ISSUE BRIEF

INCREASING THE BENEFITS FROM URBAN TREES WHILE MINIMIZING COSTS: LESSONS LEARNED FROM THE CHICAGO REGION TREES INITIATIVE

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This issue brief summarizes the benefits that trees provide to both the "built environment" and municipal planning goals. Drawing on a survey administered to public officials, it reviews strategies that municipalities use to maximize the benefits of trees, while providing evidence that trees provide both aesthetic and key functional purposes. The findings also show, however, that the management of trees comes at a cost and is frequently one of the first services to be scaled back when municipal budgets are tight.

INTRODUCTION

Urban trees are a form of "green infrastructure" that make cities and towns more livable in often under-appreciated ways. This issue brief seeks to broaden the understanding among municipal officials on the benefits of active urban forestry programs. After reviewing research in this area, it evaluates the ways in which municipal governments in the Chicago region practice urban forestry management. The final sections of this report consider strategies for conducting tree inventories and developing management plans while also acknowledging the challenges facing communities that do not allocate sufficient budgeting for even the most basic programs in these areas.

QUANTIFYING THE BENEFITS OF TREES

Although the benefits trees provide are often passive and hard to quantify, recent research has shown that trees and other types of green infrastructure save governments money and increase the quality of life for residents. One estimate suggests that the approximately 157 million trees within the seven-county Chicago region provide $51.2 billion in ecosystem services and compensatory value (Nowak et al., 2013), a figure that does not factor in stormwater uptake or water filtration. Without these trees, municipalities would be forced to implement more costly, engineered solutions to achieve the same benefits.

One important ecosystem service provided by urban trees is stormwater management. Communities in the Chicago region have cited flooding as one of their greatest concerns (Chicago Regional Trees Initiative (CRTI), unpublished data), especially with the increasing intensity and frequency of storm events (Brandt et al., 2017). Urban trees help alleviate stormwater runoff and improve water quality in several ways. First, trees intercept rainfall in their leaves and structures, slowing the velocity of rain before it hits the ground. This process increases the likelihood that rainwater penetrates the soil instead of running off (Brack, 2002). A 20-inch-diameter oak tree located in a Chicago residential neighborhood, for example, is estimated to intercept 2,600 gallons of water each year (National Tree Benefits Calculator, 2017). Trees also pull water from the soil through evapotranspiration, alleviating saturated soils and allowing future rainwater to penetrate the ground (Scharenbroch, Morgenroth and Maule, 2016; Walsh, Fletcher and Burns, 2012). The combination of intercepted rain and water taken from the soil greatly reduces the volume of water that enters drainage systems thereby reducing flooding in urban areas.

Urban areas are typically hotter than less-developed places, because impervious surfaces (such as pavement and buildings) capture the sun's energy and release it as heat (Arnfield, 2003) – a phenomenon known as the urban heat-island effect. This effect has been found to exacerbate human discomfort, heat-related health incidences, and even mortality rates due to reduced air quality (Heisler and Brazel, 2010). Trees help minimize the urban heat-island effect by shading heat-absorptive surfaces and cooling the air via evapotranspiration (Akbari, Pomerantz and Taha, 2001). Decreases in urban air temperatures also mean that buildings need to use less energy for cooling, thereby reducing energy use and their associated carbon footprints (Akbari, 2002; Sawka, Millward, Mckay and Sarkovich, 2013). Improving public health outcomes and reducing energy use help municipalities boost their bottom line.

Urban residents also often perceive trees as valuable due to their ability to provide shade and enhance aesthetics (Lohr, Pearson-Mims, Tarnai and Dillman, 2004). Research has shown that these and other positive perceptions of trees translate into higher property values. Past research has shown that houses with trees tend to sell for 3.5 to 4.5% more than houses without trees (Anderson and Cordell, 1988), and properties with trees spend less time on the market than treeless properties (Donovan and Butry, 2011). Furthermore, people are willing to spend more time and money in commercial districts that have lush tree canopies (Wolf, 2005), and residents who are surrounded by greener environments report a higher quality of life (Hipp, Gulwadi, Alves and Sequeira, 2015).

