# Lester, IA


2020 Urban Forest Management Plan
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# Executive Summary

### Overview

This plan was developed to assist the City of Lester with managing its urban forest, including budgeting and future planning. Trees can provide a multitude of benefits to the community, and sound management allows a community to best take advantage of these benefits. Management is especially important considering the serious threats posed by forest pests such as 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 (this does not include mountain ash). There is a strong possibility that 36% of Lester's city owned trees (ash) will die once EAB becomes established in the community, unless preventative treatment is used. 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 2018, a tree inventory was conducted 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 363 trees inventoried.

- Lester's trees provide $58,652 of benefits annually, an average of $161.58 a tree.
- There were over 25 species of trees inventoried, from 17 different genus.
- The top three genera are: Ash 36%, Spruce 22%, and Maple 18%.
- 13 of the trees inventoried were in need of some type of management other than routine maintenance.
- No data was collected for which trees are recommended for removal or where they are located. Additionally, no data was collected as to the maintenance priority of any given tree.

### Recommendations

The core recommendations are detailed in the Recommendations Section. The Emerald Ash Borer Plan includes management recommendations as well. Below are some key recommendations.

- EAB was not recorded when the inventory was conducted. There are 131 ash trees within Lester and it is likely that some are currently displaying symptoms of EAB. It is recommended that a visual inspection of all ash trees be conducted annually.
- All trees should be pruned on a routine schedule- one sixth of the city every 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 with a visual survey yearly

# Introduction

This plan was developed to assist Lester with the management, budgeting and future planning of their urban forest. Across the state, forestry budgets continue to decrease with more and more of that money spent on 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 or treatment and replacement planting. With proper planning and management of the current canopy in Lester, these costs can be extended over years and public safety issues from dead and dying ash trees mitigated.

Trees are an important component of Lester's infrastructure and one of the greatest assets to the community. The benefits of trees are immense. Trees provide the community with improved air quality, stormwater runoff interception, energy conservation, lower traffic speeds, increased property values, reduced crime, improved mental health and create a desirable place to live, to name just a few benefits. It is essential that these benefits be maintained for the people of Lester and future generations through good urban forestry management.

Good urban forestry management involves setting goals and developing management strategies to achieve these goals. An essential part of developing management strategies is a comprehensive public tree inventory. The inventory supplies information that will be used for maintenance, removal schedules, tree planting and budgeting. Basing actions on this information will help meet Lester's urban forestry goals.

# Inventory

In 2018, a tree inventory was conducted that included 100% of the city owned trees on both streets and parks. The tree data was collected 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 programming used to collect tree information on the data collectors 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, signs and symptoms associated with EAB were noted for all ash trees. The signs and symptoms noted were canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

# Inventory Results

The data collected for the 363 city trees was entered into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management as part of the i-Tree suite. The following are results from the i-Tree STREETS analysis.

# Annual Benefits

**Annual Energy Benefits**

Trees conserve energy by shading buildings and blocking winds. Lester's trees reduce energy related costs by approximately $15,183 annually (Appendix A, Table 1). These savings are both in Electricity (72.7 MWh) and in Natural Gas (9,860 Therms).

### Annual Stormwater Benefits

Lester's trees intercept about 762,465 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $20,663 of benefits 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 emitting volatile organic matter (ozone). In Lester, it is estimated that trees remove 909 lbs of air pollution (ozone ($O_3$), particulate matter less than 10 microns (PM10), carbon monoxide (CO), nitrogen dioxide ($NO_2$), and sulfur dioxide ($SO_2$)) per year with a net value of $2,554 (Appendix A, Table 3).

### Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Lester, trees sequester about 173,377 lbs of carbon a year with an associated value of $2,119 (Appendix A, Table 5). In addition, the trees store 2,503,409 lbs of carbon, with a yearly benefit of $18,776 (Appendix A, Table 4).

### Annual Aesthetics Benefits

Social benefits of trees are hard to capture. The 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. Lester receives $18,133 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, Lester's trees provide $58,652 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 363 trees in Lester provide approximately $161.58 annually (Appendix A, Table 7).

## Forest Structure

### Species Distribution

Lester has at least 17 different tree genera along city streets and parks (Appendix A, Figure 1).
The distribution of trees by genera is as follows:

| Genus | Count | Percent |
|---|---|---|
| Ash | 131 | 36% |
| Spruce | 79 | 22% |
| Maple | 65 | 18% |
| Hackberry | 34 | 9% |
| Honeylocust | 16 | 4% |
| Basswood | 12 | 3% |
| Elm | 6 | 2% |
| Mulberry | 5 | 1% |
| Oak | 4 | 1% |
| Apple | 3 | 1% |

| | | |
|---|---|---|
| Cottonwood | 2 | 1% |
| Corktree | 1 | 0% |
| Walnut | 1 | 0% |
| Boxelder | 1 | 0% |
| Cherry | 1 | 0% |
| Kentucky Coffee Tree | 1 | 0% |
| Catalpa | 1 | 0% |

## Age Class

Most of Lester's trees (45%) are between 6 and 18 inches in diameter at 4.5 ft (Appendix A, Figure 2). For age, it is preferred that the highest amounts of trees are in the smallest size categories (a downward slope) to prepare for natural mortality and to maintain canopy cover; in Lester, 15% of the trees inventoried had a diameter of less than 6 inches at 4.5 ft. This indicates that Lester'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 overall health of the urban forest. The foliage condition results for Lester indicate that 55% of the trees are in good health, with only 7% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 55% of Lester's trees are in good health for wood condition (appendix A, Figure 4 & Appendix B, Figure 3). Wood condition that is in poor health, dead or dying is about 7% of the population. This 7% 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).

## Canopy Cover

The total canopy with both private and public trees is 2%, or 28.65 acres. The canopy cover included in the Lester inventory includes approximately 8 acres of canopy, or 1% of the total land area of Lester (Appendix A, Figure 4). The City's Canopy goal is to increase canopy by 3%, in 30 years. To achieve this goal it is estimated that 85 trees need to be planted annually on public and private lands.

## Land Use and Location

The majority of Lester's city and park trees are in planting strips in single family residential neighborhoods (Appendix A, Figure 6 & Appendix A, Figure7). The following describes the land use and locations for the street and park trees.

| **Land Use** | **Count** | **Percent** |
|---|---|---|
| Park/Vacant/Other | 245 | 67% |
| Single family res. | 99 | 27% |
| Small commercial | 19 | 5% |

| **Location** | **Count** | **Percent** |
|---|---|---|
| Other maintained | 252 | 69% |

| | | |
|---|---|---|
| Planting Strip | 103 | 28% |
| Front Yard | 4 | 1% |
| Cutout | 2 | 1% |
| Other un-maintained | 2 | 1% |

# Recommendations

## Risk Management

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

Hazardous trees

Detailed information was not collected on which trees are potentially hazardous or where they might be located.

