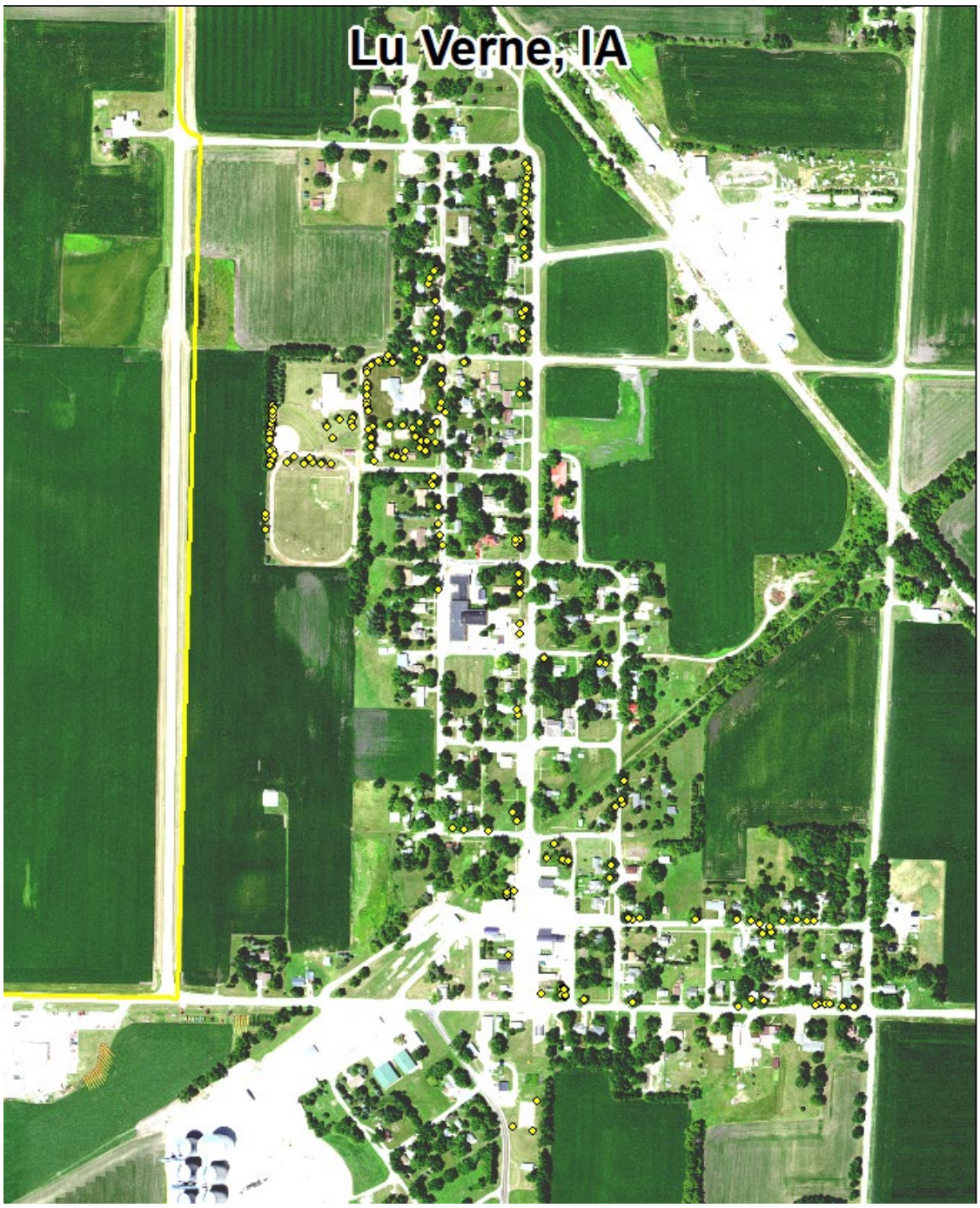
Lu Verne, IA



2019 Urban Forest Management Plan

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Executive Summary

Overview

This plan was developed to assist the City of Lu Verne 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). Without Treatment 31% of Lu Verne'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 195 trees inventoried.

- Lu Verne's trees provide $40,766 of benefits annually, an average of $209 a tree
- There are over 26 species of trees
- The top three genera are: Maple 35%, Ash 31%, and Linden 9%
- 9% of trees are in need of some type of management
- 8 trees are recommended for removal

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.

