

# Shenandoah, IA



## 2019 URBAN FOREST MANAGEMENT PLAN

IOWA DEPARTMENT OF NATURAL RESOURCES



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# Executive Summary

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## Overview

This plan was developed to assist the City of Shenandoah in managing its urban forest, including budgeting and future planning. Trees bring numerous benefits to a community, and sound management helps leaders take advantage of these benefits. Management is especially important now considering the serious threats posed by forest pests like the emerald ash borer (EAB). EAB is an invasive insect imported from Eastern Asia on wood shipping crates that kills all species of ash trees except mountain ash. There is a strong possibility that 11.5% of Shenandoah's city-owned trees will die once EAB becomes established in the community, unless local leaders begin preventative treatment. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

## Inventory and Results

In 2019, JEO conducted a tree inventory using Global Positioning System (GPS) data collectors. The inventory was a complete inventory of street and park trees. Below are some key findings of the 1,435 trees inventoried.

- Shenandoah's trees provide \$304,452 of benefits annually, an average of \$212.16 per tree
- There are over 27 species of trees
- The top three genera are: Maple 40.5%, and Oak 19%, and Ash 11.5%,
- 1% of trees need some type of management
- 17 trees should be removed

## Recommendations

We detail our core recommendations in the Recommendations Section. In the Emerald Ash Borer Plan, we include management recommendations. Below are some key recommendations.

- Out of the 17 trees needing removal, 10 trees are over 24 inches in diameter at 4.5 ft and must be addressed immediately. [\\*City ownership of the trees recommended for removal should be verified prior to any removal\\*](#)
- 5 of the 165 ash trees should be carefully examined, as they have one or more symptoms that could be related to an EAB infestation.
- All trees should be pruned on a routine schedule: one third of the city every other year.
- Plant a diverse mix of trees that do not include: ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut.
- Check ash trees yearly with a visual survey.
- With the current budget it could take 11 years to remove ash. We suggest that city officials request a budget increase to \$12,000 annually and apply for grants to plant replacement trees.

# Introduction

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This plan was developed to assist Shenandoah with managing, budgeting, and future planning of their urban forest. Across the state, forestry budgets continue to decrease as a higher percentage of the budgets are devoted to tree removal. With the anticipated arrival of Emerald Ash Borer (EAB), an invasive pest that kills native ash trees, it is time to prepare for the increased costs of tree removal, treatment, and replacement planting. With proper planning and management of the current canopy in Shenandoah, these costs can be spread out over the years and public safety issues from dead and dying ash trees can be mitigated.

Trees are an important part of Shenandoah's infrastructure and one of the city's greatest assets. The benefits of trees are immense. Trees improve air quality, intercept stormwater runoff, conserve energy, lower traffic speeds, increase property values, reduce crime, improve mental health, and create a desirable place to live, to name just a few. Good urban forestry management will maintain these important benefits for the people of Shenandoah and future generations.

Urban forestry management sets goals and develops management strategies to achieve them. To develop management strategies, a comprehensive public tree inventory must be conducted. The inventory informs maintenance, removal schedules, tree planting, and budgeting. Aligning management actions with the tree inventory results will help meet Shenandoah's urban forestry goals.

## Inventory

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In 2019, JEO conducted a tree inventory that included 100% of the city-owned trees on both streets and parks. The team collected tree data using a handheld Global Positioning System (GPS) receiver. The data collector gives Geographic Information Systems (GIS) coordinates with an accuracy of 3 meters, which can be used in Arc GIS as an active GIS data layer. Because the inventory is a digital document the data can be updated with new information and become a working document.

The data collectors' programming was written to be compatible with a state-of-the-art software suite called i-Tree. i-Tree was developed by the USDA Forest Service to quantify the structure of community trees and the environmental services that trees provide. The i-Tree suite is a public domain which can be accessed for free.

To quantify the urban forest structure and benefits, specific data is collected for each tree. This data includes: location, land use, species, diameter at 4.5 ft, recommended maintenance, priority of that maintenance, leaf health, and wood condition. Additionally, for all ash trees, the team notes signs and symptoms associated with EAB including canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

# Inventory Results

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JEO entered the data collected for the 1,435 city trees into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management as part of the i-Tree suite. Below are results from the i-Tree STREETS analysis.

## Annual Benefits

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### **Annual Energy Benefits**

Trees conserve energy by shading buildings and blocking winds. Shenandoah's trees reduce energy-related costs by approximately \$81,663 annually (Appendix A, Table 1). These savings are both in electricity (386.3 MWh) and in natural gas (53,410.7 Therms).

### **Annual Stormwater Benefits**

Shenandoah's trees intercept about 4,493,481 gallons of rainfall or snow melt per year (Appendix A, Table 2). This interception provides \$121,773 in benefit to the city.

### **Annual Air Quality Benefits**

Air quality is a persistent public health issue in Iowa. The urban forest improves air quality by removing pollutants, lowering air temperature, and reducing energy consumption, which in turn reduces emissions from power plants, and lessens emissions of volatile organic matter (ozone). In Shenandoah, it is estimated that trees remove 5,188.6 lbs of air pollution (ozone (O<sub>3</sub>), particulate matter less than 10 microns (PM<sub>10</sub>), carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), and sulfur dioxide (SO<sub>2</sub>)) per year with a net value of \$14,672 (Appendix A, Table 3).

### **Annual Carbon Benefits**

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Shenandoah, trees sequester about 805,570 lbs of carbon per year with an associated value of \$6,042 (Appendix A, Table 5). In addition, the trees store 17,494,175 lbs of carbon, with a yearly benefit of \$131,206 (Appendix A, Table 4).

### **Annual Aesthetics Benefits**

The social benefits of trees are hard to capture. The i-Tree analysis does have a calculation for this area that includes aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Shenandoah receives \$76,105 in annual social benefits from trees (Appendix A, Table 6).

### **Financial Summary of all Benefits**

According to the USDA Forest Service i-Tree STREETS analysis, Shenandoah's trees provide \$304,452 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 1,435 trees in Shenandoah provide approximately \$212.16 annually (Appendix A, Table 7).

# Forest Structure

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## Species Distribution

Shenandoah has over 27 different tree species along city streets and parks (Appendix A, Figure 1).

The distribution of trees by genera is as follows:

|                     |     |       |
|---------------------|-----|-------|
| Maple               | 582 | 40.5% |
| Oak                 | 275 | 19%   |
| Ash                 | 165 | 11.5% |
| Broadleaf Deciduous | 96  | 7%    |
| Other               |     |       |
| Locust              | 51  | 3.5%  |
| Linden/Basswood     | 49  | 3.5%  |
| Pear                | 49  | 3.5%  |
| Spruce              | 33  | 2.5%  |
| Sycamore            | 28  | 2%    |
| Elm                 | 20  | 1%    |
| Eastern redbud      | 18  | 1%    |
| Pine                | 13  | <1%   |
| Birch               | 8   | <1%   |
| Hackberry           | 8   | <1%   |
| Southern Magnolia   | 8   | <1%   |
| Boxelder            | 7   | <1%   |
| Alder               | 3   | <1%   |
| Buckeye             | 3   | <1%   |
| Catalpa             | 3   | <1%   |
| Walnut              | 3   | <1%   |
| Cedar               | 2   | <1%   |
| Chokecherry         | 2   | <1%   |
| Conifer Evergreen   | 2   | <1%   |
| Ginkgo              | 2   | <1%   |
| Apple               | 1   | <1%   |
| Juniper             | 1   | <1%   |
| Hickory             | 1   | <1%   |
| Sweetgum            | 1   | <1%   |
| Tulip tree          | 1   | <1%   |

## Age Class

Most of Shenandoah's trees (39%) are between 24 and 36 inches in diameter at 4.5 ft (Appendix A, Figure 2). To prepare for natural mortality and to maintain canopy cover, most trees should be in the smallest size category (a downward slope), indicating youth. Shenandoah's size curve is on the smaller side, indicating a younger than average stand.

## Condition: Wood and Foliage

Both wood condition and leaf condition are good indicators of the urban forest's overall health. The foliage condition results for Shenandoah indicate that 82% of the trees are in good health, with only 2% of the foliage in poor health, dead, or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 78% of Shenandoah's trees are in good health for wood condition (Appendix A, Figure 4 & Appendix B, Figure 3). Three percent of the tree population's wood condition is in poor health, dead, or dying. This 3% is an estimate of trees that need management follow up.

## Management Needs

The following outlines the specific management needs of the street and park trees by number of trees and percent of canopy (Appendix B, Figure 3).

|                 |    |    |
|-----------------|----|----|
| Crown Cleaning  | 0  | 0% |
| Crown Raising   | 0  | 0% |
| Tree Staking    | 0  | 0% |
| Tree Removal    | 17 | 1% |
| Crown Reduction | 0  | 0% |

## Land Use and Location

The majority of Shenandoah's city and park trees are in planting strips in single family residential neighborhoods (Appendix A, Figure 6 & Appendix A, Figure 7). The following describes the land use and locations for the street and park trees.

| <u>Land Use</u>             |       |
|-----------------------------|-------|
| Single family residential   | 92.5% |
| Park/vacant/other           | <1%   |
| Industrial/Large commercial | 7.5%  |
| Small commercial            | 0%    |
| Multifamily residential     | 0%    |

# Recommendations

## Risk Management

Hazardous trees can be a significant threat to both people and property. Trees that are dead, dying, or have large issues such as trunk cracks longer than 18 inches should be removed. Broken branches and branches that interfere with motorists' vision of pedestrians, vehicles, traffic signs and signals should be removed.

### Hazardous trees

Shenandoah has 17 trees that need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance Map (Appendix B, Figure 4). We recommend starting with the large-diameter, critical concern trees first. There are 10 trees over 24 inches in diameter at 4.5 ft that should be addressed immediately. Please refer to the Proposed Work Schedule and Budget at the end of this section. After all the critical concern trees are addressed, there should be follow up on the trees marked as needing maintenance. There are a total of 17 trees with maintenance needs.

### Poor tree species

After removing the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 17 removals, 5 are ash trees. There are a total of 165 ash trees, and zero of those have signs and symptoms that have been associated with EAB. In addition, there are 5 trees that are in poor health. [\*\\*City ownership of the trees recommended for removal should be verified prior to any removal\\*\*](#)

### **Pruning Cycle**

Proper pruning can extend the life and good health of trees, as well as reduce public safety issues. In the Management Needs section of the Findings there are four main maintenance issues to be addressed: routine pruning, crown cleaning, crown raising, and crown reduction. Crown cleaning removes dead, diseased, and damaged limbs. Crown raising removes lower branches that are two inches in diameter or larger to provide clearance for pedestrians or vehicles. Crown reduction removes individual limbs from structures or utility wires. We recommend that all trees be pruned on a routine schedule every five to seven years. Please refer to the Proposed Work Schedule and Budget for further information.

### **Planting**

Most of the planting over the next five years will replace the trees that are removed. We recommend planting 1.2 trees for every tree removed, since survival rates will not be 100%. It is not essential that the new trees be planted in the same location of the trees being removed. However, maintaining the same number of trees helps ensure continuation of the benefits of the existing forest in Shenandoah.

It is important to plant a diverse mix of species in the urban forest to maintain canopy health, since most insects and diseases target a genus (ash) or species (green ash) of trees. Current diversity recommendations advise that a genus (i.e. maple, oak) not make up more than 20% of the urban forest and a single species (i.e. silver maple, sugar maple, white oak, bur oak) not make up more than 10% of the total urban forest. Presently, the forest is heavily planted with maple (40.5%) (Appendix A, Figure 1). Maples should not be planted until this percentage can be lowered. Also, ash trees have not been recommended since 2002, due to the threat of EAB. Other species to avoid because they are public nuisances include: cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut. While the city currently has no existing City Code in reference to tree species planting restrictions, we encourage the city to work with the Iowa Department of Natural Resources to develop a plan moving forward.

## Continual Monitoring

Due to the threat of EAB, it is important to continuously check the health of ash trees. We recommend that ash trees be checked with a visual survey every year for tree decline and for the following signs and symptoms: canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

## Emerald Ash Borer Plan

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### Ash Tree Removal

Tree removal will be prioritized by first removing dead, dying, hazardous trees (Appendix B, Figure 4). Next will be all ash in poor condition that display EAB signs and symptoms (Appendix B, Figure 2 & Appendix B, Figure 3). *\*City ownership of the tree recommended for removal should be verified prior to any removal\**

### Treatment of Ash Trees

Chemical treatment can be an effective tool for communities to spread removal costs out over several years while allowing trees to continue providing benefits. However, treatment is not recommended if EAB is more than 15 miles away from the community. For more information on the cost of treatment strategies visit <http://extension.entm.purdue.edu/treecomputer/>

### EAB Quarantines

EAB is an extremely destructive plant pest and it is responsible for the death and decline of millions of ash trees. Ash in both forested and urban settings constitute a significant portion of the canopy cover in the United States. Current tools to detect, control, suppress and eradicate this pest are not as robust as the USDA would desire. In order to stay ahead of this hard to detect beetle, the USDA is attempting to contain the beetle before it spreads beyond its known positions by regulating articles.

A regulated article under the USDA's quarantine includes any of the following items:

- emerald ash borer
- firewood of all hardwood species (for example ash, oak, maple and hickory)
- nursery stock and green lumber of ash
- any other ash material, whether living, dead, cut or fallen, including logs, stumps, roots, branches, as well as composted and not composted chips of the genus ash (Mountain ash is not included)

In addition, any other article, product, or means of conveyance not listed above may be designated as a regulated article if a USDA inspector determines that it presents a risk of spreading EAB once a quarantine is in effect for your county.

### Wood Disposal

A very important aspect of planning is determining how wood infested with EAB will be handled, keeping in mind that quarantines will restrict its movement. Consider who will cut and haul the dead and dying trees? Is there an accessible, secured site big enough to store and sort the hundreds of trees and the associated brush and chips? How will wood be disposed of or utilized? Do you have equipment capable of handling the amount and size of ash trees your tree inventory has identified? Once your county is under quarantine for EAB, contact USDA-APHIS-PPQ at 515-251-4083 or visit the website [http://www.aphis.usda.gov/plant\\_health/plant\\_pest\\_info/emerald\\_ash\\_b/regulatory.shtml](http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/regulatory.shtml). Wood waste can be normally disposed of if your county is not part of a quarantine.

