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The Public Urban Forest: Planning and Managing a City's Tree Resource

by

Shannon Scroggins
University of Louisville

UNIVERSITY OF LOUISVILLE®
CENTER FOR ENVIRONMENTAL POLICY & MANAGEMENT

Center for Environmental Policy and Management
Environmental Finance Center: Serving EPA Region 4
University of Louisville
Department of Sociology
Louisville, KY 40292
502-852-4749
http://louisville.edu/cepm

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Introduction

Approximately 84 percent of the population of the United States lives in urban areas (United Nations, 2009; United Nations, 2011). This trend is expected to continue with an estimated 90 percent of the population in the United States residing in urban areas by 2050 (United Nations, 2009; United Nations, 2011). Urbanization can have negative effects on both local and global environments. Urban areas cover 2 percent of the globe, but produce 78 percent of all greenhouse gases (Grimm et al., 2000). Trees are an important part of the green infrastructure of cities that can help ameliorate their negative ecological and social aspects.

Urban trees provide valuable services, known as *ecosystem services*, to the residents of cities. By shading buildings in the summer and serving as windbreaks in the winter, properly placed trees can reduce cooling and heating costs (Akbari et al., 1986; Heisler, 1990; Akbari, 2002). Trees improve air and water quality by filtering and trapping air pollutants (Lovett et al., 2000; Fowler, 2002). They also remove carbon dioxide (CO_2) from the air, which is used by the tree to create its food as well as its woody structure (Nowak and Crane, 2002). Thus, trees serve as an important carbon sink. By intercepting rainfall and taking up water that infiltrates soil, trees decrease runoff into streams as well as into Combined Sewer Overflow (CSO) pipes (Sanders, 1986; Xiao et al., 1998; Bolund and Hunhammar, 1999; Nowak and Dwyer, 2007). This valuable service decreases flooding and sewage overflow in cities that have CSOs. Trees also stabilize stream banks and help prevent erosion. In coastal regions, intact coastal forests and mangrove swamps lessen storm surge and help protect coastal cities from catastrophic damage (Gedan et al., 2011; Loder et al., 2009; Lopez, 2009).

Trees can also be used for *phytoremediation*, a technique that involves the use of plants to remove pollutants from contaminated soil (Raskin, Smith, and Salt, 1997). One of the primary applications of phytoremediation is for brownfields mitigation (Eberts et al., 2005; Cook et al., 2010; El-Gendy et al., 2010). Brownfields are defined by the U.S. Environmental Protection Agency (EPA) as "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant" (U.S. Environmental Protection Agency [EPA], 2011). Common tree species used for brownfields remediation are poplar (*Populus* sp.) and willow (*Salix* sp.) (Cook et al., 2010). Trees also provide social benefits, such as providing locations for recreation (Jim and Chen, 2006), enhancing real estate values (Morales, 1980; Tyrväinen and Miettinen, 2000), providing a sense of place and aesthetic beauty (Smardon, 1988; Tyrväinen et al., 2003), potentially improving health outcomes in hospitals (Ulrich, 1984), and potentially reducing crime (Kuo and Sullivan).

Trees do have risks associated with them, such as trees or branches falling during storms, that can threaten peoples' health and safety as well as their property (Lopes et al., 2007). These risks can be minimized by proper tree selection, planting, and maintenance. Urban forest maintenance activities like pruning, cabling, and bracing are all examples of tree risk management activities that can reduce the possibility of harm or damage.

The urban forest is composed of trees in both the private and public domains. Trees in residential, business, and institutional areas are examples of privately-maintained trees. Public trees are those found in public rights-of-way and parks or any other publically-held lands. Public

managers can maximize the benefits provided by trees while minimizing costs by preserving or restoring native woodlands and managing trees in parks and on streets. In addition, land development and zoning policies and ordinances can provide and protect the preservation of forests and trees and ensure the general public's access to them as well.

This practice guide focuses on urban forest management from a municipal perspective and is meant to provide decision-makers, such as city arborists, public works officials, public policy makers, city managers, local non-profits, and park managers, with information to maximize the benefits and minimize the costs of improving and managing their public urban forest. The guide is divided into sections that give a broad overview of planning, planting, maintaining, and managing the urban forest resource. Case studies that illustrate some of these concepts in action are included, as well as an extensive list of tree-related resources.

Incorporating Trees into a Community's Planning Goals

Tree Planning

An important first step in a public urban tree program is to perform an inventory of the community's tree population to enumerate the city's current resources as well as to determine areas of need (Schwab, 2009). Tree inventories provide a range of information that contributes to the planning and management of the urban forest. Types of inventories vary depending on the nature of information urban forest managers want to collect. What follows is an overview of two types of inventories: 1) on-the-ground inventories and 2) large-scale inventories that use aerial imagery and Geographic Information Systems (GIS) analysis.

On-the-ground inventories are used for managing the tree resource in specific areas, such as parks or along streets. The collected data can then be used to determine individual tree maintenance needs, calculate ecosystem services, coordinate emergency management, and are vital in risk management (P. Barber, personal communication, *March 9*, 2012). Overhead, large-scale inventories can help with long-range planning including zoning regulations and decisions (P. Barber, personal communication, *March 9*, 2012). This type of information is also useful in estimating canopy coverage, a common measurement of the amount of land area covered by tree foliage, and establishing canopy-cover goals for both public and private trees.

Tree inventories are often done by certified arborists or experienced inventory arborists (American Public Works Association, n/d). If the city does not employ an arborist, one can be hired as a private contractor. Trained volunteers can also be used to perform tree inventories as long as the data are accurately collected (Bernhardt and Swiecki, 2001). Volunteers usually collect simple data on trees whereas arborists and urban foresters perform various levels of tree assessment and collect more complex data. Typical data collected on the target trees include (American Public Works Association, n/d; Bernhardt and Swiecki, 2001):

- Location
- Species
- Size (diameter-at-breast height, height, crown spread)
- Condition
- Age
- Maintenance need and priority

- Proximity to utility lines
- Traffic signs and signals
- Sidewalk and other hardscape damage
- Insect and disease problems
- Amount of canopy cover at the location
- Potential tree-planting sites

Ideally, a complete inventory of all public domain trees would be performed, but this may not be possible due to time and/or financial constraints. In this case, the inventory should focus on a specific subset of the public urban forest, such as street trees, and measure other components of the urban public forest as time and money allow. A statistical sample, for example, 3-6 percent of street trees or of public land area, could be used to estimate the urban forest resource (American Public Works Association, n/d). Bernhardt and Swiecki (2001) provide details on how to choose a representative subsample of the tree population for a partial inventory.

Tree inventories can be obtained by collecting data in the field via foot surveys or visual/windshield surveys. Foot surveys are used to collect detailed tree measurements as well as tree condition and management data regarding age and maintenance need. Visual or windshield surveys can be a way to evaluate trees by collecting limited data, such as tree species, size, location, and condition. The data can be written on paper inventory sheets (see Appendix A) or entered into handheld computers using commercial or public domain software inventory programs. Global positioning system (GPS) devices can be used to record tree location. (Examples of tree inventory and management software can be found at http://na.fs.fed.us/urban/inforesources/inventory/tree_inventory_mgmt_software_list.pdf.)

