Tarboro Historic Town Common

Inventory Report and Analysis

Treefull Communities, January 2017

Including: ***i-Tree Ecosystem Analysis***

NCFS Urban & Community Forestry Program, January 2017

Decay Fungi & Tree Management

NCFS Urban & Community Forestry Program, December 2016

Decay Fungi Assessment & Management Recommendations

Urban Forestry, LLC, October 2016

Suggested Trees for Tarboro's Historic Common

NCFS Urban & Community Forestry Program, December 2016

Town Of Tarboro

1760

North Carolina

Executive Summary

This document reports the findings of the tree inventory conducted on the Historic Town Common in Tarboro, North Carolina during the fall of 2015 and subsequent re-evaluations in the spring and fall of 2016. Additionally, an analysis of the ecosystem services provided by the trees was run using i-Tree Eco.

Results

Number of trees: 220 total trees were inventoried on the Historic Town Common.

Species diversity: 34 different species comprise the Common's inventoried trees with willow oak (23%), water oak (14%), and pin oak (12%) the most abundant.

Tree condition: Most trees, 67%, are in fair condition. 26% of the trees are in good condition, and 7% are in poor condition.

Tree size: 22% of inventoried trees have diameters less than or equal to 12 inches and 78% have diameters greater than 12 inches.

Tree concerns: The most frequent identified concern was Damage to Roots.

Maintenance actions: There are 9 trees that require immediate action – 6 should be removed and 3 should be pruned.

Carbon storage: An estimated 362 tons of carbon are stored by the trees on the Common.

Carbon sequestration: Annually, approximately 6 tons of carbon is sequestered by the trees on the Common.

Avoided runoff: Trees on the Common help to reduce storm or rainwater runoff by an estimated 10,008 ft^3/yr.

Recommendations

Removal of identified trees that pose a high risk to people and property should be a priority, followed by the pruning of certain trees that pose an immediate threat.

Retain and maintain existing large and older trees where possible. Promote the importance and benefits of large maturing species and mature, properly maintained trees on the Town Common.

Discontinue practices that cause damage to visible roots. Proper application of mulch can reduce the need to have mowers and string trimmers interact with trees roots when trying to trim the grass.

Young trees should be structurally pruned to promote proper form as they mature. Structural pruning should occur every 3 years for the first 9-12 years.

Species diversity should be increased. When selecting tree species to plant in areas where a large maturing species is appropriate, avoid choosing an oak tree.

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Introduction

At the request of the Town of Tarboro, an inventory of all trees was performed in September of 2015 as a re-evaluation in the prized and historic Town Common (an update to the previous project conducted in November, 2010). Numerical tagging of all trees and reassessment of the trees was conducted in March of 2016 in order to more easily identify structural issues while the deciduous trees were free of leaves. The species composition, size, health and current maintenance requirements of all the trees were identified and evaluated.

The goal of the project was to evaluate the characteristics and condition of the Town Common's trees and to provide maintenance recommendations would allow the trees to be maintained and future budget needs to be planned. This information will provide the Town of Tarboro with the opportunity to maximize the value and benefits of their publicly owned trees and minimize the problems associated with them. Two significant advantages of the tree inventory are that:

- administrators and managers will have an increased awareness of the current magnitude, condition and needs of their tree resource, and
- the data establishes the baseline for information about the trees that can be updated as trees are planted or removed, work completed or tree conditions change.

Ideally, this inventory allows community and its partners to efficiently and effectively manage their future of publicly owned trees.

Practical goals that can be realized include:

- Improved response to public inquiry
- More efficient scheduling of labor and equipment
- Realistic budget requests and long-term planning
- Improved coordination between municipal and private services

Data Collection & Inventory Methods

For the Tarboro Town Common Inventory, trees were individually examined, identified, measured and recorded. The information collected for each tree included: location by Google Earth, species, size (DBH), condition and maintenance requirements. The work was carried out by Certified Arborists, accompanied by an intern and volunteers. Data was collected using the Urban Offsets Tree Inventory data collection app (http://urbanoffsets.co/app/). The following information was recorded for each tree as described below:

Location – All trees are located with GPS coordinates through the use of the Urban Offsets Tree Inventory data collection app.

Identification – Common and botanical name identifies each tree.

Tree Size – Using a Biltmore stick, trees were measured about four and one half feet above the ground in order to obtain the Diameter at Breast Height (DBH. For trees with multiple trunks, only the diameter of the largest trunk was measured and recorded.

Condition Rating – The general health based on appearance, taking into account observations that include structural soundness, growth rate, and color and density of the crown. In general, the condition of each tree is recorded in one of the following categories adapted from the rating system established by the International Society of Arboriculture (ISA):

Good – The tree has no major structural problems; no significant damage due to diseases or pests; no significant mechanical damage; a full, balanced crown and normal twig condition and vigor for the species.

Fair – The tree may exhibit the following characteristics: minor structural problems and/or mechanical damage; significant damage from non-fatal or disfiguring diseases; minor crown imbalance or thin crown; minor structural imbalance or stunted growth compared to adjacent trees. This condition also includes trees that have been topped, but show reasonable vitality with no obvious signs of decay.

Poor – The tree appears unhealthy and may have structural defects. Trees in this category may also have severe mechanical damage, decay, and severe crown dieback or poor vigor.

Dead – This category refers only to dead trees.

Tree Concerns – Observed conditions that may indicate structural concerns, signs of decline in the tree, physical damage, maintenance issues or site limiting factors Some descriptions which may be used in this inventory include:

Broken Branches – are specifically noted where they are large enough to present a risk, or have an impact on the appearance of the tree.

Cavity – is a visible opening of hole, which can be present at the base, on the trunk or on the larger limbs. Visible cavities indicate the presence of internal decay but because the size of a cavity opening is not related to the extent of internal decay, the extent of decay should be assessed to determine treatment or mitigation of risk. It should be noted that not all cavities have an exterior opening and other indicators of decay, such as fungal fruiting bodies and carpenter ants, can indicate hidden internal decay and cavities, even when the tree appears healthy and green. Cavities can affect the structural stability of a tree.

Competition from Adjacent Tree – can occur when two or more trees grow closely together, the sides that face each other are usually sparsely branched or may be completely lacking branches in the shared space due to shade. Generally, this is not an issue for concern as the trees are in equilibrium with their growing site and one another. But if one of the trees is removed, it may expose the previously protected side of the remaining tree, which may also now appear to have an unbalanced crown. In situations where a desirable tree is being impacted by a less desirable tree (due to species, condition or age) it may be recommended to remove the lesser tree. However, some shade tolerant species, such as Flowering Dogwood, perform best under the canopy of a larger tree and are not generally negatively impacted by competition from adjacent trees.

Dead Wood – can range in size from dead twigs to large, dead branches. Dead wood is divided into two categories: major and minor. Minor dead wood consists of twigs or small limbs less than two inches in diameter and is an indication that a tree is in a state of decline. Major dead wood consists of limbs greater than two inches in diameter, and is considered by most tree experts to be the threshold at which the falling limbs become a hazard to life and property below.

Leaning – at an angle of 35 degrees or greater is noted where either: a recently planted tree may benefit from being straightened or a tree is leaning following a weather event. Large leaning trees are cannot be corrected of this defect – but assessment of the tree can indicate whether the lean is recent or long-term. Based on observations a tree may or may not be recommended for removal, but the lean and its significance will be noted and appropriate recommendations made.

Pests/Diseases – are noted when the appearance of insects or diseases are apparent.

Root Injury – is often a result of mechanical damage from lawn maintenance, construction, utility maintenance, etc. Such injuries open the roots to decay can lead to internal decay which can affect the structural integrity of the tree. Avoiding mechanical damage from mowers and string trimmers and protecting tree roots by tunneling or by locating and installing required utilities away from or around trees will prevent most major root damage that occurs beneath the ground surface.

Sidewalk/Curb/Asphalt Damage – is a common problem in areas where adequate space does not exist between the curb and sidewalk, particularly for large, old trees. As the roots grow larger over the course of many years, cracks and lifting become increasingly apparent in the infrastructure.

Split Crown – is commonly seen in, but not limited to, Bradford Pear due to wind or ice damage. Once a major portion of the canopy has broken off away, the crown may be unbalanced, similar to a tree that was growing is close proximity to a neighbor. Removal may be necessary.

Topped – trees have had a severe cutting back of limbs to stubs, whether close to the origin of the branch or further out along the limbs. Not only does this disfigure the tree, but it causes the tree stress by removing the leaves that produces food to feed the tree, all the way to its roots. A tree forced to use its stored carbohydrates to produce new leaves may be more prone to decline and disease. Should a tree survive topping, the replacement branches are weakly attached and more prone to failure. There are no good reasons for topping any tree, although trees severely damaged by storms or other causes, or certain trees under utility wires or other obstructions may be topped, where proper pruning practices will not address a conflict and tree removal is not an option. Crown reduction by a qualified Arborist is the correct approach where a reduction in tree height is desired.

Trunk Injury – occurs mostly in the same fashion as do root injuries. And, in the same way, can lead to internal decay. Even when a trunk wound has closed over (it can never “heal”) the damage and any decay can still impact the structural stability of the tree when internal cavities occur.

Weak Branch Union – is a fork, which occurs when 2 similarly-sized branches arise from the same location. In young trees, or for smaller-sized forks, this is can be addressed by training or structural pruning, respectively. In larger trees, such a fork may require other maintenance and/or monitoring to address any structural issues that exist, due to included bark, decayed wood or a combination of the two.

Maintenance Actions – By applying these recommendations, some of the "conditions" affecting the tree can be corrected, to improve or mitigate the concern. In order of priority:

Remove Tree – when the tree is either dead or is structurally unsound and cannot be mitigated due to the severity of the issue or the existing target.

Monitor – when, due to an existing condition, the tree should be placed on a monitoring schedule for the remainder of its life, to address maintenance, mitigation or other actions as the tree ages.

Remove Dead Wood – as it sounds, is the removal of dead limbs. To manage risk, branches two inches or greater in diameter should be promptly scheduled for removal.

Remove Broken Branches – Hangers and other broken limbs should be addressed to avoid damage or injury. They may not be a concern where no target exists.

Routine Prune – is recommended for trees, as all trees benefit from timely removal of dead, damaged, decayed or diseased wood, as well as for structural reasons, or sidewalk and utility clearance.

Raise – refers to the removal of the lower-most branches of the tree, usually to reduce conflict with pedestrians, vehicles or lone-of-sight for signs, road access or other visibility issues. or as the tree increases in height and caliper, eventually leaving adequate space for walking beneath. This practice, and any other pruning activity, should never result in the removal of more than 25 percent of the tree's live crown.

Reduce – is the reduction of the canopy, as opposed to the destructive practice of "topping" and involves removing the end of a branch at the juncture of a lateral branch that is at least one third of the size of the main limb. This method does not stress the tree and it also promotes strong branch attachment.

Corrective Prune – is done to improve branch structure for the long and short-term. When done on young trees, when it is inexpensive and highly effective, it can be called **Training Prune**, while for larger, mature trees it may be referred to as **Structural Prune**.

Treat Insects/Disease – when a tree is being impacted by a problem that warrants treatment, depending on the problem and its severity. Common examples include various types of aphids and Powdery Mildew on Crape Myrtle, or Septoria Leaf Spot and Spot Anthracnose on Dogwood. These conditions can be treated with an insecticide or fungicide when appropriate.

Add Mulch – is recommended when it is lacking or insufficient. The mulch layer should by between 2-3", 4" on sandy soils; thick enough to keep out weeds and extend outward from the trunk to, or beyond, the outer most branches of a young tree, and not placed in contact with the trunk.

Remove Excess Mulch – is a recommendation often used in landscaped areas due to the habit of mounding mulch around and up the trunk of the tree, similar in appearance to a cone or volcano. This is both a wasteful and detrimental practice. Trees can develop adventitious roots, girdling roots, or may simply slowly decline.

Remove Stakes/Guys – is necessary when new trees are staked at the time of planting but no one returns to remove the stakes after the trees are established. Stakes should be removed within one year of planting, if they are even necessary. Left in place the tree can be girdled as it increases in diameter. This will either kill the tree, above the tie of, if the tree survives create a weak point in the tree that can fail.

Remove Basal Sprouts – refers to the removal of a proliferation of sprouts around the base of the tree. This form of maintenance is commonly required in Crape Myrtle, and may be that species response to repeated topping.

Remove Brush/Vines – refers to shrubs or vines that may be growing around the base of the tree or on the trunk or into the crown. These not only compete with the trees for nutrients and light, but they also stress the trees. The vines must be carefully cut at the base so as not to injure the trunk of the tree.

Replace – when tree has been recommended for removal because of decline, death or injury and the site is suitable to plant another tree in the same, or nearby, location.

General Notes – This section is reserved for notations in regards to location and additional maintenance actions and tree problems. Unique qualities related to exceptional size, etc., such as "Champion Tree" may be noted here as well.

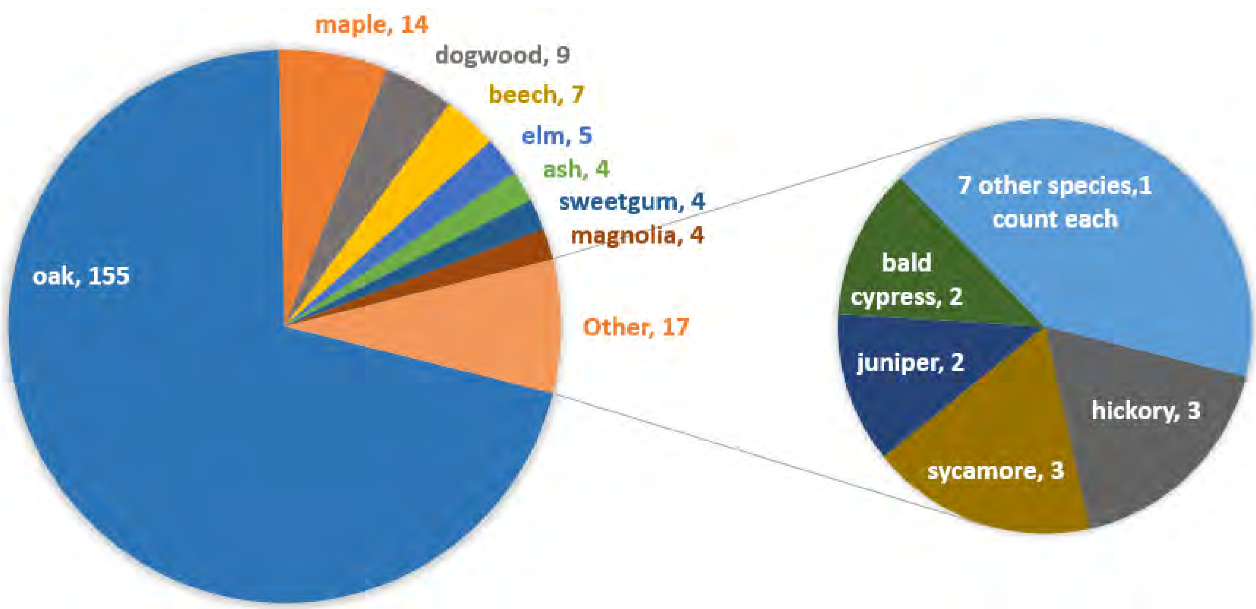
Characteristics of the Tarboro Town Common Urban Forest

The characteristics of the Tarboro Town Common urban forest include species, diameter and condition. By identifying these aspects of the Common's trees, one can learn much about the forest's composition, size and health. It is important to know the species as well as the number of trees present in a location. Species composition data is essential because tree species vary considerably in life expectancy, structure and form, and maintenance requirements, as well as susceptibility to certain pests and diseases, which affects management issues such as types of maintenance, frequency of activities and budgets. Similarly, tree diameter can help to estimate the relative age or maturity of the tree population. The condition assessment of the trees helps to develop a plan of action to both improve existing tree conditions, so they are better able to withstand stress, and to improve future management of the trees on the site so trees maintain good health and condition.

Species Diversity

Of the 220 trees inventoried, the Tarboro Town Common boasts 34 different species. Willow Oak (~ 23% of the total tree population), Water Oak (~14%) and Pin Oak (~12%) are the most common species. And the entire group of oaks comprises 70% of the trees.

Figure 1. Species Distribution

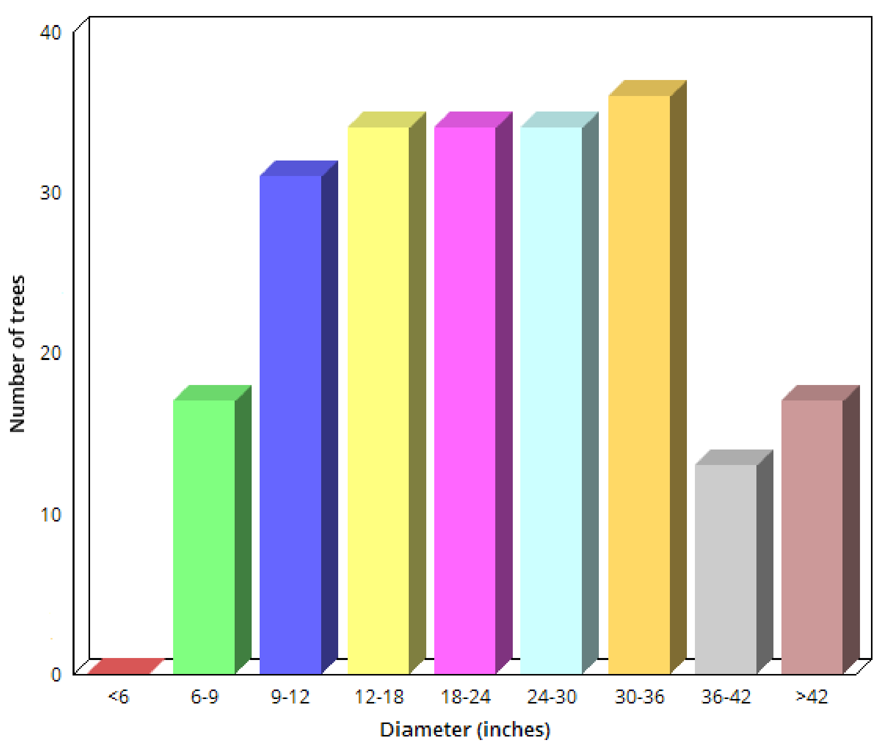


In general, no one species should account for more than 10% of the total tree population, and no group of species should account for more than 20%. That is a useful rule of thumb for maintaining a diversity of street trees. It also makes a starting point for the Common. The reason for these guidelines is to avoid having a large number of trees succumb to a problem at one time, whether a pest or disease, response to ice or wind, or aging into mortality all at the same time. This can have a significant impact on available budgets. An example of this is the over-planting of American Elms and the resulting impact of Dutch Elm-Disease, or the recent introduction of Emerald Ash Borer.

Diameter Distribution (Relative Tree Age)

Tree diameter is not only a measure of tree age and size, but it is also a valuable indicator of the benefits provided by trees. Generally, trees increase in size with age, along with the value of the tree and the magnitude of the benefits that the tree provides. An uneven-aged population is desirable for managing tree maintenance costs over time. There must be a sufficient number of younger, smaller trees in the tree population to account for the loss of trees over time and thereby maintain a sustainable urban forest. The graph in **Error! Reference source not found.** shows the number of trees in different size classes.

Figure 2. Diameter Distribution



Obviously, the majority of the trees are mature (78%).

Diameter (inches)	*Number of Trees*
0-12	48
18-36	138
36+	30

But because of the decay and damage on the site, it is expected that some of these trees will not survive to be grand old trees, which is the character desired for the Common.

Special care is required to care for larger trees and is discussed in more detail in the attached report, *Decay Fungi & Tree Management on Tarboro's Historic Common,* as special care and long-term planning is necessary to maintain and care for these larger trees. Trees provide the most benefits as they reach maturity, but without early, and less expensive, maintenance when the trees are young, tree care is significantly more expensive for large trees.

General Health and Condition

Trees were evaluated and, based on their overall outward appearance, were assigned one of four condition classes: good, fair, poor or dead. The condition class takes into account more than just the abundance of green leaves. Condition was based on visual observations of the trees' crown, trunk, and any visible roots. Indicators of stress such as the dieback of twigs and epicormic shoots along the trunk or branches can cause the condition rating to be less than good. Other factors, including the presence of decay and cavities, depending on their extent, can also reduce the condition rating.

Table 1. Tree Condition

Tree Condition	*Number of Trees*	*Proportion*
Good	57	26%
Fair	145	67%
Poor	14	7%
Dead	0	0%

While the oak genus has served the Common well, the willow, post and water oaks are nearing the end of their life spans, as befits the faster growing species of oaks. This is particularly obvious with the water and post oaks and the visible decay and history of breakage that is evident. Many of the willow oaks show general decline, which may be either from age, general site stress, or possibly due to internal decay fungi in the roots or base of the tree.

Tree Concerns

The problems observed in the trees are noted in the tables below, correspond to the descriptions at the beginning of this report. Each table has the problems by location: crown, trunk, and roots. It is possible for a single tree to have more than one problem recorded.

The most significant issue noted is the pervasive damage to tree roots (111), visible decay in roots (7) and damage to trunks (26). This is due to repeated mechanical damage from mowers and other maintenance occurring on the Common. Even where there is no grass around the base of the tree, or among the surface roots, there is evidence of new and recent damage at virtually every site visit carried out by Treefull Communities and NC Forest Service staff.

Table 2. Tree Concerns

Problems in Crowns	
Deadwood Minor	65
Structural Issues	48
History of Breakage	20
Cavity / Decay	15
Deadwood Major	13
Dieback Minor	3
Split Crown	1
Severely Pruned	1

Problems in Trunks	
Cavity	26
Damage to Trunk	26
Pests/Diseases	14
Uncorrected Lean	13
Decay in Trunk	10

Problems in Roots	
Damage to Roots	111
Girdling Roots	16
Decay in roots	7

Visible trunk decay (10) and cavities (26) are also a concern as cavities and decay weaken the structural integrity of a tree, and can result in tree failure under the right conditions.

For both trunk and root damage/decay, assessment as to the extent of the internal decay is necessary to determine whether the trees present a risk of failure and require removal, or mitigation and monitoring. The services of a certified Tree Risk Assessor who can do a more in-depth investigation is required.

While the Town has been active in pruning storm damage over the years, there are still some concerns with crown condition, including major deadwood (13), different structural issues including weak branch unions (9) and codominant stems (37), as well as cavities (9) and decay (6). Proper pruning practices can address structural issues, and proactive pruning can help correct problems that could fail during a storm, causing damage to the tree and to any targets. A pruning regime should start when the trees are young with training pruning, an inexpensive investment into the future form of the trees by reducing the development of future crown structure issues. Early and ongoing maintenance on the younger trees will maximize the ecosystem services provided by these high value members of the urban forest and help ensure that they will contribute to the Common for many years to come.

A number of more mature trees on site were identified as likely benefiting from structural pruning to reduce issues like an unbalanced crown, or an over-extended limb or crowded branching. Pruning these trees can help reduce the potential for eventual storm breakage that could damage the tree to the point where it must be removed.

Maintenance Needs

Recommendations for each tree's general maintenance needs and or corrective actions were recorded. These actions are based on a combination of the previously described Tree Concerns and the Condition Class of the tree. It is possible that there is more than one maintenance need recommended per tree. Priority should be given in the order listed in Table 3. The recommended actions also should be taken within the constraints of the community's budget.

Table 3. Maintenance Needs

Maintenance	Count	Explanation
Immediate Removal	6	Tree poses a threat and should be removed soon, before it fails
Immediate Prune	2	Tree should be pruned soon to correct a problem
Remove Broken Branches	1	Branches should be removed before they become dislodged
Clean	78	Deadwood should be cleaned out of the tree
Remove Schedule	19	Not an immediate threat, but should be removed as re-inspection directs and budget allows
Structural Prune	45	Prune tree to improve current structure and or form
Reduce	3	With proper pruning cuts reduce the size of the tree's canopy
Training Prune	2	Prune tree to improve future structure and or form
Remove Excess Soil	3	Excess soil should be removed so as to expose normal root flare
Raise	3	Prune tree to give clearance for pedestrian or vehicular traffic
Remove Brush/Vines	1	Tree health could be improved by removing competing vegetation
Remove Basal Sprouts	3	Remove epicormic sprouts from trunk of tree
Monitor Crown	25	Trees with identified maintenance need that should be monitored after corrective action for declining condition
Routine	11	Tree should be put on a regular pruning schedule

The issues of most significance are the immediate removal of 6 trees and immediate pruning of 2 trees. The number of trees requiring immediate or scheduled removal may increase as the trees are inspected more closely by a certified Tree Risk Assessor, particularly those trees noted in the attached report, *Decay Fungi & Tree Management on Tarboro's Historic Common*, for assessment and/or monitoring. This list of maintenance needs is merely a snapshot of the trees on the Historic Common at the time of the inventory. Tree conditions and maintenance needs will continue to develop, and additional removals will be necessary over time.

Urban Forest Maintenance & Management Recommendations

Much like any natural resource, the urban forest needs to be conserved and managed. A tree inventory is an important tool in managing and planning urban tree populations. By providing complete and up-to-date information about the diversity, condition, and size of trees, a tree inventory enables the community to care for the existing Historic Common as well as to plan intelligently for the future Historic Common.

Recommended Actions

Planting & Replacement

As noted in the observations about species distribution on the Common, there is a significant percentage of trees in the oak family (~70%). Reducing the proportion of oaks to 30% is likely unattainable in the medium-term and probably undesirable from the aesthetic perspective. But it is a reasonable goal to try and balance the species composition to, perhaps, 50% comprised of various oaks species. This requires broadening the species choices and limiting the planting of oak for a period of time. So, while occasional oaks can continue to be planted as trees are removed, additional species should be included to incorporate both slow growing trees for long-term presence and impact and, where desired, faster growing and small maturing trees that can help create a variety of sizes for aesthetic purposes in larger open spaces.