**Canopy Replacement**

As budget permits, all removed trees will be replaced. All trees will meet the restrictions outlined by the Iowa Department of Natural Resources. While the city currently has no existing City Code in reference to tree species restrictions, we encourage the city to work with the Iowa Department of Natural Resources to develop a plan moving forward. We encourage the new plantings to be a diverse mix and not include ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut.

**Postponed Work**

While finances, staffing, and equipment are focused on the management of ash, usual services may be delayed. Tree removal requests on genera other than ash will be prioritized by hazardous or emergency situations only.

**Monitoring**

It is recommended that ash trees be checked with a visual survey every year for tree death and for EAB signs and symptoms including canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

**Private Ash Trees**

It is strongly recommended that private property owners start removing ash trees on their property upon arrival of EAB if preventative treatments are not being used. While there is no existing City Code in reference to private tree care and removal, we encourage the city to work with the Iowa Department of Natural Resources to develop a plan moving forward

**Proposed Work Schedule and Budget**

Budget Allowance of \$10,300/Year – (Based off \$2/Capita Calculation Due to no City Reporting)

**YEAR 1**

**ESTIMATED COSTS**

|                                                   |         |
|---------------------------------------------------|---------|
| Remove 12 trees recommended for immediate removal | \$8,400 |
| Plant 12 trees in open locations                  | \$1,800 |
| Visual Survey of EAB Signs/Symptoms               |         |

**YEAR 2**

|                                                  |         |
|--------------------------------------------------|---------|
| Remove 3 trees recommended for immediate removal | \$2,100 |
| Plant 6 trees in open locations                  | \$900   |
| Prune 1/3 of City Owned Trees                    | \$7,170 |
| Visual Survey of EAB Signs/Symptoms              |         |

### **YEAR 3**

|                                                   |         |
|---------------------------------------------------|---------|
| Remove 2 trees recommended for immediate removal  | \$1,400 |
| Remove 10 ash trees (prioritize largest diameter) | \$7,000 |
| Plant 12 trees in open locations                  | \$1,800 |
| Visual Survey of EAB Signs/Symptoms               |         |

### **YEAR 4**

|                                                  |         |
|--------------------------------------------------|---------|
| Remove 3 ash trees (prioritize largest diameter) | \$2,100 |
| Plant 6 trees in open locations                  | \$900   |
| Prune 1/3 of City Owned Trees                    | \$7,170 |
| Visual Survey of EAB Signs/Symptoms              |         |

### **YEAR 5**

|                                                   |         |
|---------------------------------------------------|---------|
| Remove 12 ash trees (prioritize largest diameter) | \$8,400 |
| Plant 12 trees in open locations                  | \$1,800 |
| Visual Survey of EAB Signs/Symptoms               |         |

### **YEAR 6**

|                                                  |         |
|--------------------------------------------------|---------|
| Remove 3 ash trees (prioritize largest diameter) | \$2,100 |
| Plant 6 trees in open locations                  | \$900   |
| Prune 1/3 of City Owned Trees                    | \$7,170 |
| Visual Survey of EAB Signs/Symptoms              |         |

Estimated costs based on average costs of \$700/tree for removal, \$150/tree for planting and maintenance, and \$15/tree for pruning.

\*\*To remove all ash trees within 6 years alone, the budget would need to be \$19,250 a year. If the budget were increased to \$12,000 a year all ash could be removed in 10 years.

## **Proposed Work Schedule with Increased Budget**

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Budget Allowance of \$12,000/Year – (Budget Increase Suggested to Best Manage City Trees)

### **YEAR 1**

### **ESTIMATED COSTS**

|                                                   |          |
|---------------------------------------------------|----------|
| Remove 15 trees recommended for immediate removal | \$10,500 |
| Plant 10 trees in open locations                  | \$1,500  |
| Visual Survey of EAB Signs/Symptoms               |          |

## **YEAR 2**

|                                                  |         |
|--------------------------------------------------|---------|
| Remove 2 trees recommended for immediate removal | \$1,400 |
| Remove 2 ash trees (prioritize largest diameter) | \$1,400 |
| Plant 13 trees in open locations                 | \$1,950 |
| Prune 1/3 of City Owned Trees                    | \$7,170 |
| Visual Survey of EAB Signs/Symptoms              |         |

## **YEAR 3**

|                                                   |          |
|---------------------------------------------------|----------|
| Remove 15 ash trees (prioritize largest diameter) | \$10,500 |
| Plant 10 trees in open locations                  | \$1,500  |
| Visual Survey of EAB Signs/Symptoms               |          |

## **YEAR 4**

|                                                  |         |
|--------------------------------------------------|---------|
| Remove 4 ash trees (prioritize largest diameter) | \$2,800 |
| Plant 13 trees in open locations                 | \$1,950 |
| Prune 1/3 of City Owned Trees                    | \$7,170 |
| Visual Survey of EAB Signs/Symptoms              |         |

## **YEAR 5**

|                                                   |          |
|---------------------------------------------------|----------|
| Remove 15 ash trees (prioritize largest diameter) | \$10,500 |
| Plant 10 trees in open locations                  | \$1,500  |
| Visual Survey of EAB Signs/Symptoms               |          |

## **YEAR 6**

|                                                  |         |
|--------------------------------------------------|---------|
| Remove 4 ash trees (prioritize largest diameter) | \$2,800 |
| Plant 13 trees in open locations                 | \$1,950 |
| Prune 1/3 of City Owned Trees                    | \$7,170 |
| Visual Survey of EAB Signs/Symptoms              |         |

### **Purposed Budget Increase**

EAB could potentially kill all ash trees in Shenandoah within four years of its arrival. To remove all ash trees within six years, the budget would need to be increased to \$19,250 a year. If the budget were increased to \$12,000 per year all ash could be removed within 9.5 years. Additionally, we recommend that Shenandoah apply for grants to fund replacement trees. Utility Company grants are usually between \$500 and \$10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools.

Another option considered by many communities is treating selected trees, either to maintain those trees in the landscape or to delay their removal – to spread out the costs and number of trees needing removal all at once. Trunk injection is administered every two years for the life of the tree. If treatment

is discontinued, the tree dies. For instance, in this treatment scenario, the average ash diameter is 20 inches and at \$15 per inch, about 4 trees could be treated per year (every other year treatment). Eight trees would be selected for treatment, and Shenandoah would still need to find \$109,900 for removal of the remaining ash trees. Alternatively, if there are 15 treatable trees, it would cost approximately \$4,500 a year for treatment and leave \$5,800 for removal. These are alternatives to straight removal of ash trees. However, whether the treatment option is selected, there will be an increased cost of dealing with ash trees if EAB is found in Shenandoah. We suggest considering an increased budget to plan for this.

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## Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

| Annual Energy Benefits of Public Trees |                            |                     |                               |                     |               |                   |                     |                  |                 |
|----------------------------------------|----------------------------|---------------------|-------------------------------|---------------------|---------------|-------------------|---------------------|------------------|-----------------|
| 4/23/2020                              |                            |                     |                               |                     |               |                   |                     |                  |                 |
| Species                                | Total Electricity<br>(MWh) | Electricity<br>(\$) | Total Natural<br>Gas (Therms) | Natural<br>Gas (\$) | Total<br>(\$) | Standard<br>Error | % of Total<br>Trees | % of<br>Total \$ | Avg.<br>\$/tree |
| Norway maple                           | 50.3                       | 3,817               | 7,290.7                       | 7,143               | 10,962        | (N/A)             | 12.9                | 13.4             | 59.25           |
| Northern pin oak                       | 57.5                       | 4,367               | 8,491.5                       | 8,322               | 12,689        | (N/A)             | 12.6                | 15.5             | 70.10           |
| Silver maple                           | 60.9                       | 4,623               | 7,985.8                       | 7,826               | 12,449        | (N/A)             | 12.5                | 15.2             | 69.55           |
| Green ash                              | 41.4                       | 3,142               | 5,732.2                       | 5,618               | 8,760         | (N/A)             | 8.9                 | 10.7             | 68.98           |
| Sugar maple                            | 35.5                       | 2,696               | 4,759.8                       | 4,665               | 7,361         | (N/A)             | 8.6                 | 9.0              | 59.85           |
| Red maple                              | 20.2                       | 1,531               | 2,676.3                       | 2,623               | 4,153         | (N/A)             | 6.0                 | 5.1              | 48.29           |
| BroadleafDeciduous Mec                 | 10.1                       | 769                 | 1,487.3                       | 1,458               | 2,226         | (N/A)             | 4.9                 | 2.7              | 31.36           |
| Honeylocust                            | 14.7                       | 1,114               | 1,963.7                       | 1,924               | 3,039         | (N/A)             | 3.5                 | 3.7              | 60.77           |
| Pear                                   | 5.1                        | 389                 | 799.7                         | 784                 | 1,172         | (N/A)             | 3.4                 | 1.4              | 23.93           |
| Northern red oak                       | 9.7                        | 735                 | 1,363.2                       | 1,336               | 2,071         | (N/A)             | 3.2                 | 2.5              | 45.03           |
| American basswood                      | 12.7                       | 963                 | 1,839.6                       | 1,803               | 2,766         | (N/A)             | 2.9                 | 3.4              | 65.86           |
| White ash                              | 13.7                       | 1,043               | 1,717.9                       | 1,684               | 2,727         | (N/A)             | 2.6                 | 3.3              | 71.75           |
| American sycamore                      | 11.0                       | 837                 | 1,491.4                       | 1,462               | 2,298         | (N/A)             | 2.0                 | 2.8              | 82.08           |
| Norway spruce                          | 2.2                        | 163                 | 275.4                         | 270                 | 433           | (N/A)             | 1.5                 | 0.5              | 19.70           |
| BroadleafDeciduous Sma                 | 0.4                        | 29                  | 65.5                          | 64                  | 93            | (N/A)             | 1.4                 | 0.1              | 4.64            |
| Eastern redbud                         | 1.3                        | 101                 | 210.4                         | 206                 | 307           | (N/A)             | 1.3                 | 0.4              | 17.07           |
| White oak                              | 3.7                        | 279                 | 469.7                         | 460                 | 740           | (N/A)             | 1.1                 | 0.9              | 46.22           |
| American elm                           | 7.0                        | 532                 | 895.8                         | 878                 | 1,409         | (N/A)             | 1.0                 | 1.7              | 100.67          |
| Swamp white oak                        | 2.5                        | 192                 | 342.3                         | 335                 | 527           | (N/A)             | 0.9                 | 0.6              | 40.55           |
| Bur oak                                | 2.9                        | 222                 | 380.6                         | 373                 | 595           | (N/A)             | 0.8                 | 0.7              | 49.62           |
| Austrian pine                          | 1.4                        | 109                 | 197.6                         | 194                 | 302           | (N/A)             | 0.6                 | 0.4              | 33.60           |
| River birch                            | 1.1                        | 87                  | 155.3                         | 152                 | 239           | (N/A)             | 0.6                 | 0.3              | 29.90           |
| Northern hackberry                     | 3.2                        | 241                 | 441.1                         | 432                 | 673           | (N/A)             | 0.6                 | 0.8              | 84.14           |
| Southern magnolia                      | 1.9                        | 145                 | 229.1                         | 225                 | 370           | (N/A)             | 0.6                 | 0.5              | 46.24           |
| Littleleaf linden                      | 1.4                        | 110                 | 207.9                         | 204                 | 314           | (N/A)             | 0.5                 | 0.4              | 44.79           |
| Black maple                            | 1.8                        | 134                 | 236.2                         | 231                 | 365           | (N/A)             | 0.5                 | 0.4              | 52.17           |
| Boxelder                               | 0.8                        | 61                  | 104.4                         | 102                 | 163           | (N/A)             | 0.5                 | 0.2              | 23.31           |
| Pin oak                                | 1.5                        | 114                 | 190.1                         | 186                 | 300           | (N/A)             | 0.4                 | 0.4              | 50.04           |
| Blue spruce                            | 0.3                        | 20                  | 43.2                          | 42                  | 62            | (N/A)             | 0.4                 | 0.1              | 10.41           |
| Chinese elm                            | 1.7                        | 127                 | 211.5                         | 207                 | 334           | (N/A)             | 0.4                 | 0.4              | 55.66           |
| Black spruce                           | 0.4                        | 33                  | 62.8                          | 62                  | 94            | (N/A)             | 0.3                 | 0.1              | 18.86           |
| BroadleafDeciduous Larj                | 1.5                        | 113                 | 200.2                         | 196                 | 309           | (N/A)             | 0.3                 | 0.4              | 61.76           |
| Eastern white pine                     | 0.7                        | 52                  | 88.4                          | 87                  | 139           | (N/A)             | 0.3                 | 0.2              | 34.66           |
| Ohio buckeye                           | 0.9                        | 69                  | 134.4                         | 132                 | 200           | (N/A)             | 0.2                 | 0.2              | 66.79           |
| Black walnut                           | 1.0                        | 78                  | 143.9                         | 141                 | 219           | (N/A)             | 0.2                 | 0.3              | 73.09           |
| Northern catalpa                       | 0.7                        | 56                  | 92.1                          | 90                  | 146           | (N/A)             | 0.2                 | 0.2              | 48.59           |
| Alder                                  | 0.4                        | 34                  | 62.2                          | 61                  | 94            | (N/A)             | 0.2                 | 0.1              | 31.49           |
| Ginkgo                                 | 0.3                        | 23                  | 41.9                          | 41                  | 64            | (N/A)             | 0.1                 | 0.1              | 32.00           |
| Common chokecherry                     | 0.4                        | 28                  | 49.3                          | 48                  | 76            | (N/A)             | 0.1                 | 0.1              | 38.13           |
| Japanese maple                         | 0.1                        | 7                   | 16.6                          | 16                  | 24            | (N/A)             | 0.1                 | 0.0              | 11.80           |
| Conifer Evergreen Mediu                | 0.0                        | 2                   | 4.9                           | 5                   | 7             | (N/A)             | 0.1                 | 0.0              | 6.94            |
| Conifer Evergreen Small                | 0.0                        | 1                   | 2.5                           | 2                   | 4             | (N/A)             | 0.1                 | 0.0              | 3.62            |
| Sweetgum                               | 0.3                        | 25                  | 46.9                          | 46                  | 71            | (N/A)             | 0.1                 | 0.1              | 70.91           |
| Hickory                                | 0.3                        | 20                  | 38.1                          | 37                  | 57            | (N/A)             | 0.1                 | 0.1              | 57.32           |
| Eastern red cedar                      | 0.0                        | 1                   | 2.5                           | 2                   | 4             | (N/A)             | 0.1                 | 0.0              | 3.62            |
| Apple                                  | 0.0                        | 2                   | 3.8                           | 4                   | 5             | (N/A)             | 0.1                 | 0.0              | 5.40            |
| Black locust                           | 0.3                        | 24                  | 47.4                          | 46                  | 71            | (N/A)             | 0.1                 | 0.1              | 70.84           |
| Juniper                                | 0.1                        | 8                   | 16.4                          | 16                  | 25            | (N/A)             | 0.1                 | 0.0              | 24.57           |
| Northern white cedar                   | 0.1                        | 4                   | 9.5                           | 9                   | 14            | (N/A)             | 0.1                 | 0.0              | 13.58           |
| Oak                                    | 0.3                        | 20                  | 38.1                          | 37                  | 57            | (N/A)             | 0.1                 | 0.1              | 57.32           |
| Tulip tree                             | 0.4                        | 29                  | 53.7                          | 53                  | 82            | (N/A)             | 0.1                 | 0.1              | 82.02           |
| Total                                  | 386.3                      | 29,320              | 53,410.7                      | 52,342              | 81,663        | (N/A)             | 100.0               | 100.0            | 56.91           |

