Urban Forest Management Plan

2018 ~ WAKE FOREST, NC

TOWN *of*
WAKE FOREST
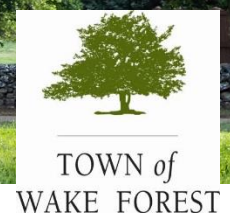
Urban Forest Management Plan
- *Wake Forest, NC* -

Acknowledgements

Cover photos source: Town of Wake Forest Photo Archives

Our vision for the **future of Wake Forest** is to create a healthy and **sustainable urban forest** that is properly managed and **cared for**, benefiting our citizens with **improved economic and environmental well-being, increasing public safety**, and enabling our employees to provide **cost effective maintenance**

Our urban forest will have a large variety of trees consisting of various sizes, ages, and species. The trees will be selected and maintained according to the Best Management Practices (BMPs) established by the International Society of Arboriculture (ISA)

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Introduction & Background

Purposes of this Plan

"Without a management plan, the governments and individuals responsible for taking care of an urban forest will not be effective in meeting the true needs of the trees and the community. A management plan establishes a clear set of priorities and objectives related to the goal of maintaining a productive and beneficial community forest." ~ American Public Works Association, 2007c.

This document is intended:

• To identify the town's goals and priorities for managing its trees and forests

 • To describe the current status of the town's urban forest resources and its management program

• To document the methods, resources, and personnel that will be used to achieve these goals over the next five years.

Statutory Requirements

The Town's Ordinance Sec. 34-74 requires the Urban Forestry Board "To study, investigate, counsel, develop and/or update annually, and administer a written plan for the care, preservation, pruning, planting, replanting, removal or disposition of trees, shrubs and other planting materials in parks, street and utility rights of way and easements and any other public areas. This plan shall constitute the official town urban forestry plan." This document is intended to fulfill this obligation by the Urban Forestry Board.

Visions and Policies from the 2009 Community Plan

"Support for street trees in Wake Forest is very strong. Area residents at town meetings held for the community plan offered a firm consensus in support of tree planting and preservation. Comments received at the first town meeting, for example, included 'strong tree preservation ordinance' and 'replant trees'. Another citizen simply said, 'Keep Wake Forest green.' Regardless of the exact words chosen, there is little doubt that residents want Wake Forest to be a beautiful community and street trees are one of the most effective, least costly ways to do that." ~ Wake Forest Community Plan, 2009

In 2009, an 11-member steering committee appointed by the Town Board created a Community Plan, containing vision statements and policies to guide staff decisions and proposed changes in town facilities and services. The Wake Forest Community Plan contains a number of visions involving the town's trees. Together, they paint a picture of a town in which quality of life benefits greatly from trees in parks, along greenways and streets, and in town-owned open space.

Vision 1: Small Town Character, Attractive Appearance

"…Streets in Wake Forest exude a welcoming, small town charm; overarching street trees, lush landscaping, understated signage, and wide, shaded sidewalks combine to create a truly inviting community character… Greenery is everywhere. Small parks and natural areas are within walking distance of most parts of town. Office and retail parking lots, once viewed as "seas of asphalt", are now tree-shaded and landscaped."

Vision 7: Open Space and Environmental Quality

"In managing its growth, Wake Forest has worked to preserve open space and minimize adverse impacts to the region's air and water quality… Streams and drain-age ways passing through Wake Forest receive less storm water runoff and pollution due, in part, to policies on dedicated open space, tree preservation, landscaped parking areas, compact two and three story buildings, and vegetated buffer strips along streams and roadsides."

Vision 8. Expanded Park and Recreation System

"As the community has grown, Wake Forest has steadily added to its system of parks and open space…An extensive system of greenway trails, primarily adjoining area streams, is enjoyed by hikers, bicyclists, and others. These greenways also serve as natural corridors for the movement of wildlife in Wake Forest."

Vision 11. Affordable Housing and Quality Neighborhoods

"Wake Forest is known for safe, secure, quiet neighborhoods in every part of the community, with well-tended yards and gardens, and small parks close at hand."

Policy ST-1: The town should prepare and maintain an official STREET TREE PLANTING MASTER PLAN to address: 1) the retrofitting of existing streets, where appropriate, 2) the planting of future streets and 3) the maintenance and replacement of dead, diseased or disfigured trees.

Policy ST-2: So as to create a unity of design and effect, CONSISTENT STREET TREE SPECIES should occur along predetermined sections of streets.

Policy ST-3: To prevent future decimation of tree cover over entire areas of the community by disease (e.g. Dutch Elm disease), NO SINGLE TREE SPECIES should comprise more than 10 to 15% of the total street tree population of the town. Further, trees in a neighborhood area should vary from street to street.

Policy ST-4: REGULARLY SPACED STREET TREES should be planted in central medians, frontage street medians, plaza strips and, where necessary, in dedicated easements on private property.

Policy CC-5: Large trees, ponds, creeks, or other natural features of the landscape should be saved when locating new streets, buildings, parking lots, etc.

Policy HSE-6: VEGETATED RIPARIAN BUFFERS (natural or planted) shall be required along all creeks, rivers, lakes and other water bodies in Wake Forest.

Policy HSE-12: A combination of incentives and disincentives may be employed to protect EXISTING TREES and/or require the replacement of trees removed for development.

Overall Urban Forestry Program Vision

To summarize these statements, the following vision is offered:

> "***Wake Forest's Urban Forestry Program develops and maintains the health, beauty, and value of the town's urban forest as a key feature that draws residents, businesses, visitors, and recognition to our community.***"

Program Goals

To achieve this vision, the following goals are recommended:

• maintain a town-wide canopy coverage of at least 50%

• maintain at least 90% of public trees in "good" condition (defined as 75%-100% of perfect condition)

• maintain living trees in at least 95% of available public planting spaces

• ensure that no species, genus, or family of trees comprise more than 10%/20%/30%, respectively, of the town's street tree population

A Brief History of Wake Forest's Trees

In the early 1700s, botanist and explorer John Lawson passed through the piedmont of North Carolina, including the Falls of the Neuse River, and described a landscape far different from today's:

"However, we all got safe to the North-Shore, which is but poor, white, sandy Land, and bears no Timber, but small shrubby Oaks. We went about 10 Miles and sat down at the Falls of a large Creek. …I take this to be the Falls of Neuse-Creek…. We lay here all Night….The next Morning we set out early….We went, this day, above 30 Miles, over a very level country, and most Pine Land."

-John Lawson, 1709

Because pine trees cannot grow in the shade of their ancestors, it is likely that the pine forests around this area were dependent on grazing herbivores and frequent fires that prevented hardwood forests from developing. These two disturbing forces also would have reduced the underbrush enough to allow the explorers to cover 30 miles per day.

Over the next century, trees had become a defining feature of this area, and by 1820, this area was known as "Wake Forest Township". In the late 1800s, trees were planted along town streets. Historical maps show trees in the campus that is now the Southeastern Baptist Theological Seminary, and some of these trees still survive.

The 1909 Sanborn fire insurance maps show two large lumber planing mills on between South White Street and the railroad, indicating the economic importance of local timber harvesting.

Aerial photos from 1938 reveal Wake Forest as a town surrounded by farms and forests, with shade trees planted in yards and along Main Street.

The Wake Forest Tree Board was established in 1978. That same year, the first recorded street tree inventory was conducted. Wake Forest was one of the first communities in North Carolina to be named a "Tree City USA" in 1979. In 1990, the Tree Board commissioned an Urban Forestry Report, and this information was used to amend the town's zoning ordinance.

During the 1990s, multiple grants helped to fund tree planting and educational projects throughout town. During the 2000s, Wake Forest grew rapidly, and many developments were created that incorporated street trees. In 2004, another street tree inventory was conducted by Davey Resource Group. In 2010, Wake Forest was named North Carolina's Tree City USA of the year. The town also received the prestigious Sterling Award for 10 years of continuous program growth. To date, only eight other municipalities in North Carolina share this distinction.

Wake Forest Power has again been named a "Tree Line USA" utility by the Arbor Day Foundation. The Tree Line USA award was first presented to Wake Forest Power during Wake Forest's 2015 Arbor Day Celebration at E. Carroll Joyner Park. The award acknowledges Wake Forest Power's national leadership in caring for the health of trees while removing branches and limbs that grow too close to its power lines.

Growth of Wake Forest's Street Tree Population

Previous tree inventories performed by Davey Resource Group in 2004 and by the NC Division of Forest Resources in 1978 and 1990 show slow, steady growth in the number of street trees. Between 2004 and 2012, many new developments were added to the town, and both population and the number of street trees increased dramatically. To date, there are a total of 17,855 trees in our inventory.

Wake Forest's Tree Resources:
Tree Canopy, Forests and Public Trees

TREE CANOPY COVERAGE

Tree canopy coverage is a measure of the portion of the town that is shaded by trees. Digital aerial photos taken during the 2010 growing season and i-Tree Canopy software were used to estimate town-wide canopy cover at 46% ± 1.5%.

American Forests' General Tree Canopy Goals

American Forests, a national not-for-profit conservation organization, has developed tree canopy goals for various areas in the United States, with the following recommended generally for cities and towns east of the Mississippi:

- 40% tree canopy overall
- 50% tree canopy in suburban residential areas
- 25% tree canopy in urban residential areas
- 15% tree canopy in central business districts

It is recommended the Town determine local and specific goals based on the summaries of this Plan.

TREES ON PUBLIC GROUNDS

In 2012 an inventory of trees on public grounds (rights-of-way, parks, and open space areas) was completed and was updated in 2017. This update included a re-inventory of existing trees and additions of trees planted after 2012. This section includes an analysis of the entire inventory dataset of 17,855 trees and the 2017 inventory of 1,788 trees. Because the entire inventory dataset has not been thoroughly maintained and updated, some summaries presented in this section only represent the 2017 inventoried trees. The Town is now actively maintaining the database. These summaries are from March 2018 data.

Project Area

This Urban Forest Management Plan (UFMP) applies to all town-managed trees which impact and benefit the entire community. The tree inventory was conducted by ISA Certified Arborists who assessed each tree in town parks, public spaces, and within the rights-of-way. Areas to inventory were provided by the Town. The map to right shows the location of all 16,996 trees in the Town's database.
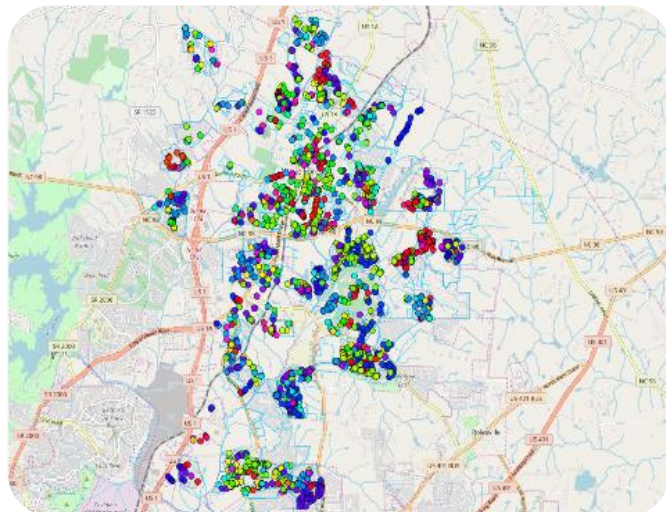
Distribution of Wake Forest's Public Trees

Tree Inventory Methodology

The 2017 tree inventory, facilitated by the Department of Parks, Recreation & Cultural Resources' Urban Forestry Program and completed by Plan-It Geo's International Society of Arboriculture (ISA) Certified Arborists, was conducted in November of 2017. The Town provided the consultants with the project area, priorities, and desired fields and values to be collected as part of the inventory.

The tree inventory crew ("arborists") utilized the Town's Tree Plotter, an inventory management software developed by Plan-It Geo, to complete the inventory. Each tree was inspected and assessed, and the values for the following fields were collected:

- Location
- Common Name, Latin Name, and Genus
- Diameter at Breast Height (DBH= 4.5')
- Height (5' increments)
- Number of Stems
- Condition (Overall)
- Primary Maintenance Need
- Risk Assessment
- Utilities Present
- Growing Space Type

- Growing Space (Width)
- Observations
- Further Inspection
- Wires
- Tree Comments
- Last Modified (Date)
  Staff Member (Name)
- Address
- Tree # and ID
- Stumps

Though Tree Plotter has built-in functionality to reduce error, after the inventory was completed, the arborists and project managers completed a quality assurance and quality check (QA/QC) process to correct any misplaced tree points, erroneous data, or other inconsistencies.

The inventory data is available in the Tree Plotter application (https://pg-cloud.com/WakeForest). Town staff were provided account information to access, view, manage, update, filter, report, and export tree data. The data management, filters, and stats/charts/graphs functionality in Tree Plotter were used to complete the inventory data analysis and summaries to inform this Urban Forest Management Plan.

Tree Plotter Software → Field Inventory → Data and Program Analyses → Urban Forest Management Plan
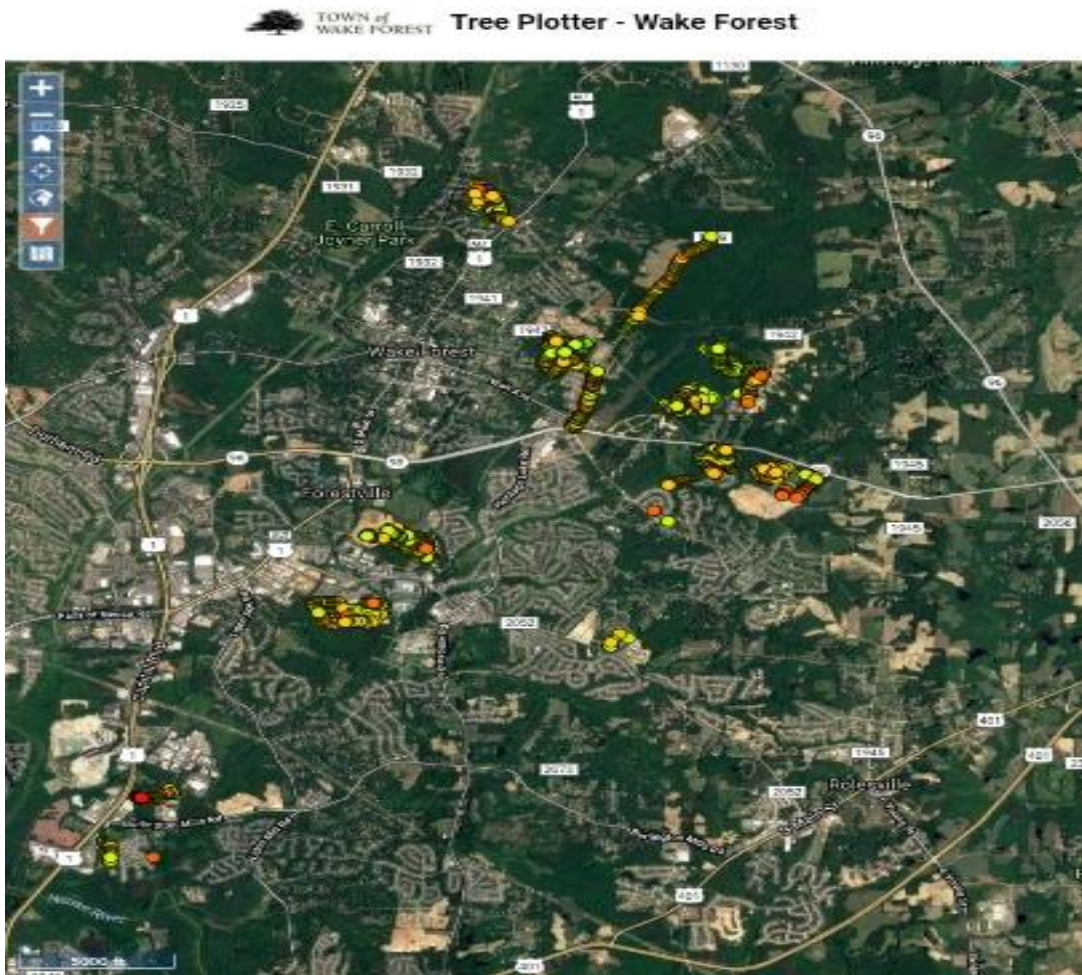
FIGURE # 1: Location of the Trees Inventoried in November 2017*

*Note: Map was produced after 14 trees were removed from the 2017 inventory

Street Tree Distribution

FIGURE # 2:
Location of Current Street Trees (All)

STREET TREE POPULATION

The Town of Wake Forest is currently responsible for maintaining approximately 17,855 trees along the public right-of-way (ROW). The total number of street trees has grown rapidly since the 2013 Urban Forest Management Plan, likely due to the large number of trees planted in new neighborhoods.