Trees are also positively correlated with human health, as they improve air quality by removing nitrous oxide and fine particulate matter (Brack, 2002), reducing impacts to individuals with compromised pulmonary systems (Donovan et al., 2013). People who live in greener areas tend to be more active and are less likely to be overweight (Bell, Wilson and Liu, 2008), and living on a street with more trees improves cardiovascular health (Kardan et al., 2015). Trees also increase social cohesion and encourage residents to spend time outdoors, which can result in lower crime rates (Kuo, 2003; Kuo and Sullivan, 2001). These social benefits are often difficult for municipalities to quantify, but they are integral to quality of life and the desire to live in a particular community or neighborhood.

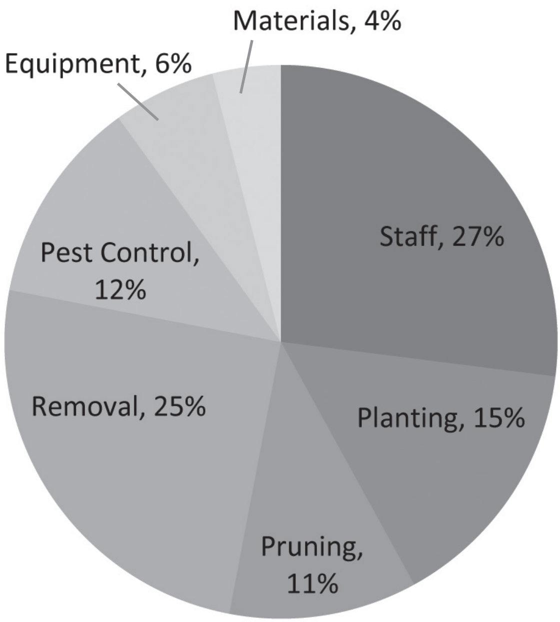
To summarize, research shows that trees have an overwhelmingly positive impact on communities. One credible estimate indicates that each dollar spent on managing urban forests returns benefits ranging from $1.37 to $3.09 annually (McPherson, Simpson, Peper, Maco and Xiao, 2005).

A SURVEY OF MUNICIPAL URBAN FORESTRY MANAGEMENT

CRTI conducts a biennial survey to track municipal spending, management practices and attitudes on urban forestry. In 2014, this survey was sent to 284 municipalities and 26 park districts and yielded responses from 132 municipalities and 20 park districts (a 49% overall response rate). The survey included 63 questions subdivided into the following sections: administrative and program profile (including budgets), tree disorders and diseases, tree planting, maintenance of trees and tree removal.

Despite the documented benefits summarized above, some municipalities consider the costs associated with managing their urban forests overwhelming and, as a result, shy away from planting new or even caring for existing trees. Survey responses indicate that the average municipal forestry budget (excluding Chicago) is about $5.8 million, or less than 5% of the average total municipal budget. The majority of forestry departments reported that they are short-staffed and do not have enough funding to adequately manage their trees. In most communities, staff has little to no formal forestry training. Even though most communities do not have adequately trained staff, municipalities spent a plurality of their forestry budgets on this category (Figure 1). Communities expressed that their greatest need going forward was more funding for staff, trees and equipment, and for better training.

FIGURE 1
2014 Distribution of Forestry Budgets



The plurality of municipal forestry spending was on staff (27%), followed by tree removal (25%). The high proportion of spending on tree removal and pest control in 2014 was related to the emerald ash borer epidemic that affected the region at that time.

Maintaining urban trees generates some predictable expenses related to planting, watering and pruning. Grants that have been administered by CRTI in the Chicago region have found that a two-inch-caliper tree generally costs between $200 and $300 with an additional $150 for planting costs. Municipalities also routinely prune trees to ensure good structure and remove hazardous branches. On average, municipalities spend about 11.9% (± 9.7) of their tree budget on routine pruning.

