Recommendations for Sustaining a Healthy Urban Forest in Durham, NC

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Executive Summary

At the request of the Durham City Council, the Durham City-County Environmental Affairs Board (EAB) has evaluated the future health of Durham's urban forest.

The EAB has determined that in order for the City of Durham to maintain the approximate canopy coverage from trees on public property, 1,680 trees must be planted and 750 trees must be safely removed each year for the next 20 years. Current tree replacement operations support the planting of only 500 trees and the removal of only 300 potentially hazardous dead/dying trees per year. Without additional resources, the City faces the reduction in the quality of life, economic, ecological, and human health benefits for its current and future citizens.

The EAB recommends that the Durham City Council allocate resources to facilitate the planting of at least 1,680 trees per year, the removal of the 750 aging trees per year, and the proper maintenance of all trees on public property in Durham.

Introduction

Benefits of Trees

Trees provide a plethora of economic, environmental, human health, and social benefits, making them a valuable part of the urban landscape. Tree coverage in cities has been linked to improvements in human health, economic improvement, child development, crime reduction, community development, and many more benefits. Several studies have shown the cost-effectiveness of trees in the urban environment. In particular the Center for Urban Forest Research, showed that in many areas of the United States young trees results in energy savings of approximately three times the cost per year, among numerous other benefits [1]. These benefits strongly outweigh the cost of investing in and maintaining trees, indicating trees and greenery in urban environments are a good investment for governments and businesses.

Economic Benefits

Trees can benefit the local economy in several ways. Property values can increase when trees are planted in the public land along streets. In Portland, Oregon, Donovan and Butry found that on average, street trees add $8870 to the price of homes and reduces the time-on-market by 1.7 days [2]. Street trees can also reduce homeowners' utility bills. In Sacramento, California, western and southern trees reduced summertime electricity bills by an average of $25.16 and northern trees reduced electricity bills by $7.48 compared to no tree coverage [3].

Tree-lined streets are more appealing business locations, encouraging an influx of businesses and patrons. Businesses' economic gains can even expand past property values. In a survey, shoppers claimed that they spend up to 12 percent more for goods and services in business districts having high quality tree canopy [4]. In the same survey, employees with views of nature reported 15 percent fewer illnesses and felt more enthusiastic and less frustrated than those without a view outside, which increased productivity [4]. Governments can also benefit as trees can dramatically cut costs. According to the Trust for Public Land and American Water Works Association, for every 10 percent increase in forest cover in a watershed, water treatment and chemical costs decreases by approximately 20 percent [5].

Environmental and Health Benefits

Some of the greatest benefits of trees are to the environment and human health. Trees combat the greenhouse effect, reduce air and water pollution, decrease ground temperature and the urban heat island effect, prevent soil and water erosion, and decrease the impact of stormwater runoff. Tree's removal of air pollution (O_3, PM_{10}, NO_2, SO_2, CO) varies across the US, but on average trees remove an estimated 711,000 metric tons of air pollution annually, a $3.8 billion value [6]. The U.S. Forest Service recently published that trees remove air pollution, saving 850 human lives a year and preventing 670,000 incidences of acute respiratory symptoms [7]. Regarding water quality, one mature tree can intercept about 10,000 gallons of rainfall per year, reducing runoff and providing cleaner water [8]. The urban heat island effect has been shown to increase heat related morbidity and mortality through increased incidence of heat stroke

and reduction of physical activity [9]. Maintaining and improving foliage has been demonstrated to reduce the urban heat island effect [10].

Trees have also been indirectly linked to improved human health. In a study published in the British Medical Journal, residents of urban areas with high levels of greenery were three times as likely to be physically active and 40 percent less likely to be overweight or obese than residents living in the least green settings [11]. Attention Deficit Disorder (ADD) symptoms in children were relieved after spending time in treed areas, and childhood asthma rates were reported as highest in parts of cities where tree density was lowest [12]. In a recent study, researchers from Columbia University found that rates of asthma fell 25 percent for every extra 340 trees per square kilometer [13]. A pattern that remained even after taking into account differing sources of pollution, levels of affluence and population density [13]. A five-year study of senior citizens found that having readily available space for walks through tree-lined streets significantly influenced the longevity of urban senior citizens [14]. This finding was independent of age, sex, marital status, and socioeconomic status, with significant higher survival rates [14]. Maintaining and improving tree coverage is a fairly cost effective manner to improve the environment and human health both directly and indirectly.