Most of these trees are along streets maintained by the Town, while some are found on streets maintained by the NC Department of Transportation (NCDOT), with Main Street (Route 1A) being the most visibly forested. Most of the trees in the right-of-way are of a size and species

ROW 9%

EASEMENT 38%

PLANTING STRIP 51%

MEDIAN 2%

OTHER (MAINTAINED) 0.2%

appropriate for Town maintenance, but a small percentage of the trees are small-growing ornamentals, which would not qualify for Town maintenance.

Planting Site Types

Almost 90% of the trees are located in Planting Strips and Easement areas. Other trees are planted in the space between the sidewalk and the street, known as the right-of-way (ROW). Other (Maintained) areas refer to open space areas that cannot be classified as any other category in the inventory database. Relatively few trees are planted in tree pits, sidewalk cutouts, or in street medians.

According to the 2017 updated inventory, Figure #3 shows most trees are planted in a Class II site width which is in the 6-10-foot range. This is adequate for many species, though greater space can improve tree growth, maintain tree health, and reduce tree stress.

Figure # 4 shows the condition of trees by planting site widths. Fair and Good condition classes are most prevalent for all site widths. An updated comprehensive inventory would likely illustrate how planting site widths affect tree condition.

FIGURE # 3:
Planting Site Widths (2017 Trees)
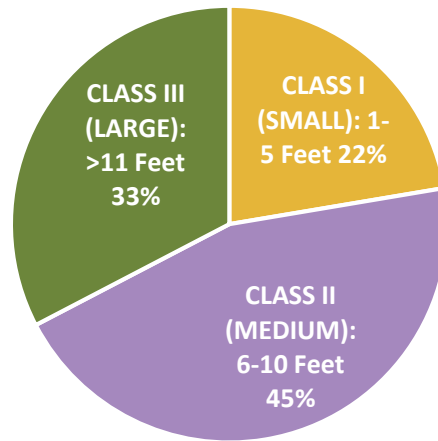
FIGURE # 4:
Condition by Planting Site Width (2017 Trees)

Stocking Level

Of the 1,788 trees inventoried, 14 trees were identified as dead. Standing dead trees are unattractive and potentially hazardous and should be removed. A comprehensive inventory identifies the number of stumps, dead trees, and available planting sites to determine the stocking level of the urban forest that the Town maintains.

Land Use

The distribution of trees across land use types helps to identify the various constraints, maintenance needs, and opportunities. Figure # 5, below, shows that of the 17,855 trees in the inventory database, 81% are in areas designated as Single Family followed by Park/ Vacant/ Other with 13%.

FIGURE # 5: Distribution of Trees by Land Use (All)

FIGURE # 6:

Example of Public Trees in Downtown, Commercial, Residential, and Parking Areas

Source of Images (clockwise): www.deeproot.com, www.depts.washington.edu, www.ecology.com, www.deeproot.com

Species

THE 10/20/30 RULE

Each tree's strengths, weaknesses, needs, and benefits are determined largely by its species. In order to reduce the threat and spread of devastating pests and diseases, such as those that decimated ash (*Fraxinus*) and elms (*Ulmus*) in other cities across the US, it is important to plant a variety of different species. It is generally recommended (Santamour, F.S., Jr. 1990, "Trees for Urban Planting") that no more than 10% of a town's street trees be of the same species, no more than 20% of the same genus, and no more than 30% of the same family. Following this 10/20/30 rule will help to ensure that pests and diseases are isolated and controllable and have little impact on the total value and function of the urban forest.

It should be noted that Santamour's 10/20/30 benchmarks have become a widely accepted rule-of-thumb, even though there is a lack of scientific or empirical evidence to validate those numbers as effective thresholds. Additionally, it has been argued that applying the 10/20/30 rule in some urban landscapes may be counterproductive to street tree management by replacing well-adapted tree species with underperforming ones (Kendal et al. 2014, "Global Patterns of Diversity in the Urban Forest"). In the ISA Arboriculture & Urban Forestry Article 43(1), January 2017, Cowett, F.D., and Bassuk, N., "Street Tree Diversity in Three Northeastern U.S. States", it is noted that increasing street tree diversity by making the most common species less prevalent is a big step in the right direction toward sustainable street tree management.

TABLE # 1: Most Common Street Tree Species (All)

SPECIES	COUNT	%
Red oak group* *(multiple species)*	3,504	20%
Red and Freeman maple**	2,076	12%
Crapemyrtle	2,056	12%
Chinese elm	665	4%
Chinese pistache	598	3%
Cherry plum	595	3%
Japanese zelkova	555	3%
Flowering dogwood	408	2%
Loblolly pine	394	2%
Callery pear	337	2%
Eastern redbud	291	2%
Southern magnolia	275	2%
Other	6,101	34%
Total	*17,855*	*100%*

*Includes 1,456 "Oaks" and willow, sawtooth, pin, scarlet, Nuttall, southern, Shumard, black, and blackjack oaks

**88 Freeman maples and does not include 1,395 identified as "Maple"

According to entire inventory database there are a total of 60 genera (includes "Broadleaf" and "Conifer" classifications) and 114 unique species. Figure # 6 shows the top ten most prevalent genera which comprise 80% (14,211) of the street trees.

Table # 1 on the previous page summarizes the most common genera of street trees in the overall inventory.

It should be noted that from the 2017 inventory, the top ten species differ from Table # 1 on page 16, that represents the entire tree inventory database (17,855 trees). Figure #7 (below) summarizes the composition of the top ten species from the 2017 inventory data.
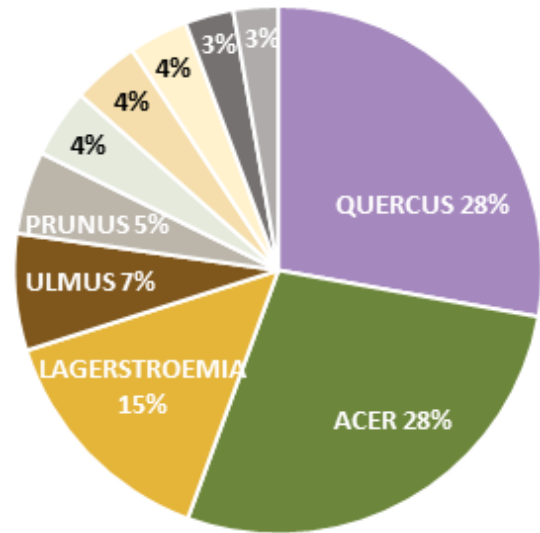
FIGURE # 7: Top 10 Species (2017 Trees)
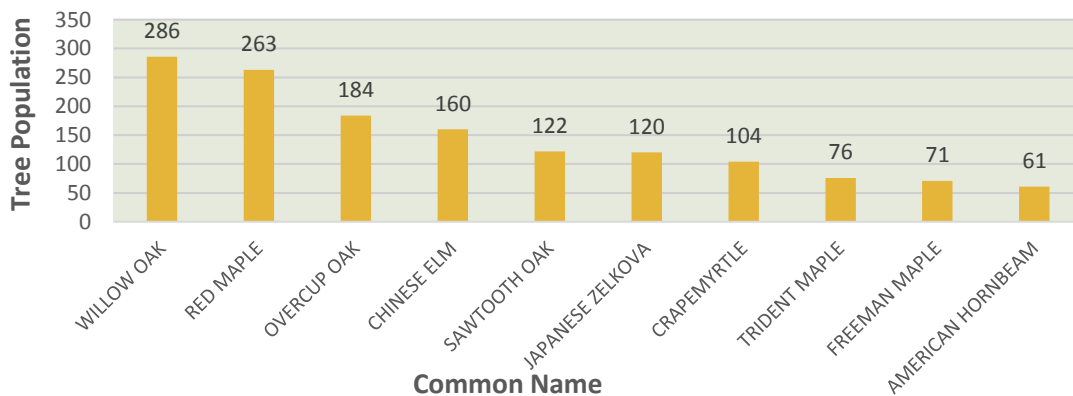
Considering the 10/20/30 rule and caveats listed above, the Town has too many red oaks, red maples, and crapemyrtles. Recommendations for alternatives to commonly planted species are provided in Table # 2.

URBAN FOREST RESOURCE ANALYSIS & SUMMARY

Oaks

In Wake Forest, one in five street/park trees is a member of the red oak group. This group contains the very popular willow oak, as well sawtooth (has traits somewhat intermediate between red and white oaks), pin, scarlet, Nuttall, southern red, Shumard, black, and blackjack oaks. The count of red oaks in Table #2 also accounts for 1,456 trees identified as "Oak" without a specific species assigned. It assumed that these "Oaks" are primarily red oaks given the white oak group only consists of 385 (2%) trees in the inventory. White oaks include white, swamp white, live, laurel, swamp chestnut, and overcup oaks. The large-growing, acorn-bearing oaks provide the majority of the value and benefits of the Town's street tree population. However, they are increasingly vulnerable to existing threats, such as root rot fungi, and potential future threats, such as oak wilt, sudden oak death, and gypsy moths. For more information about oak diseases visit the University of Georgia's Key to Diseases of Oaks in the Landscape.

TABLE # 2: Recommended Alternatives to Commonly Planted Street Trees

TREE TYPE	PLANT FEWER:	PLANT MORE:
Large growing deciduous	oaks, red or Freeman maple	river birch, tulip poplar, fruitless sweetgum, katsura tree, hackberry, hornbeam, Kentucky coffeetree, black gum, ginkgo, London planetree
Small ornamental	crapemyrtle	goldenrain tree, smoketree, witchhazel, magnolia, waxmyrtle, and chaste tree

Maples

Red maples are native trees, commonly found in low-lying areas and wetlands. Freeman maples are a hybrid cross between red maple and silver maple. Both species are prized for their fall color and rapid growth rate. However, they are vulnerable to gloomy scale and perform poorly compared to other species. Their thin bark, relatively weak wood, and low tolerance for decay can create a number of maintenance problems and lower their overall quality and lifespan.

Crape myrtles

Crape myrtles are extremely popular small trees that originate in East Asia. They are known for their summertime flowers and attractive bark, suffer from few health problems, and tolerate dry, compacted soils. However, they provide fewer benefits than larger trees and represent only one of many available small tree species. Additionally, crape myrtle bark scale (*Acanthococcus =Eriococcus*) was detected in North Carolina in August of 2016. Damage caused by the scale is not fatal to its host but can greatly reduce the appearance of the tree by creating large amounts of honeydew. The process of determining the most effective treatment times and products to be administered to slow the progress of the pest. Preventing the scale from entering a landscape or nursery is the best management strategy.

Type and Size Class

In this climate region, large-growing deciduous trees provide more total value and a better benefit-cost ratio than smaller-growing trees or conifers (USFS, 2006). It is preferred to plant trees that will grow to the largest size category though there are some locations where large trees cannot be planted due to lack of root space, overhead power lines, or nearby buildings.

TREE DIAMETER

The figures below summarize the diameter class distribution of the entire street inventory (17,855) and the 2017 inventory (1,788 trees). Diameter was measured at breast height (DBH) or 4.5 feet from the ground. While the entire inventory is not up-to-date, it provides an estimate of the tree structure.

The average DBH of all 17,855 trees is 5.7 inches with 70% (12,578) of the trees less than 6 inches in diameter (Figure # 8). Some of these are small-growing trees, while others are larger growing trees that have been planted in recent years. Few trees were observed in the larger diameter classes; these largest trees provide the most value to the Town, but many have not received the care they require. Following neglect or injury, it is not uncommon for a large growing tree to be removed as a potential risk.

FIGURE # 8: Trees by Diameter Class (All)
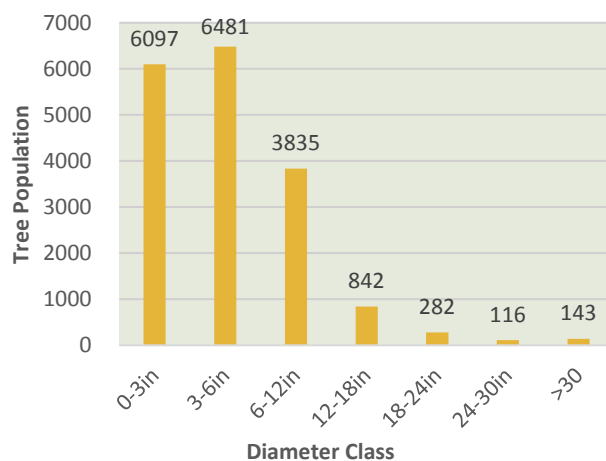
FIGURE # 9: Trees by Diameter Class (2017 Trees)
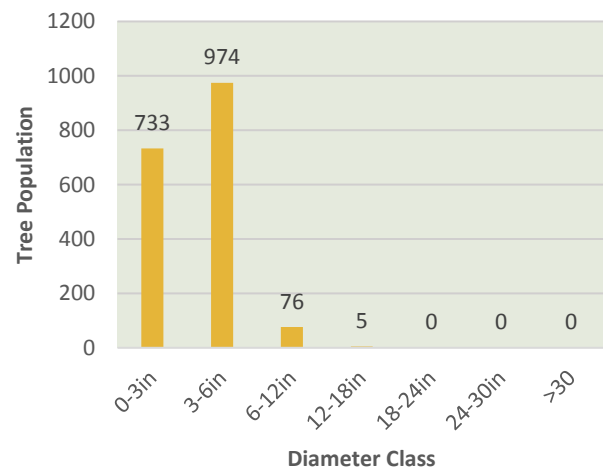
An ideal size distribution would contain more large-diameter trees and fewer young trees. The large percentage of young trees also represents a maintenance challenge, as problems with health or structure are best addressed when a tree is young.

FIGURE # 10: Tree Height (2017 Trees)

TREE HEIGHT

During the 2017 inventory, an estimate of each tree's height was measured (Figure 10). Of the 1,788 trees, 65% (1,130) of the trees are in the 15-30-foot height range followed by 33% (574) trees that are less than 15 feet in height. The 2017 inventory primarily focused on newly planted trees and is reflected in this summary and not all trees were given a height measurement (52).

Tree Health Condition

During the 2012 and 2017 inventories, the health and structure of each living tree were assessed, and the tree given one of four condition ratings; "Excellent", "Good", "Fair", "Poor", or "Dead" (Figure # 11). Because condition can quickly change, the outdated inventory data cannot be used, and the following only summarizes the 2017 inventory data of 1,788 trees.

Most of the Town's street trees are in "Good" condition (43%), meaning that they have no health or structural problems that would reduce their value to less than 75% of a tree in perfect condition. They may have some minor issues with their foliage, stems, or roots, but are structurally sound. With neglect, these trees can degenerate into "fair" or "poor" health in a matter of years.

Approximately 41% of the street trees are in "Fair" condition, meaning their health or structural integrity is between 50% and 75% of a tree in perfect condition. With effort, these trees could become "Good" trees, but without effort, they are likely to decline into "Poor" condition.

12% of trees are in "Poor" condition, indicating major health or structural problems that can lead to death or structural failure. Trees in these conditions are likely to require removal in the near future, and recovery is only possible with sustained effort.

FIGURE #11: Overall Condition of Wake Forest's Street Trees (2017 Trees)

The large number of "Good" trees likely reflects the recent planting of these trees and does not mean that the trees do not require immediate attention. The majority of trees observed in this inventory showed signs of significant issues that require correction, such as buried root collars, structural pruning needs, stakes, pests, or disease. Trees can have significant energy reserves that are depleted by stress and decline rapidly once these reserves are exhausted. Without attention, many of the Town's street trees will decline in health.

The top five trees from the 2017 inventory comprise 57% of the inventory and therefore, it is important to summarize their condition ratings, seen in Table #3 on page 19.