- 8 trees are needing removal *City ownership of the trees recommended for removal should be verified prior to any removal*
- 3 of the 60 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 with a visual survey yearly
- With the current budget it could take 40 years to remove ash – Suggestion: request a budget increase to $5,000 annually and apply for grants to plant replacement trees

Introduction

This plan was developed to assist Lu Verne 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 Lu Verne, these costs can be extended over years and public safety issues from dead and dying ash trees mitigated.

Trees are an important component of Lu Verne'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 Lu Verne 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 Lu Verne'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 195 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. Lu Verne's trees reduce energy related costs by approximately $10,078 annually (Appendix A, Table 1). These savings are both in Electricity (48.2 MWh) and in Natural Gas (6,553.2 Therms).

Annual Stormwater Benefits

Lu Verne's trees intercept about 613,045 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $16,614 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 Lu Verne, it is estimated that trees remove 631.1 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 $1,779 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Lu Verne, trees sequester about 130,386 lbs of carbon a year with an associated value of $1,493 (Appendix A, Table 5). In addition, the trees store 2,398,026 lbs of carbon, with a yearly benefit of $17,985 (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. Lu Verne receives $10,802 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, Lu Verne's trees provide $40,766 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 195 trees in Lu Verne provide approximately $209 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Lu Verne has over 26 different tree species along city streets and parks (Appendix A, Figure 1).
The distribution of trees by genera is as follows:

Maple	68	35%

Ash	60	31%
Basswood/Linden	17	9%
Spruce	15	8%
White Cedar	15	8%
Mulberry	4	2%
Pine	3	2%
Poplar/Cottonwood	3	2%
Cedar	2	1%
Oak	2	1%
Lilac	2	1%
Elm	2	1%
Hickory	1	<1%
Apple	1	<1%

Age Class

Most of Lu Verne's trees (32%) 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 category (a downward slope) to prepare for natural mortality and to maintain canopy cover. Lu Verne's size curve is heavy in the middle, indicating a lack of recent tree planting.

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 Lu Verne indicate that 96% 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, 32% of Lu Verne'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 9% of the population. This 9% 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	7	4%
Tree Staking	1	<1%
Tree Removal	8	4%

Canopy Cover

The total canopy with both private and public trees is 4%, 62 acres. The canopy cover included in the Lu Verne inventory includes approximately 6 acres (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 106 trees need to be planted annually on public and private lands.

Land Use and Location

The majority of Lu Verne'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	
Single family residential	58%
Park/vacant/other	41%
Industrial/Large commercial	0%
Small commercial	0%
Multifamily residential	0%

Location	
Planting strip	37%
Other maintained locations	0%
Cutout (surrounded by pavement)	0%
Front yard	62%

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

Lu Verne has 1 critical concern tree that need immediate removal. This tree can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). It is recommended to start with the large diameter critical concern trees first. There are 7 trees marked for removal should be addressed immediately. Please refer to the six year maintenance plan at the end of this section. After all of the critical concern trees are addressed, there should be follow up on the trees marked as needing maintenance. There are a total of 15 trees with these needs.

Poor tree species

After the removal of the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 8 removals, 3 are ash trees. There are a total of 60 ash trees, and 3 of those have signs and symptoms that have been associated with EAB. In addition, there are 6 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 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 Lu Verne.

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 (35%) (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. All trees planted must meet the restrictions in city ordinance.

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.

Six Year Maintenance Plan with <u>No Additional Funding</u>

Year 1

- Removal: 2 largest and critical concern trees
- Planting and Replacement: 2 trees to be planted in open locations
- Young Tree Pruning & Maintenance:
- Visual Survey for signs and symptoms of EAB

Year 2

- Removal: 1 tree
- Planting and Replacement: 1 tree
- Young Tree Pruning & Maintenance:
- Routine trimming: Contract to trim 1/3 of the city trees
- Visual Survey for signs and symptoms of EAB

Year 3

- Removal: 2 largest and critical concern trees
- Planting and Replacement: 2 trees to be planted in open locations

Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 4
Removal: 1 tree
Planting and Replacement: 1 tree
Young Tree Pruning & Maintenance:
Routine trimming: Contract to trim 1/3 of the city trees
Visual Survey for signs and symptoms of EAB

Year 5
Removal: 2 largest and critical concern trees
Planting and Replacement: 2 trees to be planted in open locations
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 6
Removal: 1 additional tree - removal of any new critical concern trees and ash in poor health
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 2 trees
Routine trimming: Contract to trim 1/3 of the city trees
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

*Reduction of ash over 6 years: Approximately 4 to 5 ash trees removed (approximately 2% of ash). It will take approximately 40 years to remove all ash with the current budget. EAB could potentially kill all ash within 4 to 15 years of its arrival.
**To remove all ash trees within 6 years, the budget would need to be increased to $10,000 a year. If the budget were increased to $5,000 a year all ash could be removed in 12 years.

