

**Utilizing Inventory Data and Public Opinion to Develop an Urban Tree
Management Plan for Oak Ridge, TN**

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Thomas E. Jennings

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Abstract

Proper management by a trained urban forester is essential for the health of urban trees, due to the adverse growing conditions they face. Unfortunately, many cities do not have the luxury of employing an urban forester for various reasons, which is the case for the City of Oak Ridge, TN. This study utilized inventory data of the street trees, park trees, and trees surrounding the municipal complexes in Oak Ridge, as well as evaluated park visitor satisfaction in three of the city parks through the use of a survey to aid in the development of an urban tree management plan. Understanding what plant species are growing within cities and the benefits associated with those trees are only small parts of proper urban tree management. Additionally, assessing citizens' attitudes towards the benefits of vegetation in areas such as city parks is important, due to the fact that the purpose of these areas is public enjoyment.

The total urban tree inventory was completed over two years and consisted of 2,442 trees ($H' = 3.55$). The inventory data was utilized to calculate benefit estimations for the city in the software program i-Tree, producing a total \$133,796 in benefits, and a benefit-cost ratio of 0.90. For the park visitor survey, a total of 263 people participated in the survey among the three parks. Survey results revealed that for the two future management factors produced (future planting efforts and future tree care) there was a significant relationship for both factors with attitudes toward trees as well as a significant relationship between future planting efforts and visitor personal preference of park aspects.

The inventory data, i-Tree benefit estimations, and survey results were used to aid in the development of a 10-year management plan for the city of Oak Ridge. This management plan contains 1) specific guidelines for proper tree care, 2) planting protocols, 3) strategies to manage pest or disease outbreaks, and 4) guidelines for raising public awareness of the urban forest

through citizen engagement outreach programs. The management plan will be completed and presented to the city of Oak Ridge in September of 2015.

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Part I
Introduction

Introduction

The Need for Healthy Urban Trees

There are so many changes happening to our natural world that one has to wonder where it is all going to lead. Urban areas across the country are growing rapidly, thereby decreasing the amount of naturally forested areas almost daily (Heimlich and Anderson, 2001). With so much change to the natural landscape occurring so quickly, the management and care of the green spaces and forested areas of urban landscapes can sometimes be put to the side and deprioritized.

In the recent history of the U.S. it seems that the majority of the population is beginning to realize the benefits of green areas and park spaces within urban living environments. (Millward and Sabir, 2011; Chiesura, 2004; Nowak and Dwyer, 2007). Central Park in New York is one example highlighting the management of forested areas within a city that the majority of America's population can point to (Weinstein, 1983). Plans for the improvement and expansion of the park area began in 1858, and were eventually completed in 1873. The park was designated a national historic landmark in 1962, and today Central Park encompasses 840.1 acres of land and is the most visited urban park in the United States (Central Park Conservancy, 2012).

The success of Central Park is only one example of society's realization of the benefits and enjoyment that the proper management of urban natural areas can bring. Urban parks can provide a more natural setting, indicative of what was most likely lost in the development of the city (Thompson, 2002). People seem to enjoy areas where they can have a change of scenery away from the concrete and man-made structures of the urban environment (Central Park Conservancy, 2011). Research has shown that being able to utilize parks seems to have several benefits such as reducing stress, improving mental health, and also promoting social integration and interaction with others (Hartig et al., 1991; Conway, 2000; Coley et al., 1997). Unfortunately

some cities are still having trouble prioritizing their management of park trees for multiple reasons (Miller et al., 2015). Some cities are simply behind on the developments in urban forestry, not realizing that proper urban tree management should not be left to the city's department of parks and recreation who most likely have very little forestry background. Many cities across the country, and even throughout the world, have developed an entire urban forestry department to better manage their street and park trees. However another problem that plagues many cities is the lack of funding for these efforts (Chiesura, 2003).

There are several components to the best management practices for the proper care of trees in urban environments. First, it is important to understand what is meant by "forested land." Forest land is defined by the USDA Forest Service's Forest Inventory and Analysis program as areas at least 1 acre in size, at least 120 feet wide, and at least 10 % stocked with trees. This program also has the requirements that forest lands that meet those parameters must have an understory that is undisturbed by other land uses such as parks, agricultural lands, and residential property (U.S. Department of Agriculture, 2010).

Areas referred to as "urban forests" are actually defined as "non-forest land" by the FIA. Non-forest land is land that does not support or has never supported forests, which includes areas that were previously forested and have been harvested for timber or other developments. Other developments could include pasture land, agriculture, city parks, or residential areas (USDA, 2010). It is important for the area that is being monitored to be clearly defined in order to have an understanding of what exactly is being managed. Just like any national park or naturally forested area, an inventory needs to be conducted in order to find out exactly what is in the area and the best management techniques specific to the vegetation and desired outcomes (Nowak et al., 1996).

Thorough studies of urban vegetation were not common practice until the late 20th century in the U.S. One of the first studies conducted of a city's urban vegetation was by Schmid (1975), who conducted his inventory in the city of Chicago. This early research was to determine the effects of the surrounding urban environment on the vegetation of the city. Their results found that the urban environment seemed to have a negative impact on the structure of the plants found throughout the city. Research such as this continues today and is widely used throughout the U.S as well as other countries (Jim, 2001; Pouyat, 2008).

As the interest in examining urban areas and their effects on the vegetation found growing there continued to rise, so did the scale of the implications (Florgård, 2000). Focus has changed from small-scale, very location specific studies to large-scale interaction studies. Scientists want to know what the overall impact of the urban landscape is on the natural world and have used urban forest inventories and research to provide very interesting results (Chiesura, 2003). One of the first large-scale urban forest assessment programs was launched in 2001 by the USDA Forest Service. Its purpose was to understand the large-scale ecological impacts of urban areas with a high population density on the surrounding natural environments. Urban areas were classified based on areas with a core population density of 1,000 people per square mile and then tree information was collected from established plots within the urban areas (U.S. Department of Commerce, 2011).

Most people have preferences of the types of trees and forest cover that they like to see in urban green spaces and public parks. The majority of the public seems to prefer a diversity of species and a forest type that is not too dense so they can enjoy walking through the understory and have a better view of the natural beauty (Welch, 1994). Knowing the condition of the trees is also essential in order to improve upon past management practices that may not have been

affective, as well as care for or remove potentially hazardous trees. This not only benefits the parks and other green spaces but the city itself as more people wish to visit parks they enjoy and find pleasing to the eye, therefore increasing the reputation of the city as well as boosting the economy (Welch, 1994).

The Human Dimension of Urban Tree Management

Investigating Attitudes through Survey Research

So many times in scientific research the focus is on the natural world that is absent from human populations (Schreyer, 1980). It would seem however that the idea of gathering human perceptions on their surroundings is growing rapidly in popularity. The focus of the science of human dimensions in parks and recreation is becoming increasingly prevalent in the scientific community (Vaske and Manfredo, 2012). Researchers are becoming more and more interested in people's opinions and values in parks and recreation. The concept of listening to and understanding the feelings of park visitors is not a new concept by any means, as parks have obtained direct information from the public they encounter every day for many years. But the science of human dimensions attempts to focus directly on inquiries aimed at a specific audience in order to obtain reliable and valid responses that are representative of a population's mindset (Vaske, 2008).

One of the most frequently studied concepts in the social sciences are individual's basic attitudes (Eagly and Chaiken, 1993; Manfredo et al., 2004). Vaske (2008) defines values as "the evaluation, either favorable or unfavorable, of an entity (e.g. person, object, or action)." Attitudes are an important concept for natural resource managers because they can influence behavior. This means that it is possible to investigate what attitudes are important in things such as citizen involvement in a public program or their support for certain management practices being implemented (Bright and Manfredo, 1996). This can only occur, however, when the attitudes

toward a concept or practice are measured at levels of specificity that are similar (Fishbein and Manfredo, 2002). There are four specific variables identified by Ajzen and Fishbein (1980) across which measurements of attitude and behavior should correspond: target, context, action, and time. When there is no correspondence among beliefs, attitudes, and behaviors, the magnitude of the relationship declines (Whittaker et al., 2006).

This concept is illustrated, for example, by Zhang et al. (2007) who examined public attitudes toward urban trees and supporting urban tree maintenance from federal, state, and local governments. Their research found that individuals who are aware of forestry-related programs, hold a full-time job, belong in the age group of younger than 56 years, and earn an annual income greater than \$75,000, were more willing to donate money and volunteer time toward urban forestry programs and activities. They also found that more than 90% of citizens appreciated urban trees and strongly considered them in their decision of choosing where to live (Zhang et al., 2007). Their findings showed that citizens' attitudes toward government programs in general did have a relationship with their willingness to support tree maintenance programs at different government levels. Also, they found that a large majority of participants who held strong attitudes of appreciation toward urban trees considered that aspect in choosing where to live. Certain underlying attitudes did in fact have a relationship on their willingness to support the target variable of government funded tree maintenance programs.

An area where is extremely important to understand the attitudes held by the public in is park management (Vaske, 2008). Public parks rely very heavily on the attitudes of their visitors, and park managers have been utilizing different methods of measuring visitor satisfaction for many years. Specifically in urban parks, visitor satisfaction is immensely important due to the fact that the primary purpose of the park is for human enjoyment, rather than some other purpose

that a national park may have such as the preservation of plants or wildlife (Baur et al., 2013). It is therefore important to understand what attitudes can form an opinion such as satisfaction so that management officials can work to improve upon those basic aspects.

Satisfaction Approach to Survey Research

When it comes to understanding the behavior of recreationists, it seems that two main approaches have been heavily utilized and researched: the motivational approach and the satisfaction approach (Vaske, 2008). If someone is interested in utilizing the motivational approach, then one would need to understand why people are driven to do a certain activity to obtain a certain goal or experience. This approach attempts to see what the cause of interest is before the recreationist participates in the activity in question (Vaske, 2008).

The second approach is the satisfaction approach, which seeks to focus on the outcomes received from the particular recreation experience (Manfredo et al., 1995). A satisfaction approach to examining recreationists' behavior is very inclusive and contains many facets, due to the fact that a positive recreation experience may be made up of a combination of factors (i.e. time spent with family, love of the outdoors, exercise, etc.) (Vaske, 2008). Satisfaction at its most basic element is an attitude or an evaluation, usually derived from a feeling of enjoyment from an experience (Vaske and Manfredo, 2012).

Research to measure park visitor satisfaction has continued to evolve and become more complex and effective. A project by Balram and Dragičević (2005) developed a two-part method with qualitative and quantitative phases in order to strengthen the operationalization of the attitude concept. They utilized a combination of collaborative geographic information system (GIS) techniques and informal interviews for the qualitative stage and factor analysis and reliability analysis for the quantitative stage. Their findings showed that behavior and usefulness

combine to make the multi-dimensional attitude structure toward urban green spaces for a household (Balram and Dragičević, 2005).

Another example of examining public perceptions to look specifically at satisfaction is a study conducted by Crilley et al. (2012). This study is an example of measuring satisfaction of park users, but in a national park setting. The research was conducted in Kakadu National Park, Australia and compared two approaches to predicting overall satisfaction as well as looking at whether or not visitors would recommend the park. They analyzed importance-performance measures on a range of visitor service quality items and also measured the desired and attainment of visitor's perceived benefits associated with a recreation experience. Their results showed that visitors' attained benefits are stronger predictors of an overall positive response to visiting the park than service quality ratings. This suggests that greater attention should be given to the benefits that people desire in order to create experiences that would give the visitor a more positive experience and thereby make the visitor more likely to return and/or recommend the park to another (Crilley et al., 2012).

The Human Dimension in National and City Parks

America's National Parks pride themselves on being able to provide recreation areas that are enjoyable and satisfactory to park visitors (Runte, 1997). The realization that park management practices must incorporate the best interests of the public has allowed for growing interest in our country's natural areas over the past decades (Kuser, 2007). National parks have found that making decisions such as vegetation management, care of park facilities, and program implementation are much more effective when they cater specifically to visitor's needs rather than management practices being an ad hoc decision by the park itself (Wardell and Moore, 2005). The keys to a successful and enjoyable park are careful planning and management, and in

order to carry out these goals effectively, quality information from the public is necessary. The better quality the information, the more effective management practices the park can implement (Hornback and Eagles, 1999).

Today, National Parks across the U. S. and even most other countries have acknowledged the need for visitor data collection have implemented a collection technique such as questionnaires, telephone surveys, or face-to-face interaction (Vaske, 2008). Visitor surveys are used by natural and protected areas across the globe, which makes comparisons possible among different parks and natural areas among different countries (Newsome et al., 2002). Throughout recent years, increasing attention has been paid by government officials as well as the public to more effective data collection efforts, due to increasing requirements for public accountability as well as the need for data when it comes to government funding (Wardell and Moore, 2005).