TABLE #3: Summary of the Condition Ratings for the Top Five Species (2017 Trees)

Common Name	Total Count by Species	Excellent		Good		Fair		Poor		Dead		Total Assessed
		Count	%	Count	%	Count	%	Count	%	Count	%	Count
Willow oak	286	0	0%	116	41%	152	53%	18	6%	0	0%	286
Red maple	263	2	1%	80	30%	94	36%	85	32%	2	1%	263
Overcup oak	184	4	2%	73	40%	87	47%	18	10%	2	1%	184
Chinese elm	160	0	0%	88	55%	61	38%	11	7%	0	0%	160
Sawtooth oak	122	29	24%	50	41%	34	28%	9	7%	0	0%	122
TOTAL	1,015	35		407		428		141		4		1,015

RELATIVE PERFORMANCE INDEX

The Relative Performance Index (RPI) allows the Town to assess how a tree species is performing relative to all tree species in a community. It is based on the proportion of each individual species classified as "Good" condition class divided by the total population of trees classified as Good. In essence, it helps the Town determine if a tree species is performing better or worse than the overall population based on either a below or above average condition rating. The following RPIs were calculated for the top ten species in the 2017 inventory. It should be noted that the majority of the inventory consisted of trees less than 6 inches in diameter.

TABLE # 4: Relative Performance Index of the Top Ten Trees (2017 Trees)

Common Name	Total Stem Count	Count Good	% Good	RPI
Crapemyrtle	104	63	61%	1.4
Chinese elm	160	88	55%	1.3
American hornbeam	61	30	49%	1.1
Japanese zelkova	120	59	49%	1.1
Sawtooth oak	122	50	41%	0.9
Willow oak	286	116	41%	0.9
Overcup oak	184	73	40%	0.9
Freeman maple	71	25	35%	0.8
Red maple	263	80	30%	0.7
Trident maple	76	22	29%	0.7
Total	1,447	606		
Average	145		43%	1.0

FIGURE # 12: RPI for the Top Ten Species (2017 Trees)
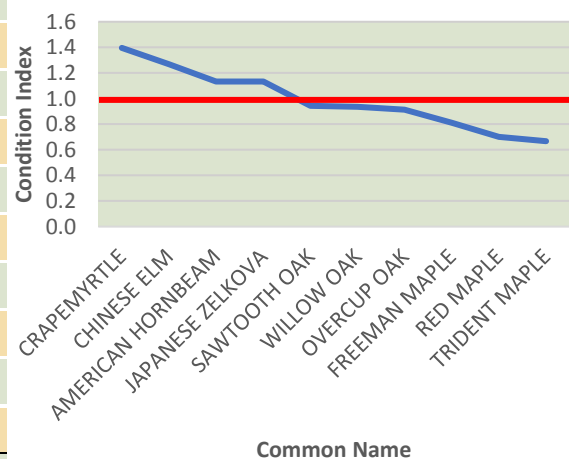
According to the RPI study, any species with an RPI value greater than 1.0 is performing better than the overall population and those less than 1.0 are underperforming. Crape myrtles have a high count of "good" condition trees because of their ability to establish easy and perform well on sites with restricted

soil volume. Crape myrtles are often "topped" or pruned by making a heading cut to reduce the size or control its shape. These types of cuts damage the tree, cause decay, and reduce the condition of the tree.

More favorable trees such as the oaks and zelkova could perform better (i.e. improved condition, improved RPI) if these trees are properly planted, mulched, and pruned in the early stages of establishment and are part of a routine pruning cycle. Following these practices would improve the RPI value for these favorable trees which provide substantial benefits to the ecosystem and community.

To learn more about RPI visit http://www.itreetools.org/streets/resources/.

Value and Benefits of Street Trees

Throughout Wake Forest, forests and trees along streets, in parks, yards, and throughout natural areas constitute a valuable urban and community forest. This resource is critical for the Town's green infrastructure, contributing to environmental quality, public health, water supply, local economies, and aesthetic appeal. Urban forests provide "triple bottom line" benefits: *social, economic,* and *environmental.*

Living trees provide services which can also be assigned a financial value, using the peer-reviewed i-Tree research. These services include stormwater retention, increased property values, energy conservation, improved air quality, and carbon dioxide reduction.

The total annual benefits of Wake Forest's inventoried trees (17,855 trees, 16,754 with benefits values) are estimated at $447,540. Stormwater retention represents 17% of the monetary value ($77,326) followed by energy conservation and air quality improvement/savings. Increases in property values are estimated at over $265,700 though it should be noted that the research is dated and uses regional estimates. It is still important to demonstrate that trees add value to properties in terms of aesthetics, well-being, increased tourism, sense of community, etc. If the large numbers of small trees currently growing are maintained properly and new trees are planted after removals, these benefits are likely to sustain and potentially increase.
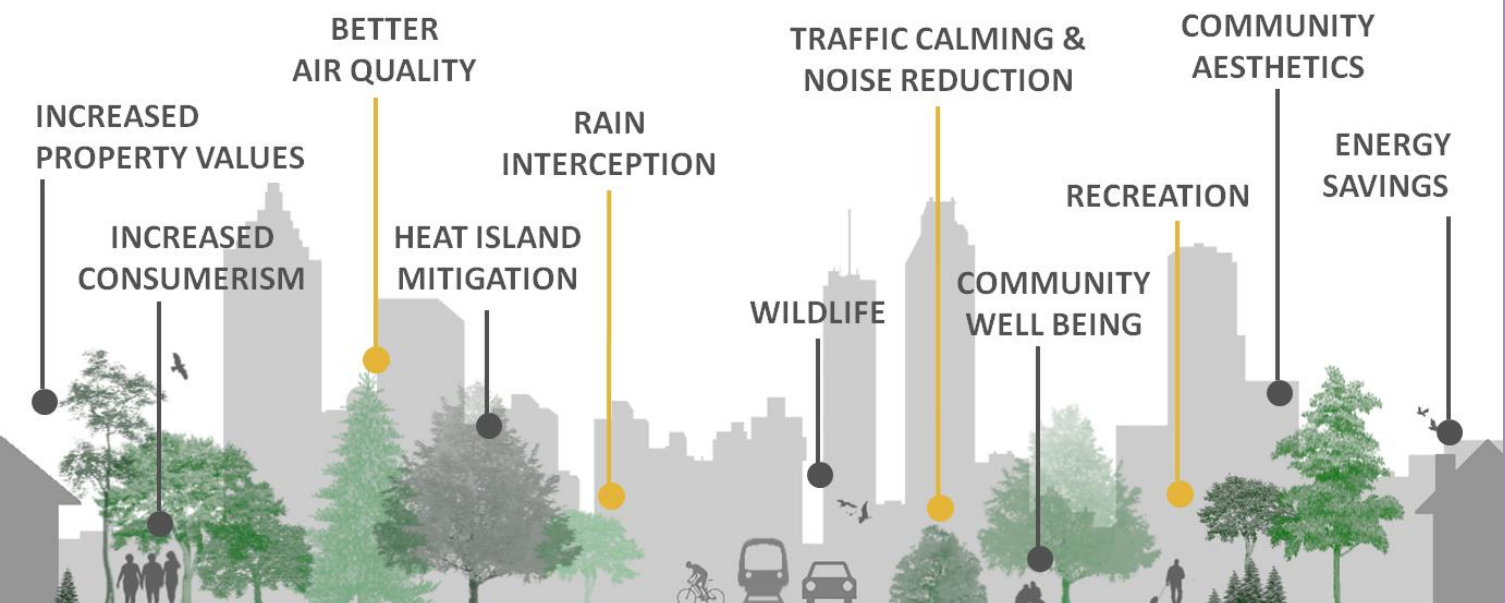
Real-World Equivalents of Wake Forest's Tree Benefits

Stormwater: 12.7 million gallons is equivalent to 19 Olympic-size swimming pools[1]

Energy Savings: 629,826 kWh is equivalent to the average annual electricity consumption of 58 households[2]

Carbon Sequestration: 1.2 million lbs of carbon sequestered is equivalent to the annual CO_2 emission of 102 cars[3]
[1]www.livestrong.com [2]www.eia.gov [3]www.cartalk.com

Figure # 13, below, summarizes the benefits of the top species (62% of the inventory) in the inventory database (17,855 trees). The top ten are comprised of 11,094 trees but 556 of these trees do not have ecosystem benefits values because they are either removed or dead. While the full inventory database is out of date, these values are still useful in portraying the enormous benefit and role trees have in the Town of Wake Forest.

Large canopy trees such as the willow oaks make up a smaller portion compared to maples but have the second highest overall annual value with $65,662. Crapemyrtles are the most common tree in the inventory database yet they're valued at just over $10,000. Also, Chinese elms have a high Relative Performance Index but a low ecosystem benefit value.

Figure # 13: Summary of the Overall Benefits for the Top Ten Species (All)

CHERRY PLUM $3,902 — FLOWERING DOGWOOD $2,489
CHINESE PISTACHE $9,750
CRAPEMYRTLE $10,516
CHINESE ELM $13,337
JAPANESE ZELKOVA $16,360
RED MAPLE $67,961
WILLOW OAK $65,662
MAPLE $33,931
OAK $32,361

RED MAPLE · WILLOW OAK · MAPLE · OAK · JAPANESE ZELKOVA · CHINESE ELM · CRAPEMYRTLE · CHINESE PISTACHE · CHERRY PLUM · FLOWERING DOGWOOD
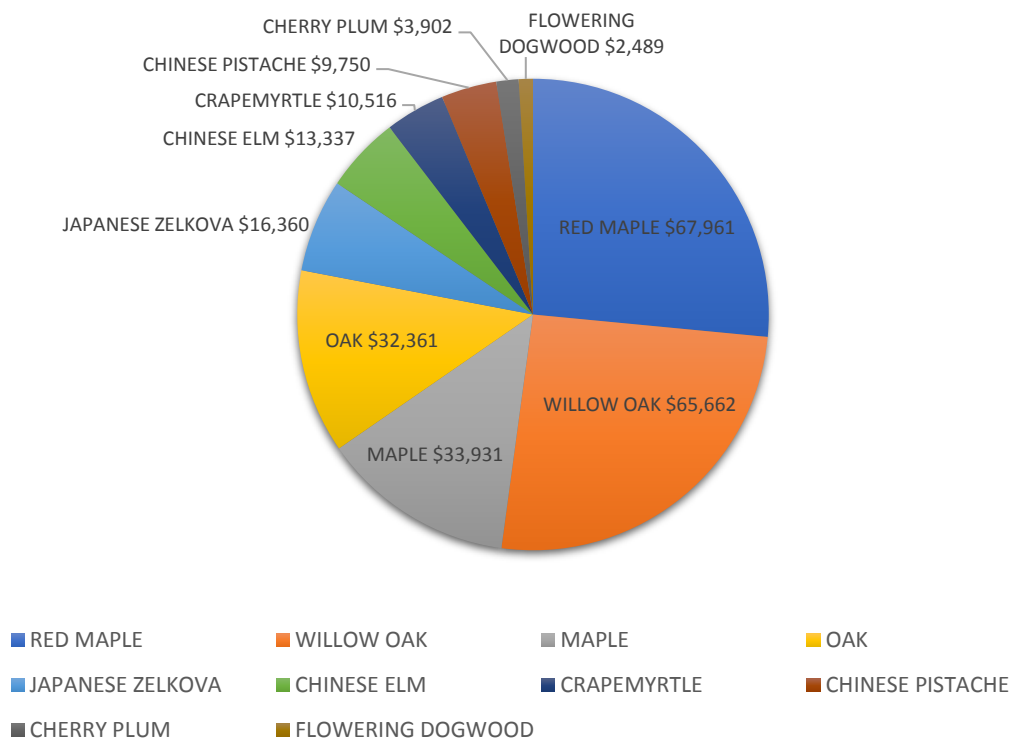
Maintenance Needs

Tree characteristics and outside forces affect the management needs for urban trees. An analysis of the condition and maintenance requirements assists managers in planning the urban forest. Tree condition indicates how well trees are managed and how well they perform given site-specific conditions. Tree maintenance needs are inventoried for public safety reasons and for the health and longevity of the trees. Understanding the maintenance needs assists tree managers in establishing daily work plans and has also complemented the development of the Urban Forest Management Plan. Because the Town is actively managing the street trees and maintenance needs change, the following summaries are primarily derived from the most recent 2017 tree inventory of 1,788 trees.

PRUNING

- 83% of trees need at least one type of maintenance
- 71% of trees need at least one type of pruning maintenance
- 70% require structural pruning
- 9% need crown raising
- 7% need to have dead branches removed (cleaning)

The figures to the right provide summaries of the maintenance needs of the trees inventoried in 2017. Figure # 14 provides a summary of the general maintenance requirements whereas the Figure # 15 provides the maintenance details.

Of the 1,788 trees, 1,372 trees need a type of pruning maintenance and 1,253 of those require structural pruning. The high count of structural pruning and root flare excavation needs is a result of the inventory consisting primarily of trees less than 6 inches in diameter. It should be noted that the Primary Maintenance field wasn't completed for each tree but the specific tree maintenance ("Tree Work") was completed if maintenance is needed.

FIGURE # 14: Primary Maintenance Needs (2017 Trees)
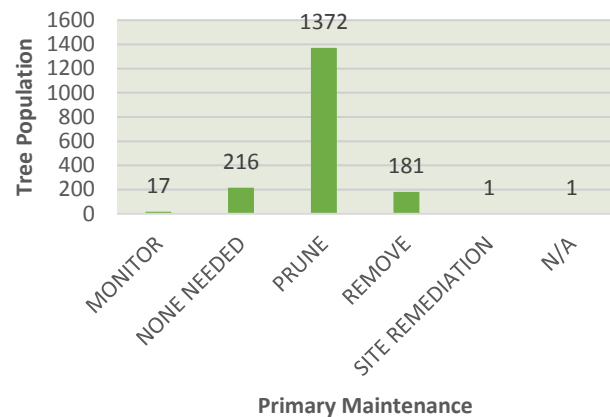
FIGURE # 15: Specific Tree Maintenance Needs (2017 Trees)
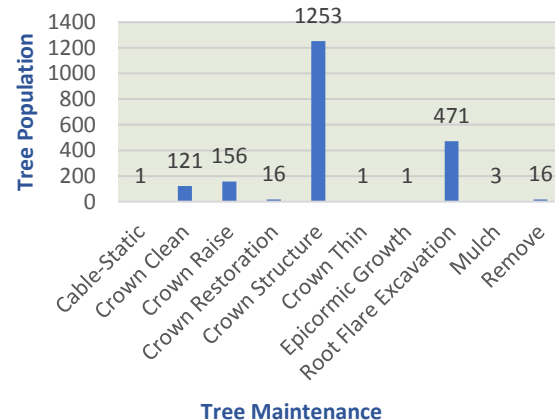
Pruning is the predominant need for most Town street trees. Young trees need to have future structural problems addressed early on, while older trees have dead or decaying limbs that could pose a threat to people or property.

Street trees are pruned to maintain the health of the tree and to protect people and property from decaying limbs. Image Source: 2013 Wake Forest Urban Forest Management Plan

Pruning for Health

A tree in need of a crown raise.

Codominant stems; frequent structural pruning can prevent these weak joints, which can split in a storm.

A tree with poor structure, with multiple limbs originating at the same point, no dominant stem.