**Table 2: Annual Stormwater Benefits**

| <b>Annual Stormwater Benefits of Public Trees</b> |                                   |            |                |                  |               |              |
|---------------------------------------------------|-----------------------------------|------------|----------------|------------------|---------------|--------------|
| 4/23/2020                                         |                                   |            |                |                  |               |              |
| Species                                           | Total rainfall interception (Gal) | Total (\$) | Standard Error | % of Total Trees | % of Total \$ | Avg. \$/tree |
| Norway maple                                      | 510,854                           | 13,844     | (N/A)          | 12.9             | 11.4          | 74.83        |
| Northern pin oak                                  | 667,641                           | 18,093     | (N/A)          | 12.6             | 14.9          | 99.96        |
| Silver maple                                      | 921,473                           | 24,972     | (N/A)          | 12.5             | 20.5          | 139.51       |
| Green ash                                         | 512,626                           | 13,892     | (N/A)          | 8.9              | 11.4          | 109.39       |
| Sugar maple                                       | 424,613                           | 11,507     | (N/A)          | 8.6              | 9.4           | 93.55        |
| Red maple                                         | 171,820                           | 4,656      | (N/A)          | 6.0              | 3.8           | 54.14        |
| BroadleafDeciduous Medi                           | 77,735                            | 2,107      | (N/A)          | 4.9              | 1.7           | 29.67        |
| Honeylocust                                       | 156,147                           | 4,232      | (N/A)          | 3.5              | 3.5           | 84.63        |
| Pear                                              | 22,861                            | 620        | (N/A)          | 3.4              | 0.5           | 12.64        |
| Northern red oak                                  | 107,627                           | 2,917      | (N/A)          | 3.2              | 2.4           | 63.41        |
| American basswood                                 | 150,592                           | 4,081      | (N/A)          | 2.9              | 3.4           | 97.17        |
| White ash                                         | 168,483                           | 4,566      | (N/A)          | 2.6              | 3.7           | 120.15       |
| American sycamore                                 | 161,267                           | 4,370      | (N/A)          | 2.0              | 3.6           | 156.08       |
| Norway spruce                                     | 36,049                            | 977        | (N/A)          | 1.5              | 0.8           | 44.41        |
| BroadleafDeciduous Smal                           | 1,214                             | 33         | (N/A)          | 1.4              | 0.0           | 1.64         |
| Eastern redbud                                    | 5,634                             | 153        | (N/A)          | 1.3              | 0.1           | 8.48         |
| White oak                                         | 28,711                            | 778        | (N/A)          | 1.1              | 0.6           | 48.63        |
| American elm                                      | 61,944                            | 1,679      | (N/A)          | 1.0              | 1.4           | 119.91       |
| Swamp white oak                                   | 16,743                            | 454        | (N/A)          | 0.9              | 0.4           | 34.90        |
| Bur oak                                           | 29,962                            | 812        | (N/A)          | 0.8              | 0.7           | 67.66        |
| Austrian pine                                     | 24,329                            | 659        | (N/A)          | 0.6              | 0.5           | 73.26        |
| River birch                                       | 8,492                             | 230        | (N/A)          | 0.6              | 0.2           | 28.77        |
| Northern hackberry                                | 35,881                            | 972        | (N/A)          | 0.6              | 0.8           | 121.55       |
| Southern magnolia                                 | 18,893                            | 512        | (N/A)          | 0.6              | 0.4           | 64.00        |
| Littleleaf linden                                 | 16,789                            | 455        | (N/A)          | 0.5              | 0.4           | 65.00        |
| Black maple                                       | 15,301                            | 415        | (N/A)          | 0.5              | 0.3           | 59.24        |
| Boxelder                                          | 5,625                             | 152        | (N/A)          | 0.5              | 0.1           | 21.78        |
| Pin oak                                           | 16,320                            | 442        | (N/A)          | 0.4              | 0.4           | 73.71        |
| Blue spruce                                       | 3,098                             | 84         | (N/A)          | 0.4              | 0.1           | 13.99        |
| Chinese elm                                       | 17,734                            | 481        | (N/A)          | 0.4              | 0.4           | 80.10        |
| Black spruce                                      | 6,899                             | 187        | (N/A)          | 0.3              | 0.2           | 37.39        |
| BroadleafDeciduous Large                          | 18,746                            | 508        | (N/A)          | 0.3              | 0.4           | 101.60       |
| Eastern white pine                                | 15,353                            | 416        | (N/A)          | 0.3              | 0.3           | 104.01       |
| Ohio buckeye                                      | 10,008                            | 271        | (N/A)          | 0.2              | 0.2           | 90.41        |
| Black walnut                                      | 13,773                            | 373        | (N/A)          | 0.2              | 0.3           | 124.41       |
| Northern catalpa                                  | 5,522                             | 150        | (N/A)          | 0.2              | 0.1           | 49.88        |
| Alder                                             | 1,598                             | 43         | (N/A)          | 0.2              | 0.0           | 14.43        |
| Ginkgo                                            | 2,159                             | 59         | (N/A)          | 0.1              | 0.0           | 29.25        |
| Common chokecherry                                | 1,333                             | 36         | (N/A)          | 0.1              | 0.0           | 18.06        |
| Japanese maple                                    | 333                               | 9          | (N/A)          | 0.1              | 0.0           | 4.51         |
| Conifer Evergreen Medium                          | 256                               | 7          | (N/A)          | 0.1              | 0.0           | 6.95         |
| Conifer Evergreen Small                           | 183                               | 5          | (N/A)          | 0.1              | 0.0           | 4.97         |
| Sweetgum                                          | 3,943                             | 107        | (N/A)          | 0.1              | 0.1           | 106.85       |
| Hickory                                           | 2,591                             | 70         | (N/A)          | 0.1              | 0.1           | 70.21        |
| Eastern red cedar                                 | 183                               | 5          | (N/A)          | 0.1              | 0.0           | 4.97         |
| Apple                                             | 69                                | 2          | (N/A)          | 0.1              | 0.0           | 1.86         |
| Black locust                                      | 3,764                             | 102        | (N/A)          | 0.1              | 0.1           | 102.01       |
| Juniper                                           | 1,635                             | 44         | (N/A)          | 0.1              | 0.0           | 44.30        |
| Northern white cedar                              | 596                               | 16         | (N/A)          | 0.1              | 0.0           | 16.14        |
| Oak                                               | 2,591                             | 70         | (N/A)          | 0.1              | 0.1           | 70.21        |
| Tulip tree                                        | 5,491                             | 149        | (N/A)          | 0.1              | 0.1           | 148.79       |
| Citywide total                                    | 4,493,481                         | 121,773    | (N/A)          | 100.0            | 100.0         | 84.86        |