National parks have utilized survey techniques for many years in order to acquire a great deal of information from visitors. A park survey would most likely seek to find out the demographics of the sample population first, i.e. age, gender, area of residence, ethnic background, etc. Some of the most basic questions however can provide very useful results. According to a demographic survey conducted by the Grand Teton National Park, the visitor profile was slightly older than in 1997. In 2008, 59 percent of the park's visitors were 41 or older, 11 percent were above 65, and just 19 percent were 15 or younger. This survey also reported results such as 48 percent of the visitors were coming to the park because they were also visiting Yellowstone National Park. They also found that visitor spending had increased dramatically since the last study was conducted. In 2008, each visitor group spent an average of \$1,388, as compared to \$575 spent per visitor group in 1997 (Repanshek, 2010).

Park surveys can uncover a tremendous amount of information, and all of it can be taken into consideration when making management decisions, such as what activities the predominant visitor age would enjoy (Kuser, 2007). Visitor information surveys in national parks have been the norm for many years. The techniques continue to evolve to better administer surveys and acquire more reliable data. Davis et al. (2012) found that park visitors from 11 different national refuges and parks enjoyed taking on-site surveys on iPads more than traditional paper surveys. But in recent history a focus has emerged on obtaining the public's opinions on city parks.

City governments have made the move to collect important data from urban park users in order to better manage their park space. New York City's Central Park has continued to be a model for urban park management and in April 2011 they released a report of their research designed to analyze the public use of the park. It was the first systematic effort to measure an entire year of Central Park's public use since 1873 and was designed to report detailed information of one of America's most visited parks (Central Park Conservancy, 2011). The survey was conducted from July 2008 to May 2009 and included approximately 4,600 entrance counts, 3,300 exit interviews, and over 9,100 observational surveys. Their results reported an estimated 37-38 million annual visits by approximately 8-9 million different individuals which represents a dramatic increase in use since the 1970s and early 1980s. Their research showed an estimated 13 million visits to the park in the summer season as opposed to 4.6 million in the winter season, as well as almost 40 percent of their visiting population being over the age of 50, and an equal male to female ratio (Central Park Conservancy, 2011). These results can provide management officials with baseline data upon which they can build their management practices. Decisions such as types of recreational facilities, amount of public space, and even the number of restrooms can be better determined by simple visitor surveys such as this. The Central Park

survey is simply one example of the types of information that can be obtained and utilized by park officials to implement the best park management practices possible.

Economic, Ecological, and Aesthetic Properties of a Park

One of the most important resources for a city are their public parks. They contribute to the reputation of a city in aspects that are rarely noticed, and are more essential than the majority of the population would think. Multiple studies have shown that parks have a positive impact on nearby residential property values (Harnik and Welle, 2009). A property's value can be affected by mainly two aspects of a park: the distance to the park and the quality of the park. In Washington D.C., the National Mall was shown to increase surrounding property value by \$1.2 billion, with the value of all residential properties within 500 ft. of a park being almost \$24 billion in 2006 (Nowak et al., 2006).

Parks also have an impact on the visitors by saving them money on direct usage of the park through activities such as team sports, bicycling, and picnicking that would otherwise cost more money if enjoyed in the private marketplace (Harnik and Welle, 2009). Nowak et al. (2002) showed that Boston's park and recreation system provided a total of \$354,352,000 in direct use value. Parks are responsible for so many other economic value boosts as well such as tourism, health, community cohesion, reduced cost of storm water management, and removal of air pollution by vegetation (Harnik and Welle, 2009).

While the economic properties of an urban park are important, the ecological properties are of equal or even greater value. The presence of natural areas in urban settings provides a refuge for vegetation and wildlife that once most likely naturally existed there. Urbanization can sometimes enhance the animal and plant habitats of the area which, in turn, enhances the overall biodiversity of the area. For example, in a study done by Nowak (1993) in Oakland, California,

tree species diversity and richness had increased from an index value (Shannon-Weaver diversity index) of 1.9 and 10 species in 1988 to 5.1 and more than 350 species.

However the ecology of the area can also be disrupted by urban natural areas, possibly through the introduction of an exotic plant species or the displacement of an endangered species (Nowak and Rowntree, 1990). Urban hydrology can also be affected by increased vegetation eliminating much of the urban runoff that contaminate water ways, thereby improving the quality of the water as well as reducing erosion. Neville (1996) found that heavily forested areas can reduce total runoff by up to 26% as compared to non-forested areas of the same land cover and land use conditions.

One last important property of parks that is often overlooked in the scientific community is the idea of park aesthetics and the benefits they entail. A visually pleasing park has been shown to improve the quality of life in many different ways. Aspects such as amount of greenery and visual light have been shown to improve human well-being through intensive park visitor analyses (Jackson, 2003). Urban trees can help alleviate some of the hardships of inner city living (Dwyer et al., 1992) and have even been shown to reduce urban noise (Aylor, 1972).

Developing a Survey

The process of developing a survey requires a great deal of proper planning and implementation. Surveys are generally designed to reach a very specific group of people, so therefore much consideration must be given to all of the details that come with gathering information from a human population (Vaske, 2008). One of the first tasks in the process of using a survey is deciding who the target audience is going to be. The sample population is key because it must be representative of the entire population of interest and be able to describe the characteristics of that larger population (Salant and Dillman, 1994). Not only can surveys be

representative of a larger population, but responses can also be compared among sample groups because surveys use consistent and standardized questions (Vaske, 2008).

According to Salant and Dillman (1994) the basic questions that must be considered before administering a survey are, “What problem is the project trying to solve?” and “What new information is needed to solve this problem?” A survey must contain questions that are relevant to the topic at hand in order to retrieve useful data. The questions can be developed in a number of ways, either by basing them off of past research, focus groups, or other means (Vaske, 2008). Once the target audience is identified and the questions are developed based on the desired information to be collected, the next step of the process is to choose the survey type. Surveys can be administered in many different ways such as mail, on site, e-mail, internet, or mixed-mode surveys which involve two or more techniques (Vaske, 2008). Each method will yield different results such as the amount of bias a telephone interview can entail or the possible lack of response to a mail survey (de Leeuw et al., 1996).

Developing an Urban Tree Management Plan

Urban forestry planning requires a great deal of foresight, due to the fact that the goal is to create a sustainable system for the trees that are being managed for many years to come (Clark et al., 1997). The planning processes required to do this successfully are usually laid out in an official management plan. The management plan serves as a blueprint for the processes that will take place in the near and distant future in terms of urban tree management (Dwyer et al., 2003). These plans are very specific to an area, and are generally based off of a very detailed tree inventory of the area of interest (Nowak et al., 1996).

Typically, a management plan includes several things, such as: identifying tree care needs, identifying possible tree planting sites, developing pest and disease prevention and

outbreak strategies, and developing public outreach programs to raise public awareness of aspects associated with urban trees (TDADF, 2010). One other aspect that is generally very important in the development of a management plan is the eventual creation of a tree board or some form of community based organization that can oversee the implementation of many of the management goals of the plan (Flott, 2013). The individuals that make up a tree board generally are citizens with an interest in and knowledge of trees and the resources that are related to their proper care. Their duties generally include keeping current the goals and procedures of the management plan for the city, advising city officials and departments on matters concerning trees and their related resources, and coordinating special projects involving the general public for the improvement of the urban forest (TDADF, 2010).

One example of a city that has been held in very high regard in recent history for their urban tree care practices is the city of Chattanooga, TN. In 2002, the city of Chattanooga spent over 7,000 hours pruning and maintaining nearly 4,500 trees. The city officials wanted to put Chattanooga on the forefront of tree management technology, and apply the most up to date maintenance practices that were available. It took 4 months to inventory the trees in the city's expanded central business district, an area that covers about 200 square blocks. Workers mapped the trees utilizing GPS units, keeping track of key characteristics, even down to how the tree was irrigated. The city then built a GIS tree inventory map based on diameter class in order to determine the number of pruning hours required to maintain them. This database is not only affective for determining effort toward pruning, but also allows urban forestry personnel to query by tree height, condition, pests, and other maintenance needs (Brown, 2003).

Utilizing Inventory Data to Develop a Management Plan

As previously mentioned, a management plan is based off of a very specific tree inventory (Nowak et al., 1996). In order to properly care for trees, there is a great deal of information that is essential to collect and understand. Generally, there are several standard pieces of information that are included in an urban tree inventory (TDADF, 2010). The first measurement taken is to identify the species of tree. Proper tree identification is essential, due to the fact that each species requires a different management strategy (Rydberg and Falck, 2000). Another important aspect of the inventory is to mark the GPS coordinates of the tree, in order to return to the tree when carrying out specific management practices. This is also useful when utilizing any type of GIS based software for mapping the inventory. In order to understand tree growth, dbh (diameter at breast-height) is also taken, generally in conjunction with some sort of initial tree condition measurement, usually a number scale (typically 1-5 or 1-10), or just describing the tree as good, fair, poor, or dead (TDADF, 2010). Understanding how specific trees are growing and what kind of condition they are in is essential for providing the best management practices possible through tree removals if necessary, or other tree care practices to improve the existing trees (McPherson et al., 2005).

Utilizing Public Opinion in Developing a Management Plan

When making management decisions for tree care, the general public can sometimes be left out of consideration. This however can cause some major problems for managers, due to the fact that the majority of trees that they are caring for in an urban area are either privately owned by citizens, or are heavily integrated into their everyday lives such as trees along streets or within parks (Moskell and Allred, 2013). A city's management plan must utilize public opinion in their management decisions, this will lead to a more satisfied population of citizens, and also could

lead to citizens with an increased interest in participating in tree care practices. Several studies have investigated the public's attitudes toward wanting to gain more knowledge and participate in tree care activities such as the study by Allred et al. (2010) which, through the use of a survey of residents conducted in the South Bronx neighborhood of New York City, found that a large majority of participants (76%) wanted to learn more about trees. Their educational interests included learning more about the human and environmental health benefits of trees, and also how to plant and care for trees.

Continually gathering data from the public through the use of surveys is essential for a city's tree care professionals. These inquiries need to be specific toward the issue of interest, and need to be continually monitored and repeated if necessary to make sure the managers have the most up to date information (Vaske, 2008). One of the most essential parts of an urban forestry management plan is the continual education of the public and city officials that deal directly with the care of the city's trees. Once a city understands the attitudes and values held by its residents, they can begin to implement those management practices, and begin educating the public on how they can help provide tree care services on their own to ensure the most sustainable urban forest possible (Sommer et al., 1994).

Statement of Problem

Urban landscapes are characterized by manmade structures (i.e., roads, buildings, parking lots, sewers, etc.) that compartmentalize natural systems in small, discrete patches. Vegetation dispersed throughout urban landscapes is used for architectural, aesthetic, recreational, wildlife, climatological, and engineering purposes. Specifically, trees in urban environments are planted to enhance and beautify cities but are challenged to: 1) adapt to poor soils that have often been polluted, 2) compete with grass for nutrients and water, 3) develop roots under impervious

surfaces, 4) resist disease and insect pressures, and 5) endure abuse from automobiles, lawnmowers, pests, and people. Proper management by trained personnel (i.e. urban foresters) is essential for the health of urban street and park trees. Unfortunately, many cities do not have the luxury of employing an urban forester for various reason(s) such as budget constraints, which is the case for the City of Oak Ridge, TN. In order to properly care for and manage urban trees, the basic planning model (Miller, 2007) can be applied to ask three questions: 1) establishment of baseline data through inventory (What do we have?), 2) assessing community values, consideration of opposing viewpoints and consensus building (What do we want?), and 3) decision making, public information, education, and legislation (How do we get what we want?). Years of scientific research have only solidified how important trees are to their ecological communities. Without trees, nutrient cycling would be disrupted causing valuable elements to be lost, habitat for wildlife would be diminished, food sources would be depleted for many animals, and even air quality would suffer due to loss of oxygen production (Boettcher and Kalisz, 1990).

The habitat for trees must be properly managed in order for them to thrive and provide for their ecological niche. Urban forest and green areas must be surveyed and inventoried in order to properly manage the species of trees that are found there (Tate, 1985). But simply knowing what species are growing in an urban area is not enough to be able to apply the best management practices possible. If a city truly cares about its urban green spaces it will listen to the people who come to enjoy them (Manning, 2010), and implement management practices based off of public opinion (Welch, 1994). All of this data through inventory and analyzing public opinion is essential in developing an effective management plan that can provide a healthy urban forest for a city for many years to come.