Careful species and cultivar selection are necessary and a suggested list of alternative species is provided in in the final tab of this combined report document: *Suggested Trees for Tarboro's Historic Common*. When developing bid specifications for nurseries, it is recommended that specific cultivars be named, as well as transportation and handling standards according to ANSI Z60.1 standards. Whether using Town staff to plant trees or contracting it out, planting BMPs should be followed, according to ANSI A300 Part 6 – Tree, Shrub and Other Woody Plant Management – Standard Practices (Planting). (See Appendix A)

Management Issues

As noted in all three of the reports in this combined document, lawn maintenance on the Historic Common is a serious concern. The repeated and long-term damage to the trees, young and old, contributes significantly to the spread of decay fungi and an additional, and unnecessary, cause of stress. To maximize the longevity of the trees in maximum health and condition requires some changes:

1. Lawn Maintenance – Training of maintenance staff and monitoring of work is strongly recommended. As discussed in more detail in the accompanying reports, *Decay Fungi & Tree Management on Tarboro's Historic Common* and *Tarboro Commons Decay Fungi Assessment and Management Recommendations*, the mechanical damage caused by the mowers and trimmers creates wounds that open the trees to decay and that decay is a significant complicating factor in the management of the trees on the Common. Avoiding future damage is a priority if the Common is to continue to serve the Town of Tarboro into the future. This means that workers should be trained on "why" avoiding damage is important and how to avoid causing more injuries. And then be periodically assessed as to their success in implementing change.

2. Mulch – Not only is mulch an important cultural practice that benefits tree health but the correct application of mulch can also provide protection to trees and tree roots from mechanical damage. Mulch can reduce the extent of mowing required on the Common as well as provide visual boundaries for lawn maintenance workers.

   Ideally, mulch should be installed, or raked or added as necessary in the spring to provide soil cover and limit turf competition. There may be some factors to consider depending on when the public events on the Common occur, as to whether it would be better to install mulch before or after the events. Additionally, an educational outreach to Tarboro residents might help in engaging them to support the mulching activities, and reduce complaints.

   Appendix B provides information on proper mulching practices and materials.

Tree Maintenance Recommendations

The purpose of this report is to provide a snapshot of the current structure and maintenance needs of the tree population on the Historic Common. Based on the data collected and presented in this report, any recommendations in this report should be carried out in accordance with applicable Town of Tarboro Code of Ordinances and conform to written specifications from the tree care standards provided in ANSI A300 and follow safety standards in ANSI Z133.

As previously discussed, the maintenance requirements for each tree is determined from observations of the base, trunk, large branches and canopy of each tree. These recommendations are the basis for the development of appropriate and realistic management goals. The implementation of the recommendations will allow the Town to realize the full potential of the urban forest through the most cost-effective use of available funds.

Maintenance	Count
Immediate Removal	6
Immediate Prune	3
Remove Schedule	19
Prune Schedule*	142

* includes Clean, Structural, Train, Reduce, Raise, and Routine

Removals

Based on this inventory, the Tarboro Town Common has 25 trees recommended for removal. But in actuality, since the initial inventory visit was first conducted in 2015 until October 2016, 4 trees have already been removed from the Town Common. One dead tree, two trees that were in poor condition and already scheduled for removal by the town, and another tree that was toppled by Hurricane Matthew. As time goes by, more changes to the Town Common will come as well. The removal of trees identified as needing immediate removal, as well as those that should be scheduled for removal, will bring a more proactive approach to managing the trees on the Common.

Pruning

While there are only 3 trees listed as requiring immediate pruning, many of the trees would benefit from scheduled pruning for the reasons listed above. Improving the branch structure (cleaning and structural), removing deadwood and training will benefit the trees. The largest challenge remains prioritizing these trees to ensure that the trees with the best long-term potential to remain on the site, so that the budget targets those trees before spending funds on trees with other issues or decline that limit their long-term potential. The attached document, *Decay Fungi & Tree Management on Tarboro's Historic Common*, provides guidance on making such decisions, in partnership with a certified arborist and Tree Risk Assessor.

Any pruning work must follow the ANSI A300 Part 1 – Tree, Shrub and Other Woody Plant Management – Standard Practices (Pruning) and Best Management Practices. Information on proper pruning is in Appendix C.

Maintenance & Monitoring

Once the removal, pruning and additional maintenance of the specified trees have been completed, attention should be given to establishing a routine monitoring and maintenance cycle. This on-going cycle should be structured enough to ensure inspection of all trees at time frame advised by a certified aborist working with the community on a long-term basis to manage the Common's trees.

The advantages that result from establishing a routine maintenance cycle will:

- Maximize tree crew efficiency, whether contracted or in-house
- Reduce routine pruning costs, improve tree structure and health
- Prompt identification and management of risk tree conditions
- Decrease tree mortality through the early identification and treatment of disease and insect conditions
- Reduce future tree damage from storms

In addition to planning, there is also a need to establish procedures to ensure that the Tree Inventory information is kept up to date. Inspections following major storm events, even when no immediate or serious damage has occurred is advised, with any observed issues documented and immediately entered into the inventory with the required maintenance scheduled.

Sources of Funding

The need for funding to initiate and implement a sound maintenance plan as discussed in this and following documents is a priority for the Community. Committed funds are necessary to be proactive and to ensure that the Historic Town Common will contribute to the Town of Tarboro well into the future.

Funding sources for tree care may range from the Town's budget to joint programs with area companies and merchants. The Town of Tarboro is encouraged to explore the following sources of support for tree care operations:

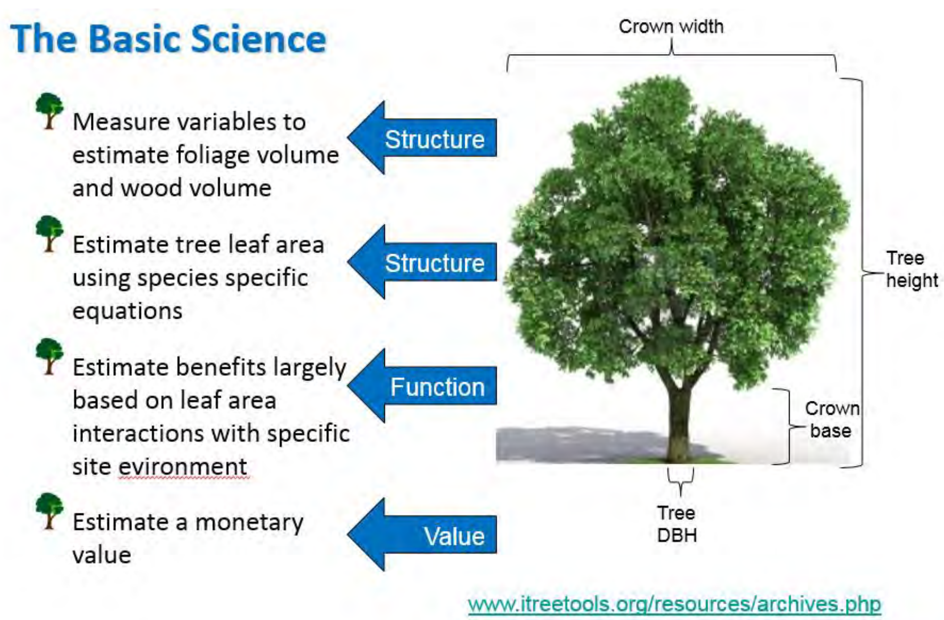
- Government grants. Federal programs such as the Urban and Community Forestry Grant (which is funding this project) appropriate funds for tree planting and maintenance programs in cities throughout the United States. The North Carolina Department of Transportation (NCDOT) has funding available for transportation enhancement activities, including roadside beautification.
- Foundation grants. The Foundation Center, online at http://fdncenter.org/ is a good reference.
- Private donations. Area corporations and organizations may donate funds to special tree planting and maintenance programs. Local officials can generate public support of tree care through programs such as the existing "memorial tree" program or special tree improvement projects. Individuals, businesses or local groups might also be sources of funding as has the Tarboro Rotary Club for this project.
- Volunteer groups. Local officials can encourage community organizations to donate funds or organize fund-raising activities or other support for tree planting and maintenance programs.

Funding does not have to be tied solely to tree management activities as there are numerous grant possibilities that target healthy living, storm water management and other services that the trees contribute or support. A strong partnership with between the Town and the Rotary Club will be essential for proposal writing and implementation.

Ecosystem Services Provided by the Trees on the Common

An additional review of the inventoried trees still remaining after removals and storms in 2016 was carried out using a tool called i-Tree Eco. i-Tree is a suite of tools where i-Tree Eco uses four different tree measurements and other local data to estimate ecosystem services and structural characteristics of the urban or rural forest.

Figure 3. i-Tree Eco



As with any algorithm, the more thorough and accurate the information going in, the more reliable the results. Since the inventory on the trees on the Common did not collect the total information that Eco uses to carry out an analysis, program default values were used: 1) the crowns of all trees were assumed to have 13% missing when, in fact, many trees had more missing; 2) the crown condition of all trees was assumed to have 13% dieback, but many trees on the Common had more. This means that the values calculated by i-Tree Eco are estimated to be higher than is likely, however, the exercise gives the community a good idea of the general value and contributions to the community as well as what would be possible with a healthy and vital tree population on the Historic Common.

The complete i-Tree Eco report can be found in Appendix D. Some of the results that Eco produced show the value of ecosystem services that the inventoried trees provide include carbon storage of 362 tons, carbon sequestration of 6 tons per year, and oxygen production of 16 tons per year.

i-Tree
Ecosystem Analysis

Town Common

Urban Forest Effects and Values
January 2017

Summary

Understanding an urban forest's structure, function and value can promote management decisions that will improve human health and environmental quality. An assessment of the vegetation structure, function, and value of the Town Common urban forest was conducted during 2016. Data from 216 trees located throughout Town Common were analyzed using the i-Tree Eco model developed by the U.S. Forest Service, Northern Research Station.

- Number of trees: 216
- Tree cover: 6.01 acres
- Most common species of trees: Willow oak, Water oak, Pin oak
- Percentage of trees less than 6" (15.2 cm) diameter: 7.9 %
- Pollution removal: 0 tons/year ($1.29 thousand/year)
- Carbon storage: 362 tons ($48.2 thousand)
- Carbon sequestration: 6 tons/year ($813/year)
- Oxygen production: 16 tons/year
- Avoided runoff: 10,008 cubic feet/year ($669/year)
- Building energy savings: $0/year
- Avoided carbon emissions: 0 tons/year ($0/year)
- Structural values: $1.01 million

Ton: short ton (U.S.) (2,000 lbs)
Monetary values $ are reported in US Dollars throughout the report except where noted
Ecosystem service estimates are reported for trees.

For an overview of i-Tree Eco methodology, see Appendix I. Data collection quality is determined by the local data collectors, over which i-Tree has no control.

Table of Contents

I. Tree Characteristics of the Urban Forest

The urban forest of Town Common has 216 trees with a tree cover of 6.01 acres. The three most common species are Willow oak (23.1 percent), Water oak (13.4 percent), and Pin oak (12.5 percent).

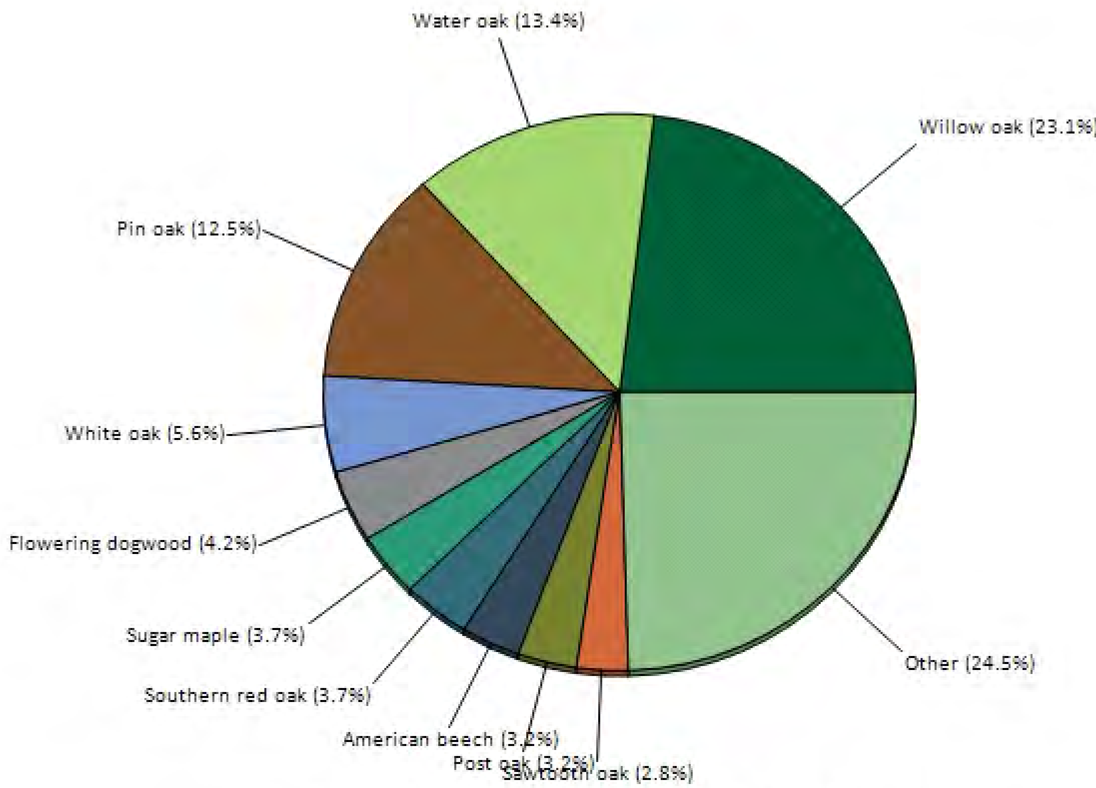


Figure 1. Tree species composition in Town Common

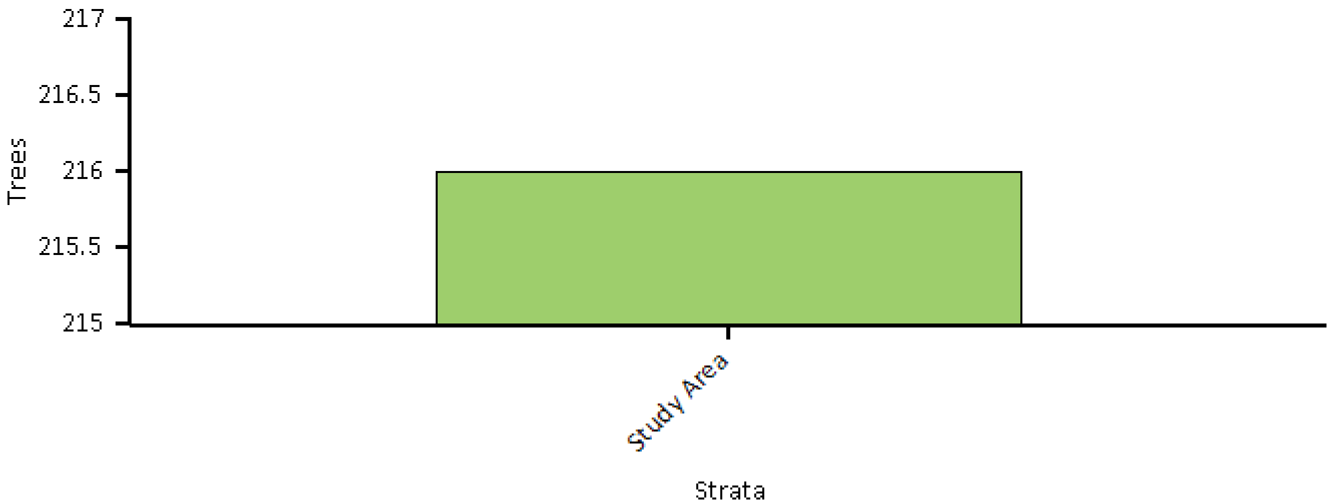


Figure 2. Number of trees in Town Common by strata

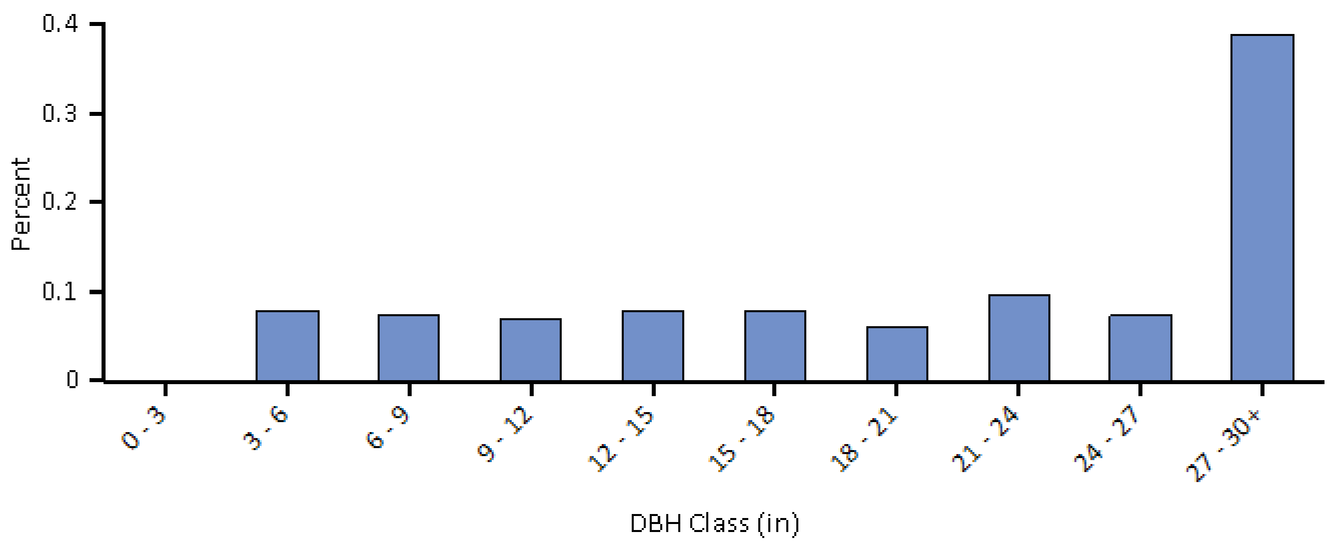


Figure 3. Percent of tree population by diameter class (DBH=stem diameter at 4.5 feet)

Urban forests are composed of a mix of native and exotic tree species. Thus, urban forests often have a tree diversity that is higher than surrounding native landscapes. Increased tree diversity can minimize the overall impact or destruction by a species-specific insect or disease, but it can also pose a risk to native plants if some of the exotic species are invasive plants that can potentially out-compete and displace native species. In Town Common, about 96 percent of the trees are species native to North America, while 94 percent are native to North Carolina. Species exotic to North America make up 4 percent of the population. Most exotic tree species have an origin from Asia (4 percent of the species).

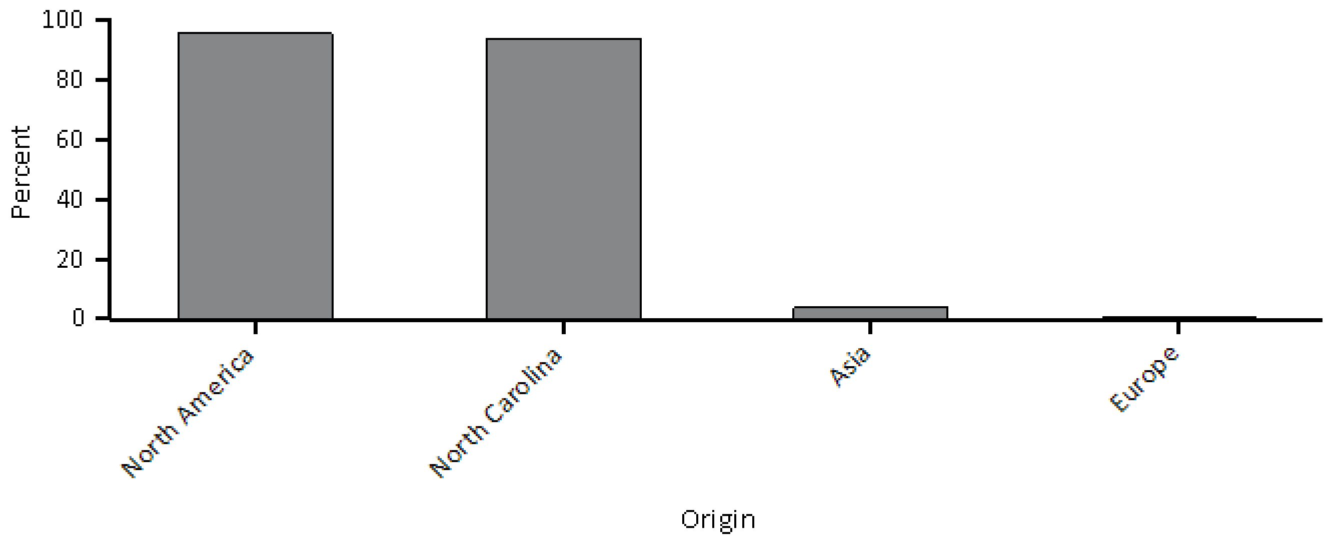


Figure 4. Percent of live tree population by area of native origin, Town Common

Invasive plant species are often characterized by their vigor, ability to adapt, reproductive capacity, and general lack of natural enemies. These abilities enable them to displace native plants and make them a threat to natural areas (National Invasive Species Information Center 2011). One of the 34 tree species in Town Common are identified as invasive on the state invasive species list (). This invasive species (Sawtooth oak) comprises 2.8 percent of the tree population though it may only cause a minimal level of impact (see Appendix V for a complete list of invasive species).

II. Urban Forest Cover and Leaf Area

Many tree benefits equate directly to the amount of healthy leaf surface area of the plant. Trees cover about 6.0 acres of Town Common and provide 0.035 square miles of leaf area.

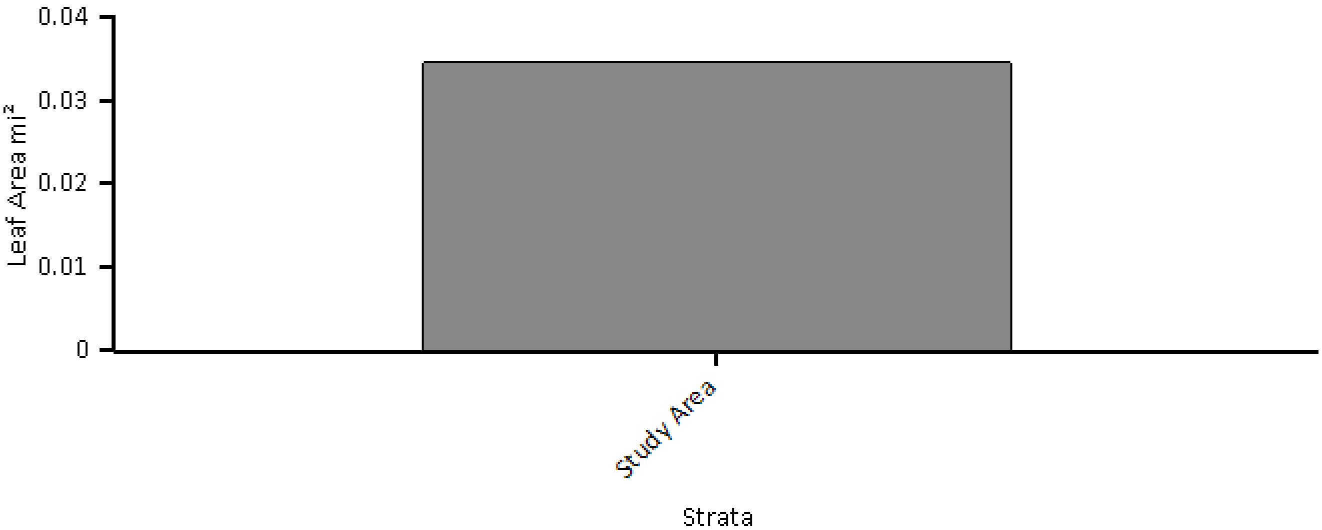


Figure 5. Leaf area by strata, Town Common

In Town Common, the most dominant species in terms of leaf area are Willow oak, Water oak, and Pin oak. The 10 species with the greatest importance values are listed in Table 1. Importance values (IV) are calculated as the sum of percent population and percent leaf area. High importance values do not mean that these trees should necessarily be encouraged in the future; rather these species currently dominate the urban forest structure.

Table 1. Most important species in Town Common

Species Name	*Percent Population*	*Percent Leaf Area*	*IV*
Willow oak	23.1	24.5	47.7
Water oak	13.4	16.0	29.4
Pin oak	12.5	8.9	21.4
White oak	5.6	7.5	13.1
American beech	3.2	6.6	9.9
Post oak	3.2	4.7	7.9
Southern red oak	3.7	3.3	7.0
Sugar maple	3.7	2.6	6.3
Flowering dogwood	4.2	1.1	5.3
American sycamore	1.4	3.7	5.0

Common ground cover classes (including cover types beneath trees and shrubs) in Town Common are not available since they are configured not to be collected.

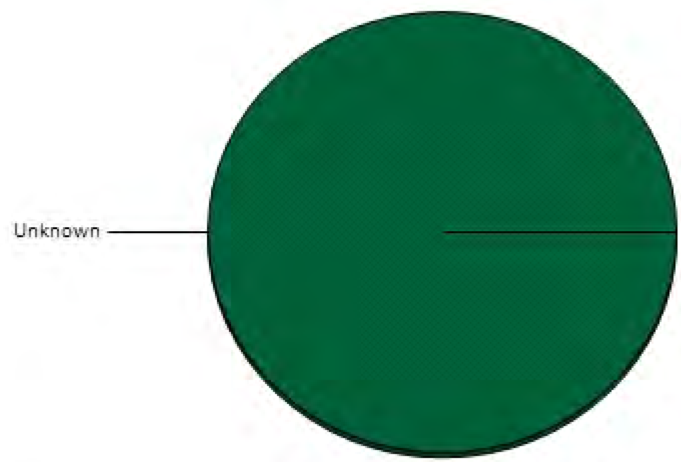


Figure 6. Percent of land by ground cover classes, Town Common

III. Air Pollution Removal by Urban Trees

Poor air quality is a common problem in many urban areas. It can lead to decreased human health, damage to landscape materials and ecosystem processes, and reduced visibility. The urban forest can help improve air quality by reducing air temperature, directly removing pollutants from the air, and reducing energy consumption in buildings, which consequently reduces air pollutant emissions from the power sources. Trees also emit volatile organic compounds that can contribute to ozone formation. However, integrative studies have revealed that an increase in tree cover leads to reduced ozone formation (Nowak and Dwyer 2000).