Poor tree species

The data collectors did not collect appropriate data on this, however it was noted that 131 trees in Lester are ash trees, which is 36% of the total trees inventoried. While the collectors did not gather data on EAB, it is common though out the region and very likely affecting many of the ash trees in Lester. Visual inspections of ash trees should be conducted annually in order track their conditions. Treatment for EAB is an effective preventative measure that can be taken to prevent the death of healthy ash trees. It is not recommended to be used on ash trees already displaying two or more symptoms of EAB. Since data for EAB was not collected, we will present two separate scenarios regarding ash management versus removal. If all 131 ash trees in Lester are healthy and could be treated, it would cost an estimated $288.15 every two years, which is an average of $288.15 per tree. If all 131 ash trees in Lester are suffering from EAB, it would cost an estimated $104,800 to remove them, which is an average of $800 per tree. These scenarios represent two different extremes and while it is likely that many ash trees within Lester are displaying signs of EAB, it is also likely that many are not and would therefore be eligible for treatment. It is recommended that Lester treat many of its larger, healthier ash trees and begin removing dead or dying ash trees, as well as those found to be displaying 2 or more symptoms of EAB.

## 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 is the removal of lower branches that are 2 inches in diameter or larger in the case of providing clearance for pedestrians or vehicles. Crown reduction is removing individual limbs from structures or utility wires. It is recommended that all trees be pruned on a routine schedule every five to seven years. Please refer to the six year maintenance plan for further information.

### Planting

Most of the planting over the next 5 years will replace the trees that are removed. It is recommended to plant 1.2 trees for every tree removed, since survival rates will not be 100%. Please refer to the six year maintenance plan at the end of this section. 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 Lester.

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 Ash (36%) (Appendix A, Figure 1). Ash have not been recommended since 2002 and new ash trees should not be planted due to the threat that EAB poses to their long-term survival. Due to the high percentage of ash present though out Lester, the city should consider accelerating the planting of new trees to prepare for a significant loss of canopy that EAB could cause. Some species to avoid because they are public nuisances include: cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut, as outlined Lester's city ordinance (Appendix C). All trees planted must abide by any restrictions in Lester's city ordinance (Appendix C).

### Continual Monitoring

Due to the threat of EAB, it is important to continuously check the health of ash trees. It is recommended 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

### Ash Tree Removal

Tree removal will be prioritized with dead, dying, hazardous trees to be removed first (Appendix B, Figure 4). Next will be all ash in poor condition and displaying signs and symptoms of EAB (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 effective tool for communities to spread removal costs out over several years while allowing trees to continue to provide 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. Wood waste can be disposed of as you normally would if your county is not part of a quarantine.

### Canopy Replacement

As budget permits, all removed trees will be replaced. All trees must meet any restrictions in Lester's city ordinance (Appendix C). The new plantings should be a diverse mix of trees that should not include ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow, black walnut, or any tree specifically prohibited by Lester's city ordinances.

### 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 the following signs and symptoms: 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.

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# Appendix A: i-Tree Data

**Table 1: Annual Energy Benefits**

**Lester**

**Annual Energy Benefits of Public Trees**

6/18/2020

| Species | Total Electricity (MWh) | Electricity ($) | Total Natural Gas (Therms) | Natural Gas ($) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|
| Green ash | 32.4 | 2,458 | 4,346.2 | 4,259 | 6,717 | (N/A) | 36.1 | 44.2 | 51.28 |
| Blue spruce | 4.4 | 335 | 613.8 | 601 | 937 | (N/A) | 21.2 | 6.2 | 12.17 |
| Silver maple | 14.2 | 1,074 | 1,850.5 | 1,813 | 2,888 | (N/A) | 12.4 | 19.0 | 64.17 |
| Northern hackberry | 7.6 | 577 | 1,106.4 | 1,084 | 1,661 | (N/A) | 9.4 | 10.9 | 48.85 |
| Honeylocust | 4.8 | 367 | 649.5 | 636 | 1,003 | (N/A) | 4.4 | 6.6 | 62.71 |
| Norway maple | 1.8 | 140 | 275.4 | 270 | 410 | (N/A) | 3.0 | 2.7 | 37.23 |
| Littleleaf linden | 0.8 | 62 | 97.4 | 95 | 157 | (N/A) | 2.2 | 1.0 | 19.64 |
| Sugar maple | 0.9 | 68 | 122.9 | 120 | 189 | (N/A) | 1.7 | 1.2 | 31.44 |
| Mulberry | 0.2 | 19 | 42.9 | 42 | 61 | (N/A) | 1.4 | 0.4 | 12.17 |
| Northern red oak | 0.7 | 54 | 101.1 | 99 | 153 | (N/A) | 1.1 | 1.0 | 38.17 |
| American basswood | 1.0 | 78 | 141.6 | 139 | 217 | (N/A) | 1.1 | 1.4 | 54.28 |
| Apple | 0.2 | 16 | 29.1 | 29 | 44 | (N/A) | 0.8 | 0.3 | 14.80 |
| Siberian elm | 1.1 | 85 | 142.3 | 139 | 225 | (N/A) | 0.8 | 1.5 | 74.95 |
| Red maple | 0.2 | 17 | 33.0 | 32 | 49 | (N/A) | 0.6 | 0.3 | 24.58 |
| Norway spruce | 0.1 | 9 | 19.0 | 19 | 27 | (N/A) | 0.6 | 0.2 | 13.58 |
| Cottonwood | 0.2 | 14 | 27.5 | 27 | 41 | (N/A) | 0.6 | 0.3 | 20.64 |
| Elm | 0.7 | 53 | 97.1 | 95 | 148 | (N/A) | 0.6 | 1.0 | 74.17 |
| Common chokecherry | 0.0 | 2 | 3.8 | 4 | 5 | (N/A) | 0.3 | 0.0 | 5.40 |
| American elm | 0.1 | 6 | 11.7 | 11 | 18 | (N/A) | 0.3 | 0.1 | 17.66 |
| Black walnut | 0.1 | 7 | 13.7 | 13 | 21 | (N/A) | 0.3 | 0.1 | 20.64 |
| Black maple | 0.3 | 19 | 30.1 | 29 | 49 | (N/A) | 0.3 | 0.3 | 48.95 |
| Amur corktree | 0.2 | 18 | 29.5 | 29 | 47 | (N/A) | 0.3 | 0.3 | 46.78 |
| Boxelder | 0.2 | 15 | 23.9 | 23 | 39 | (N/A) | 0.3 | 0.3 | 38.63 |
| Northern catalpa | 0.1 | 7 | 13.7 | 13 | 21 | (N/A) | 0.3 | 0.1 | 20.64 |
| Kentucky coffeetree | 0.3 | 20 | 38.1 | 37 | 57 | (N/A) | 0.3 | 0.4 | 57.32 |
| Total | 72.7 | 5,520 | 9,860.0 | 9,663 | 15,183 | (N/A) | 100.0 | 100.0 | 41.83 |