Geographic Information Systems (GIS) software and satellite data can be used to determine the extent of a community's green infrastructure and to estimate the benefits provided by all of its trees, not just those under public control (Schwab, 2009). Using GIS, planners can create a digital representation of tree cover in a community (Schwab, 2009). This green infrastructure layer can then be used to determine community-wide tree canopy cover as well as provide input into land use planning. Two-types of GIS layers can be created from different tree data sources: one is point-data, which uses individual tree location coordinates collected via GPS during the tree inventory, and the other is a digital green data layer consisting of land cover data obtained from satellites or aerial photography, which can then be used to determine the amount of tree canopy cover in a community (Schwab, 2009). Quantification of tree canopy coverage can provide information on where tree planting efforts need to be focused and over time can be used to map changes in tree coverage.

Tree canopy coverage information can be used to set urban forest canopy goals, which is another important step in developing a public urban tree program. As stated earlier, a healthy tree community provides urban areas with vital services such as improved air and water quality, decreased energy usage, and pollutant removal. American Forests has general guidelines for tree canopy coverage that are based on climate and planting zones (Table 1). Local climate, land use, geography, and politics would need to be taken into account to modify these goals for a specific community (Schwab, 2009).

Table 1

American Forests' Tree Canopy Goals

For Metropolitan Areas East of the Mississippi and in the Pacific Northwest	
Average total tree cover – all zones	40%
Suburban residential zones	50%
Urban residential zones	25%
Central business districts	15%
For Metropolitan Areas in the Southwest and Dry West	
Average total tree cover – all zones	25%
Suburban residential zones	35%
Urban residential zones	18%
Central business districts	9%

Another part of the tree planning process includes quantifying the services that public trees provide to city residents. The USDA Forest Service has created a free suite of software tools that can be used to inventory the urban public tree resource as well as calculate the various benefits provided by these trees (http://www.itreetools.org/index.php).

Two of the programs calculate urban forest ecosystem benefits. The first program, i-Eco (formerly called the Urban Forest Effects or *UFORE* model), uses on-the-ground inventory methods to collect data on individual trees as well as plot attributes that are used to quantify the structure of the urban forest and the benefits it provides. The collected data are submitted to the server on the i-Tree website (http://www.itreetools.org/index.php) and the analysis is performed, free-of-charge, in one to two hours (R. Hoehn, personal communication, *January 17,* 2012). The newest release of i-Tree Eco (version 4.0) also has an automatic report generator. The second program, i-Streets, uses street tree inventory data to calculate the environmental and aesthetic benefits provided by street trees. The data are analyzed using "Streets" (formerly called STRATUM), which is downloaded to the user's computer. Data for both of these models can be collected using small, complete inventories or large-scale, partial inventories that use a simple or stratified random sampling protocol.

There are four other i-Tree tools available: the i-Tree Hydro, the i-Tree Vue, the i-Tree Design, and the i-Tree Canopy. The i-Tree Hydro (beta) allows users to analyze vegetation at the watershed scale as well as the effects of impervious cover on hydrology. The i-Tree Vue provides access to freely available National Land Cover Data maps that can be used to evaluate a community's land cover, including the amount of tree canopy coverage, to calculate some of the ecosystem services provided by the urban forest. The software can also be used to model different tree planting ideas and estimate how different scenarios will affect ecosystem benefits. The i-Tree Design (beta) is a simple tool that can be used to estimate the benefits provided by an individual tree. The final tool, i-Tree Canopy allows the user to estimate land-cover types, such as tree cover, using the aerial images available in Google Maps.

Tree Planting

When choosing tree species to plant, many factors should be considered, including species diversity. To avoid disasters, such as the massive loss of American Elm trees to Dutch Elm Disease in the 1950s and 1960s, it is important to use a variety of tree species to prevent catastrophic loss of urban tree canopy due to disease or insect pests. Species diversity should be considered not only at the community-wide level, but also for individual planting projects, such as trees along a street or in a neighborhood. Miller and Miller (1991) recommended that any one species should not exceed 10 percent of the total street tree population. However, Richards (1993) made the argument that rigidly sticking to this guideline could lead to species that are not adapted to harsh urban conditions being planted as street trees, where they will ultimately fail.

Instead of aiming for a strict species diversity guideline, a city could determine a palette of tree species that are adapted to the challenging growing conditions found at the sides of roads and streets and make a commitment to planting a variety of species from this list. Simons and Johnson (2008) suggest that if overuse of a particular species is an issue, capping a species at 20 percent and genus at 35 percent of the total tree population is a reasonable target. Other public forest areas, such as parks, could be used to increase overall city-wide public tree species diversity, since growing conditions in park settings are usually less challenging than along roadways. A preference for native species should also be considered in making a tree palette, but as stated above they must be suitable for the growing conditions in the area in which they will be planted.

Tree siting is also an important factor when planting new trees. An improperly sited tree may not only fail to thrive, but may also become a public hazard. Several site characteristics need to be considered in making the decision about whether to plant a tree in a given location as well as which species to plant at the site. Schwab (2009) suggests that local water availability, soil conditions, terrain, native-versus-non-native species, and the surrounding built infrastructure all need to be taken into consideration in planning tree plantings. The location of above- and below-ground utilities as well as the size of the planting space needs to be evaluated prior to planting. For example, small tree species (25 foot height or less) are the best choice to plant underneath or near power lines in order to prevent branches from interfering with power transmission (Fazio, 2003). Collaboration between local government officials and utility companies is essential to properly maintain trees near power lines. Some communities have instituted programs to reduce tree-power line conflicts. Columbia, Missouri has a Trade-a-Tree program that allows customers with qualifying trees to have them removed and replaced for free (http://www.gocolumbiamo.com/WaterandLight/Home/t-trade.php). The Bowling Green, Kentucky Tree Advisory Board has developed a tag that can be attached to tree species that are "utility friendly" (http://www.bgky.org/tree/utility.php).

Once a tree and planting location are selected, proper planting is imperative to give it the best chance of survival (Appendix B). The best time of year to plant is in the fall or spring, but specific planting dates depend on local climate. The International Society of Arboriculture provides detailed step-by-step instructions on tree planting (http://www.treesaregood.com/treecare/tree_planting.aspx).

The American National Standards Institute (ANSI) has a voluntary set of tree care guidelines that were developed in conjunction with the Tree Care Industry Association that include instructions on how to transplant trees. An overview of the steps can be found at: http://www.treecareindustry.org/standards/part6/transplanting.htm. The page also contains a link to purchase the complete set of standards for tree care maintenance operations.

The Arbor Day Foundation has a series of videos that give instructions on how to plant bare root trees, balled and burlapped trees, and containerized trees (http://www.arborday.org/trees/tips/treePlanting.cfm).

Providing trees with optimal soil structure is important in increasing their chances of thriving in the potentially challenging urban environment. This is especially important for street trees. Tree pits need to be as large as possible to accommodate a tree's root growth and keep the roots from creating structural damage to sidewalks. According to the New York City Parks and Recreation's Tree Planting Standards Guide (2009), the ideal street tree pit should be 4-5 feet x 10 feet. However, sidewalk width can constrain the ability to meet this recommendation. The guide includes a table of sample tree pit configurations (http://www.nycgovparks.org/sub_permits_and_applications/images_and_pdfs/TreePlantingStandards.pdf, pages 19-20). If the planting area available along a sidewalk is inadequate, it would be better to consider alternate planting sites, since a too small tree pit will compromise the tree's health and longevity. Simons and Johnson (2008) suggest that in such situations alternate sites to consider, space permitting, are medians and private property "at least three feet from inside property line subject to easements and agreement." In areas of continuous sidewalk, trees can also be placed in planters, although this decreases longevity due to water stress and lack of root space (Simons and Johnson, 2008).