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 will meet the restrictions in city ordinance. The new plantings will be a diverse mix and will 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 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.

Budget

Current Budget

Total $9,600 over 6 years ($1,600/year)

FY 2019 Budget

Removal: $1400
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Watering & Maintenance: $50

FY 2020 Budget

Removal: $700
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Routine trimming: $700
Watering & Maintenance: $50

FY 2021 Budget

Removal: $1400
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Watering & Maintenance: $50

FY 2022 Budget

Removal: $700
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Routine trimming: $700
Watering & Maintenance: $50

FY 2023 Budget

Removal: $1400
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Watering & Maintenance: $50

FY 2024 Budget

Removal: $700
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Routine trimming: $700

Watering & Maintenance: $50

*Reduction of ash over 6 years: approximately 4 to 35 ash trees removed (approximately 2% of ash). **It will take approximately 40 years to remove all ash with the current budget.**

Purposed Budget Increase

EAB could potentially kill all ash trees in Lu Verne within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $10,000 a year. If the budget were increased to $5,000 a year all ash could be removed within 12 years. Additionally, it is recommended that Lu Verne 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 being considered by many communities is treating a number of 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 removed 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). This would be 8 trees selected for treatment, and Lu Verne would still need to find $36,400 for removal. Alternatively, if there are 15 treatable trees, it would cost approximately $2,250 a year for treatment and leave $31,500 for removal. These are alternatives to straight removal of ash trees. However, whether or not the treatment option is selected, there will be an increased cost of dealing with ash trees if EAB is found in Lu Verne. It is suggested to consider increasing the budget to plan for this.

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Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Lu Verne

Annual Energy Benefits of Public Trees

1/16/2019

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	19.2	1,455	2,649.5	2,597	4,052	(N/A)	30.8	40.2	67.53
Silver maple	14.3	1,082	1,845.0	1,808	2,891	(N/A)	20.5	28.7	72.26
Norway maple	5.1	384	717.5	703	1,087	(N/A)	10.8	10.8	51.78
Littleleaf linden	2.6	195	337.6	331	526	(N/A)	7.7	5.2	35.08
Northern white cedar	0.4	31	70.7	69	100	(N/A)	7.7	1.0	6.67
Blue spruce	0.7	55	111.8	110	165	(N/A)	5.6	1.6	14.97
Mulberry	0.2	16	29.7	29	45	(N/A)	2.1	0.4	11.32
Red maple	0.2	14	27.0	26	40	(N/A)	1.5	0.4	13.43
Eastern white pine	0.6	42	73.8	72	115	(N/A)	1.5	1.1	38.17
Black walnut	0.7	50	93.7	92	142	(N/A)	1.0	1.4	70.91
Eastern cottonwood	0.9	66	118.0	116	182	(N/A)	1.0	1.8	91.02
Sugar maple	0.4	32	59.0	58	90	(N/A)	1.0	0.9	44.87
American basswood	0.4	33	52.1	51	84	(N/A)	1.0	0.8	41.84
Lilac	0.1	7	16.6	16	24	(N/A)	1.0	0.2	11.80
Spruce	0.3	22	39.4	39	61	(N/A)	1.0	0.6	30.47
Cottonwood	0.3	25	46.9	46	71	(N/A)	0.5	0.7	70.91
Boxelder	0.1	8	14.9	15	22	(N/A)	0.5	0.2	22.45
Northern red oak	0.3	20	36.4	36	55	(N/A)	0.5	0.5	55.22
Maple	0.0	0	0.7	1	1	(N/A)	0.5	0.0	1.03
Elm	0.3	25	46.9	46	71	(N/A)	0.5	0.7	70.91
Catalpa	0.4	29	53.7	53	82	(N/A)	0.5	0.8	82.02
Black spruce	0.1	5	10.2	10	15	(N/A)	0.5	0.1	14.80
Chinese elm	0.2	18	27.0	26	44	(N/A)	0.5	0.4	44.23
Apple	0.0	2	3.8	4	5	(N/A)	0.5	0.1	5.40
Bur oak	0.3	25	46.9	46	71	(N/A)	0.5	0.7	70.91
Norway spruce	0.2	14	24.6	24	38	(N/A)	0.5	0.4	38.17
Total	48.2	3,656	6,553.2	6,422	10,078	(N/A)	100.0	100.0	51.68