**Table 2: Annual Stormwater Benefits**

Lester

## Annual Stormwater Benefits of Public Trees

6/18/2020

| Species | Total rainfall interception (Gal) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|
| Green ash | 318,875 | 8,642 | (N/A) | 36.1 | 41.8 | 65.97 |
| Blue spruce | 57,090 | 1,547 | (N/A) | 21.2 | 7.5 | 20.09 |
| Silver maple | 199,003 | 5,393 | (N/A) | 12.4 | 26.1 | 119.84 |
| Northern hackberry | 58,425 | 1,583 | (N/A) | 9.4 | 7.7 | 46.57 |
| Honeylocust | 49,477 | 1,341 | (N/A) | 4.4 | 6.5 | 83.80 |
| Norway maple | 15,281 | 414 | (N/A) | 3.0 | 2.0 | 37.65 |
| Littleleaf linden | 5,066 | 137 | (N/A) | 2.2 | 0.7 | 17.16 |
| Sugar maple | 6,019 | 163 | (N/A) | 1.7 | 0.8 | 27.19 |
| Mulberry | 870 | 24 | (N/A) | 1.4 | 0.1 | 4.71 |
| Northern red oak | 7,118 | 193 | (N/A) | 1.1 | 0.9 | 48.22 |
| American basswood | 8,947 | 242 | (N/A) | 1.1 | 1.2 | 60.61 |
| Apple | 743 | 20 | (N/A) | 0.8 | 0.1 | 6.71 |
| Siberian elm | 13,289 | 360 | (N/A) | 0.8 | 1.7 | 120.05 |
| Red maple | 1,251 | 34 | (N/A) | 0.6 | 0.2 | 16.95 |
| Norway spruce | 1,191 | 32 | (N/A) | 0.6 | 0.2 | 16.14 |
| Cottonwood | 1,216 | 33 | (N/A) | 0.6 | 0.2 | 16.47 |
| Elm | 9,830 | 266 | (N/A) | 0.6 | 1.3 | 133.19 |
| Common chokecherry | 69 | 2 | (N/A) | 0.3 | 0.0 | 1.86 |
| American elm | 432 | 12 | (N/A) | 0.3 | 0.1 | 11.72 |
| Black walnut | 608 | 16 | (N/A) | 0.3 | 0.1 | 16.47 |
| Black maple | 1,604 | 43 | (N/A) | 0.3 | 0.2 | 43.46 |
| Amur corktree | 1,409 | 38 | (N/A) | 0.3 | 0.2 | 38.19 |
| Boxelder | 1,456 | 39 | (N/A) | 0.3 | 0.2 | 39.46 |
| Northern catalpa | 608 | 16 | (N/A) | 0.3 | 0.1 | 16.47 |
| Kentucky coffeetree | 2,591 | 70 | (N/A) | 0.3 | 0.3 | 70.21 |
| Citywide total | 762,465 | 20,663 | (N/A) | 100.0 | 100.0 | 56.92 |