Another solution to increasing the health and longevity of street trees is the use of structural soil. Structural soil has been designed to be compactable, so it meets the load-bearing requirements of sidewalks and other paved surfaces, while at the same time providing suitable structure for root growth (Grabosky and Bassuk, 1995; Grabosky and Bassuk, 1996). The Cornell University Urban Horticulture Institute (http://www.hort.cornell.edu/uhi/outreach/csc/article.html) has designed a structural soil that is comprised of specific ratios by weight of crushed stone (100), clay loam (20), and a hydrogel stabilizing agent (0.03) with total moisture at mixing of 10 percent. Through their research, they have found that this mixture meets or exceeds the load-bearing requirements for sidewalks and provides a matrix in which tree roots can grow (Grabosky and Bassuk, 1995; Grabosky and Bassuk, 1996).

Tree Maintenance

Routine, long-term maintenance is necessary in order to protect a city's tree resource. Not only does routine maintenance increase a tree's health and longevity, it also helps reduce risks to life and property. Comprehensive tree maintenance includes "pruning, fertilization, integrated pest management, wound treatment, bracing and cabling, and hazard inspections" (Simons and Johnson, 2008). Many of these maintenance components have been addressed by the American National Standards Institute.

The *American National Standards Institute (ANSI) A 300 Standards for Tree Care Operations* are industry standards that were developed by the Tree Care Industry Association (TCIA). The standards are voluntary, based on accepted tree care principles, and are to be used to develop tree management practices. The committee that develops, reviews, and revises the standards as needed is composed of a diverse and experienced group of tree industry professionals, including commercial tree care organizations, utility managers, and government-sector employees. The standards are divided into the following parts and may be purchased on TCIA's website at http://www.tcia.org/standards/A300.htm:

1. ANSI A 300 (Part 1) – 2008 Pruning.
2. ANSI A 300 (Part 2) – 2011 Soil Management (includes fertilization).
3. ANSI A 300 (Part 3) 2006 Supplemental Support Systems (includes cabling, bracing, guying, and propping).
4. ANSI A 300 (Part 4) – 2008 Lightning Protection Systems.
5. ANSI A 300 (Part 5) – 2005 Management of Trees and Shrubs During Site Planning, Site Development, and Construction.
6. ANSI A 300 (Part 6) – 2005 Transplanting (includes planting).
7. ANSI A 300 (Part 7) – 2006 Integrated Vegetation Management (IVM).
8. ANSI A 300 (Part 9) – 2011 Tree Risk Assessment.
9. ANSI A 300 (Part 10) – 20xx Integrated Pest Management (IPM) – under development.

Another important aspect of proper tree maintenance is how often trees are pruned. The Society of Municipal Arborists has set standards for street tree pruning maintenance (Roush and McFarland, 2006). The minimum standard is to prune each street tree every eight years with the optimal schedule being to prune young trees every three years and older trees every five years (Roush and McFarland, 2006). Putting trees on such a cyclical pruning schedule can help reduce pruning and other maintenance costs. Browning and Wiant (1997) found that when line clearance tree pruning was delayed beyond the optimal time, which in their study was every five to six years, the cost of pruning increased significantly. They also determined that the amount of biomass removed increased as a tree was allowed to grow for longer periods of time and the greater the amount of biomass, the greater the disposal costs (Browning and Wiant, 1997). Miller (1997) calculated that the optimal tree pruning cycle in Milwaukee, Wisconsin was every five years, although young trees might need to be pruned on a three-year cycle. He proposed that this cycle would be appropriate for other communities with a northern temperate climate, but that an optimal pruning cycle depends on the species, age, and condition of a city's trees as well as the local climate (Miller, 1997).

Urban Forest Management

Unlike in natural settings, the urban forest has to be actively managed to keep it healthy and prevent it from becoming a hazard to human life and property. Proactive management also reduces the cost of maintaining the urban tree canopy and maximizes the important services that trees provide. Since trees and humans are highly interconnected in the urban environment, collaboration between many different groups and agencies is another important aspect of managing the urban forest. This section will look at ways to bring interested parties together to

work toward a sustainable urban forestry plan, conduct public outreach to engage citizen participation and support, and finally, find various funding mechanisms.

An important piece of urban forestry management is the creation of tree ordinances and urban forest master plans. Tree ordinances provide the authority for municipalities to manage public trees (Miller, 1997). They also outline which agencies are responsible for various tree care activities, create public tree management and maintenance standards, and define the conditions under which privately-owned trees can be declared nuisances (Miller, 1997). Separate tree ordinances are often written for different tree subpopulations, such as street trees or park trees, because there may be different management requirements as well as different agencies in charge of a specific subpopulation's management. Bernhardt and Swiecki (2001) have grouped tree ordinances into three broad categories based on a survey of city and county tree ordinances in California: 1) street tree ordinances, 2) tree protection ordinances, and 3) view ordinances. View ordinances are adopted to provide guidelines for resolving conflicts between property owners when trees block views (Bernhardt and Swiecki, 2001). According to Miller (1997), a tree ordinance will contain some or all of the following components:

1. Purpose of the ordinance and its necessity.
2. Definitions.
3. Establishment of a tree board.
4. Description of the education and experience requirements for the city arborist or forester.
5. Duties of the city arborist/forester.
6. Statement of the authority granted to the city arborist/forester or other municipal agencies to plant, maintain, and protect urban trees.
7. The requirement of permits for the removal of public trees by anyone other than the urban arborist/forester and/or designated municipal agencies.
8. Maintenance standards.
9. Requirement for private tree owners to keep their trees from obstructing streets, sidewalks, and signage.
10. Definition of nuisance trees and the authority to condemn them.
11. Prohibition of public tree abuse or mutilation.
12. Protection of public trees during construction and other potentially harmful activities.
13. Guidelines for enforcement of the tree ordinance, penalties for violations of the ordinance, and an appeals process.

Tree ordinances provide the guidelines for management of the urban forest by codifying which personnel and agencies have the authority to manage public trees. According to Bernhardt and Swiecki (2001), tree ordinances should be part of a larger urban forestry management plan. There are seven broad areas that need to be covered in the management plan:

1. Assessing the public tree resource.
2. Reviewing past tree management practices.
3. Identifying urban forestry needs.
4. Establishing specific goals
5. Developing a management strategy to address urban forestry goals
6. Implementing the urban forest management plan.
7. Evaluating the results and revising as needed (Bernhardt and Swiecki, 2001).

Urban forestry management plans incorporate both short- and long-term planning goals. Short-term goals focus on day-to-day management of the urban forest and include activities such as determining work priorities, scheduling personnel, and maintaining equipment while long-term management incorporates setting and prioritizing goals and objectives, and making plans to accomplish these goals (Miller, 1997).

Maintaining the urban forest is not solely the responsibility of municipal agencies. Because of the interdependency between trees and humans in urban settings, it is important to gain the support and involvement of a city's residents. One way to accomplish this is to establish a tree advisory board. Tree advisory boards or commissions are composed of volunteer, local citizens who are interested in the preservation and maintenance of the urban forest. Some of the tasks that tree advisory boards may perform are public outreach and education, communicating with elected officials, small tree maintenance projects, and working on funding by applying for grants and obtaining private donations (American Public Works Association, n/d). Tree advisory board members serve in an advisory capacity only and are primarily committed to providing citizen-based input to municipal tree managers (American Public Works Association, n/d). A tree board is one of the four qualification standards for the Arbor Day Foundation's Tree City USA recognition program along with a tree care ordinance, $2 per capita expenditure on community forestry, and an official Arbor Day event (Arbor Day Foundation, 2012).