Source of Images: 2013 Wake Forest Urban Forest Management Plan and the
City of Shoreline, WA

FIGURE # 16: Clearance Conflicts Caused by Trees (2017 Trees)

Chart — Y axis: Tree Population (0–160); X axis: Clearance Conflict

- LIGHT: 18
- PEDESTRIAN: 145
- VEHICLE: 82
- OVERHEAD WIRES: 1
- SIGN OR SIGNAL: 1
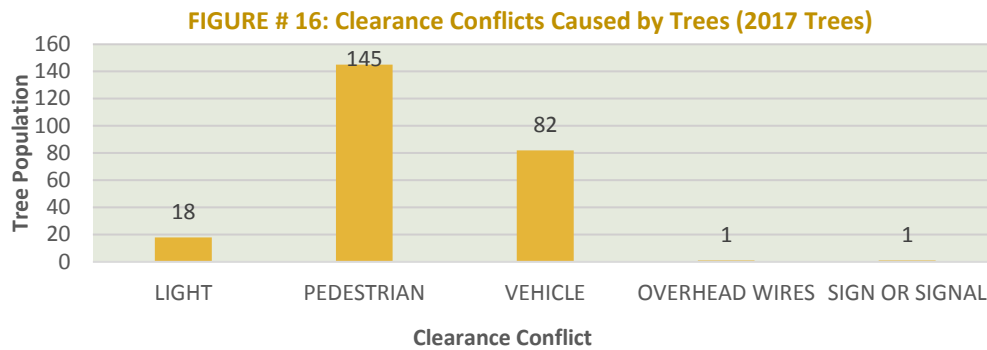
TREE OBSERVATIONS IMPACTING MAINTENANCE

Observations were noted during the 2017 inventory to indicate common issues of the street and park trees such as mechanical damage, cavity decay, and overly mulched. 1,481 trees have an observation value. Figure # 17, below, summarizes these observations.

FIGURE # 17: Tree Observations Impacting Maintenance and Tree Health (2017 Trees)

Horizontal bar chart — Y axis: Observation; X axis: Tree Population (0–700)

- IMPROPERLY MULCHED: 583
- 579
- CAVITY/DECAY: 448
- 436
- REMOVE HARDWARE: 413
- 137
- IMPROPERLY INSTALLED: 115
- 35
- FROST CRACKS: 28
- 22
- PESTS: 19
- 11
- SERIOUS DECLINE: 9
- 4
- GIRDLING ROOTS: 1
- 0
- HARDSCAPE DAMAGE: 0
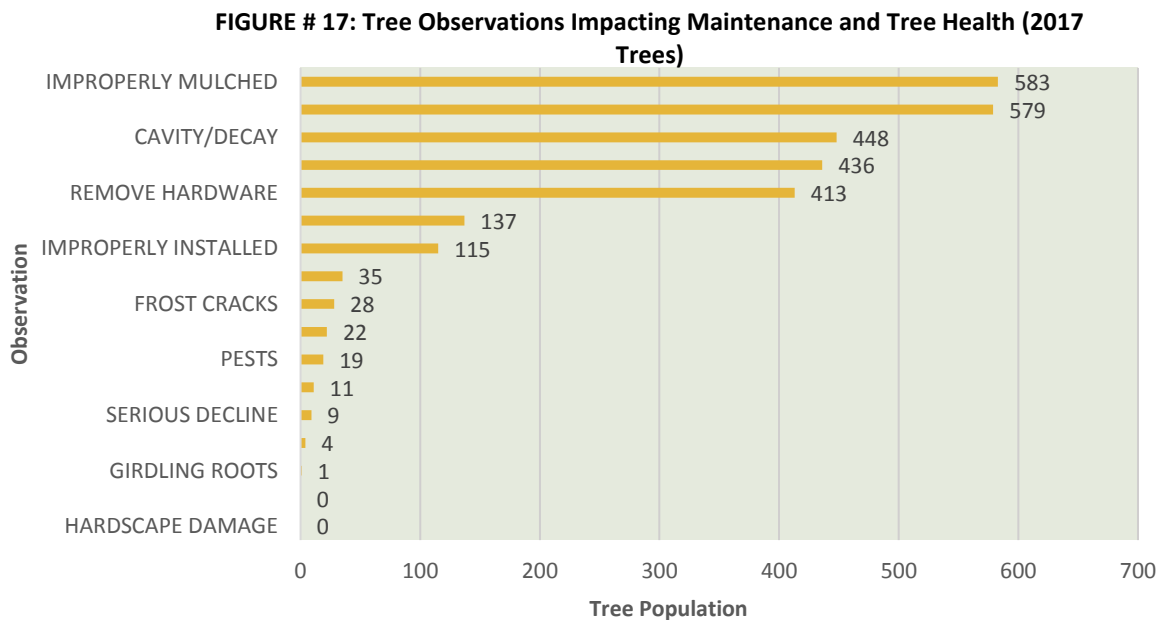
Many of these observations can be remediated and should be addressed at a tree's early stage of establishment and growth in order to improve overall tree health. Observations such as improperly mulched, poor structure, remove hardware, improperly installed, and girdling roots are all issues that the Town can address while trees are young to improve tree health and to minimize future maintenance costs.

FIGURE # 18: Examples of Common Tree Observations

Root Health

During the 2017 inventory, observations regarding root health were noted. The complete inventory database does contain root health observations but are out of date. Details regarding these observations and others are described in the Tree Observations Impacting Maintenance section.

An extreme example of excessive mulching, which creates perfect conditions for fungus and termites to attack the lower stem.

- 26% require root flare excavation
- 33% are improperly mulched
- Newly planted trees require mulch
- Girdling roots exist on several inventoried trees

More than a quarter of all street trees inventoried in 2017 have more than 3 inches of soil and mulch piled on the root system and require root flare excavation. Having the root flare covered with mulch can cause roots to girdle the stem, cutting off circulation to the canopy. It also creates an environment that encourages termites and fungus that can eventually kill the tree. Other common issues include lack of mulch on newly planted trees and surface roots, indicating very poor, compacted soil conditions.

Source of Images: 2013 Wake Forest Urban Forest Management Plan

This cherry tree has roots that girdle the stem and can cut off circulation and eventually kill the tree.

Trunk Health

The trunk health of inventoried trees was generally good; however, there are a number of trees that have uneven wounds that will not heal quickly, or stakes and supports that can constrict circulation. Stakes and supports can kill a tree if unchecked but are easy to address if caught early.

Young maple tree with trunk wounds.

Borer hole in a Shumard oak.

Support lines, if left on too long, can injure and kill young trees.

[1]www.johnson.k-state.edu, [2]www.treesaregood.org, [3]www.umass.edu, [4]Plan-It Geo, [5]www.umass.edu

PEST AND DISEASE OBSERVATIONS

The complete tree inventory database of 17,855 trees contains a field for noting pest and disease observations. The figure below is not meant to be a complete summary since these observations may be old, treated, or the tree was removed. This summary is meant to illustrate the common pests and diseases that the trees in Wake Forest may be exposed to, potential related symptoms to anticipate, and the proper prevention and treatment practices to consider.

The pest and disease observations noted in Figure # 19, right, were the most common in the tree inventory database. Gloomy scale affects red maple which is a difficult pest to eradicate due to limited resources or time required to treat every infected maple. Also, the timing is crucial as treatment must occur during the scale's crawler stage.

FIGURE # 19: Tree Pests, Diseases, and Observations (All)

Pest/Disease Observation	Tree Population
SCALE	173
TOPPED	60
GLOOMY SCALE	39
ORANGE STRIPED OAKWORM	33
CANKER	27
ELM LEAF BEETLE	26
ANTHRACNOSE	2
LECANIUM SCALE	1

Therefore, proper maintenance practices such as appropriate mulching and species selection will reduce the impact of gloomy scale without the cost of treatment.

Similarly, orange-striped oakworm affects red oaks and with the large population of red oaks, treatment of all trees with orange striped oakworm is not feasible and the appropriate management approach involves proper maintenance practices and species selection for new plantings.

Common Pests and Diseases

Below:

1) Gloomy scale on a maple, 2) defoliation by orange striped oakworm, 3) *Cristulariella* leaf spots on a sycamore leaf, 4) minor defoliation on a cherry tree, 5) leaf spots on water oak, 6) orange striped oakworm.
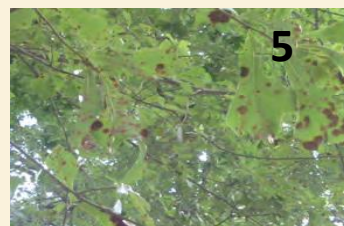
Scale

Scales are small insects that suck the sap out of trees, reducing the tree's resources. Freeman and red maples are affected by gloomy scale. Additionally, a different type of scale (*lecanium*) can affect willow oaks. Given the large amount of value in maples and willow oaks, and the abundance of willow oaks in Heritage and Olde Mill Stream, the impacts of scale could be severe if untreated.

Emerald Ash Borer

The emerald ash borer (EAB) is a metallic green nonnative beetle that was first found in Michigan in 2002 and attacks all native ash (*Fraxinus*) species as well as the native white fringetree (*Chionanthus virginicus*). Adult beetles lay eggs on the bark of trees and once the eggs hatch the larvae bore into the bark and feed on the transportation tissues of the tree which disrupts the movement of nutrients and water, girdling the tree, and ultimately causing tree death.

EAB was first found in North Carolina in June of 2013 and the North Carolina Department of Agriculture & Consumer Services announced recently that Wake and Franklin counties have been added to the list of counties under an EAB quarantine after borers were confirmed in both counties. Quarantine rules restrict the movement of hardwood firewood, ash nursery stock and other ash materials. The insect has also been detected in nearby Granville, Vance and Person Counties resulting in an EAB quarantine in these areas.

Based on the complete inventory dataset of 17,855 trees, Wake Forest has 101 ash trees and 1 white fringe-tree in public rights-of-way. To view a map of the location of these trees see Appendix B. However, the larger concern for the Town's tree population is the large number of ash trees located on private property, in open spaces within neighborhoods, and forested areas. The Wake Forest Urban Forestry Coordinator is working with representatives from the North Carolina Department of Agriculture & Consumer Services and the NC Forest Service to develop an action plan to address the monitoring, treatment, removal and replacement of ash trees over the next 10 years.

FIGURE # 20: Key Characteristics for Ash (*Fraxinus*) Tree and Emerald Ash Borer (*Agrilus planipennis*) Identification

Photo Source: www.csfs.colostate.edu

Work Management Plan,

Staffing & Budget

Street Tree Management Priorities

In order to minimize the risks and costs and maximize the long-term value of the public trees, the following management activities are recommended, in order of descending priority:

1) Inventory all trees, inspect potential risk trees, and maintain inventory by inspecting 1/5 of the Town's trees annually. This will ensure the safety of people and property and ensure that accurate information is used to guide management decisions.
2) Remove any high-risk trees and correct any dangerous structural issues such as dead limbs and weak forks to ensure public safety.
3) Maintain large trees, particularly in heavily used parks and Town property, as these are the Town's most valuable trees and also those most likely to become hazardous if not maintained.
4) Increase the frequency of pruning cycles to correct and prevent problems that become more difficult or impossible to address in the future.
5) Create a plan to respond to trees damaged by storms.
6) Maintain young trees to prevent problems that may become public safety concerns in the future, or which could lead to the decline or death of the tree in the future.
    a. Remove stakes and ties that are no longer needed.
    b. Prune for structure and clearance.
    c. Excavate root collars and correct girdling roots.
    d. Provide mulch and water to ensure survival and increase growth rate.
7) Maintain pests and diseases at an acceptable level using an integrated pest management (IPM) approach. Reduce the number of willow oak and maple plantings.
8) Replace trees that have been recently removed.
9) Plant additional trees in available spaces using inexpensive stock and volunteers where possible.
10) Plant resilient and well-suited tree species and maintain a 10/20/30 diversity target. Remove species from the planting list that are not performing well based on their Relative Performance Index values and observations made in future inventories.

Urban Forest Management Priorities

1) Complete an updated aerial tree canopy assessment that looks at the extent of canopy cover and available planting space town wide, by land use, management areas, and other boundaries.
2) In order to increase the benefits that trees provide, an urban forest canopy cover goal should be established based on an updated aerial tree canopy assessment town wide.
3) Identify areas of below-average coverage and encourage measures to preserve and expand tree canopy coverage.

4) Continue to purchase and preserve forested open space to offset canopy loss due to new development.

Urban Forest Program Priorities

The following provides general recommendations relating to Wake Forest's urban forestry program. A more comprehensive list of recommendations, strategies, and measures are under development by Town staff which involves an analysis of the Town's urban forestry program and engagement of stakeholders and the community. Detailed recommendations for tree maintenance are provided in the Overview of Tree Management Needs section.

INVENTORY DATA
1) Assign staff and protocols for adding, editing, removing, and updating trees and maintenance needs.
2) Identify and involve stakeholders so that they become familiar with the inventory database and provide input on how best to use information for urban forestry program development.
3) Place a link to the tree inventory on the Town's website, create accounts for other department use. Database should be maintained and kept current as trees are planted, replaced, maintained, and reassessed.

PLAN DEVELOPMENT
1) Develop thorough recommendations based on this Plan and an urban forestry program analysis.
2) Develop strategies to achieve the goals and recommendations.
3) Develop measurements and milestones that monitor progress towards achieving goals and allows for adaptive management.

URBAN FORESTRY PROGRAM
1) Develop street tree planting master plans that balance tree functions, diversity, design, and neighborhood character. Include an updated tree species list.
2) Enhance and develop programs that encourage active participation by volunteers such as the Tree Steward Program.
3) Strengthen working relationships and partnerships with businesses, organizations, and contractors whose activities impact Town trees by instituting regular dialogue and project coordination.
4) Continue to seek support for urban forestry projects through grants, private donations, and volunteer assistance.
5) Hire Arborist Technicians and interns as needed based on the analysis of the Urban Forestry Program.
6) Review the Town's tree ordinances and revise as needed.
7) Integrate the Urban Forest Management Plan with other Town and regional plans and initiatives.
8) Continue to implement the Trees for Tomorrow program and distribute the Citizen's Guide to Trees in the Community brochure.
9) Obtain the highest and best use of wood from trees removed by the Town.
10) Systematically review progress towards achieving Urban Forest Management Plan recommendations and goals. Adjust accordingly as part of an adaptive management process.

An Overview of Tree Management Needs

The following summaries of management needs are based on the 2017 inventory data and an assessment of the Town's program and available resources. In addition to the 2017 inventory of 1,788 trees, the Town had a comprehensive inventory completed in 2012 resulting in a database of 17,855 trees. Upkeep of the data has been limited and may be outdated. The Town has an ongoing maintenance program therefore, maintenance requirements may have changed during and after completion of the inventory. It is recommended to update the entire public tree inventory in the near future for more accurate tree management guidelines and strategies.

The 5-year plan is provided to address all aspects of tree management and budgeting in the Town. This first 5-year plan and strategy addresses the most high-risk trees and maintenance needs and marks the beginning of a routine low-risk 10-year maintenance cycle.

Maintenance Recommendations Summary

➢ The first 5-year strategy requires all high-risk maintenance to be completed.
➢ Monitor and address other trees recommended for removal.
➢ Perform a continuing routine pruning cycle for public trees, beginning in Year 1 on a 10-year rotation.
➢ Perform cyclical pruning of young trees (<6" DBH), beginning in Year 1, dispersed over 5 years.
➢ Develop plans for the aftercare of newly planted trees which may include watering, mulching, staking, and pruning.

HIGH-RISK AND RECOMMENDED TREE REMOVALS

The 2017 tree inventory did not identify any high-risk trees requiring removal. Ongoing inventories, surveys, and the Town's service request system should be utilized to identify any high-risk trees. Those trees should be reviewed, prioritized, and addressed accordingly. Addressing these maintenance needs as soon as possible will help to prevent or reduce potential risks. It is understood that the Town will not be able to perform all needed activities immediately due to budget constraints, but a systematic program will achieve the requirements timely and demonstrate the proactive efforts pursued by the Town.

The 2017 inventory focused primarily on trees less than 6 inches in diameter. This inventory does include trees recommended for removal but do not pose a high risk. Figure # 18, on the next page, shows the summary of trees to be removed by diameter class. Cost for maintenance, specifically removals, is often determined by the tree's size. Additional trees beyond what was observed from the 2017 tree inventory will likely also need to be removed.

