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TreeKIT: Measuring, Mapping, and Collaboratively Managing Urban Forests

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TreeKIT: Measuring, Mapping, and Collaboratively Managing Urban Forests

As cities across the United States expand their stock of street trees to address a range of environmental sustainability goals, municipal foresters are increasingly turning to volunteers to supplement their tree care efforts. TreeKIT is a small non-profit organization that helps city dwellers collaboratively measure, map, and manage urban forests. Using TreeKIT's mapping methods, volunteers are able to create spatially accurate inventories of street trees. In the process, volunteers learn to identify street trees and develop an effective appreciation for their local urban forest. The following article describes the TreeKIT mapping methods and ongoing efforts to scale these techniques for large, synchronous street tree census initiatives.

Keywords
urban forestry, mapping, GIS, street trees, volunteer

Introduction

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Tree Inventories and Distributed Urban Forest Management

Municipal agencies increasingly rely on volunteers to help care for urban street trees. In recent years, many large American cities have worked to grow – often by significant numbers – their inventory of street trees[1]. These burgeoning inventories have placed even greater strain on municipal forestry departments and created greater demand for supplementary help from local volunteers. In New York City, an aggressive "Million Trees" campaign added more than 200,000 new trees to the city's street tree inventory since 2007 (New York City Department of Parks and Recreation, 2012). Though New York is home to a vibrant and diverse community of volunteer tree "stewards," few tools exist to help this distributed network of lay-foresters track their work, see the work that their peers have done on local trees, or connect with each other to coordinate their efforts. In order to build tools that will help volunteers collaboratively manage their work, one small NYC-based non-profit has mobilized to help volunteers accurately measure and map the city's entire inventory of street trees.

New York City's Urban Forestry Structure

New York City's volunteer foresters are engaged at a variety of scales, from the individual that takes it upon herself to water, prune, and mulch a few street trees in front of her home, to city-wide organizations coordinating volunteers across the city's five boroughs. Between these extremes block associations, neighborhood-based non-profits, and borough-wide institutions– coordinate volunteer street tree stewards. Similarly, there are a variety of outlets for volunteers to learn about street tree stewardship. Under the direction of the city's MillionTreesNYC campaign, local organizations are partnering with some of the city's Botanic Gardens and other large-scale groups to offer hour-long "Street Tree Stewardship" workshops. Trees New York, one of the city's leading street tree education and advocacy organizations, offers a more in-depth training experience through its five-session "Citizen Pruner" course. At the end of the course, volunteers

[1] Some cities that have set major tree canopy goals:
- New York City (http://www.milliontreesnyc.org)
- PA/NJ/DE tri-state regional (http://www.plantonemillion.org)
- Baltimore (http://articles.baltimoresun.com/2006-03-30/news/0603300035_1_tree-canopy-forestry-feldberg)
- Washington, DC (http://caseytrees.org/wp-content/uploads/2012/02/report-2009-trc.pdf)
- New Haven (http://environment.yale.edu/uri/programs/tree-haven)
- Los Angeles (http://www.milliontreesla.org)
- Denver (http://milehighmillion.org)

are licensed to prune damaged, diseased, and dead branches off of street trees throughout the city (Trees New York, 2012).

At the same time, New York is home to a robust and professional urban forest management staff housed within various branches of the city's Department of Parks and Recreation. The Department of Central Forestry and Horticulture, which grew significantly with the onset of MillionTreesNYC, is responsible for identifying new tree planting sites, specifying tree species for each site, managing contracts with private companies that plant the trees in curbside beds, coordinating with utilities, and ensuring quality throughout the tree installation and warranty period (typically two years). Staff within each of the five Borough Forestry divisions pick up where the Central Forestry staff leave off, managing ongoing pruning, watering, and tree bed enlargement after the contractor warranty expires on each tree. The resources for ongoing maintenance are chronically stretched, and volunteers care for most of the city's street trees.

The small staff that make up the MillionTreesNYC campaign round out the city's municipal forestry workforce. Working from within the Parks Department's central office, the MillionTreesNYC team develops and manages the program's outreach, education, and social marketing initiatives, and coordinates with non-profit partners throughout the city. Since the start of the MillionTreesNYC campaign, they have served as the default public engagement unit around street tree stewardship issues.