In many cities, an urban arborist or forester is responsible for public tree care and enforcing urban forest ordinances (Fazio, 2003). People holding this position may have degrees in forestry, horticulture, landscape architecture, or other areas of natural resource management (Schwab, 2009). Where the urban arborist is placed depends on a municipality's approach to urban forestry. Urban arborists may work within the public works department, the parks department, the planning department, or head a separate urban forestry division (Schwab, 2009).

Public Outreach, Education, and Involvement

Collaboration is a vital component in promoting and maintaining the urban forest. Not only is it important for various public officials and departments to work together to create and enforce ordinances and urban forest management plans, but the participation of private citizens is also necessary in order to have a vital and sustainable urban forestry program. In many cities much of the urban forest resource is in the hands of private citizens (Schwab, 2009). The better educated the citizenry is about proper tree care, the healthier the urban forest will be. Support from private citizens for the public tree resource is also imperative. Citizens can volunteer to help plant and maintain trees, which helps extend limited public funding (Schwab, 2009). Community members are also more apt to make public tree funding a priority when they understand the benefits that trees provide and the importance of properly caring for the public urban tree resource.

There are many ways to build public outreach and education into an urban forestry program. The public media can be used to make public service announcements, inform the public of scheduled maintenance activities, disseminate information on proper tree care, and publicize public events, such as Arbor Day festivities (Miller, 1997). A city-developed website that contains information on various aspects of tree care as well as the city's urban forest management plan and ordinances, and relevant contact information is an important resource for a city's residents. Organized volunteer activities provide opportunities for education in tree planting and

maintenance from tree professionals while building support for public trees. Direct mailings, phone calls, and e-mails can be used to contact specific subsets of a city's population in order to build support for a public tree project or target tree owners (Fazio, 2003).

Funding

While volunteer citizen activities can help a city meet some of their public forestry needs, it is virtually impossible to have a sustainable public tree program without adequate funding. The commitment to public tree replacement and care must be part of a city's budget (Fazio, 2003). Long-term maintenance requires a financial commitment to the public urban forest in the form of personnel and equipment as well as replacement tree plantings (Schwab, 2009). It may be necessary to educate public officials about the cost-saving benefits trees provide to municipalities such as decreasing the amount of storm water runoff, potentially decreasing the cost of cooling and heating public buildings, and decreasing pollutant levels - some of which may already be goals for the city - in order to get their commitment to providing adequate funding for public trees. Federal and state programs may have grant opportunities to finance urban forestry programs (Fazio, 2003). Corporate sponsorships, private donations, and grants from charitable foundations are also sources for monetary support for trees (Fazio, 2003). Local or regional utility companies and water/sewer districts may even contribute to tree planting programs in order promote energy savings and decrease storm water runoff.

There are also many creative ways to generate needed funds without applying for grants or depending on government financing. Fazio (2003) suggests a number of different ideas that can be used to earmark collected money for urban forestry needs. They include:

- Memorial tree planting program donations
- Selling plaques to put on public benches
- Selling firewood, lumber, or mulch from removed trees
- Hosting garage sales, bake sales, or auctions
- Instituting a tax-form check-off that provides an opportunity for citizens to donate money to community forest programs
- Selling special tree-themed license plates
- Setting up a tree bank that allows developers to donate money as a form of mitigation

Other ideas for alternative funding could be generated at brainstorming sessions of public tree officials, tree advisory board meetings, or by volunteer organizations (Fazio, 2003).

Case Studies

Tree Planning

<u>Louisville, Kentucky</u>

After Louisville, Kentucky's trees were devastated by both the remnants of Hurricane Ike in September 2008 and a significant ice storm in January 2009, residents of the Cherokee Triangle neighborhood formed the Cherokee Triangle Tree Association. The residents sought guidance from experts at the Kentucky Division of Forestry and the University of Louisville on how to inventory and evaluate the street trees in their neighborhood. The neighborhood volunteers

inventoried a total of 1,233 street trees by recording the species, size, and condition for each tree. As a result, they found that only a third of the street trees were thriving. The association recommended that medium-sized species be planted as street trees in the future and that larger tree species be limited to being planted in private yards. The Cherokee Triangle Tree Association also made a list of tree species, grouped by size, that are suitable choices for urban settings and Kentucky's climate (Millar, 2011a). As a follow-up project, the association hired arborists to inoculate the 24 largest and healthiest ash trees inventoried to protect them from damage by Emerald Ash Borer larvae. The treated trees comprised about one-third of the total number of ash trees planted along streets in the neighborhood (Millar, 2011b).

The Tree Committee is currently sending letters to residents of the neighborhood to gain permission to enter their yards and inventory the trees. The committee hopes that they will be able to obtain a comprehensive survey of *all* trees – both public and private - in their community in order to most effectively plan and manage the tree canopy and increase species diversity. They have received two grants to plant trees, a $1,000 matching grant from Louisville Gas & Electric and seven-year, $40,000 grant from the Metropolitan Sewer District (J. Millar, personal communication, *May 8,* 2012).

Palm Beach County, Florida

After suffering sizable losses of tree canopy due to hurricanes, Palm Beach County, Florida obtained Federal Emergency Management Agency (FEMA) grant money to commission a study to quantify tree losses as well as the subsequent losses in tree ecosystem services. An Urban Ecosystems Analysis was performed in conjunction with American Forests at two scales – moderate resolution and high resolution – using satellite imagery. The analysis provided the county with information on whether tree canopy losses were due to hurricane damage or to development pressures. CITYgreen software was used to quantify losses in ecosystem services due to changes in land cover, such as loss of trees. The county now has a GIS land cover map created by the satellite imagery analysis as a tool for county planners when prioritizing tree planting efforts. (American Forests, 2007)

Baltimore County, Maryland

In 2005, Baltimore County, Maryland created a comprehensive Forest Sustainability Program that contained three goals: assess forest health, protect remaining forests, and reforest priority lands). Priority lands included riparian buffers, reservoir watersheds, and urban communities. Urban communities were a priority because 75% of the county's forests are under private management. The Baltimore County Forest Sustainability Strategy was created by a steering committee that was formed during a sustainability issues forum in 2003.

The Steering Committee crafted a vision statement and identified 15 ecological and economic issues as being the most important for Baltimore County's forest sustainability initiatives. The Steering Committee also drafted a set of guiding principles to help them move forward with their program and then detailed recommended goals, actions, and assessment and data needs. The primary audience for this forest sustainability strategy is Baltimore County agencies and leaders and the document provides a framework for the creation of a county-wide forest management program. Although it is not a work plan, it provides an example of how to create an urban and community forest plan (Outen, 2005).

Tree Maintenance

Urbana, Illinois

As part of their urban forestry program, Urbana, Illinois employs cyclical tree pruning and emphasizes public outreach and education. In the past, the city's public tree pruning was driven by citizen complaints, but the city arborist, Mike Brunk, implemented a system of pruning street trees on a 13-year rotation. A thorough tree inventory determined which trees were imminent public hazards and these trees were given the highest priority for intervention. The initial pruning cycle ran from 1995-2008. This method was expected to reduce tree maintenance costs and shifted the focus of tree maintenance from crisis management to prevention (Schwab, 2009).