Social Benefits

Trees can give a neighborhood an increased sense of community. Crime reduction has been linked to tree coverage [15]. Compared with housing that has little or no vegetation, buildings with trees and grass have 48 percent fewer property crimes and 56 percent fewer crimes with a small amount of greenery making a significant difference [15]. Just a 10 percent increase in tree canopy cover is associated with a roughly 12 percent decrease in crime [16].

Trees in Other Cities

The local governments of several similar and nearby cities have developed Urban Forestry Master Plans. These entail specific plans and budgets for sustaining tree-filled urban environments.

Charlotte, North Carolina

The City of Charlotte's Urban Forestry Management Plan goal is to reach a tree canopy of 50 percent by 2050. The City of Charlotte plans to achieve this goal through (1) tree planting programs, (2) tree management and planting during city projects, (3) tree management and planting at city facilities, (4) use of tree ordinance fee-in-lieu revenue, and (5) city partnerships for tree canopy preservation. The City of Charlotte Forestry Management Plan can be found in the references and at http://charmeck.org/city/charlotte/charlottetrees/documents/ufmp.pdf [17].

Raleigh, North Carolina

Raleigh funds its tree replacement through a combination of 75 percent Capital Improvement Project and 25 percent operational budget, and thus spends roughly $65,000 per year to plant approximately 100 new and replacement street trees. Trees are purchased and planted by contractors and receive a two year warrantee (including watering, mulching, and pruning). The operational budget also has a fully funded

NeighborWoods program which further supports tree planting in residential neighborhoods (utilizing paid staff and volunteers), planting an average of 1,000 trees per year. Raleigh's annual urban forestry budget is over $1,440,000, not including $25,000 in additional contractual service funds used to prune trees in parks. Raleigh has also recently shifted its ordinance-required urban tree planting away from the private lots of commercial and residential projects back into the right-of-way through a series of amendments to its city code. Raleigh has a full 100 percent active tree inventory and is using $25,000 in CIP money to hire a consultant to create an Urban Forest Master Plan. Raleigh uses Fees in Lieu generated by Tree Conservation Areas for new development on private property (through their Tree Conservation Ordinance-TC-704). Information regarding trees in Raleigh was obtained from Zach Manor, an Urban Forester in Raleigh. Please contact him if any additional information is needed.

Alexandria, Virginia

The City of Alexandria, Virginia has adopted an Urban Forestry Master Plan, which adds trees as part of the City's Capital Improvement Plan (CIP). Its plan includes a tree canopy coverage goal of 40 percent and the development of a citywide strategy to meet this goal. Beginning in 2010, Alexandria began planting an additional 400 trees per year on all types of public properties. They have also detailed best planting practices to ensure healthy tree growth in an urban environment. The City of Alexandria Urban Forestry Master Plan can be found in the references and at https://www.alexandriava.gov/uploadedFiles/budget/info/budget2010/memos/Budget%20Memo%2054%20Street%20Trees%20in%20the%20CIP.pdf [18].

Trees in Durham

Tree Loss in Durham over the Next 20 Years

The City of Durham is a wonderful place to live, due in part to trees along streets, in parks and other public land. Durham's urban forest is at a critical juncture due to a large wave of tree-planting that occurred in the 1930s. These trees, mostly Willow Oaks, will reach the end of their lifespan over the next two decades. Willow Oaks are large, averaging 100 feet tall, 40 inch trunk diameter [19] and providing 200-250 square feet of canopy coverage per mature Willow Oak [20]. Due to their size, Willow Oak removal is costly and results in a significant reduction of canopy coverage. The City of Durham must take action to prevent the loss of trees planted in the 1930s from leading to a significant reduction in the number of trees located on public property.

Because of this tree situation in Durham, the Durham City-County Environmental Affairs Board (EAB) has worked to estimate the number of trees expected to be lost over the next 20 years (Fig. 1). In addition, we have approximated the number of trees that the City of Durham will likely plant each future year, based on trees planted per year in the past. Finally, we have calculated the difference between the above numbers and estimate the number of additional trees the City of Durham must plant to maintain the current level of canopy coverage.

The EAB has utilized the expertise and knowledge of several people, including Alexander Johnson, the City of Durham Urban Forestry Manager, and Tobin Freid, the

Durham City-County County Sustainability Manager, to better understand the issues associated with tree loss in Durham. Based on Alex Johnson's estimates, there are currently roughly 13,000 large trees remaining from the thousands that were planted in the 1930s. The lifespan of these trees is approximately 90 years, which means they will require removal and replacement over the next 20 years. Dividing the 13,000 trees by the 20 years gives an average of 650 trees that will require removal and replacement over each of the next 20 years. This methodology is imperfect, however, because variables affecting the death and decline of trees include weather, pest, pathogen, site (location), and genetic variability. The true number of trees that will require removal and replacement can be expected to trend upward over the next 5 to 7 years, plateau for 3 to 5 years, and then decrease for the remainder of the 20-year period (like the tail end of a bell curve).