Urban trees can also incur costs from forces that are less predictable, such as pests, diseases and severe weather. For example, the emerald ash borer (EAB) has been a major threat to ash trees throughout the Chicago region such that, by 2013, many such trees were visibly failing due to infestation. Municipalities in the Chicago region on average spent $234,000 (37% of their forestry budget) in 2014 on treating or removing EAB-damaged trees. Nowak et al., (2013) estimated that the EAB epidemic could result in $4.2 billion in compensatory damage throughout the region. The damage caused by EAB is not an anomaly. In the past, Dutch elm disease caused catastrophic damage to elms beginning in the 1960s. Foresters are also concerned about the future threat posed by the Asian long-horned beetle (currently present in Ohio), which has the potential to destroy many maple trees in the area.

It should be noted here that the 2014 CRTI survey was sent at the height of the EAB epidemic. As a result, the survey did not capture an average year in forestry management given that municipal resources were directed towards treating and removing ash trees. In 2014, budgets were derailed, regular pruning stopped and planting all but halted because of EAB. CRTI conjectures that, going forward, a smaller portion of the budget will be dedicated towards removing and treating trees.

When talking to municipal leaders, CRTI staff often hear the concern that damage caused to and by trees during storm events makes trees too costly and dangerous to plant. Many municipalities in the region have experienced frequent storm damage over the past decade. The CRTI survey found that between 2004 and 2014, 24% of communities reported experiencing major storm damage more than six times, and 32% of communities reported experiencing major storm damage four to six times. While trees can require substantial spending by municipalities, there are also ways to reduce these costs through strategic and proactive forestry management.

PROACTIVE MANAGEMENT AND TAKING INVENTORIES OF TREES

Management practices for trees have changed dramatically in the past couple of decades. Previously, trees were largely planted for aesthetic reasons. Now that their contributions to a city's infrastructure are better understood, urban planners and land managers are utilizing trees in a more strategic manner. Municipalities are increasingly keeping records of their trees, proactively pruning and tending to them, and ensuring that they are planting trees where they will have the biggest impact. Since 2013, CRTI has worked with municipalities to help them manage their urban trees and improve the skills of those who care for them.

Informed management requires good data, and the cornerstone of urban forestry management is a tree inventory. These inventories catalog the trees that are present in a given area. There are a variety of inventory types, from sample inventories that measure a subset of trees and extrapolate the results to understand species composition across an area, to complete inventories that record the location, species, size, health and management history of each individual tree (Figure 2). Inventories allow foresters to ensure that they have a diverse, sustainable urban forest, and to track issues relating to tree health. In this example, a community has completed a spatially referenced, comprehensive tree inventory. Such an inventory allows foresters to monitor how trees change over time and to track management activities.

FIGURE 2

Example of a Complete Urban Tree Inventory

This complete inventory has an interactive feature to show the species, size, health and management history of each tree in a community. Such inventories allow foresters to track species composition of their entire urban forest as well as the performance of individual trees.

The diversity of tree species in an area is one of the best ways to measure urban forest resilience to pests and diseases (Santamour Jr., 2004). Most insects and diseases that affect trees only affect a single genus, such as EAB with ash species and Dutch elm disease with elm species (Brasier, 1991; Poland and McCullough, 2006). Both EAB and Dutch elm disease have been devastating, because municipalities aggressively planted these two genera in the past. Inventories from 2012 (before EAB established in the Chicago region) have shown that ash made up nearly half of the street trees in some municipalities (CRTI, unpublished data). These municipalities are now dealing not only with the expense of removing and replacing these trees, but also the loss of benefits that the trees provided. Tree inventories allow foresters to track the distribution of their trees, and to make sure that an adequate distribution of species and genera are planted. As municipalities replace these dead and dying ashes, it is especially important to increase diversity through the planting of underutilized species. CRTI recommends that no more than 5% of a single species, 10% of a genus and 15% of a family are planted in an area.

Complete inventories that include the specific location of each tree allow managers to track the health, growth and management of individual trees. This allows foresters to observe trees over time, to monitor performance of new species, identify potential problem areas where species or age diversity might be low and to follow up on specific tree issues such as disease or damage. In addition, it allows trees to be mapped in conjunction with other municipal infrastructure to offset impacts from gray infrastructure or reduce potential conflicts. Tracking can also ensure that trees are being pruned in regular cycles and respond to threats as they present themselves, which helps with budgeting.