Pollution removal[1] by trees in Town Common was estimated using field data and recent available pollution and weather data available. Pollution removal was greatest for ozone (Figure 7). It is estimated that trees remove 0.129 tons of air pollution (ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter less than 2.5 microns (PM2.5)[2], and sulfur dioxide (SO_2)) per year with an associated value of $1.29 thousand (see Appendix I for more details).

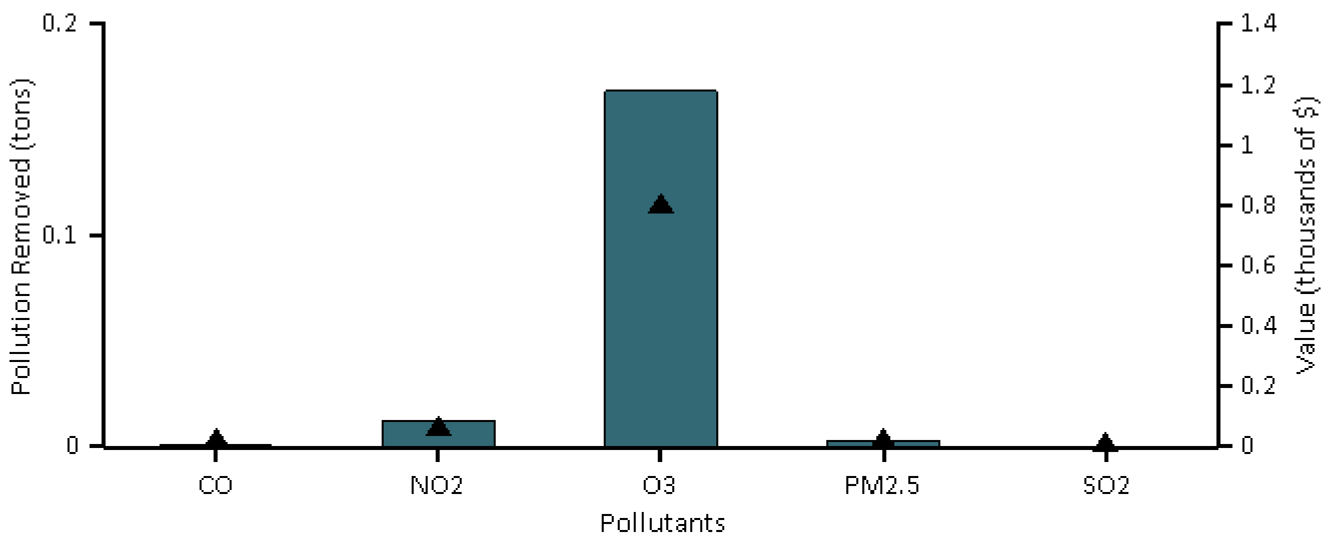


Figure 7. Annual pollution removal (points) and value (bars) by urban trees, Town Common

[1] Particulate matter less than 10 microns is a significant air pollutant. Given that i-Tree Eco analyzes particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

[2] Trees remove PM2.5 when particulate matter is deposited on leaf surfaces. This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors (see Appendix I for more details).

In 2016, trees in Town Common emitted an estimated 0.3 tons of volatile organic compounds (VOCs) (0.3 tons of isoprene and 0.0 tons of monoterpenes). Emissions vary among species based on species characteristics (e.g. some genera such as oaks are high isoprene emitters) and amount of leaf biomass. Fifty-five percent of the urban forest's VOC emissions were from Willow oak and Water oak. These VOCs are precursor chemicals to ozone formation.[3]

General recommendations for improving air quality with trees are given in Appendix VIII.

[3] Some economic studies have estimated VOC emission costs. These costs are not included here as there is a tendency to add positive dollar estimates of ozone removal effects with negative dollar values of VOC emission effects to determine whether tree effects are positive or negative in relation to ozone. This combining of dollar values to determine tree effects should not be done, rather estimates of VOC effects on ozone formation (e.g., via photochemical models) should be conducted and directly contrasted with ozone removal by trees (i.e., ozone effects should be directly compared, not dollar estimates). In addition, air temperature reductions by trees have been shown to significantly reduce ozone concentrations (Cardelino and Chameides 1990; Nowak et al 2000), but are not considered in this analysis. Photochemical modeling that integrates tree effects on air temperature, pollution removal, VOC emissions, and emissions from power plants can be used to determine the overall effect of trees on ozone concentrations.

IV. Carbon Storage and Sequestration

Climate change is an issue of global concern. Urban trees can help mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in tissue and by altering energy use in buildings, and consequently altering carbon dioxide emissions from fossil-fuel based power sources (Abdollahi et al 2000).

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of Town Common trees is about 6 tons of carbon per year with an associated value of $813. See Appendix I for more details on methods.

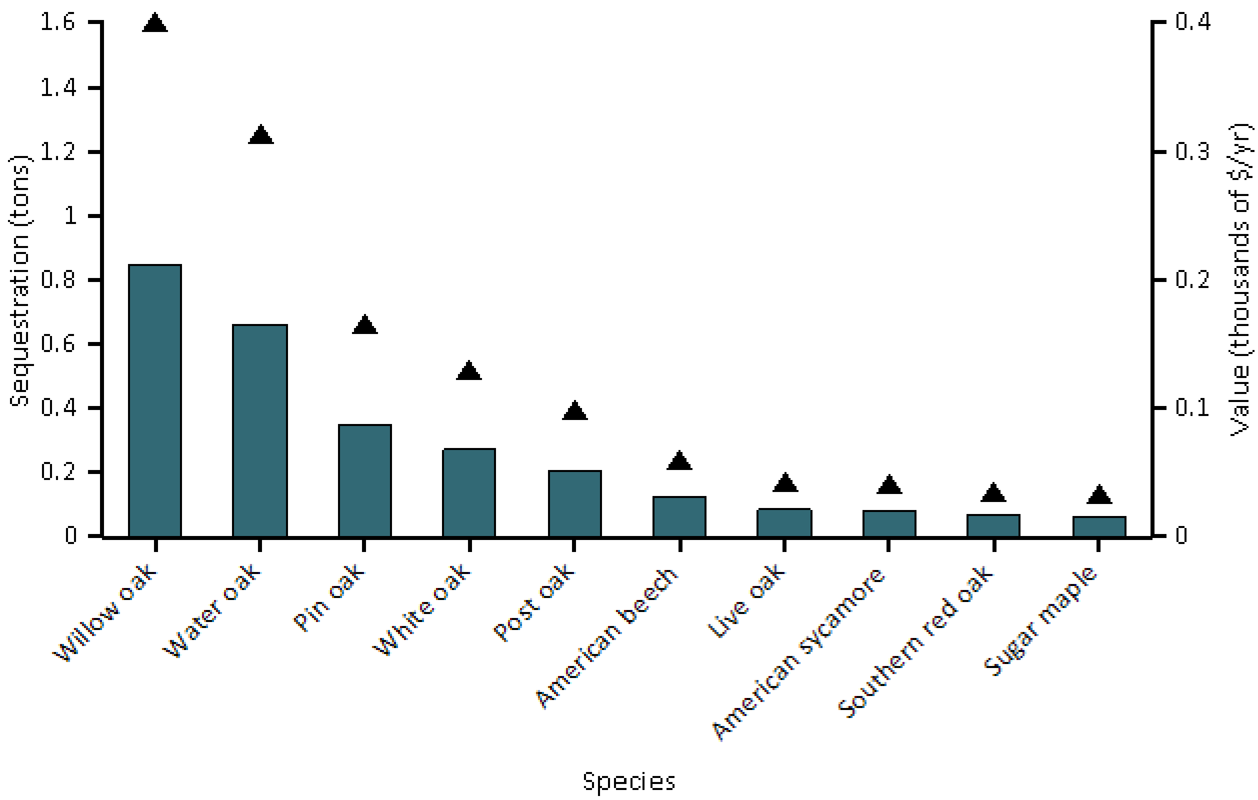


Figure 8. Estimated annual gross carbon sequestration (points) and value (bars) for urban tree species with the greatest sequestration, Town Common

Carbon storage is another way trees can influence global climate change. As a tree grows, it stores more carbon by holding it in its accumulated tissue. As a tree dies and decays, it releases much of the stored carbon back into the atmosphere. Thus, carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose. Maintaining healthy trees will keep the carbon stored in trees, but tree maintenance can contribute to carbon emissions (Nowak et al 2002c). When a tree dies, using the wood in long-term wood products, to heat buildings, or to produce energy will help reduce carbon emissions from wood decomposition or from fossil-fuel or wood-based power plants.

Trees in Town Common are estimated to store 362 tons of carbon ($48.2 thousand). Of the species sampled, Willow oak stores and sequesters the most carbon (approximately 37.3% of the total carbon stored and 26.1% of all sequestered carbon.)

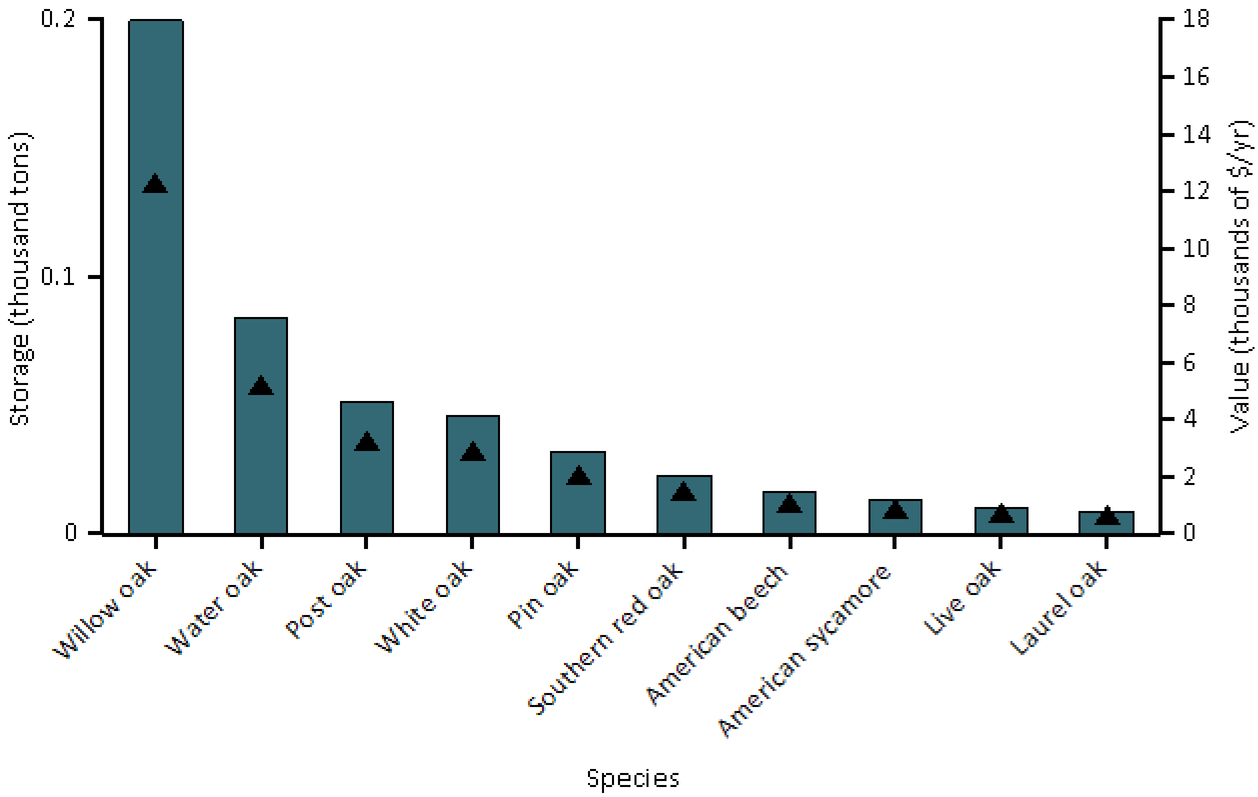


Figure 9. Estimated carbon storage (points) and values (bars) for urban tree species with the greatest storage, Town Common

V. Oxygen Production

Oxygen production is one of the most commonly cited benefits of urban trees. The annual oxygen production of a tree is directly related to the amount of carbon sequestered by the tree, which is tied to the accumulation of tree biomass.

Trees in Town Common are estimated to produce 16 tons of oxygen per year.[4] However, this tree benefit is relatively insignificant because of the large and relatively stable amount of oxygen in the atmosphere and extensive production by aquatic systems. Our atmosphere has an enormous reserve of oxygen. If all fossil fuel reserves, all trees, and all organic matter in soils were burned, atmospheric oxygen would only drop a few percent (Broecker 1970).

Table 2. The top 20 oxygen production species.

Species	*Oxygen (tons)*	*Gross Carbon Sequestration (tons/yr)*	*Number of Trees*	*Leaf Area (square miles)*
Willow oak	4.26	1.60	50	0.01
Water oak	3.32	1.24	29	0.01
Pin oak	1.74	0.65	27	0.00
White oak	1.37	0.51	12	0.00
Post oak	1.03	0.38	7	0.00
American beech	0.62	0.23	7	0.00
Live oak	0.43	0.16	5	0.00
American sycamore	0.41	0.15	3	0.00
Southern red oak	0.35	0.13	8	0.00
Sugar maple	0.33	0.12	8	0.00
Laurel oak	0.29	0.11	2	0.00
Winged elm	0.27	0.10	4	0.00
Southern magnolia	0.27	0.10	4	0.00
Pecan	0.26	0.10	2	0.00
Sweetgum	0.18	0.07	4	0.00
Green ash	0.16	0.06	4	0.00
Flowering dogwood	0.13	0.05	9	0.00
Red maple	0.12	0.05	6	0.00
Northern catalpa	0.09	0.04	1	0.00
Scarlet oak	0.09	0.03	3	0.00

VI. Avoided Runoff

Surface runoff can be a cause for concern in many urban areas as it can contribute pollution to streams, wetlands, rivers, lakes, and oceans. During precipitation events, some portion of the precipitation is intercepted by vegetation (trees and shrubs) while the other portion reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil becomes surface runoff (Hirabayashi 2012). In urban areas, the large extent of impervious surfaces increases the amount of surface runoff.

Urban trees and shrubs, however, are beneficial in reducing surface runoff. Trees and shrubs intercept precipitation, while their root systems promote infiltration and storage in the soil. The trees and shrubs of Town Common help to reduce runoff by an estimated 10,000 cubic feet a year with an associated value of $670 (see Appendix I for more details). Avoided runoff is estimated based on local weather from the user-designated weather station. In Town Common, the total annual precipitation in 2013 was 53.6 inches.

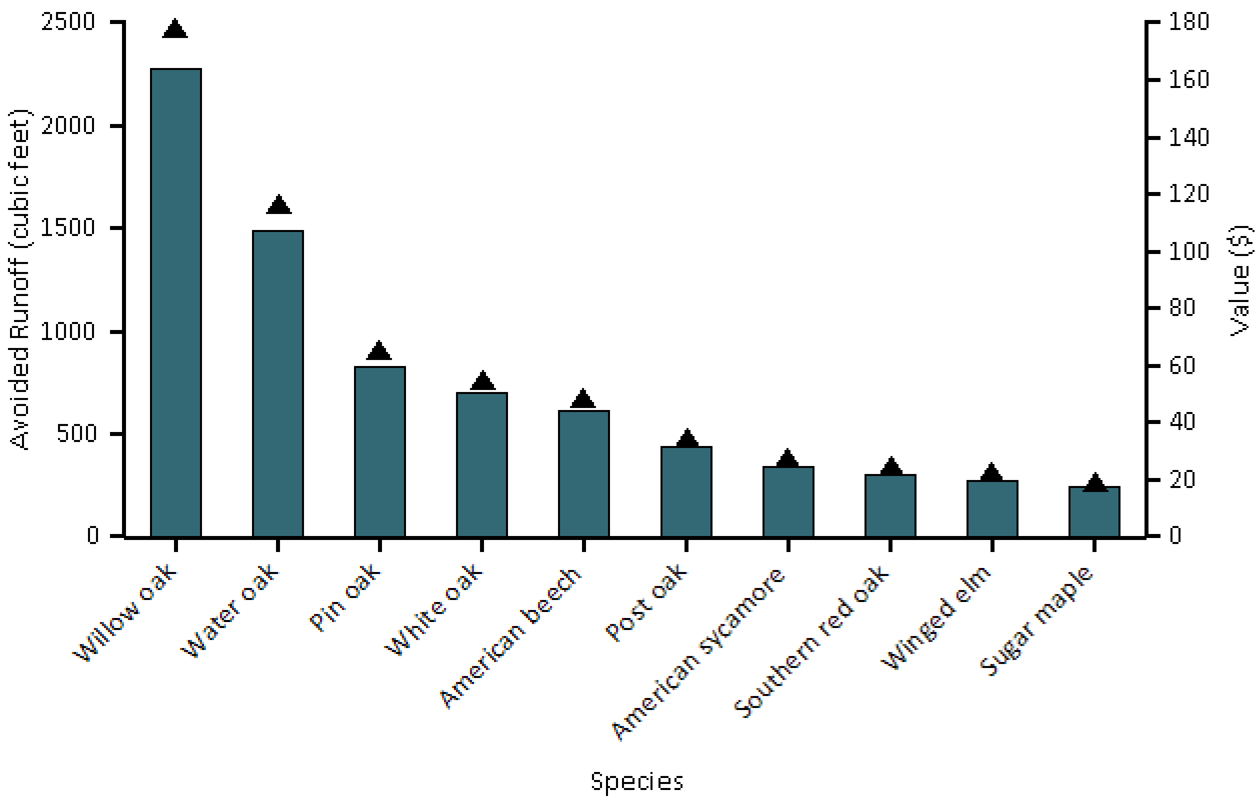


Figure 10. Avoided runoff (points) and value (bars) for species with greatest overall impact on runoff, Town Common

VII. Trees and Building Energy Use

Trees affect energy consumption by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months and can either increase or decrease building energy use in the winter months, depending on the location of trees around the building. Estimates of tree effects on energy use are based on field measurements of tree distance and direction to space conditioned residential buildings (McPherson and Simpson 1999).

Trees in Town Common are estimated to reduce energy-related costs from residential buildings by $0 annually. Trees also provide an additional $0 in value by reducing the amount of carbon released by fossil-fuel based power plants (a reduction of 0 tons of carbon emissions).

Note: negative numbers indicate that there was not a reduction in carbon emissions and/or value, rather carbon emissions and values increased by the amount shown as a negative value.[5]

Table 3. Annual energy savings due to trees near residential buildings,Town Common

	Heating	*Cooling*	*Total*
MBTU[a]	0	n/a	0
MWH[b]	0	0	0
Carbon avoided (ton)	0	0	0

[a]MBTU = one million British Thermal Units

[b]MWH = megawatt-hour

Table 4. Annual savings[a] ($) in residential energy expenditure during heating and cooling seasons, Town Common

	Heating	*Cooling*	*Total*
MBTU[b]	0	n/a	0
MWH[c]	0	0	0
Carbon avoided	0	0	0

[b]Based on the prices of $108.68 per MWH and $12.82 per MBTU (see Appendix I for more details)

[c]MBTU = one million British Thermal Units

[c]MWH = megawatt-hour

[5] Trees modify climate, produce shade, and reduce wind speeds. Increased energy use or costs are likely due to these tree-building interactions creating a cooling effect during the winter season. For example, a tree (particularly evergreen species) located on the southern side of a residential building may produce a shading effect that causes increases in heating requirements.

VIII. Structural and Functional Values

Urban forests have a structural value based on the trees themselves (e.g., the cost of having to replace a tree with a similar tree); they also have functional values (either positive or negative) based on the functions the trees perform.

The structural value of an urban forest tends to increase with a rise in the number and size of healthy trees (Nowak et al 2002a). Annual functional values also tend to increase with increased number and size of healthy trees. Through proper management, urban forest values can be increased; however, the values and benefits also can decrease as the amount of healthy tree cover declines.

<u>Urban trees in Town Common have the following structural values:</u>

- Structural value: $1.01 million
- Carbon storage: $48.2 thousand

<u>Urban trees in Town Common have the following annual functional values:</u>

- Carbon sequestration: $813
- Avoided runoff: $669
- Pollution removal: $1.29 thousand
- Energy costs and carbon emission values: $0.00

(Note: negative value indicates increased energy cost and carbon emission value)

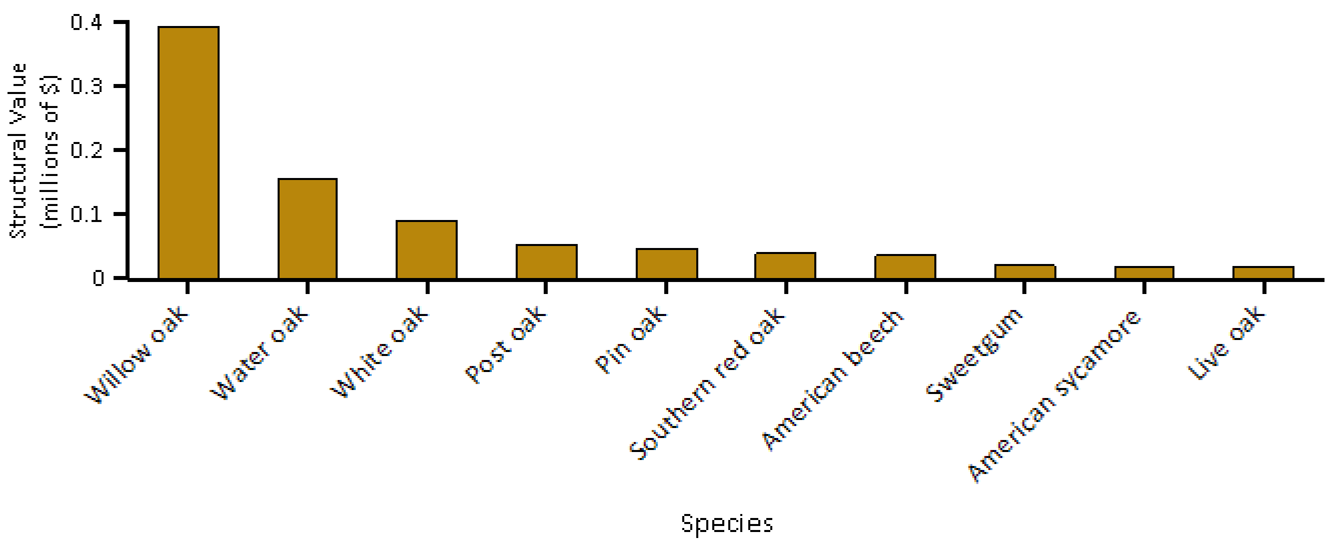


Figure 11. Tree species with the greatest structural value, Town Common

IX. Potential Pest Impacts

Various insects and diseases can infest urban forests, potentially killing trees and reducing the health, structural value and sustainability of the urban forest. As pests tend to have differing tree hosts, the potential damage or risk of each pest will differ among cities. Thirty-six pests were analyzed for their potential impact and compared with pest range maps (Forest Health Technology Enterprise Team 2014) for the conterminous United States to determine their proximity to Edgecombe County. Four of the thirty-six pests analyzed are located within the county. For a complete analysis of all pests, see Appendix VII.

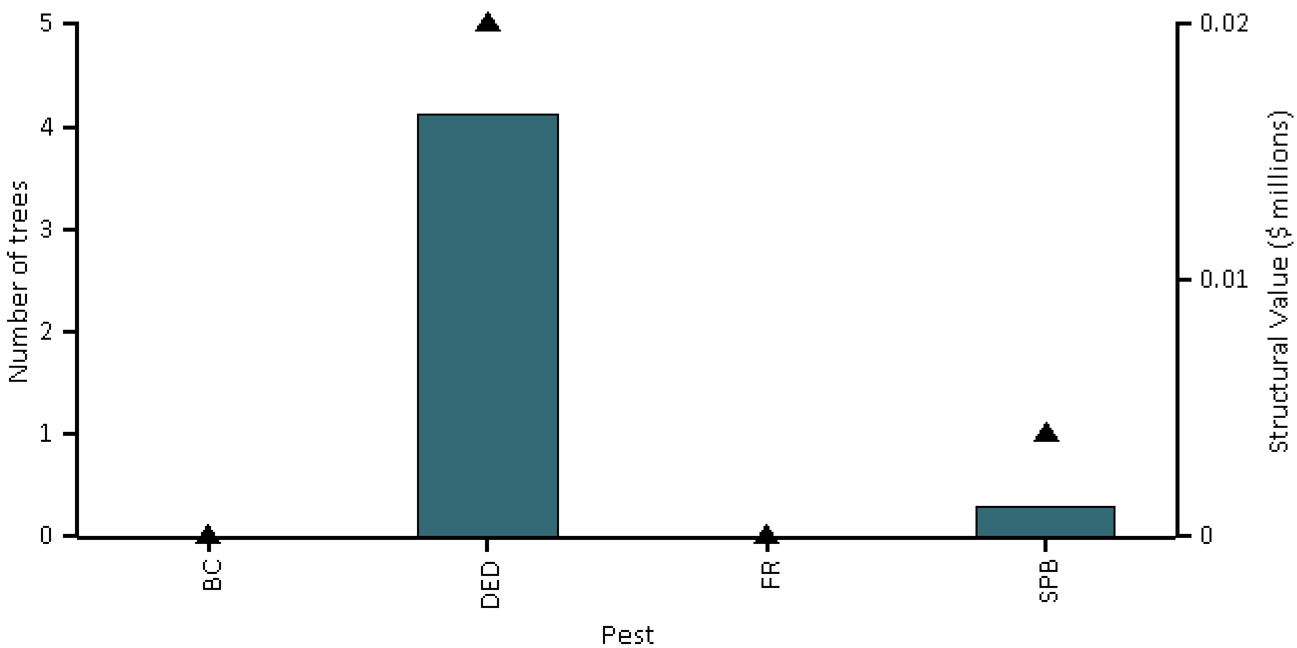


Figure 12. Number of trees at risk (points) and associated compensatory value (bars) for most threatening pests located in the county, Town Common

Butternut canker (BC) (Ostry et al 1996) is caused by a fungus that infects butternut trees. The disease has since caused significant declines in butternut populations in the United States. Potential loss of trees from BC is 0.0 percent ($0 in structural value).

American elm, one of the most important street trees in the twentieth century, has been devastated by the Dutch elm disease (DED) (Northeastern Area State and Private Forestry 1998). Since first reported in the 1930s, it has killed over 50 percent of the native elm population in the United States. Although some elm species have shown varying degrees of resistance, Town Common could possibly lose 2.3 percent of its trees to this pest ($16.5 thousand in structural value).