**Table 3: Annual Air Quality Benefits**

| Annual Air Quality Benefits of Public Trees |                 |                 |                  |                 |                   |                 |                  |       |                 |                    |                     |                     |            |              |
|---------------------------------------------|-----------------|-----------------|------------------|-----------------|-------------------|-----------------|------------------|-------|-----------------|--------------------|---------------------|---------------------|------------|--------------|
| 4/23/2020                                   |                 |                 |                  |                 |                   |                 |                  |       |                 |                    |                     |                     |            |              |
| Species                                     | Deposition (lb) |                 |                  |                 | Total Depos. (\$) | Avoided (lb)    |                  |       |                 | Total Avoided (\$) | BVOC Emissions (lb) | BVOC Emissions (\$) | Total (lb) | Total (\$)   |
|                                             | O <sub>3</sub>  | NO <sub>2</sub> | PM <sub>10</sub> | SO <sub>2</sub> |                   | NO <sub>2</sub> | PM <sub>10</sub> | VOC   | SO <sub>2</sub> |                    |                     |                     |            |              |
| Norway maple                                | 109.6           | 18.9            | 53.2             | 4.9             | 590               | 244.1           | 35.3             | 33.6  | 228.1           | 1,511              | -25.2               | -95                 | 702.3      | 2,007 (N/A)  |
| Northern pin oak                            | 152.5           | 26.3            | 72.9             | 6.7             | 818               | 280.6           | 40.4             | 38.5  | 261.0           | 1,734              | -34.4               | -129                | 844.5      | 2,423 (N/A)  |
| Silver maple                                | 164.2           | 27.8            | 80.0             | 7.3             | 884               | 286.8           | 42.0             | 40.1  | 275.5           | 1,795              | -84.6               | -317                | 839.1      | 2,361 (N/A)  |
| Green ash                                   | 68.4            | 10.9            | 31.8             | 3.1             | 362               | 198.3           | 28.8             | 27.5  | 187.6           | 1,234              | 0.0                 | 0                   | 556.4      | 1,595 (N/A)  |
| Sugar maple                                 | 60.6            | 10.3            | 29.6             | 2.7             | 326               | 168.5           | 24.6             | 23.5  | 160.9           | 1,052              | -47.2               | -177                | 433.4      | 1,201 (N/A)  |
| Red maple                                   | 41.5            | 7.1             | 19.3             | 1.8             | 221               | 95.4            | 14.0             | 13.3  | 91.3            | 596                | -13.9               | -52                 | 269.8      | 765 (N/A)    |
| Broadleaf Deciduous Med                     | 13.5            | 2.3             | 7.0              | 0.6             | 74                | 49.4            | 7.1              | 6.8   | 46.0            | 305                | -3.4                | -13                 | 129.3      | 367 (N/A)    |
| Honeylocust                                 | 30.2            | 5.0             | 13.8             | 1.4             | 160               | 69.5            | 10.2             | 9.7   | 66.4            | 434                | -22.8               | -85                 | 183.5      | 509 (N/A)    |
| Pear                                        | 6.9             | 1.1             | 3.3              | 0.3             | 37                | 25.3            | 3.6              | 3.4   | 23.2            | 156                | 0.0                 | 0                   | 67.2       | 192 (N/A)    |
| Northern red oak                            | 23.5            | 4.0             | 11.3             | 1.0             | 126               | 46.5            | 6.8              | 6.4   | 43.9            | 289                | -33.8               | -127                | 109.6      | 288 (N/A)    |
| American basswood                           | 21.2            | 3.6             | 10.3             | 0.9             | 114               | 61.6            | 8.9              | 8.5   | 57.6            | 381                | -17.9               | -67                 | 154.8      | 429 (N/A)    |
| White ash                                   | 32.2            | 5.2             | 14.6             | 1.4             | 169               | 64.1            | 9.4              | 9.0   | 62.2            | 403                | 0.0                 | 0                   | 198.1      | 572 (N/A)    |
| American sycamore                           | 25.6            | 4.1             | 11.4             | 1.1             | 134               | 52.5            | 7.7              | 7.3   | 49.9            | 327                | 0.0                 | 0                   | 159.6      | 461 (N/A)    |
| Norway spruce                               | 4.1             | 0.8             | 3.4              | 0.5             | 27                | 10.1            | 1.5              | 1.4   | 9.8             | 63                 | -17.9               | -67                 | 13.7       | 24 (N/A)     |
| Broadleaf Deciduous Small                   | 0.1             | 0.0             | 0.1              | 0.0             | 1                 | 1.9             | 0.3              | 0.3   | 1.7             | 12                 | 0.0                 | 0                   | 4.4        | 12 (N/A)     |
| Eastern redbud                              | 1.6             | 0.3             | 0.8              | 0.1             | 8                 | 6.6             | 0.9              | 0.9   | 6.0             | 41                 | 0.0                 | 0                   | 17.1       | 49 (N/A)     |
| White oak                                   | 2.6             | 0.4             | 1.4              | 0.1             | 14                | 17.3            | 2.5              | 2.4   | 16.7            | 108                | 0.0                 | 0                   | 43.4       | 123 (N/A)    |
| American elm                                | 20.0            | 3.4             | 9.4              | 0.9             | 107               | 32.9            | 4.8              | 4.6   | 31.7            | 206                | 0.0                 | 0                   | 107.8      | 313 (N/A)    |
| Swamp white oak                             | 2.7             | 0.5             | 1.4              | 0.1             | 15                | 12.1            | 1.8              | 1.7   | 11.5            | 75                 | -0.7                | -3                  | 30.9       | 87 (N/A)     |
| Bur oak                                     | 3.6             | 0.6             | 1.8              | 0.2             | 19                | 13.8            | 2.0              | 1.9   | 13.3            | 86                 | 0.0                 | 0                   | 37.2       | 106 (N/A)    |
| Austrian pine                               | 4.3             | 0.8             | 3.4              | 0.5             | 28                | 6.8             | 1.0              | 0.9   | 6.5             | 43                 | -9.4                | -35                 | 14.9       | 35 (N/A)     |
| River birch                                 | 1.5             | 0.3             | 0.8              | 0.1             | 8                 | 5.5             | 0.8              | 0.8   | 5.2             | 34                 | -0.4                | -1                  | 14.5       | 41 (N/A)     |
| Northern hackberry                          | 6.2             | 1.1             | 3.1              | 0.3             | 34                | 15.2            | 2.2              | 2.1   | 14.4            | 95                 | 0.0                 | 0                   | 44.6       | 128 (N/A)    |
| Southern magnolia                           | 1.8             | 0.4             | 1.8              | 0.2             | 13                | 8.8             | 1.3              | 1.2   | 8.6             | 55                 | -5.4                | -20                 | 18.7       | 48 (N/A)     |
| Littleleaf linden                           | 3.1             | 0.5             | 1.5              | 0.1             | 17                | 7.0             | 1.0              | 1.0   | 6.6             | 43                 | -1.5                | -5                  | 19.3       | 55 (N/A)     |
| Black maple                                 | 3.7             | 0.6             | 1.7              | 0.2             | 20                | 8.4             | 1.2              | 1.2   | 8.0             | 52                 | -1.2                | -5                  | 23.7       | 67 (N/A)     |
| Boxelder                                    | 0.5             | 0.1             | 0.3              | 0.0             | 3                 | 3.8             | 0.6              | 0.5   | 3.6             | 24                 | -0.3                | -1                  | 9.0        | 25 (N/A)     |
| Pin oak                                     | 3.0             | 0.5             | 1.5              | 0.1             | 16                | 7.0             | 1.0              | 1.0   | 6.8             | 44                 | -5.6                | -21                 | 15.4       | 40 (N/A)     |
| Blue spruce                                 | 0.3             | 0.1             | 0.3              | 0.0             | 2                 | 1.3             | 0.2              | 0.2   | 1.2             | 8                  | -1.0                | -4                  | 2.6        | 6 (N/A)      |
| Chinese elm                                 | 2.7             | 0.4             | 1.3              | 0.1             | 14                | 7.8             | 1.1              | 1.1   | 7.6             | 49                 | 0.0                 | 0                   | 22.2       | 64 (N/A)     |
| Black spruce                                | 1.2             | 0.2             | 0.9              | 0.1             | 8                 | 2.1             | 0.3              | 0.3   | 2.0             | 13                 | -2.6                | -10                 | 4.5        | 11 (N/A)     |
| Broadleaf Deciduous Large                   | 2.6             | 0.4             | 1.2              | 0.1             | 14                | 7.1             | 1.0              | 1.0   | 6.7             | 44                 | 0.0                 | 0                   | 20.1       | 58 (N/A)     |
| Eastern white pine                          | 1.9             | 0.4             | 1.5              | 0.2             | 12                | 3.2             | 0.5              | 0.5   | 3.1             | 20                 | -9.1                | -34                 | 2.1        | -2 (N/A)     |
| Ohio buckeye                                | 2.2             | 0.4             | 1.1              | 0.1             | 12                | 4.4             | 0.6              | 0.6   | 4.1             | 27                 | -0.5                | -2                  | 13.0       | 37 (N/A)     |
| Black walnut                                | 1.9             | 0.3             | 0.9              | 0.1             | 10                | 4.9             | 0.7              | 0.7   | 4.7             | 31                 | 0.0                 | 0                   | 14.2       | 41 (N/A)     |
| Northern catalpa                            | 0.5             | 0.1             | 0.3              | 0.0             | 3                 | 3.4             | 0.5              | 0.5   | 3.3             | 21                 | 0.0                 | 0                   | 8.6        | 24 (N/A)     |
| Alder                                       | 0.5             | 0.1             | 0.2              | 0.0             | 2                 | 2.1             | 0.3              | 0.3   | 2.0             | 13                 | 0.0                 | 0                   | 5.5        | 16 (N/A)     |
| Ginkgo                                      | 0.6             | 0.1             | 0.3              | 0.0             | 3                 | 1.4             | 0.2              | 0.2   | 1.4             | 9                  | -0.2                | -1                  | 4.0        | 11 (N/A)     |
| Common chokecherry                          | 0.4             | 0.1             | 0.2              | 0.0             | 2                 | 1.7             | 0.3              | 0.2   | 1.7             | 11                 | 0.0                 | 0                   | 4.6        | 13 (N/A)     |
| Japanese maple                              | 0.0             | 0.0             | 0.0              | 0.0             | 0                 | 0.5             | 0.1              | 0.1   | 0.4             | 3                  | 0.0                 | 0                   | 1.1        | 3 (N/A)      |
| Conifer Evergreen Medium                    | 0.0             | 0.0             | 0.0              | 0.0             | 0                 | 0.1             | 0.0              | 0.0   | 0.1             | 1                  | -0.1                | 0                   | 0.3        | 1 (N/A)      |
| Conifer Evergreen Small                     | 0.0             | 0.0             | 0.0              | 0.0             | 0                 | 0.1             | 0.0              | 0.0   | 0.1             | 0                  | -0.1                | 0                   | 0.1        | 0 (N/A)      |
| Sweetgum                                    | 0.5             | 0.1             | 0.2              | 0.0             | 3                 | 1.6             | 0.2              | 0.2   | 1.5             | 10                 | 0.0                 | 0                   | 4.4        | 12 (N/A)     |
| Hickory                                     | 0.3             | 0.0             | 0.1              | 0.0             | 1                 | 1.3             | 0.2              | 0.2   | 1.2             | 8                  | 0.0                 | 0                   | 3.3        | 9 (N/A)      |
| Eastern red cedar                           | 0.0             | 0.0             | 0.0              | 0.0             | 0                 | 0.1             | 0.0              | 0.0   | 0.1             | 0                  | -0.1                | 0                   | 0.1        | 0 (N/A)      |
| Apple                                       | 0.0             | 0.0             | 0.0              | 0.0             | 0                 | 0.1             | 0.0              | 0.0   | 0.1             | 1                  | 0.0                 | 0                   | 0.3        | 1 (N/A)      |
| Black locust                                | 0.9             | 0.1             | 0.4              | 0.0             | 5                 | 1.6             | 0.2              | 0.2   | 1.5             | 10                 | -0.2                | -1                  | 4.7        | 14 (N/A)     |
| Juniper                                     | 0.3             | 0.1             | 0.3              | 0.0             | 2                 | 0.5             | 0.1              | 0.1   | 0.5             | 3                  | -0.9                | -3                  | 1.0        | 2 (N/A)      |
| Northern white cedar                        | 0.1             | 0.0             | 0.1              | 0.0             | 0                 | 0.3             | 0.0              | 0.0   | 0.3             | 2                  | -0.2                | -1                  | 0.6        | 1 (N/A)      |
| Oak                                         | 0.3             | 0.0             | 0.1              | 0.0             | 1                 | 1.3             | 0.2              | 0.2   | 1.2             | 8                  | 0.0                 | 0                   | 3.3        | 9 (N/A)      |
| Tulip tree                                  | 0.8             | 0.1             | 0.4              | 0.0             | 4                 | 1.9             | 0.3              | 0.3   | 1.8             | 12                 | 0.0                 | 0                   | 5.5        | 16 (N/A)     |
| Citywide total                              | 826.6           | 140.1           | 400.4            | 37.8            | 4,444             | 1,848.6         | 268.8            | 256.2 | 1,750.3         | 11,504             | -340.4              | -1,276              | 5,188.6    | 14,672 (N/A) |
|                                             |                 |                 |                  |                 |                   |                 |                  |       |                 |                    |                     |                     |            | 1000 10.22   |

Table 4: Annual Carbon Stored

| Stored CO2 Benefits of Public Trees |                           |               |                   |                     |                  |                 |
|-------------------------------------|---------------------------|---------------|-------------------|---------------------|------------------|-----------------|
| 4/23/2020                           |                           |               |                   |                     |                  |                 |
| Species                             | Total Stored<br>CO2 (lbs) | Total<br>(\$) | Standard<br>Error | % of Total<br>Trees | % of<br>Total \$ | Avg.<br>\$/tree |
| Norway maple                        | 1,806,803                 | 13,551        | (N/A)             | 12.9                | 10.3             | 73.25           |
| Northern pin oak                    | 2,519,051                 | 18,893        | (N/A)             | 12.6                | 14.4             | 104.38          |
| Silver maple                        | 3,781,228                 | 28,359        | (N/A)             | 12.5                | 21.6             | 158.43          |
| Green ash                           | 2,233,742                 | 16,753        | (N/A)             | 8.9                 | 12.8             | 131.91          |
| Sugar maple                         | 1,768,441                 | 13,263        | (N/A)             | 8.6                 | 10.1             | 107.83          |
| Red maple                           | 448,566                   | 3,364         | (N/A)             | 6.0                 | 2.6              | 39.12           |
| Broadleaf Deciduou                  | 227,560                   | 1,707         | (N/A)             | 4.9                 | 1.3              | 24.04           |
| Honeylocust                         | 383,543                   | 2,877         | (N/A)             | 3.5                 | 2.2              | 57.53           |
| Pear                                | 110,944                   | 832           | (N/A)             | 3.4                 | 0.6              | 16.98           |
| Northern red oak                    | 522,322                   | 3,917         | (N/A)             | 3.2                 | 3.0              | 85.16           |
| American basswood                   | 789,501                   | 5,921         | (N/A)             | 2.9                 | 4.5              | 140.98          |
| White ash                           | 506,856                   | 3,801         | (N/A)             | 2.6                 | 2.9              | 100.04          |
| American sycamore                   | 863,139                   | 6,474         | (N/A)             | 2.0                 | 4.9              | 231.20          |
| Norway spruce                       | 43,375                    | 325           | (N/A)             | 1.5                 | 0.2              | 14.79           |
| Broadleaf Deciduou                  | 3,540                     | 27            | (N/A)             | 1.4                 | 0.0              | 1.33            |
| Eastern redbud                      | 25,937                    | 195           | (N/A)             | 1.3                 | 0.1              | 10.81           |
| White oak                           | 84,719                    | 635           | (N/A)             | 1.1                 | 0.5              | 39.71           |
| American elm                        | 392,282                   | 2,942         | (N/A)             | 1.0                 | 2.2              | 210.15          |
| Swamp white oak                     | 44,780                    | 336           | (N/A)             | 0.9                 | 0.3              | 25.83           |
| Bur oak                             | 121,065                   | 908           | (N/A)             | 0.8                 | 0.7              | 75.67           |
| Austrian pine                       | 38,034                    | 285           | (N/A)             | 0.6                 | 0.2              | 31.69           |
| River birch                         | 25,825                    | 194           | (N/A)             | 0.6                 | 0.1              | 24.21           |
| Northern hackberry                  | 100,061                   | 750           | (N/A)             | 0.6                 | 0.6              | 93.81           |
| Southern magnolia                   | 25,004                    | 188           | (N/A)             | 0.6                 | 0.1              | 23.44           |
| Littleleaf linden                   | 65,762                    | 493           | (N/A)             | 0.5                 | 0.4              | 70.46           |
| Black maple                         | 40,130                    | 301           | (N/A)             | 0.5                 | 0.2              | 43.00           |
| Boxelder                            | 10,987                    | 82            | (N/A)             | 0.5                 | 0.1              | 11.77           |
| Pin oak                             | 83,633                    | 627           | (N/A)             | 0.4                 | 0.5              | 104.54          |
| Blue spruce                         | 1,141                     | 9             | (N/A)             | 0.4                 | 0.0              | 1.43            |
| Chinese elm                         | 93,975                    | 705           | (N/A)             | 0.4                 | 0.5              | 117.47          |
| Black spruce                        | 10,116                    | 76            | (N/A)             | 0.3                 | 0.1              | 15.17           |
| Broadleaf Deciduou                  | 85,681                    | 643           | (N/A)             | 0.3                 | 0.5              | 128.52          |
| Eastern white pine                  | 23,641                    | 177           | (N/A)             | 0.3                 | 0.1              | 44.33           |
| Ohio buckeye                        | 36,506                    | 274           | (N/A)             | 0.2                 | 0.2              | 91.26           |
| Black walnut                        | 63,489                    | 476           | (N/A)             | 0.2                 | 0.4              | 158.72          |
| Northern catalpa                    | 15,801                    | 119           | (N/A)             | 0.2                 | 0.1              | 39.50           |
| Alder                               | 6,982                     | 52            | (N/A)             | 0.2                 | 0.0              | 17.46           |
| Ginkgo                              | 8,274                     | 62            | (N/A)             | 0.1                 | 0.0              | 31.03           |
| Common chokecher                    | 6,074                     | 46            | (N/A)             | 0.1                 | 0.0              | 22.78           |
| Japanese maple                      | 1,086                     | 8             | (N/A)             | 0.1                 | 0.0              | 4.07            |
| Conifer Evergreen N                 | 43                        | 0             | (N/A)             | 0.1                 | 0.0              | 0.32            |
| Conifer Evergreen S                 | 43                        | 0             | (N/A)             | 0.1                 | 0.0              | 0.32            |
| Sweetgum                            | 15,773                    | 118           | (N/A)             | 0.1                 | 0.1              | 118.30          |
| Hickory                             | 8,458                     | 63            | (N/A)             | 0.1                 | 0.0              | 63.43           |
| Eastern red cedar                   | 43                        | 0             | (N/A)             | 0.1                 | 0.0              | 0.32            |
| Apple                               | 178                       | 1             | (N/A)             | 0.1                 | 0.0              | 1.33            |
| Black locust                        | 14,280                    | 107           | (N/A)             | 0.1                 | 0.1              | 107.10          |
| Juniper                             | 1,102                     | 8             | (N/A)             | 0.1                 | 0.0              | 8.27            |
| Northern white ceda                 | 257                       | 2             | (N/A)             | 0.1                 | 0.0              | 1.93            |
| Oak                                 | 8,458                     | 63            | (N/A)             | 0.1                 | 0.0              | 63.43           |
| Tulip tree                          | 25,943                    | 195           | (N/A)             | 0.1                 | 0.1              | 194.57          |
| Citywide total                      | 17,494,175                | 131,206       | (N/A)             | 100.0               | 100.0            | 91.43           |