## Table 3: Annual Air Quality Benefits

**Lester**

**Annual Air Quality Benefits of Public Trees**

6/18/2020

| Species | Deposition (lb) $O_3$ | $NO_2$ | $PM_{10}$ | $SO_2$ | Total Depos. ($) | Avoided (lb) $NO_2$ | $PM_{10}$ | VOC | $SO_2$ | Total Avoided ($) | BVOC Emissions (lb) | BVOC Emissions ($) | Total (lb) | Total ($) | Standard Error | % of Total Trees | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Green ash | 36.3 | 5.8 | 18.0 | 1.6 | 195 | 153.8 | 22.5 | 21.4 | 146.8 | 960 | 0.0 | 0 | 406.2 | 1,155 | (N/A) | 36.1 | 8.82 |
| Blue spruce | 7.2 | 1.4 | 6.2 | 0.9 | 48 | 21.1 | 3.1 | 2.9 | 20.0 | 132 | -20.1 | -75 | 42.6 | 104 | (N/A) | 21.2 | 1.35 |
| Silver maple | 33.5 | 5.7 | 16.5 | 1.5 | 181 | 66.6 | 9.8 | 9.3 | 64.0 | 417 | -17.5 | -66 | 189.5 | 532 | (N/A) | 12.4 | 11.83 |
| Northern hackberry | 7.4 | 1.3 | 4.1 | 0.3 | 41 | 36.9 | 5.3 | 5.1 | 34.5 | 228 | 0.0 | 0 | 94.9 | 270 | (N/A) | 9.4 | 7.94 |
| Honeylocust | 9.5 | 1.6 | 4.4 | 0.4 | 50 | 22.9 | 3.3 | 3.2 | 21.9 | 143 | -7.1 | -27 | 60.1 | 167 | (N/A) | 4.4 | 10.42 |
| Norway maple | 2.8 | 0.5 | 1.4 | 0.1 | 15 | 9.0 | 1.3 | 1.2 | 8.3 | 56 | -0.7 | -3 | 24.0 | 68 | (N/A) | 3.0 | 6.21 |
| Littleleaf linden | 0.6 | 0.1 | 0.3 | 0.0 | 4 | 3.8 | 0.6 | 0.5 | 3.7 | 24 | -0.4 | -1 | 9.3 | 26 | (N/A) | 2.2 | 3.25 |
| Sugar maple | 0.5 | 0.1 | 0.3 | 0.0 | 3 | 4.3 | 0.6 | 0.6 | 4.1 | 27 | -0.5 | -2 | 10.1 | 28 | (N/A) | 1.7 | 4.67 |
| Mulberry | 0.1 | 0.0 | 0.1 | 0.0 | 1 | 1.3 | 0.2 | 0.2 | 1.1 | 8 | 0.0 | 0 | 3.0 | 8 | (N/A) | 1.4 | 1.69 |
| Northern red oak | 1.5 | 0.3 | 0.7 | 0.1 | 8 | 3.4 | 0.5 | 0.5 | 3.2 | 21 | -2.1 | -8 | 7.9 | 21 | (N/A) | 1.1 | 5.27 |
| American basswood | 1.0 | 0.2 | 0.5 | 0.0 | 6 | 4.9 | 0.7 | 0.7 | 4.7 | 31 | -0.9 | -4 | 11.9 | 33 | (N/A) | 1.1 | 8.24 |
| Apple | 0.2 | 0.0 | 0.1 | 0.0 | 1 | 1.0 | 0.1 | 0.1 | 0.9 | 6 | 0.0 | 0 | 2.6 | 7 | (N/A) | 0.8 | 2.46 |
| Siberian elm | 2.6 | 0.4 | 1.2 | 0.1 | 14 | 5.3 | 0.8 | 0.7 | 5.1 | 33 | 0.0 | 0 | 16.3 | 47 | (N/A) | 0.8 | 15.66 |
| Red maple | 0.2 | 0.0 | 0.1 | 0.0 | 1 | 1.1 | 0.2 | 0.1 | 1.0 | 7 | -0.1 | 0 | 2.6 | 7 | (N/A) | 0.6 | 3.64 |
| Norway spruce | 0.1 | 0.0 | 0.1 | 0.0 | 1 | 0.6 | 0.1 | 0.1 | 0.5 | 3 | -0.3 | -1 | 1.1 | 3 | (N/A) | 0.6 | 1.48 |
| Cottonwood | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.9 | 0.1 | 0.1 | 0.9 | 6 | 0.0 | 0 | 2.1 | 6 | (N/A) | 0.6 | 2.99 |
| Elm | 1.4 | 0.2 | 0.6 | 0.1 | 7 | 3.4 | 0.5 | 0.5 | 3.2 | 21 | 0.0 | 0 | 9.9 | 28 | (N/A) | 0.6 | 14.19 |
| Common chokecherry | 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) | 0.3 | 0.71 |
| American elm | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.4 | 0.1 | 0.1 | 0.4 | 2 | 0.0 | 0 | 0.9 | 3 | (N/A) | 0.3 | 2.54 |
| Black walnut | 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) | 0.3 | 2.99 |
| Black maple | 0.3 | 0.1 | 0.2 | 0.0 | 2 | 1.2 | 0.2 | 0.2 | 1.2 | 7 | -0.1 | 0 | 3.1 | 9 | (N/A) | 0.3 | 8.75 |
| Amur corktree | 0.2 | 0.0 | 0.1 | 0.0 | 1 | 1.1 | 0.2 | 0.2 | 1.1 | 7 | -0.1 | 0 | 2.8 | 8 | (N/A) | 0.3 | 7.92 |
| Boxelder | 0.1 | 0.0 | 0.1 | 0.0 | 1 | 0.9 | 0.1 | 0.1 | 0.9 | 6 | -0.1 | 0 | 2.3 | 6 | (N/A) | 0.3 | 6.37 |
| Northern catalpa | 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) | 0.3 | 2.99 |
| Kentucky coffeetree | 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) | 0.3 | 9.34 |
| Citywide total | 106.1 | 17.8 | 55.4 | 5.3 | 582 | 346.2 | 50.5 | 48.1 | 329.5 | 2,159 | -49.9 | -187 | 909.0 | 2,554 | (N/A) | 100.0 | 7.04 |

**Table 4: Annual Carbon Stored**

Lester

## Stored CO2 Benefits of Public Trees

6/18/2020

| Species | Total Stored CO2 (lbs) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|
| Green ash | 1,187,433 | 8,906 | (N/A) | 36.1 | 47.4 | 67.98 |
| Blue spruce | 46,181 | 346 | (N/A) | 21.2 | 1.8 | 4.50 |
| Silver maple | 751,852 | 5,639 | (N/A) | 12.4 | 30.0 | 125.31 |
| Northern hackberry | 105,588 | 792 | (N/A) | 9.4 | 4.2 | 23.29 |
| Honeylocust | 120,019 | 900 | (N/A) | 4.4 | 4.8 | 56.26 |
| Norway maple | 46,580 | 349 | (N/A) | 3.0 | 1.9 | 31.76 |
| Littleleaf linden | 14,430 | 108 | (N/A) | 2.2 | 0.6 | 13.53 |
| Sugar maple | 15,972 | 120 | (N/A) | 1.7 | 0.6 | 19.97 |
| Mulberry | 2,915 | 22 | (N/A) | 1.4 | 0.1 | 4.37 |
| Northern red oak | 32,527 | 244 | (N/A) | 1.1 | 1.3 | 60.99 |
| American basswood | 37,668 | 283 | (N/A) | 1.1 | 1.5 | 70.63 |
| Apple | 3,229 | 24 | (N/A) | 0.8 | 0.1 | 8.07 |
| Siberian elm | 64,030 | 480 | (N/A) | 0.8 | 2.6 | 160.07 |
| Red maple | 2,201 | 17 | (N/A) | 0.6 | 0.1 | 8.26 |
| Norway spruce | 513 | 4 | (N/A) | 0.6 | 0.0 | 1.93 |
| Cottonwood | 2,069 | 16 | (N/A) | 0.6 | 0.1 | 7.76 |
| Elm | 47,716 | 358 | (N/A) | 0.6 | 1.9 | 178.94 |
| Common chokecherry | 178 | 1 | (N/A) | 0.3 | 0.0 | 1.33 |
| American elm | 908 | 7 | (N/A) | 0.3 | 0.0 | 6.81 |
| Black walnut | 1,035 | 8 | (N/A) | 0.3 | 0.0 | 7.76 |
| Black maple | 3,624 | 27 | (N/A) | 0.3 | 0.1 | 27.18 |
| Amur corktree | 3,624 | 27 | (N/A) | 0.3 | 0.1 | 27.18 |
| Boxelder | 3,624 | 27 | (N/A) | 0.3 | 0.1 | 27.18 |
| Northern catalpa | 1,035 | 8 | (N/A) | 0.3 | 0.0 | 7.76 |
| Kentucky coffeetree | 8,458 | 63 | (N/A) | 0.3 | 0.3 | 63.43 |
| Citywide total | 2,503,409 | 18,776 | (N/A) | 100.0 | 100.0 | 51.72 |