Fusiform rust (FR) (Phelps and Czabator 1978) is a fungal disease that is distributed in the southern United States. It is particularly damaging to slash pine and loblolly pine. FR has the potential to affect 0.0 percent of the population ($0 in structural value).

Although the southern pine beetle (SPB) (Clarke and Nowak 2009) will attack most pine species, its preferred hosts are loblolly, Virginia, pond, spruce, shortleaf, and sand pines. This pest threatens 0.5 percent of the population, which represents a potential loss of $1.14 thousand in structural value.

Appendix I. i-Tree Eco Model and Field Measurements

i-Tree Eco is designed to use standardized field data and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects (Nowak and Crane 2000), including:

- Urban forest structure (e.g., species composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year.
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power sources.
- Structural value of the forest, as well as the value for air pollution removal and carbon storage and sequestration.
- Potential impact of infestations by pests, such as Asian longhorned beetle, emerald ash borer, gypsy moth, and Dutch elm disease.

Typically, all field data are collected during the leaf-on season to properly assess tree canopies. Typical data collection (actual data collection may vary depending upon the user) includes land use, ground and tree cover, individual tree attributes of species, stem diameter, height, crown width, crown canopy missing and dieback, and distance and direction to residential buildings (Nowak et al 2005; Nowak et al 2008).

During data collection, trees are identified to the most specific taxonomic classification possible. Trees that are not classified to the species level may be classified by genus (e.g., ash) or species groups (e.g., hardwood). In this report, tree species, genera, or species groups are collectively referred to as tree species.

Tree Characteristics:

Leaf area of trees was assessed using measurements of crown dimensions and percentage of crown canopy missing. In the event that these data variables were not collected, they are estimated by the model.

An analysis of invasive species is not available for studies outside of the United States. For the U.S., invasive species are identified using an invasive species list ()for the state in which the urban forest is located. These lists are not exhaustive and they cover invasive species of varying degrees of invasiveness and distribution. In instances where a state did not have an invasive species list, a list was created based on the lists of the adjacent states. Tree species that are identified as invasive by the state invasive species list are cross-referenced with native range data. This helps eliminate species that are on the state invasive species list, but are native to the study area.

Air Pollution Removal:

Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter less than 2.5 microns. Particulate matter less than 10 microns (PM10) is another significant air pollutant. Given that i-Tree Eco analyzes particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

Air pollution removal estimates are derived from calculated hourly tree-canopy resistances for ozone, and sulfur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models (Baldocchi 1988; Baldocchi et al 1987). As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature (Bidwell and Fraser 1972; Lovett 1994) that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere (Zinke 1967).

Recent updates (2011) to air quality modeling are based on improved leaf area index simulations, weather and pollution processing and interpolation, and updated pollutant monetary values (Hirabayashi et al 2011; Hirabayashi et al 2012; Hirabayashi 2011).

Trees remove PM2.5 when particulate matter is deposited on leaf surfaces (Nowak et al 2013). This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors. Generally, PM2.5 removal is positive with positive benefits. However, there are some cases when net removal is negative or resuspended particles lead to increased pollution concentrations and negative values. During some months (e.g., with no rain), trees resuspend more particles than they remove. Resuspension can also lead to increased overall PM2.5 concentrations if the boundary layer conditions are lower during net resuspension periods than during net removal periods. Since the pollution removal value is based on the change in pollution concentration, it is possible to have situations when trees remove PM2.5 but increase concentrations and thus have negative values during periods of positive overall removal. These events are not common, but can happen.

For reports in the United States, default air pollution removal value is calculated based on local incidence of adverse health effects and national median externality costs. The number of adverse health effects and associated economic value is calculated for ozone, sulfur dioxide, nitrogen dioxide, and particulate matter less than 2.5 microns using data from the U.S. Environmental Protection Agency's Environmental Benefits Mapping and Analysis Program (BenMAP) (Nowak et al 2014). The model uses a damage-function approach that is based on the local change in pollution concentration and population. National median externality costs were used to calculate the value of carbon monoxide removal (Murray et al 1994).

For international reports, user-defined local pollution values are used. For international reports that do not have local values, estimates are based on either European median externality values (van Essen et al 2011) or BenMAP regression equations (Nowak et al 2014) that incorporate user-defined population estimates. Values are then converted to local currency with user-defined exchange rates.

For this analysis, pollution removal value is calculated based on the prices of $1,469 per ton (carbon monoxide), $10,339 per ton (ozone), $10,339 per ton (nitrogen dioxide), $2,531 per ton (sulfur dioxide), $6,903 per ton (particulate matter less than 2.5 microns).

Carbon Storage and Sequestration:

Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation. To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations (Nowak 1994). To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

Carbon sequestration is the removal of carbon dioxide from the air by plants. To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year x) to estimate tree diameter and carbon storage in year x+1.

Carbon storage and carbon sequestration values are based on estimated or customized local carbon values. For international reports that do not have local values, estimates are based on the carbon value for the United States (U.S. Environmental Protection Agency 2015, Interagency Working Group on Social Cost of Carbon 2015) and converted to local currency with user-defined exchange rates.

For this analysis, carbon storage and carbon sequestration values are calculated based on $133.0 per ton.

Oxygen Production:

The amount of oxygen produced is estimated from carbon sequestration based on atomic weights: net O2 release (kg/yr) = net C sequestration (kg/yr) × 32/12. To estimate the net carbon sequestration rate, the amount of carbon sequestered as a result of tree growth is reduced by the amount lost resulting from tree mortality. Thus, net carbon sequestration and net annual oxygen production of the urban forest account for decomposition (Nowak et al 2007). For complete inventory projects, oxygen production is estimated from gross carbon sequestration and does not account for decomposition.

Avoided Runoff:

Annual avoided surface runoff is calculated based on rainfall interception by vegetation, specifically the difference between annual runoff with and without vegetation. Although tree leaves, branches, and bark may intercept precipitation and thus mitigate surface runoff, only the precipitation intercepted by leaves is accounted for in this analysis.

The value of avoided runoff is based on estimated or user-defined local values. For international reports that do not have local values, the national average value for the United States is utilized and converted to local currency with user-defined exchange rates. The U.S. value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series (McPherson et al 1999; 2000; 2001; 2002; 2003; 2004; 2006a; 2006b; 2006c; 2007; 2010; Peper et al 2009; 2010; Vargas et al 2007a; 2007b; 2008).

Building Energy Use:

If appropriate field data were collected, seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature (McPherson and Simpson 1999) using distance and direction of trees from residential structures, tree height and tree condition data. To calculate the monetary value of energy savings, local or custom prices per MWH or MBTU are utilized.

For this analysis, energy saving value is calculated based on the prices of $108.68 per MWH and $12.82 per MBTU.

Structural Values:

Structural value is the value of a tree based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree). Structural values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition, and location information (Nowak et al 2002a; 2002b). Structural value may not be included for international projects if there is insufficient local data to complete the valuation procedures.

Potential Pest Impacts:

The complete potential pest risk analysis is not available for studies outside of the United States. The number of trees at risk to the pests analyzed is reported, though the list of pests is based on known insects and disease in the United States.

For the U.S., potential pest risk is based on pest range maps and the known pest host species that are likely to experience mortality. Pest range maps for 2012 from the Forest Health Technology Enterprise Team (FHTET) (Forest Health Technology Enterprise Team 2014) were used to determine the proximity of each pest to the county in which the urban forest is located. For the county, it was established whether the insect/disease occurs within the county, is within 250 miles of the county edge, is between 250 and 750 miles away, or is greater than 750 miles away. FHTET did not have pest range maps for Dutch elm disease and chestnut blight. The range of these pests was based on known occurrence and the host range, respectively (Eastern Forest Environmental Threat Assessment Center; Worrall 2007).

<u>Relative Tree Effects:</u>

The relative value of tree benefits reported in Appendix II is calculated to show what carbon storage and sequestration, and air pollutant removal equate to in amounts of municipal carbon emissions, passenger automobile emissions, and house emissions.

Municipal carbon emissions are based on 2010 U.S. per capita carbon emissions (Carbon Dioxide Information Analysis Center 2010). Per capita emissions were multiplied by city population to estimate total city carbon emissions.

Light duty vehicle emission rates (g/mi) for CO, NOx, VOCs, PM10, SO2 for 2010 (Bureau of Transportation Statistics 2010; Heirigs et al 2004), PM2.5 for 2011-2015 (California Air Resources Board 2013), and CO2 for 2011 (U.S. Environmental Protection Agency 2010) were multiplied by average miles driven per vehicle in 2011 (Federal Highway Administration 2013) to determine average emissions per vehicle.

Household emissions are based on average electricity kWh usage, natural gas Btu usage, fuel oil Btu usage, kerosene Btu usage, LPG Btu usage, and wood Btu usage per household in 2009 (Energy Information Administration 2013; Energy Information Administration 2014)

- CO2, SO2, and NOx power plant emission per KWh are from Leonardo Academy 2011. CO emission per kWh assumes 1/3 of one percent of C emissions is CO based on Energy Information Administration 1994. PM10 emission per kWh from Layton 2004.
- CO2, NOx, SO2, and CO emission per Btu for natural gas, propane and butane (average used to represent LPG), Fuel #4 and #6 (average used to represent fuel oil and kerosene) from Leonardo Academy 2011.
- CO2 emissions per Btu of wood from Energy Information Administration 2014.
- CO, NOx and SOx emission per Btu based on total emissions and wood burning (tons) from (British Columbia Ministry 2005; Georgia Forestry Commission 2009).

Appendix II. Relative Tree Effects

The urban forest in Town Common provides benefits that include carbon storage and sequestration, and air pollutant removal. To estimate the relative value of these benefits, tree benefits were compared to estimates of average municipal carbon emissions, average passenger automobile emissions, and average household emissions. See Appendix I for methodology.

Carbon storage is equivalent to:

- Amount of carbon emitted in Town Common in 2 days
- Annual carbon (C) emissions from 256 automobiles
- Annual C emissions from 105 single-family houses

Carbon monoxide removal is equivalent to:

- Annual carbon monoxide emissions from 0 automobiles
- Annual carbon monoxide emissions from 0 single-family houses

Nitrogen dioxide removal is equivalent to:

- Annual nitrogen dioxide emissions from 1 automobiles
- Annual nitrogen dioxide emissions from 1 single-family houses

Sulfur dioxide removal is equivalent to:

- Annual sulfur dioxide emissions from 13 automobiles
- Annual sulfur dioxide emissions from 0 single-family houses

Annual carbon sequestration is equivalent to:

- Amount of carbon emitted in Town Common in 0.0 days
- Annual C emissions from 0 automobiles
- Annual C emissions from 0 single-family houses

Appendix III. Comparison of Urban Forests

A common question asked is, "How does this city compare to other cities?" Although comparison among cities should be made with caution as there are many attributes of a city that affect urban forest structure and functions, summary data are provided from other cities analyzed using the i-Tree Eco model.

I. City totals for trees

City	% Tree Cover	Number of trees	Carbon Storage (tons)	Carbon Sequestration (tons/yr)	Pollution removal (tons/yr)
Calgary, Canada	7.2	11,889,000	445,333	21,385	326
Atlanta, GA	36.8	9,415,000	1,344,818	46,407	1,662
Toronto, Canada	20.5	7,542,000	992,079	40,345	1,213
New York, NY	21.0	5,212,000	1,351,432	42,329	1,677
Baltimore, MD	21.0	2,627,000	596,350	16,094	430
Philadelphia, PA	15.7	2,113,000	530,211	16,094	577
Washington, DC	28.6	1,928,000	522,495	16,094	418
Boston, MA	22.3	1,183,000	318,568	10,472	284
Woodbridge, NJ	29.5	986,000	159,835	5,512	211
Minneapolis, MN	26.5	979,000	250,224	8,929	305
Syracuse, NY	23.1	876,000	173,063	5,401	109
Morgantown, WV	35.9	661,000	93,696	2,976	66
Moorestown, NJ	28.0	583,000	116,845	3,748	118
Jersey City, NJ	11.5	136,000	20,944	882	41
Freehold, NJ	34.4	48,000	19,842	551	21

II. Per acre values of tree effects

City	No. of trees/acre	Carbon Storage (tons/acre)	Carbon Sequestration (tons/yr/acre)	Pollution removal (tons/yr/acre)
Calgary, Canada	66.7	2.50	0.06	1.8
Atlanta, GA	111.6	15.90	0.28	19.7
Toronto, Canada	48.3	6.40	0.13	7.8
New York, NY	26.4	6.80	0.11	8.5
Baltimore, MD	50.8	10.43	0.14	7.5
Philadelphia, PA	25.0	6.30	0.09	6.8
Washington, DC	49.0	13.30	0.21	10.6
Boston, MA	33.5	9.00	0.15	8.0
Woodbridge, NJ	66.5	10.80	0.19	14.2
Minneapolis, MN	26.2	6.70	0.12	8.2
Syracuse, NY	54.5	10.80	0.17	6.8
Morgantown, WV	119.7	17.00	0.27	11.9
Moorestown, NJ	62.0	12.50	0.20	12.6
Jersey City, NJ	14.3	2.20	0.05	4.3
Freehold, NJ	38.5	16.00	0.22	16.8

Appendix IV. General Recommendations for Air Quality Improvement

Urban vegetation can directly and indirectly affect local and regional air quality by altering the urban atmosphere environment. Four main ways that urban trees affect air quality are (Nowak 1995):

- Temperature reduction and other microclimate effects
- Removal of air pollutants
- Emission of volatile organic compounds (VOC) and tree maintenance emissions
- Energy effects on buildings

The cumulative and interactive effects of trees on climate, pollution removal, and VOC and power plant emissions determine the impact of trees on air pollution. Cumulative studies involving urban tree impacts on ozone have revealed that increased urban canopy cover, particularly with low VOC emitting species, leads to reduced ozone concentrations in cities (Nowak 2000). Local urban management decisions also can help improve air quality.

Urban forest management strategies to help improve air quality include (Nowak 2000):

Strategy	***Result***
Increase the number of healthy trees	Increase pollution removal
Sustain existing tree cover	Maintain pollution removal levels
Maximize use of low VOC-emitting trees	Reduces ozone and carbon monoxide formation
Sustain large, healthy trees	Large trees have greatest per-tree effects
Use long-lived trees	Reduce long-term pollutant emissions from planting and removal
Use low maintenance trees	Reduce pollutants emissions from maintenance activities
Reduce fossil fuel use in maintaining vegetation	Reduce pollutant emissions
Plant trees in energy conserving locations	Reduce pollutant emissions from power plants
Plant trees to shade parked cars	Reduce vehicular VOC emissions
Supply ample water to vegetation	Enhance pollution removal and temperature reduction
Plant trees in polluted or heavily populated areas	Maximizes tree air quality benefits
Avoid pollutant-sensitive species	Improve tree health
Utilize evergreen trees for particulate matter	Year-round removal of particles

Appendix V. Invasive Species of the Urban Forest

The following inventoried tree species were listed as invasive on the North Carolina invasive species list ():

Species Name[a]	*Number of trees*	*% Tree Number*	*Leaf Area (mi²)*	*% Leaf Area*
Sawtooth oak	6	2.78	0.00	0.44
Total	**6**	**2.78**	**0.00**	**0.44**

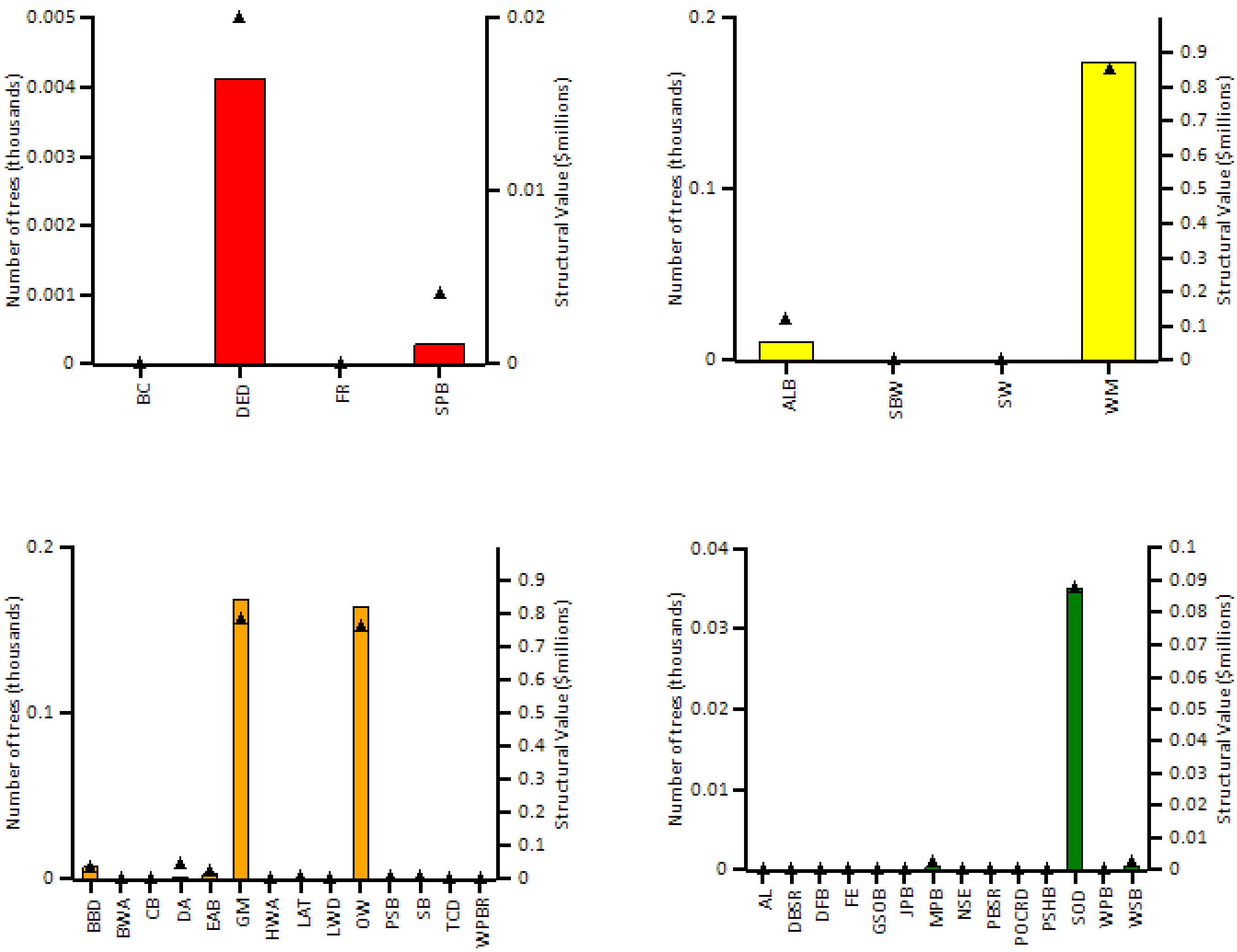
[a]Species are determined to be invasive if they are listed on the state's invasive species list

Appendix VI. Potential Risk of Pests

Thirty-six insects and diseases were analyzed to quantify their potential impact on the urban forest. As each insect/ disease is likely to attack different host tree species, the implications for Town Common will vary. The number of trees at risk reflects only the known host species that are likely to experience mortality.

Code	Scientific Name	Common Name	Trees at Risk (#)	Value ($ millions)
AL	Phyllocnistis populiella	Aspen Leafminer	0	0
ALB	Anoplophora glabripennis	Asian Longhorned Beetle	24	0
BBD	Neonectria faginata	Beech Bark Disease	7	0
BC	Sirococcus clavigignenti juglandacearum	Butternut Canker	0	0
BWA	Adelges piceae	Balsam Woolly Adelgid	0	0
CB	Cryphonectria parasitica	Chestnut Blight	0	0
DA	Discula destructiva	Dogwood Anthracnose	9	0
DBSR	Leptographium wageneri var. pseudotsugae	Douglas-fir Black Stain Root Disease	0	0
DED	Ophiostoma novo-ulmi	Dutch Elm Disease	5	0
DFB	Dendroctonus pseudotsugae	Douglas-Fir Beetle	0	0
EAB	Agrilus planipennis	Emerald Ash Borer	4	0
FE	Scolytus ventralis	Fir Engraver	0	0
FR	Cronartium quercuum f. sp. Fusiforme	Fusiform Rust	0	0
GM	Lymantria dispar	Gypsy Moth	157	1
GSOB	Agrilus auroguttatus	Goldspotted Oak Borer	0	0
HWA	Adelges tsugae	Hemlock Woolly Adelgid	0	0
JPB	Dendroctonus jeffreyi	Jeffrey Pine Beetle	0	0
LAT	Choristoneura conflictana	Large Aspen Tortrix	1	0
LWD	Raffaelea lauricola	Laurel Wilt	0	0
MPB	Dendroctonus ponderosae	Mountain Pine Beetle	1	0
NSE	Ips perturbatus	Northern Spruce Engraver	0	0
OW	Ceratocystis fagacearum	Oak Wilt	152	1
PBSR	Leptographium wageneri var. ponderosum	Pine Black Stain Root Disease	0	0
POCRD	Phytophthora lateralis	Port-Orford-Cedar Root Disease	0	0
PSB	Tomicus piniperda	Pine Shoot Beetle	1	0
PSHB	Euwallacea nov. sp.	Polyphagous Shot Hole Borer	0	0
SB	Dendroctonus rufipennis	Spruce Beetle	1	0
SBW	Choristoneura fumiferana	Spruce Budworm	0	0
SOD	Phytophthora ramorum	Sudden Oak Death	35	0
SPB	Dendroctonus frontalis	Southern Pine Beetle	1	0
SW	Sirex noctilio	Sirex Wood Wasp	0	0
TCD	Geosmithia morbida	Thousand Canker Disease	0	0
WM	Operophtera brumata	Winter Moth	170	1
WPB	Dendroctonus brevicomis	Western Pine Beetle	0	0
WPBR	Cronartium ribicola	White Pine Blister Rust	0	0
WSB	Choristoneura occidentalis	Western Spruce Budworm	1	0

In the following graph, the pests are color coded according to the county's proximity to the pest occurrence in the United States. Red indicates that the pest is within the county; orange indicates that the pest is within 250 miles of the county; yellow indicates that the pest is within 750 miles of the county; and green indicates that the pest is outside of these ranges.



Note: points --- Number of trees, bars --- Structural value

Based on the host tree species for each pest and the current range of the pest (Forest Health Technology Enterprise Team 2014), it is possible to determine what the risk is that each tree species in the urban forest could be attacked by an insect or disease.

Spp. Risk	Risk Weight	Species Name	AL	ALB	BBD	BC	BWA	CB	DA	DBSR	DED	DFB	EAB	FE	FR	GM	GSOB	HWA	JPB	LAT	LWD	MPB	NSE	OW	PBSR	POCRD	PSB	PSHB	SB	SBW	SOD	SPB	SW	TCD	WM	WPB	WPBR	WSB
	12	Norway spruce																																				
	10	River birch																																				
	9	Pin oak																																				
	9	Southern red oak																																				
	8	Willow oak																																				
	8	Water oak																																				
	8	White oak																																				
	8	Post oak																																				
	8	Live oak																																				
	8	Winged elm																																				
	8	Scarlet oak																																				
	8	Laurel oak																																				
	8	Shumard oak																																				
	8	Cherrybark oak																																				
	8	Overcup oak																																				
	8	American elm																																				
	7	Green ash																																				
	6	Sawtooth oak																																				
	4	Sugar maple																																				
	4	Red maple																																				
	3	Flowering dogwood																																				
	3	American beech																																				
	3	Sweetgum																																				

Note:
Species that are not listed in the matrix are not known to be hosts to any of the pests analyzed.

Species Risk:

- Red indicates that tree species is at risk to at least one pest within county
- Orange indicates that tree species has no risk to pests in county, but has a risk to at least one pest within 250 miles from the county
- Yellow indicates that tree species has no risk to pests within 250 miles of county, but has a risk to at least one pest that is 250 to 750 miles from the county
- Green indicates that tree species has no risk to pests within 750 miles of county, but has a risk to at least one pest that is greater than 750 miles from the county

Risk Weight:
Numerical scoring system based on sum of points assigned to pest risks for species. Each pest that could attack tree species is scored as 4 points if red, 3 points if orange, 2 points if yellow and 1 point if green.

Pest Color Codes:

- Red indicates pest is within Lenawee county

- Orange indicates pest is within 250 miles of Lenawee county
- Yellow indicates pest is within 750 miles of Lenawee county
- Green indicates pest is outside of these ranges

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URBAN & COMMUNITY FORESTRY PROGRAM

NORTH CAROLINA FOREST SERVICE

December 2016

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Decay Fungi & Tree Management on Tarboro's Historic Common

Executive Summary

The trees on Tarboro's Historic Common are an important and valuable asset to the community. Managing this asset so that it continues to be a significant presence for many years to come presents several challenges due to age, storm damage, disease, and cost.

The Town received a match grant from the Urban & Community Forestry Grant Program to carry out a tree inventory, which was completed in 2016. The results of the inventory, with respect to tree condition and structure, indicated significant complexity in management and planning that warranted additional consideration. NC Forest Service staff re-visited the site several times, collecting additional information and observations, particularly regarding tree decay and disease. The recommendations for planning and management are compiled in this report, with the assumption that budgets will be established to carry out the necessary work, mitigate liability, and improve the future potential of the Common.

The intent of this report is to provide the basis for making management decisions after the initial recommendations from the tree inventory for immediate removals and immediate pruning have been followed. Management decisions include prioritizing trees and areas to address, but the expectation is that the entire site will eventually be under a sound pruning and monitoring schedule, which must be budgeted for.

While the inventory provides information and sound immediate recommendations, managing the site for the long-term requires further identification of trees to be retained and monitored, and carrying out that work. This includes further assessment of some trees to determine whether they require removal. Removal of risk trees will remain a priority, and a budget cost, on this site for many years to come.

It is very important that any mature trees to be retained are pruned. The majority of failures in trees are branch failures, and many trees on the Historic Common have had branch failures in the past, and future failures can be expected. Improving maintenance practices starts with properly pruning the identified priority trees and extends to properly pruning all retained trees.

Trees with structural defects will likely require immediate or scheduled removals, particularly in high traffic areas. Attempting to retain trees with significant structural defects is not the best use of limited funds at this time. Decisions will need to be on a case-by-case basis under the expertise of a certified arborist with Tree Risk Assessment Qualifications and experience in managing elderly trees.