**Table 5: Annual Carbon Sequestered**

| Annual CO <sub>2</sub> Benefits of Public Trees |                  |                  |                            |                          |                     |              |              |                |              |                |                  |               |              |
|-------------------------------------------------|------------------|------------------|----------------------------|--------------------------|---------------------|--------------|--------------|----------------|--------------|----------------|------------------|---------------|--------------|
| 4/23/2020                                       |                  |                  |                            |                          |                     |              |              |                |              |                |                  |               |              |
| Species                                         | Sequestered (lb) | Sequestered (\$) | Decomposition Release (lb) | Maintenance Release (lb) | Total Released (\$) | Avoided (lb) | Avoided (\$) | Net Total (lb) | Total (\$)   | Standard Error | % of Total Trees | % of Total \$ | Avg. \$/tree |
| Norway maple                                    | 58,687           | 440              | -8,674                     | -547                     | -69                 | 84,348       | 633          | 133,815        | 1,004 (N/A)  |                | 12.9             | 9.8           | 5.42         |
| Northern pin oak                                | 11,462           | 86               | -12,091                    | -745                     | -96                 | 96,507       | 724          | 95,133         | 713 (N/A)    |                | 12.6             | 7.0           | 3.94         |
| Silver maple                                    | 267,455          | 2,006            | -18,152                    | -688                     | -141                | 102,158      | 766          | 350,774        | 2,631 (N/A)  |                | 12.5             | 25.7          | 14.70        |
| Green ash                                       | 100,223          | 752              | -10,722                    | -443                     | -84                 | 69,448       | 521          | 158,506        | 1,189 (N/A)  |                | 8.9              | 11.6          | 9.36         |
| Sugar maple                                     | 85,142           | 639              | -8,491                     | -392                     | -67                 | 59,591       | 447          | 135,850        | 1,019 (N/A)  |                | 8.6              | 10.0          | 8.28         |
| Red maple                                       | 41,221           | 309              | -2,153                     | -182                     | -18                 | 33,824       | 254          | 72,709         | 545 (N/A)    |                | 6.0              | 5.3           | 6.34         |
| Broadleaf Deciduous Me                          | 17,602           | 132              | -1,104                     | -107                     | -9                  | 16,991       | 127          | 33,383         | 250 (N/A)    |                | 4.9              | 2.4           | 3.53         |
| Honeylocust                                     | 42,389           | 318              | -1,843                     | -121                     | -15                 | 24,623       | 185          | 65,047         | 488 (N/A)    |                | 3.5              | 4.8           | 9.76         |
| Pear                                            | 8,558            | 64               | -533                       | -73                      | -5                  | 8,589        | 64           | 16,542         | 124 (N/A)    |                | 3.4              | 1.2           | 2.53         |
| Northern red oak                                | 5,394            | 40               | -2,507                     | -130                     | -20                 | 16,251       | 122          | 19,007         | 143 (N/A)    |                | 3.2              | 1.4           | 3.10         |
| American basswood                               | 44,811           | 336              | -3,790                     | -151                     | -30                 | 21,287       | 160          | 62,157         | 466 (N/A)    |                | 2.9              | 4.6           | 11.10        |
| White ash                                       | 32,899           | 247              | -2,433                     | -119                     | -19                 | 23,053       | 173          | 53,399         | 400 (N/A)    |                | 2.6              | 3.9           | 10.54        |
| American sycamore                               | 23,070           | 173              | -4,143                     | -124                     | -32                 | 18,490       | 139          | 37,293         | 280 (N/A)    |                | 2.0              | 2.7           | 9.99         |
| Norway spruce                                   | 1,826            | 14               | -208                       | -41                      | -2                  | 3,612        | 27           | 5,189          | 39 (N/A)     |                | 1.5              | 0.4           | 1.77         |
| Broadleaf Deciduous Sm                          | 647              | 5                | -17                        | -9                       | 0                   | 634          | 5            | 1,254          | 9 (N/A)      |                | 1.4              | 0.1           | 0.47         |
| Eastern redbud                                  | 1,913            | 14               | -125                       | -21                      | -1                  | 2,234        | 17           | 4,002          | 30 (N/A)     |                | 1.3              | 0.3           | 1.67         |
| White oak                                       | 7,921            | 59               | -407                       | -34                      | -3                  | 6,171        | 46           | 13,651         | 102 (N/A)    |                | 1.1              | 1.0           | 6.40         |
| American elm                                    | 8,647            | 65               | -1,883                     | -68                      | -15                 | 11,747       | 88           | 18,443         | 138 (N/A)    |                | 1.0              | 1.4           | 9.88         |
| Swamp white oak                                 | 4,409            | 33               | -216                       | -23                      | -2                  | 4,237        | 32           | 8,407          | 63 (N/A)     |                | 0.9              | 0.6           | 4.85         |
| Bur oak                                         | 6,344            | 48               | -581                       | -30                      | -5                  | 4,916        | 37           | 10,650         | 80 (N/A)     |                | 0.8              | 0.8           | 6.66         |
| Austrian pine                                   | 1,180            | 9                | -183                       | -29                      | -2                  | 2,405        | 18           | 3,373          | 25 (N/A)     |                | 0.6              | 0.2           | 2.81         |
| River birch                                     | 1,450            | 11               | -126                       | -12                      | -1                  | 1,924        | 14           | 3,236          | 24 (N/A)     |                | 0.6              | 0.2           | 3.03         |
| Northern hackberry                              | 4,245            | 32               | -480                       | -31                      | -4                  | 5,322        | 40           | 9,055          | 68 (N/A)     |                | 0.6              | 0.7           | 8.49         |
| Southern magnolia                               | 1,567            | 12               | -120                       | -18                      | -1                  | 3,212        | 24           | 4,641          | 35 (N/A)     |                | 0.6              | 0.3           | 4.35         |
| Littleleaf linden                               | 3,034            | 23               | -316                       | -19                      | -3                  | 2,425        | 18           | 5,123          | 38 (N/A)     |                | 0.5              | 0.4           | 5.49         |
| Black maple                                     | 3,902            | 29               | -193                       | -16                      | -2                  | 2,955        | 22           | 6,648          | 50 (N/A)     |                | 0.5              | 0.5           | 7.12         |
| Boxelder                                        | 1,492            | 11               | -54                        | -9                       | 0                   | 1,344        | 10           | 2,773          | 21 (N/A)     |                | 0.5              | 0.2           | 2.97         |
| Pin oak                                         | 1,162            | 9                | -401                       | -16                      | -3                  | 2,518        | 19           | 3,263          | 24 (N/A)     |                | 0.4              | 0.2           | 4.08         |
| Blue spruce                                     | 158              | 1                | -5                         | -5                       | 0                   | 446          | 3            | 593            | 4 (N/A)      |                | 0.4              | 0.0           | 0.74         |
| Chinese elm                                     | 2,983            | 22               | -451                       | -17                      | -4                  | 2,800        | 21           | 5,315          | 40 (N/A)     |                | 0.4              | 0.4           | 6.64         |
| Black spruce                                    | 429              | 3                | -49                        | -9                       | 0                   | 725          | 5            | 1,097          | 8 (N/A)      |                | 0.3              | 0.1           | 1.65         |
| Broadleaf Deciduous Lar                         | 5,383            | 25               | -411                       | -16                      | -3                  | 2,488        | 19           | 5,444          | 41 (N/A)     |                | 0.3              | 0.4           | 8.17         |
| Eastern white pine                              | 116              | 1                | -113                       | -16                      | -1                  | 1,149        | 9            | 1,135          | 9 (N/A)      |                | 0.3              | 0.1           | 2.13         |
| Ohio buckeye                                    | 840              | 6                | -175                       | -11                      | -1                  | 1,517        | 11           | 2,171          | 16 (N/A)     |                | 0.2              | 0.2           | 5.43         |
| Black walnut                                    | 2,429            | 18               | -305                       | -11                      | -2                  | 1,728        | 13           | 3,841          | 29 (N/A)     |                | 0.2              | 0.3           | 9.60         |
| Northern catalpa                                | 1,550            | 12               | -76                        | -7                       | -1                  | 1,227        | 9            | 2,695          | 20 (N/A)     |                | 0.2              | 0.2           | 6.74         |
| Alder                                           | 649              | 5                | -34                        | -5                       | 0                   | 741          | 6            | 1,352          | 10 (N/A)     |                | 0.2              | 0.1           | 3.38         |
| Ginkgo                                          | 58               | 0                | -40                        | -5                       | 0                   | 507          | 4            | 521            | 4 (N/A)      |                | 0.1              | 0.0           | 1.95         |
| Common chokecherry                              | 535              | 4                | -29                        | -4                       | 0                   | 617          | 5            | 1,119          | 8 (N/A)      |                | 0.1              | 0.1           | 4.20         |
| Japanese maple                                  | 152              | 1                | -5                         | -2                       | 0                   | 161          | 1            | 306            | 2 (N/A)      |                | 0.1              | 0.0           | 1.15         |
| Conifer Evergreen Medin                         | 12               | 0                | 0                          | -1                       | 0                   | 48           | 0            | 60             | 0 (N/A)      |                | 0.1              | 0.0           | 0.45         |
| Conifer Evergreen Small                         | 13               | 0                | 0                          | -1                       | 0                   | 26           | 0            | 39             | 0 (N/A)      |                | 0.1              | 0.0           | 0.29         |
| Sweetgum                                        | 857              | 6                | -76                        | -4                       | -1                  | 552          | 4            | 1,330          | 10 (N/A)     |                | 0.1              | 0.1           | 9.97         |
| Hickory                                         | 660              | 5                | -41                        | -3                       | 0                   | 441          | 3            | 1,058          | 8 (N/A)      |                | 0.1              | 0.1           | 7.93         |
| Eastern red cedar                               | 13               | 0                | 0                          | -1                       | 0                   | 26           | 0            | 39             | 0 (N/A)      |                | 0.1              | 0.0           | 0.29         |
| Apple                                           | 38               | 0                | -1                         | -1                       | 0                   | 37           | 0            | 74             | 1 (N/A)      |                | 0.1              | 0.0           | 0.55         |
| Black locust                                    | 370              | 3                | -69                        | -4                       | -1                  | 539          | 4            | 837            | 6 (N/A)      |                | 0.1              | 0.1           | 6.27         |
| Juniper                                         | 0                | 0                | -5                         | -2                       | 0                   | 187          | 1            | 180            | 1 (N/A)      |                | 0.1              | 0.0           | 1.35         |
| Northern white cedar                            | 53               | 0                | -1                         | -1                       | 0                   | 94           | 1            | 145            | 1 (N/A)      |                | 0.1              | 0.0           | 1.08         |
| Oak                                             | 660              | 5                | -41                        | -3                       | 0                   | 441          | 3            | 1,058          | 8 (N/A)      |                | 0.1              | 0.1           | 7.93         |
| Tulip tree                                      | 960              | 7                | -125                       | -4                       | -1                  | 650          | 5            | 1,481          | 11 (N/A)     |                | 0.1              | 0.1           | 11.11        |
| Citywide total                                  | 805,570          | 6,042            | -83,997                    | -4,329                   | -662                | 647,967      | 4,860        | 1,365,212      | 10,239 (N/A) |                | 100.0            | 100.0         | 7.14         |