## Table 5: Annual Carbon Sequestered

**Lester**

**Annual CO Benefits of Public Trees**

6/18/2020

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Green ash | 74,114 | 556 | -5,700 | -327 | -45 | 54,321 | 407 | 122,408 | 918 (N/A) | 36.1 | 43.3 | 7.01 |
| Blue spruce | 3,320 | 25 | -222 | -80 | -2 | 7,414 | 56 | 10,433 | 78 (N/A) | 21.2 | 3.7 | 1.02 |
| Silver maple | 57,092 | 428 | -3,610 | -154 | -28 | 23,739 | 178 | 77,067 | 578 (N/A) | 12.4 | 27.3 | 12.84 |
| Northern hackberry | 7,951 | 60 | -507 | -70 | -4 | 12,741 | 96 | 20,115 | 151 (N/A) | 9.4 | 7.1 | 4.44 |
| Honeylocust | 12,826 | 96 | -576 | -40 | -5 | 8,108 | 61 | 20,318 | 152 (N/A) | 4.4 | 7.2 | 9.52 |
| Norway maple | 3,253 | 24 | -225 | -20 | -2 | 3,086 | 23 | 6,094 | 46 (N/A) | 3.0 | 2.2 | 4.16 |
| Littleleaf linden | 2,130 | 16 | -69 | -9 | -1 | 1,362 | 10 | 3,414 | 26 (N/A) | 2.2 | 1.2 | 3.20 |
| Sugar maple | 1,440 | 11 | -77 | -9 | -1 | 1,508 | 11 | 2,861 | 21 (N/A) | 1.7 | 1.0 | 3.58 |
| Mulberry | 388 | 3 | -14 | -4 | 0 | 415 | 3 | 785 | 6 (N/A) | 1.4 | 0.3 | 1.18 |
| Northern red oak | 1,034 | 8 | -156 | -9 | -1 | 1,184 | 9 | 2,053 | 15 (N/A) | 1.1 | 0.7 | 3.85 |
| American basswood | 2,481 | 19 | -181 | -11 | -1 | 1,732 | 13 | 4,021 | 30 (N/A) | 1.1 | 1.4 | 7.54 |
| Apple | 314 | 2 | -16 | -3 | 0 | 351 | 3 | 647 | 5 (N/A) | 0.8 | 0.2 | 1.62 |
| Siberian elm | 2,094 | 16 | -307 | -12 | -2 | 1,888 | 14 | 3,663 | 27 (N/A) | 0.8 | 1.3 | 9.16 |
| Red maple | 331 | 2 | -11 | -2 | 0 | 371 | 3 | 689 | 5 (N/A) | 0.6 | 0.2 | 2.58 |
| Norway spruce | 105 | 1 | -2 | -2 | 0 | 189 | 1 | 289 | 2 (N/A) | 0.6 | 0.1 | 1.08 |
| Cottonwood | 418 | 3 | -10 | -2 | 0 | 318 | 2 | 723 | 5 (N/A) | 0.6 | 0.3 | 2.71 |
| Elm | 1,572 | 12 | -229 | -8 | -2 | 1,176 | 9 | 2,511 | 19 (N/A) | 0.6 | 0.9 | 9.42 |
| Common chokecherry | 38 | 0 | -1 | -1 | 0 | 37 | 0 | 74 | 1 (N/A) | 0.3 | 0.0 | 0.55 |
| American elm | 111 | 1 | -4 | -1 | 0 | 137 | 1 | 242 | 2 (N/A) | 0.3 | 0.1 | 1.82 |
| Black walnut | 209 | 2 | -5 | -1 | 0 | 159 | 1 | 361 | 3 (N/A) | 0.3 | 0.1 | 2.71 |
| Black maple | 483 | 4 | -17 | -2 | 0 | 431 | 3 | 895 | 7 (N/A) | 0.3 | 0.3 | 6.71 |
| Amur corktree | 386 | 3 | -17 | -2 | 0 | 395 | 3 | 762 | 6 (N/A) | 0.3 | 0.3 | 5.71 |
| Boxelder | 418 | 3 | -17 | -2 | 0 | 336 | 3 | 735 | 6 (N/A) | 0.3 | 0.3 | 5.51 |
| Northern catalpa | 209 | 2 | -5 | -1 | 0 | 159 | 1 | 361 | 3 (N/A) | 0.3 | 0.1 | 2.71 |
| Kentucky coffeetree | 660 | 5 | -41 | -3 | 0 | 441 | 3 | 1,058 | 8 (N/A) | 0.3 | 0.4 | 7.93 |
| Citywide total | 173,377 | 1,300 | -12,019 | -775 | -96 | 121,997 | 915 | 282,579 | 2,119 (N/A) | 100.0 | 100.0 | 5.84 |

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

**Lester**

## Annual Aesthetic/Other Benefits of Public Trees

6/18/2020

| Species | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|
| Green ash | 6,554 | (N/A) | 36.1 | 36.1 | 50.03 |
| Blue spruce | 1,090 | (N/A) | 21.2 | 6.0 | 14.15 |
| Silver maple | 4,522 | (N/A) | 12.4 | 24.9 | 100.49 |
| Northern hackberry | 1,335 | (N/A) | 9.4 | 7.4 | 39.26 |
| Honeylocust | 2,889 | (N/A) | 4.4 | 15.9 | 180.57 |
| Norway maple | 330 | (N/A) | 3.0 | 1.8 | 30.04 |
| Littleleaf linden | 231 | (N/A) | 2.2 | 1.3 | 28.91 |
| Sugar maple | 183 | (N/A) | 1.7 | 1.0 | 30.56 |
| Mulberry | 21 | (N/A) | 1.4 | 0.1 | 4.26 |
| Northern red oak | 80 | (N/A) | 1.1 | 0.4 | 20.04 |
| American basswood | 197 | (N/A) | 1.1 | 1.1 | 49.21 |
| Apple | 18 | (N/A) | 0.8 | 0.1 | 5.86 |
| Siberian elm | 137 | (N/A) | 0.8 | 0.8 | 45.57 |
| Red maple | 60 | (N/A) | 0.6 | 0.3 | 29.84 |
| Norway spruce | 31 | (N/A) | 0.6 | 0.2 | 15.42 |
| Cottonwood | 57 | (N/A) | 0.6 | 0.3 | 28.56 |
| Elm | 116 | (N/A) | 0.6 | 0.6 | 58.01 |
| Common chokecherry | 2 | (N/A) | 0.3 | 0.0 | 2.06 |
| American elm | 20 | (N/A) | 0.3 | 0.1 | 19.89 |
| Black walnut | 29 | (N/A) | 0.3 | 0.2 | 28.56 |
| Black maple | 66 | (N/A) | 0.3 | 0.4 | 65.89 |
| Amur corktree | 39 | (N/A) | 0.3 | 0.2 | 39.16 |
| Boxelder | 39 | (N/A) | 0.3 | 0.2 | 39.36 |
| Northern catalpa | 29 | (N/A) | 0.3 | 0.2 | 28.56 |
| Kentucky coffeetree | 58 | (N/A) | 0.3 | 0.3 | 57.69 |
| Citywide total | 18,133 | (N/A) | 100.0 | 100.0 | 49.95 |

