Wisconsin, multispectral imagery helped map ash trees ahead of the emerald ash borer invasion.

Cost Sharing Can Make it Possible

"Communities should realize that remote sensing data can have many potential users and numerous applications. This opens up the possibility of cost-sharing partnerships with other agencies or neighboring communities. In some cases, the coverage area can be expanded at only a small extra cost. This allows neighboring communities to purchase data together at a lower cost than if they had purchased the same data separately. Communities should also consider their future data needs. They may, for instance, choose to acquire multispectral data instead of black-and-white or natural color data, so the data might be used for natural resource analyses outside the context of urban tree canopy."

— Urban Tree Canopy Goal Setting: A Guide for Chesapeake Bay Communities

Protect and Expand the TREE CANOPY

The purpose of measuring the urban tree canopy is to protect what exists and set goals to expand it and reap the additional benefits provided by urban trees. The U.S. Forest Service's Center for Watershed Protection recommends the following actions:

- Permanently protect priority forest tracts through acquisition, conservation easements, or other methods.
- Prevent forest loss during development by adopting or amending site development regulations (e.g., forest conservation regulations, open space design, clearing restrictions) and zoning.
- Maintain existing forest canopy by adopting regulations that restrict tree removal.
- Increase tree planting during development by adopting or revising site development regulations, such as landscaping and parking lot shading.
- Reforest public lands, beginning with priority sites.
- Encourage reforestation of private land by developing education, stewardship, and incentive programs.

Canopy Assessments in Action

More and more communities are turning to urban tree canopy assessments to guide future actions. Keep reading to find out how two in particular are benefiting.

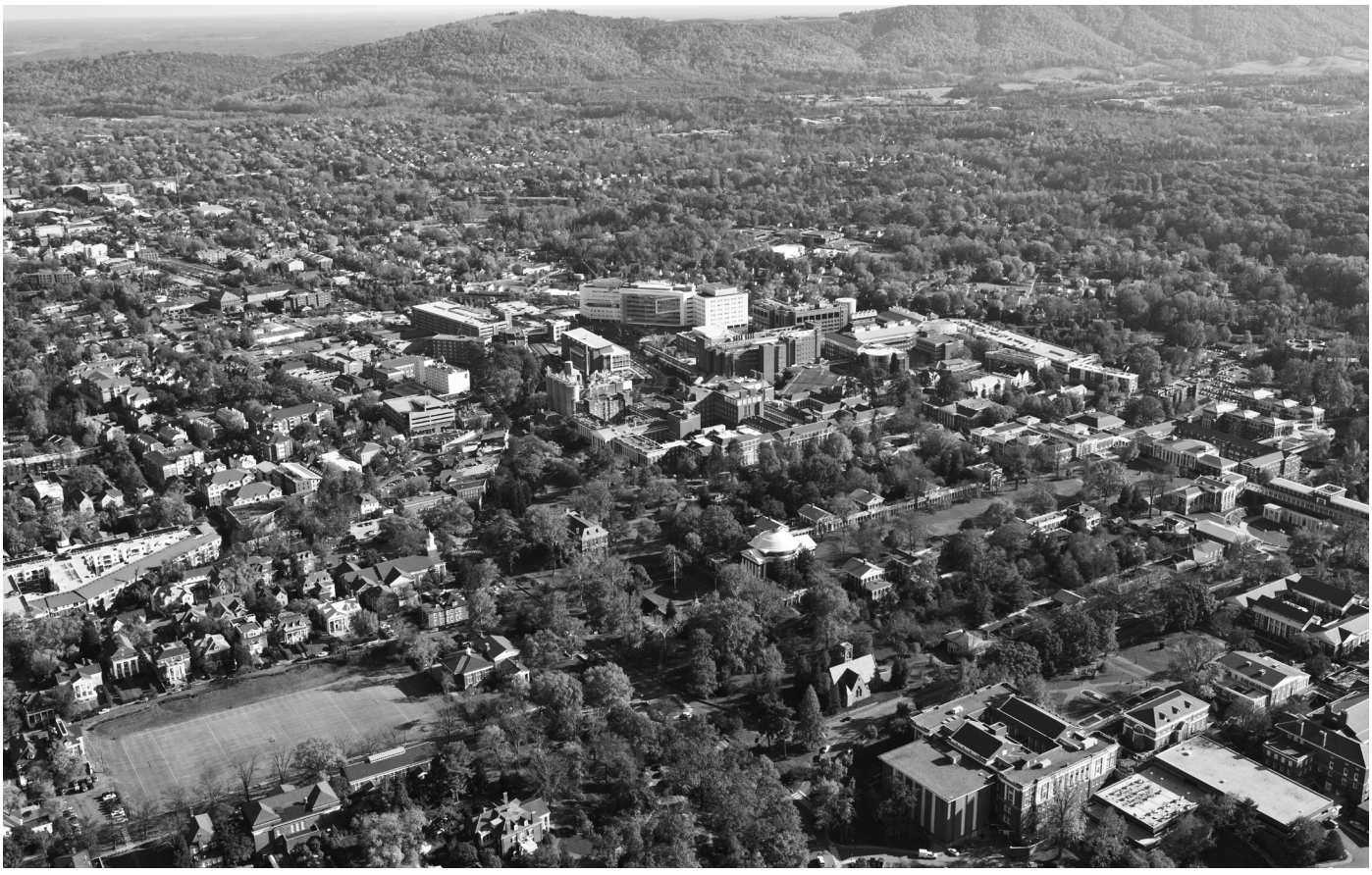
CHARLOTTESVILLE, VIRGINIA

In 2015, a consulting firm was contracted with funds provided by the Virginia Department of Forestry's Urban and Community Forestry Program and the U.S. Forest Service. The firm used high-resolution multispectral aerial photographs from the USDA's National Agricultural Imagery Program and ESRI's Image Classification Toolset that automatically classified what was "seen" into five kinds of land cover classes. This information was then refined with several more layers. The firm determined accuracy by randomly selecting points and then manually interpreting and comparing them to the automated classification.