Table 2: Annual Stormwater Benefits

Lu Verne

Annual Stormwater Benefits of Public Trees

1/16/2019

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	242,329	6,567	(N/A)	30.8	39.5	109.45
Silver maple	212,826	5,768	(N/A)	20.5	34.7	144.19
Norway maple	46,673	1,265	(N/A)	10.8	7.6	60.23
Littleleaf linden	19,868	538	(N/A)	7.7	3.2	35.89
Northern white cedar	3,957	107	(N/A)	7.7	0.6	7.15
Blue spruce	8,600	233	(N/A)	5.6	1.4	21.19
Mulberry	750	20	(N/A)	2.1	0.1	5.08
Red maple	900	24	(N/A)	1.5	0.1	8.13
Eastern white pine	13,814	374	(N/A)	1.5	2.3	124.79
Black walnut	7,886	214	(N/A)	1.0	1.3	106.85
Eastern cottonwood	14,478	392	(N/A)	1.0	2.4	196.17
Sugar maple	4,342	118	(N/A)	1.0	0.7	58.84
American basswood	2,377	64	(N/A)	1.0	0.4	32.21
Lilac	333	9	(N/A)	1.0	0.1	4.51
Spruce	5,938	161	(N/A)	1.0	1.0	80.46
Cottonwood	3,943	107	(N/A)	0.5	0.6	106.85
Boxelder	720	20	(N/A)	0.5	0.1	19.51
Northern red oak	3,030	82	(N/A)	0.5	0.5	82.12
Maple	12	0	(N/A)	0.5	0.0	0.32
Elm	3,943	107	(N/A)	0.5	0.6	106.85
Catalpa	5,491	149	(N/A)	0.5	0.9	148.79
Black spruce	755	20	(N/A)	0.5	0.1	20.47
Chinese elm	1,466	40	(N/A)	0.5	0.2	39.72
Apple	69	2	(N/A)	0.5	0.0	1.86
Bur oak	3,943	107	(N/A)	0.5	0.6	106.85
Norway spruce	4,605	125	(N/A)	0.5	0.8	124.79
Citywide total	613,045	16,614	(N/A)	100.0	100.0	85.20