Methods

TreeKIT is a small environmental research organization sponsored by the Citizen Action program of the Open Space Institute – a New York-based organization engaged in conservation advocacy throughout the state. Since the middle of 2010, TreeKIT has worked with neighborhood-based volunteers to create spatially accurate inventories of New York City's street trees. These inventories can be viewed in mapping applications that range from ESRI's Geographic Information Systems ("ArcGIS") to no-charge downloadable programs like Google Earth as well as online in TreeKIT's own webmap (http://treekit.org/map). Recently TreeKIT staff have worked with the developers of OpenTreeMap on expanding and refining the stewardship management features available on that particular open-source application. When coupled with geospatially accurate street tree inventories like those produced by TreeKIT, these features will allow volunteer foresters to publicly track the work they've done to any particular tree, see the work that other city dwellers have done to any tree in the inventory, and connect with each other to form larger stewardship initiatives.

Geolocating street trees in a dense and vertically developed city like New York poses a variety of challenges. The process of "dropping points on a map" has been widely used since the emergence of freely available satellite imagery beginning in the mid-2000's. This process invites users to visually determine the location of a tree using satellite images available in applications like Google Maps. Once the tree location has been identified, the user "drops" a point on the spot. Though this method may yield accurate results in some instances, it has some significant drawbacks. Aerial imagery is rarely perfectly perpendicular to the surface of the earth, and a slight "tilt" in the image can cause any building taller than the street tree canopy to mask a tree's location. Lacking on-street cues to triangulate tree locations, map-makers may also run the risk of dropping a point meant to represent a particular tree on another tree nearby. Alternately, using

Global Positioning System (GPS) hardware in the field can be expensive and may yield inaccurate locations in settings where tall buildings create a "canyon effect" that interrupts satellite signals.

The TreeKIT methodology relies on affordable off-the-shelf tools and simple site-surveying skills to determine the locations of street trees. Instead of mapping single trees in isolation, the TreeKIT methods create a string of linearly referenced locations for trees on straight-line block segments that stretch from one intersection corner to another. Working with local volunteers, TreeKIT staff begin the mapping process for any individual block by identifying a "start point" in the field that is also easily located in a desktop GIS using public geographic data on streets and sidewalks. These "start points" are derived by visually extruding perpendicular curb edges at a rounded street corner and approximating their likely intersecting point (note Step 1 in the Figure 1 diagram).

Using a standard engineer's measuring wheel or "rolling tape measure" (approximately $80 retail as compared to upwards of $350 for the most basic GPS system), the field team records the distance from the start point and the near edge of the first tree bed along the street. Length measurements are recorded in feet and tenths of a foot. Then the team measures the length and width of the tree bed quadrangle – length being parallel to the street curb and width being perpendicular to the curb, labeled 2 in Figure 1. Finally, the team notes the species of the tree in the bed, the address of the nearest building, and the circumference of the tree at breast height (54" above the ground), rounded to the nearest half-inch. If a tree is missing or dead or all that remains of the tree is a stump, those conditions are also noted. The process is continued once more, with the team measuring the distance between the far edge of the tree bed and the near edge of the next tree bed along the street. The process ends when the team arrives at the next intersecting street and derives an "end point" using the same method they used to derive a "start point." In this way, the location of all the tree beds – and the trees within them – is related back to a point (Figures 1 & 2) that is easily given an accurate geospatial coordinate in GIS.