FIGURE # 21: Summary of Recommended Removals by Diameter Class (2017 Trees)
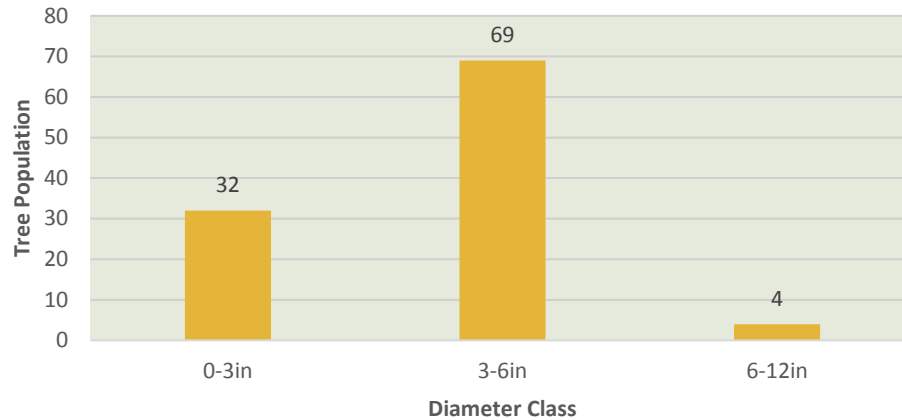
Based on the 2017 inventory, a total of 181 trees were recommended for removal. Following the inventory, the Town actively addressed many of the necessary removals. Figure # 21, above, summarizes the remaining trees from the 2017 inventory that require removal (105 trees). The 105 trees need to be prioritized based on DBH, likelihood of failure, likelihood of impacting a target, consequence of failure, location, and other maintenance schedules. Any high-risk trees identified beyond these trees should be addressed first. The Maintenance Worksheet provides suggested schedules for trees recommended for removal.

The Town should also plan for natural mortality that occurs in a tree population. It is estimated that for tree populations in urban areas, 1% die annually from natural causes or harsh conditions of urban environments. With a total of 17,855 trees (as of March 2018) currently in the Town inventory database and accounting for the removals identified above, the Town may experience a mortality rate of approximately 180 trees per year and maintenance budgets should account for these.

ROUTINE TREE MAINTENANCE

Trees that have been inventoried that require priority maintenance that doesn't involve removal were assigned Tree Work. The types of tree maintenance to address immediately include a large hazardous broken limb that needs to be removed, large deadwood in a high traffic area, or other situations that warrant immediate care. The following summarizes the maintenance needs as of March 2018.

Tree Pruning Best Practices
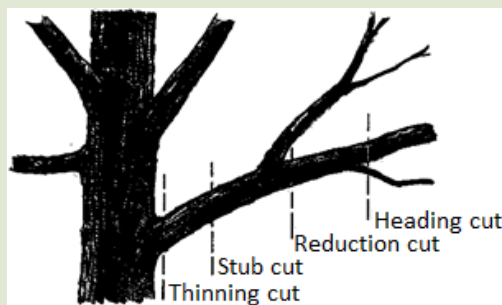
Types of pruning cuts.

Source of Images: Plan-It Geo photo stock
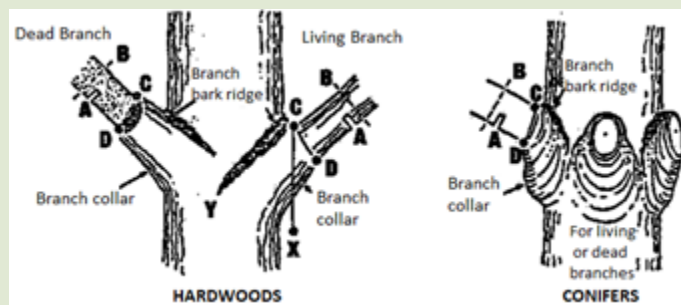
Natural target pruning properly removes a branch while protecting the branch collar, which is essential for wounds to heal. First cut A, second cut B, and third cut C-D

Routine pruning includes crown cleaning, clearance pruning, crown reduction, structural pruning, restoration pruning, and training pruning (>6 inches DBH). Routine pruning should be completed for established trees along streets and in parks and open space. Routine maintenance is more efficient and cost effective, potentially reducing per-tree maintenance costs by as much as 50 percent by leveraging economies of scale from block pruning instead of emergency and service request response. Routine maintenance would further reduce costs by releasing the Town from a portion of claims payments, as the Town can effectively argue that it took all necessary precautions to assess and maintain trees.

Routine pruning should be conducted on a cyclical basis for all public trees to increase the safety and overall health and longevity of the tree population. This section summarizes trees needing routine pruning and the appropriate schedules generally for trees greater than 6 inches in diameter. Young tree pruning is addressed in a later section. Routine cyclical pruning should be conducted using already established zones such as Town subdivisions or by creating new management zones to distribute the pruning cycles evenly throughout the Town.

Of the 17,855 total trees in the inventory, 5,218 trees are greater than 6 inches in diameter. The 2017 inventory of 1,788 trees identified 1,372 trees as needing pruned (e.g. clearance, structural, cleaning). Though this plan focuses on a 5-year time span, the available budget, staff, resources, and inventory data require a 10-year pruning cycle to be implemented for all trees greater than 6 inches in diameter. The Town should address maintenance of these 1,372 trees following a routine pruning cycle. As a result, approximately 522 trees should be routinely pruned each year. Plans for action should be in place for emergency maintenance to trees not included in the inventory. All public trees should be included in this rotation and the Town should update the comprehensive tree inventory.

More consideration and priority should be placed on trees within the Town's rights-of-way and the trees in parks where target risk is greatest. Table # 5 below shows a total count and number of trees to be pruned per year for each size class, excluding trees with a 0-3" and 3-6" DBH since they are on a separate pruning cycle. Note, this is based on the complete inventory dataset (17,855 trees)

TABLE #5 : Routine 10-Year Pruning Cycle for Trees >6" Diameter (All Trees)

DBH Class	Count	Routine Prune (Trees/Year)	% of Total Trees >6" DBH
6-12in	3,835	384	73%
12-18in	842	84	16%
18-24in	282	28	5%
24-30in	116	12	2%
>30	143	14	3%
TOTAL	5,218	522	100%

Young Tree Pruning

Young tree pruning is described separately because the Town should address these with a different approach than routine pruning. Young tree pruning is conducted to "train" the trees by removing dead, dying, diseased, broken, interfering, conflicting, and/or weak branches and to direct future branch growth. This maintenance is performed in order to develop a strong structural architecture at an early stage when costs are much lower.

Young tree pruning should not occur before three years of their planting date in order to prevent additional stress placed on the tree. Generally, it is recommended that young tree pruning be completed for all trees that are less than 6 inches in diameter on a one-year cyclical basis. The one-year cycle is designated for new trees because of the faster growth rates for most species.

According to the inventory database of 17,855 trees and shown in Table #6 below, a total of 12,578 trees are less than 6 inches in diameter and comprise 70% of the total tree inventory. 6,097 trees are in the 0-3-inch DBH range and 6,481 trees are in the 3-6-inch DBH range. As recommended above, the young tree pruning should be completed in one year but because of the large quantity of trees in this size class, it is not feasible to complete in one year. It is recommended to complete the young tree pruning in five years, distributed evenly each year. This results in a total of 2,516 trees per year. Though resources may be limited, young tree pruning can be completed throughout the year and require very few tools or equipment (e.g. no bucket truck). Also, volunteers and interns can be trained for this type of work.

This aggressive young tree pruning cycle is recommended so that the Town can bring each young tree to the same level of maintenance need. Starting in year 4 after this implementation, additional young trees will need to be pruned to account for new trees that were planted as a result of this Plan and the Town's goals to increase canopy, diversity, and maintain, at minimum, a no net loss policy.

TABLE # 6: Young Tree 5-Year Pruning Cycle for Trees <6" Diameter (All Trees)

DBH Class	Count	Routine Prune (Trees/Year)	% of Total Trees <6" DBH
0-3in	6,097	1,219	48%
3-6in	6,481	1,296	52%
TOTAL	12,578	2,516	100%

Young Tree Pruning

Training of staff and volunteers for young tree pruning

Source of Images: Plan-It Geo photo stock
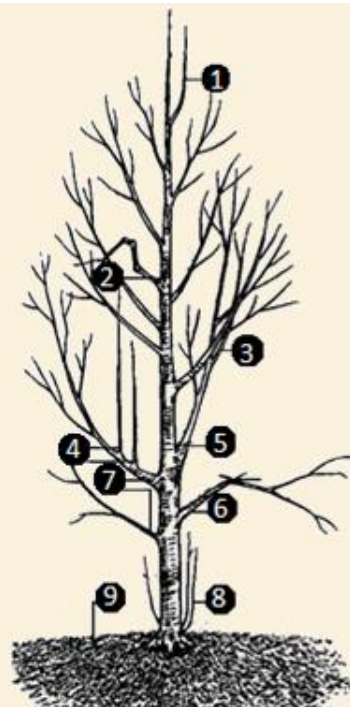
1. Prune competing leader
2. Prune malformed branches
3. Remove crossing branches
4. Remove water sprouts
5. Remove branches with poor angles
6. Prune broken or damaged branches
7. Prune temporary branches over time
8. Remove suckers
9. Apply 2-3" of mulch

Proper young tree pruning

WORK MANAGEMENT PLAN, STAFFING & BUDGET

Tree Management Schedules and Budget Recommendations

The following work plan and budget is established for a 5-year program budget for all relevant tree maintenance activities and based on an assessment of existing resources. The previous section provided the information to develop the prioritized and cyclical maintenance plan in this section. This section is intended to provide an example of relative costs that could be incurred by the recommended activities to fulfill a sustaining urban forest and program. The budgeting recommendations are estimates based on proper urban forest management procedures and Town forestry operations. Over the course of the 5-year timespan, the work plan should be adjusted to account for changes in the urban forest and resources.

MANAGEMENT PROGRAM BUDGET

The following table estimates the total in-house versus contractual costs of tree pruning by tree size class for all tree's in the Town's inventory database based on the American Public Works Association's Urban Forestry Best Management Practices for Public Works Managers publication (page 8).

TABLE # 7: Estimated Hours and Costs of Pruning In-House and Contracted by Tree Size Class

Tree Size Class	0-6"	7-12"	13-24"	25-36"	36"+	Total
Total Trees	12,578	3,613	1,021	174	76	17,462
Hours to Prune	1.0	1.4	3.5	6.3	7.0	NA
Total Time (hrs)	12,578	5,058	3,574	1,096	532	22,838
In-House Costs[1]	$320,739	$128,984	$91,124	$27,953	$13,566	$582,366
Contractual Costs[2]	$735,813	$404,656	$285,880	$87,696	$42,560	$1,556,605
In-House Savings	$415,074	$275,672	$194,756	$59,743	$28,994	$974,239

[1] Uses the average ($25.50) from the 2013 UFMP in-house cost range of $18-$33/hour
[2] Uses the average ($58.50) from the 2013 UFMP contracted cost range of $39-$78/hour for young tree pruning and $80/hour for large tree pruning

As tree size increases, the costs for pruning increase. It should be noted that performing pruning in-house offers considerable savings to the Town with a total $974,239 saved if all trees were to be pruned in-house. The following table lists the costs based on industry estimates and is to be considered equivalent to maintenance costs performed in-house (US Forest Service Piedmont Community Tree Guide).

TABLE # 8: Per Tree Cost Estimates by Size Class for Removals and Planting

DBH Range	Removal Cost	Stump Removal	Tree Planting
0-3in	$25	$25	
3-6in	$105	$25	
6-12in	$220	$25	
12-18in	$355	$40	~$500/tree
18-24in	$525	$60	
24-30in	$845	$85	
>30in*	$1,140	$110	

Annual Work Schedule for Community Trees (Each dot in chart below = one week/month. Circle dot(s) to show when work will be done.)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Example: Work to be done first two weeks of May.	. . . .	. . . .	. . . .	. . . .	⟳ . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
1. Planning and administration												
a. prioritize work to be done	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
b. organize activities	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
2. Tree planting												
a. survey potential planting sites	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
b. decide locations, species, and cultivars	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
c. notify adjacent property owners	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
d. announce and hold public hearing	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
e. order trees	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
f. inspect and tag trees in nursery	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
g. receive, inspect, and store trees	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
h. plant trees, prune, stake, and water	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
i. water trees periodically	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
3. Tree pruning												
a. survey trees, decide which to prune	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .

TABLE # 9: Example Annual Work Schedule for Community Trees (https://extension.psu.edu/annual-work-plans-for-tree-commissions - click "Download PDF")

The costs presented in Table # 8 on page 34, show that as a tree's size increases, so does the cost to remove. These costs are used to estimate the budget for implementing the maintenance recommendations for high-risk trees, recommended removals, routine pruning, young tree pruning, stump removal, and planting. The following table provides an example of an annual work schedule. See Appendix I for the complete worksheet.

To estimate costs by tree management activity, each maintenance task is divided by either a 5-year or 10-year rotation depending on the urgency of the given task (see Figure # 22 below). The following illustration summarizes the methodology.

FIGURE # 22: Diagram for Utilizing the Maintenance Program Budget Worksheet
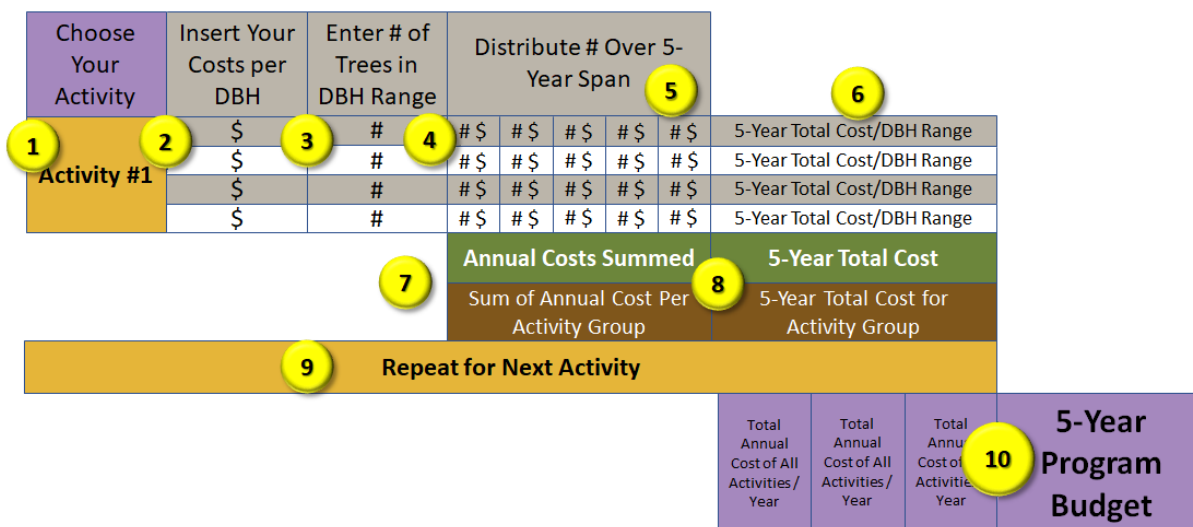
Continue to the next page to view the initial Work Management Plan and Budget
(Actual worksheet available as a Microsoft Excel file)

TABLE #: Estimated Budget for the Maintenance Tasks of All Inventoried Public Trees (removals based on 2017 inventory)