Objectives

This research project has been developed collaboratively between the City of Oak Ridge, TN and the Department of Forestry, Wildlife, and Fisheries at the University of Tennessee Knoxville *to assist the city in developing a tree management plan based on a tree inventory and assessment*. The project has three main objectives: (1) Show the utility of the software program i-Tree in calculating benefit estimations for the trees along the city's major corridors, public spaces, and parks, as well as the importance of using city-specific information in these calculations, (2) Evaluate human perceptions of aspects of park trees through the use of a survey by examining how factors analyzed differ among the parks and also how personal preference of parks visitors and their attitudes towards trees relate to what they believe should be a future management priority, and (3) Utilize tree inventory data and survey input from the public and city leaders to aid in the development of a tree management plan for the City of Oak Ridge.

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Part II

The utility of online urban tree inventory software to develop urban forestry management plans

Thomas E. Jennings, Sharon R. Jean-Philippe*, John Zobel, Tom Simpson, Donald Hodges, DeEtra Young, Adam Willcox

University of Tennessee, Department of Forestry, Wildlife and Fisheries, 274 Ellington Plant Science Building, Knoxville, Tennessee 37996-4563

*Address correspondence to author. Phone 865-974-2946; email: jeanphil@utk.edu

Abstract

Urban trees can provide numerous benefits for a city such as increased property values, reduced storm water runoff, and improved general human well-being. In order for a city to capitalize on these benefits, effective management of these trees is essential. The first step in the proper management of urban trees is to conduct an inventory, and to analyze this data so that management professionals can understand the resources they have and can have that information available to the public. A program that allows managers to do this very effectively is the free software program i-Tree. However, the program utilizes the concept of a reference city if information specific to the city in which the analysis is being conducted is not available, which may affect the reliability of the results. This study was conducted in the city of Oak Ridge, TN in order to provide city officials with baseline data to aid in the management of their urban street trees, park trees, and trees surrounding their municipal complexes. This research will specifically utilize the program i-Tree streets in order to 1) show the usefulness of the program in calculating benefit estimations for the urban trees in the city of Oak Ridge and 2) show the differences in benefit estimations between a data set containing information specific to the city and a data set based off values from the reference city. The program showed that there was a total of \$133,796 in annual benefits associated with the urban trees of Oak Ridge when analyzed with information provided by city officials. Also, the same analysis utilizing reference city data over-estimated the total annual benefits at \$143,885. Overall, this study provided insight into the type of

information that can be produced by the program i-Tree that may be useful for urban tree managers and also how important it is to utilize city-specific information.

Keywords: Urban Trees, i-Tree®, Cost-Benefit Analysis, Tree Inventory, Urban Forestry

Introduction

An urban forest is defined as the sum of all woody and associated vegetation in urban areas (Miller, 1997). Managing trees in an urban forest can be challenging. Urban trees provide multiple benefits to cities including: increased property values (Harnik & Welle, 2009), reduced storm water runoff (Neville, 1996), improved general human well-being (Jackson, 2003), and increased biodiversity of nonnative plant species (Nowak, 1993). The investment of time and resources into tree management improves these essential benefits and enhances public living conditions. Urban forest management usually begins with a thorough inventory of trees (Nowak, Rowntree, McPherson, Sisinni, Kerkmann, & Stevens, 1996). Managers can make more effective management decisions when they understand the composition and track maintenance tasks of the tree community that constitute their urban forests (Bassett, 1978). Additionally, a tree inventory can provide appraised values for city-owned trees (Gerhold, Steiner, & Sacksteder, 1987). Knowledge of the urban forest composition and its existing value also can lead to more efficient tree maintenance (Smiley & Baker, 1998), and a more satisfied general population by maximizing public benefits associated with the trees at minimal expense (Miller, 2007).

Introduction to urban tree management software programs

The ability to accurately track and maintain vegetative inventory records for cities evolved from field data sheets to the development of multiple free public domain tree inventory computer programs. Such programs include, Street Tree Electronic Management System (STEMS), Mobile Community Tree Inventory system (MCTI), Davey Resource Group's Tree Keeper®, and i-Tree, among others. STEMS and MCTI were developed collaboratively by the USDA Forest Service and the University of Massachusetts. STEMS allows practitioners to track public complaints or work requests, generate and process work orders, compile tabular and

graphic reports, and work in conjunction with MCTI. Additionally, MCTI allows users to record their tree inventory information on a tally sheet, store and manage their data within the desktop software application, and also collect and analyze data in the field with a PDA data collection software package. Davey Resource Group's Tree Keeper® program (www.davey.com) is comparable to i-Tree, and specifically i-Tree Streets. This software allows users to manage tree inventories, track calls from community residents, manage work orders, create data reports, and utilize an integrated mapping system. Contrary to i-Tree and other free software programs, Davey Resource Group's Tree Keeper® program is only available through a paid subscription.

Within the last 10 years, i-Tree Tools for Assessing and Managing Community Forest (www.itreetools.org) has allowed management professionals to more effectively track trees in cities. Released in August 2006, i-Tree was designed by the USDA Forest Service as a free public domain software, and is comprised of six individual urban ecosystem assessment tools: i-Tree Eco, i-Tree Streets, i-Tree Hydro, i-Tree Vue, i-Tree Design, and i-Tree Canopy. Each of these tools allows resource professionals to evaluate and manage various components of the urban forest.

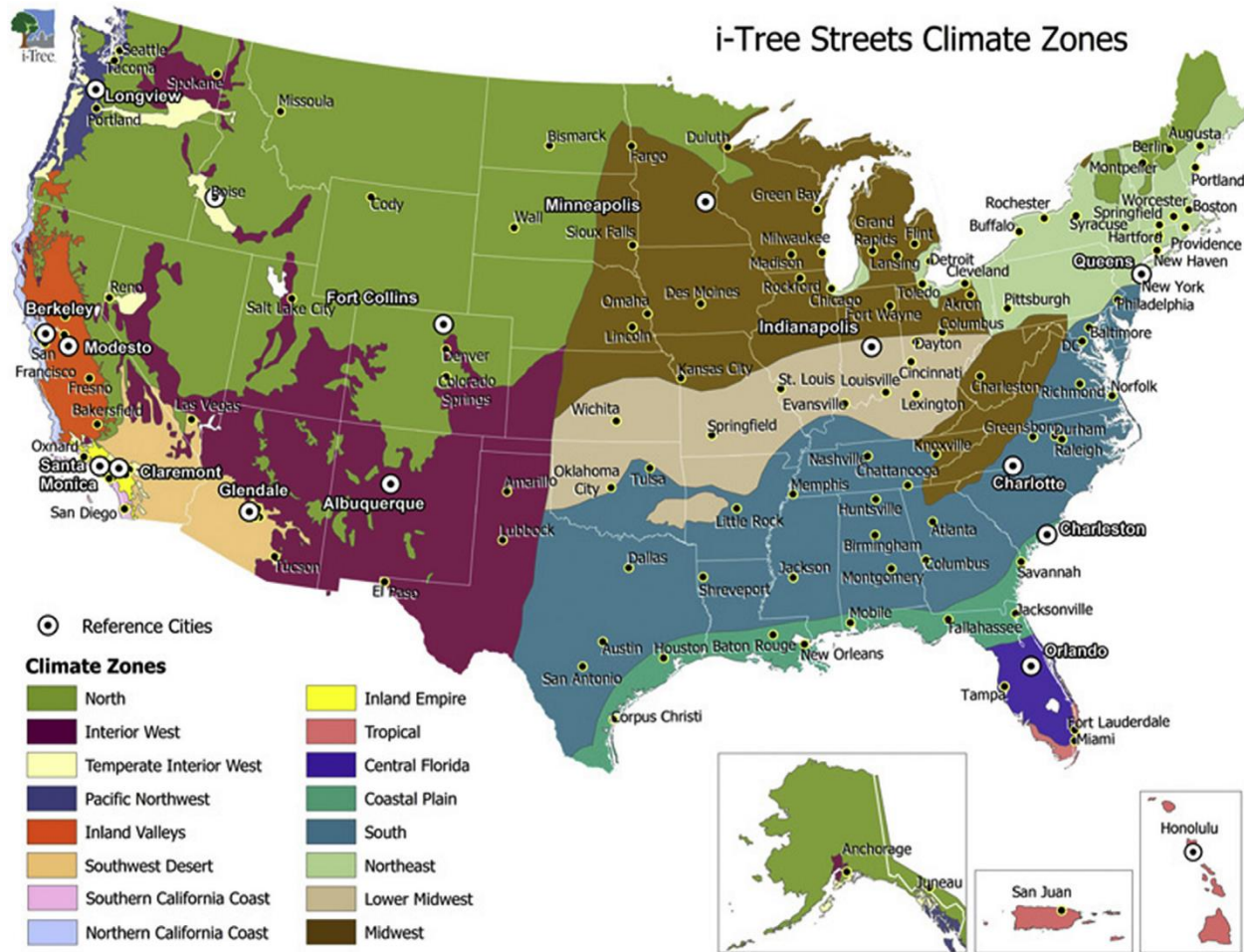
Quantifying ecosystem services with i-Tree Streets

Numerous studies quantifying urban forest monetary values have been conducted over the past few decades (Dwyer, McPherson, Schroeder, & Rowntree, 1992; McPherson, Simpson, Peper, Maco, & Xiao, 2005; Nowak, Hoehn III, Crane, Stevens, & Walton, 2007), with the earliest efforts performed by the U.S. Forest Service. The Urban Forest Effects (UFORE) model was developed in the late 1990s, and allows users to examine the structure and environmental characteristics of urban forest for calculating the ecosystem services these forest provide (Nowak & Crane, 2000; Nowak, Crane, Stevens, & Hoehn, 2005). Specifically, UFORE quantifies urban

forest benefits to mitigate greenhouse gases, reduce building energy cost, and improve air quality (U.S. Forest Service, 2012a). The utility of quantifying urban forest benefits to cities, along with increased public awareness and education of city leaders, has justified the establishment of community, municipal, and/or city forestry positions in urban areas (Pincetl, Gillespie, Pataki, Saatchi, & Saphores, 2012).

Although several urban tree management computer programs are available, i-Tree's ease and utility has increased its popularity among practitioners. We utilized i-Tree Streets to examine the benefits of management and assess the utility of tree benefit estimation. The i-Tree Streets program uses tree inventory data to estimate the monetary value of annual environmental and aesthetic benefits for cities or communities. It allows managers to effectively track their resources, develop policies, and prioritize management actions. Originally called the STRATUM model, i-Tree was developed by the Forest Service and PSW Research Station Center for Urban Forest Research in Davis, CA, and requires only a basic inventory of a community's urban trees to estimate the value of their public street tree population (U.S. Forest Service, 2012b).

Benefit estimations are calculated based on an existing tree inventory and city specific demographic metrics. This city-specific feature is very useful and somewhat unique to i-Tree. Being able to use city-specific demographic metrics data allows for much more accurate estimates of local tree benefits. Values such as electricity (\$ Kwh⁻¹), natural gas (\$ Therm⁻¹), average home resale value, and city budgets are utilized to develop reliable results. The model is able to estimate costs and benefits based on data specific to 16 climate zones (Fig. 2.1). These



areas reflect differences in growing conditions, management practices, climate, and soils that can affect species distribution and growth (U.S. Forest Service, 2010). The values within the climate region are based on a reference city within that region in which 40 trees of the most common species were randomly sampled for DBH, height, crown diameter, crown shape, condition, and planting date. Leaf area and crown volume were also estimated using digital images (Peper & McPherson, 2003). We will examine the capability of i-Tree to estimate the monetary and environmental benefits of trees in the city of Oak Ridge, TN and compare city-specific estimates

to references city estimates. These monetary and environmental benefits obtained will be used to develop a ten-year management plan for the city of Oak Ridge, TN.

Methods

Site Description

Oak Ridge is located in Anderson County in east Tennessee, USA. The city covers around 220.8 km² with a population of approximately 29,500 people (US Census Bureau, 2013). Oak Ridge has an annual average precipitation of 129.3 cm and the growing season for the area spans 220 days (NOAA; Tennessee Climatological Service). The tree inventory was developed collaboratively by the City of Oak Ridge and the Department of Forestry, Wildlife and Fisheries at the University of Tennessee Knoxville and consisted of three phases: street trees along five major corridors (Phase I), trees around municipal complexes (Phase II), and 13 city parks (Phase III).