Establishing a monitoring program will help address maintenance and management decisions so that work can be scheduled and unexpected failures of branches and trunks reduced. There may also be benefits of carrying out more detailed testing on some highly significant trees, such as assessment of internal decay and wind load reduction (see Dr. Luley's report, *Decay Fungi Assessments & Management Recommendations*), where the funds are available.

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The Trees on Tarboro's Historic Common

Introduction

The trees on the Tarboro Historic Common have weathered many storms, some more successfully than others. The majority of trees on the Common can be considered overmature to declining, if not due to age, then because of the damage and stress they have encountered over the years.

Every tree goes through the same stages, some more rapidly than others, but in nature they follow the same sequence:

Seedling Sapling Young Mature Overmature Senescent Dead

Source: Veteran Trees: a guide to good management, Ch 3, 1999

In nature, the full life cycle of a tree can occur uninterrupted, aside from fire or other catastrophic events, but in a developed landscape or urban environment, such elderly trees require active management decisions. Managing mature and declining trees, particularly when the goal is to keep them on-site, can be challenging as many factors contribute to the management decisions:

1. Use of the site & targets: frequency of people, vehicles, events and maintenance staff
2. Site maintenance: turf management, equipment use and damage caused to trees
3. History of damage: weather events, construction, utility installation, digging
4. History of management: training, structural and cleaning pruning, mulch, fertilization
5. Pests and diseases: severity and outcomes of infestation or infection, treatability
6. Decay: lower tree root and butt rots, cavities in the trunk and scaffold limbs, dead wood

The final factor that must be addressed when managing mature trees is cost. Infinite funds can be spent on every tree to retain it as long as possible – but how long is "as long as possible"? 1 year? 5 years? 10 years? Where funds are finite, decisions must be made on which trees are the best candidates for maintenance, which trees will benefit most and are likely to survive intact longest. Those that are not good long-term candidates require removal.

Where the line is drawn between removal and maintenance, is budget driven. Limited budgets require decisions that prioritize spending to maximize the presence and condition of trees that will be improved by maintenance, and that have long-term potential to remain on-site, along with removal and planting expenditures.

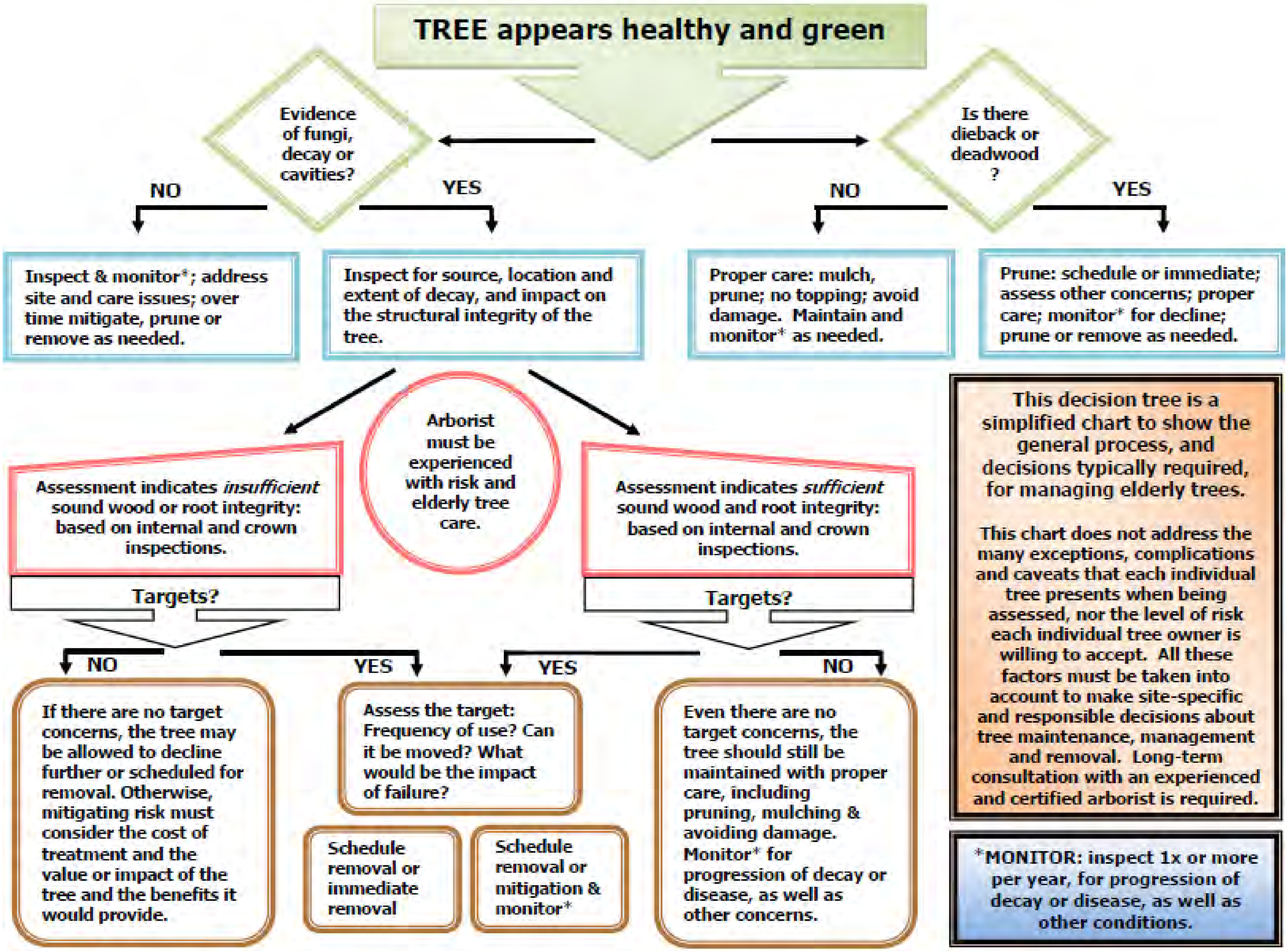
Trees can fall into several different categories, but time or disease or damage can move a tree into another category at any time. Good cultural practices and proper maintenance are recommended to slow that progression as much as possible.

TREE	Immediate Removal	Removal	Monitor	Mitigate
1. Trees that require immediate removal due to a compromised structural condition, regardless of their contribution to the site.	✓			
2. Trees that do not make much contribution to the site in appearance, shade or location but do not present any immediate risk factors. Removal decisions may be scheduled according to available budget or based on monitoring observations.		✓ to schedule removal		
3. Trees that contribute to the site in appearance, shade or location but show signs of decay. The type of decay, its rate of advancement, and location on the tree may require removal due to the virulence of the fungi, or structural concerns.	✓ *based on assessment*	✓ *based on assessment*	✓ assess for action	
4a. Trees that contribute character to the site and present less immediate risk may not require removal. But whether such trees will also benefit from maintenance must be determined, otherwise the trees may be permitted to continue to decline, with no management or maintenance activities beyond deadwood pruning and a monitoring schedule. Trees may remain for an indefinite period of time.		✓ based on monitoring	✓ assess for action; reassess on schedule if not removed	✓ based on results of assessment
4b. Trees that contribute character to the site and have healthy crowns and crown structure, are usually the best candidates for maintenance and long term presence. Eventually the trees may require a reassessment of on-going budget investment as they age and decline, or develop fungal conks or are damaged by storms.		*eventually*	✓ assess for action and reassess on schedule	✓ on-going maintenance as long as deemed appropriate
5. Young trees have long-term potential based on species, condition, structure and location, but may not make a significant contribution in their early stages. But managed with care and maintenance, especially in the early years, will pay dividends in the future.		*someday, far in the future*		✓ on-going maintenance

The most significant issues the trees on the Historic Common are facing are not the past storm damage or the natural decline of the trees. The most significant issues Tarboro must address are:

1. The ongoing maintenance damage from management practices and equipment use, and
2. The presence of more than 6 different decay fungi impacting many trees with visible indications and likely present in many more trees, particularly due to item 1, above.

The presence of decay fungi is a major complicating factor in assessing and monitoring trees, as many decay fungi increase the rate of decline. And, while fungal species rates of decay and location in the tree may vary, trees must be regularly monitored internally and externally, to make decisions that will address the usage and traffic, the level of acceptable risk and the character of Tarboro's Historic Common, now and into the future.


TREE appears healthy and green
Evidence of fungi, decay or cavities?
NO
YES
Is there dieback or deadwood ?
NO
YES
Inspect & monitor*; address site and care issues; over time mitigate, prune or remove as needed.
Inspect for source, location and extent of decay, and impact on the structural integrity of the tree.
Proper care: mulch, prune; no topping; avoid damage. Maintain and monitor* as needed.
Prune: schedule or immediate; assess other concerns; proper care; monitor* for decline; prune or remove as needed.
Arborist must be experienced with risk and elderly tree care.
Assessment indicates *insufficient* sound wood or root integrity: based on internal and crown inspections.
Targets?
Assessment indicates *sufficient* sound wood and root integrity: based on internal and crown inspections.
Targets?
NO
YES
YES
NO
If there are no target concerns, the tree may be allowed to decline further or scheduled for removal. Otherwise, mitigating risk must consider the cost of treatment and the value or impact of the tree and the benefits it would provide.
Assess the target: Frequency of use? Can it be moved? What would be the impact of failure?
Schedule removal or immediate removal
Schedule removal or mitigation & monitor*
Even there are no target concerns, the tree should still be maintained with proper care, including pruning, mulching & avoiding damage. Monitor* for progression of decay or disease, as well as other concerns.
This decision tree is a simplified chart to show the general process, and decisions typically required, for managing elderly trees.
This chart does not address the many exceptions, complications and caveats that each individual tree presents when being assessed, nor the level of risk each individual tree owner is willing to accept. All these factors must be taken into account to make site-specific and responsible decisions about tree maintenance, management and removal. Long-term consultation with an experienced and certified arborist is required.
*MONITOR: inspect 1x or more per year, for progression of decay or disease, as well as other conditions.

Decay on the Historic Common

Virtually all the trees in the Common show long-term and repeated injury to the base, basal flare, and surface roots. While some fungal diseases CAN be spread by root grafts between trees of the same species, the extent of mechanical damage suggests that is the MAIN way that the fungal diseases are spread from tree to tree on the Common; either by wounding the tree so that fungal spores spread by wind can establish, or by cutting fruiting bodies on one tree and then damaging another tree with those same blades to spread the diseases.

Ganoderma lucidum (or *curtisii*, or both) and *Inonotus dryadeus* are two of the most serious fungi affecting trees and, when their fruiting bodies become evident, trees are in a significant state of decay at the base and present a significant risk of failure. *Bondarzewia berkeleyi*, *Laetiporus sulphureus, L. cincinnatus,* and *Meripilus sumstinei* also present serious concerns and, if the decay in the trees is not extensive enough to require immediate removal, they require regular monitoring by a professional experienced in decay assessments. To further expand on the table and decision tree on the previous pages, retention decisions must be based on a determination of the extent of internal decay, the location of the tree, the exposure of the tree to wind and the general appearance of the tree, with respect to thinning of the crown, as well as the level of monitoring possible.

While the relatively low number of trees showing fruiting bodies on the Common in the fall of 2016 is less extensive than expected, this does not mean that the remaining trees are free from disease. The trees may simply not be at the point where the spread of the decay has produced fruiting bodies. But other indicators, aside from fruiting bodies, can reveal issues. As a rule, the presence of carpenter ants can indicate the presence of internal decay. Also, trees with thinning crowns MAY be an indication of decay, or merely an indication of stress or other factors contributing to decline.

A policy of long-term commitment to monitoring annual conk production is required, with the subsequent removal or mitigation and monitoring decisions, carried out according to the final policy and practices that are established with the community and their consulting arborist.

<u>Decay Fungi observed on the Historic Common</u>

Bondarzewia berkeleyi, multiple trees

Ganoderma lucidum/curtisii, multiple trees

Inonotus dryadeus, multiple trees

Laetiporus cincinnatus, #159

Laetiporus sulphureus, #107

Meripilus sumstinei, near #170 & #174

Inonotus ludovicianus, #153

Phellinus everhartii, #31

Several of the fungi were observed on only one tree. Since they are all annual conks (except the *Phellinus*) they may not appear every year, even when the fungus is capable of producing a fruiting body. That means that other trees may also have one or more of these fungi present.

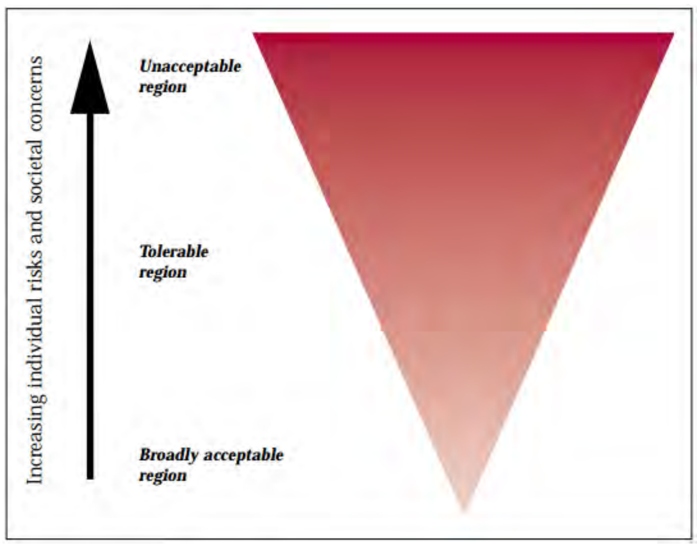
Managing Risk on the Historic Common

The Historic Common has suffered through multiple storm events that have damaged trees and caused the loss of standing trees, through windthrow and catastrophic limb loss, most recently in October 2016 from Hurricane Matthew. Future tree management requires the care of existing trees to reduce potential for breakage in future storms and the removal of trees that show compromised structural integrity that, should they fail, could cause damage to infrastructure (public or private) or to other important trees on the Common.

As mentioned in the introduction, the number of trees on the Historic Common and the costs for maintaining each and every one of them would be substantial. Therefore, some decisions must be made, based on the budget and on the level of risk acceptable to the Town. Risk level is the acceptance that something could happen to a tree or by a tree. The level of risk acceptance ranges between no risk (e.g. all trees removed, or only small trees replanted) to high risk (e.g. no trees removed or mitigated).

While the list on page 2 and the flow chart on page 3 show the general decision-making processes, and incorporate risk assessment, an explanation of risk and its management may be helpful.

The goal of risk management with respect to trees is to manage the trees so that they can provide the benefits we value in a way that reduces the potential for injury or damage. For trees, that should fall between removing all trees so that they never have the opportunity to fail, and never touching a tree once it has been planted, regardless of its structure or the visible problems.

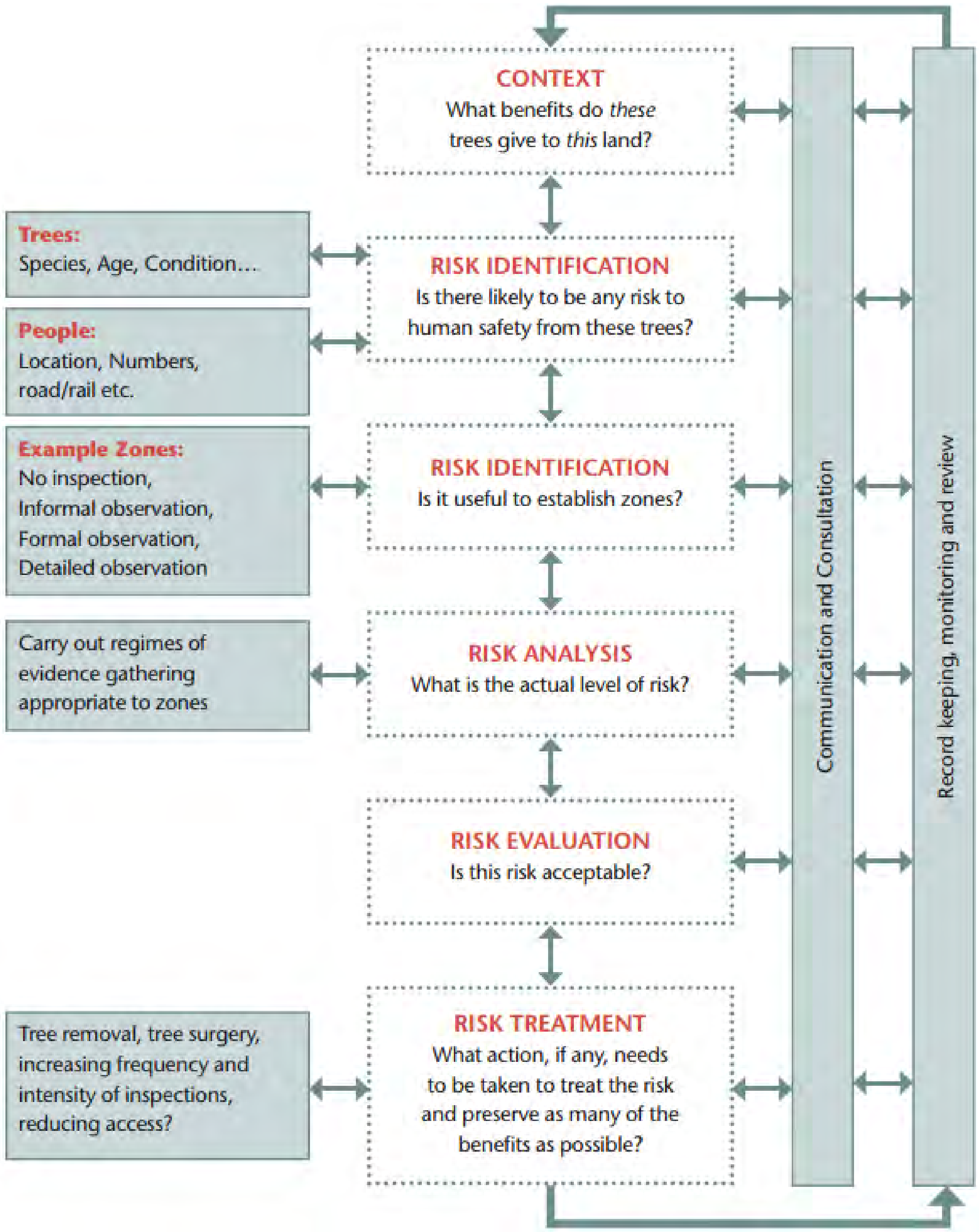


Source: Reducing Risks, Protecting People, 2001

Assessing tree risk requires the knowledge of a Certified Arborist with Tree Risk Assessment Qualification. The qualification itself and the methodology for assessing risk utilize industry-accepted Best Management Practices. This is the basis on which Tarboro can determine its tolerable or acceptable risk. To date, in fact, the failures that *have* occurred on the Common are an excellent example of the typical types of failure and impacts that are most likely to occur throughout the existence of the Common. And, if that were the only concern of the community, the Historic Common could be left on its own. But the community also wants the Common to continue to provide its benefits and the connection with the Town's history – and that requires action, whether pruning, removal, or planting – and to do so in a way that retains the existing character, creates a basis for its future character, establishes a management policy for the future to reach its goals and be financially sustainable.

The “many exceptions, complications and caveats that each individual tree presents when being assessed” as noted in the flowchart on page 3, is expanded for more detail in the flow chart below. This is why long-term consultation with an experienced and certified arborist is strongly recommended; and why an accepted industry standard for assessing tree risk exists.

And this is also why an established management policy for the trees and risk should be developed and then carried out: to demonstrate the duty of care in a rational and cost-effective basis to and for the residents of Tarboro.



Source: Common Sense Risk Management of Trees, 2011

Why are we spending so much time discussing management, and removals, and decay:

Tree #108 failed during Hurricane Matthew. The manner in which the tree failed shows *3* concerns that are shared by many of the other trees on the site, regardless of how green/leafy they may look.

1. Basal Decay – Decay does not have to be externally visible to weaken the structural integrity of a tree; the presence of basal decay fungi on the Common is a concern.
2. Root decay – Root decay is generally not visible above ground but the impact can be seen here with a *very* small root plate that supports and feeds the tree; the presence of decay fungi that affect tree roots is a concern.
3. Target – The street, traffic and parked cars, or even a house across the street, could have been impacted, had the tree fallen in a slightly different direction.

Budgeting to manage trees properly and mitigate existing risk requires context and knowledge.

It should be noted that crown reduction can be a very effective way to mitigate risk as it reduces the size of the crown and leaf area, so that a tree presents less sail to strong winds which are a typical force that results in tree failure. However, trees also need their leaf area to support cell function and tree growth. So any trees treated in this way must have sufficient crown and leaf area remaining so that they can continue to grow and survive.

Some trees on the Historic Common, such as tree #35, may be good candidates for crown reduction (see Dr. Luley's discussion in his accompanying report, and noted in the Appendix), while others would not benefit from the treatment sufficiently to warrant the cost. This is why prioritizing the trees for treatment and working with a certified arborist to monitor and treat the trees is so essential.

Developing a Management Strategy for the Historic Common

Step 1

The inventory and labelling of the trees on the Historic Common in 2016 was just the step to develop a management strategy that will serve the Common and the community for years to come.

Step 2

The second step is carrying out the immediate recommendations of that inventory report. The immediate removals and pruning are based on mitigating any immediate risk presented by trees that may be structurally compromised by decay, damage or death and where, should failure occur, the possibility of damage or injury exists. Following through on the immediate recommendations of the inventory is a very important step.

Step 3

Once the immediate work has been completed, the third, longer and more involved, task of managing for the priorities must occur:

1. Healthy mature trees.
2. Structurally sound trees able to withstand extreme weather events with reduced breakage.
3. Canopy and shade that provides a setting for community events and a welcoming place for residents to enjoy.
4. Contributing to the character and quality of life within the community.
5. Maintaining the history of the community.

But Tarboro can only get to that vision through the existing trees on the site, many of which are compromised and/or declining. Before Step 3 can be fully accomplished, the community must navigate the management of an aging population of trees in a way that retains the existing character of the Historic Common and creates a basis for its future character. Out of those efforts, not only will the framework for a management policy become clearer, but the budget requirements and long-term commitments will be more clearly understood.

Step 2.5

The interim step that must occur, before Step 3, is at the crossroads of budget and need. Given the number of older trees and the general decline of many of them, most of the trees require some sort of work to improve their present structure. While each tree might benefit from maintenance work to some degree, the question is: Would that work make a difference in how long the tree would possibly survive and the level it could contribute to the site during that time? What is the cost:benefit ratio of treatment:longevity.

Investing limited funds in the trees that have the best potential for a long-term presence is the main priority, now and in the future. But right now, it is expected that many of these older trees are going to require removal and replacement in the next 1-10 years, which would skew the tree population to young trees and change its character for many years to come.

So the priority for Step 2.5 is buffering the impact of removal and replacement, in order to allow the Historic Common to retain a degree of its existing character. The Common needs some its older mature trees to remain intact, so selecting older trees which would benefit from maintenance and ensure their longevity for 5 or 10 years *or more*, is essential.

To expand on the description in the table on page 2, and some of the considerations, exceptions, complications and caveats that must be considered:

1. IMMEDIATE REMOVAL: That some trees must be removed now, refers mainly to trees with internal or external decay that compromises structural stability and where there is a target. The extent of the decay, and the age and species of the trees, as well as the tree location, are additional factors in this decision.
2. SCHEDULED REMOVAL: Tree may be in a similar condition as the trees listed above, but they do not have the same target potential.

   Considerations for both 1 and 2:
   - Even if the problems could be mitigated, or reduced in severity, the length of contribution by the tree must be considered to the cost of treating them. Ultimately, the tree will still require removal. This decision should be impacted by cost for multiple treatments and final removal.
   - The low risk option would be removal; mitigating the trees now and in the future would be a moderate to moderate/high risk, depending on the condition of the tree, with maintenance and, ultimately, removal costs.

3. MONITORED DECLINE to scheduled removal: Some trees are structurally sound enough to be left in place and observed. As long as they do not present a risk of failure and do not have large dead limbs or hangers, they can remain until their status changes. These trees may be in fair, or even poor, condition, e.g. show signs of past storm damage and/or signs of decline (thin or thinning crowns, dieback of small branches, epicormic shoots along main limbs).
   - When the tree status changes, the Town may choose to mitigate risk and retain the tree, or to remove the tree. It will depend on the Town budget and its priorities at the time, for example, if several trees in the area around such a tree had required removal for some reason, maintaining that one declining tree may be determined to be important. Or it could be decided that the tree must be removed so when new trees are planted, they will not be impacted when the time DOES come to remove that long-declining tree.
   - The low risk option would be removal, while leaving the trees and only removing large dead limbs or hangers as required would be a moderate to low risk, as long as the trees were regularly inspected for changes in status.

4a&b MONITORED & MITIGATED: Some trees are reasonably healthy and may withstand being neglected, but they would benefit from pruning maintenance for structure and for health. This can help extend the life of the tree before it begins to decline, and reduce branching habits that make the tree more prone to damage from storms. These may be younger trees or older trees that have good crown density.
   - Managing these trees and budgeting for maintenance it is recommended.
   - Low risk could be doing nothing for a long time, but it could also mean that these trees will require removal sooner than if they had been managed properly. Routine maintenance for deadwood and broken limbs is a wise investment.

5. YOUNG TREES: Most young trees are un-managed until they reach a size where their issues are more costly to address. While tree selection, planting and post-planting care are very important, so is training pruning. Trees that are 20’ or less can be very inexpensively pruned from the ground to improve their mature structure. This is a cost-effective approach that will pay large dividends as the trees mature.

Prioritizing Trees to Receive Treatment on the Historic Common

<u>Anchor or Priority Trees</u>
These are trees of a size or species that have long term potential to contribute to the Historic Common, its environment and its aesthetics. An initial list was identified by the Town, which was reviewed and adapted based on health, condition, presence of decay or decline, maturity, species, structural integrity and potential. Location and size were also considered for some trees.

Trees have been selected to be present in every block section. The selected trees are not the ONLY trees that can contribute to the future of the site, this list is merely a way to make some initial prioritizations that can help direct limited funds, after the immediate removal and pruning work, as recommended by the inventory, has been carried out. These trees would still require regular monitoring, they are merely deemed as being prime candidates for management and mitigation, where all other factors are appropriate.

In order to direct maintenance and budget to the trees with the greatest potential for longevity and contribution to the Common, the trees on each block segment have been reviewed. The trees are listed and then identified by the descriptive list on page 10.