Estimated Costs for Each Activity				Year 1		Year 2		Year 3		Year 4		Year 5		5-Year
Activity	DBH Range	Cost/Tree	Total # of Trees	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	Total Cost
High-Risk Removals[1] (with stump removal cost added)	0-3in	$50	0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	3-6in	$130	0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	6-12in	$245	0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	12-18in	$395	0		$0		$0		$0		$0		$0	$0
	18-24in	$585	0		$0		$0		$0		$0		$0	$0
	24-30in	$930	0		$0		$0		$0		$0		$0	$0
	>30in	$1,250	0		$0		$0		$0		$0		$0	$0
Activity Total			0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Natural Mortality Removals (1%)[2]	Removals	$512	178	36	$18,227	36	$18,227.20	36	$18,227.20	36	$18,227	36	$18,227	$91,136
Activity Total			178	36	$18,227	36	$18,227	36	$18,227	36	$18,227	36	$18,227	$91,136
Low-Risk Removals (with stump removal cost added)	0-3in	$50	76	15	$760	15	$760	15	$760	15	$760	15	$760	$3,800
	3-6in	$130	100	20	$2,600	20	$2,600	20	$2,600	20	$2,600	20	$2,600	$13,000
	6-12in	$245	5	5	$1,225	0	$0	0	$0	0	$0	0	$0	$1,225
	12-18in	$395	0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	18-24in	$585	0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	24-30in	$930	0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	>30in	$1,250	0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total			181	40	$4,585	35	$3,360	35	$3,360	35	$3,360	35	$3,360	$18,025
Projected Removal Costs					$22,812		$21,587		$21,587		$21,587		$21,587	$109,161
Routine Pruning[3]	6-12in	$75	3,835	384	$28,763	384	$28,763	384	$28,763	384	$28,763	384	$28,763	$143,813
	12-18in	$120	842	84	$10,104	84	$10,104	84	$10,104	84	$10,104	84	$10,104	$50,520
	18-24in	$170	282	28	$4,794	28	$4,794	28	$4,794	28	$4,794	28	$4,794	$23,970
	24-30in	$225	116	12	$2,610	12	$2,610	12	$2,610	12	$2,610	12	$2,610	$13,050
	>30in	$305	143	14	$4,362	14	$4,362	14	$4,362	14	$4,362	14	$4,362	$21,808
Activity Total			5,218	522	$50,632	522	$50,632	522	$50,632	522	$50,632	522	$50,632	$253,160
Young Tree Pruning[4]	0-3in	$20	6,097	1,219	$24,388	1,219	$24,388	1,219	$24,388	1,289	$25,788	1,289	$25,788	$124,740
	3-6in	$30	6,481	1,296	$38,886	1,296	$38,886	1,296	$38,886	1,296	$38,886	1,296	$38,886	$194,430
Activity Total			12,578	2,516	$63,274	2,516	$63,274	2,516	$63,274	2,586	$64,674	2,586	$64,674	$319,170
Projected Pruning Costs					$113,906		$113,906		$113,906		$115,306		$115,306	$572,330
Tree Planting[5]		$500	350	70	$35,000	70	$35,000	70	$35,000	70	$35,000	70	$35,000	$175,000
Activity Total			350	70	$35,000	70	$35,000	70	$35,000	70	$35,000	70	$35,000	$175,000
Projected Planting Costs					$35,000		$35,000		$35,000		$35,000		$35,000	$175,000
Projected Budget					$171,718		$170,493		$170,493		$171,893		$171,893	$856,491

1 Address any high-risk trees as soon as possible (none noted in the 2017 inventory)
2 Based on average cost of removal and 1% natural mortality of the 17,855 inventoried trees
3 Based on a 10-year cycle and all trees assigned a DBH >6" (5,218 trees)
4 Accounts for an additional 70 trees planted per year for no net loss which get pruned after 2 years planted
5 Accounts for removals and natural mortality equal to 70 trees for a no net loss policy

Summary of Inventory Analysis & Recommendations

CANOPY COVERAGE	
Canopy Coverage, 2010	44%
Recommended canopy goal	50%

STREET TREES	
Current street trees	17,855
Available planting spaces	2,612
Total replacement value of street trees	21,400,000
Current annual benefits of street trees	$447,540
Predominant species (all trees)	Red oaks, red and Freeman maple, crapemyrtle
Trees in "Good" condition (2017 trees)	43%
Predominant maintenance needs (2017 trees)	Structural pruning, root flare excavation
STREET TREE VALUES, COSTS, AND BENEFITS	
Average street tree replacement value	$1200
Average annual benefits per tree	$26.71
Per tree annual spending	$13.72
Benefit/cost ratio for street trees	1.9:1
FORESTS	
Percentage of forest cover in town limits	29%
Acres of forest owned by town (2010)	630
STAFFING AND BUDGET	
Current FTE	2
Current program funding	$224,465
Value of volunteer service, 2017	$15,366

Recommendations

This section to be completed after all other sections completed.

Summarize Street Tree, Urban Forest, and Program Priorities/Recommendations listed in the Work Management Plan, Staffing & Budget section. Sections that remain to be completed in the Work Management Plan, Staffing & Budget section include (based on the 2013 UFMP):

- Updated Levels of Service
- Contractor and staff street tree work costs
- Additional responsibilities
- Program staff and volunteers
- Vehicles, tools, and equipment
- Urban forestry program budget

Urban Forest Resource Analysis & Summary section

- Complete the Canopy Coverage and Town Forests sections
- No Replacement Value or Replacement Value by species calculations were completed. Must enter inventory data into i-Tree Streets

Other tasks:

- Complete the Introduction & Background section
- Add figure, table, and appendix #'s
- Add the figure, table, and appendix #'s when referenced in the text
- Complete the Table of Contents
- Add page numbers
- Remove highlights

Appendices

Appendix A: Map of Trees Requiring Plant Health Care

Appendix B: Location of Ash and Fringe trees

Appendix C: Trees Requiring Pruning or Removal (All)

Appendix D: Primary Maintenance Needs (2017 Trees)

Appendix E: Tree Risk Ratings (2017 Trees)

Appendix F: Tree Pruning by Diameter Class (All)

Appendix G: Small Trees Requiring Structural Pruning, Root Flare Excavation, Mulch, and/or Root Corrections by Condition (All)

Appendix H: Small Trees Requiring Structural Pruning, Root Flare Excavation, and/or Girdling Root Correction (2017 Trees)

Appendix I: Example Annual Work Schedule Sheet

Appendix J: Urban Forestry Resources

Appendix A: Map of Trees Requiring Plant Health Care
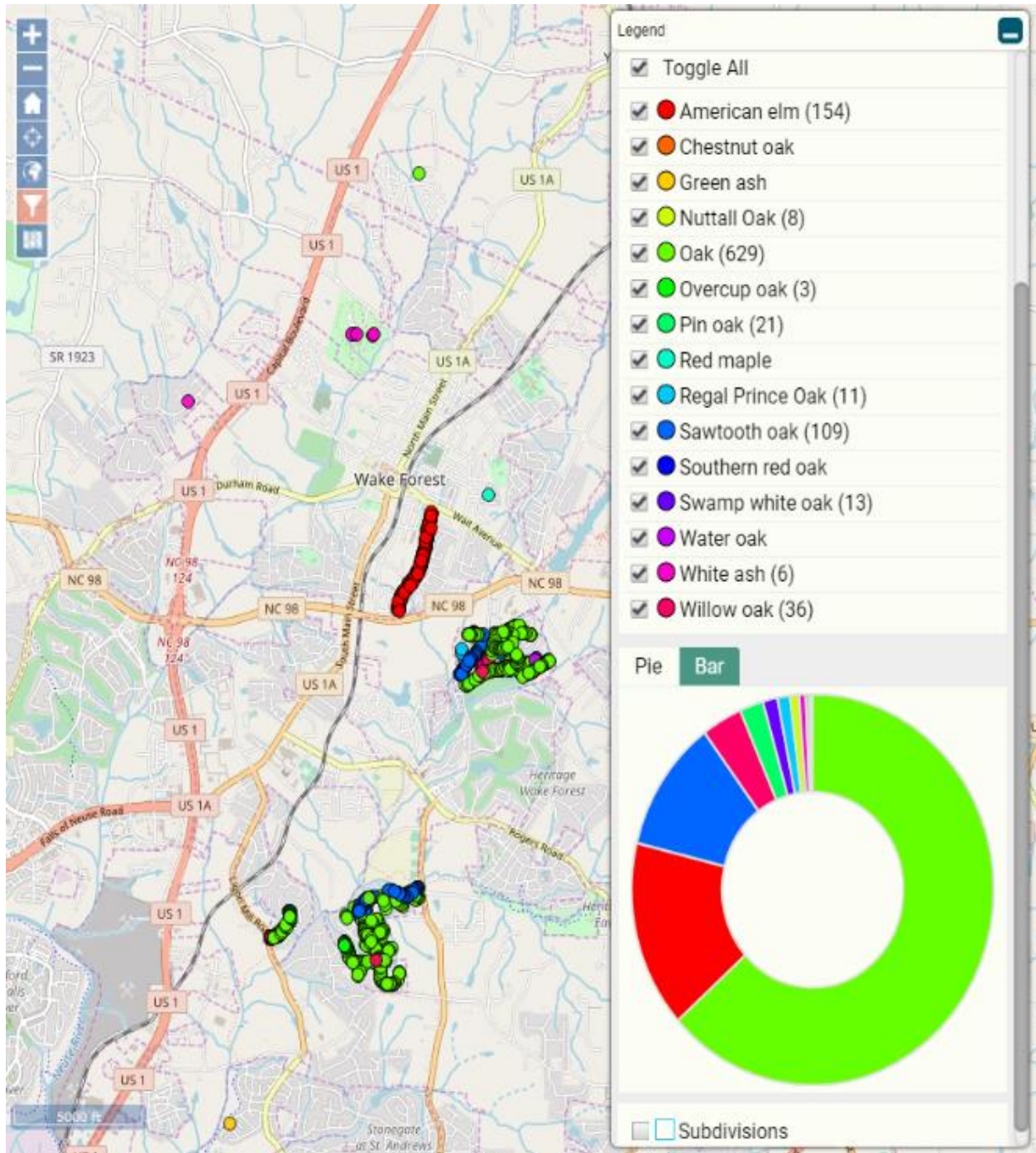
Appendix B: Location of Ash and Fringe trees
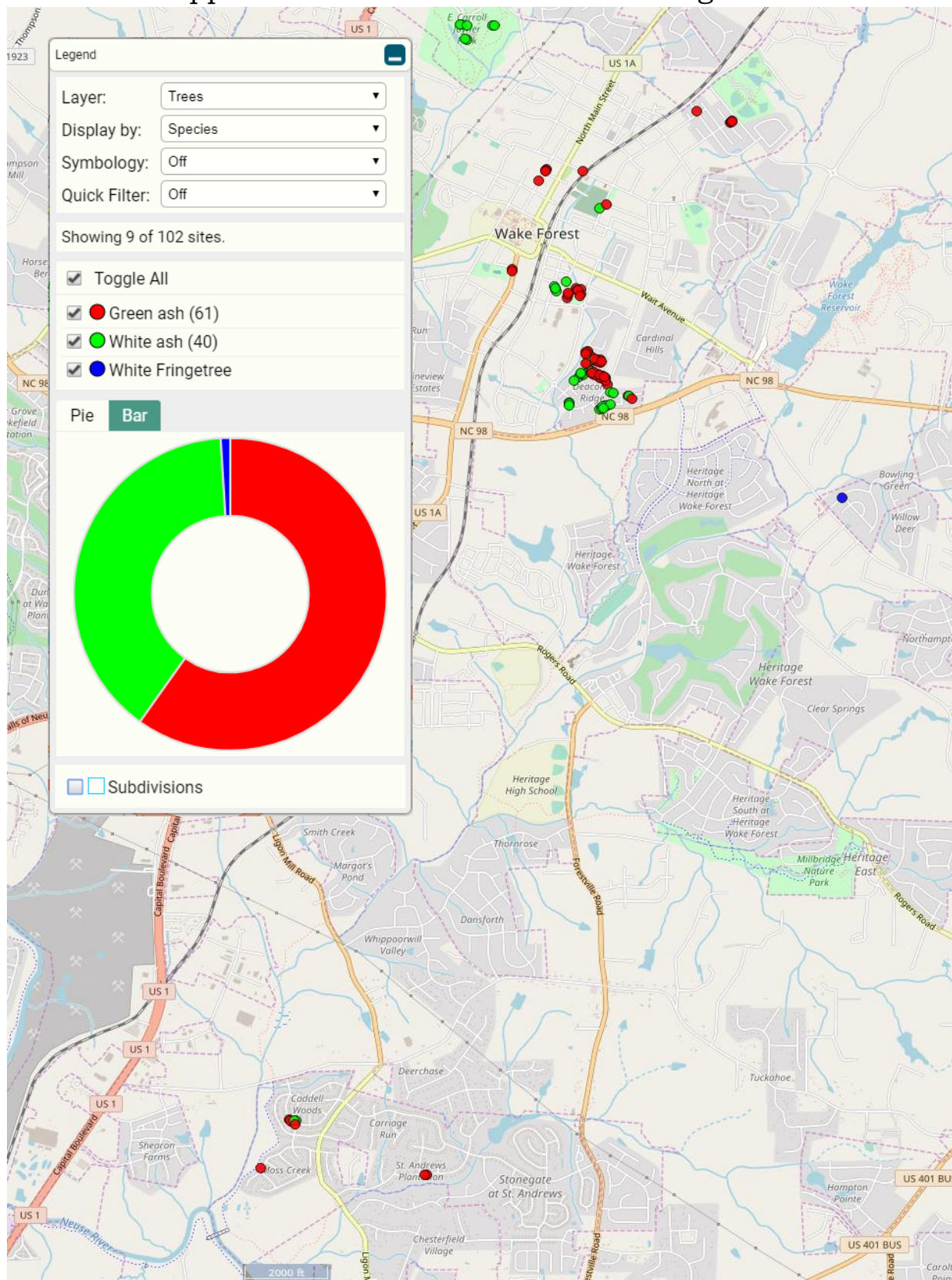
Appendix C: Trees Requiring Pruning or Removal (All)
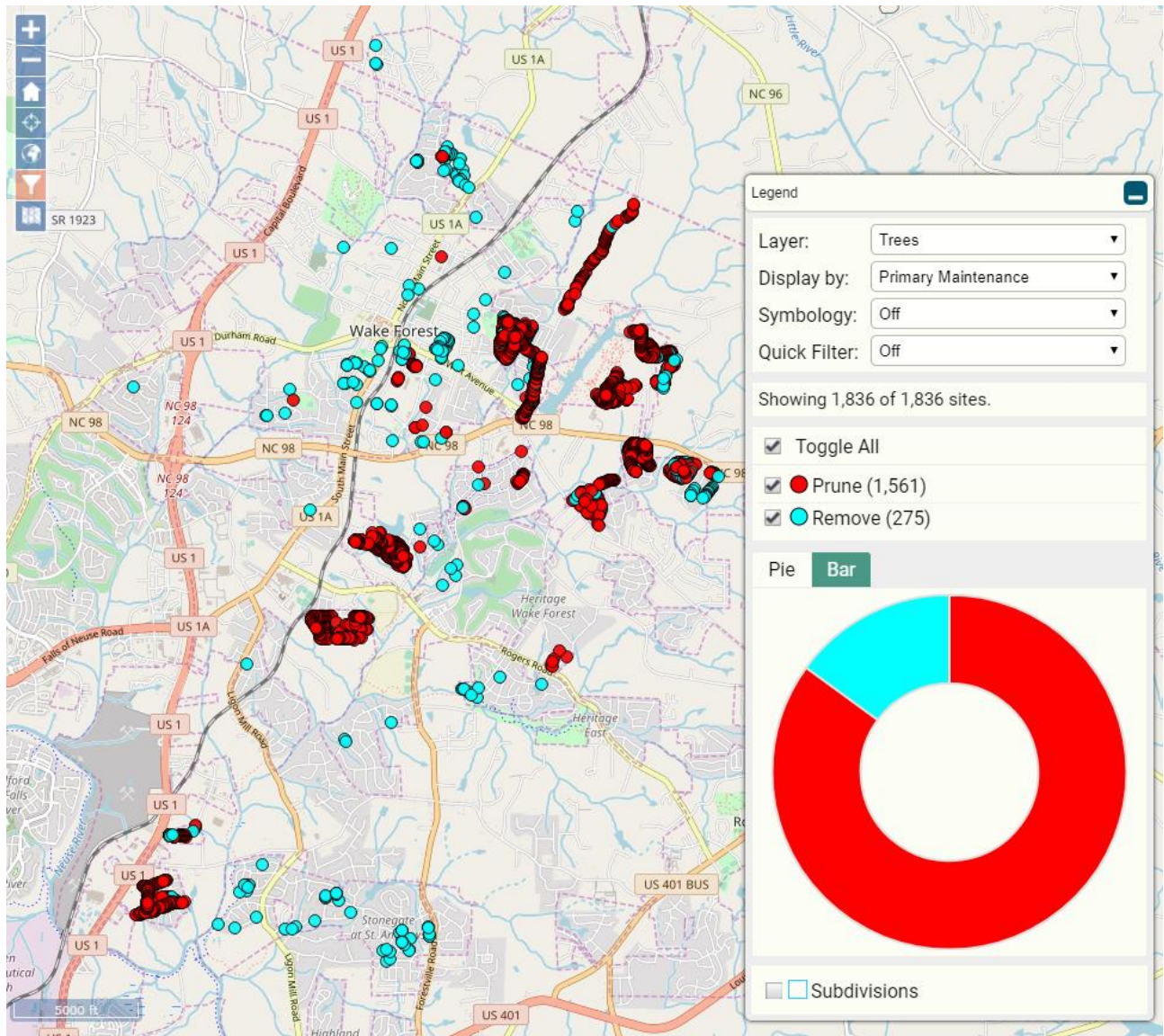
Appendix D: Primary Maintenance Needs (2017 Trees)
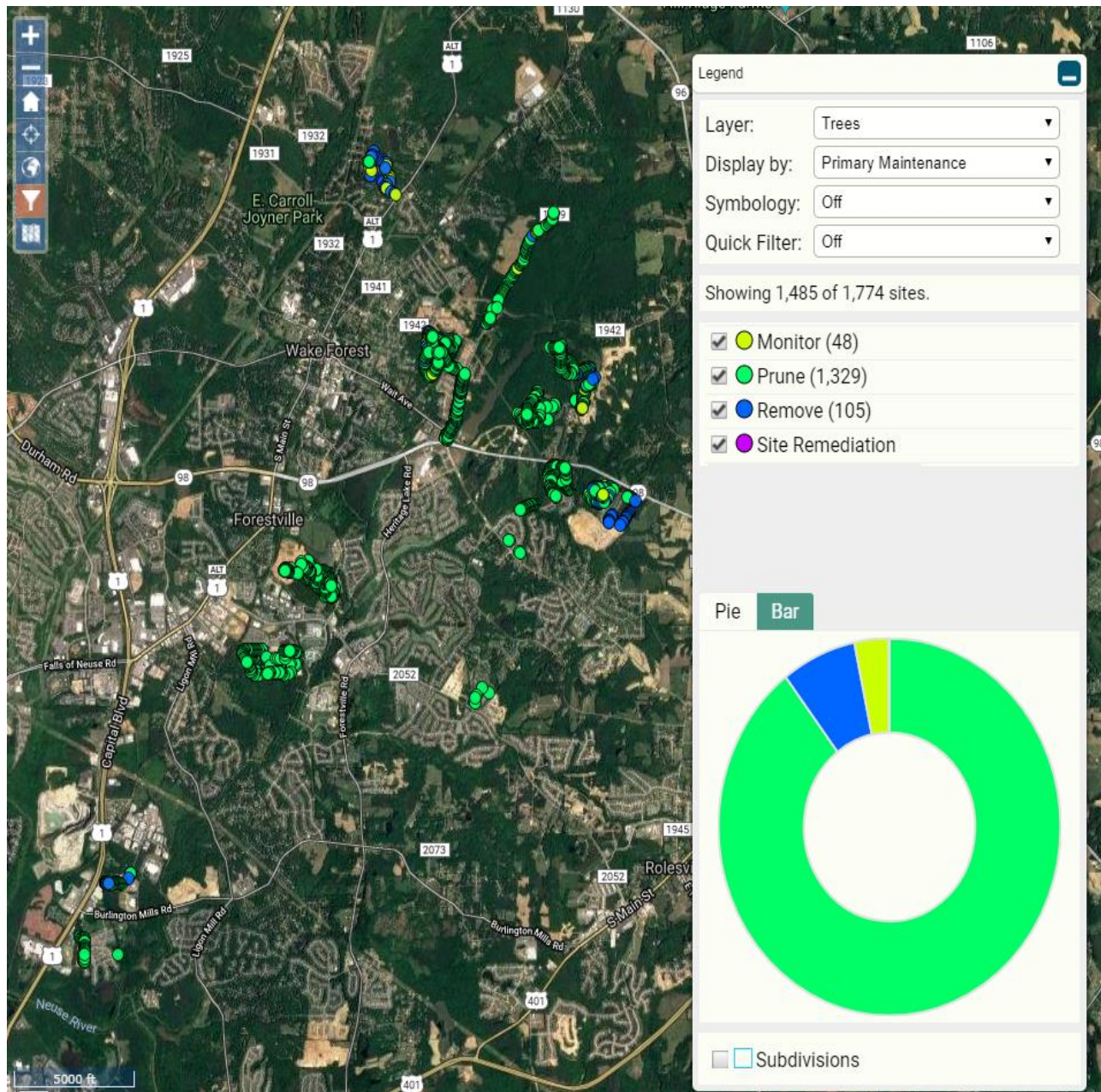
Appendix E: Tree Risk Ratings (2017 Trees)