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

Lester

## Total Annual Benefits of Public Trees by Species ($)

6/18/2020

| Species | Energy | $CO_2$ | Air Quality | Stormwater | Aesthetic/Other | Total ($) | Standard Error | % of Total $ |
|---|---|---|---|---|---|---|---|---|
| Green ash | 6,717 | 918 | 1,155 | 8,642 | 6,554 | 23,986 | (N/A) | 40.9 |
| Blue spruce | 937 | 78 | 104 | 1,547 | 1,090 | 3,756 | (N/A) | 6.4 |
| Silver maple | 2,888 | 578 | 532 | 5,393 | 4,522 | 13,913 | (N/A) | 23.7 |
| Northern hackberry | 1,661 | 151 | 270 | 1,583 | 1,335 | 5,000 | (N/A) | 8.5 |
| Honeylocust | 1,003 | 152 | 167 | 1,341 | 2,889 | 5,552 | (N/A) | 9.5 |
| Norway maple | 410 | 46 | 68 | 414 | 330 | 1,268 | (N/A) | 2.2 |
| Littleleaf linden | 157 | 26 | 26 | 137 | 231 | 577 | (N/A) | 1.0 |
| Sugar maple | 189 | 21 | 28 | 163 | 183 | 585 | (N/A) | 1.0 |
| Mulberry | 61 | 6 | 8 | 24 | 21 | 120 | (N/A) | 0.2 |
| Northern red oak | 153 | 15 | 21 | 193 | 80 | 462 | (N/A) | 0.8 |
| American basswood | 217 | 30 | 33 | 242 | 197 | 720 | (N/A) | 1.2 |
| Apple | 44 | 5 | 7 | 20 | 18 | 94 | (N/A) | 0.2 |
| Siberian elm | 225 | 27 | 47 | 360 | 137 | 796 | (N/A) | 1.4 |
| Red maple | 49 | 5 | 7 | 34 | 60 | 155 | (N/A) | 0.3 |
| Norway spruce | 27 | 2 | 3 | 32 | 31 | 95 | (N/A) | 0.2 |
| Cottonwood | 41 | 5 | 6 | 33 | 57 | 143 | (N/A) | 0.2 |
| Elm | 148 | 19 | 28 | 266 | 116 | 578 | (N/A) | 1.0 |
| Common chokecherry | 5 | 1 | 1 | 2 | 2 | 11 | (N/A) | 0.0 |
| American elm | 18 | 2 | 3 | 12 | 20 | 54 | (N/A) | 0.1 |
| Black walnut | 21 | 3 | 3 | 16 | 29 | 71 | (N/A) | 0.1 |
| Black maple | 49 | 7 | 9 | 43 | 66 | 174 | (N/A) | 0.3 |
| Amur corktree | 47 | 6 | 8 | 38 | 39 | 138 | (N/A) | 0.2 |
| Boxelder | 39 | 6 | 6 | 39 | 39 | 129 | (N/A) | 0.2 |
| Northern catalpa | 21 | 3 | 3 | 16 | 29 | 71 | (N/A) | 0.1 |
| Kentucky coffeetree | 57 | 8 | 9 | 70 | 58 | 202 | (N/A) | 0.3 |
| Citywide Total | 15,183 | 2,119 | 2,554 | 20,663 | 18,133 | 58,652 | (N/A) | 100.0 |