Table 3: Annual Air Quality Benefits

Lu Verne

Annual Air Quality Benefits of Public Trees

1/16/2019

Species	Deposition (lb)				Total Depos. ($)	Avoided (lb)				Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($)	Standard Error	% of Total Trees	Avg. $/tree
	O_3	NO_2	PM_{10}	SO_2		NO_2	PM_{10}	VOC	SO_2								
Green ash	32.7	5.2	15.2	1.5	173	91.8	13.3	12.7	86.9	571	0.0	0	259.3	744	(N/A)	30.8	12.40
Silver maple	37.0	6.3	18.1	1.6	199	66.9	9.8	9.4	64.5	419	-18.8	-70	194.9	549	(N/A)	20.5	13.71
Norway maple	9.6	1.7	4.7	0.4	52	24.4	3.5	3.4	23.0	152	-2.2	-8	68.4	195	(N/A)	10.8	9.29
Littleleaf linden	2.9	0.5	1.5	0.1	16	12.2	1.8	1.7	11.7	76	-1.5	-6	30.9	87	(N/A)	7.7	5.77
Northern white cedar	0.2	0.0	0.3	0.0	2	2.1	0.3	0.3	1.8	13	-1.1	-4	3.9	10	(N/A)	7.7	0.68
Blue spruce	0.8	0.2	0.8	0.1	6	3.6	0.5	0.5	3.3	22	-2.7	-10	7.0	17	(N/A)	5.6	1.59
Mulberry	0.2	0.0	0.1	0.0	1	1.0	0.1	0.1	1.0	6	0.0	0	2.6	7	(N/A)	2.1	1.87
Red maple	0.1	0.0	0.1	0.0	1	0.9	0.1	0.1	0.8	5	0.0	0	2.1	6	(N/A)	1.5	1.96
Eastern white pine	1.7	0.3	1.3	0.2	11	2.6	0.4	0.4	2.5	16	-8.6	-32	0.9	-5	(N/A)	1.5	-1.58
Black walnut	1.0	0.2	0.5	0.0	5	3.2	0.5	0.4	3.0	20	0.0	0	8.7	25	(N/A)	1.0	12.48
Eastern cottonwood	2.3	0.4	1.0	0.1	12	4.2	0.6	0.6	4.0	26	0.0	0	13.1	38	(N/A)	1.0	19.04
Sugar maple	0.5	0.1	0.3	0.0	3	2.0	0.3	0.3	1.9	13	-0.4	-2	5.0	14	(N/A)	1.0	6.93
American basswood	0.2	0.0	0.1	0.0	1	2.0	0.3	0.3	2.0	13	-0.2	-1	4.7	13	(N/A)	1.0	6.46
Lilac	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)	1.0	1.63
Spruce	0.7	0.1	0.6	0.1	5	1.4	0.2	0.2	1.3	9	-2.8	-10	1.8	3	(N/A)	1.0	1.45
Cottonwood	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)	0.5	12.48
Boxelder	0.1	0.0	0.0	0.0	0	0.5	0.1	0.1	0.5	3	0.0	0	1.2	3	(N/A)	0.5	3.26
Northern red oak	0.7	0.1	0.3	0.0	4	1.2	0.2	0.2	1.2	8	-1.0	-4	2.9	8	(N/A)	0.5	7.65
Maple	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0	(N/A)	0.5	0.13
Elm	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)	0.5	12.48
Catalpa	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)	0.5	15.71
Black spruce	0.1	0.0	0.1	0.0	0	0.3	0.0	0.0	0.3	2	-0.2	-1	0.6	2	(N/A)	0.5	1.53
Chinese elm	0.1	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	0.0	0	2.6	7	(N/A)	0.5	7.42
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)	0.5	0.71
Bur oak	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)	0.5	12.48
Norway spruce	0.6	0.1	0.4	0.1	4	0.9	0.1	0.1	0.8	5	-2.9	-11	0.3	-2	(N/A)	0.5	-1.58
Citywide total	93.8	15.7	46.5	4.5	507	229.5	33.4	31.9	218.2	1,431	-42.4	-159	631.1	1,779	(N/A)	100.0	9.12

Table 4: Annual Carbon Stored

Lu Verne

Stored CO2 Benefits of Public Trees

1/16/2019

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	1,076,903	8,077	(N/A)	30.8	44.9	134.61
Silver maple	823,742	6,178	(N/A)	20.5	34.4	154.45
Norway maple	159,394	1,195	(N/A)	10.8	6.6	56.93
Littleleaf linden	64,361	483	(N/A)	7.7	2.7	32.18
Northern white cedar	1,010	8	(N/A)	7.7	0.0	0.50
Blue spruce	3,719	28	(N/A)	5.6	0.2	2.54
Mulberry	3,243	24	(N/A)	2.1	0.1	6.08
Red maple	1,538	12	(N/A)	1.5	0.1	3.84
Eastern white pine	22,471	169	(N/A)	1.5	0.9	56.18
Black walnut	31,546	237	(N/A)	1.0	1.3	118.30
Eastern cottonwood	78,517	589	(N/A)	1.0	3.3	294.44
Sugar maple	15,381	115	(N/A)	1.0	0.6	57.68
American basswood	7,190	54	(N/A)	1.0	0.3	26.96
Lilac	1,086	8	(N/A)	1.0	0.0	4.07
Spruce	6,685	50	(N/A)	1.0	0.3	25.07
Cottonwood	15,773	118	(N/A)	0.5	0.7	118.30
Boxelder	1,101	8	(N/A)	0.5	0.0	8.26
Northern red oak	15,239	114	(N/A)	0.5	0.6	114.29
Maple	17	0	(N/A)	0.5	0.0	0.13
Elm	15,773	118	(N/A)	0.5	0.7	118.30
Catalpa	25,943	195	(N/A)	0.5	1.1	194.57
Black spruce	284	2	(N/A)	0.5	0.0	2.13
Chinese elm	3,672	28	(N/A)	0.5	0.2	27.54
Apple	178	1	(N/A)	0.5	0.0	1.33
Bur oak	15,773	118	(N/A)	0.5	0.7	118.30
Norway spruce	7,490	56	(N/A)	0.5	0.3	56.18
Citywide total	2,398,026	17,985	(N/A)	100.0	100.0	92.23