As in most urban tree canopy assessments, an important part of this project was to determine the potential planting areas. When the land cover mapping was completed and the existing tree cover was determined, unsuitable planting areas, such as buildings and bodies of water, were removed. From the areas classified as "other vegetation," sites such as ballfields and golf courses were also removed as unsuitable. What remained were the potential planting areas — the sites of greatest interest to tree planters. In Charlottesville, the city already had an enviable 45 percent tree canopy, but in some areas the canopy was found to be as low as 14 percent. On average, 19 percent of the city contained potential planting areas, with the highest percentage being on city property. The potential planting areas were visually displayed on a map that highlighted areas that exceeded the overall average.

Results of the assessment were provided at geographic levels to allow a variety of audiences to use the actionable information. Levels included citywide, neighborhoods, public vs. private ownerships, and rights-of-ways.

Alerting the public and decision makers to the big picture of change over time was part of the purpose of this assessment. By using Google Earth images and other earlier aerial images, researchers found that the city's canopy had decreased 6.2 percent between 2005 and 2014. The project also showcased the importance of urban trees by using i-Tree Canopy to determine ecosystem service values, such the amounts of pollutants removed and carbon sequestered ($990,071). The use of i-Tree Hydro revealed the existing canopy mitigated approximately 765 million gallons of runoff annually.



Aerial view of the University of Virginia in Charlottesville, Virginia.

IDAHO'S TREASURE VALLEY

The Treasure Valley Canopy Study in southwestern Idaho encompassed not just one city, but a 240-square- mile area that included nine communities plus agricultural land. Stimulus for the project was deteriorating air quality in the valley — including Boise, several bedroom communities, and connecting highways. The idea was to show the value of trees in mitigating air pollution and the potential for cleaner air through planting more trees. The resulting statistics certainly met this goal, but — in addition to determining canopy cover — the study accomplished much more.

First, grant money from the U.S. Forest Service was obtained thanks in large part to the application coming from a coalition of organizations: the Idaho Department of Lands, all the cities involved, two county governments, Idaho Power Company, and the Southwest Idaho Resource Conservation and Development Council. Secondly, students were included and trained to do the on-the-ground data collection consisting of 250 one-tenth-acre plots. This not only provided summer employment but met internship requirements and introduced the students to opportunities in urban forestry.

The consulting firm Plan-It Geo did the canopy mapping and ground cover classification using multispectral aerial photography and digitized GIS layers. It also used an ArcGIS extension called CommunityViz that allows users to prioritize planting sites and even digitally place trees within individual sites and "grow" the trees to determine current and future ecoservice values in dollars.

One of the project partners, Idaho Power, is now a cooperating utility in the Arbor Day Foundation's Energy-Saving Trees program (**energysavingtrees.arborday.org**), which uses i-Tree tools and canopy assessment data to help inform the company's distribution of free trees to homeowners to help them reduce energy demands.

With existing tree canopy ranging from 5 percent to 20 percent in the Treasure Valley communities and 581 tons of air pollutants currently removed by trees, and with 1.8 million possible planting sites identified by the project — the opportunity for increased services from trees is clear.

Treasure Valley's story gets even better. As a result of the project and the potential for trees to improve the valley's environment, the Treasure Valley Canopy Network was formed. This is a coalition of natural resource and urban infrastructure professionals throughout the region with the common goal of improved planning, public education about trees, and a sharing of information and resources. Learn more at tvcanopy.net.

Under the supervision of Community Forestry Assistant Gerry Bates, a team of students prepare their equipment to gather data for use with i-Tree Eco software. This information was later combined with a top-down geospatial assessment.

Patti Best, program specialist with Idaho Power, inspects trees that will be given to residents as part of the Treasure Valley Shade Tree Project. This energy-saving program is designed to help expand tree cover in southwestern Idaho communities following findings of the regionwide canopy assessment.

Tree City USA Growth Award

Conducting a tree canopy assessment in your community would qualify for points toward a Tree City USA Growth Award.

Professional Help is Available

Obtaining aerial or satellite images and knowing what to do with them is not something most urban foresters or tree boards can do alone. In addition, the tools and procedures in this area of work are changing rapidly, most of it ultimately making canopy assessments more useful than ever. Fortunately there are many companies that are willing to assist with any aspect of urban tree canopy assessment. Some of these, along with links to additional information, are listed on the Arbor Day Foundation's Supplemental Resources Library found at **arborday.org/bulletins**.

What's to love about tree canopies? Of course they are home to squirrels and birds, but they also provide clues to the environmental health of a community. Measurement of the tree canopy can help quantify ecoservices, including carbon sequestration, removal of air-polluting particles and gases, stormwater runoff mitigation, and energy savings. When combined with mapping existing and potential canopy, a valuable tool is added to the planning and management of community forests.

FOR MORE INFORMATION …

For more information and references, please visit **arborday.org/bulletins**. Explore the Foundation's website for other helpful pages on trees, sale items, the Tree City USA program, public education, the management of community forests, and much more.

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