Since citizens were accustomed to calling the city and getting a quick response to tree concerns, Brunk needed to sell the public on the idea of long-term tree maintenance. He did this by contacting citizens by phone and spending time in neighborhoods. He noticed a significant decline in phone calls after the first few years of the program's initiation. Brunk and his staff continue to focus on community education and outreach by disseminating information on tree planting and care, producing tree-themed publications, and using local media to spread the message about the importance of trees and proper tree care (Schwab, 2009).

Conclusion

Trees in the urban setting provide valuable benefits by reducing the amount of storm water that has to be actively managed and decreasing the amount of pollutants that are washed into urban waterways. Urban forests also filter air pollutants, cool buildings and the surrounding environment, store and sequester carbon, provide habitat for wildlife, and bring pleasure and beauty to the built urban environment. To optimize the benefits provided by this living green infrastructure, it is imperative that communities actively manage the urban forest resource by adopting *and enforcing* tree ordinances, creating comprehensive urban forest management plans, evaluating and revising plans as needed, and educating the public about the importance of maintaining a healthy urban forest.

Caring for the public urban forest is collaborative and depends on the combined efforts of public officials, urban arborists, public works employees, park managers, planners, developers, and private citizens. Everyone benefits from the services provided by public trees and it is important that there is extensive support for the care and continuance of a healthy urban tree population. A broad consensus that trees are an important part of a city's green infrastructure is necessary to create the funding and long-term commitment necessary to have a viable, productive urban forest. "Trees are not merely amenities; they are assets that pay regular dividends when well managed" (Schwab, 2009).

Resources

General Tree Information

Alliance for Community Trees: http://actrees.org/site/index.php

American Forests: http://www.americanforests.org/

Arbor Day Foundation: http://www.arborday.org/

Ecosystem Services: Information and links to publications from the U.S.D.A. Forest Service on the ecosystem services provided by trees: http://www.fs.fed.us/ecosystemservices/

International Society of Arboriculture:

Provides information on tree care, tree ordinance guidelines and planting specifications: http://www.isa-arbor.com/home.aspx

Trees Are Good: Source of information aimed at the general public on a variety of tree care topics http://www.treesaregood.com/

State Urban and Community Forest Programs (EPA Region 4):

Alabama: Alabama Forestry Commission: http://www.forestry.state.al.us/Default.aspx
Alabama Cooperative Extension System: http://www.aces.edu/ucf/

Florida: Florida Forest Service:
http://www.floridaforestservice.com/forest_management/cfa_urban_index.html

Georgia: http://www.gfc.state.ga.us/index.cfm (click on "Community Forests" link)

Kentucky:
http://forestry.ky.gov/Urban%20Forestry%20and%20Community%20Programs/Pages/default.aspx

Mississippi: http://www.mfc.ms.gov/urabancommunity.php

North Carolina: http://ncforestservice.gov/Urban/Urban_Forestry.htm

South Carolina: http://www.state.sc.us/forest/urban.htm

Tennessee: http://www.tn.gov/agriculture/forestry/urbanforests.shtml

U.S.D.A. Forest Service: Urban and Community Forestry Program: http://www.fs.fed.us/ucf/

U.S.D.A. PLANTS Database: http://plants.usda.gov/java/

Urban Forestry Coordinators by State:
http://www.arborday.org/programs/treeCityUSA/forestryCoordinators.cfm

Vermont Division of Forestry: Community Forestry Library:
http://www.vtfpr.org/urban/for_urbcomm_library.cfm#Developing

Tree Inventories

Guidelines for Developing and Evaluating Tree Ordinances: http://www.isa-arbor.com/tree-ord/

Tree Inventory and Management Software List of Resources (Revised September 2010):
http://na.fs.fed.us/urban/inforesources/inventory/tree_inventory_mgmt_software_list.pdf

GIS Information

ESRI (Environmental Systems Research Institute, Inc.) GIS software (commercial): www.esri.com

GRASS (Geographic Resources Analysis Support System) GIS software (freeware): http://grass.osgeo.org/

Informational poster from the United States Geographical Survey: http://egsc.usgs.gov/isb/pubs/gis_poster/#what

Kentucky Geography Network: a geospatial data resource for the Commonwealth of Kentucky: http://kygeonet.ky.gov/

List of GIS software resources from the University of Colorado created in 2004, so not all links are functional: http://www.colorado.edu/geography/virtdept/resources/vendors/vendors.htm

Tree Planting

City of New York Parks and Recreation: Tree Planting Standards guide contains valuable information on planting, including a table of different tree pit dimension configurations: http://www.nycgovparks.org/sub_permits_and_applications/images_and_pdfs/TreePlantingStandards.pdf

Cornell University Urban Horticulture Institute: A number of tree planting resources, including: a woody plants database and a 128-page guide of urban tree recommendations: http://www.hort.cornell.edu/uhi/outreach/index.htm

International Society of Arboriculture: Graphic and written resources on tree planting: http://www.isa-arbor.com/education/onlineResources/cadPlanningSpecifications.aspx?utm_source=homepageclicks&utm_medium=homepagebox&utm_campaign=IAmA

Selecting the right tree for the right place: http://selectree.calpoly.edu/right_tree.html

Structural soil: Information from Cornell University's Urban Horticulture Institute: http://www.hort.cornell.edu/uhi/outreach/csc/article.html and http://www.hort.cornell.edu/uhi/outreach/index.htm#soil

Trees Are Good (International Society of Arboriculture): http://www.treesaregood.com/treecare/tree_planting.aspx

ANSI (American National Standards Institute) tree transplanting guidelines: http://www.treecareindustry.org/standards/part6/transplanting.htm

National Arbor Day Foundation videos: http://www.arborday.org/trees/tips/treePlanting.cfm

Tree Maintenance

Best Management Practices for Community Trees: A Technical Guide to Tree Conservation in Athens-Clarke County, Georgia (2001): https://athensclarkecounty.com/DocumentView.aspx?DID=280

Cabling and bracing trees: http://www.treecareindustry.org/pdfs/A300Part3TCICablingArticle.pdf; https://utextension.tennessee.edu/publications/Documents/SP659.pdf

Fertilization: http://www.extension.umn.edu/distribution/horticulture/dg7410.html; http://www.clemson.edu/extension/hgic/plants/landscape/trees/hgic1000.html; http://www.treecaretips.org/Fertilization/Fertilization.htm

Insect and disease problems: http://www.treesaregood.com/treecare/insect_disease.aspx; http://www.treecaretips.org/Diseases/Diseases.htm

Integrated Pest Management: http://www.epa.gov/pesticides/factsheets/ipm.htm

Mulching: http://www.treesaregood.com/treecare/mulching.aspx; http://www.treecaretips.org/Mulching/Mulchrings.htm

Pruning: http://www.treecaretips.org/Pruning/Pruning.htm
Young trees: http://www.treesaregood.com/treecare/pruning_young.aspx
Mature trees: http://www.treesaregood.com/treecare/pruning_mature.aspx

Recognizing and managing tree hazards: http://www.treesaregood.com/treecare/hazards.aspx; http://www.na.fs.fed.us/spfo/pubs/howtos/ht_haz/ht_haz.htm#cabl