Trees can pose a significant risk to power lines, property and people, especially during inclement weather. Given the costs associated with cleanup after storms – including equipment rental, disposal of debris and overtime for staff – municipal leaders sometimes consider trees as high-risk and high-cost. However, it has been found that in communities where trees are routinely inspected and maintained, overall costs including tree management, storm cleanup and liability are reduced (Vogt, Hauer and Fischer, 2015). However, many communities in the Chicago region do not proactively prune their trees; according to the CRTI survey only 55% of communities reported having a proactive forestry management plan to mitigate risks and only 60% of communities reported conducting risk assessments on their trees.

The International Society of Arboriculture has created a standardized method for assessing risk in trees (called the Tree Risk Assessment Qualification or TRAQ), and arborists can receive a certification for this training. Conducting risk assessments on trees, especially when the assessment is included as part of a tree inventory, can help municipalities create a management plan for proactively pruning and maintaining trees. It may also show that municipalities have conducted due diligence in maintaining urban trees, which may be helpful if a tree does cause damage. In fact, many municipalities begin risk assessment activities after a lawsuit is filed against them, when they realize that proactively managing risk can help avoid future liability (Koeser, Hauer, Miesbauer and Peterson, 2016). Proactively managing risk may also provide peace of mind that residents and property are protected.

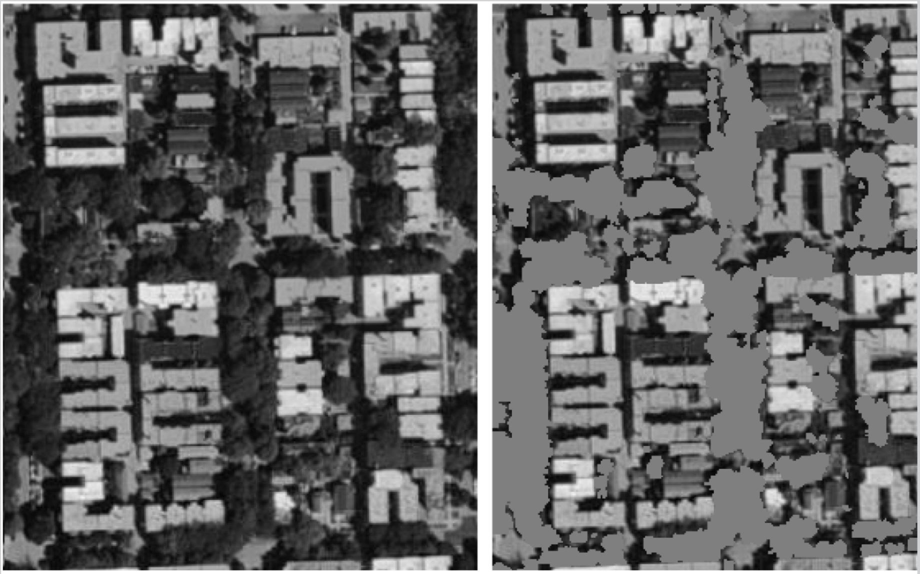
Proper tree care and maintenance can expand the life of a tree, and mature, healthy trees offer more ecosystem services than smaller trees (Nowak, Crane and Dwyer, 2002). By proactively caring for the urban forest, municipalities can maximize the benefits that each tree gives while reducing the costs that it can incur (Vogt et al., 2015). A thoughtful management plan can provide the guidance necessary to achieve that balance.