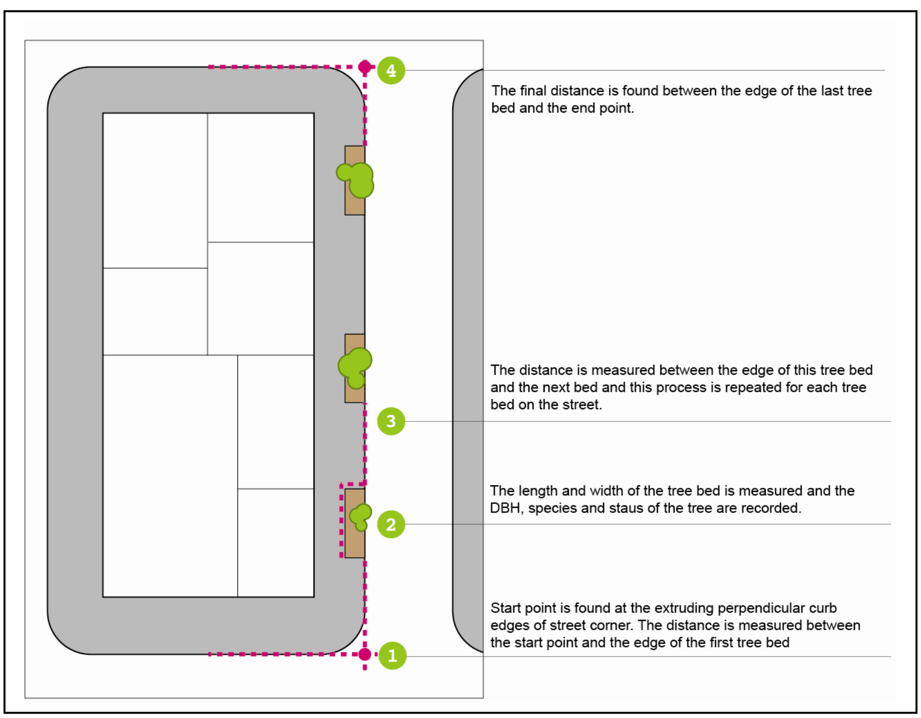

Figure 1. A schematic of the TreeKIT mapping methodology

Figure 2. TreeKIT staff guide a mapping volunteer in the field

In addition to all of the measures described above, teams note the name of the street where they are mapping, the name of the intersecting streets at the start and end points, and the side of the street (left or right) they are mapping, based on the direction in which they are walking. Mapping teams track all data on simple 8.5"x11" paper data sheets designed for ease of use and efficient data collection. (See sample at http://treekit.org/wp-content/uploads/2011/06/110421.temp_alt.pdf.) All of the resulting data is entered through an HTML form and a simple, Google Maps-based interface where start and end points are selectable by clicking on map markers (Figure 3). The data is stored in an online database and processed into map files by a small program custom-built for TreeKIT by a freelance geographer. The same applet translates tree circumference into tree diameter at breast height, the standard measure of trunk thickness in forestry.

It is important to note that the spatial inventory of street trees that results from this process sits separate and apart from existing municipal tree inventories. Traditionally, urban foresters have used an address-based system (rather than a geospatial reference) to define the approximate location of street trees in municipal inventories. When mapped using modern geographic software, these data points "drop" on top of the related building or nearby roadbeds instead of corresponding with the actual tree location in the curbside tree bed. Though some efforts have been made to automatically correct for this spatial discrepancy, the results are not as accurate as the field-based approach described above.