Urban Forest Management

Guidelines for writing tree ordinances: http://www.isa-arbor.com/tree-ord/; http://www.dec.ny.gov/lands/5276.html

General guidelines for urban forest master plans:

The Road to a Thoughtful Street Tree Master Plan: A practical to systematic planning and design: http://www.urbanforestrysouth.org/resources/library/the-road-to-a-thoughtful-street-tree-master-plan

Guidelines for Developing Urban & Community Forestry Plans: Strategic Plans & Management Plans for Street and Park Tree Management: http://www.vtfpr.org/urban/documents/PlanGuid.pdf

Urban Forestry Best Management Practices for Public Works Managers: Urban Forest Management Plan: http://www2.apwa.net/documents/About/CoopAgreements/UrbanForestry/UrbanForestry-4.pdf

Examples of urban forest master plans:

City of Seattle, WA: http://www.mrsc.org/govdocs/s42urbanforest.pdf

City of Portland, OR:

Urban Forest Management Plan (2004):
http://www.portlandonline.com/parks/index.cfm?a=184641&c=38306
Urban Forest Action Plan (2007):
http://www.portlandonline.com/parks/index.cfm?c=38294&a=226238

City of Charlottesville, VA (May 2009):
http://www.charlottesville.org/Index.aspx?page=1721

City of Baltimore, MD (Draft – April 2007):
http://www.louisvilleky.gov/NR/rdonlyres/CB60DA78-EBC7-4D45-A280-264C9061C7EE/0/TreeBaltimoreUrbanForestManagementPlan.pdf

Funding

Note: Each state has dedicated funding from the federal government to support urban and community forestry (P. Barber, personal communication, *March 9*, 2012). This funding is awarded on an annual basis. The name of the program may change, so it is necessary to check the individual state's forestry website periodically for information on what is currently available.

Alliance for Community Trees: Information on funding opportunities:
http://actrees.org/site/resources/funding/

Community Forestry Program: A grant program that "authorizes the Forest Service to provide financial assistance to local governments, Tribal governments, and qualified nonprofit entities to establish community forests that provide continuing and accessible community benefits":
http://www.fs.fed.us/spf/coop/programs/loa/cfp.shtml

EPA Region 4:

Alabama:

Urban and Community Forestry Financial Assistance Program:
http://www.forestry.state.al.us/urbanfinancialassistanceprogram.aspx?bv=4&s=1

Florida:

Urban and Community Forestry Grant Program:
http://www.floridaforestservice.com/forest_management/cfa_urban_grants.html

Georgia:

Urban and Community Forestry Grant Program (check for current availability):
http://www.gfc.state.ga.us/CommunityForests/Grants.cfm

Kentucky:

Urban and Community Forestry Grant Program:
http://forestry.ky.gov/grantopportunities/Pages/default.aspx
Bluegrass Pride provides community grants for 7 counties in Kentucky (Clark, Estill, Garrard, Lincoln, Madison, Montgomery, and Powell):
http://www.bgpride.org/PRIDECommunityGrants.htm

Mississippi:

Urban and Community Forestry Grant Program (check for current availability):
http://www.mfc.ms.gov/grant-funding.php
Mississippi Department of Wildlife, Fisheries, and Parks: Land and Waters Conservation Fund's Outdoor Recreation Grant:
http://home.mdwfp.com/more.aspx

North Carolina:

Urban and Community Forestry Grant Program: http://ncforestservice.gov/Urban/urban_grant_overview.htm

Community Firewise and Urban Interface Grant Program: http://ncforestservice.gov/ui_firewise_grant/ui_firewise_grant.htm

South Carolina:

No current state-level grant programs for community and urban forestry

Tennessee:

Urban and Community Forestry Grant Program Information (contacts at end of document): http://www.tn.gov/agriculture/forms/infopak.pdf

Tennessee Agricultural Enhancement Program: Community Tree Planting Projects Information (contacts at end of document): http://www.tn.gov/agriculture/publications/forestry/TAEPforestry.pdf

Global ReLeaf (American Forests): Provides cost-share grants for restoration tree planting projects conducted by non-profit organizations and public agencies: http://www.americanforests.org/our-programs/global-releaf-projects/global-releaf-grant-application/

National Urban and Community Forestry Advisory Council Challenge Cost-Share Grant Program (check for current deadlines): http://www.fs.fed.us/ucf/nucfac.html

State and Private Forestry Redesign Competitive Grant Program: http://www.fs.fed.us/spf/redesign/index.shtml

References

Akbari, H., Taha, H., Huang, J., and Rosenfeld, A. (1986). Undoing uncomfortable summer heat islands can save gigawatts of peak power. *Proceedings from the ACEEE 1986 Summer Study on Energy Efficiency in Buildings 2*, 7-22.

Akbari, H. (2002). Shade trees reduce building energy use and CO_2 emissions from power plants. *Environmental Pollution 116*(2002), S119-S126.

American Forests. (2007). Urban Ecosystem Analysis Palm Beach County, Florida: Calculating the value of nature. Retrieved on December 14, 2011 from http://www.pbcgov.com/erm/downloads/pdf/AmforReport_PalmBeach.pdf

American Public Works Association. (n/d). Urban forestry best management practices for public works managers: Urban forest management plan. Retrieved on November 15, 2011 from http://www2.apwa.net/documents/About/CoopAgreements/UrbanForestry/UrbanForestry4.pdf

Arbor Day Foundation. (2012). *Tree City USA Standards*. Retrieved on January 23, 2012 from http://www.arborday.org/programs/treeCityUSA/standards.cfm

Barber, P. (2012). Kentucky Division of Forestry. Personal communication, March 9, 2012.

Bernhardt, E.A. and Swiecki, T.J. (2001). Guidelines for developing and evaluating tree ordinances. Retrieved on November 8, 2011 from http://www.isa-arbor.com/tree-ord/

Bolund, P. and Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics 29*(1999), 293-301.

Browning, D.M. and Wiant, H.V. (1997). The economic impacts of deferring electrical utility tree maintenance. *Journal of Arboriculture 23*(3), 106-112.

City of New York Parks and Recreation. (2009). Tree planting standards. Available at: http://www.nycgovparks.org/sub_permits_and_applications/images_and_pdfs/TreePlantingStandards.pdf.

Cook, R.L., Landmeyer, J.E., Atkinson, B., Messier, J-P, and Nichols, E.G. (2010). Field note: Successful establishment of a phytoremediation system at a petroleum hydrocarbon contaminated shallow aquifer: Trends, trials, and tribulations. *International Journal of Phytoremediation 12*(7), 716-732.

Eberts, S.M., Jones, S.A., Braun, C.L., and Harvey, G.J. (2005). Long-term changes in ground water chemistry at a phytoremediation demonstration site. *Ground Water 43*(2), 178-186.

El-Gendy, A.S., Espina, A.A., Chapman, B., and Schnoo, J.L. (2010). Beneficial effects of Oxygen addition and hybrid poplar phytoremediation of petroleum-contaminated soils.

Journal of Environmental Science and Health Part A 45(12), 1492-1503.

Fazio, J.R. (2003). *Urban & community forestry: A practical guide to sustainability*. The National Arbor Day Foundation: Lincoln, NE.

Fowler, D. (2002). Pollutant deposition and uptake by vegetation. In: Bell, J.N.B., Tresow, M. (eds.). *Air Pollution and Plant Life. 2nd ed*. Chichester, England: John Wiley & Sons. P. 43-67.