EXPANDING WITH PURPOSE

The benefits that trees provide are generally positively correlated with the extent of their canopy (Schwarz et al., 2015), and by understanding where canopy does and does not exist, planners can identify where additional trees might have the biggest impact. The U.S. Forest Service has created a protocol for mapping tree canopy at a sub one-meter resolution using high-resolution imagery and Light Detection and Ranging (LiDAR; Figure 3) (O'Neil-Dunne, MacFaden, Royar and Pelletier, 2013). This protocol has been implemented in scores of cities across the United States, including the entire seven-county Chicago region. The Chicago region dataset is freely available for download on the Chicago Metropolitan Agency for Planning's data hub.[1]

Mapping canopy can help forest managers visualize the extent of trees in a more complete way than using an inventory alone. Municipal tree inventories only capture the trees that are publicly owned, which are usually a small subset of the trees in a municipality. Across the Chicago region, it is estimated that 70% of trees are on private land (Nowak et al., 2013). Trees provide equal ecosystem services regardless of where they are growing. That is, even if the municipality does not actively manage trees that are on private property, these trees contribute the majority of stormwater mitigation, heat-island reduction and other critical infrastructure services. It is therefore essential to consider privately-owned trees when identifying where additional trees could have the biggest impact.

FIGURE 3
High-Resolution Mapping Used to Identify Tree Canopy at a Sub One-Meter Resolution



On the left, a satellite image shows tree cover at a representative location in northern Chicago. At right, this same area is shown with the tree canopy highlighted using the U.S. Forest Service's Urban Tree Canopy protocols.

Once municipal planners have mapped the canopy, they can more effectively focus on where new trees would have the greatest impact. To do this, flood maps, maps of surface temperature, air quality, socio-economic characteristics and other data can all be considered. These sorts of strategies have been implemented in Baltimore (Troy and Grove, 2008) and New York City (Locke et al., 2010), and are currently being completed by CRTI in the Chicago region. When identifying places for tree plantings, municipal planners and public-works departments should consider their broader goals. For instance, if flooding is a problem they should identify areas with extensive impervious cover, that are in flood plains, or that have had previous flooding issues. Due to the extensive flooding recently experienced in the northeastern part of Illinois, as well as the highly publicized disasters in Florida, Puerto Rico and Texas, attention to this issue will no doubt rise.

Identifying priority areas for tree plantings can also give municipalities an advantage on grant applications, which frequently are awarded to projects that address multiple issues and/or address issues at a larger scale. If municipalities can show that trees will be planted in under-resourced areas, or that they will have extensive environmental benefits locally and/or outside of where the trees will be planted, they may be more likely to receive a grant (CRTI, unpublished data).

BEST PRACTICES IN URBAN FORESTRY MANAGEMENT

Practicing effective forestry management, including the collection and utilization of data, can be challenging for municipalities, as it requires long-term planning, trained staff and consistent budgeting. Nevertheless, many municipalities are doing it well, and can attest to how it has helped their financial bottom line and improved the quality of life of their residents.

The Village of Homewood, Illinois, has a tree inventory, an urban forestry management plan, trained and certified urban forestry staff, and excels at communicating with its residents. This allows it to proactively manage the damage caused by EAB. This southern suburb was one of the region's first municipalities to create a management plan for the borer, which was first found in Michigan in 2002. In 2008, Homewood stopped planting ash trees in case the insect migrated to the region. When EAB was discovered in the Chicago metropolitan area, Homewood was able to act quickly by using its comprehensive inventory to locate all ash trees in its jurisdiction as well as prioritize which trees should be removed first. Homewood was also able to budget for the crisis ahead of time and was not hit with unforeseen expenses. Many other municipalities that were hit especially hard by EAB did not fare as well as Homewood and were forced to remove and replace a large number of hazard trees in a single year. Residents often balk at the removal of seemingly healthy trees, but because Homewood had already established a good relationship with stakeholders, it was able to effectively communicate its reasoning for removing the doomed trees.

Homewood further reduced the cost of tree removal by recycling the wood. Rather than paying to dispose of its wood waste, as many other communities do, Homewood arranged to have their ash trees turned into lumber or chipped, which saved hundreds of thousands of dollars. The municipality's forest is now more resilient than ever. The ashes were replaced by 83 different species that Homewood's inventory showed were currently underplanted. This will allow the municipality to fare better during the next pest or disease outbreak.

The Village of Riverside, Illinois, one of the first planned municipalities in the country, was designed by the renowned landscape architect Frederick Olmstead. Olmstead imagined the community as a place of respite from Chicago's urban bustle. He emphasized the use of native plants so that the community would exemplify the natural areas that surrounded it. Today, Riverside almost exclusively plants trees that are native to Illinois. Using this reduced palette of tree species can be challenging, as it makes it more difficult to plant a diverse, and thereby resilient, forest. However, Riverside's up-to-date and complete inventory of its trees allows it to ensure that every block has a diversity of species.