**Table 6: Annual Social and Aesthetic Benefits**

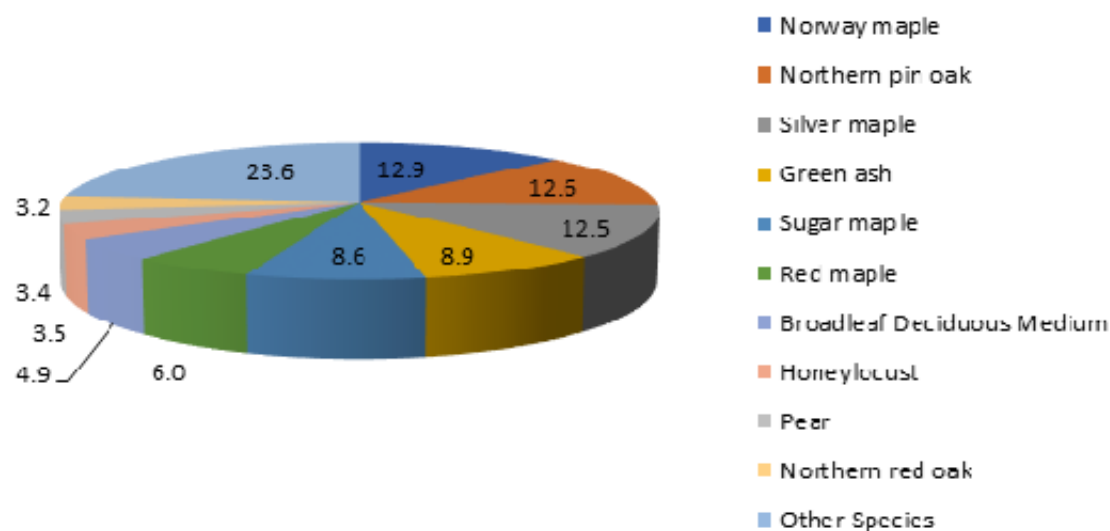
| <b>Annual Aesthetic/Other Benefits of Public Trees</b> |              |                |                  |               |              |
|--------------------------------------------------------|--------------|----------------|------------------|---------------|--------------|
| 4/23/2020                                              |              |                |                  |               |              |
| Species                                                | Total (\$)   | Standard Error | % of Total Trees | % of Total \$ | Avg. \$/tree |
| Norway maple                                           | 5,430 (N/A)  |                | 12.9             | 7.1           | 29.35        |
| Northern pin oak                                       | 1,009 (N/A)  |                | 12.6             | 1.3           | 5.58         |
| Silver maple                                           | 20,217 (N/A) |                | 12.5             | 26.6          | 112.95       |
| Green ash                                              | 7,683 (N/A)  |                | 8.9              | 10.1          | 60.49        |
| Sugar maple                                            | 8,576 (N/A)  |                | 8.6              | 11.3          | 69.72        |
| Red maple                                              | 5,195 (N/A)  |                | 6.0              | 6.8           | 60.41        |
| BroadleafDeciduous Medi                                | 1,853 (N/A)  |                | 4.9              | 2.4           | 26.10        |
| Honeylocust                                            | 9,768 (N/A)  |                | 3.5              | 12.8          | 195.37       |
| Pear                                                   | 499 (N/A)    |                | 3.4              | 0.7           | 10.18        |
| Northern red oak                                       | 396 (N/A)    |                | 3.2              | 0.5           | 8.62         |
| American basswood                                      | 3,126 (N/A)  |                | 2.9              | 4.1           | 74.43        |
| White ash                                              | 3,568 (N/A)  |                | 2.6              | 4.7           | 93.88        |
| American sycamore                                      | 1,598 (N/A)  |                | 2.0              | 2.1           | 57.09        |
| Norway spruce                                          | 435 (N/A)    |                | 1.5              | 0.6           | 19.76        |
| BroadleafDeciduous Small                               | 32 (N/A)     |                | 1.4              | 0.0           | 1.58         |
| Eastern redbud                                         | 109 (N/A)    |                | 1.3              | 0.1           | 6.03         |
| White oak                                              | 766 (N/A)    |                | 1.1              | 1.0           | 47.88        |
| American elm                                           | 1,094 (N/A)  |                | 1.0              | 1.4           | 78.12        |
| Swamp white oak                                        | 452 (N/A)    |                | 0.9              | 0.6           | 34.75        |
| Bur oak                                                | 564 (N/A)    |                | 0.8              | 0.7           | 47.01        |
| Austrian pine                                          | 109 (N/A)    |                | 0.6              | 0.1           | 12.14        |
| River birch                                            | 159 (N/A)    |                | 0.6              | 0.2           | 19.86        |
| Northern hackberry                                     | 521 (N/A)    |                | 0.6              | 0.7           | 65.16        |
| Southern magnolia                                      | 283 (N/A)    |                | 0.6              | 0.4           | 35.34        |
| Littleleaf linden                                      | 309 (N/A)    |                | 0.5              | 0.4           | 44.13        |
| Black maple                                            | 489 (N/A)    |                | 0.5              | 0.6           | 69.83        |
| Boxelder                                               | 198 (N/A)    |                | 0.5              | 0.3           | 28.31        |
| Pin oak                                                | 126 (N/A)    |                | 0.4              | 0.2           | 21.03        |
| Blue spruce                                            | 94 (N/A)     |                | 0.4              | 0.1           | 15.73        |
| Chinese elm                                            | 261 (N/A)    |                | 0.4              | 0.3           | 43.55        |
| Black spruce                                           | 64 (N/A)     |                | 0.3              | 0.1           | 12.81        |
| BroadleafDeciduous Large                               | 265 (N/A)    |                | 0.3              | 0.3           | 52.99        |
| Eastern white pine                                     | 32 (N/A)     |                | 0.3              | 0.0           | 8.08         |
| Ohio buckeye                                           | 75 (N/A)     |                | 0.2              | 0.1           | 24.84        |
| Black walnut                                           | 182 (N/A)    |                | 0.2              | 0.2           | 60.54        |
| Northern catalpa                                       | 149 (N/A)    |                | 0.2              | 0.2           | 49.80        |
| Alder                                                  | 37 (N/A)     |                | 0.2              | 0.0           | 12.46        |
| Ginkgo                                                 | 7 (N/A)      |                | 0.1              | 0.0           | 3.39         |
| Common chokecherry                                     | 31 (N/A)     |                | 0.1              | 0.0           | 15.48        |
| Japanese maple                                         | 8 (N/A)      |                | 0.1              | 0.0           | 4.23         |
| Conifer Evergreen Medium                               | 12 (N/A)     |                | 0.1              | 0.0           | 12.31        |
| Conifer Evergreen Small                                | 13 (N/A)     |                | 0.1              | 0.0           | 13.37        |
| Sweetgum                                               | 66 (N/A)     |                | 0.1              | 0.1           | 65.59        |
| Hickory                                                | 58 (N/A)     |                | 0.1              | 0.1           | 57.69        |
| Eastern red cedar                                      | 13 (N/A)     |                | 0.1              | 0.0           | 13.37        |
| Apple                                                  | 2 (N/A)      |                | 0.1              | 0.0           | 2.06         |
| Black locust                                           | 31 (N/A)     |                | 0.1              | 0.0           | 31.46        |
| Juniper                                                | 0 (N/A)      |                | 0.1              | 0.0           | 0.00         |
| Northern white cedar                                   | 15 (N/A)     |                | 0.1              | 0.0           | 15.42        |
| Oak                                                    | 58 (N/A)     |                | 0.1              | 0.1           | 57.69        |
| Tulip tree                                             | 67 (N/A)     |                | 0.1              | 0.1           | 66.60        |
| Citywide total                                         | 76,105 (N/A) |                | 100.0            | 100.0         | 53.04        |

**Table 7: Summary of Benefits in Dollars**

| <b>Annual Benefits of Public Trees by Species (\$/tree)</b> |        |                 |             |            |                 |                           |
|-------------------------------------------------------------|--------|-----------------|-------------|------------|-----------------|---------------------------|
| 4/23/2020                                                   |        |                 |             |            |                 |                           |
| Species                                                     | Energy | CO <sub>2</sub> | Air Quality | Stormwater | Aesthetic/Other | Total (\$) Standard Error |
| Norway maple                                                | 59.25  | 5.42            | 10.85       | 74.83      | 29.35           | 179.71 (N/A)              |
| Northern pin oak                                            | 70.10  | 3.94            | 13.39       | 99.96      | 5.58            | 192.97 (N/A)              |
| Silver maple                                                | 69.55  | 14.70           | 13.19       | 139.51     | 112.95          | 349.89 (N/A)              |
| Green ash                                                   | 68.98  | 9.36            | 12.56       | 109.39     | 60.49           | 260.78 (N/A)              |
| Sugar maple                                                 | 59.85  | 8.28            | 9.77        | 93.55      | 69.72           | 241.17 (N/A)              |
| Red maple                                                   | 48.29  | 6.34            | 8.90        | 54.14      | 60.41           | 178.08 (N/A)              |
| BroadleafDeciduou                                           | 31.36  | 3.53            | 5.16        | 29.67      | 26.10           | 95.82 (N/A)               |
| Honeylocust                                                 | 60.77  | 9.76            | 10.17       | 84.63      | 195.37          | 360.70 (N/A)              |
| Pear                                                        | 23.93  | 2.53            | 3.92        | 12.64      | 10.18           | 53.20 (N/A)               |
| Northern red oak                                            | 45.03  | 3.10            | 6.27        | 63.41      | 8.62            | 126.42 (N/A)              |
| American basswood                                           | 65.86  | 11.10           | 10.20       | 97.17      | 74.43           | 258.76 (N/A)              |
| White ash                                                   | 71.75  | 10.54           | 15.05       | 120.15     | 93.88           | 311.38 (N/A)              |
| American sycamore                                           | 82.08  | 9.99            | 16.47       | 156.08     | 57.09           | 321.71 (N/A)              |
| Norway spruce                                               | 19.70  | 1.77            | 1.07        | 44.41      | 19.76           | 86.70 (N/A)               |
| BroadleafDeciduou                                           | 4.64   | 0.47            | 0.62        | 1.64       | 1.58            | 8.96 (N/A)                |
| Eastern redbud                                              | 17.07  | 1.67            | 2.72        | 8.48       | 6.03            | 35.97 (N/A)               |
| White oak                                                   | 46.22  | 6.40            | 7.66        | 48.63      | 47.88           | 156.80 (N/A)              |
| American elm                                                | 100.67 | 9.88            | 22.36       | 119.91     | 78.12           | 330.94 (N/A)              |
| Swamp white oak                                             | 40.55  | 4.85            | 6.72        | 34.90      | 34.75           | 121.78 (N/A)              |
| Bur oak                                                     | 49.62  | 6.66            | 8.82        | 67.66      | 47.01           | 179.78 (N/A)              |
| Austrian pine                                               | 33.60  | 2.81            | 3.90        | 73.26      | 12.14           | 125.71 (N/A)              |
| River birch                                                 | 29.90  | 3.03            | 5.14        | 28.77      | 19.86           | 86.70 (N/A)               |
| Northern hackberry                                          | 84.14  | 8.49            | 16.06       | 121.55     | 65.16           | 295.39 (N/A)              |
| Southern magnolia                                           | 46.24  | 4.35            | 6.01        | 64.00      | 35.34           | 155.94 (N/A)              |
| Littleleaf linden                                           | 44.79  | 5.49            | 7.80        | 65.00      | 44.13           | 167.20 (N/A)              |
| Black maple                                                 | 52.17  | 7.12            | 9.62        | 59.24      | 69.83           | 197.98 (N/A)              |
| Boxelder                                                    | 23.31  | 2.97            | 3.61        | 21.78      | 28.31           | 79.98 (N/A)               |
| Pin oak                                                     | 50.04  | 4.08            | 6.58        | 73.71      | 21.03           | 155.44 (N/A)              |
| Bluespruce                                                  | 10.41  | 0.74            | 1.08        | 13.99      | 15.73           | 41.96 (N/A)               |
| Chinese elm                                                 | 55.66  | 6.64            | 10.59       | 80.10      | 43.55           | 196.54 (N/A)              |
| Black spruce                                                | 18.86  | 1.65            | 2.16        | 37.39      | 12.81           | 72.87 (N/A)               |
| BroadleafDeciduou                                           | 61.76  | 8.17            | 11.53       | 101.60     | 52.99           | 236.05 (N/A)              |
| Eastern white pine                                          | 34.66  | 2.13            | -0.48       | 104.01     | 8.08            | 148.41 (N/A)              |
| Ohio buckeye                                                | 66.79  | 5.43            | 12.44       | 90.41      | 24.84           | 199.90 (N/A)              |
| Black walnut                                                | 73.09  | 9.60            | 13.62       | 124.41     | 60.54           | 281.26 (N/A)              |
| Northern catalpa                                            | 48.59  | 6.74            | 8.06        | 49.88      | 49.80           | 163.07 (N/A)              |
| Alder                                                       | 31.49  | 3.38            | 5.22        | 14.43      | 12.46           | 66.97 (N/A)               |
| Ginkgo                                                      | 32.00  | 1.95            | 5.71        | 29.25      | 3.39            | 72.30 (N/A)               |
| Common chokecherry                                          | 38.13  | 4.20            | 6.56        | 18.06      | 15.48           | 82.43 (N/A)               |
| Japanese maple                                              | 11.80  | 1.15            | 1.63        | 4.51       | 4.23            | 23.32 (N/A)               |
| Conifer Evergreen N                                         | 6.94   | 0.45            | 0.75        | 6.95       | 12.31           | 27.41 (N/A)               |
| Conifer Evergreen S                                         | 3.62   | 0.29            | 0.20        | 4.97       | 13.37           | 22.45 (N/A)               |
| Sweetgum                                                    | 70.91  | 9.97            | 12.48       | 106.85     | 65.59           | 265.81 (N/A)              |
| Hickory                                                     | 57.32  | 7.93            | 9.34        | 70.21      | 57.69           | 202.49 (N/A)              |
| Eastern red cedar                                           | 3.62   | 0.29            | 0.20        | 4.97       | 13.37           | 22.45 (N/A)               |
| Apple                                                       | 5.40   | 0.55            | 0.71        | 1.86       | 2.06            | 10.58 (N/A)               |
| Black locust                                                | 70.84  | 6.27            | 13.58       | 102.01     | 31.46           | 224.17 (N/A)              |
| Juniper                                                     | 24.57  | 1.35            | 2.19        | 44.30      | 0.00            | 72.40 (N/A)               |
| Northern white cedar                                        | 13.58  | 1.08            | 1.48        | 16.14      | 15.42           | 47.70 (N/A)               |
| Oak                                                         | 57.32  | 7.93            | 9.34        | 70.21      | 57.69           | 202.49 (N/A)              |
| Tulip tree                                                  | 82.02  | 11.11           | 15.71       | 148.79     | 66.60           | 324.23 (N/A)              |
| Citywide total                                              | 56.91  | 7.14            | 10.22       | 84.86      | 53.04           | 212.16 (N/A)              |