Gedan, K.G., Kirwan, M.L., Wolanski, E., Barbier, E.B., and Silliman, B.R. (2011). The present and future role of coastal wetland vegetation in protecting shorelines: answering recent challenges to the paradigm. *Climatic Change 106*(1), 7-29.

Grabosky, J. and Bassuk, N. (1995). A new urban tree soil to safely increase rooting volumes under sidewalks. *Journal of Arboriculture 21*(4), 187-201.

Grabosky, J. and Bassuk, N. (1996). Testing of structural urban tree soil materials for use under pavement to increase street tree rooting volumes. *Journal of Arboriculture 22*(6), 255-263.

Grimm, N.B., Grove, J.M., Pickett, S.T.A., and Redman, C.L. (2000). Integrated approaches to long-term studies of urban ecological systems. *BioScience 50*(7), 571-584.

Heisler, G.M. (1990). Mean wind speed below building height in residential neighborhoods with different tree densities. *ASHRAE Transactions 96*(1), 1389-1396.

Hoehn, R. (2012). USDA Forest Service, Northern Research Station. Personal communication, January 17, 2012.

Jim, C.Y. and Chen, W.Y. (2006). Recreation-amenity use and contingent valuation of urban greenspaces in Guangzhou, China. *Landscape and Urban Planning 75*(1-2): 81-96.

Kuo, F. E. and Sullivan, W.C. (2001). Environment and crime in the inner city: Does vegetation reduce crime? *Environment and Behavior 33*(3): 343-367.

Loder, N.M., Irish, J. L., Cialone, M.A., and Wamsley, T.V. (2009). Sensitivity of storm water surge to morphological parameters of coastal wetlands. *Estuarine, Coastal and Shelf Science 84*(4), 625-636.

Lopes, A., Oliveira, S., Fragoso, M., Andrade, H.A., and Pedro, P. (2007). Wind risk assessment in urban environments: The case of falling trees during windstorm events in Lisbon. In: Střelcová, K., Škvarenina, J., Blaženec, M. (eds.). *Bioclimatology and Natural Hazards*. International Scientific Conference, Poľana nad Detvou, Slovakia, September 17-20, 2007.

Lopez, J.A. (2009). The multiple lines of defense strategy to sustain coastal Louisiana. *Journal of Coastal Research* SI(54), 186-197.

Lovett, G.M., Traynor, M.M., Pouyat, R.V., Carreiro, M.M., Zhu, W., and Baxter, J.W. (2000). Atmospheric deposition to oak forests along an urban-rural gradient. *Environmental Science and Technology 34*(20), 4294-4300.

Millar, J. (2011a). CTA's tree committee report. *Cherokee Triangle Newsletter 10*(1), 1-11.

Millar, J. (2011b). Tree committee update – Emerald Ash Borer. *Cherokee Triangle Newsletter 10*(2), 1-11.

Millar, J. (2012). Cherokee Triangle Tree Committee. Personal communication, May 8, 2012.

Miller, R.H. and Miller, R.W. (1991). Planting and survival of selected street tree taxa. *Journal of Arboriculture 17*: 185-191.

Miller, R.W. (1997). *Urban forestry: Planning and managing urban greenspaces. 2nd ed.* Upper Saddle River, NJ: Prentice Hall.

Morales, D.J. (1980). The contribution of trees to residential property values. *Journal of Arboriculture 6*(11), 305-308.

Nowak, D.J. and D.E. Crane. (2002). Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution 116*(3), 381-389.

Nowak, D.J. and Dwyer, J.F. (2007). Understanding the benefits and costs of urban forest Ecosystems. In: Kuser, J.E. (ed.). *Urban and Community Forestry in the Northeast. 2nd ed.* New York: Springer pp. 25-46.

Outen, D.C. (2005). Baltimore County forest sustainability strategy: Steering Committee final draft. Retrieved on December 13, 2011 from http://resources.baltimorecountymd.gov/Documents/Environment/Workgroup/Forest%20Sustainability/finalstrategy_110505.pdf

Raskin, I., Smith, R.D., and Salt, D.E. (1997). Phytoremediation of metals: Using plants to remove pollutants from the environment. *Current Opinion in Biotechnology 8*(2), 221-226.

Richards, N.A. (1993). Reasonable guidelines for street tree diversity. *Journal of Arboriculture 19*(6), 344-349.

Roush, J. and McFarland, K.M. (2006). *The City of Olympia Master Street Tree Plan: 2001-2011*. Retrieved on December 14, 2011 from http://olympiawa.gov/~/media/Files/CPD/Urban%20Forestry/Forms/2006%20Master%20Street%20Tree%20Plan.ashx.

Sanders, R.A. (1986). Urban vegetation impacts on urban hydrology of Dayton, Ohio. *Urban Ecology 9*(3-4), 361-376.

Simons, K. and Johnson, G.R. (2008). *The road to a thoughtful street tree master plan: A practical guide to systematic planning and design*. Retrieved on January 4, 2012 from http://www.urbanforestrysouth.org/resources/library/the-road-to-a-thoughtful-street-tree-master-plan

Smardon, R.C. (1988). Perception and aesthetics of the urban environment: review of the role of vegetation. *Landscape and Urban Planning 15*(1-2), 85-106.

Schwab, J.C. ed. (2009). *Planning the urban forest: Ecology, economy, and community development*. American Planning Association: Chicago, IL.

Sreetheran, M., Adnan, M., and Khairil Azuar, A.K. (2011). Street tree inventory and tree risk assessment of selected major roads in Kuala Lumpur, Malaysia. *Arboriculture & Urban Forestry 37*(5), 226-235.

Tyrväinen, L. and A. Miettinen. (2000). Property prices and urban forest amenities. *Journal of Environmental Economics and Management 39*(2), 205-223.

Tyrväinen, L., Silvennoinen, H., and Kolehmainen, O. (2003). Ecological and aesthetic values in urban forest management. *Urban Forestry and Urban Greening 1*(3), 135-149

Ulrich, R.S. (1984). View through a window may influence recovery from surgery. *Science. 224*(4647), 420-421.

United Nations, Department of Economic and Social Affairs, Population Division. (2009). *World urbanization prospects: The 2009 revision*. New York: United Nations. Retrieved on November 2, 2011 from http://www.un.org/esa/population/unpop.htm.

United Nations, Department of Economic and Social Affairs, Population Division. (2011). *World population prospects: The 2010 revision*. New York: United Nations. Retrieved on November 2, 2011 from http://www.un.org/esa/population/unpop.htm.

United States Department of Agriculture, Northeast Area. (n/d). *A guide: Developing a street and park tree management plan*. Retrieved on January 5, 2012 from http://na.fs.fed.us/urban/inforesources/mgmtplanguide/mgtplanguide.pdf

United States Environmental Protection Agency. (2011). *Brownfields and land revitalization: brownfields definition*. Retrieved on November 7, 2011 from http://www.epa.gov/brownfields/overview/glossary.htm.

Xiao, Q., McPherson, E.G., Simpson, J.R., and Ustin, S.L. (1998). Rainfall interception by Sacramento's urban forest. *Journal of Arboriculture 24*(4), 235-244.

Appendix A

Name: .....
Street: .....
Date: .....