Trees with thinning crowns have 2 numbers for possible assessment results: #4 if it is possible to mitigate and monitor, and #3 or #2 or #1 – these decisions would be clarified to one number once properly assessed. Magnolias are assumed to be managed and maintained, if not showing any other indicators and have not been selected as priority trees at this time.

These observations do not preclude the area being re-visited now or at any time in the future, and removing any of the trees from the list or additional trees being identified. Decay fungi, storm damage or other factors may change the status of any tree and its suitability for being a priority tree.

Each map uses the following key:

◇ Original priority tree selection
□ Recommended priority tree selection
○ To be inspected prior to making a priority determination

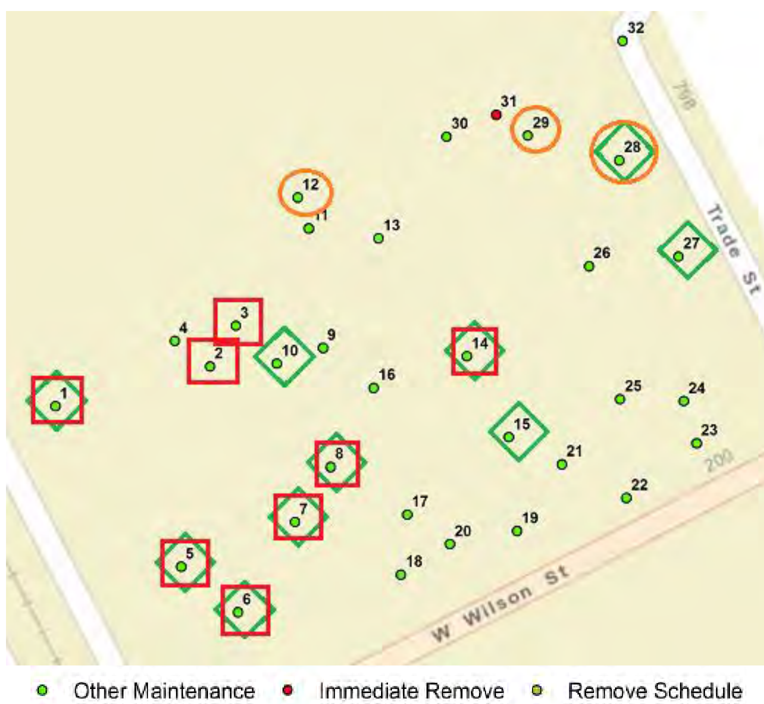
Area 1 – The Flagpole Block (between Albemarle Avenue and Trade Street)
Area 2 – The Memorial Block (between Trade Street and N Main Street)
Area 3 – The Fountain Block (between N Main Street and St. Andrew Street)
Area 4 – The Small Memorials Block (between St. Andrew Street and St. Patrick Street)
Area 5 – The Block West of the School Parking Lot Block (east of St. Patrick Street)

NOTE: Areas 4 and 5 see the most usage of the Common as the location of events, at least three times per year. While this higher usage could not be considered a significant increase in risk, the use, during those periods, is sustained and, as such, removal and retention decisions should be considered carefully, with respect to the level of risk acceptable to the Town.

Area 1 – The Flagpole Block (between Albemarle Avenue and Trade Street)

10 trees were identified by the Town as being priority trees, however some of those trees were identified as having fungal decay, as evidenced by the presence of annual fruiting bodies.

1 **Live Oak** – beginning to develop its mature form, #5.
5 Southern Red Oak – still quite young and requires structural prune, #5.
6 Dawn Redwood – newly planted tree that should not require pruning, #5.
7 **Sycamore** – long term potential, #4.
8 **Sycamore** – long term potential, #4.
10 Norway Spruce –thin crown, would require on-going intervention in hopes of improving condition to make a real contribution to the site, #2.
14 **Sycamore** – long term potential, #4.
15 Water Oak – *Inonotus dryadeus*; weaker wooded than most other oaks; pro: crown looks fairly healthy; con: a number of cavities up the stem; inspection required to determine fate: #2 (due to potential to damage surrounding trees) or #3.
27 Willow Oak – has a sparse crown and has lost limbs in past storms, near #28 and #35 so monitor for development of fruiting bodies, #3 for now.
28 Willow Oak – *Bondarzewia berkeleyi* occurs around entire base of tree; crown appears better than #27; inspection required to determine fate but #2 (due to location on street) or very vigilant #4 with crown reduction.



Additional trees suggested for inclusion as priority trees, based on species:

2 Live Oak – small but good future potential, #5.
3 Live Oak – small but good future potential, #5.
12 Pecan – stressed with sapsucker damage and needs structural pruning for the unbalanced crown, with fertilization and mitigation this would be one of two pecans on the Common, #4 should be considered, otherwise #3.
29 American Elm – a rare species in urban locations these days and in relatively good condition until crown damage from Hurricane Matthew. Although it appears to be girdled by underground roots on one side and should be monitored for Dutch Elm Disease, if corrective pruning can improve the crown damage it should be a #4, otherwise it would be #3.

Total priority trees in the flagpole block:

- 4 (plus 4 young trees that are obvious candidates for training pruning).
- up to 11 if mitigation/monitoring is suitable for #12, 28 and/or 29.

Area 2 – The Memorial Block (between Trade Street and N Main Street)

6 trees were identified by the Town as being priority trees, however some of those trees were identified as having fungal decay, as evidenced by the presence of annual fruiting bodies or the presence of carpenter ants.

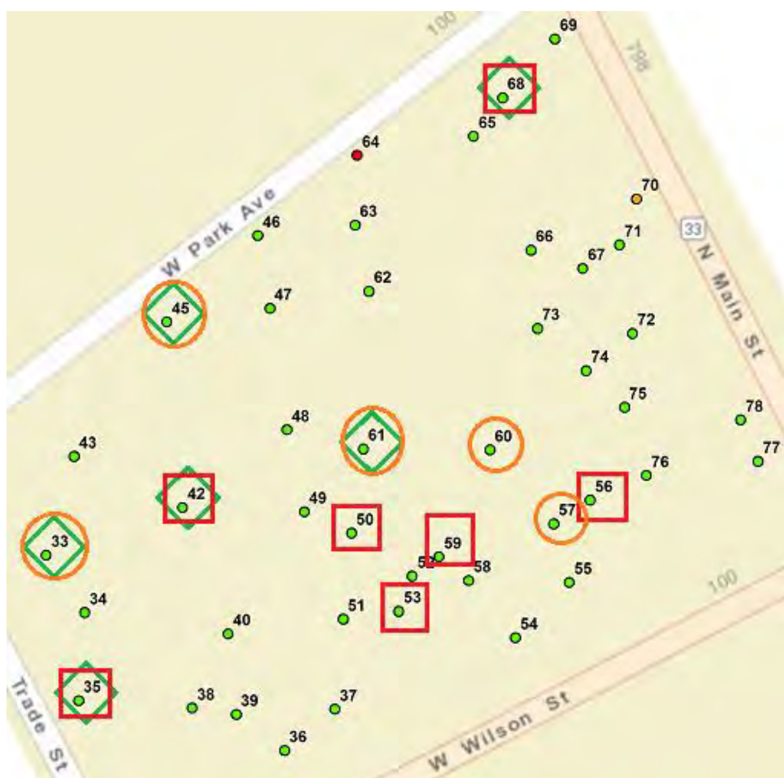
33 White Oak – thin crown and some minor deadwood; a small external cavity visible ~20' should be inspected; #4 if cavity not an immediate concern; #2 if cavity more of an issue.
35 Willow Oak – the crown of this tree looks fairly good but there is *Bondarzewia berkeleyi* around the base of the tree, as well as *Inonotus dryadeus*. Due to the significance of the tree, wind resistance mitigation was assessed to require a crown reduction of 15' (noted in the Appendix and Dr. Chris Luley's report). Retaining this tree would require a commitment of close monitoring for decay, #4.
42 White Oak – long term potential, #4.
45 Water Oak – lost a limb during Hurricane Matthew; the crown looks healthy but a cavity ~30' should be inspected before making a determination; if suitable for retention, prune the crown to reduce weight over the street and monitor; #4 if cavity not an immediate concern; #2 or even #1 if the cavity is more of a concern.
61 Willow Oak – has a thin crown but the form is good; #4 without other indicators; #2 or even #1 if closer examination identifies issues.
68 Willow Oak – crown is reasonably dense, but it is a bit straggly, so pruning advised, #4.

Additional trees suggested for inclusion as priority trees, based on species:

50 White Oak – a decent crown and a good u-shaped fork, #4.
53 White Oak – a decent crown and great form, cleaning prune, #4.
56 American Beech – the crown structure is crowded but worth trying to improve, prune for #4 .
57 Deodar Cedar – should be inspected to see if multiple leaders could be improved for better structure; if yes this is a #4 at least.
59 White Oak – has a lean away from the Cedrus but well protected, #4.
60 White Oak – has a thinning crown so would need closer inspection before determining #2 or #1 or, with treatment, #4 or #5.

Total priority trees in the memorial block:

- 7, up to 12, if inspections show #33, 45, 57, 60 and/or #61 are suitable for mitigation and monitoring.



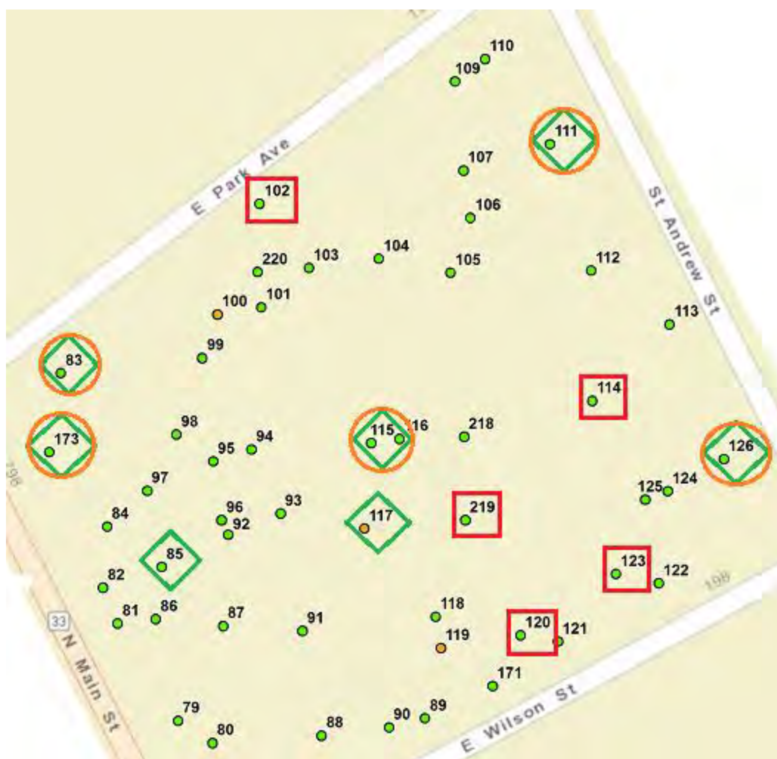
Area 3 – The Fountain Block (between N Main Street and St. Andrew Street)

7 trees were identified by the Town as being priority trees, however some of those trees were identified as having fungal decay, as evidenced by the presence of annual fruiting bodies or the presence of carpenter ants. A number of trees were noted to have quite active carpenter ant populations and should be inspected more closely and monitored.

83 Southern Red Oak – broken top with possible decay, a heavy fork over street, inspect to determine if mitigation appropriate; #1 if cannot be mitigated, could be a temporary #4.
85 Willow Oak – *Inonotus dryadeus*, thinning crown and deadwood; carpenter ants near conk and also seen climbing higher into tree; inspection may choose to mitigate to #2 but #1 more likely.
111 Willow Oak –clean prune and reduce crown weight over the street; inspect before determining if fertilization would be appropriate, due to location; #4 is possible.
115 Post Oak – cavity at base of structural limbs must be inspected to determine whether removal is necessary, #1, or if mitigation is appropriate to reduce crown weight; depending on form and function post-mitigation #2 or #4 possible.
117 Post Oak – cavity at the base of the broken codominant fork, a #2 at best or a #1, depending on budget and pedestrian traffic in the area or possible damage to surrounding trees.
126 Willow Oak – crown looks stressed and a steady path of carpenter ants into a seam at the base of the tree; requires inspection to determine whether the tree should be removed, #1 or #2.
173 Post Oak –crown weight over the street needs assessment to determine if tree form and function is worth the cost of mitigation and monitoring; if yes, temporary #4 due to location.

Additional trees suggested for inclusion as priority trees, based on species:

102 Post Oak – this tree is worth monitoring and managing, after a closer inspection, one of the few post oaks without immediately obvious structural issues, #4.
114 White Oak – deserves structural pruning, #4.
120 American Beech – remove stubs and bad pruning to maximize future potential, #4.
123 White Oak – a rather narrow form due to having a former neighbor but appears vigorous, inspect crown and cleaning prune, #4.
219 White Oak – some dieback and minor deadwood but excellent form, a far better candidate than its neighbor #117, #4.



Total priority trees in the fountain block:

- 5, up to 10, if mitigation is sufficient to retain, even temporarily: #83, 111, 115, 126, 173.

Area 4 – The Small Memorials Block (between St. Andrew Street and St. Patrick Street)

9 trees were identified by the Town as being priority trees, however some of those trees were identified as having fungal decay, as evidenced by the presence of annual fruiting bodies or the presence of carpenter ants. A number of trees were noted to have quite active carpenter ant populations and should be inspected more closely and monitored.

127 Sweetgum – not a long-lived tree and is brittle-wooded, but with monitoring and maintenance due to the location and size, #5.

131 Willow Oak – requires cleaning pruning but is decent shape for a willow oak, #5.

134 Willow Oak – requires cleaning pruning but is decent shape for a willow oak, #5.

139 Post Oak – a history of crown loss does not make this a good priority tree; monitor and maintain as a #3, or make it a #1 and structural prune its neighbor, #140 (white oak), as a slightly better candidate for a generous #4.

146 Water Oak – a cavity at ~20’ requires an inspection, but given the species and the higher usage of this area, #1 would be a better use of limited funds.

153 Willow Oak – thinning crown and carpenter ants, inspect if retaining tree as a #2, otherwise #1.

160 Willow Oak – thinning crown, inspect before determining if fertilization would be appropriate, due to location for a possible and temporary #4, otherwise #2 or #1.

167 Water Oak – multiple cavities and many carpenter ants make this a #1.

174 Southern Red Oak – dieback, deadwood and carpenter ants; *Meripilus sumstinei* is in the vicinity and this tree may be its host, based on location of fruiting bodies; #1 seems the wiser choice, unless internal inspection allows very close monitoring and mitigation for #4.

Additional trees suggested for inclusion as priority trees, based on species:

149 **American Beech** – structural prune, #4.

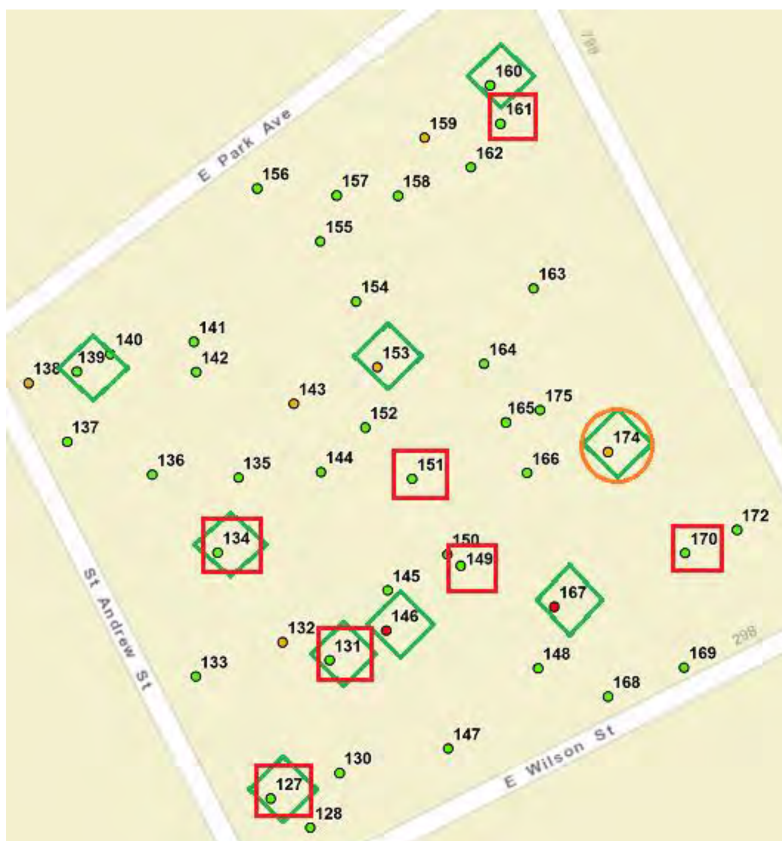
151 **White Oak** – a younger tree with great form and potential; clean and structural prune for codominant limb; #4.

161 **American Beech** – structural prune to reduce competition within the crown, #4.

170 **American Beech** – immediate prune and structural pruning needed, #4.

Total priority trees in the fountain block:

- 7, up to 8 if #174 can be retained and managed.



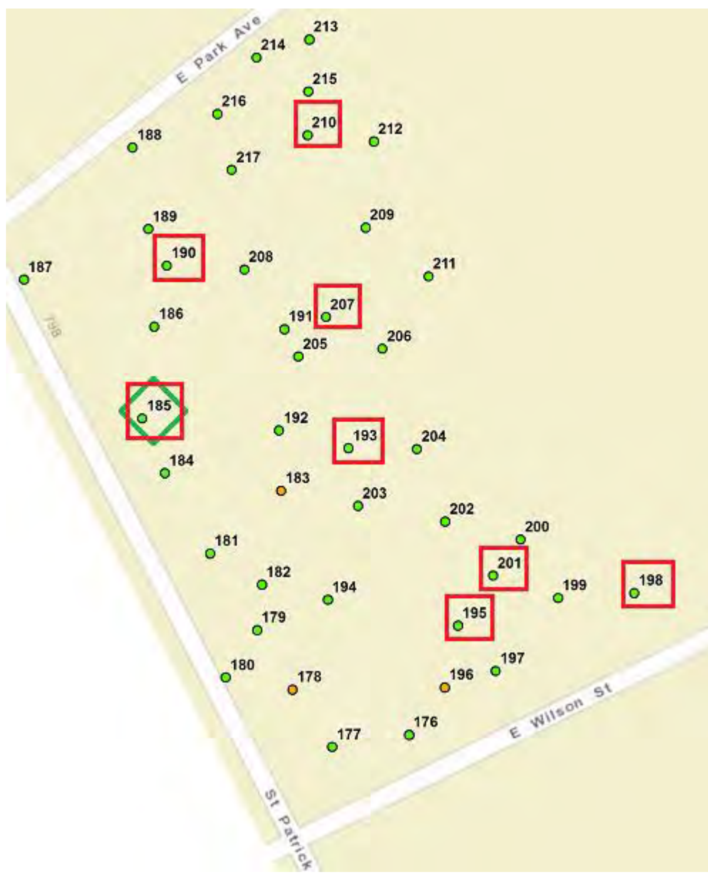
Area 5 – The Block West of the School Parking Lot (east of St. Patrick Street)

1 tree was identified by the Town as being a priority tree, no trees were noted in this section as having fungal fruiting bodies at the time of the inspection in September 2016. Several larger green ash were identified which may be considered as candidates for injections to help protect them from Emerald Ash Borer. Injections must be done every few years to maintain sufficient protection from this pest.

Unlike the other 4 sections, there are also several younger water oaks in this section that can be considered for long-term maintenance as they do not show any damage or decay at this time. Managing these water oaks would allow the Common to keep this species as a presence on the Common.

185 **White Oak** – beautiful spreading tree that should be managed for optimum health and structure, long-lived species could be here for your great and great-great grandchildren. The spreading crown may benefit from monitoring and the installation of cables and braces in the future.

Additional trees suggested for inclusion as priority trees, based on species:



190 **Live Oak** – on the Common, young #4.
193 **Green Ash** – to ensure the survival of this tree, chemical treatment should be considered as a long-term management strategy, #4.
195 **Pecan** – has sapsucker issues just like the pecan in Area 1; fertilize and cleaning prune and prune to reduce breakage potential of this rather brittle tree, #4.
198 **Live Oak** – the largest live oak on the Common, and great form, cleaning prune, #4.
201 **Green Ash** – to ensure the survival of this tree, chemical treatment should be considered as a long-term management strategy, #4.
207 **Pin Oak** – largest of this species on the Common shows stress, good potential with improved maintenance, #4.
210 **Green Ash** – to ensure the survival of this tree, chemical treatment should be considered as a long-term management strategy, cleaning prune recommended, #4.

Total priority trees in the school block:

- 8

Prioritizing the Zones to Receive Treatment on the Historic Common

Further prioritizing may be required, if the work must be carried out in stages, due to budget or other restrictions. If that is the case, the zones to focus on first are the perimeters of each block section. These areas receive the most traffic as vehicles travel the streets that travel around and through the Common. Areas 4 and 5, which are the locations for community events are the 2nd zone or priority area, and Area 1 is the 3rd zone or priority area, with Areas 2 and 3 being the 4th.

<u>Priority Areas:</u>

ZONE 1

ZONE 2

ZONE 3

ZONE 4

Further Comments on Maintenance of the Trees on Tarboro's Historic Common

The existing site management concerns have been discussed previously in person on-site, in this report, as well as addressed in the Tree Inventory Report completed by Treeful Communities in 2016, and is noted in the accompanying 2016 report by Urban Trees, LLC (and noted the Appendix). However, their impact on the site and the trees bears repeating.

Physical damage by mowers is not only evident on trees of all sizes, but this damage is the primary cause of the spread the fungal decay organisms from tree to tree. Virtually every large tree shows repeated damage, not only to the surface roots but on the trunks as well. And the small trees are no less impacted.

Tree #28: This damage is between the curb and the street, there is no grass here to mow. The "ledge" where damage has been occurring for many years is very visible. The tree continues to try and grow over the wound, its natural response to damage.

Repeated damage to roots cause stress to the trees and opens the trees to decay. Here, even without any fungal decay organisms present, the combination of repeat damage and tree growth response creates a concave area where water can collect.

The majority of trees have bare soil with very sparse grass from the shade, which would suggest that mowing so close to the trees is simply not necessary.

This goes hand-in-hand with a policy, and training, for mowing staff regarding damaging trees on the Common

Mulch is STRONGLY recommended for each tree, or for groups of trees. This may slow the speed of the mowers, as they must not drive over the mulch or mulch beds, but management must decide which investment to protect, staff hours or the trees on the Historic Common. Mulch 2-3" in depth, to a maximum of 4", and place so that it is not piled against the base of the trees.

Other management or maintenance issues will also need to be addressed:

1. The practice of re-seeding the grasses regularly may need to be assessed and options considered to keep root damage to the extensive tree roots throughout the Common to a minimum. The majority of tree roots are in the top 6-18" of soil and the small feeder roots are necessary for the trees to access water and nutrients and maintain their health and vitality. Even more important given the general condition and age of the trees.

2. Any utility installation, improvement or repair should be done in consultation with a certified arborist, preferably one with a good understanding of the site and the trees, as well as the management and concerns for the specific trees affected. This should also be required if planning to attach any infrastructure to any trees.

3. The appeal of the aluminum tree tags to squirrels means that some tags may require replacement, including some of the nails. Different methods or styles of tagging may be considered in future since the tags are helpful to identify specific trees for maintenance or other work, should the workers not have access to the electronic data while on-site.
   a. Steel or brass are more expensive but may be less appealing to the squirrels, although if the tree is allowed to grow around a steel tag, it could be an issue at removal; https://nationalband.com/tree-tags/
   b. UV-stable cable ties rather than nails used to attach tags www.proaxis.com/~johnbell/equipment/equip56a.htm
   c. Or use other methods of attachment or signage as need requires as, depending on the success and use of the Common in the future, an arboretum type of labelling for public use may become a more useful option. https://info.plantsmap.com/journal/best-way-to-attach-an-identification-sign-to-a-mature-tree or http://myplantlabel.com/products or http://bigticketoutdoors.com/store/tree-mounting-hardware.

4. Mulch will need to be refreshed periodically. Wind and rain, foot traffic and composting will reduce mulch thickness, as will mowers on the edges of the installed mulch. Woodchips are preferred over bark chips, and dyeing is not necessary. Smaller chips will break down more quickly, which is not a bad thing, and are also less likely to blow around. Partnering with utility contractors and having a site where chips can be dumped, and even partially composted, can be a way to reduce replacement costs.

5. With the extensive presence of the various decay fungi throughout the Common, a recommendation to fertilize trees with thin crowns is not advisable, as increasing the weight of the crown could put more stress on any invisible internal weak or decayed areas of the trees. Fertilization decisions should be made in consultation with a professional experienced in decay assessments.

6. *Establishing a long-term working relationship with a consultant who can advise, recommend, review, and treat the trees on the Historic Common is essential. A consistent management approach and clear communication between all parties involved is essential for the success of the long-term management of your trees.*

APPENDIX: Site Visit by Dr. Chris Luley, Urban Forestry, LLC, on 21 Sept 2016

On 21 September 2016, Dr. Chris Luley visited Tarboro's Historic Common. Dr. Luley, the author of several books and numerous articles, is an acknowledged expert in the area of tree decay fungi, including the 2012 article Indicators of Decay in Urban Trees and his reference book, Wood Decay Fungi. Dr. Luley has also developed a website: Wood Decay Fungi of Living Trees, with the simple url of *www.treerot.com*.

Despite the steady rain that limited the use of much of Dr. Luley's assessment equipment, he was able to collect some data and note a number of observations, which he has presented in the attached Consulting Arborist report: *Tarboro Commons Decay Fungi Assessment and Management Recommendations.*

One of Dr. Luley's observations was the significance of Tree #35, the large willow oak on Trade Street. The tree has *Bondarzewia berkeleyi* around the base of the tree, as well as *Inonotus dryadeus*. Further assessment of the tree indicates that there is some decay in several of the roots but the wood at the base of the tree is fairly solid, which was an encouraging sign, given the extensive extent of the fungal fruiting bodies. While on-going monitoring and assessment will be necessary to maintain the tree on the Common, Dr. Luley submitted the tree data to a relatively new process of Wind Load Analysis, to assess the degree of crown pruning that would be recommended to reduce crown sail by 25%. This discussion can be found on page 7-8 of Dr Luley's report, as well as Appendix B, on page 12 of the report.