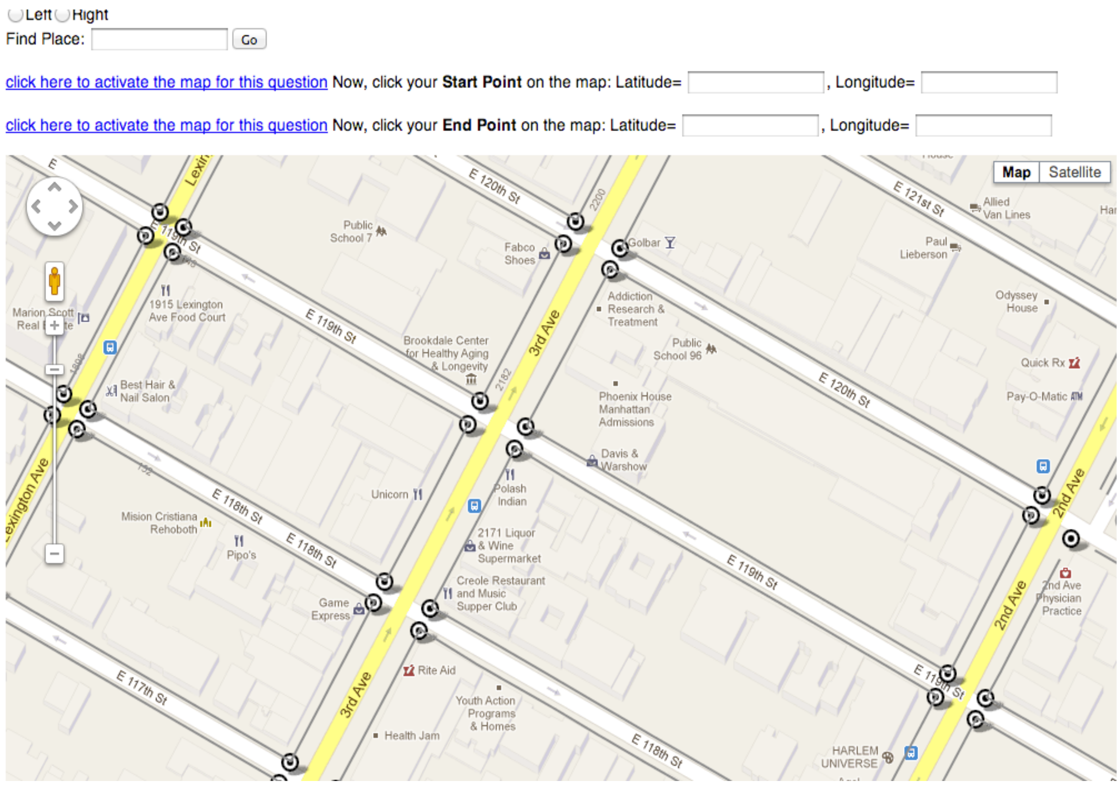

Figure 3. Picking up "start points" in the TreeKIT data entry form

The data collected in this process could be used to reach far beyond a spatial inventory of trees. The geometry of the tree beds can become GIS objects that can be queried to reveal some environmental characteristics of the mapped areas. For example, the area of permeable soil in the public right-of-way could be found by subtracting a tree's basal area from the area of the tree bed, and this information could be useful for studies of stormwater collection potential. Other functions – such as estimating stored carbon by calculated approximate biomass, calculating summer shading patterns, and comparing urban forest characteristics at a variety of scales – could also be possible with the use of the TreeKIT data.

Lessons Learned

From July 2010 to September 2012, TreeKIT and its growing network of volunteers has mapped more than 10,000 street tree beds in the New York City neighborhoods of Prospect Heights, Long Island City, Astoria, Sunnyside, East Harlem, and Gowanus in the boroughs of Manhattan, Queens, and Brooklyn. Most of the mapped trees are viewable on TreeKIT's public web map, with ongoing data entry efforts adding more tree beds to the map weekly (Figure 4). In Queens, the map is helping foresters determine opportunities to plant new street trees based on the available space between existing beds, the mapped location of empty beds, and the mapped location of tree stumps in beds. In the future, the data may also be used to determine the ecosystem benefits provided by the full street tree inventory, using analytic tools like the US Forest Service's i-Tree software (www.itreetools.org).