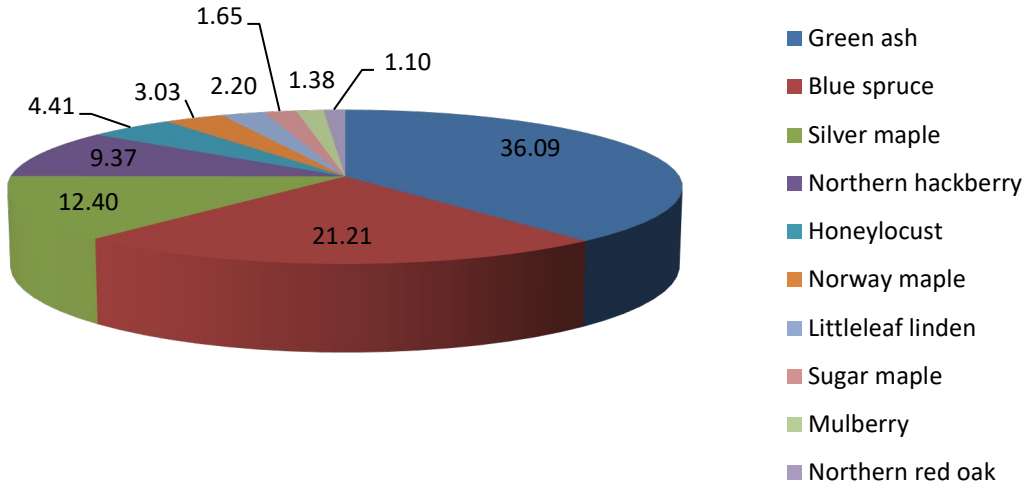


**Figure 1: Species Distribution**

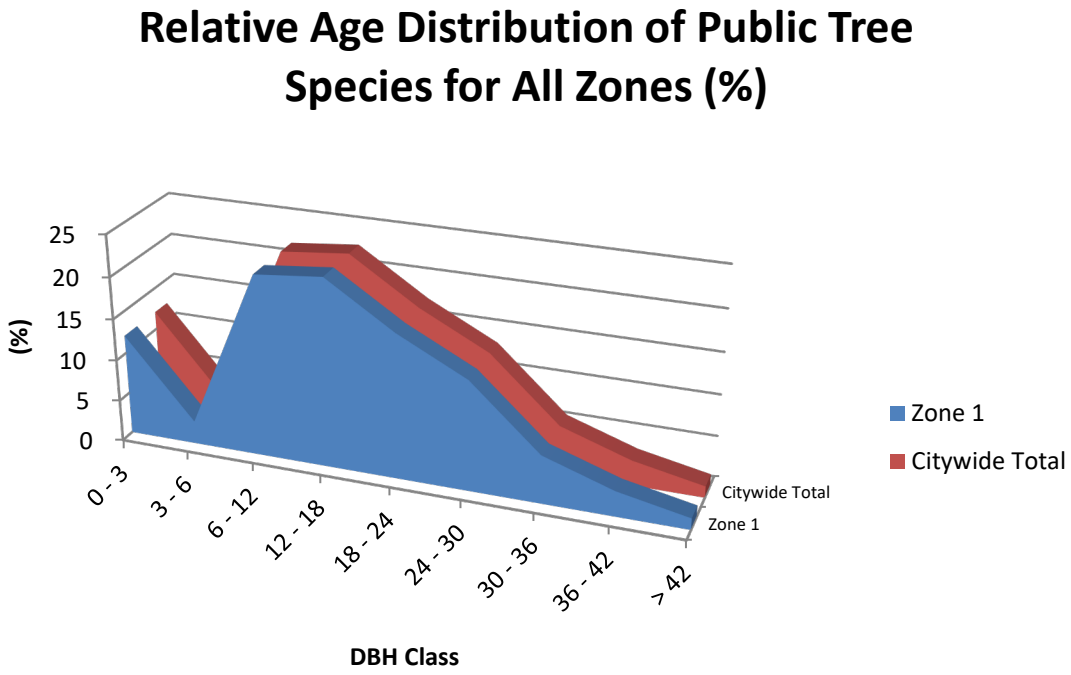


**Figure 2: Relative Age Class**

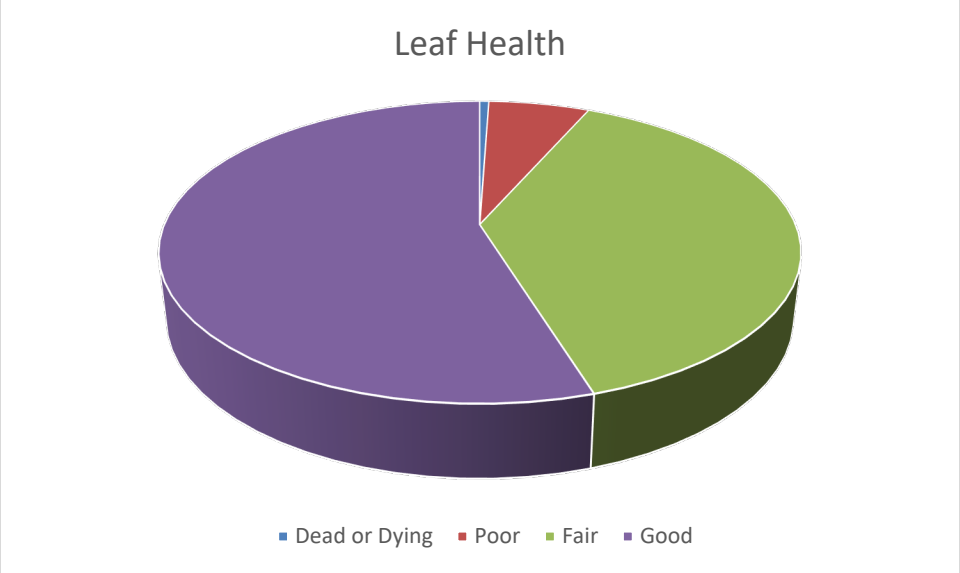


**Figure 3: Foliage Condition**

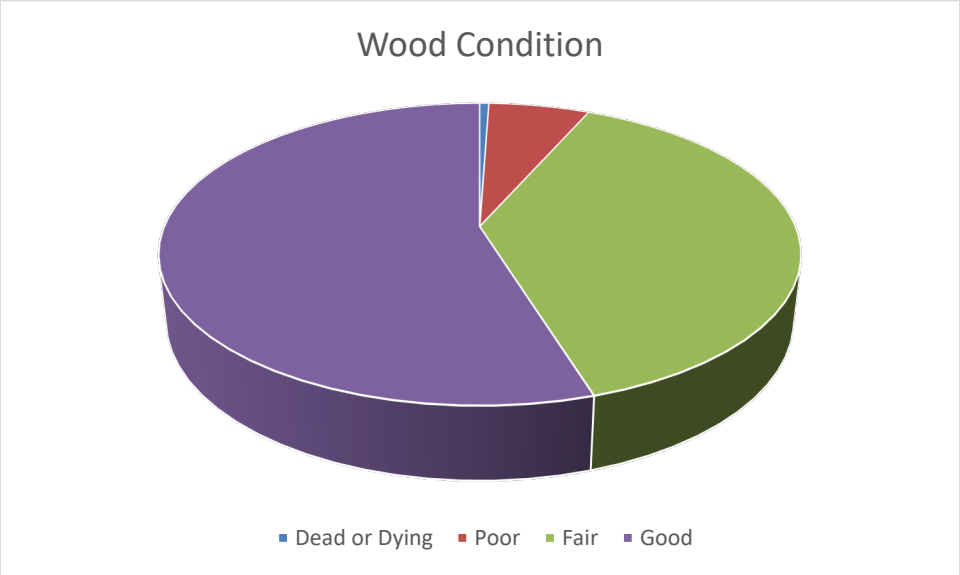


**Figure 4: Wood Condition**

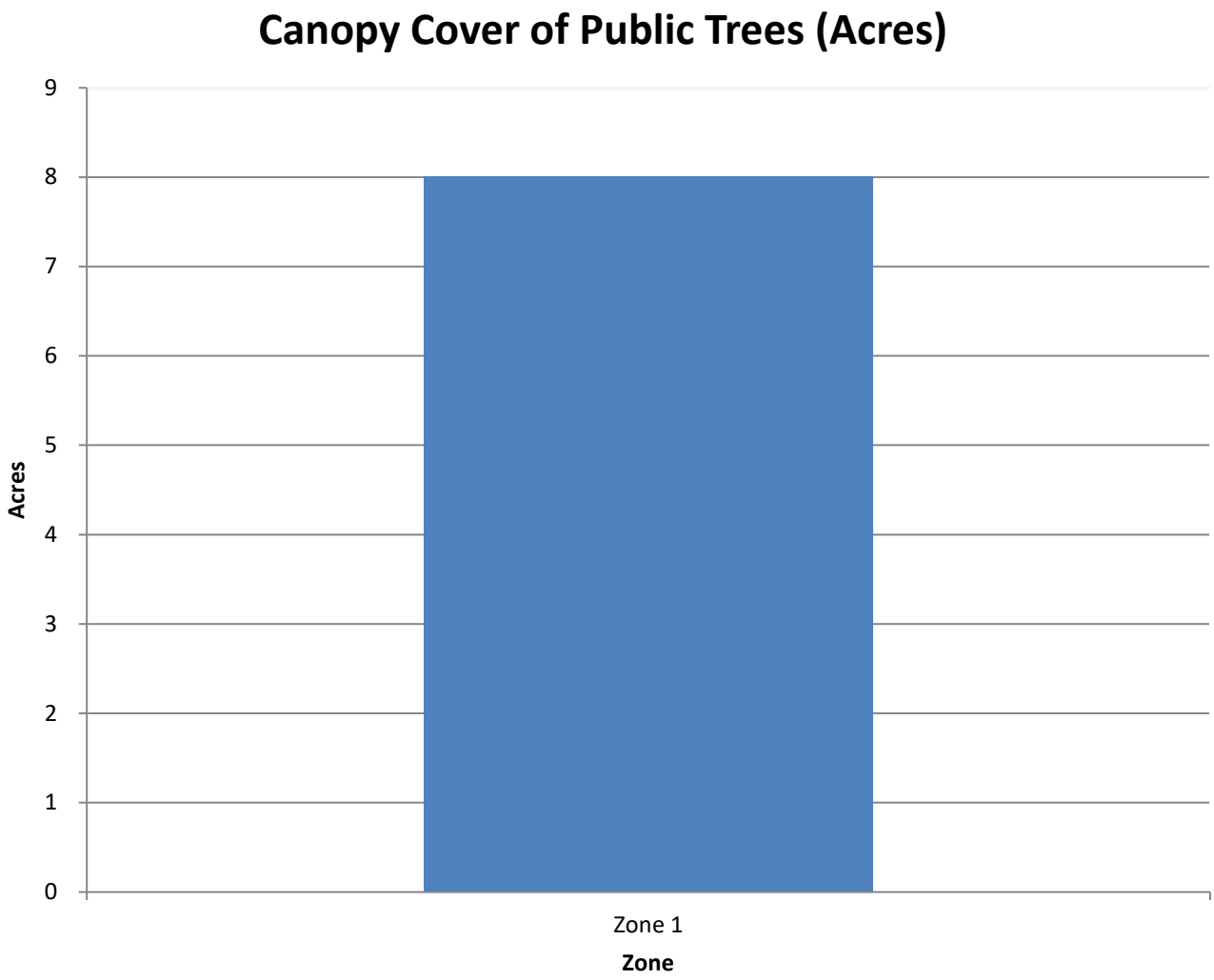