12 trees with Low Risk Rating and 1 tree with Moderate Risk Rating

Appendix F: Tree Pruning by Diameter Class (All)

Legend

Current Filter: (Tree Work='Crown Clean' or
Tree Work='Crown Raise' or
Tree Work='Crown Reduction' or
Tree Work='Crown Restoration' or
Tree Work='Crown Structure' or
Tree Work='Crown Thin' or
Tree Work='Deadwood > 2 inches')

Showing 1,647 of 1,647 sites.

☑ Toggle All

☑ 🟢 0-3in (537)
☑ 🟢 3-6in (808)
☑ 🟡 6-12in (211)
☑ 🟠 12-18in (86)
☑ 🟠 18-24in (4)
☑ 🔴 >30in

Pie | Bar

☐ ☐ Subdivisions
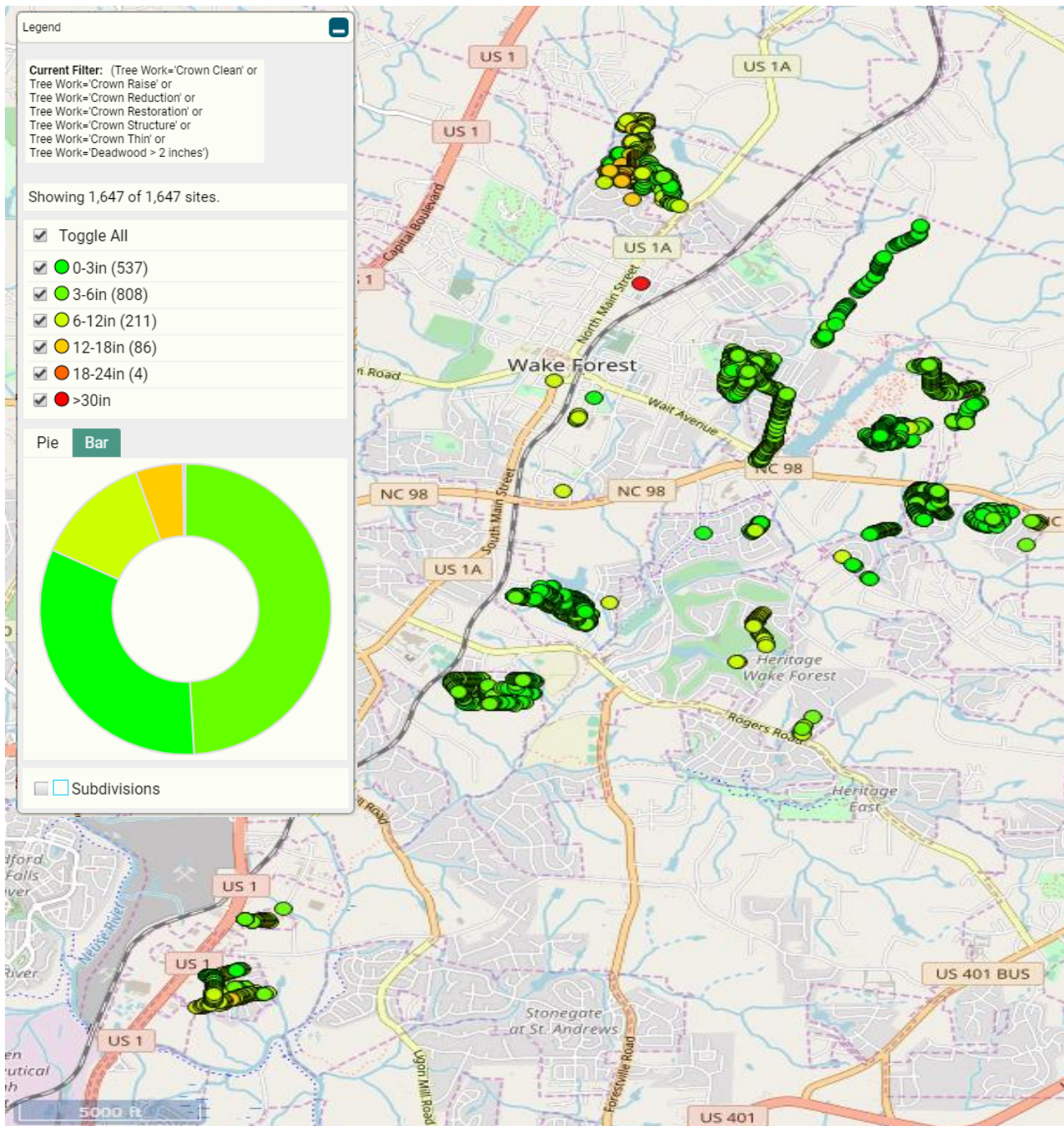
Appendix G: Small Trees Requiring Health Care and Corrections (2017 Trees)

See Tree Inventory Workbook for location and information regarding these trees.
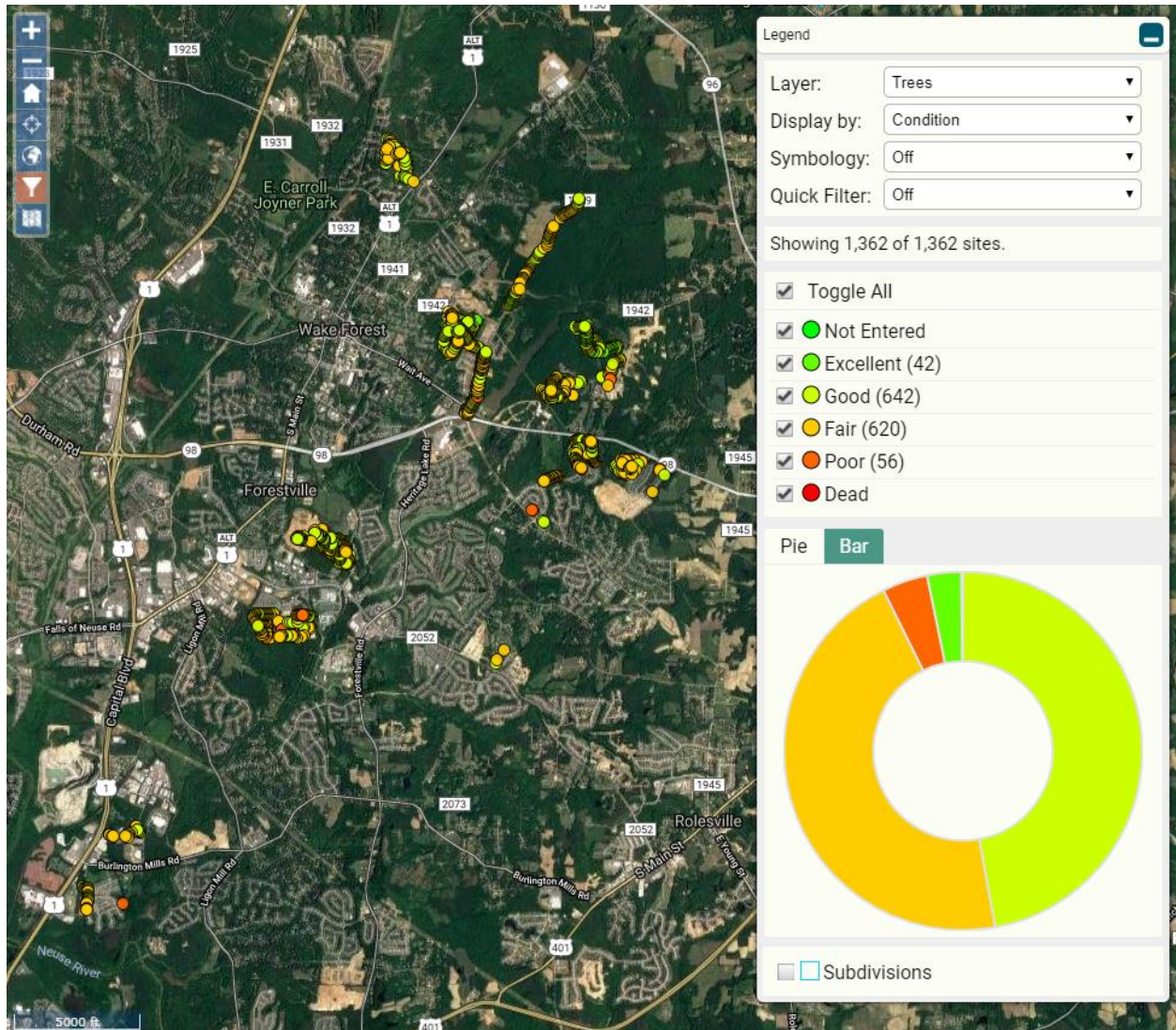
Appendix H: Small Trees Requiring Health Care and Corrections (All)

Appendix I: Example Annual Work Schedule Sheet

Annual Work Schedule for Community Trees (Each dot in chart below = one week/month. Circle dot(s) to show when work will be done.)