The streets selected were the five main streets that bisect the city: Illinois Avenue 3.09 km (SW-NW), Rutgers Avenue 1.50 km (S-N), Tulane Avenue 0.80 km (S-N), Lafayette Avenue 2.40 km (S-N), and Oak Ridge Turnpike 9.25 km (SW-NE). The street origins are found at the following coordinates: Illinois Avenue (36.00183, -84.24476), Rutgers Avenue (36.00553, -84.25121), Tulane Avenue (36.00715, -84.25693), Lafayette Avenue (36.00326, -84.24223), and Oak Ridge Turnpike (36.04993, -84.20698). All roadways had two traffic lanes with the exception of Illinois Avenue, which had three lanes of traffic from its intersection with Lafayette to its intersection with Tulane before it decreased to two lanes. Thirteen city parks were selected: A.K. Bissell (36.01209, -84.26316), Big Turtle (35.99268, -84.31691), Briarcliff (36.02419, -84.22030), Carl Yearwood (36.02391, -84.23678), Cedar Hill (36.03807, -84.24828), Elm Grove (36.03876, -84.22837), Elza Gate (36.05042, -84.20777), Highland View (36.02523, -84.27102),

LaSalle (36.01287, -84.29317), Melton Lake (36.03668, -84.19438), Milt Dickens (36.04737, -84.21189), Pinewood (36.02655, -84.23970), and Solway (35.99989, -84.19060). Major municipal complexes were selected: the city municipal building which houses city officials and the police department (36.01293, -84.26047), central services building for all city public works (36.00115, -84.25404), Scarboro Community recreation center (35.99665, -84.26027), fire station #1 (36.00001, -84.29713), fire station #2 (36.02974, -84.23160), fire station #3 (36.00177, -84.25920), and fire station #4 (36.92675, -84.39161).

The natural forest cover for Anderson County is predominantly oak-hickory; however, the urban tree community deviates from the natural forest type. According to the Anderson County Soil Survey (1981), the general soil environment found in Oak Ridge is Collegedale-Gladeville-Rock Outcrop. Other soil types are Collegedale-rock outcrops, Upshur Variant silt clay loam, Hamblen silt loam, and Capshaw silt loam. The streets, parks, and municipal complexes are found in a variety of areas within the city, ranging from government buildings, to business areas, to residential neighborhoods. The city's most notable landmark, the Oak Ridge National Laboratory, is located in the southern region of the town and was crucial in the economic development of the city and has affected the natural environment in the area substantially.

Streets, Parks and, Municipal Complexes Inventory

The street trees, parks and municipal complexes inventories were conducted in the summers of 2012, 2013 and 2014, respectively. All live street trees, dead street trees, and stumps that were within the public right-of-way were included in the total inventory of the five streets. Species name, diameter at breast height (dbh), geographic coordinates, and tree condition (good, fair, poor, dead) were recorded for each street tree with a dbh of 2.54 cm or greater. A Garmin

etrex 20 hand-held GPS was used with the mark waypoint feature to assign the latitudinal and longitudinal coordinates to each tree and stump. Trees that fell within the property boundaries of each of the city's municipal complexes as well as trees within the parks were inventoried using the same methods. Additionally, several parks within the study were classified as woodlots or containing woodlots. Within these park sites, a 10% inventory was taken (with the exception of the woodlots found in A. K. Bissell and LaSalle, in which case 100% of the trees were inventoried), measuring all trees with a diameter greater than 10.16 cm. The 10% inventory was accomplished by using ArcGIS® to randomly generate 0.10 acre (0.04 ha) plots along a transect generated by the program. The number of plots was based on the size of the parks, with Elza Gate Park containing 5 plots, and Carl Yearwood Park containing 8 plots.

Streets, Parks and Municipal Complexes Inventory Analysis

Shannon's diversity index was calculated for the total inventory, as well as each phase of the inventory. Other notable characteristics were also calculated for the total inventory as well as for each phase, including condition totals, average dbh, as well as maximum and minimum DBH. Native and non-native species distributions were also calculated for the park inventory.

i-Tree Analysis

The computer program i-Tree Streets was utilized to produce benefit estimates for the tree population within each of the three phases of the inventory. Information specific to the city of Oak Ridge was provided by city officials, including 1) total municipal general fund budget, 2) average sidewalk width, 3) total linear miles of streets, 4) average street width, 5) budgets (planting, pruning, tree/stump removal, and pest and disease control, and 6) average home resale value. Based on the program description, these values should allow for much more accurate

results than those generated with values from a reference city (Charlotte, NC in the case of Oak Ridge), which may differ from the actual values.

For the benefit-cost analysis, annual benefits were calculated for energy, stormwater, air quality, carbon dioxide, carbon stored, aesthetic/other values, and a total summary. Results were produced for species as well as for each street, park, and municipal building. Summary results were also produced in dollar per tree as well as total dollars. Management costs and net annual benefits then were calculated. Also, canopy cover was calculated for each phase as well as for the total inventory.

Results

Inventory Analysis

A total of 607 trees were inventoried for Phase I (five main city streets). The inventory included 37 different species, with the most abundant being *Acer rubrum*. For condition analysis, 53.9% of the trees were in good condition, 30.6% fair, 13.8% poor, and 1.7% were classified as dead or dying. Most trees fell in the 15-30 and 30-45 cm dbh classes, with an average dbh of approximately 30 cm and a maximum dbh of 94 cm (*Acer rubrum*). Shannon's diversity index for the total street inventory was $H' = 1.39$.

The inventory of the trees surrounding the city's municipal complexes included 148 trees and 29 different species, with the most abundant species being *Pinus strobus*. For condition analysis, 83.9% of the trees were in good condition, 12.8% fair, and 3.4% poor. No trees were classified as dead or dying. The majority of trees were in the 15-30 cm dbh class, with the average dbh being 32.3 cm, and the maximum dbh being 118.6 cm (*Taxodium ascendens*). Shannon's diversity index for the total municipal building tree inventory was $H' = 2.96$.

A total of 1,687 trees were inventoried for the park tree inventory. The inventory included 72 different species, with the most abundant species being *Juniperus virginiana*. For condition analysis, 77.2% were in good condition, 18.1% fair, 3.9% poor, and 0.8% were classified as dead or dying. The majority of trees were in the 30-45 cm dbh class, with the average dbh being 33.3, and the maximum dbh being 118.6 cm (*Liriodendron tulipifera*). Shannon's diversity index for the total park tree inventory was $H' = 3.56$. The percentage of native vs. non-native species composition was also calculated, revealing that 71.8% of the trees inventoried were native to Tennessee.

i-Tree Analysis

For the benefit-cost analysis of the street trees in Oak Ridge, total dollar benefits per year for energy, CO₂, air quality, stormwater, and aesthetic/other were calculated for each of the five streets. Table 2.1 shows these benefits for each street, as well as the citywide total and complete total dollar amount. The total annual dollar benefit for the city's street trees was \$36,714, with the largest percentage (51.2%) being from the Oak Ridge Turnpike which was the longest street inventoried. By species, *Acer rubrum* accounted for the largest percentage of total benefits at 21.1% (\$7,752), with *Pyrus calleryana* responsible for an additional 18.9% (\$6,928). Also, the street trees provided 9 acres (3.6 ha) of canopy cover area for the city (Table 2.5).

The total annual dollar benefit for trees surrounding the municipal buildings was \$10,674, with the largest percentage (36.7%) coming from the trees at the city municipal building (police station). Benefits for each building as well as the citywide total are listed in Table 2.2. For the benefits calculated by species, 16.6% (\$1,771) of the total came from the *Pinus strobus* population. The trees inventoried surrounding these buildings also contributed approximately 3 acres (1.2 ha) of canopy cover to the citywide total (Table 2.5).

Table 2.1. Total annual benefits of public street trees.

Street	Energy (MWh Therms ⁻¹)	CO ₂ (lb year ⁻¹)	Air Quality (lb year ⁻¹)	Stormwater (gal year ⁻¹)	Aesthetic/ Other	Total	% of Total \$
Illinois Ave.	\$711	\$206	\$88	\$1,718	\$2,402	\$5,125	14.0
Rutgers Ave.	\$146	\$42	\$(-10)	\$330	\$754	\$1,262	3.4
Tulane Ave.	\$384	\$107	\$159	\$695	\$1,011	\$2,356	6.4
Oak Ridge Tpk.	\$2,595	\$733	\$331	\$6,246	\$8,881	\$18,787	51.2
Lafayette	\$1,216	\$339	\$249	\$3,146	\$4,235	\$9,184	25.0
Citywide Total	\$5,052	\$1,427	\$818	\$12,134	\$17,284	\$36,714	100

Note. Energy based on electricity (MWh) and natural gas (Therms) values. CO₂ values calculated by lb. sequestered. Air quality based on lb. deposited and lb. avoided. Stormwater based on gal. intercepted. Aesthetic/Other values report the tangible and intangible benefits of trees reflected in increases in property values).

Table 2.2. Total annual benefits of trees surrounding city municipal complexes.

Building	Energy (MWh Therms ⁻¹)	CO ₂ (lb year ⁻¹)	Air Quality (lb year ⁻¹)	Stormwater (gal year ⁻¹)	Aesthetic/ Other	Total	% of Total \$
Municipal Building	\$549	\$162	\$(-4)	\$1,664	\$1,543	\$3,914	36.7
Central Services	\$161	\$47	\$23	\$298	\$719	\$1,248	11.7
Scarboro Center	\$259	\$73	\$36	\$661	\$883	\$1,912	17.9
Fire House #1	\$42	\$9	\$(-64)	\$229	\$82	\$297	2.8
Fire House #2	\$133	\$37	\$56	\$290	\$370	\$886	8.3
Fire House #3	\$279	\$95	\$(-36)	\$787	\$1,160	\$2,285	21.4
Fire House #4	\$20	\$5	\$8	\$47	\$51	\$132	1.2
Citywide Total	\$1,443	\$427	\$19	\$3,976	\$4,809	\$10,674	100.0

Note. Energy based on electricity (MWh) and natural gas (Therms) values. CO₂ values calculated by lb. sequestered. Air quality based on lb. deposited and lb. avoided. Stormwater based on gal. intercepted. Aesthetic/Other values report the tangible and intangible benefits of trees reflected in increases in property values).

Table 2.3. Total annual benefits of public park trees.

Park	Energy (MWh Therms ⁻¹)	CO ₂ (lb year ⁻¹)	Air Quality (lb year ⁻¹)	Stormwater (gal year ⁻¹)	Aesthetic/ Other	Total	% of Total \$
A.K. Bissell	\$3,250	\$992	\$(-690)	\$9,482	\$12,149	\$25,183	29.7
Big Turtle	\$1,570	\$492	\$(-586)	\$4,911	\$5,780	\$12,165	14.1
Briarcliff	\$937	\$276	\$(-13)	\$2,896	\$2,783	\$6,880	8.0
Carl Yearwood	\$372	\$107	\$31	\$883	\$1,334	\$2,727	3.2
Cedar Hill	\$878	\$243	\$(-119)	\$2,694	\$3,139	\$6,836	7.9
Elm Grove	\$986	\$305	\$(-212)	\$3,071	\$3,632	\$7,781	9.0
Elza Gate	\$246	\$70	\$(-48)	\$710	\$792	\$1,770	2.0
Highland View	\$3	\$2	\$1	\$4	\$6	\$17	0.0
LaSalle	\$52	\$17	\$2	\$158	\$234	\$463	0.5
Melton Lake	\$1,288	\$389	\$(-24)	\$3,199	\$5,190	\$10,043	11.6
Milt Dickens	\$416	\$126	\$(-88)	\$1,226	\$1,470	\$3,149	3.6
Pinewood	\$149	\$43	\$57	\$309	\$454	\$1,011	1.2
Solway	\$1,125	\$314	\$(-110)	\$3,502	\$3,553	\$8,383	9.7
Citywide Total	\$11,270	\$3,375	\$(-1,798)	\$33,045	\$40,516	\$86,408	100.0

Note.

Energy based on electricity (MWh) and natural gas (Therms) values. CO₂ values calculated by lb. sequestered. Air quality based on lb. deposited and lb. avoided. Stormwater based on gal. intercepted. Aesthetic/Other values report the tangible and intangible benefits of trees reflected in increases in property values).

Table 2.4. Net annual benefits of public trees in Oak Ridge.