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Consulting Arborist Report

Tarboro Commons
Decay Fungi Assessment and Management Recommendations

to

North Carolina Forest Service
Urban and Community Forestry Program
1616 Mail Service Center
Raleigh, NC 27699-1600

by

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October 2016

Introduction and Scope of Services

This report provides the results of field observations and limited additional testing of mature oaks on the Tarboro Commons conducted on September 21, 2016. The field work was conducted according to an agreed upon Scope of Work. Nancy Stairs and Alan Moore of the North Carolina (NC) Forest Service, and John Suggs a private consultant were present during the field work.

Methods

The tree population on the Tarboro Commons was previously inventoried and the trees were mapped and tagged with numbered aluminum tags. The same aluminum tag numbers are referenced in this report. The NC Forest Service had previously collected, photographed, and documented the presence of root decay and other decay fungi over the past two years, and had made maintenance recommendations for individual trees.

On-site the NC Forest Service staff identified individual trees for evaluation and identification of decay fungi. The site visit was not proposed to provide systematic risk assessment of the population present or of any individual tree. The goal of the evaluations was to:

- Identify the decay fungi present,
- Test on a limited basis individual trees with decay fungi fruiting around them,
- Generally evaluate tree health and extent of decay in the Common's tree population, and
- To evaluate potential approaches for management given the results of the above testing and observations

Additional Assessment

Most trees were evaluated by sounding with a mallet and visually from the ground. Persistent rain during the time we were on site precluded use of the binoculars or electronic decay testing equipment that had been planned (RinnTech ArboTom (Rinntech.da) sonic tomography and the RinnTech Series 6 Resistograph resistance drill). Two trees were tested with the Resistograph (trees with tag numbers 110 and 159) but further testing was stopped because of the rain.

One tree was selected for wind load analysis because of the extensive fruiting *of Bondarzewia berkeleyi* on woody roots (Photograph 1). The wind load analysis was conducted by Andreas Detter of Tree-consult.org using measurements and images of the tree provided by UFLLC.

A single sample of a bleeding canker on tree #107 was taken and sent to Research Associates Laboratory (vetdna.com) for *Phytophthora* DNA testing. One other tree with similar bleeding canker symptoms was observed but was not tested.

Results

General Observations

I observed the following when on site:

- The tree population on the Tarboro commons is mature to over mature although new trees have been planted in some areas. Most of the oaks are large in diameter.
- Based on a general visual assessment, the majority of mature trees are in fair to poor biological health, although some individual trees are in good biological health.
- Many trees have positive indicators of decay on their roots, butts and trunks such as wood decay fungi fruiting and cavities and/or carpenter ant nesting.
- General absence of regular pruning maintenance was evident by the presence of varying

degrees and sizes of deadwood, and defective and decayed branches in many trees

- Several trees on the Commons are growing as street trees because of their location directly next to the street, which is a high target area due to usage.
- Several of the trees along the streets have root decay fungi and are in poor biological health.
- Non-pathogen fungi such as *Boletus sp.*, and *Russula sp*. were also common near and within the drip zone of many trees.

Wood Decay Fungi

The following root and butt decay fungi were identified on site, from previous photographs, or from specimens identified on site by the North Carolina Forest Service. Individual specimens were collected and some samples had been previously submitted to the plant diagnostic laboratory at North Carolina State. Individual trees had two or more root and or trunk decay fungi fruiting around them.

Root and Butt Decay Fungi

Bondarzewia berkeleyi
Laetiporus cincinnatus
Meripilus sumstinei
Ganoderma curtsii
Inonotus dryadeus
Inonotus ludovicianus

Trunk and Stem Decay

Phellinus everhartii
Inonotus hispidus

Significance of Decay Fungi Observed

All these fungi are problematic when evaluating trees for likelihood of failure because they are either known to be relatively aggressive (e.g. *Inonotus dryadeus, Ganoderma curtsii, and Meripilus sumstinei, Inonotus hispidus*) or have been reported as common causes of decay in roots and trunks without clarification of the extent of decay likely to be associated with their fruiting (*Laetiporus cincinnatus, Bondarzewia berkeleyi, Inonotus ludovicianus, and P. everhartii*), making the importance of their fruiting unknown.

A number of trees had known root decay fungi fruiting on roots or their butts around much of the circumference of the tree. The extent of fruiting indicates decay is likely spread throughout the woody root system. In some cases, the trees were in good biological health despite the extensive fruiting on the root system (for example Tree #35; Photograph 1L). *M. sumstinei* was also observed at a substantial distance from a tree or apparently where a tree had been removed previously.

The NC Forest Service documented individual trees with each species of wood decay fungus. Several fungi were unknown prior to the site assessment and were identified on site including Tree #31 with *Phellinus everhartii* and tree # 153 with what appears to be *Inonotus ludovicianus*.

Other Indicators of Concern

Damage from lawn maintenance equipment to woody roots and buttress roots closer to the trunk in some cases was also common throughout the population. These wounds are a concern as they are potential infection sites for wood decay fungi which were sporulating or fruiting around many trees.

It was also easy to identify trees that were in poor biological health as indicated by crowns that had low foliar density, smaller than normal leaf size, and varying degrees of branch dieback. These crown symptoms can be due to a variety of causes such as over maturity, soil or site conditions, or infection and death of roots from root decay fungi. Some of the decay fungi such as *G. curtsii* are known to kill roots in addition to decaying them. Thus, the poor crown health can be a direct result of infection by root pathogens. Crown health is also an important factor to consider when assessing the long term potential of trees to survive, particularly those that are known to be infected with root decay fungi.

Advanced Testing

Two trees were selected for testing with a Resistograph. These trees were selected based on the presence of root decay fungi, sounding with a mallet and listening for results that indicated decay is present in the base of the tree, and crown condition. Sounding with a mallet was also used to generally assess other trees in the population for decay. As diagnostic method it is considered part of a basic assessment and to be effective primarily in identifying trees that have extensive decay in the base or trunk.

The two trees tested with the Resistograph were Tree #159 which was reported to have *L. cincinnatus* fruiting around it and Tree #110 which had extensive *B. berkeleyi* on the roots and at the base. Testing results for trees #110 and #159 are presented in Figures 1 and 2.

The testing showed decay was fairly extensive in both trees. The Resistograph charts are marked with the bark, soundwood and decayed wood on each chart. For example in the chart below from Tree#159 (Figure 1A) the drilling was made on the north side of the tree at 16 inches off the ground (see header information). It showed about 3 inches of sound wood remained in the outer shell at the point of drilling. Similar results were found in the other two locations where this tree was test (Figure 1B and 1C).

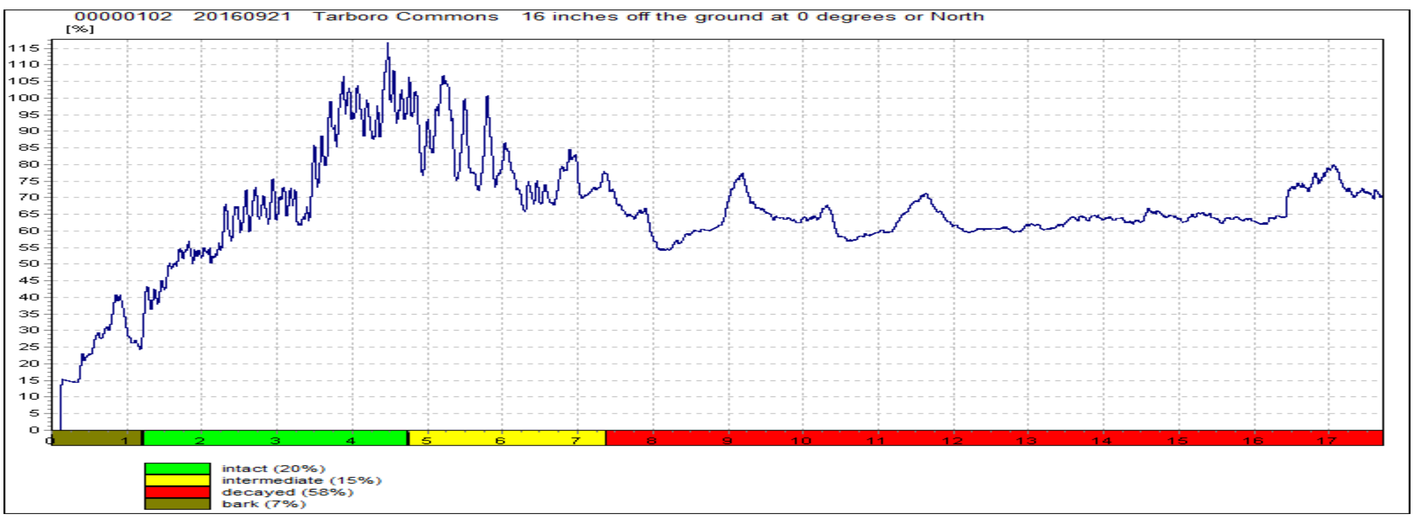

Figure 1A. Resistograph chart from Tree #159. The drilling showed extensive decay in the trunk in the location tested with about 3 inches of sound wood remaining. The exact drill location is noted on the header of the chart. Note the scale is inches but the chart compressed to fit on the page.

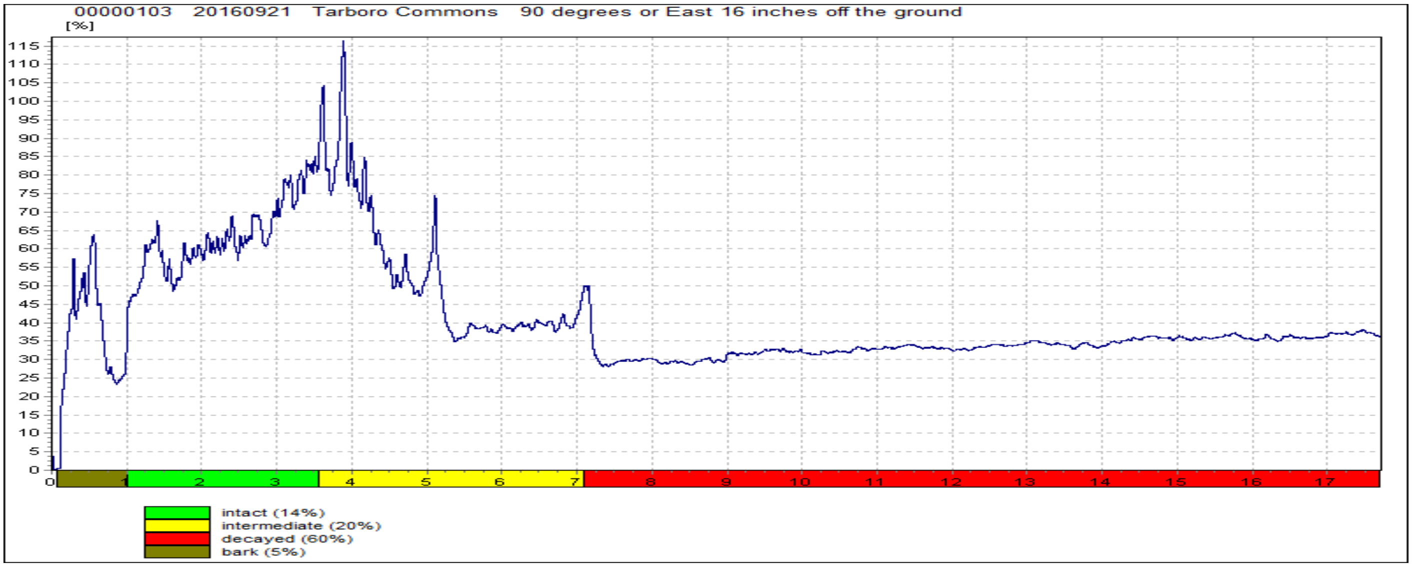

Figure 1B. Resistograph chart from Tree #159. The drilling showed extensive decay in the trunk in the location tested with about 2 inches of sound wood remaining. The exact drill location is noted on the chart. Note the scale is inches but the chart compressed to fit on the page.

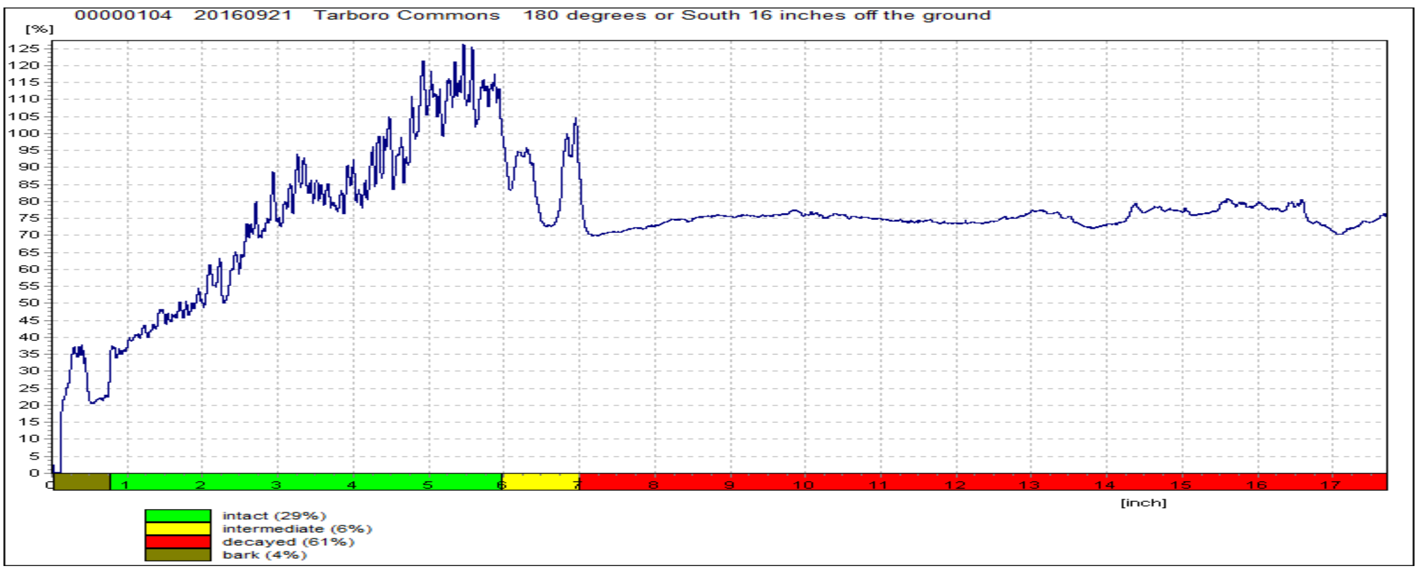

Figure 1C. Resistograph chart from Tree #159. The drilling showed extensive decay in the trunk in this location with about 5 inches of sound wood remaining. The exact drill location is noted on the chart. Note the scale is inches but the chart compressed to fit on the page.

Resistograph charts for Tree #110 showed that decay was also extensive and had progressed to the outside of the trunk in near where one of the conks or mushrooms was present. On the southeast side of the tree there was more sound wood (Figure 2C).

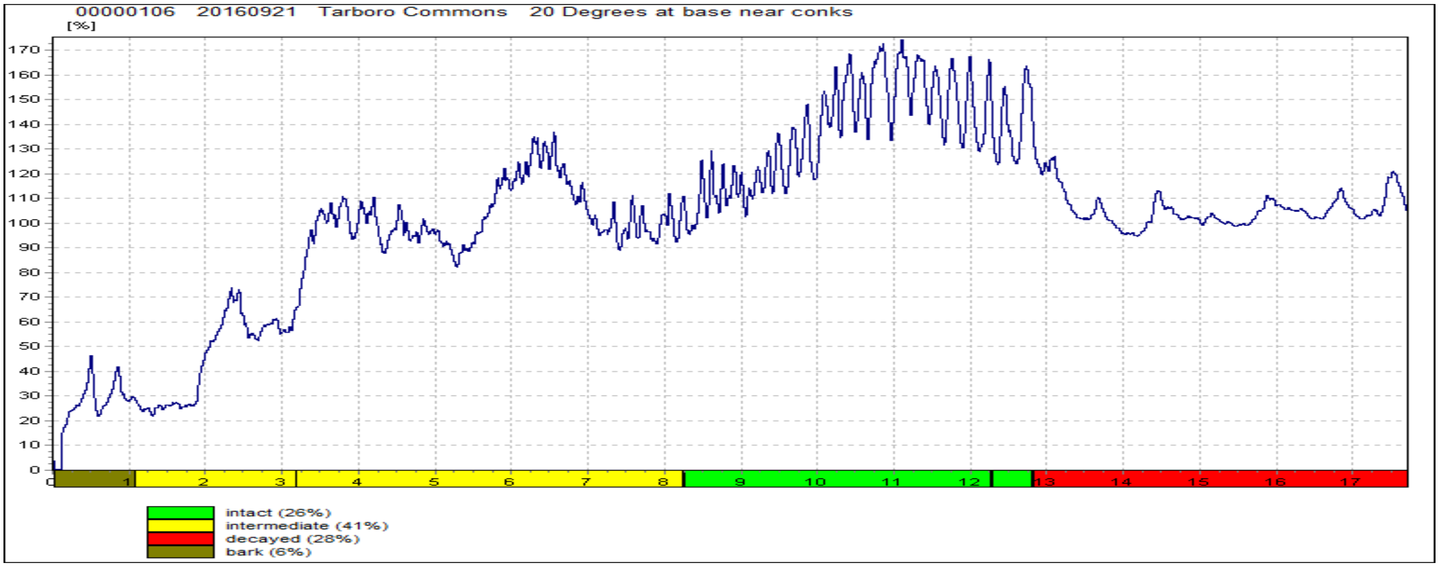

Figure 2A. Resistograph chart from Tree #110. The drilling showed extensive decay in the trunk in the location tested with the decay had extended to the surface of the bark. The exact drill location is noted on the chart. Note the scale is inches but the chart compressed to fit on the page.

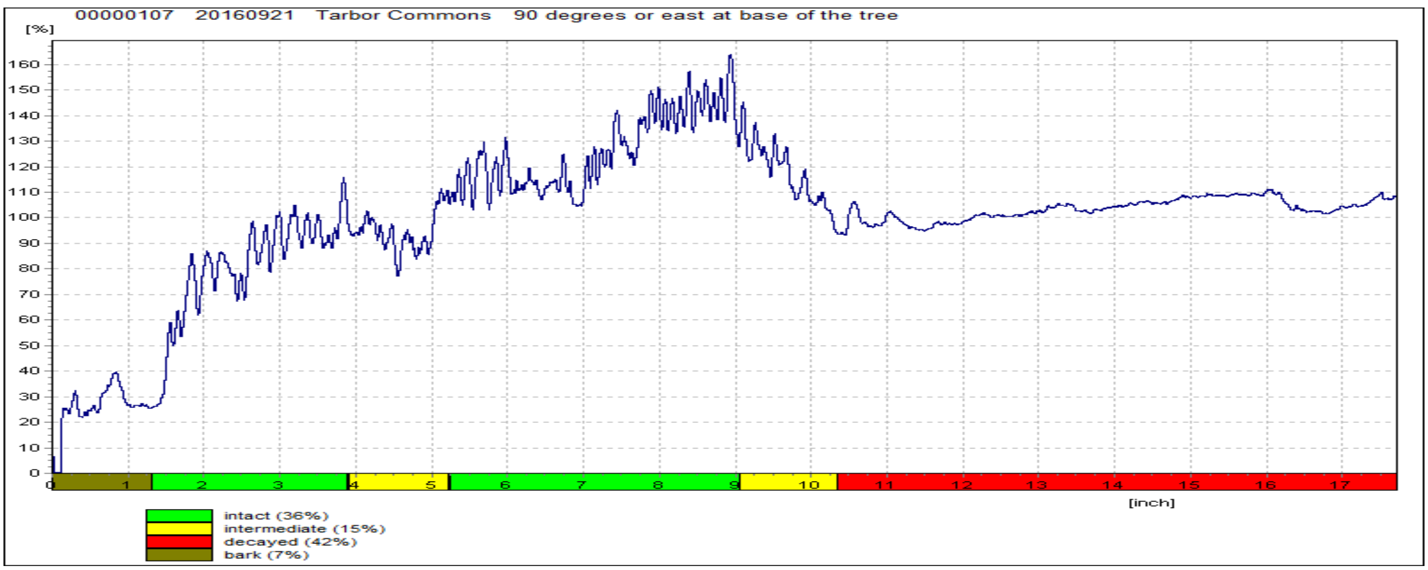

Figure 2B. Resistograph chart from Tree #110. The drilling showed extensive decay in the trunk in the location tested with the decay near the surface of the bark. The exact drill location is noted on the chart. Note the scale is inches but the chart compressed to fit on the page.

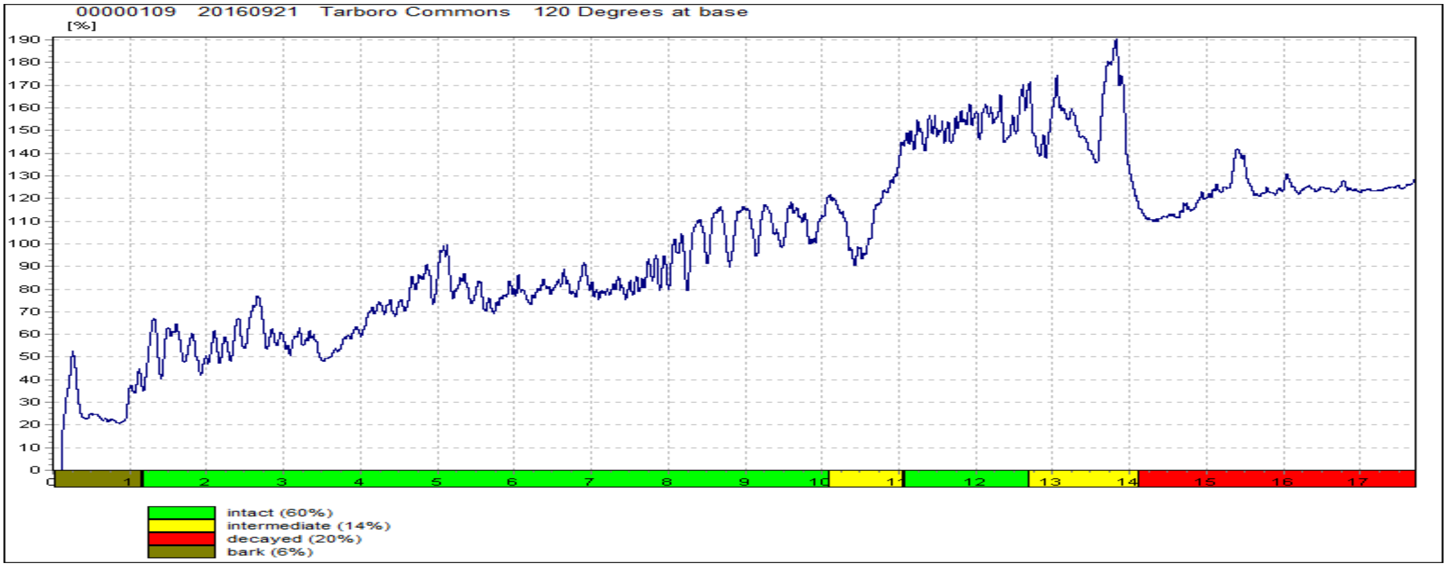

Figure 2C. Resistograph chart from Tree #110. The drilling showed there was about 9 inches of soundwood in the location tested. The exact drill location is noted on the chart. Note the scale is inches but the chart compressed to fit on the page.

Photograph 1L. Left. Tree #35 showing relatively good condition crown. 1R. Right. Extensive fruiting of *B. bondarzewia* on the woody roots of Tree #35.

<u>Advanced Testing-Wind Load Analysis</u>

Tree #35 is a large and significant tree with extensive fruiting bodies around the entire root area. While the rate and impact of the fungi has not been extensively documented, it is still a significant indicator and the tree should be tested further for decay as this was not possible when on-site. Since the crown of the tree was reasonably healthy looking, the tree may be a candidate for mitigation and careful monitoring. A wind load analysis was therefore performed to determine the extent of crown reduction that would be required to decrease wind loading by 25%. The results are presented in

Figures 3 and 4. The analyses were done using two different programs and both showed the same result that a crown reduction of 15% would provide this level of load reduction on the tree.

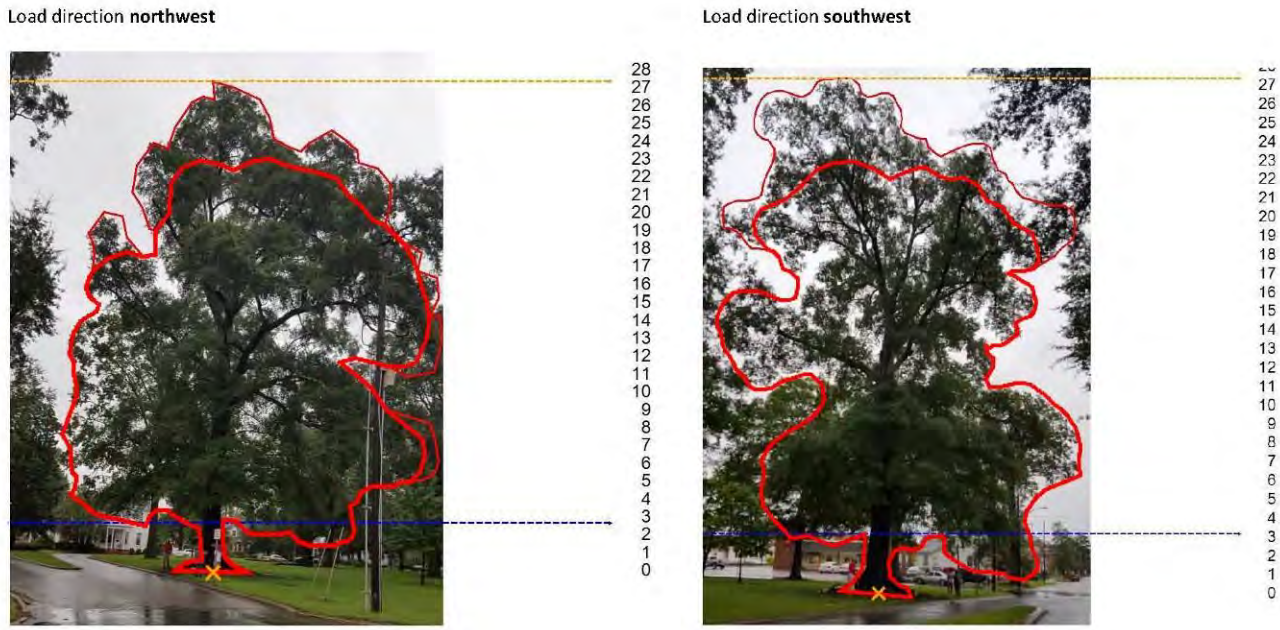

Figure 3. The amount of crown reduction recommended to provide a 25% reduction in load based on measurements made on Tree #35 and its location in the landscape. Calculations are provided in Appendix B. Wind load analysis performed by Andreas Detter of Tree-consult-org.