Table 5: Annual Carbon Sequestered

Lu Verne

Annual CO Benefits of Public Trees

1/16/2019

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	45,517	341	-5,169	-207	-40	32,157	241	72,298	542 (N/A)	30.8	36.3	9.04
Silver maple	59,797	448	-3,954	-157	-31	23,922	179	79,608	597 (N/A)	20.5	40.0	14.93
Norway maple	6,042	45	-765	-53	-6	8,492	64	13,715	103 (N/A)	10.8	6.9	4.90
Littleleaf linden	7,467	56	-309	-28	-3	4,318	32	11,448	86 (N/A)	7.7	5.7	5.72
Northern white cedar	339	3	-5	-10	0	680	5	1,005	8 (N/A)	7.7	0.5	0.50
Blue spruce	450	3	-18	-13	0	1,217	9	1,636	12 (N/A)	5.6	0.8	1.12
Mulberry	323	2	-16	-3	0	357	3	661	5 (N/A)	2.1	0.3	1.24
Red maple	243	2	-7	-2	0	306	2	539	4 (N/A)	1.5	0.3	1.35
Eastern white pine	0	0	-108	-14	-1	933	7	811	6 (N/A)	1.5	0.4	2.03
Black walnut	1,714	13	-151	-7	-1	1,105	8	2,660	20 (N/A)	1.0	1.3	9.97
Eastern cottonwood	1,824	14	-377	-10	-3	1,469	11	2,906	22 (N/A)	1.0	1.5	10.90
Sugar maple	907	7	-74	-5	-1	705	5	1,534	12 (N/A)	1.0	0.8	5.75
American basswood	632	5	-35	-4	0	721	5	1,315	10 (N/A)	1.0	0.7	4.93
Lilac	152	1	-5	-2	0	161	1	306	2 (N/A)	1.0	0.2	1.15
Spruce	375	3	-32	-5	0	493	4	830	6 (N/A)	1.0	0.4	3.11
Cottonwood	857	6	-76	-4	-1	552	4	1,330	10 (N/A)	0.5	0.7	9.97
Boxelder	181	1	-5	-1	0	173	1	347	3 (N/A)	0.5	0.2	2.60
Northern red oak	370	3	-73	-4	-1	432	3	725	5 (N/A)	0.5	0.4	5.44
Maple	3	0	0	0	0	7	0	9	0 (N/A)	0.5	0.0	0.07
Elm	857	6	-76	-4	-1	552	4	1,330	10 (N/A)	0.5	0.7	9.97
Catalpa	960	7	-125	-4	-1	650	5	1,481	11 (N/A)	0.5	0.7	11.11
Black spruce	39	0	-1	-1	0	106	1	142	1 (N/A)	0.5	0.1	1.07
Chinese elm	445	3	-18	-2	0	393	3	819	6 (N/A)	0.5	0.4	6.14
Apple	38	0	-1	-1	0	37	0	74	1 (N/A)	0.5	0.0	0.55
Bur oak	857	6	-76	-4	-1	552	4	1,330	10 (N/A)	0.5	0.7	9.97
Norway spruce	0	0	-36	-4	0	311	2	271	2 (N/A)	0.5	0.1	2.03
Citywide total	130,386	978	-11,511	-548	-90	80,802	606	199,129	1,493 (N/A)	100.0	100.0	7.66

Table 6: Annual Social and Aesthetic Benefits

Lu Verne

Annual Aesthetic/Other Benefits of Public Trees

1/16/2019

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	3,503	(N/A)	30.8	32.4	58.39
Silver maple	4,598	(N/A)	20.5	42.6	114.95
Norway maple	594	(N/A)	10.8	5.5	28.29
Littleleaf linden	809	(N/A)	7.7	7.5	53.92
Northern white cedar	120	(N/A)	7.7	1.1	7.98
Blue spruce	227	(N/A)	5.6	2.1	20.66
Mulberry	18	(N/A)	2.1	0.2	4.40
Red maple	44	(N/A)	1.5	0.4	14.80
Eastern white pine	0	(N/A)	1.5	0.0	0.00
Black walnut	131	(N/A)	1.0	1.2	65.59
Eastern cottonwood	117	(N/A)	1.0	1.1	58.34
Sugar maple	98	(N/A)	1.0	0.9	48.87
American basswood	57	(N/A)	1.0	0.5	28.70
Lilac	8	(N/A)	1.0	0.1	4.23
Spruce	94	(N/A)	1.0	0.9	47.08
Cottonwood	66	(N/A)	0.5	0.6	65.59
Boxelder	27	(N/A)	0.5	0.3	27.10
Northern red oak	24	(N/A)	0.5	0.2	23.84
Maple	0	(N/A)	0.5	0.0	0.04
Elm	66	(N/A)	0.5	0.6	65.59
Catalpa	67	(N/A)	0.5	0.6	66.60
Black spruce	21	(N/A)	0.5	0.2	21.08
Chinese elm	46	(N/A)	0.5	0.4	45.86
Apple	2	(N/A)	0.5	0.0	2.06
Bur oak	66	(N/A)	0.5	0.6	65.59
Norway spruce	0	(N/A)	0.5	0.0	0.00
Citywide total	10,802	(N/A)	100.0	100.0	55.40