Phase	Total Benefits
Streets	\$36,714
Municipal Complexes	\$10,674
Parks	\$86,408
Total Benefits	\$133,796
Costs	
Planting	\$2,436
Pruning	\$23,870
Pest Management	\$500
Removal	\$121,595
Total Costs	\$148,401
Net Benefits (\$)	\$(-14,605)
Benefit-Cost Ratio	0.90

Note. Management costs were provided by the city of Oak Ridge and are based on an annual budget.

The total annual dollar benefit for the city's park trees was estimated at \$86,408, with the largest percentage (29.1%) coming from trees in A. K. Bissell Park. Table 2.3 provides the benefits calculated for each park as well as for the citywide total. As for benefits calculated by species, 12.6% (\$10,848) were attributed to *Quercus phellos* and 11.6% (\$10,065) to *Quercus palustris*. The 13 parks provide 20 acres (8.1 ha) of canopy cover for the city (Table 2.5).

Net annual benefits were also calculated based on the total dollar benefits from each phase of the inventory and the management costs provided by the city of Oak Ridge (Table 2.4). The benefits of the public trees inventoried totaled \$133,796 and the total expenditures for management, made up of planting, pruning, pest management, and removals were \$148,401, resulting in a deficit of \$14,605 for the urban trees inventoried in Oak Ridge. The benefit-cost ratio was calculated as 0.90:1.0.

Table 2.5. Canopy cover of Oak Ridge public trees
(acres)

Phase	Acres	% of Total Canopy Cover
Streets		
Illinois Ave.	1	2.4%
Rutgers Ave.	<1	0.6%
Tulane Ave.	1	2.4%
Oak Ridge Tkp.	4	9.5%
Lafayette	2	4.8%
Municipal Complexes		
Municipal Building		
Central Services	<1	0.7%
Scarboro Center	<1	1.3%
Fire House #1	<1	0.2%
Fire House #2	<1	0.7%
Fire House #3	<1	1.3%
Fire House #4	<1	0.0%
Parks		
A.K. Bissell	6	14.3%
Big Turtle	3	7.1%
Briarcliff	2	4.8%
Carl Yearwood	1	2.4%
Cedar Hill	2	4.8%
Elm Grove	2	4.8%
Elza Gate	<1	1.0%
Highland View	<1	0.0%
LaSalle	<1	0.0%
Melton Lake	2	4.8%
Milt Dickens	1	2.4%
Pinewood	<1	0.6%
Solway	2	4.8%
Citywide Total	42	100.0%

Percentages not equal to 100% due to the fact that i-Tree only produces whole number acreage estimates. All areas less than 1 acre are shown as <1.

Citywide canopy cover was calculated for each phase of the inventory. Table 2.5 depicts the total canopy cover in acres for each street, park, and municipal complexes, as well as the

percentage each provides to total canopy cover. The program does not produce partial acreage estimates, therefore, to maintain consistency, values were only shown in acres or as being less than one acre. The total canopy cover for the areas inventoried was 42 acres (17 ha). Street trees comprised 21.4% of the total, park trees 47.6%, and trees surrounding municipal complexes 7.1%. Total citywide canopy cover percentage was not calculated due to the fact that only five of the city's streets were inventoried, making the percentage not representative of the true cover.

Benefits were also calculated in i-Tree without utilizing the information provided by the city of Oak Ridge, but rather using the default data from a reference city (Charlotte, NC). The program results using the reference city differed from the total dollar benefit estimates with the Oak Ridge data. Table 2.6 provides the benefit summaries for all three phases of the inventory based on reference city data compared to those for the collected data. While some of the estimates for the individual benefit categories did not change, many did, leading to a larger total dollar benefit, with street trees providing \$39,499, park trees \$92,937, and trees within municipal complexes \$11,449, for a citywide total annual benefits associated with the public trees of \$143,885.

Table 2.6. Comparison of total annual benefits of Oak Ridge public trees.

Phase	Total
City Data	
Streets	\$36,714
Municipal Complexes	\$10,674
Parks	\$86,408
Citywide Total	\$133,796
Reference City Values	
Streets	\$39,499
Municipal Complexes	\$11,449
Parks	\$92,937
Citywide Total	\$143,885

Note. City data and reference city values.

Discussion

New technologies continue to emerge that allow for more effective analysis of the urban tree resource. Proper care of urban trees is essential to a healthy, thriving city (Welch, 1994), and tools such as i-Tree allow managers to fully understand the benefits associated with their urban forest. This research was intended to assess the utility of the program i-Tree in quantifying the annual benefits associated with urban trees in Oak Ridge, TN. This project also aimed to determine differences in information specific to the city in which the research was conducted to estimates produced through the program's use of a reference city.

The individual benefit estimates of the street, park, and municipal complex trees provide a large list of substantial benefits to the city. The program i-Tree allows resource managers to calculate these benefits in monetary terms, making it easier to justify management expenses. In Oak Ridge, it would seem that the city's parks are currently providing the largest portion of annual benefits with a total of \$86,408. This is expected however, since the park inventory contained more than twice the number of trees than in either of the other two phases of the inventory. In total, the urban trees of Oak Ridge provide rather impressive annual benefits in other specific aspects such as savings in stormwater runoff management which totaled \$49,155. Another interesting figure is the amount of CO₂ sequestered by the urban trees. In total, the urban trees of Oak Ridge provided an annual savings of \$5,229 in CO₂ storage, which is equal to 268.5 kg of sequestered CO₂.

The results reveal, however, that the city of Oak Ridge is actually losing money through their urban tree management. The net annual benefits associated with the trees measured equaled -\$14,605, or a cost-benefit ratio of 0.90:1.0. However, this is most likely due to the fact that only five of the city's streets were inventoried, which is only a fraction of the 338 total linear km of

streets within the city limits. Therefore, their management budget covers a much larger tree population than what has been currently inventoried which makes the cost-benefit ratio not representative of the true ratio. It is interesting however that there is only a deficit of \$14,605 when there is still a large portion of the city's total inventory to be completed. Therefore, it could be assumed that if a total inventory were to be completed in the future, the benefits associated with the city's urban trees would surpass the money being spent on their management, and would provide a substantially higher cost-benefit ratio.

The initial assessment of Oak Ridge's urban tree canopy revealed a total of 42 acres (17 ha) of canopy coverage. This information may be useful for the city as baseline data for future management. However, once again it is not a representative number of the city's tree canopy cover area because only five of the city's streets were inventoried. The city covers 220.8 km², which means that there is still a great deal more area to be inventoried. In the future, when the city is able to complete their inventory, they can then develop a tree canopy goal. In a well-known review of analyzing urban tree cover, Nowak et al. (1996) presented cities with a wide range of canopy cover percentages from Baton Rouge, LA with 55% to Palm Springs, CA with only 4%. The goal for Oak Ridge should be ambitious but one that can definitely be achieved based on their available resources.

The second objective of the study was to assess the differences in benefit estimates between a data set containing information specific to the city and a data set of values from the reference city. The analysis performed utilizing the default values for Oak Ridge based on Charlotte, NC provided larger benefit estimates than those based on the urban tree population. The initial total, using data provided by the city, was \$133,796, compared to the reference city analysis which produced a total of \$143,885 in benefits. These figures suggest that it is important

to utilize city-specific information in order to produce valid benefit estimations. This is due to the fact that even though reference cities may be similar to the city in which the analysis is being done, there may still be some drastic differences in certain areas. Also, as Figure 1 shows, certain areas, such as some cities in East Tennessee, may be close to the border of a climate region, making it difficult to determine the most appropriate area to choose as the representative region.

The tool i-Tree Streets is very useful for managers who want to obtain estimates of monetary values in order to demonstrate the benefits associated with the proper care of the urban forest. This free tool, along with several others, is quickly growing in popularity, although the current body of literature on urban forest ecosystem services is still relatively small. Many are still skeptical of the reliability and utility of these services, which was discussed in a workshop in February of 2013 by the National Academy of Sciences, titled “Urban Forestry: Toward an Ecosystem Services Research Agenda.” This workshop examined a wide range of issues, many of which centered on trying to understand the current capabilities of quantifying the benefits of urban trees and how results can be better applied toward decision and policymaking (National Academy of Sciences, 2013). One study by Hilde & Paterson (2014) examined the usefulness of the program by integrating i-Tree into their own mainstream planning process for an area in Central Texas. Despite the lack of applied research with i-Tree, it still has great potential in the future for cities that want to be able to develop a foundation for their planning scenarios.

Conclusion

The program i-Tree provided a good base for calculating benefit estimates for Oak Ridge. The program was able to produce useful monetary estimates that can be utilized by city officials to prioritize their urban tree management efforts and determine the benefits associated with their urban tree resource. Also, this research has demonstrated that it is important to utilize

information that is specific to the city in which the i-Tree analysis is performed in order to produce reliable benefit estimations. Continuing inventory procedures will be essential to obtaining more useful information for the city. A long term goal for city officials should be to utilize this information for the eventual development of an urban forestry position. This would allow for continual improvement to the urban forest structure of Oak Ridge and could lead to an even larger increase in benefits, possible funding opportunities for management projects, and increased public awareness through outreach programs.

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Part III
Public perceptions on aspects of park trees in Oak Ridge, TN

Thomas E. Jennings, Sharon R. Jean-Philippe*, Adam Willcox, John Zobel, and Tom Simpson

University of Tennessee, Department of Forestry, Wildlife and Fisheries, 274 Ellington Plant Science Building, Knoxville, Tennessee 37996-4563

*Address correspondence to author. Phone 865-974-2946; email: jeanphil@utk.edu

Abstract

There are many different areas of research in which it is important to obtain information from the general public, one of those being in parks and recreation research. The purpose of parks are to be places of enjoyment for the public, it is therefore imperative to obtain information from these people that are utilizing these areas. This study surveyed public opinion in three parks within the City of Oak Ridge, TN. The survey focused primarily on aspects of park trees in order to determine what visitors believed should be a future priority for park management. This was accomplished by investigating what aspects may contribute to the development of this perception by looking at initial personal preferences for many of the aspects measured as well as some of the basic attitudes held by the visitor toward trees. The survey was completed by 263 park visitors, providing an overall response rate of 69%. Exploratory factor analysis was performed in order to examine the overall factors that were produced in each section of the survey. Mean differences of the factor scores among the parks were also analyzed, producing only one significant difference for the factor dealing with visitors' current opinions of the city Recreation and Parks management officials between A.K. Bissell and Melton Lake Parks. Regression analysis was also utilized for the two future management factors produced (future planting efforts and future tree care) indicating a significant relationship for both factors with attitudes toward trees as well as a significant relationship between future planting efforts and visitor personal preference of park aspects. This research is intended to not only provide useful park management information, but to also expound on the development of park visitor perceptions.

Keywords: Urban Parks, Public Attitudes, Visitor Satisfaction, Urban Trees

Introduction

So many times in scientific research the focus is on the natural world that is absent from human populations. But the idea of gathering human perceptions on their surroundings is growing rapidly in popularity. The focus on the science of human dimensions in parks and recreation is becoming increasingly valid in the scientific community (Vaske and Manfredo, 2012). Researchers are becoming more and more interested in people's opinions and values in parks and recreation. One of the most frequently studied concepts in the social sciences are individual's basic attitudes (Eagly and Chaiken, 1993; Manfredo et al., 2004). Vaske (2008) defines values as "the evaluation, either favorable or unfavorable, of an entity (e.g. person, object, or action)." Attitudes are an important concept for natural resource managers because they can influence behavior. This means that it is possible to investigate what attitudes are important in areas such as citizen involvement in a public program or their support for certain management practices being implemented (Bright and Manfredo, 1996).

An example of this concept was illustrated by Kirkpatrick et al. (2012) who looked at how residents' attitudes towards trees influenced the planting and removal of different types of trees in cities. They found that attitudes towards trees were relatively durable and not easily amenable to change. Attitudes towards trees affected how likely they were to plant trees, and also build upon the reasons why individuals were planting them such as the fact that they simply make the surrounding landscape more beautiful. Similar studies such as this have examined the relationship that basic attitudes held by individuals can have toward tree care such as the fact that they provide shade (Lohr et al., 2004; Summit and McPherson, 1998), wildlife habitat (Head and Muir, 2005), and are generally pleasing aesthetically (Jim and Chen, 2010).

Examining the attitudes held by park visitors is very useful to management officials because it allows them to understand what factors contribute to a more satisfied general public. Research studies focused on obtaining a measure of some sort of park user satisfaction continue to emerge in today's scientific community (Crilley et al., 2012). Many of these visitor satisfaction studies seem to be based on very tangible management assets of the park such as service quality studies (Wade and Eagles, 2003; Ryan and Cessford, 2003; Tonge and Moore, 2007) as well as examining benefits gained by visitors (Anderson et al., 2000; Scheider et al., 2005). However it seems that studies focused on examining a deeper connection between park visitor satisfaction and specific aspects of the park are becoming increasingly popular (Baur et al., 2013). This project is intended to build upon the growing knowledge base of human dimensions research in urban parks in an effort to obtain very useful and insightful knowledge for management purposes as well as to aid in further understanding human perceptions.