This tree loss is in addition to the normal annual tree loss resulting from natural tree death, storms, accidents, etc. Approximately 100 smaller trees (e.g. maples, pears and crepe myrtles) were lost from public property in the City of Durham during the 2014 calendar year. A similar number of trees is expected to be lost in the 2015 calendar year. Therefore we estimate that 100 small trees will require removal and replacement each year over the next 20 years.

Though care is given to give newly-planted trees every chance, not all trees survive. In New Haven, Connecticut, study of nearly 1400 newly-planted trees, street trees had an average survival rate of 77.5 percent (average age 9 years) and park trees 80.1 percent (7.9 years) [21]. Based on these findings, the EAB has assumed a tree survival rate of 80 percent.

As the canopy coverage of young trees starts out small and takes decades to reach full size, the replacement of a dead, mature tree with a young tree results in reduced canopy coverage as well as the benefits derived from the tree in the short- to medium-term. Also, the current selections of species for use as street trees have a smaller mature size potential than the original Willow Oak of Durham's first generation of street trees due to restricted growth potential resulting from infrastructure conflict. Therefore, the goal is to replace each lost tree with a larger number of young trees to maintain current levels of canopy coverage and benefits derived from city trees.

For the sake of simplicity, tree species can be separated into three mature size categories; small, medium and large.

- Small trees have a height and crown spread potential in the 20-30' range and should be planted at a 3 to 1 ratio when replacing large trees. Only small trees are considered suitable for planting under power lines.
- Medium trees have a height and crown spread potential in the 40-60' range and should be planted in a 2 to 1 ratio when replacing large trees. These trees should be planted where root space is limited, but crown space is not.
- Large trees have a height and crown spread potential in the 70-100' range and should be planted in a 1 to 1 ratio when replacing large trees. They are planted where soil and crown space is sufficient to allow unrestricted growth.

Therefore, the City of Durham will need to plant 1,680 trees (260 large trees, 500 medium trees, and 840 small trees) and remove 750 trees per year to maintain the current level of canopy coverage and public safety. As the current budget will only support the planting of 500 trees the removal of 300 trees per year, additional funds must be made available.

Figure 1: Analysis of the number trees that must be planted and removed in Durham each year over the next 20 years to maintain the current level of canopy coverage and public safety.

	Trees that can be planted each year with current budget	Tree loss over each of the next 20 years	Equivalent planting ratio for loss of large trees and restricted space for replacements*ǂ	Trees that must be planted to account for the 80% survival rateʅ
Large Trees	150	650	⅓ x 650 = 217	217 x 1.2 = 260
Medium Trees	150	50	(⅓ x 650) x 2 + 50 = 483	483 x 1.2 = 580
Small Trees	200	50	(⅓ x 650) x 3 + 50 = 700	700 x 1.2 = 840
Total Trees	500	750	1,400	**1,680**

*Not every site where a large tree is removed will accept a large tree as a replacement. It is assumed that for every 100 large trees removed, there will be sites made open for 33 large trees, 66 medium trees, and 99 small trees.

ǂTrees require time to reach mature canopy size, and replacement tree species will not grow as large as the Willow Oaks that they are replacing. Therefore we advise replacing a single mature tree with two young medium trees and three young small trees to maintain current levels of canopy coverage.