1. Tree Characteristics
Tree ID: .....
Species: .....
Local Name: .....
DBH: .....
Height: .....
Spread: .....
Form:
☐ generally symmetric
☐ minor asymmetry
☐ major asymmetry

2. Site Condition
Site topography:
☐ flat
☐ slope
☐ others: .....

Root surface cover:
☐ paved .....%
☐ turf .....%
☐ bare soil .....%
☐ others: .....

3. Tree Health
Foliage color:
☐ normal
☐ chlorotic
☐ necrotic

Foliage density:
☐ dense
☐ sparse

Vigor class:
☐ good
☐ average
☐ poor

4. Hazard Status
Trees defect:
☐ poor taper
☐ co-dominants
☐ multiple attachments
☐ included bark
☐ excessive end weight
☐ cracks
☐ hangers
☐ girdling
☐ wounds
☐ decay
☐ cavity
☐ conks/mushroom
☐ sap flow
☐ loose/cracked bark
☐ deadwood/stub
☐ termites/ants
☐ cankers
☐ galls
☐ lean
☐ exposed root

Tree part most likely to fail:
.....

Target under the tree:
☐ building
☐ parking
☐ traffic
☐ pedestrian
☐ landscape
☐ hardscape
☐ utility lines

Can target be moved?
☐ yes
☐ no

Occupancy:
☐ occasional use
☐ frequent use
☐ constant use

Hazard ratings:
☐ low
☐ medium
☐ high
☐ severe

Hazard abatement:
☐ remove defective part
☐ reduce end weight
☐ crown clean
☐ crown thin
☐ raise canopy

5. Comment

Source: Streethan et al. 2011

Key for the tree inventory sheet that follows:

Using the Tree Inventory Data Sheet

The following items will be found on the sheets. For each response mark an X in the appropriate location. The items are as follows:

Tree information

Tree number – Record the Tree Number
Code – Record a two letter Species Code (ie: **AR** = Acer rubrum)
DBH – Record Diameter at Breast Height

Tree Condition

Place an X in the appropriate box
G = Good
F = Fair
P = Poor
D = Dead
H = Hazard

Planting Location

Record the location where the tree is located on a map of the street or park
Swlk = Sidewalk planting pit
<4' = Planting strip less than four feet of area
>4' = Planting strip more than four feet of area
Lwn = Lawn area

Condition

Weak Fork = Weak Fork
Over Wires = Overhead Utility Wires
Dead Wood = Dead Wood in Crown
Cav = Cavity

If Pruning Needed, What Type?

Clean = Crown Cleaning
Raise = Crown Raising
Reduc. = Crown Reduction

Comments

Example = Broken sidewalk
Bark damage
Broken support stake
Needs additional inspection

Source: USDA Forest Service, Northeastern Area

Date:____ Map#:____

Tree Inventory Data Sheet

Tree Information			Tree Condition					Planting Location				Conditions				If Pruning Needed What Type?			Comments
Tree #	Code	DBH	G	F	P	D	H	Swlk	<4'	>4'	Lwn	Weak Fork	Over. Wires	Dead Wood	Cav	Clean	Raise	Reduct.	

Legend:

(Tree Condition) G = Good F = Fair D = Dead H = Hazard

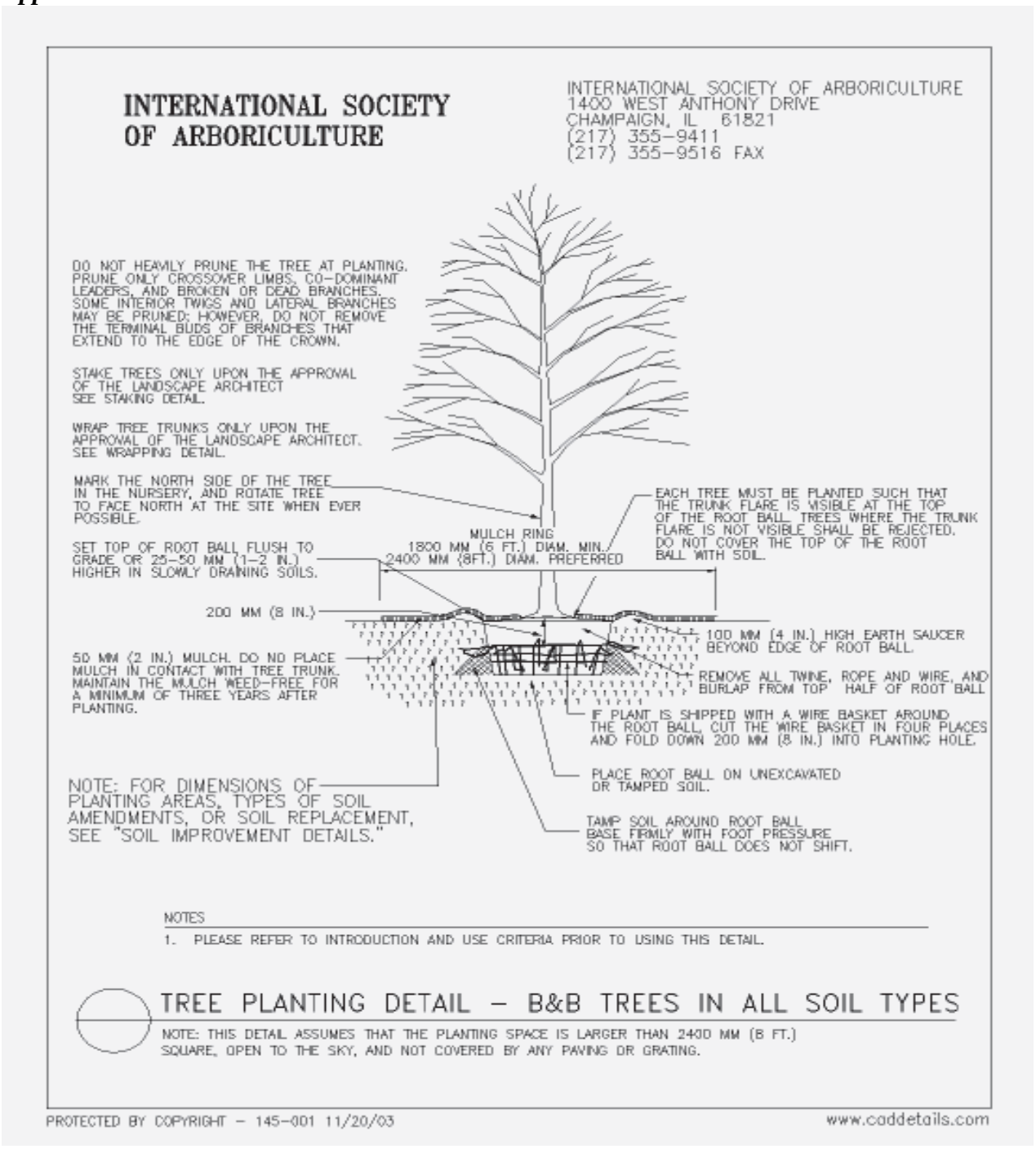
(Planting Location) Swlk = Sidewalk <4' = less than 4' >4' = more than 4' Lwn = Lawn

(Conditions) Weak Fork = Weak Branch Fork Connection Over Wires = Overhead Utility Wires Dead Wood = Dead Wood in Crown Cav = Cavity in Trunk

(If Pruning Needed What Type?) Clean = Crown Cleaning Raise = Crown Raising Reduct. = Crown Reduction

Source: USDA Forest Service, Northeastern Area

Appendix B



Source: International Society of Arboriculture