Effective management of urban parks is essential due to the fact that they provide a numerous amount of benefits to a city. Multiple studies have shown that parks have a positive impact on nearby residential property values (Harnik and Welle, 2009). A property's value can be affected by mainly two aspects of a park: the distance to the park and the quality of the park. In Washington D.C., the National Mall was shown to increase surrounding property value by \$1.2 billion, with the value of all residential properties within 500 ft. of a park being almost \$24 billion in 2006 (Nowak et al., 2006). The ecological benefits of a park are also very evident, as they provide a refuge for vegetation and wildlife that once most likely naturally existed there. Nowak (1993) showed through a study conducted in Oakland, California that tree species diversity and richness increased from an index value (Shannon-Weaver diversity index) of 1.9 and 10 species in 1988 to 5.1 and more than 350 species. One last important property of parks

that is often overlooked in the scientific community is the idea of park aesthetics and the benefits they entail. A visually pleasing park has been shown to improve the quality of life in many different ways. Aspects such as amount of greenery and visual light have been shown to improve human well-being through intensive park visitor analyses (Jackson, 2003). Urban trees can help alleviate some of the hardships of inner city living (Dwyer et al., 1992) and have even been shown to reduce urban noise (Aylor, 1972).

The objective of this study is to evaluate human perceptions of aspects of park trees through the use of a survey by examining how factors analyzed differ among the parks and also how personal preference of parks visitors and their attitudes towards trees relate to what they believe should be a future management priority. This research project has been developed collaboratively between the City of Oak Ridge, TN and the Department of Forestry, Wildlife, and Fisheries at the University of Tennessee Knoxville and will be utilized in collaboration with inventory data for the development of an urban tree management plan.

Methods

Study Area

The surveys were administered in three of the city parks in Oak Ridge, TN. The city of Oak Ridge is located in Anderson County in East Tennessee, USA. The city covers around 220.8 km² with a population of approximately 29,500 people (US Census Bureau, 2013). The parks were chosen out of the thirteen total city parks for differing aspects such as tree diversity, number of planted trees, as well as facilities such as playgrounds and walking trails to ensure sufficient visitation. The three parks utilized for the survey were A. K. Bissell Park (36.01209, -84.26316), Cedar Hill Park (36.03807, -84.24828), and Melton Lake Park (36.03668, -84.19438). All parks contain similar facilities (i.e. walking trails, playground, picnic shelter).

Park Visitor Survey

We developed our park survey by interviewing 23 visitors in A. K. Bissell and Melton Lake Parks in the spring of 2014. The interview instrument contained 7 open-ended questions which are as follows: 1) “Why did you come to the park today?”, 2) “What characteristics do you like about this park?”, 3) “What characteristics do you not like about this park?”, 4) “What aspects would you change about this park?”, 5) “What environmental benefits do you think that this park provides?”, 6) “What characteristics of urban park trees are most important to you?”, and 7) “What do you think should be the primary management goal for the city's recreation and parks department for the future?”. Our interviews yielded a high number of responses regarding interest in tree diversity. These responses were taken into consideration along with requests for information from the Oak Ridge Department of Recreation and Parks officials who were interested in visitor perceptions of aspects such as number of trees, planted arrangement of trees, and condition of trees. These themes were utilized to develop the survey comprised of 7 sections, containing 35 individual questions.

The survey was developed and tested utilizing the software program iSurvey (www.isurveysoft.com) along with the accompanying iSurvey App (Version 2.12.8) on Apple iPads. The survey was pilot tested by 15 individuals including Oak Ridge city officials, academic peers, and the general public. We employed cognitive interviews during pilot testing that considered difficulty answering or understanding questions, survey flow, and formatting of response categories, among others.

The first two sections of the survey investigate reasons why the visitor has come to the park. The first section asked what the visitor's primary reason for visiting was (answer manually typed). The second section asked them to choose from a list of activities that they may or may

not be participating in at the park. The third section was designed to obtain public opinion of the current management practices of the Recreation and Parks Department. This section consisted of 6 individual questions with responses ranging from Excellent – Very Poor on a 5-point scale. The fourth section investigated how important certain aspects of the park (i.e. diversity of trees, number of trees, etc.) are to the visitor. This section consisted of 6 individual questions with responses ranging from Greatly Increase – Greatly Decrease on a 5-point scale. The fifth section investigated the attitudes held by the visitor towards trees that could affect satisfaction responses, and was made up of 8 individual questions with responses ranging from Very Important – Not Important on a 5-point scale. The sixth section investigated park user perception of what should be a future management priority for the park, looking at aspects such as tree diversity, number, species, and condition. This section was made up of 5 individual questions asking the respondent to indicate the level to which he or she agreed or disagreed that each aspect should be a future priority for park management officials. Responses ranged from Very High Priority – Very Low Priority on a 5-point scale. The seventh and last section gathered basic demographic information such as how often the visitor came to the park, distance traveled, who the visitor was with, gender, age, ethnic group, work status, and approximate annual household income.

The survey was administered during the spring of 2015 from April 11 – May 2 on 9 weekdays between the hours of 10:00 AM and 4:00 PM, and on two Saturdays between the hours of 9:00 AM and 5:00 PM. The park at which the survey was being administered was randomized by assigning a number (1-3) to each park and utilizing a random number generator. Park visitors above the age of 18 were intercepted within the parks and asked to complete the survey. The survey was self-administered by the visitor at a central location within the park.

Total number of park visitors during the survey period was recorded along with the number of refusals.

Survey Analysis

Completed surveys were stored on the iPads and uploaded to our iSurvey account and results were downloaded into SPSS format. IBM's SPSS Statistics 22 program was utilized for the survey analysis. General descriptives were calculated for each section of the survey, giving frequencies for sections 1, 2, and 7, and means for sections 3-6. The responses for the first section asking participants to list their primary reason for visiting the park were recoded into 9 general categories based on number of responses. Exploratory factor analysis (Agresti and Finlay, 1997) with a Varimax rotation was used to categorize opinions of how well visitors believe the Oak Ridge Department of Parks and Recreation are doing at certain jobs, visitors' personal preference of certain aspects of the parks, visitors' attitudes towards certain aspects of trees, and how much of a priority certain aspects of the park should be in the future for management officials. Extracted factor reliability was assessed using Cronbach's α , examining if the factor produced an alpha of at least 0.65 – 0.70 for high reliability (Vaske, 2008).

Mean differences of factor scores were also calculated utilizing a One-Way ANOVA with Least Squares Differences analysis among all parks and all factors. Finally, two separate regression analysis were performed utilizing the two future management factors as dependent variables, with initial analysis including responses to why the visitor had come to the park, demographics, personal preference of park aspects, attitudes toward trees as independent variables. Final regression analysis however only utilized personal preference of park aspects and attitudes toward trees as independent variables. For all analysis, statistical significance was concluded at the $P \leq 0.05$ level.

Results

Out of the 380 total visitors to the three parks over the survey period, 263 individuals were successfully surveyed with 72 refusals, providing a response rate of 69%. Average time for survey completion was 4 minutes and 23 seconds. The majority of participants visited the park at least once or more per week (53.2%), with 59.3% of visitors living within 1-10 mi. of the park. The majority of visitors had come that day with a child or multiple children or by themselves at 33.8% and 28.9% respectively. Of the total participants, 60.1% were female and the large majority at 85.2% indicated White (Caucasian) as their ethnic group. Most visitors were either employed full time or retired or disabled at 44.9% and 30% respectively. Also, 70.4% of participants indicated their annual household income to be less than \$100,000. All of the demographics can be found in Table 3.1.

Survey demographics were compared to the 2010 U.S. Census data for the City of Oak Ridge. Chi-square test of independence showed no statistical difference between the 84% Caucasian and 8% African American census populations, and the survey percentages of 85.2% and 8.4% respectively ($P>0.05$). However, the survey showed that 53.3% of participants were employed (full-time or part time), which is significantly lower than the 60.7% shown by the census ($P<0.05$). There were significantly more participants 65 years old or older as well (25.9%), compared to the city-wide percentage of 19.3% ($P<0.01$). Also, the number of female participants significantly higher at 60.1%, than the 52.8% shown by the census ($P<0.05$).

The first two sections of the survey focused on asking participants why he or she had visited the park (Table 3.2). The first section allowed the participant to manually enter in a response, and the second section let him or her choose from a list of additional activities. Out of the 9 general categories created to describe the primary reasons visitors had come to the park,

30.8% said that they were there to walk alone or with another person, with another 9.9% walking their dog. Another 14.5% said they were there exercising, whether it be running, jogging, or using the park's exercise equipment along the trails. As for the additional categories participants were asked about, 41.8% said they would also be utilizing the park's playground, with another 39.5% saying that they would be taking some sort of walk to simply observe nature.

Table 3.1. Park visitor demographics.^a

Question	Frequency	Percent
How often do you visit one of the Oak Ridge city parks?		
Every day	45	17.1
Once or more per week	140	53.2
Once or more per month	42	16.0
2-3 times per year	21	8.0
First time ever	15	5.7
How far away do you live in relation to this park?		
Less than 1 mi.	44	16.7
1-5 mi.	95	36.1
6-10 mi.	61	23.2
11-15 mi.	11	4.2
16-20 mi.	23	8.7
21-25 mi.	11	4.2
More than 25 mi.	17	6.5
Who have you come to the park with today?		
By yourself	76	28.9
Spouse	62	23.6
Parent(s)	6	2.3
Kid(s)	89	33.8
Grandparent(s)	2	0.8
Grandkid(s)	17	6.5
Other relative(s)	18	6.9
Friend(s)	61	23.2

Table 3.1. cont. Park visitor demographics.^a

Question	Frequency	Percent
Are you...?		
Male	105	39.9
Female	158	60.1
Please indicate ethnic group		
Age		
18-24	11	4.2
25-34	59	22.4
35-44	48	18.3
45-54	34	12.9
55-64	43	16.3
65+	68	25.9
White	224	85.2
Black or African American	22	8.4
Hispanic, Latino, or Spanish Origin	4	1.5
American Indian or Alaskan Native	1	0.4
Asian	3	1.1
Other Race or Origin	3	1.1
Please describe your current work status		
Employed (Full Time)	118	44.9
Employed (Part Time)	22	8.4
Unemployed	37	14.1
Retired or Disabled	79	30.0
Student	5	1.9
Please indicate you approximate annual household income		
\$0-\$24,999	42	16.0
\$25,000-\$49,999	61	23.2
\$50,000-\$99,999	82	31.2
\$100,000-\$149,999	36	13.7
\$150,000-4199,999	12	4.6
\$200,000 or more	7	2.7

^a Total n = 263

Table 3.2. Reasons for visiting the park.

Question	Frequency	Percent
What is your primary reason for visiting the park today? ^a		
Eat	12	4.6%
Enjoy Outdoors	17	6.5%
Exercise	38	14.5%
Family Time	25	9.5%
Play Outside	20	7.6%
Playground	29	11.0%
Walk	81	30.8%
Walk Dog	26	9.9%
Other	15	5.7%
Have you or will you be participating in any other activities at the park such as?		
Bird Watching	54	20.5%
Boating	6	2.3%
Fishing	11	4.2%
Nature Walk	104	39.5%
Observe Wildlife	75	28.5%
Organized Sports	10	3.8%
Picnics	50	19.0%
Playground	110	41.8%
Relaxing in the Shade	92	35.0%
Walking/Jogging	73	27.8%
Other	12	4.6%
Total	263	100%

^a Responses recoded into general categories.

Park Visitor Perceptions

For all other parts of the survey, means were calculated for the participants' responses.

Table 3.3 shows the responses for how well visitors believe the Oak Ridge Department of Recreation and Parks is doing at providing certain functions. With the ordered response

categories being 1=Excellent to 5=Very Poor, most visitors believed that the Recreation and Parks Department was doing an excellent to good job of providing the functions listed, with all of the means of the responses falling in between the 1-2 range. The overall mean for these responses was 1.64. Factor analysis for this section produced only 1 factor with high reliability (Cronbach's $\alpha = 0.852$).