Table 7: Summary of Benefits in Dollars

Lu Verne

Total Annual Benefits of Public Trees by Species ($)

1/16/2019

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Green ash	4,052	542	744	6,567	3,503	15,408	(N/A)	37.8
Silver maple	2,891	597	549	5,768	4,598	14,402	(N/A)	35.3
Norway maple	1,087	103	195	1,265	594	3,244	(N/A)	8.0
Littleleaf linden	526	86	87	538	809	2,046	(N/A)	5.0
Northern white cedar	100	8	10	107	120	345	(N/A)	0.8
Blue spruce	165	12	17	233	227	655	(N/A)	1.6
Mulberry	45	5	7	20	18	96	(N/A)	0.2
Red maple	40	4	6	24	44	119	(N/A)	0.3
Eastern white pine	115	6	-5	374	0	490	(N/A)	1.2
Black walnut	142	20	25	214	131	532	(N/A)	1.3
Eastern cottonwood	182	22	38	392	117	751	(N/A)	1.8
Sugar maple	90	12	14	118	98	331	(N/A)	0.8
American basswood	84	10	13	64	57	228	(N/A)	0.6
Lilac	24	2	3	9	8	47	(N/A)	0.1
Spruce	61	6	3	161	94	325	(N/A)	0.8
Cottonwood	71	10	12	107	66	266	(N/A)	0.7
Boxelder	22	3	3	20	27	75	(N/A)	0.2
Northern red oak	55	5	8	82	24	174	(N/A)	0.4
Maple	1	0	0	0	0	2	(N/A)	0.0
Elm	71	10	12	107	66	266	(N/A)	0.7
Catalpa	82	11	16	149	67	324	(N/A)	0.8
Black spruce	15	1	2	20	21	59	(N/A)	0.1
Chinese elm	44	6	7	40	46	143	(N/A)	0.4
Apple	5	1	1	2	2	11	(N/A)	0.0
Bur oak	71	10	12	107	66	266	(N/A)	0.7
Norway spruce	38	2	-2	125	0	163	(N/A)	0.4
Citywide Total	10,078	1,493	1,779	16,614	10,802	40,766	(N/A)	100.0