**Figure 5: Canopy Cover in Acres**

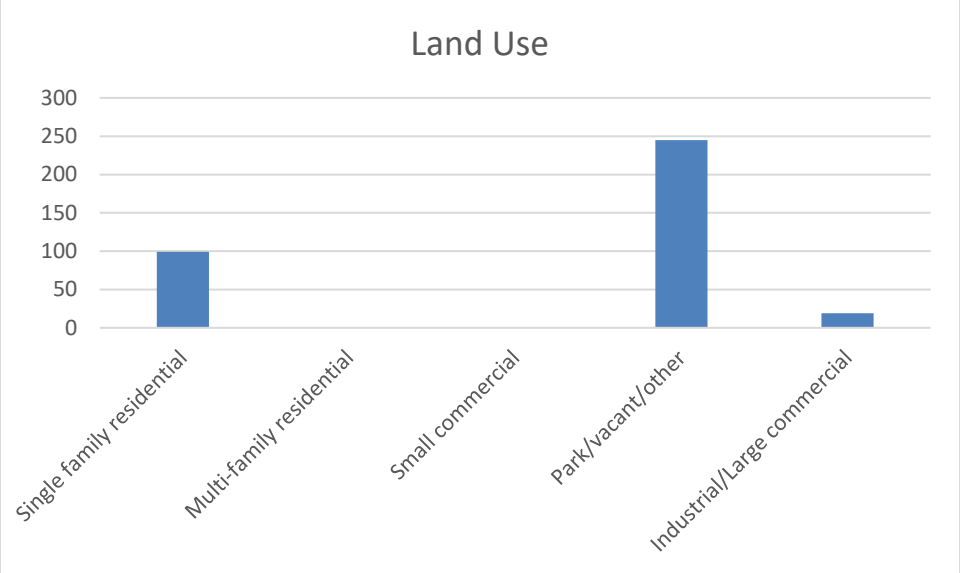


**Figure 6: Land Use of city/park trees**

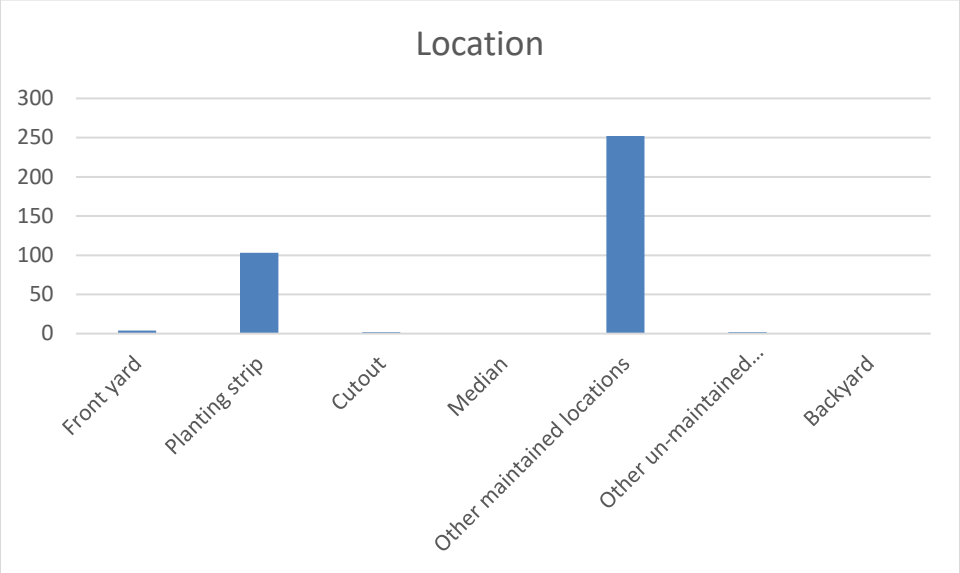


**Figure 7: Location of city/park trees**

# 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**

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