## Species Distribution of Public Trees

4/23/2020

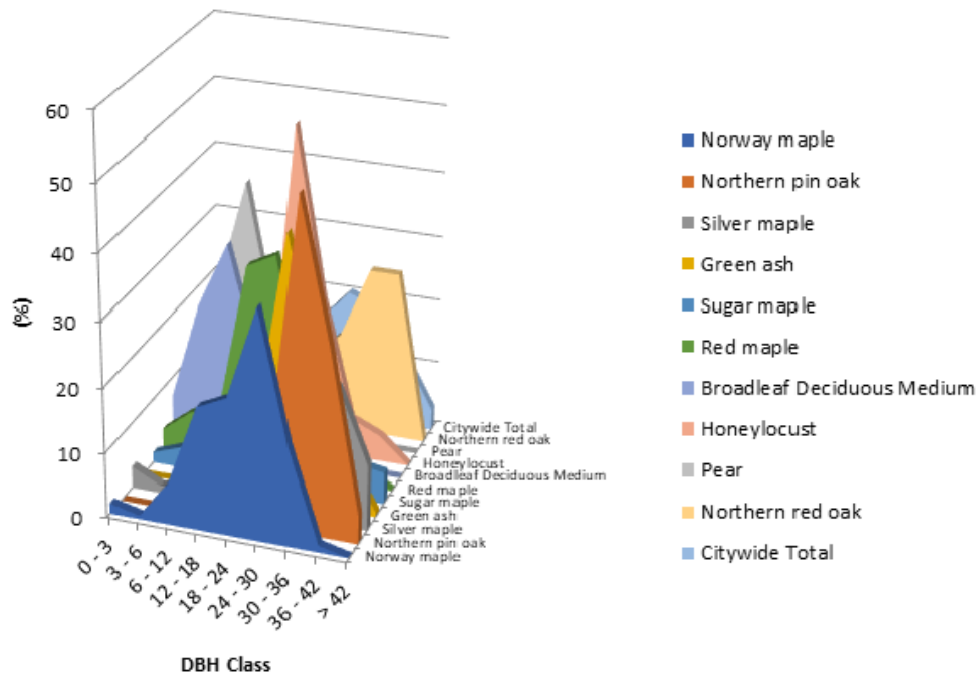


| Species                | Percent |
|------------------------|---------|
| Norway maple           | 12.9    |
| Northern pin oak       | 12.6    |
| Silver maple           | 12.5    |
| Green ash              | 8.9     |
| Sugar maple            | 8.6     |
| Red maple              | 6.0     |
| Broadleaf Deciduous Me | 4.9     |
| Honeylocust            | 3.5     |
| Pear                   | 3.4     |
| Northern red oak       | 3.2     |
| Other Species          | 23.6    |
| Total                  | 100.0   |

Figure 1: Species Distribution

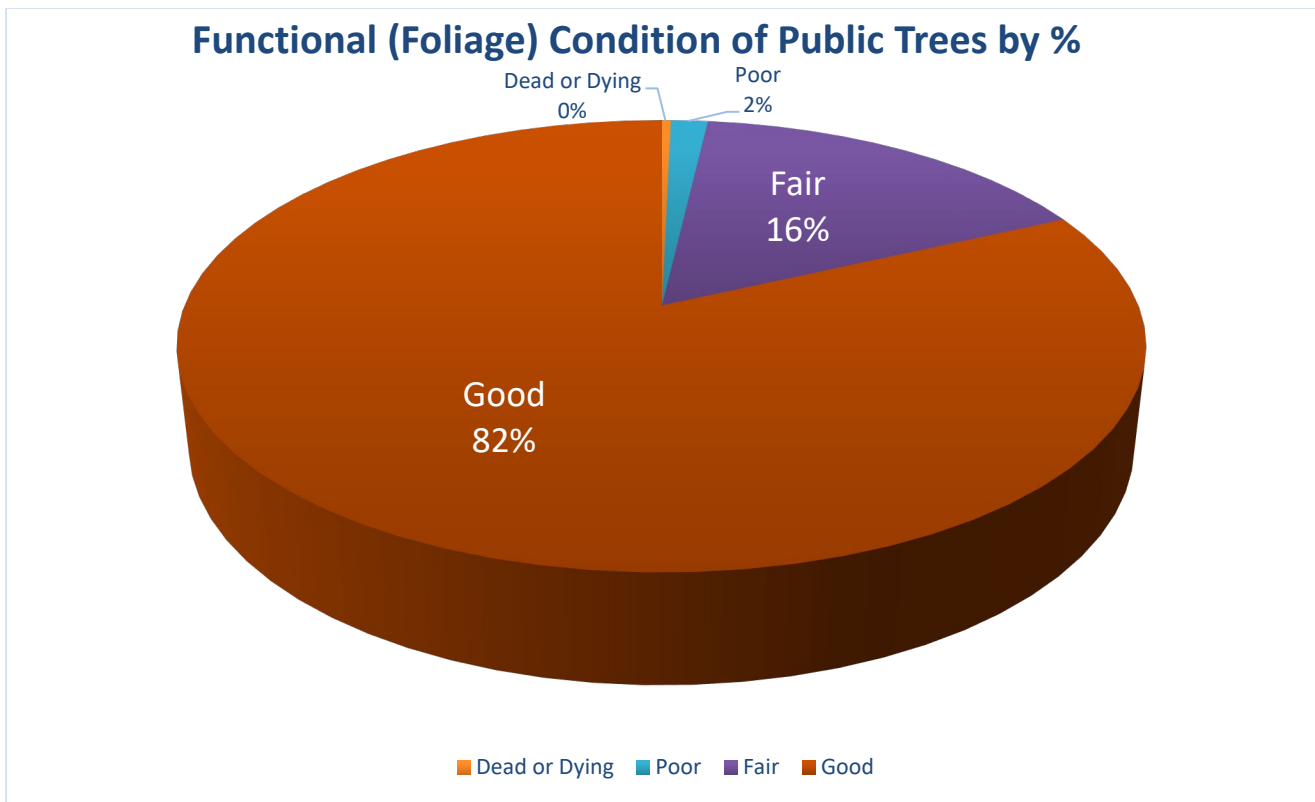
## Relative Age Distribution of Top 10 Public Tree Species for All Zones (%)

4/23/2020

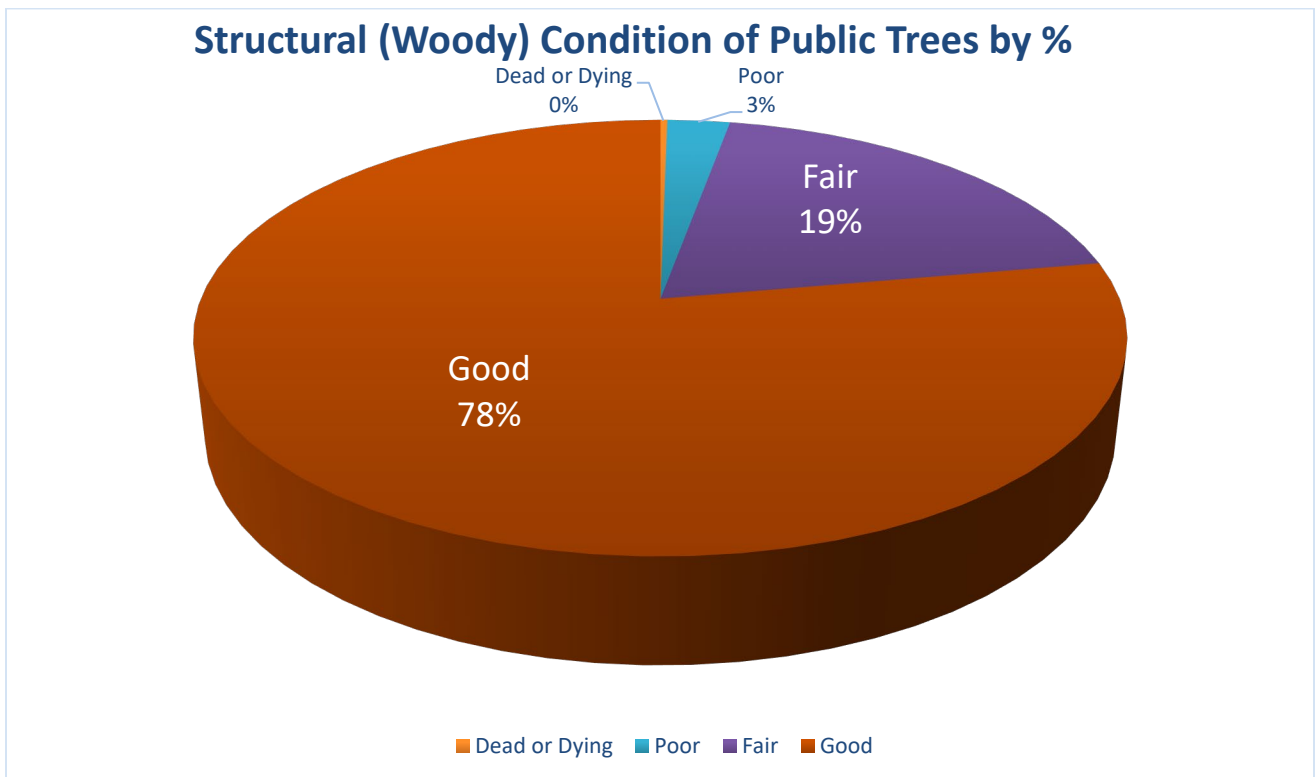


| Species                    | DBH class (in) |       |       |       |       |       |       |       |       |
|----------------------------|----------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                            | 0-3            | 3-6   | 6-12  | 12-18 | 18-24 | 24-30 | 30-36 | 36-42 | > 42  |
| Norway maple               | 1.62           | 0.54  | 6.49  | 18.92 | 21.08 | 35.14 | 15.14 | 1.08  | 0.00  |
| Northern pin oak           | 0.00           | 0.00  | 0.00  | 1.10  | 3.87  | 11.05 | 50.28 | 29.28 | 4.42  |
| Silver maple               | 3.35           | 1.12  | 2.23  | 8.38  | 11.73 | 18.44 | 23.46 | 21.23 | 10.06 |
| Green ash                  | 0.00           | 0.00  | 3.15  | 11.02 | 13.39 | 40.94 | 22.05 | 8.66  | 0.79  |
| Sugar maple                | 1.63           | 3.25  | 8.13  | 14.63 | 10.57 | 34.96 | 16.26 | 5.69  | 4.88  |
| Red maple                  | 3.49           | 6.98  | 8.14  | 31.40 | 33.72 | 10.47 | 3.49  | 2.33  | 0.00  |
| Broadleaf Deciduous Medium | 7.04           | 22.54 | 32.39 | 15.49 | 15.49 | 5.63  | 1.41  | 0.00  | 0.00  |
| Honeylocust                | 4.00           | 8.00  | 0.00  | 4.00  | 50.00 | 24.00 | 6.00  | 4.00  | 0.00  |
| Pear                       | 2.04           | 22.45 | 38.78 | 16.33 | 16.33 | 4.08  | 0.00  | 0.00  | 0.00  |
| Northern red oak           | 8.70           | 6.52  | 2.17  | 4.35  | 10.87 | 15.22 | 26.09 | 26.09 | 0.00  |
| Citywide Total             | 3.07           | 5.57  | 8.50  | 14.08 | 15.40 | 20.28 | 18.40 | 11.36 | 3.34  |

Figure 2: Relative Age Class



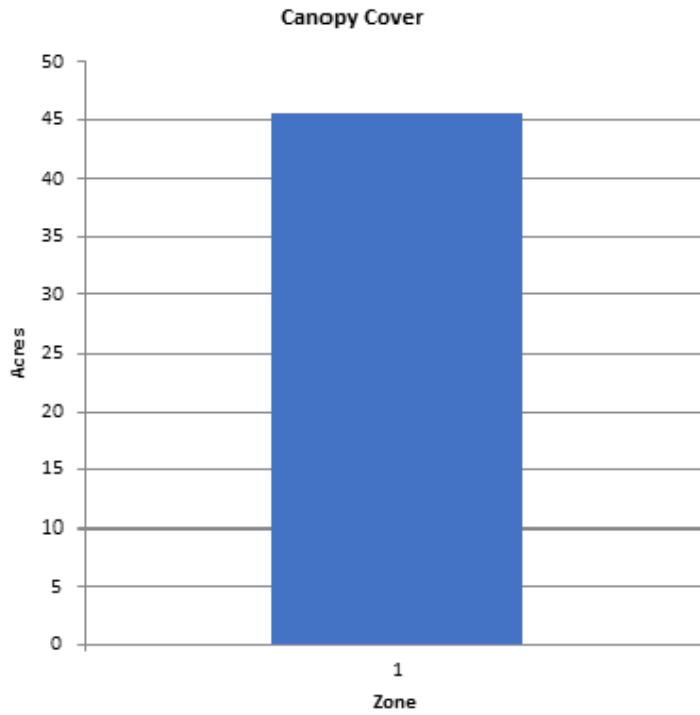
**Figure 3: Foliage Condition**



**Figure 4: Wood Condition**

## Canopy Cover of Public Trees (Acres)

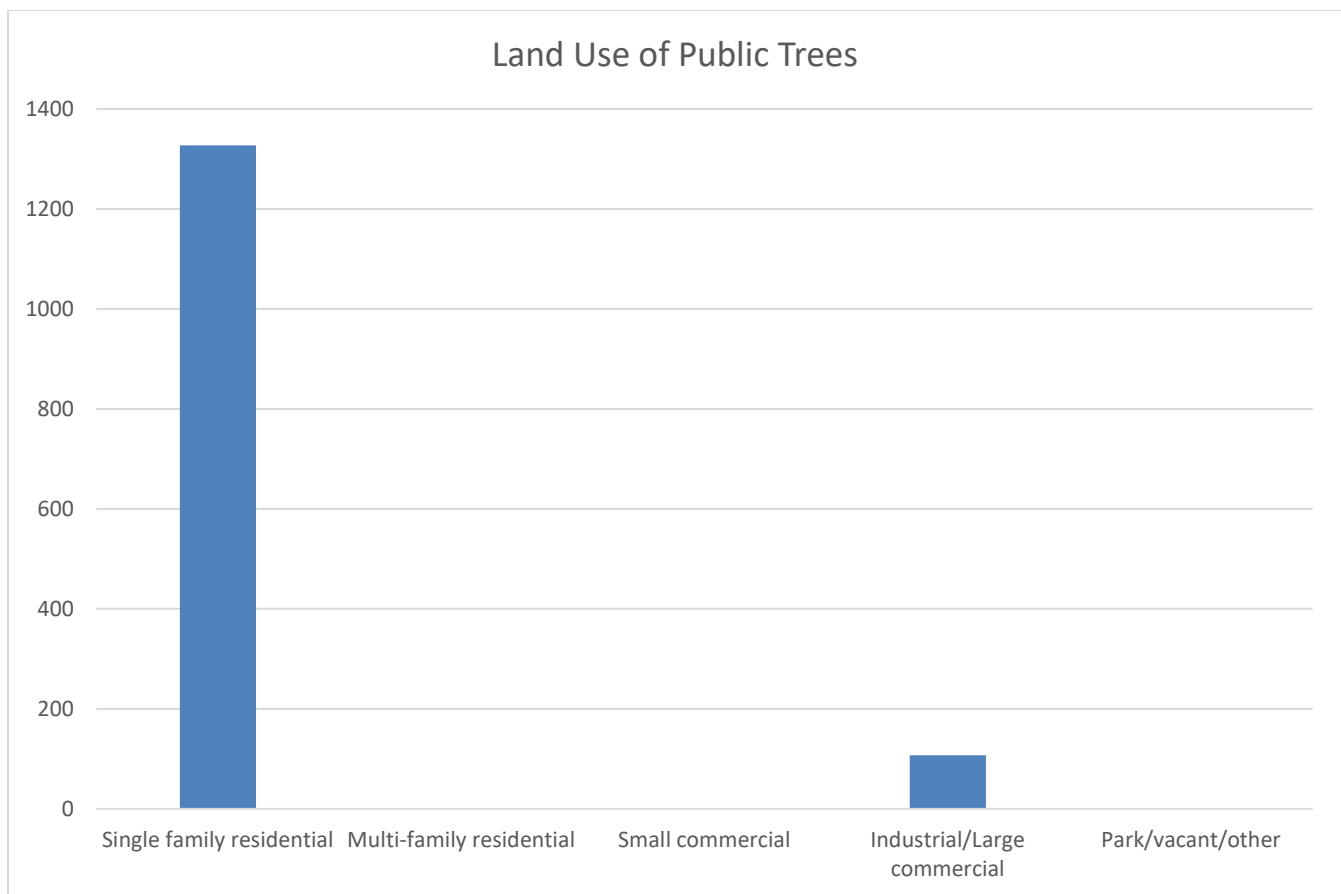
4/23/2020



| Zone           | Acres | % of Total Canopy Cover |
|----------------|-------|-------------------------|
| 1              | 46    | 100.0                   |
| Citywide total | 46    | 100.0                   |