For the survey questions dealing with the level of change that the visitor would like to see be made for certain aspects of the park, factor analysis initially yielded 2 factors dealing with their personal preference of these items. However, due to a low factor loadings of two of the variables (planted arrangement and visual appearance), they were dropped from the analysis. This produced only one factor with high reliability (Cronbach's $\alpha = 0.765$) dealing with the visitors' personal preference of park aspects, which can be seen in Table 3.4. As for the means of the responses in this section, most were toward the positive side of the scale once again which was 1=Greatly Increase to 5=Greatly Decrease, falling between 2 to 3.

Table 3.5 shows that for the questions dealing with visitors' attitudes toward trees in general, factor analysis yielded one factor with high reliability (Cronbach's $\alpha = 0.756$), described in the analysis simply as tree attitudes. The ordered response categories of this section were 1=Very Important to 5=Not Important. Means for the responses were all within the 1-2 range, except for one variable asking how important it was to have trees to block out the surrounding city landscape, producing a mean response of 2.35.

Factor analysis for questions dealing with how much of a future priority certain aspects of the park should be for management produced two factors described as 1) future planting efforts (Cronbach's $\alpha = 0.730$) and 2) future tree care (Cronbach's $\alpha = 0.799$). The response categories for this section were 1=Very High Priority to 5=Very Low Priority. The variables attributed

Table 3.3. Oak Ridge city park visitors' perceptions toward management efforts.

Question^a	$\bar{x}$	SE	Factor 1^b management efforts
Providing places that allow for the enjoyment of the outdoors	1.44	0.0	0.755
Operating parks that are safe	1.52	0.0	0.786
Operating parks that are clean/well-maintained	1.57	0.0	0.813
Providing community activities within the parks	1.93	0.1	0.695
Maintaining park trees	1.63	0.0	0.785
Providing natural area for wildlife (habitat)	1.75	0.1	0.757
Eigenvalues ^b			3.522
Variance explained (%) ^b			58.71
Cronbach's α			0.852

^a Ordered response categories: Excellent, Good, Fair, Poor, Very Poor.

^b Factor analysis with a Varimax rotation (n =263).

Table 3.4. Oak Ridge city park visitors' perceptions toward personal preference of park aspects.

Question^a	$\bar{x}$	SE	Factor 1^b park aspects	Factor 2^b visual appearance
I would like to see tree species diversity	2.68	0.0	0.735	0.063
I would like to see the number of trees planted	2.55	0.0	0.866	0.028
I would like to see the number of trees planted in straight rows ^c	3.24	0.0	-0.376	0.578
I would like to see the density of trees	2.67	0.0	0.800	0.055
I would like to see the effort toward pruning and caring for trees to make sure they are visually appealing ^c	2.89	0.0	0.256	0.820
I would like to see the effort toward making sure trees are healthy (disease free, planted properly, etc.)	2.71	0.0	0.537	0.520
Eigenvalues ^b			2.544	1.166
Variance explained (%) ^b			42.41	19.44
Cronbach's α ^d			0.765	0.203

^a Ordered response categories: Greatly Increase, Increase, Stay the Same, Decrease, Greatly Decrease.

^b Factor analysis with a Varimax rotation (n = 263).

^c Variable excluded from analysis due to low factor loadings.

^d Data with factor loadings ≥ 0.65 used in calculations.

Table 3.5. Oak Ridge city park visitors' attitudes toward aspects of park trees.

Question^a	$\bar{x}$	SE	Factor 1^b tree attitudes
Having trees that provide shade	1.49	0.1	0.580
Having trees that have colorful leaves	1.89	0.1	0.592
Having trees that provide wildlife habitat	1.55	0.1	0.616
Having trees with strong branches to avoid safety hazards	1.46	0.1	0.649
Planting trees that are resistant to pests and diseases	1.55	0.1	0.714
Having trees with a long life span	1.49	0.1	0.759
Planting trees that are representative of the natural forests of the area	1.52	0.1	0.712
Having trees that block out the surrounding city landscape	2.35	0.1	0.390
Eigenvalues ^b			3.231
Variance explained (%) ^b			40.39
Cronbach's α			0.756

^a Ordered response categories: Very Important, Important, Somewhat Important, Less Important, Not Important

^b Factor analysis with a Varimax rotation (n = 263).

Table 3.6 Oak Ridge city park visitor perception of future management of park trees.

Question^a	$\bar{x}$	SE	Factor 1^b future planting efforts	Factor 2^b future tree care
Oak Ridge should maintain a high diversity of trees species in this park	1.93	0.1	0.842	0.096
Oak Ridge should maintain a high number of trees in this park	1.83	0.1	0.881	0.125
Oak Ridge should plant more trees that are native to Tennessee in this park	1.88	0.1	0.608	0.465
The trees in this park should be more effectively pruned and cared for the make them more visually appealing	2.27	0.1	0.090	0.902
The trees in this park should be more effectively cared for to make them healthier	2.06	0.1	0.211	0.873
Eigenvalues ^b			2.604	1.121
Variance explained (%) ^b			52.08	22.43
Chronbach's α^c			0.730	0.799

^a Ordered response categories: Very High Priority, High Priority, Neither High nor Low Priority, Low Priority, Very Low Priority

^b Factor analysis with a Varimax rotation (n = 263).

^c Data with factor loadings ≥ 0.65 used in calculations.

Table 3.7. Mean differences of factor scores for park visitors' perceptions for management efforts of the Oak Ridge Recreation and Parks Department.

Park	Parks	Mean Difference	SE
A.K. Bissell	Cedar Hill	-0.2419	0.148
	Melton Lake	-0.4712*	0.153
Cedar Hill	A.K. Bissell	0.2419	0.148
	Melton Lake	-0.2293	0.158
Melton Lake	A.K. Bissell	0.4712*	0.153
	Cedar Hill	0.2293	0.158

*Mean separation by LSD ($P < 0.05$)

towards future planting efforts all fell within the 1-2 range, and the variables associated with future tree care fell within the 2-3 range, which can be seen in Table 3.6.

Analysis of Variance among Parks

An Analysis of Variance with Least Squares Difference was performed among all of the parks, utilizing the factor scores obtained from the exploratory factor analysis. Analysis showed only one mean difference of the factor scores differed significantly between the responses for park visitors' perceptions of management efforts of the Recreation and Parks Department for A. K. Bissell Park and Melton Lake Park, with $P \leq 0.05$ (Table 3.7). No other mean differences were significantly different among the other parks for the other factors.

Regression Analysis

Two separate linear regression analyses were performed utilizing the two factors associated with the future priority of planting efforts and future priority of tree care as the dependent variables. The full model initially included the responses to why the visitor had come to the park, demographics, personal preference of certain park aspects, and attitudes toward trees.

Analysis revealed no significant relationship when controlling for why the visitor had come to the park as well as any of the demographic variables. Regression analysis was then performed with each of the independent variables separately, as well as together to see their relationship with both of the management factors.

The first regression analysis can be seen in Table 3.8a which shows a significant relationship between the participant's personal preference of certain park aspects and how much of a future priority planting efforts should be within that park in model A. If a respondent wanted to see an aspect increase by one level, the priority for that aspect showed an increase in scale of 0.291 ($P<0.01$). Model B showed a significant relationship between the participant's attitudes toward trees and how much of a future priority planting efforts should be in that park. One level of importance toward an aspect of a tree showed an increase in priority of 0.346 ($P<0.01$). Also, the full model (Model C) showed a significant relationship for both aspects with how much of a future priority planting efforts should be ($P<0.01$)

The second regression analysis (Table 3.8b) showed a significant relationship between the participant's attitudes toward trees and how much of a future priority tree care should be in that park in Model A. One level of importance toward an aspect of a tree showed an increase in priority of 0.343 ($P<0.01$). Also, a significant relationship was shown in the full model (Model C) between the participant's attitudes towards trees and how much of a future priority tree care should be in that park when accounting for the personal preferences of park visitors ($P<0.01$). One level of importance toward an aspect of a tree showed an increase in priority of 0.340 ($P<0.01$). All residual plots for both regression analysis revealed that data points were normal and were best fit along a linear plot. Residual plots also did not reveal any potential outliers or any influential points.

Table 3.8a. Regression results for future planting efforts.

	A	B	C
Constant	0.007 (0.061)	-0.009 (0.060)	-0.002 (0.057)
Personal preference of park aspects	0.291** (0.060)		0.266** (0.057)
Attitudes toward trees		0.346** (0.059)	0.326** (0.057)
R-squared	0.086	0.123	0.195
Sig.	<0.001	<0.001	<0.001

Model A includes only "Personal preference of park aspects". Model B includes only Attitudes toward trees. Model C includes both variables. *, ** indicates significance at the 95% and 99% level, respectively. Standard errors are reported in parentheses. n=263

Table 3.8b. Regression results for future tree care.

	A	B	C
Constant	0.002 (0.063)	0.003 (0.061)	0.004 (0.061)
Personal preference of park aspects	0.065 (0.063)		0.037 (0.060)
Attitudes toward trees		0.343** (0.060)	0.340** (0.060)
R-squared	0.004	0.118	0.120
Sig.	0.304	<0.001	<0.001

Model A includes only "Personal preference of park aspects". Model B includes only "Attitudes toward trees". Model C includes both variables. *, ** indicates significance at the 95% and 99% level, respectively. Standard errors are reported in parentheses. n=263

Discussion

This study examined visitor perceptions in three different city parks in Oak Ridge, TN, looking specifically at aspects of the park trees. For the analysis of variance among the parks, we found that visitor perceptions of the Recreation and Parks Department's management efforts were the only responses of the survey that showed a large enough mean difference to be

statistically significant among any of the three parks, in this case, between A. K. Bissell and Melton Lake parks (Table 5). For these responses, the overall mean for the responses in A. K. Bissell Park was 1.50 and 1.73 for Melton Lake Park. The largest difference that could be found for any of the specific questions was that there was a higher number of respondents saying that officials were only doing a fair job of providing community activities within the park (25%). However the overall means for this section are still very similar and are still producing the same response since the survey was only on a five-point scale. Even though a statistical difference was produced, it would seem that the public perceptions between these two parks were still relatively similar.

It is difficult to say exactly what factor caused the statistical difference. In reality, these parks do differ slightly in their characteristics, such as the fact that A. K. Bissell Park is located in the center of the city and is mainly used for its walking trails, whereas Melton Lake Park is located right on the water of the Clinch River, attracting a very different group of visitors. There are many other aspects of the park that differ and could contribute to visitors' responses such as aspects dealing specifically with trees. For example, utilizing Shannon's diversity index, it was found that A. K. Bissell Park has a much higher diversity of trees at $H' = 3.43$ than Melton Lake at $H' = 2.15$. A. K. Bissell Park also had a much higher number of trees than Melton Lake at 504 and 135 respectively. However, as previously mentioned, the overall perception of the management practices for these parks were positive on average, meaning that these aspects, even though different, did not greatly effect public opinion.

For the questions dealing with visitors' personal preferences of what they would like to see in the park in terms of aspects of the trees most wanted to see them only slightly increase or stay the same. This section of the survey was intended to be utilized in the regression analysis for

future management priority as an independent variable to better explain the responses similar to an attitude battery type of approach which can be very useful in survey interpretation (Vaske, 2008). For example, if an individual indicated that they wanted to see tree species diversity decrease, then tree diversity may not be very important to that visitor and they may be satisfied with a low diversity of trees in the park and may not necessarily want management to focus on that aspect.

Attitudes toward trees were also measured and showed that the majority of the aspects examined were held in high regard for the visitors. However, the question dealing with having trees that block out the surrounding city landscape seemed to be of less importance to many of the visitors. This finding is in direct contradiction to what most would expect, which is that park visitors would be there to enjoy a more natural setting and to separate themselves from the surrounding man-made landscape. This was illustrated in a report published by the Central Park Conservancy (2011) which showed that when visitors were asked to identify the single thing that they enjoyed most about Central Park, the majority of users either cited the landscape or its value as a retreat from the city. However, much of the surrounding area of the City of Oak Ridge is rather natural in and of itself, such as the water access the city has, as well as the neighboring mountains, containing Lone Mountain State Forest as well as Frozen Head State Park. This could contribute to the lack of desire for escape from the urban landscape within a city park.

Finally, we utilized the survey to examine the factors that can affect what visitors believe should be a future management priority for park officials. Based on survey results, it would seem that the majority of respondents believed that all of the aspects mentioned should at least be a high priority in the future for management officials. Analysis revealed that the stronger the attitudes toward trees were to the visitor, the greater of a priority for management all of the

aspects measured became. It would seem that the very basic attitudes that individuals have toward trees can in fact have a very profound impact on what they believe is important when it comes to urban tree management. Their own personal preference of what they wanted to see in the parks was also important in terms of determining future planting efforts. All of these factors contributed in some way in determining the areas that park management should focus their efforts on in the future.