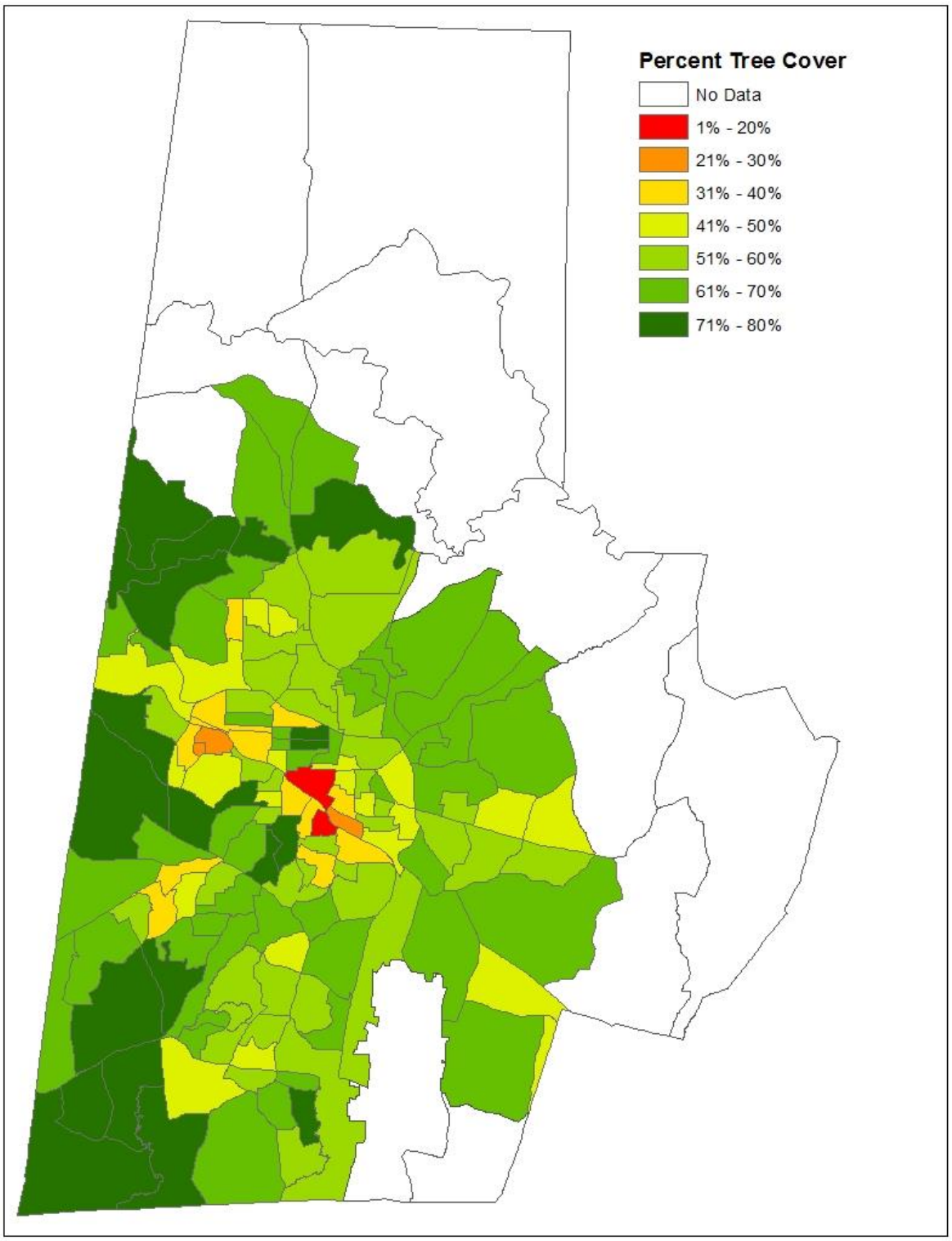
ʅThis analysis does not take into account cankerworms, a potential cause of additional tree loss. Actions are being taken to minimize the damage caused by cankerworms, but cankerworm damage could add to the number of dead/dying trees in Durham in the future.

Number of Trees and Tree Canopy Coverage in Durham

The percentage of aggregate canopy coverage in the City of Durham is known to be roughly 40 percent (Fig. 2), but the percentage of this canopy coverage that is made up by public trees is unknown. The first step toward understanding and managing the tree situation in Durham and establishing the greatest feasible level of urban tree cover is to

determine the existing urban tree cover [22]. This can be performed with geographic information system (GIS) analysis and modeling.

Figure 2. Map of canopy coverage levels in the City of Durham.



Tree Planting Practices in Durham

Tree Planting Locations

In addition to resources the City provides for urban forestry, trees are planted in Durham through various other means. Some are planted by private individuals or developers on private land. Others are planted by organizations such as the Ellerbe Creek Watershed Association and Keep Durham Beautiful. Keep Durham Beautiful also contributes cost-share through its Adopt-A-Tree program to the City of Durham's Urban Forestry Division. In the past two fiscal years, Durham County has contributed resources for tree planting through Trees Across Durham, a joint City-County Strategic Plan Initiative launched in 2013. While these funds have been instrumental in increasing the number of trees planted in the past, there is no guarantee that this funding will continue in future years.

Identifying locations in which to plant the trees is also an important issue. Currently, the locations of newly planted trees in Durham are allocated based on requests from and the financial support of economically-advantaged residents. Though arborists often know where trees can or should be planted in Durham, they presently lack guiding principles beyond "service-on-demand" or resources beyond what can fund a cost-share model.