This inventory has helped Riverside plan for the future. Urban trees are thought to be especially sensitive to climate change, as they frequently live in stressful environments with alkaline, salty, compacted soils. The additional stress from hotter days and inconsistent rain might be more than many urban trees can handle. Riverside has partnered with the U.S. Forest Service's Northern Institute of Applied Climate Science to improve its forest's ability to cope with climate change. Together, they have identified which native tree species are likely to be able to cope with the region's predicted hotter and dryer climate. Going forward, Riverside will increase planting of these species and reduce plantings of species that are not expected to be able to endure these conditions. Its tree inventory and careful planting practices will ensure that its investment will generate benefits for decades to come.

The Village of Oak Park, Illinois, with its wide parkways and historic architecture, provides an attractive setting for people to enjoy its ecologically rich urban forest. The village's decades-long commitment to nurturing its trees was formally acknowledged in 2015, when it was recognized as Illinois' first municipal arboretum in response to an application submitted jointly by the village and its independent park district through the Morton Arboretum's ArbNet Arboretum Accreditation Program. The distinction was, in part, enabled by the village's development and maintenance of a comprehensive tree inventory, which not only helped the general cataloging of trees, but also improved the efficiency with which village staff manages and monitors tree diversity, health and upkeep.

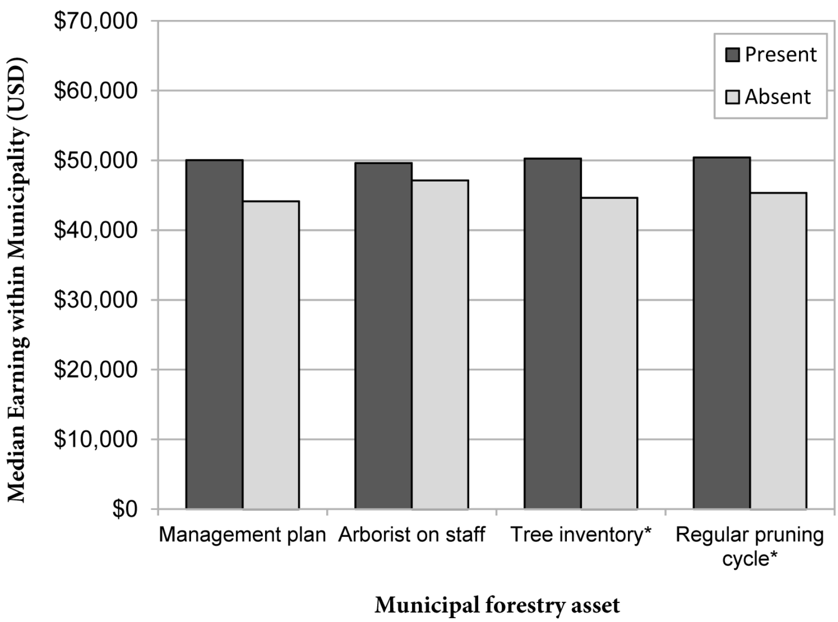
Information concerning tree height, trunk diameter and canopy have also been used by Oak Park to monetize a tree's social and ecological benefits, while information concerning genus, species and variety have been used to identify and track progress toward achieving various performance targets. For example, the village has established a biodiversity-related goal in which no single species family should comprise more than 10% of the overall tree population. The village also works collaboratively with its park district, residents, and contractors to share information about pruning schedules and tree-maintenance best practices.