From a management perspective, city officials must look to encompass a wide range of factors into developing their management strategies in order to provide an enjoyable park experience. Through the use of this survey, we have shown that many visitors do in fact hold in high regard basic attitudes associated with park trees. This is important because it provides an understanding of the areas that can be tapped into by management officials that can lead to a more supportive population that believes they are being heard and understood in terms of what they would like to see in their parks (Chib et al., 2009). Management officials should strive to plant and care for trees in a way that is pleasing to the park visitors, thereby improving upon the experience the natural areas can provide.

Conclusion

The purpose of a park within any city is to be a place of enjoyment for the people who live there. This is why it is so important for park management officials to understand the feelings of the visitors that are utilizing the parks on a daily basis. This survey provided insight into several different aspects that can be utilized by the City of Oak Ridge for management purposes. It would seem that multiple aspects of trees in the city parks were important in contributing to what visitors believed should be a future management priority. It also provided an interesting perspective to examine the relationship of certain attitudes and perceptions that might build an

individual's perception of urban tree management. Through the implementation of this survey, it can be seen that an individual's basic attitudes toward trees did in fact have an impact on how they developed their idea of what needed to be done in the park in the future. Aspects such as a tree's colorful leaves or its ability to provide shade can prove to be some of the most important basic functions that individuals seek from a park tree. The survey also showed that the researcher must take into account several factors when attempting to understand the voice of the public in what they want to see done to their public areas. The field of human dimensions in parks and recreation research is an ever-growing area of study, which is why it is important understand the most basic factors that contribute to how individuals perceives the world around them. The people that are visiting the parks can be the most useful tool for managers that want to provide an enjoyable place of recreation.

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Appendix

A3.1. Survey Instrument

1. What is your primary reason for visiting the park today? _____

2. Have you or will you participate in any activities at the park today such as:

Bird Watching	yes/no
Boating	yes/no
Fishing	yes/no
Nature Walk	yes/no
Observe Wildlife	yes/no
Organized Sports	yes/no
Picnics	yes/no
Playground	yes/no
Relaxing in the Shade	yes/no
Walking/Jogging	yes/no
Other	_____

3. Please indicate how well you believe the Oak Ridge Department of Recreation and Parks is doing at providing the following functions.

a. Providing places that allow for the enjoyment of the outdoors.

Excellent	Good	Fair	Poor	Very Poor
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b. Operating parks that are safe.

Excellent	Good	Fair	Poor	Very Poor
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c. Operating parks that are clean/well-maintained.

Excellent	Good	Fair	Poor	Very Poor
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d. Providing community activities within the parks.

Excellent	Good	Fair	Poor	Very Poor
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e. Maintaining park trees.

Excellent	Good	Fair	Poor	Very Poor
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f. Providing natural area for wildlife (habitat).

Excellent	Good	Fair	Poor	Very Poor
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4. Please indicate the level of change (if any) that you would like to see be made to this park for each of the following items.

- a. In this park, I would like to see tree species diversity:
Greatly Increase Increase Stay the Same Decrease Greatly Decrease
- b. In this park, I would like to see the number of trees planted:
Greatly Increase Increase Stay the Same Decrease Greatly Decrease
- c. In this park, I would like to see the amount of trees planted in straight rows:
Greatly Increase Increase Stay the Same Decrease Greatly Decrease
- d. In this park, I would like to see the density of trees:
Greatly Increase Increase Stay the Same Decrease Greatly Decrease
- e. In this park, I would like to see the effort toward pruning and caring for trees to make sure they are visually appealing:
Greatly Increase Increase Stay the Same Decrease Greatly Decrease
- f. In this park, I would like to see the effort toward making sure trees are healthy (properly pruned, disease free, planted properly, etc.):
Greatly Increase Increase Stay the Same Decrease Greatly Decrease

5. Please indicate how important each of these aspects associated with trees are to you.

- a. Having trees that provide shade
Very Important Important Somewhat Important Less Important Not Important
- b. Having trees that have colorful leaves
Very Important Important Somewhat Important Less Important Not Important
- c. Having trees that provide wildlife habitat
Very Important Important Somewhat Important Less Important Not Important
- d. Having trees with strong branches to avoid safety hazards
Very Important Important Somewhat Important Less Important Not Important
- e. Planting trees that are resistant to pests and diseases
Very Important Important Somewhat Important Less Important Not Important
- f. Having trees with a long life span
Very Important Important Somewhat Important Less Important Not Important
- g. Planting trees that are representative of the natural forests of the area
Very Important Important Somewhat Important Less Important Not Important
- h. Having trees that block out the surrounding city landscape
Very Important Important Somewhat Important Less Important Not Important

6. Please indicate the level to which you agree or disagree that the following aspects should be a future priority for the park management officials for this particular park.

a. Oak Ridge should maintain a high diversity of tree species in this park.

Very high priority High priority Neither high nor low priority Low priority Very low priority

b. Oak Ridge should maintain a high number of trees in this park.

Very high priority High priority Neither high nor low priority Low priority Very low priority

c. Oak Ridge should plant more trees that are native to Tennessee in this park.

Very high priority High priority Neither high nor low priority Low priority Very low priority

d. The trees in this park should be more effectively pruned and cared for to make them more visually appealing.

Very high priority High priority Neither high nor low priority Low priority Very low priority

e. The trees in this park should be more effectively cared for to make them healthier.

Very high priority High priority Neither high nor low priority Low priority Very low priority

7. Please provide us with some basic demographic information to help us better understand who is visiting the park today.

a. How often do you visit one of the Oak Ridge city parks?

Every day, once or more per week, once or more per month, 2-3 per year, first time ever

b. How far away do you live in relation to this park?

Less than 1 mi., 1-5 mi., 6-10 mi., 11-15 mi., 16-20 mi., 21-25 mi., More than 25 mi.

c. Who have you come to the park with today?

By yourself, Spouse, Parent(s), Kid(s), Grandparent(s), Grandkid(s),
Other Relative(s), Friend(s)

d. Are you

Male Female

e. What year were you born?

f. Please indicate ethnic group

White; Black or African American; Hispanic, Latino, or Spanish Origin; American Indian or Alaskan Native; Asian; Native Hawaiian or Other Pacific Islander; Other Race or Origin

- g. Please describe your current work status.
Employed (Full Time), Employed (Part Time), Unemployed, Retired or Disabled,
Student
- h. Please indicate your approximate annual household income.
\$0 - \$24,999; \$25,000 - \$49,999; \$50,000 - \$99,999; \$100,000 - \$149,999;
\$150,000 - \$199,999; \$200,000 or More

Part IV

Conclusions and Implications

Overview

There are numerous cities throughout the U.S. that have not had the opportunity to focus on the proper management of their urban forests for many different reasons. Many times, it is a combination of factors such as lack of personnel, budget constraints, and the absence of a forestry background for the management professionals. Such is the case in the city of Oak Ridge, TN where, due to its rapid land use change and unique history, Oak Ridge has not had the opportunity to focus directly on the management of its urban forests until recent years. The city is perhaps most famous for the role it played during the years of World War II. Approximately 59,000 acres of land that would later become the city of Oak Ridge, TN was purchased in 1942 by the U.S. Federal government for the development of the Manhattan Project. This land was historically utilized primarily for agriculture, and over the next three years (1942-1945), the area's population quickly grew from around 3,000 to over 75,000. Four years after the end of World War II, Oak Ridge became a self-governing city in 1959 (Olwell, 2004).

Because of the lack of infrastructure for the management of the city's urban forest, this research project was developed to assist the city in developing a tree management plan based on a tree inventory and assessment. The first step in this project was to develop an urban tree inventory consisting of the trees along the city's five major thoroughfares (Turnbull, 2014), within the city parks, and within the boundaries of the city's municipal complexes. In addition to developing the inventory, the benefits for the city associated with those trees were investigated utilizing the software program i-Tree. The second step in the project was to develop and implement a survey in three of the city parks to investigate park visitor perceptions of aspects of the park trees. This survey was intended to gather information related to park visitor satisfaction in order to provide the city with helpful management information and also to aid in

understanding the factors that help shape an individual's perceptions. All of this data will be utilized in the development of the city's urban tree management plan which will be completed in September of 2015. Implications of this study as well as future efforts toward the development of the urban tree management plan are discussed below.

Implications

The realization that properly trained urban foresters are necessary to efficiently maintain a city's urban tree resource is quickly spreading across our country and parts of the world. Research in this area continues to emerge investigating the many factors associated with proper urban forest management (Ostoić and Konijnendijk van den Bosch, 2015). The basic foundation for the City of Oak Ridge that has been laid out in this project will allow the city to begin improving on its management protocols and develop new tree care guidelines that will benefit the city for many years to come.

The information obtained through the development of the urban tree inventory in Oak Ridge revealed that the city has a fairly impressive tree resource to manage. The three phases of the inventory (streets, parks, and municipal complexes) all showed relatively high diversity indices which is important for many different reasons such as the fact that a high diversity of species makes the population much more resistant to pests and diseases. Investigation into the inventory also showed that the majority of trees were in good condition, meaning that the city has a starting point to continue building on their current management practices.

The inventory data gathered was further investigated to attempt to understand the benefits that the trees provide to the city. Fully understanding and quantifying the ecosystem services that trees provide to a city can be difficult (Daily and Matson, 2008). However, having a grasp of the monetary benefits that trees provide to a city is necessary in order to justify expenses that are

often associated with proper management of trees as a resource. While current benefit estimations revealed a deficit for the City of Oak Ridge in terms of what it was costing them to manage their trees, a complete inventory of the city's street trees would most likely reveal a surplus of benefits provided by their urban trees. This should be one of the necessary future objectives for Oak Ridge in order to truly understand their tree resource.

This project also attempted to obtain public opinion of one of the city's most important assets, its parks. The survey focused specifically on obtaining perceptions of parks visitors towards aspects of the park trees. Parks that are properly managed can provide residents of a city with an area of natural refuge from the surrounding man-made landscape and are important to the general well-being of a city (Millward and Sabir, 2011). The results of this survey should allow the city officials of Oak Ridge to have a grasp on how the general public is viewing some of their current management practices. Perhaps the most important section of the survey from a management perspective was the section which asked participants how they believed the Recreation and Parks department were doing at providing certain functions in the parks. Analysis of this section showed mean differences large enough between two of the parks to be statistically significant. However, even though a statistical difference existed, public perception was generally very positive. Management personnel should be encouraged by the fact that the average response in regards to their practices was very good and they should strive to maintain and even improve on those perceptions.

The survey also provided insight into factors that contribute to what areas an individual wants to see park management focus their efforts. The attitudes toward trees that were investigated showed a strong relationship with what visitors thought should be a high management priority for the future and should be considered when officials are implementing

any management protocols. The survey itself should be a future priority for city officials if they want to truly manage their urban trees effectively. There are many other aspects that the city should strive to obtain public opinion for in terms of their management decisions. Continued interest in what the public has to say will show the population that city officials are dedicated to the people, and could allow them to be more accepting and supportive of future policy decisions (Zhang et al., 2007).

The most important area for future application that the research conducted in this project will provide will be in the development of an urban tree management plan for the City of Oak Ridge. This plan includes specific guidelines for proper tree care, planting protocols, strategies to manage pest or disease outbreaks, and guidelines for raising public awareness of the urban forest through citizen engagement outreach programs. The plan also contains results from the inventory and i-Tree analysis, as well as the park visitor survey. The overall purpose of this plan is to provide the city with the necessary information it needs to properly manage its urban tree resource. It is also intended to aid in the eventual development of a city forester position by helping city officials understand the importance of proper tree care and the benefits that they can provide to the city.

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VITA

Thomas Jennings was born in Kingsport, TN in October of 1990. After graduating from Tri-Cities Christian High School in 2009, he went on to attend Carson-Newman University where he obtained his Bachelor of Arts Degree in Biology with an emphasis in Environmental Studies in 2013. Thomas began his pursuit of a Master's Degree in Forestry in August of 2013 at the University of Tennessee, studying under Dr. Sharon Jean-Philippe. His research has focused primarily on the field of Urban Forestry, aiding in the development of an urban forest management plan for the City of Oak Ridge, TN by providing the city with baseline tree inventory data and public perception data to aid in their management decisions. Thomas hopes to continue to utilize the knowledge he has received through his graduate research in a career focused on the management of cities' urban forests.