|                | Total Land Area | Total Street and Sidewalk Area | Total Canopy Cover | Canopy Cover as % of Total Land Area | Canopy Cover as % of Total Streets and Sidewalks |
|----------------|-----------------|--------------------------------|--------------------|--------------------------------------|--------------------------------------------------|
| Citywide Total | 0               | 0                              | 46                 | 0.00                                 | 0.00                                             |

Figure 5: Canopy Cover in Acres



**Figure 6: Land Use of city/park trees**

## Appendix B: ArcGIS Mapping

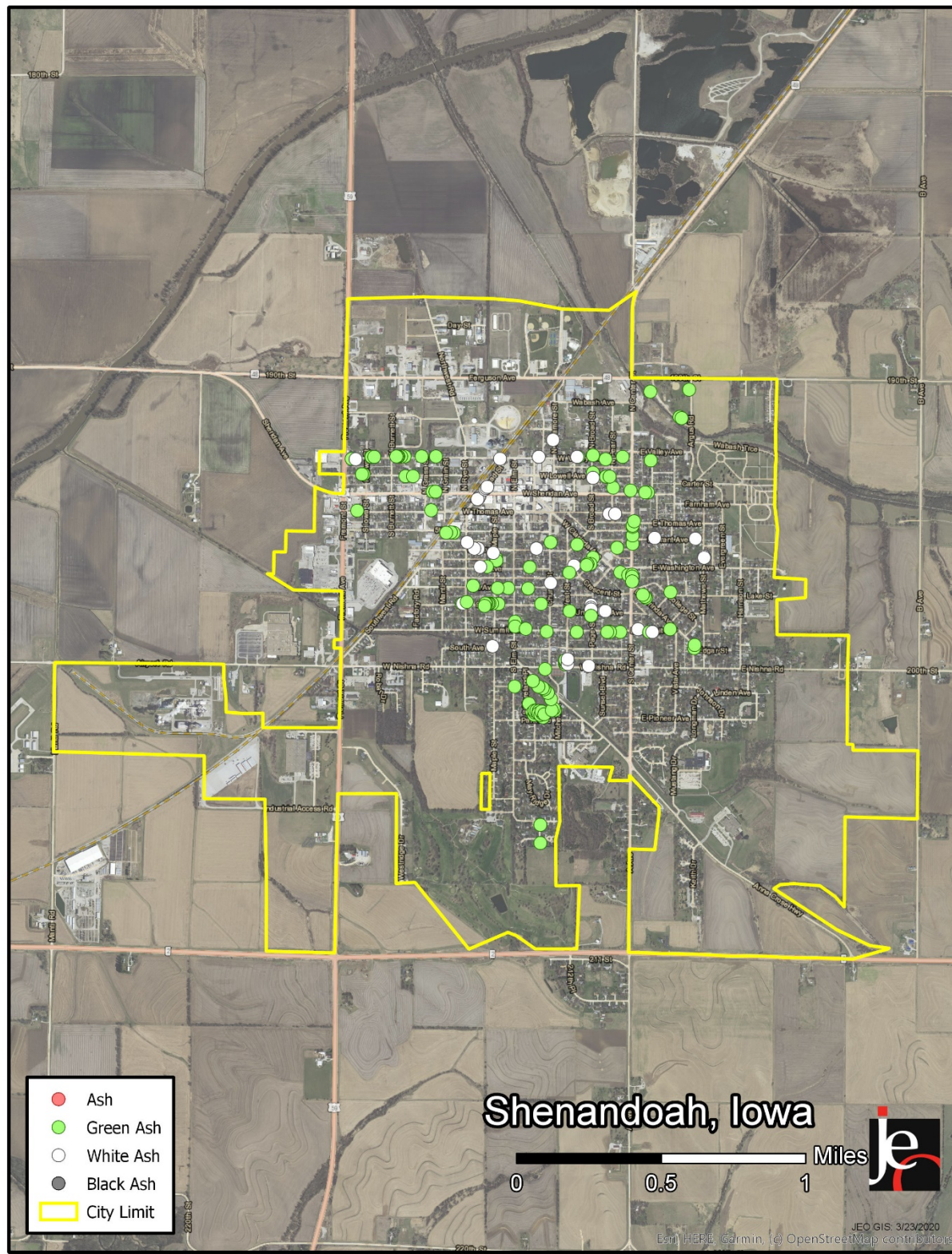
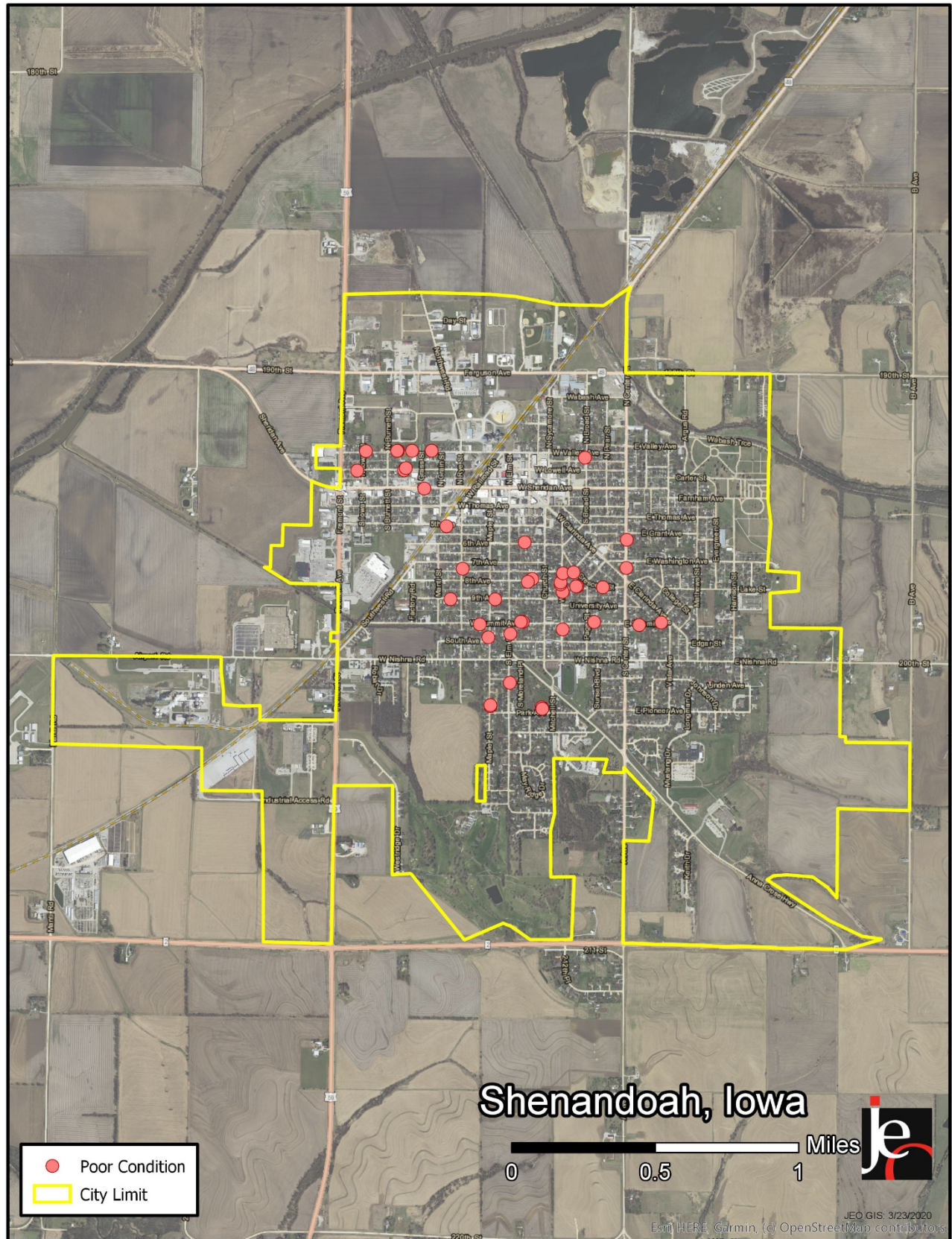
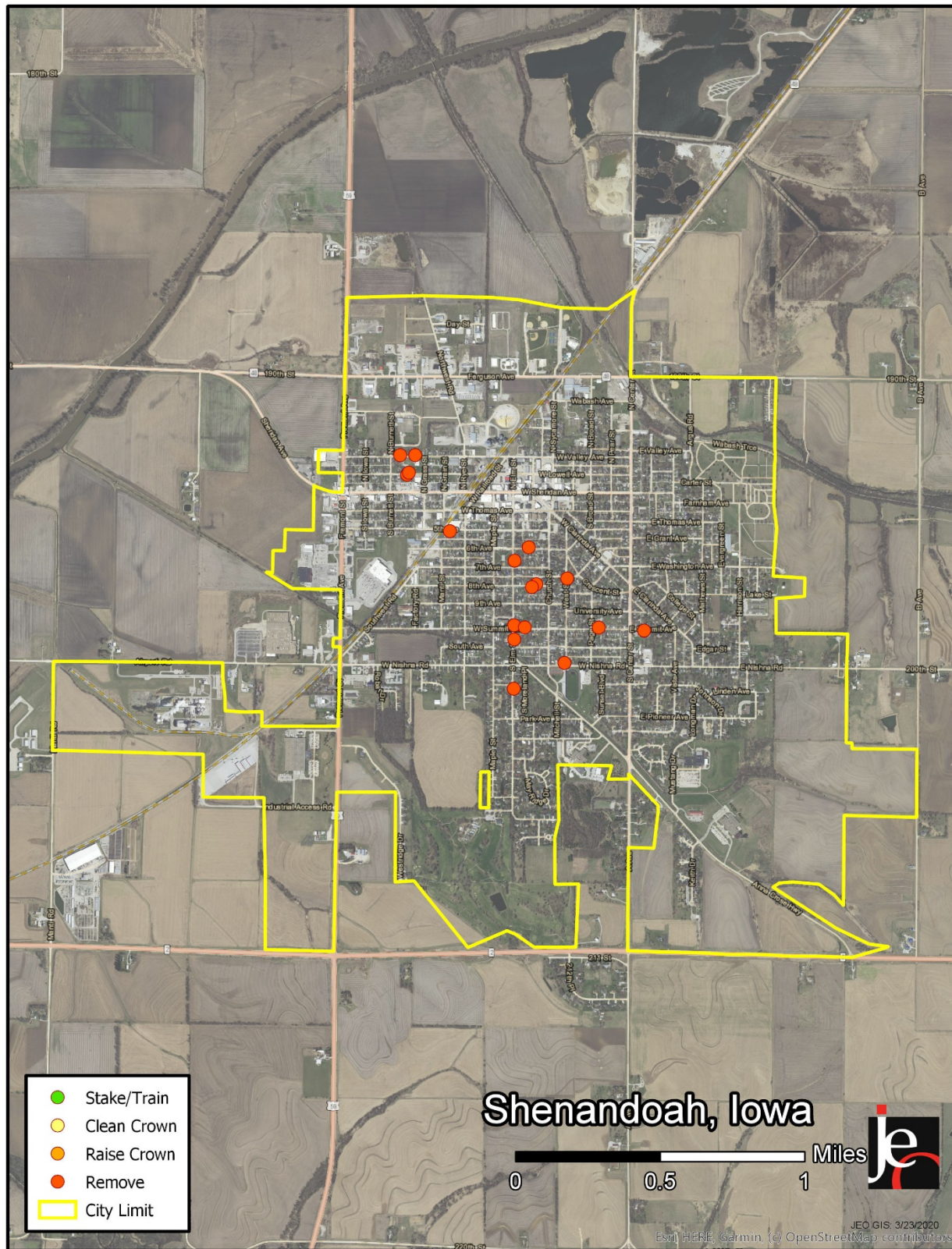


Figure 1: Location of Ash Trees





**Figure 3: Location of Poor Condition Trees**



**Figure 4: Location of Trees with Recommended Maintenance** \*City ownership of the trees recommended for removal should be verified prior to any removal\*

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