INEQUITY IN FOREST RESOURCES

The majority of the forestry management techniques described above require trained forestry staff and funds. In the Chicago region, municipalities with

FIGURE 4

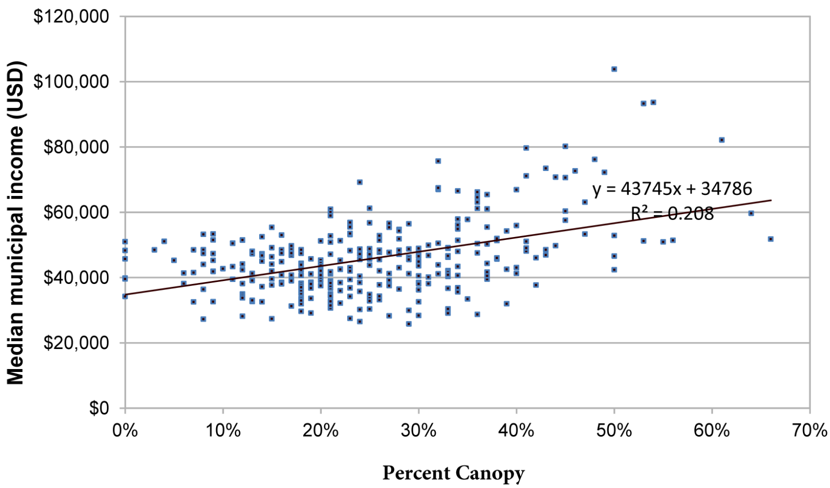
Differences of Median Earnings for Municipalities by Status of Forestry Activity



Source: Assessment of forestry activities are from the capacity survey and income was found using 2010 U.S. Census data

In all cases, municipalities with more advanced forestry activities had higher median income than those that did not. However, only the relationships between tree inventories and regular pruning cycles were found to be significant ($p < 0.001$).*

FIGURE 5
Relationship between Median Income of Municipalities and Canopy Abundance



Municipalities in the Chicago region with higher income tend to have more extensive tree canopy ($p < 0.001$).

higher median incomes are more likely to have an arborist on staff, to have an inventory, to prune on a regular cycle and to have an urban forest management plan (Figure 4). Lower-income communities not only tend to have less capacity to manage trees, but also lower canopy cover (Figure 5). This means that the communities that could most benefit from the ecosystem services that trees provide have less access to that resource.

Numerous governmental and not-for-profit organizations are working to address this inequity. Many forestry grants are preferentially awarded to under-resourced communities; however, these communities frequently lack the capacity to apply for these grants. CRTI has held workshops to help train communities on how to apply, while the Community Trees Program of the Morton Arboretum offers one-on-one technical assistance on grant applications for municipal forestry programs.

Other forms of assistance are also available. For example, the Community Trees Program offers assistance on the development of forestry management plans. CRTI provides a compendium of resources developed by their 100+ partners and offers training and networking opportunities for municipal and park district staff and volunteers on multiple forestry topics. Similarly, Openlands in Chicago provides forestry training for volunteers to help plant and maintain trees in under-resourced communities in and near Chicago. The Delta Institute has several tools and reports that can aid the development of green infrastructure in communities. In many cases, there are also resident groups (e.g., beautification committees, garden clubs and environmental justice groups) that can be consulted to aid in the planting and care of trees. Formalizing relationships with these community groups can provide validation of their efforts and increase community commitment and capacity, while securing a workforce of engaged volunteers.

CONCLUSION

Urban trees are a significant investment for municipalities, but their benefits far outweigh their costs. Trees create more pleasant and livable urban areas and save municipalities money through stormwater mitigation, heat-island reduction, air quality improvements, increased property values and numerous other benefits. Proactive management of existing trees – coupled with planting new trees in locations where they will have the largest benefits – has allowed municipalities to maximize the benefits that trees can provide while minimizing their costs. However, proactive management of trees requires investment, and many of the communities that have the greatest forestry needs do not have the capacity to invest in their trees. A number of organizations and grants have been established to help these municipalities, so that the forestry resource is more equitably distributed.

Respectively, Lindsay Darling, Melissa Custic and Lydia Scott are the Data and GIS Analyst, Coordinator and Director of the Chicago Region Trees Initiative. C. Scott Smith, Ph.D., is the Assistant Director of the Chaddick Institute for Metropolitan Development at DePaul University.

[1] For more information, please visit https://datahub.cmap.illinois.gov/dataset/high-resolution-land-cover-cook-county-2010.

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