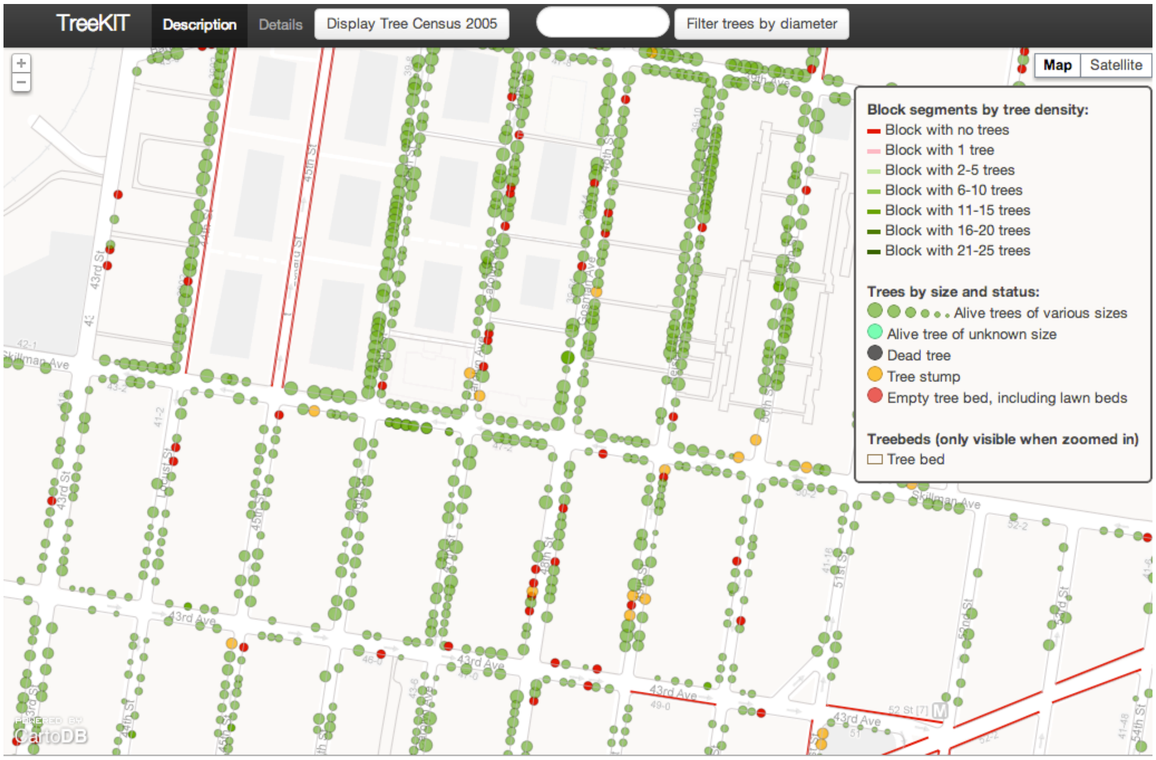

Figure 4. TreeKIT's public web map, zoomed in to reveal the neighborhood of Sunnyside, Queens (NYC)

On average, we have found that it takes a team of three mappers approximately fifteen minutes to map the trees along a single block segment. Shorter block segments generally take less time to map, though the number of trees found on each segment will have the greatest impact on completion times. Up to now, TreeKIT has relied on knowledgeable staff and occasional volunteers from the forestry and horticulture community to serve as "team leaders," guiding new volunteers through the process of tree species identification and the measuring methods. As a result, TreeKIT has had no more than four or five teams mapping in tandem during any given mapping event. Though this approach works on a neighborhood-by-neighborhood scale, it presents challenges for any city-wide, synchronous street tree census. In New York City, the Department of Parks and Recreation administers a decennial tree census that relies on volunteer labor working across the city during a single growing season. The sheer number of volunteers working all at once would make it impossible to affordably provide enough team leaders to guide the process.

In order to address these limits, TreeKIT is developing a web-based training program to help incoming volunteers gain skills in tree identification before they head out into the field. TreeKIT is also working to develop a mobile "app" to guide volunteers through the measuring and data entry process in the field, thereby reducing the need for on-site management and eliminating the need for data entry after a mapping event. Though this scaled-up approach will reduce the need for team leaders working directly with volunteers in the field, it may have an adverse impact on volunteer motivation. Volunteers have valued the one-on-one learning that happens in the field with a team leader. During a typically 3-hour mapping session, volunteers learn about a range of topics in urban forestry, with team leaders informally interpreting the experience through dialogue. Most returning volunteers have cited the learning dimensions of the experience as their main reason for coming back. The new approaches to distributed learning will need to approximate the positive aspects of this experience and continue to emphasize the valuable transactional learning that happens when volunteers first come to explore the urban forest.

The TreeKIT methodology is limited by one other factor. At the moment, it cannot be used on curved streets. The linear referencing method used to map tree beds in relation to a known start point relies on straight curb edges. TreeKIT is working with tech advisors to develop a complementary method for mapping curved streets, with further work pending additional funding. In the meantime, most streets in older U.S. cities – especially in dense urban cores where trees are most in need of stewardship – follow a grid layout and are available to be mapped using the existing TreeKIT method.

Conclusion

The TreeKIT mapping methodology has been used to successfully map and inventory more than 10,000 street trees throughout New York City since 2010. Though the technique uses simple, off-the-shelf tools to accurately locate street trees and tree beds, further investments in technological development are necessary to scale the project for large, synchronous tree census efforts. New tech tools, aimed at mobilizing volunteers to map trees with minimal support from trained staff, may have unintended negative impacts on volunteer motivation. Careful user-interaction design, coupled with attentive volunteer organizing on the part of TreeKIT staff, may help compensate for less "face-time" between volunteers and knowledgeable staff.

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