Shifting tree planting practices towards more environmentally beneficial locations for tree planting could allow Durham to become a pioneer in using the benefits of tree as an incentive for planting. This would involve going beyond stipulating the number of trees required to be planted during development projects and creating incentives for planting that takes into consideration the potential environmental benefits. For example, offsetting stormwater fees when trees are planted where they will reduce runoff.

To determine the locations in which trees would serve the greatest benefit, a city-wide tree inventory must first be performed. Then models can be generated and integrated with known spatial data to identify opportunities in which the addition of trees could provide the greatest benefits. Alex Johnson has used grant funding to a collect some preliminary inventory data (including replacement sites) for portions of the city's right-of-ways laying under Duke Energy's distribution network (including the trees subject to electrical utility pruning), but there is currently no funding to manage replacement any differently than current resource-limited options allow.

Different species and genera provide various levels of canopy coverage, stormwater mitigation, aesthetic beauty, carbon sequestration, and air quality. Therefore it is also important to consider the desired benefit before selecting the site or attempting to match it with a species of tree. Whatever the desired benefits, research continually shows that bringing trees back into our urban environments is one of the biggest returns on investment that citizens, businesses, and governments can make.

Tree Removal

Conversely, the removal of dead and injured trees is also necessary to preserve public safety and to create locations for the planting of replacement trees. Though the exact staff and resource needs are beyond the scope of this report, the number of trees requiring removal is conservatively estimated to be around 750 trees per year over the

next 20 years. These 15,000 dead and/or dying trees could be extremely dangerous to the public, potentially causing property damage and personal injuries.

Tree Age at Planting

Young trees are less expensive to purchase and install, but will require frequent pruning during the first few years to “train” the trees to grow upwards instead of outwards. Older trees incur a greater initial expense, but require less frequent pruning. A flexible mixture of both types allows for the widest variety of species to be obtained and sites to be accommodated.

Conclusions

In order for the City of Durham to maintain the approximate tree canopy coverage on public property, **at least 1,680 trees must be planted and 750 trees must be removed each year for the next 20 years**. Currently, resources are inadequate to accomplish this goal and the City faces the reduction in the quality of life, economic, ecological and human health benefits for its current and future citizens.

Recommendations*

In order to sustain the quality of life, economic, ecological and human health benefits for its current and future citizens, the Durham City-County EAB recommends that:

I. The City of Durham recognize that maintaining the canopy coverage and urban forest benefits requires continued costs and adopt a Capital Improvement Program (CIP) for maintaining/improving tree infrastructure. The EAB believes the best way to accomplish this is to have a third party develop and the City Council adopt a proactive Urban Forest Master Plan (UFMP) as part of an environmental planning/green infrastructure portion of the Durham CIP. The UFMP should include tree maintenance, removal, and the planting of at least 1,680 trees per year over the next 20 years. The UFMP should also state the City's goal of at least maintaining the current level of canopy coverage, or increasing it if canopy analysis shows it to be below best practice levels. Finally, the UFMP should include plans for a city-wide inventory and risk analysis of the number, location, and condition of trees currently located on public property. This will inform arborists of where the addition, removal, and maintenance of trees will result in the greatest beneficial impacts (e.g. heat island effect, stormwater, air quality, etc.) and the locations of potentially hazardous aging trees.

II. The City of Durham support tree health by approving an Urban Forestry Operations Budget which includes funds for: 1) frequent pruning cycles of newly-planted trees, 2) increased levels of tree maintenance including removal, 3) and the planting of at least 1,680 trees per year over the next 20 years.

III. The City of Durham implement a policy for the immediate replacement of dead/dying trees. The policy should state that a fallen, damaged, or dead tree will be removed and replaced (likely with two medium or three small trees) within the next planting season, allowing for the current number and location of trees to remain approximately constant. As this strategy alone will perpetuate any existing inequalities in tree distribution, the City of Durham should implement a policy prioritizing the planting of additional city trees based on 1) the results of a city-wide tree inventory and analysis, and 2) determinations by the Urban Forestry Division in conjunction with stakeholder input.

IV. The City of Durham consider increasing the number of trees required to be planted/preserved by policies in the Unified Development Ordinance and begin using tree services and/or benefits as an incentive for tree planting.

*Please note that several individual recommendations are contingent upon others. For example, conducting a tree inventory without also committing to addressing the results of the inventory could create a liability (e.g. the responsibility to remove trees identified as dead and/or dying).

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