Phytophthora Testing
The sample from Tree# 107 tested positive for *Phytophthora* species but negative for *P. ramorum* (Appendix B).

Discussion and Recommendations

Management of the tree population on the Tarboro Commons will require substantial inputs in terms of both dollars for pruning maintenance and removals, and critical survey and judgement on how to approach prioritization for management. This site is particularly challenging because of the sizeable population of mature to over mature trees with easily observable defects (fruiting of known root decay fungi) that are difficult to quantify and assess. Based on my brief site visit and the testing conducted, the Commons has a substantial population of trees with:

- Mushrooms and conks and other positive indicators of decay where the decay is difficult to quantify because it is in the roots or requires advanced tools to test each tree
- Extensive decay associated with the fruiting of some of the root decay fungi based on limited Resistograph testing of two trees
- Varying but mostly fair to poor biological health of the many tree crowns that indicates limited ability of them to limit known decay infections.
- Elevated target importance of individual trees due to their location next to streets or structures
- General absence of past pruning maintenance, and
- Significant crown defects such as dead wood, decay, poor architecture, and evidence of past

failures.

Given this and what is reported to me to be “limited” budgets available for management of these issues, I make the following recommendations. I highly recommend a systematic “basic inspection” (visual and sounding with a mallet and qualifying risk based on the Tree Risk BMP matrix method) of all mature trees on the Commons to prioritize management based on risk. I recommend the following to guide this process and to initiate management until this systematic inspection can be done.

1. Schedule for removal on a prioritized basis as soon as funds are available the trees with
    - Root decay fungi fruiting on their roots or base, or with positive decay indicators, and on visual inspection with sounding indicate extensive trunk and/or root decay
    - Poor biological health of the crown
    - Located in important target locations near the street or adjacent structures

Trees with root decay fungi or other positive indicators of decay that on sounding indicate extensive decay that have poor crown condition and high target locations should be removed first from the population. During my site inspection this would include Tree # 110, 31 and 159 (located more interior but confirmed to have extensive decay) as these trees were inspected with the characteristics in (1) above. These trees have extensive fruiting, decay and are very likely to have increased decay going forward because of their poor biological health. They will not improve in structural or biological health.

2. Trees as in (1) above but with crowns that are “good” biological health should be inspected with a basic inspection using a sounding mallet.

Tree #35 with the extensive fruiting of *B. berkeleyi* was sounded but extensive decay was not detected using this method despite the amount of fruiting on the outer woody roots (Photograph 1). While further investigation into the root system using a Resistograph is recommended, at this time given the fruiting and unknown potential for decay in the outer woody roots, crown reduction is a good alternative to removal. The reduction should be done similar to the amount recommended in the wind load analysis (Figure 3).

3. Trees with root decay fungi in lower target locations should be prioritized at a lower level and removed as funds are available in the future based on a full risk survey of the Commons using a basic inspection and the existing inventory data to guide the inspection.

Tree with poor biological health and extensive fruiting of root decay fungi would likely be higher priority. However, sounding with a mallet during a systematic survey may identify trees with no fruiting or less extensive fruiting that also have significant decay.

4. Establish a pruning schedule for trees that will be retained on the Commons.

Branch failures far exceed whole tree failure in all tree populations. Pruning could be prioritized for trees with existing observable deadwood or defects, or could be systematic where all trees are pruned to a specification. The former will require systematic survey as recommended above to identify trees with observable defects that can be remediated by pruning. If full survey of the Commons is not possible, then areas where higher target occupancy is likely should be targeted first for evaluation and/or pruning.

<u>Phytophthora Treatment</u>
The presence of *Phytophthora sp*. on individual trees is important because the fungus kills bark and

cambium on trunks and roots. Treatment with phosphoric acid containing fungicides (e.g. AgriFos or Reliant) and PentraBark is possible but may be cost or financially restricted. Trees with extensive bleeding in addition to other significant defects or decay would be good candidates for removal. The *Phytophthora* pathogen is soil borne and is likely widely distributed in the soils on the Commons. Trees with extensive infections are likely to decline from the disease, and consideration needs to be given to the fact that woody roots may also be infected but cannot be seen without a root crown excavation.

<u>Root Decay Fungi</u>

All the decay fungi identified on the Common can lead to tree failure from the root or butt. There is very little research to support aggressive removal based on the presence of one fungal species. However, "extensive" fruiting of *I. dryadeus, M. sumstinei*, or *G. curtsii* around or on the base or buttress root of any tree would be reason for removal. In general, the closer and/or more extensive the fruiting is to the base of the tree the greater the concern for stability. Extensive fruiting around any tree base or on buttress roots by a known root pathogen is reason for significant concern. At a minimum such trees should be sounded with a mallet to test for extensive decay. The decay quantified on Trees #110 and 159 indicate the potential for the fungi *B. berkeleyi* and *L. cincinnatus* to be associated with extensive decay and the importance of assessing each tree individually if positive indicators of decay are present.

It is very important to recognize that the presence of a single conk of a known root decay pathogen is reason for concern equal to the presence of other positive indicators of decay such as cavities or carpenter ant nesting. All positive decay indicators require inspection of equal intensity and concern of trees with extensive decay fungus fruiting.

There is no testing method for except static load testing (also known as "pull testing"; See Matheny and Clark. 2009. Arborist News 28-33) for trees with decay in woody roots away from the trunk or buttress or further out on root plate (such as Photograph 1R). Pull testing is not commonly practiced in the United States. Testing of the buttress roots and butt of the tree with advanced methods is possible but will require considerable financial input from Tarboro because of the number of trees with positive indicators of decay, and it may not provide definitive answers to trees with known root decay fungi fruiting at distances from the trunk.

Appendix A. Phytophthora Test Results VetDNA.com

Research Associates Laboratory
(R.A.L.,Inc.)

14556 Midway Road, Dallas, TX 75244
Phone: (972)960-2221 Fax: (972)960-1997
www.vetdna.com

TEST RESULTS

Acct ID: **T103**
URBAN FORESTRY
Attn: DR. CHRIS LULEY
6050 HICKS ROAD
NAPLES, NE 14512
Phone: 585-394-9460
Fax: --
Email: chris@urbanforestryllc.com

Owner Name: **NC FOREST SERVICE**
Lab ID: **224496**
Test Date: **09/29/2016**
Animal Name: **OAK 107**
Species: **WILLOW OAK**
Medium: **TRUNK BORE**

Test Description	Result	Comments
Phytophthora ramorum	**Negative**	
Root Rot (Phytophthora)	**Positive**	**CT: 32.4**

DIAGNOSTIC ANALYSIS PERFORMED BY QUANTITATIVE REAL TIME POLYMERASE CHAIN REACTION (qPCR)

Appendix B. Wind Load Analysis by Andreas Detter TreeConsult

Wind Load Analysis analogous to DIN 1055-4

Tree Number **1**

Project

Project Name	Tarboro NC
Project Number	
Test Date	02.10.2016

Site

Trade St.

27886 Tarboro, NC, Deutschland
Altitude a. sea level 15 m

Tree Data

Tree Species	Quercus phellos	
Stem circumference	396	cm
Stem Diameter ‖	126,1	cm
in 1m height ⊥	126,1	cm
Bark Thickness	5	cm
Tree Height	**27,4**	**m**

Applied Material Properties

as for	Quercus phellos	
Source	Kretschmann 2010	
Compressive Strength	20,7	MPa
Modulus of Elasticity	8900	MPa
Limit of Elasticity	0,23	%
Green Density	0,84	g/cm³

Crown Outline

Load Direction NW

Surface Area Analysis

Crown Base	2,7	m
Effective Height	17,5	m
Total Surface Area	389	m²
Crown Eccentricity	2,08	m

Applied Structural Parameters

Drag Factor	0,25	
Natural Frequency	0,45	Hz
Damping Decrement	0,6	
Form Factor for Dead Weight	0,8	

Applied Site Parameters

Windzone	117 km/h	
Speed of Applied Design Wind Speed	22,5	m/s
Air Density	1,29	kg/m³
Roughness Catagory	Suburb	
Exponent for Wind Profile	0,22	
Proximity Factor for Effects in Near Ground Wind Flow	1,1	
Factor for Crown Exposure	0,80	

Results

Wind Load Analysis

Mean Wind Pressure	20,8	kN
Gust Reaction Factor	2,38	
Load Centre	14,1	m
Torsion Moment	103	kNm
Design Wind Load	**700**	**kNm**

Tree Static Analysis

Dead Weight Tree	19,5	t
Critical Degree of Hollowness	92	%
Critical Residual Wall Thickness	5	cm
Assuming an Uncompromised Residual Wall		
Basic Safety Factor	**4,5**	

General

Comments

Wind Load Analysis analogous to DIN 1055-4

Tree Number 1

Project

Project Name	Tarboro NC
Project Number	
Test Date	02.10.2016

Site

Trade St.

27886 Tarboro, NC, Deutschland

Altitude a. sea level 15 m

Tree Data

Tree Species	Quercus phellos		
Stem circumference		396	cm
Stem Diameter	||	126,1	cm
in 1m height	_|_	126,1	cm
Bark Thickness		5	cm
Tree Height		**27,4**	**m**

Applied Material Properties

as for	Quercus phellos	
Source	Kretschmann 2010	
Compressive Strength	20,7	MPa
Modulus of Elasticity	8900	MPa
Limit of Elasticity	0,23	%
Green Density	0,84	g/cm³

Crown Outline

Load Direction	SW	
Surface Area Analysis		
Crown Base	3,2	m
Effective Height	17,7	m
Total Surface Area	342	m²
Crown Eccentricity	0,8	m
Applied Structural Parameters		
Drag Factor	0,25	
Natural Frequency	0,45	Hz
Damping Decrement	0,6	
Form Factor for Dead Weight	0,8	
Applied Site Parameters		
Windzone	117 km/h	
Speed of Applied		
Design Wind Speed	22,5	m/s
Air Density	1,29	kg/m³
Roughness Catagory	Suburb	
Exponent for Wind Profile	0,22	
Proximity Factor for Effects		
in Near Ground Wind Flow	1,1	
Factor for Crown Exposure	0,80	

Results

Wind Load Analysis		
Mean Wind Pressure	18,5	kN
Gust Reaction Factor	2,39	
Load Centre	14,9	m
Torsion Moment	35	kNm
Design Wind Load	**657**	**kNm**

Tree Static Analysis		
Dead Weight Tree	19,5	t
Critical Degree of Hollowness	93	%
Critical Residual Wall Thickness	4	cm
Assuming an Uncompromised Residual Wall		
Basic Safety Factor	**4,8**	

General

Comments

Brudi & Partner TreeConsult Baumsachverständige for Chr. Luley, Urban Forestry LLC- Naples © ArboSafe

Wind Load Analysis analogous to DIN 1055-4

Tree Number **1-reduction 15%**

Project

Project Name	Tarboro NC
Project Number	
Test Date	02.10.2016

Site

Trade St.

27886 Tarboro, NC, Deutschland

Altitude a. sea level	15 m

Tree Data

Tree Species	Quercus phellos	
Stem circumference	396	cm
Stem Diameter ‖	126,1	cm
in 1m height ⊥	126,1	cm
Bark Thickness	5	cm
Tree Height	**23**	**m**

Applied Material Properties

as for	Quercus phellos	
Source	Kretschmann 2010	
Compressive Strength	20,7	MPa
Modulus of Elasticity	8900	MPa
Limit of Elasticity	0,23	%
Green Density	0,84	g/cm³

Crown Outline

Load Direction	NW	
Surface Area Analysis		
Crown Base	3,3	m
Effective Height	15,1	m
Total Surface Area	332	m²
Crown Eccentricity	1,96	m
Applied Structural Parameters		
Drag Factor	0,25	
Natural Frequency	0,65	Hz
Damping Decrement	0,6	
Form Factor for Dead Weight	0,8	
Applied Site Parameters		
Windzone	117 km/h	
Speed of Applied Design Wind Speed	22,5	m/s
Air Density	1,29	kg/m³
Roughness Catagory	Suburb	
Exponent for Wind Profile	0,22	
Proximity Factor for Effects in Near Ground Wind Flow	1,1	
Factor for Crown Exposure	0,80	

Results

Wind Load Analysis		
Mean Wind Pressure	17,1	kN
Gust Reaction Factor	2,41	
Load Centre	12,6	m
Torsion Moment	81	kNm
Design Wind Load	**518**	**kNm**

Tree Static Analysis		
Dead Weight Tree	16,4	t
Critical Degree of Hollowness	94	%
Critical Residual Wall Thickness	4	cm
Assuming an Uncompromised Residual Wall		
Basic Safety Factor	**6,1**	

General

Comments

Brudi & Partner TreeConsult Baumsachverständige for Chr. Luley, Urban Forestry LLC- Naples © ArboSafe

Wind Load Analysis analogous to DIN 1055-4

Tree Number **1-reduction 15%**

Project		**Site**	
Project Name	Tarboro NC	Trade St.	
Project Number			
		27886 Tarboro, NC, Deutschland	
Test Date	02.10.2016	Altitude a. sea level	15 m

Tree Data		**Applied Material Properties**	
Tree Species	Quercus phellos	as for	Quercus phellos
Stem circumference	396 cm	Source	Kretschmann 2010
Stem Diameter	|| 126,1 cm	Compressive Strength	20,7 MPa
in 1m height	_|_ 126,1 cm	Modulus of Elasticity	8900 MPa
Bark Thickness	5 cm	Limit of Elasticity	0,23 %
Tree Height	**23 m**	Green Density	0,84 g/cm³

Crown Outline

Load Direction	SW	
Surface Area Analysis		
Crown Base	3,3	m
Effective Height	15,1	m
Total Surface Area	287	m²
Crown Eccentricity	1,08	m
Applied Structural Parameters		
Drag Factor	0,25	
Natural Frequency	0,65	Hz
Damping Decrement	0,6	
Form Factor for Dead Weight	0,8	
Applied Site Parameters		
Windzone	117 km/h	
Speed of Applied Design Wind Speed	22,5	m/s
Air Density	1,29	kg/m³
Roughness Catagory	Suburb	
Exponent for Wind Profile	0,22	
Proximity Factor for Effects in Near Ground Wind Flow	1,1	
Factor for Crown Exposure	0,80	

Results

Wind Load Analysis			**Tree Static Analysis**		
Mean Wind Pressure	14,7	kN	Dead Weight Tree	16,4	t
Gust Reaction Factor	2,42		Critical Degree of Hollowness	95	%
Load Centre	12,7	m	Critical Residual Wall Thickness	3	cm
Torsion Moment	39	kNm	Assuming an Uncompromised Residual Wall		
Design Wind Load	**455**	**kNm**	**Basic Safety Factor**	**6,9**	

General

Comments

Brudi & Partner TreeConsult Baumsachverständige for Chr. Luley, Urban Forestry LLC- Naples © ArboSafe

Suggested Trees for Tarboro’s Historic Common

The preponderance of oak trees on the common is impressive and even historic, but a healthy tree population uses a variety of species, of a variety of ages and longevity, so that management is not overly exposed to one particular trait or problem. The variety of native tree species in North Carolina allows for consideration of other tree species that can be used on the Common, adding their own charm and value to the Common, while maintaining a certain historical accuracy.

The Historic Common presently has 216 tree and a decision will be needed as to how many trees is desirable. Perhaps aiming towards a final population of about 250 would allow planting of some additional tree species and set a goal that could be achieved over a number of years.

The population can be composed of:

1. Large maturing and long-lived species
   Besides oaks, there are other species that can provide a long-term presence and character.
2. Smaller maturing, and typically shorter-lived, species
   Scattered beneath the shade of larger trees. or in small groups, with spring or fall color.
3. Fast-growing species, generally shorter-lived, species
   For use in open areas to help create a natural appearance with a variety of differently-sized trees, or for other reasons. These species do not grow well in shade, tend to have aggressive roots, and weaker wood, which may be more prone to breakage.
4. Specimen trees or unusual cultivars
   Different forms or colors can provide a point of interest when used judiciously. Native species that have a litter or seeds that may be a maintenance issue can be planted along a natural area. A little extra maintenance and care may be helpful to keep a specimen tree in good health and worthy of being a specimen. One or two trees per block would be sufficient.

For the short term, planting species other than oaks should be considered, while caring for the existing oaks and ensuring the younger oak trees reach a healthy maturity through proper maintenance and a lack of mechanical damage. As more of the older oaks are removed, and the distribution of tree species shifts, oaks can be reincorporated into the planting list.

Refer to page 7 for the 2016 species distribution.

A good relationship with a reputable nursery (or nurseries), that grows, prunes and harvests its trees to ANSI Z60.1 standards helps with your choices, and ensures that you get what you ask for, is very important. They may also be able to provide direction when they do not carry a species or cultivar you are looking for, suggesting a comparable alternative, or even pointing you in the direction to find what you want.

Tree Species Presently on the Historic Common

What the Common has: Large maturing and long-lived species

There are several **American Beech** already present, in the early maturity stages. Several of these trees require structural pruning to improve their branching, but planting some additional American Beech in the future, especially where they have open space to spread their broad and heavy crowns, is never a bad idea.

Baldcypress, the native deciduous conifer, does surprisingly well in compacted soils so adding several more over time is an option.

American Sycamore is a very solid species that, while not immune to decay, seems to have an ability to remain structurally sound for a long time. With only 3 of these trees located in the Flagpole Block, there is room to plant several more through the Common.

The **hickory family** is represented by 2 **pecans** which are suffering from enthusiastic sapsucker feeding, which is a significant cause of stress. There is also **a mockernut hickory**. Because of the fruits, hickories are not generally planted in the landscape, however, planting several along the natural area in the Flagpole block, where their seeds would be less of an annoyance, should be considered.

There are some Sugar and Red Maples on the site but, in general, their overuse in the landscape and susceptibility to a variety of insect pests, particularly scale makes them generally undesirable. Future planting of **maple** should be limited to southern species, which tend to be smaller when mature.

There is one young **Norway Spruce** that is not doing so well, mainly due to the heat and humidity. And, other than pines and **Eastern Redcedar**, there are not any native coniferous species that will do very well on the Common. If evergreen species are desired for the Common, **Southern Magnolia** is one of the few large options, or eastern redcedar (although height can vary), or non-native cedars like the Atlas or **Deodar cedars**.

There are several **Green Ash** in the block beside the parking lot, they are in need of proper pruning and, if the Town wishes to retain them, should be treated to protect them from Emerald Ash Borer(EAB), which must be reapplied every few years. There is another green ash in the flagpole block but it is not a good candidate for long-term investment. Ash of any species are not recommended for planting on the Common.

American Elm is a very desirable tree but Dutch Elm Disease (DED) makes it an iffy long-term option. **Winged Elm** is native but not quite as large as American, but additional planting could be considered.

There is one **persimmon** on the Common. A slow grower, difficult to transplant and unpredictable as to its contribution to the landscape. But perhaps the edge of natural area in the flagpole block would be a good place to test another tree or two.

What the Common has: Smaller maturing, and typically shorter-lived, species

The small maturing trees on the Common are limited to a number of stressed **Flowering Dogwoods**. Small trees that grow better in the shade also do better in mulched beds or in groupings where they are protected from physical damage. Trees that are adapted to growing in the shade also do best in good soils and sufficient moisture, two more sources of stress for these trees.

What the Common has: Fast-growing species, generally shorter-lived, species

Along with **Red Maple**, **Sweetgum** is a fast growing species. This also means that they are brittle-wooded, i.e. more prone to breakage. Sweetgum fruit can also be a pedestrian hazard and a maintenance annoyance. There are many cultivars that could be considered to reduce the fruit issue, and some have quite dramatic fall color, as long as they are well-suited to Tarboro's climate.

Catalpa can develop into large, dramatic trees but is prone to a number of problems and a tendency to breakage which limits their use in the landscape.

Honeylocust, like Red Maple, is commonly seen in landscaped sites but it seems to door poorly in urban sites in the south, likely due to the extremes of heat and drought. Although the tree has an attractive form and the fine leaves create virtually no litter, unless you can find a fruitless Honeylocust that will do better in the south, it is best to avoid planting this species.

River Birch are named for their preference for moist soils, where they are most often found. Easily stressed by shade and by dry and compacted soils, River Birch or, indeed, any of the birches are not good choices to plant on the Common.

What the Common has: Specimen Trees or Unusual Cultivars

A new **Dawn Redwood**, planted in the spring of 2016, is not a native species but as a deciduous confer it is a lovely tree with fine and graceful branching. Like all the trees on the Common, it would benefit from mulching and proper care.

Tree Species to Consider Planting on the Historic Common

Large maturing and long-lived species

The natural range of **American Basswood** (*Tilia americana*) reaches into western NC, but can be found throughout the South. It is a substantial tree that produces small, fragrant, yellow flowers in the spring. It can be a fast grower, under the right conditions, but also has a natural lifespan of up to 200 years. I would avoid crosses or *Tilia cordata.*

Much work has been done with **American Chestnut** (*Castanea dentata*) by the American Chestnut Foundation (www.acf.org) and it is worth considering if you can find a nursery producing landscape planting stock. Of course, the fruits may be an issue so avoid planting in Areas 4 and 5, the Small Memorial Block and the Block West of the School Parking Lot and Area 1, the Flagpole Block.

Black Tupelo (*Nyssa sylvatica*) has a wonderful fall color, although it can be difficult to transplant. Will need to select a cultivar for improved resistance to a leaf spot but worth the effort.

Smaller maturing, and typically shorter-lived, species

Serviceberry (*Amelanchier arborea* or *laevis*) is typically a small multi-stemmed tree and has small white flowers in the spring and can have a brilliant fall color, as well fruit that birds love. Prefers light to shade.

Eastern Redbud (*Cercis canadensis*) prefers filtered shade, as can be seen by its natural environment on the edges of wooded areas. Planted in well-prepared beds and groupings, this may be a suitable understory tree.

Carolina silverbell (*Halesia Carolina*) can grow to 30' and tolerates shade. Small white flowers in spring and pest resistant.

There are so many **hollies** in form and mature size, both evergreen and deciduous. If there is interest in planting evergreen hollies for winter color and texture, in spite of their spiny leaves, you can consider trees to 30' like American Holly (*Ilex opaca*) or Dahoon (*Ilex cassine*), or some of the smaller shrubby hollies. Discussion with your nursery provider is a good place to consider your options, as there are many.

American Hophornbeam or ironwood (*Ostrya virginiana*) is a native understory tree that slowly grows up to 40' in sun or light shade.

Sourwood (*Oxydendron arboreum*) produces fragrant flowers that look like sprays of lily-of-the-valley. A nice understory tree, to 30', that does not get replanted often in the landscape.

Fast-growing species, generally shorter-lived, species

Maples can be considered but they will not be as large at maturity as Red or Sugar Maple. **Florida maple** or Southern Sugar Maple (*Acer saccharum var. floridum*) can become a medium-sized tree and can have good fall color, if you get the right variety. **Chalkbark Maple** (*Acer leucoderme*) is another even smaller possibility. The longevity of these trees is not mentioned in the literature. Prefers light to shade.

Sugarberry or Sugar Hackberry (*Celtis laevigata*) has some cultivars which might be of interest and can have a vase-shaped form and smooth gray bark.

Tuliptree or Yellow Poplar (Liriodendron tulipifera) is a large maturing trees that is a very attractive option for providing contrast and texture. It is fast growing but can still live 100-200 years in the right situation, which could make it a good semi-long-lived option.

Specimen Trees or Unusual Cultivars

The **Dove-tree** or Handkerchief Tree (*Davidia involucrata*) is not easy to find in nurseries but it has stunning spring flowers. It can grow up to ~40 feet in height and prefers lights shade but will tolerate sun with a good planting site.

Gingko (*Gingko biloba*), male cultivar only (and not grafted into female cultivar roots) has a brilliant golden fall color. Reaching 50-80' at maturity, this is a tough tree that is also free of pests.

Kentucky Coffeetree (*Gymnocladus dioicus*) leafs out late and loses it leaves early, and its fruits are large bean pods, but it is a very interesting native tree and is worthwhile considering. There are male cultivars, so by selecting one of those the fruit issue could be avoided, which could move this species to the Large Maturing and Long-Lived column.

Between the appropriate species already on the Common and additional species discussed, there are sufficient options to begin the replacement tree process for the next several years.

This is not an exhaustive list as there are so many options it could be overwhelming. After 5 or 10 years of a planting regime, this list can be revisited. And reintroduction of various oaks onto the planting list will be appropriate as older trees decline and are removed. Do not plant sawtooth oak.

Large maturing and long-lived	**Smaller maturing, and typically shorter-lived**	**Fast-growing species, generally shorter-lived**	**Specimen Trees or Unusual Cultivars**
Baldcypress	***Dogwood***	***Sweetgum***	***Dawn Redwood***
American Sycamore	***Carolina Cherrylaurel***	Florida Maple	Dove-tree
Hickories	Serviceberry	Chalkbark Maple	Gingko
Winged Elm	American Hophornbeam	Sugarberry	Kentucky Coffeetree
Southern Magnolia	Eastern Redbud	Tuliptree	
American Beech	Carolina Silverbell		
Eastern Redcedar	Hollies		
American Basswood	Sourwood		
American Chestnut			
Black Tupelo			
Kentucky Coffeetree			
Tuliptree			

References:

- ANSI Z60.1 – American Standard for Nursery Stock
- ANSI A300, Part 6 – Tree, Shrub and Other Woody Plant Management Standard Practices (Planting and Transplanting)
- Best Management Practices – Tree Planting

Attached:

- Sample Nursery specifications
- Guideline Specifications for Selecting, Planting and Early Care of Young Trees
- Buying High Quality Trees
- New Tree Planting
- Pruning Young Trees