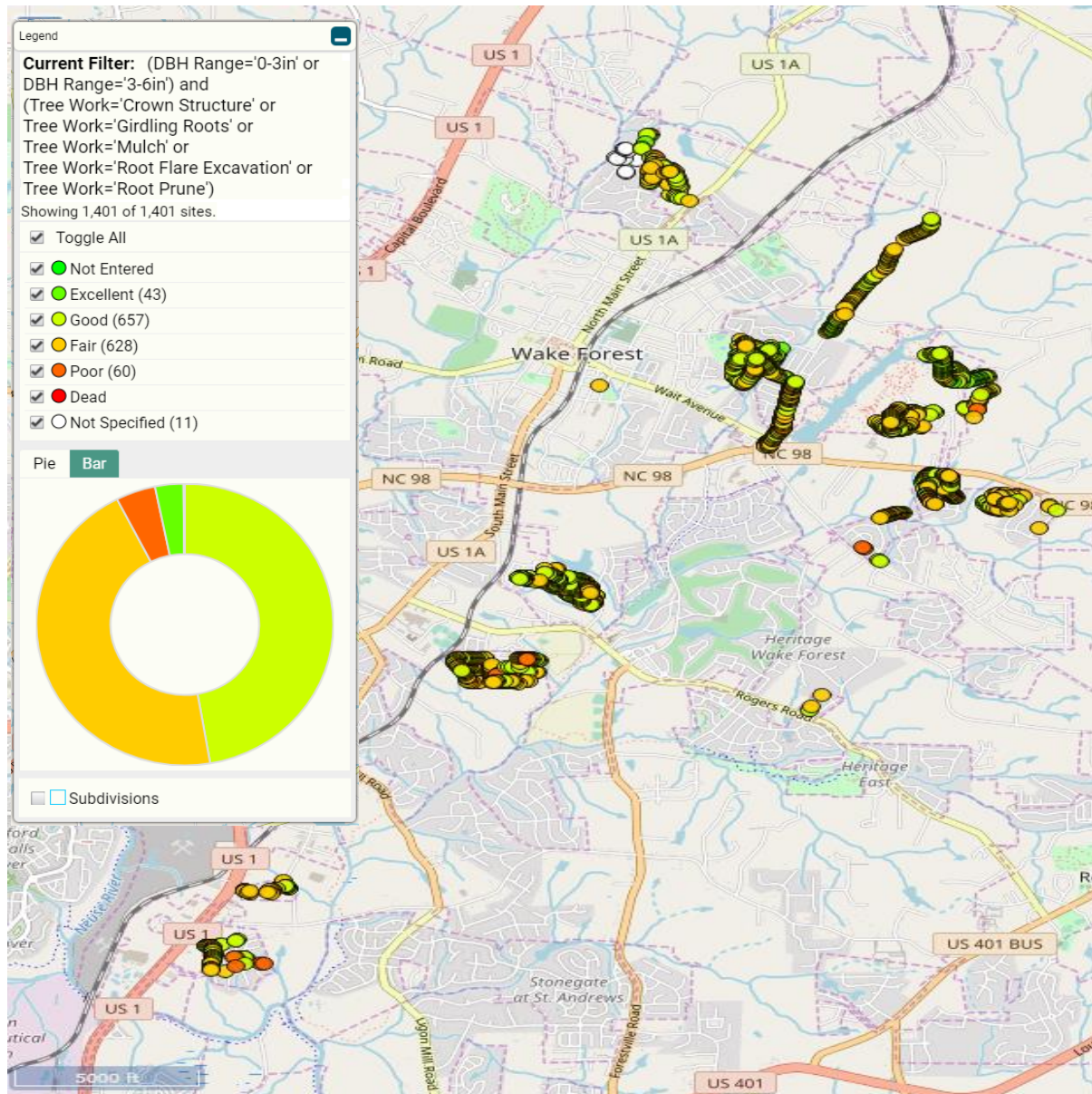|	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Example: Work to be done first two weeks of May.	....	....	....	....	....	....	....	....	....	....	....	....
1. Planning and administration												
a. prioritize work to be done	....	....	....	....	....	....	....	....	....	....	....	....
b. organize activities	....	....	....	....	....	....	....	....	....	....	....	....
2. Tree planting												
a. survey potential planting sites	....	....	....	....	....	....	....	....	....	....	....	....
b. decide locations, species, and cultivars	....	....	....	....	....	....	....	....	....	....	....	....
c. notify adjacent property owners	....	....	....	....	....	....	....	....	....	....	....	....
d. announce and hold public hearing	....	....	....	....	....	....	....	....	....	....	....	....
e. order trees	....	....	....	....	....	....	....	....	....	....	....	....
f. inspect and tag trees in nursery	....	....	....	....	....	....	....	....	....	....	....	....
g. receive, inspect, and store trees	....	....	....	....	....	....	....	....	....	....	....	....
h. plant trees, prune, stake, and water	....	....	....	....	....	....	....	....	....	....	....	....
i. water trees periodically	....	....	....	....	....	....	....	....	....	....	....	....
3. Tree pruning												
a. survey trees, decide which to prune	....	....	....	....	....	....	....	....	....	....	....	....
b. arrange for crew, equipment, and supplies,	....	....	....	....	....	....	....	....	....	....	....	....
or arrange for service contract	....	....	....	....	....	....	....	....	....	....	....	....
c. supervise pruning and disposal of wastes	....	....	....	....	....	....	....	....	....	....	....	....
4. Tree removal												
a. survey trees, decide on removals	....	....	....	....	....	....	....	....	....	....	....	....
b. notify adjacent property owners	....	....	....	....	....	....	....	....	....	....	....	....
c. announce and hold public hearings	....	....	....	....	....	....	....	....	....	....	....	....
d. arrange for crew, equipment, and supplies,	....	....	....	....	....	....	....	....	....	....	....	....
or arrange for service contract	....	....	....	....	....	....	....	....	....	....	....	....
e. supervise removals	....	....	....	....	....	....	....	....	....	....	....	....
f. grind stumps, reseed	....	....	....	....	....	....	....	....	....	....	....	....
5. Public relations and funding												
a. report to municipal officials	....	....	....	....	....	....	....	....	....	....	....	....
b. prepare news releases	....	....	....	....	....	....	....	....	....	....	....	....
c. arrange news and TV coverage of events	....	....	....	....	....	....	....	....	....	....	....	....
d. submit Tree City USA application	....	....	....	....	....	....	....	....	....	....	....	....
e. submit grant applications	....	....	....	....	....	....	....	....	....	....	....	....
f. develop education programs	....	....	....	....	....	....	....	....	....	....	....	....
g. hold Arbor Day ceremony	....	....	....	....	....	....	....	....	....	....	....	....
h. conduct youth education	....	....	....	....	....	....	....	....	....	....	....	....
6. Other tasks												
a. water trees during drought	....	....	....	....	....	....	....	....	....	....	....	....
b. fertilize deficient trees	....	....	....	....	....	....	....	....	....	....	....	....
c. control diseases and insects, as needed	....	....	....	....	....	....	....	....	....	....	....	....
d. collect leaves and recycle	....	....	....	....	....	....	....	....	....	....	....	....
e. clean up storm breakage	....	....	....	....	....	....	....	....	....	....	....	....
f. conduct training, professional development	....	....	....	....	....	....	....	....	....	....	....	....
g. train tree workers	....	....	....	....	....	....	....	....	....	....	....	....

Appendix J: Urban Forestry Resources

WAKE FOREST URBAN FORESTRY

- Wake Forest Urban Forestry Program:
  https://www.wakeforestnc.gov/parksrecreation_urbanforestry.aspx
- Wake Forest Tree Steward Program: https://www.wakeforestnc.gov/tree-steward-program.aspx
- Wake Forest Urban Forestry Board: https://www.wakeforestnc.gov/urban-forestry-board1.aspx
- Wake Forest Tree Inventory Management Software Application: www.pg-cloud.com/WakeForest

COMMUNITY OUTREACH AND EDUCATION

- Wake Forest "Citizen's Guide to Trees in the Community":
  https://www.wakeforestnc.gov/Data/Sites/1/media/departments/communications/citizensguidet
  otrees.pdf
- NC Urban Forest Council "Tree Owner's Manual": http://treescharlotte.org/wp-
  content/uploads/2013/03/NCUFC_TreeOwner_manual.pdf
- The Nature Conservancy "Health Trees, Healthy Cities":
  https://www.conservationgateway.org/ConservationPractices/cities/hthc/Pages/default.aspx/trai
  ning-resources
- US Forest Service "Outreach Services Strategies for all Communities":
  http://actrees.org/files/What_We_Do/OutreachStrategies.pdf
- Project Learning Tree: https://forestry.ces.ncsu.edu/ncplt/

STREET TREE SELECTION

- NC Forest Service "Suggested Urban Street Trees in North Carolina":
  http://ncforestservice.gov/Urban/pdf/NCStreetTreeSuggestions.pdf
- University of FL Environmental Horticulture "Tree Fact Sheets":
  http://hort.ifas.ufl.edu/database/trees/trees_scientific.shtml
- NC Forest Service "Tree Species Selection: What to Consider":
  http://ncforestservice.gov/Urban/pdf/speciesConsiderations.pdf

EMERALD ASH BORER & OTHER PESTS

- Wake Forest Emerald Ash Borer Page: https://www.wakeforestnc.gov/emerald-ash-borer.aspx
- Emerald Ash Borer Information Network: http://www.emeraldashborer.info/about-eab.php
- NC Forest Service EAB FAQ: http://ncforestservice.gov/forest_health/fh_eabfaq.htm
- NC State University Plant Disease and Insect Clinic:
  https://projects.ncsu.edu/cals/plantpath/extension/clinic/pest-threats.html

REGIONAL URBAN FORESTRY

- NC Forest Service Urban & Community Forestry:
  http://ncforestservice.gov/Urban/Urban_Forestry.htm
- NC Urban Forest Council: www.ncufc.org
- NC State University Forest Resources Cooperative Extension:
  https://www.ces.ncsu.edu/categories/forest-resources/
- Urban Forestry South: www.urbanforestrysouth.org
- US Forest Service Urban and Community Forestry Program: www.fs.fed.us/managing-land/urban-
  forests/ucf
- Southern Regional Extension Forestry: https://sref.info/
- National Urban and Community Forestry Advisory Council: https://www.fs.fed.us/managing-
  land/urban-forests/ucf/nucfac
- American Forests: http://www.americanforests.org/
- Urban Forestry Index: www.urbanforestryindex.com
- TreeLink: www.treelink.org

- Trees Are Good: www.treesaregood.org
- American Grove: http://thegrove.americangrove.org/
- Society of Municipal Arborists: http://www.urban-forestry.com/
- Arbor Day Foundation: www.arborday.org
- Alliance for Community Trees: https://www.arborday.org/programs/alliance-for-community-trees/
- Tree Care Industry Association: http://www.tcia.org/

TREE ORDINANCES

- Guidelines for Developing and Evaluating Tree Ordinances (automatic download):
- https://ir.library.oregonstate.edu/downloads/pg15bm22x
- NC Forest Service "Developing Tree Protection Ordinances in North Carolina": http://ncforestservice.gov/Urban/pdf/treeProtection.pdf
- NC Forest Service "Protecting Trees during Construction": http://ncforestservice.gov/Urban/protecting_trees_during_construction.htm
- Sample Tree Ordinance:
- https://www.arborday.org/programs/treecityusa/documents/sample-tree-ordinance.pdf
- Charlotte, NC Tree Ordinance: https://library.municode.com/nc/charlotte/codes/code_of_ordinances?nodeId=PTIICOOR_CH21TR&searchText=
- Charlotte, NC "Tree Ordinance Checklists for Plan Submittal": http://charlottenc.gov/ld/treeordinance/Documents/Tree%20Ordinance%20Checklist%20for%20Commercial%20and%20Urban%20Plan%20Submittal.pdf
- Example Tree Contracting Specifications: https://www.springfieldmo.gov/DocumentCenter/View/11756
- Trees and Development Guidelines: http://www.a2gov.org/departments/field-operations/forestry/Pages/StreetTreesDevelopment.aspx
- American Public Works Association "Urban Forestry Best Management Practices for Public Works Managers: Ordinances, Regulations, & Public Policies": https://www2.apwa.net/Documents/About/CoopAgreements/UrbanForestry/UrbanForestry-3.pdf

URBAN FOREST STORM PREPAREDNESS

- NC Forest Service "Community Forest Storm Mitigation Planning": http://ncforestservice.gov/Urban/pdf/CFSMP_W2017.pdf
- NC Forest Service "Community Forest Storm Mitigation Plan Template" (automatic download): http://ncforestservice.gov/Urban/CFSMP_T2017.docx
- NC Forest Service "Trees After the Storm: Planning Your Response": http://ncforestservice.gov/Urban/pdf/treesAfterStorm.pdf
- NC Forest Service "Post Storm Assessment Guide to Evaluating Trees": http://ncforestservice.gov/Urban/pdf/postStorm.pdf
- NC Forest Service "Trees After the Storm: Remove, Repair or Replace?": http://ncforestservice.gov/Urban/pdf/removeRepairReplacetrees.pdf
- NC Forest Service "Tree Care Before and After a Storm": http://ncforestservice.gov/Urban/pdf/stormTreeCare.pdf

TREES AND STORMWATER

- Urban Forestry South Trees and Stormwater Links: https://www.urbanforestrysouth.org/resources/collections/trees-and-stormwater-runoff-green-infrastructure
- Urban Watershed Forestry Management: http://www.forestsforwatersheds.org/
- EPA Green Infrastructure: http://water.epa.gov/polwaste/green/upload/stormwater2streettrees.pdf

- OKI Regional Council of Governments "Trees & Stormwater": http://treesandstormwater.org/

URBAN FORESTS AND CLIMATE CHANGE

- NC Forest Service "Urban Forests & Climate Change": http://www.ptrc.org/modules/showdocument.aspx?documentid=4687
- US Forest Service "Urban Forests and Climate Change": https://www.fs.usda.gov/ccrc/topics/urban-forests-and-climate-change

TREE MANAGEMENT BEST PRACTICES

- ANSI A300 Standards: https://tcia.org/TCIA/BUSINESS/ANSI_A300_Standards_/TCIA/BUSINESS/A300_Standards/A300_Standards.aspx?hkey=202ff566-4364-4686-b7c1-2a365af59669
- ANSI A300 Pruning Specification Writing Guide: https://www.tcia.org/TCIAPdfs/Resources/Arboriculture/A300TreeCareStandards/A300Pruning-SpecificationWritingGuide-20170413.pdf
- NC Cooperative Extension "Pruning Shade Trees": https://franklin.ces.ncsu.edu/2014/03/pruning-shade-trees/
- NC Urban Forest Council "Determining Critical Root Zone": http://www.ncufc.org/determining-root-zone.php
- NC Urban Forest Council "Mulching the Right Way": http://www.ncufc.org/mulches.php

TREES AND UTILITIES

- Penn State Extension "Questions about Trees and Utilities": https://extension.psu.edu/questions-about-trees-and-utilities
- Utility Arborist Association "Common Questions about Electric Utility Pruning": https://uaa.wildapricot.org/page-18073
- VA Cooperative Extension "Trees and Shrubs for Problem Landscape Sites: Overhead Utility Easements" (automatic download): https://www.urbanforestrysouth.org/resources/library/ttresources/trees-and-shrubs-for-problem-landscape-sites-overhead-utility-easements/at_download/file
- The eXtension Foundation "Trees for Energy Conservation": http://articles.extension.org/trees_for_energy_conservation
- Arbor Day Foundation "Energy-Saving Trees": http://energysavingtrees.arborday.org/#About

URBAN WOOD UTILIZATION

- NC Forest Service "Urban Wood Utilization": http://ncforestservice.gov/Urban/urban_wood_resources.htm
- NC Urban Forest Council "Urban Wood Group": http://ncufc.org/urban_wood_utilization_introduction.php

PLANNING RESOURCES

- US Forest Service and Davey Institute "Sustainable Urban Forest Guide": http://www.itreetools.org/resources/content/Sustainable_Urban_Forest_Guide_14Nov2016.pdf
- NC Wildlife Resources Commission's Green Growth Toolbox: http://www.ncwildlife.org/Conserving/Programs/Green-Growth-Toolbox
- WI DNR "Technical Guide to Developing Urban Forestry Strategic Plans & Management Plans: http://dnr.wi.gov/topic/UrbanForests/documents/UFPlanningGuide.pdf
- Municipal Urban Forestry Staff American Public Works Association "Urban Forestry Best Management Practices for Public Works Managers: Staffing": https://www2.apwa.net/Documents/About/CoopAgreements/UrbanForestry/UrbanForestry-2.pdf
- Tree Boards: http://www.tufc.com/pdfs/treeboard_handbook.pdf

URBAN FORESTRY FUNDING

- Davey Resource Group "Funding Your Urban Forest Program": http://www.urban-forestry.com/assets/documents/funding-your-uf-program-jenny-gulick.pdf
- Alliance for Community Trees "Funding Sources": http://actrees.org/resources/tools-for-nonprofits/fundraising-tools-for-nonprofits/
- Penn State Extension "Sustaining and Funding an Urban Forestry Program": https://extension.psu.edu/sustaining-and-funding-an-urban-forestry-program
- American Public Works Association "Urban Forestry Best Management Practices for Public Works Managers: Budgeting & Funding": https://www2.apwa.net/Documents/About/CoopAgreements/UrbanForestry/UrbanForestry-1.pdf
- University of North Carolina Environmental Finance Center "Financing Urban Forestry": http://efc.web.unc.edu/2013/08/09/financing-urban-forestry/

TREE AND URBAN FOREST ECOSYSTEM BENEFITS

- US Forest Service i-Tree: www.itreetools.org
- US Forest Service Piedmont Community Tree Guide: https://www.fs.fed.us/psw/topics/urban_forestry/products/2/cufr_647_gtr200_piedmont_tree_guide.pdf
- US Forest Service "The Urban Forest and Ecosystem Services": https://www.fs.fed.us/psw/publications/mcpherson/psw_2016_mcpherson001_livesley.pdf

TREE ASSESSMENT RESOURCES

- US Forest Service Urban Tree Canopy Assessments (UTC): www.nrs.fs.fed.us/urban/utc/
- Plan-It Geo Urban Tree Canopy Assessments: http://www.planitgeo.com/urban-tree-canopy
- i-Tree Canopy Assessments: https://canopy.itreetools.org/
- Plan-It Geo Tree Inventory Software: www.treeplotter.com
- NC Urban Forest Council "Street Tree Inventories": http://www.ncufc.org/street-tree-inventories.php

OTHER RESOURCES

- American Forests "Vibrant Cities Lab": http://www.vibrantcitieslab.com/
- Urban Forestry South "Resources and Links": https://www.urbanforestrysouth.org/resources/links
- NC Forest Service "Forest Action Plan": http://www.ncforestactionplan.com/
- NC Champion Big Tree Database: http://ncforestservice.gov/Urban/nc_champion_big_trees_database_search.asp
- ISA International Dictionary Online: https://wwv.isa-arbor.com/education/onlineresources/dictionary
- Plan-It Geo Reports and Plans: https://issuu.com/planitgeoissuu