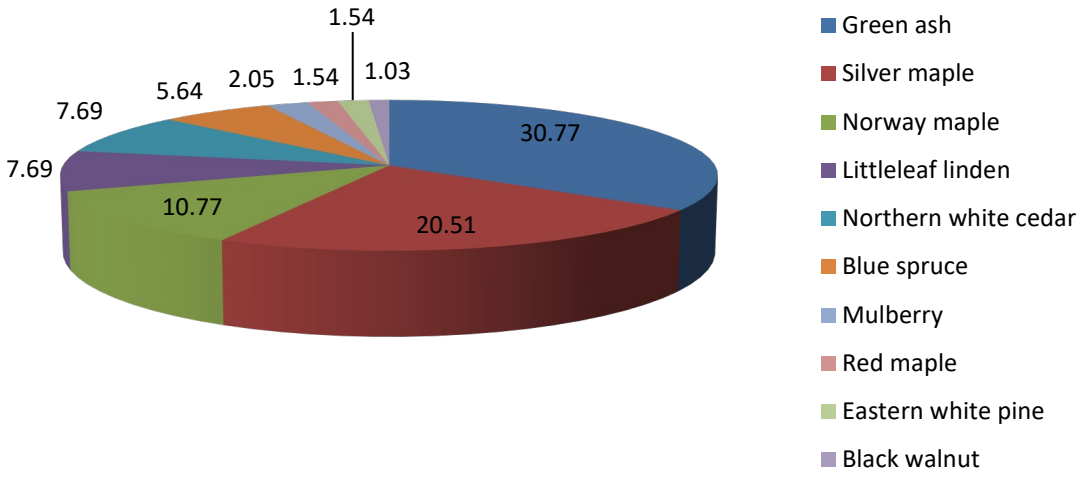

Figure 1: Species Distribution

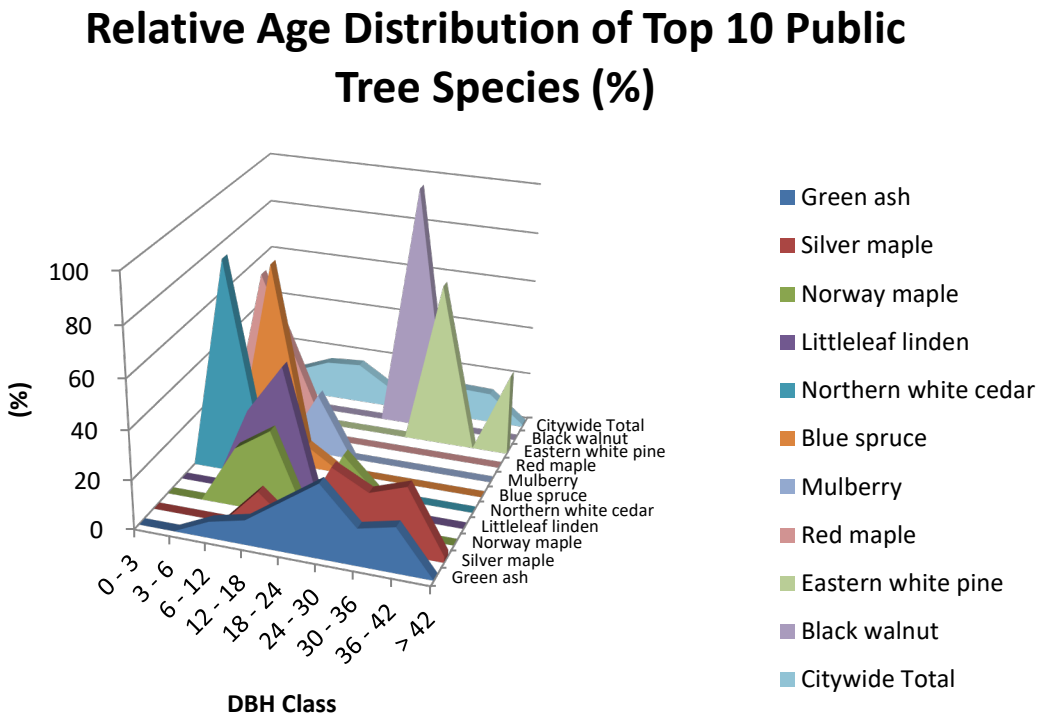

Figure 2: Relative Age Class

Figure 3: Foliage Condition

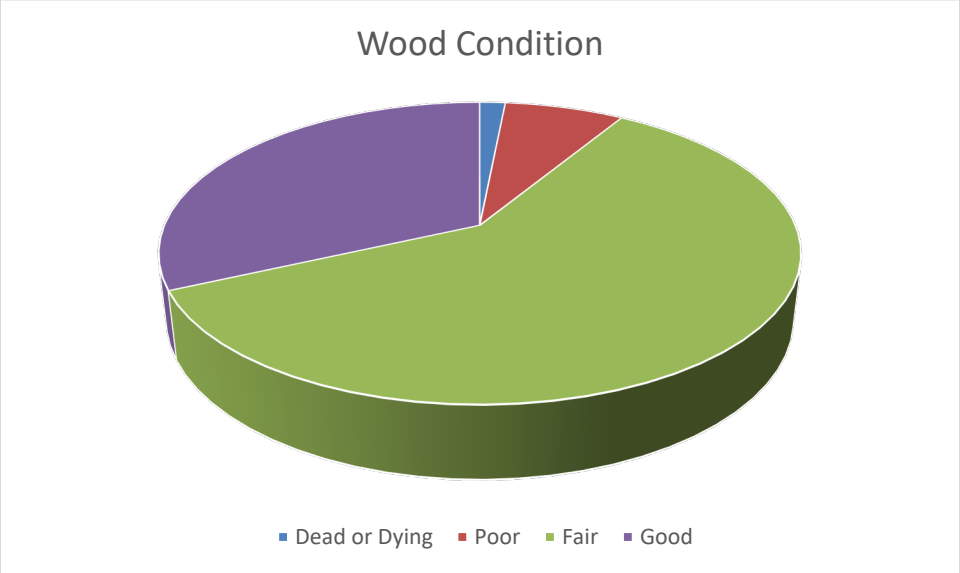

Figure 4: Wood Condition

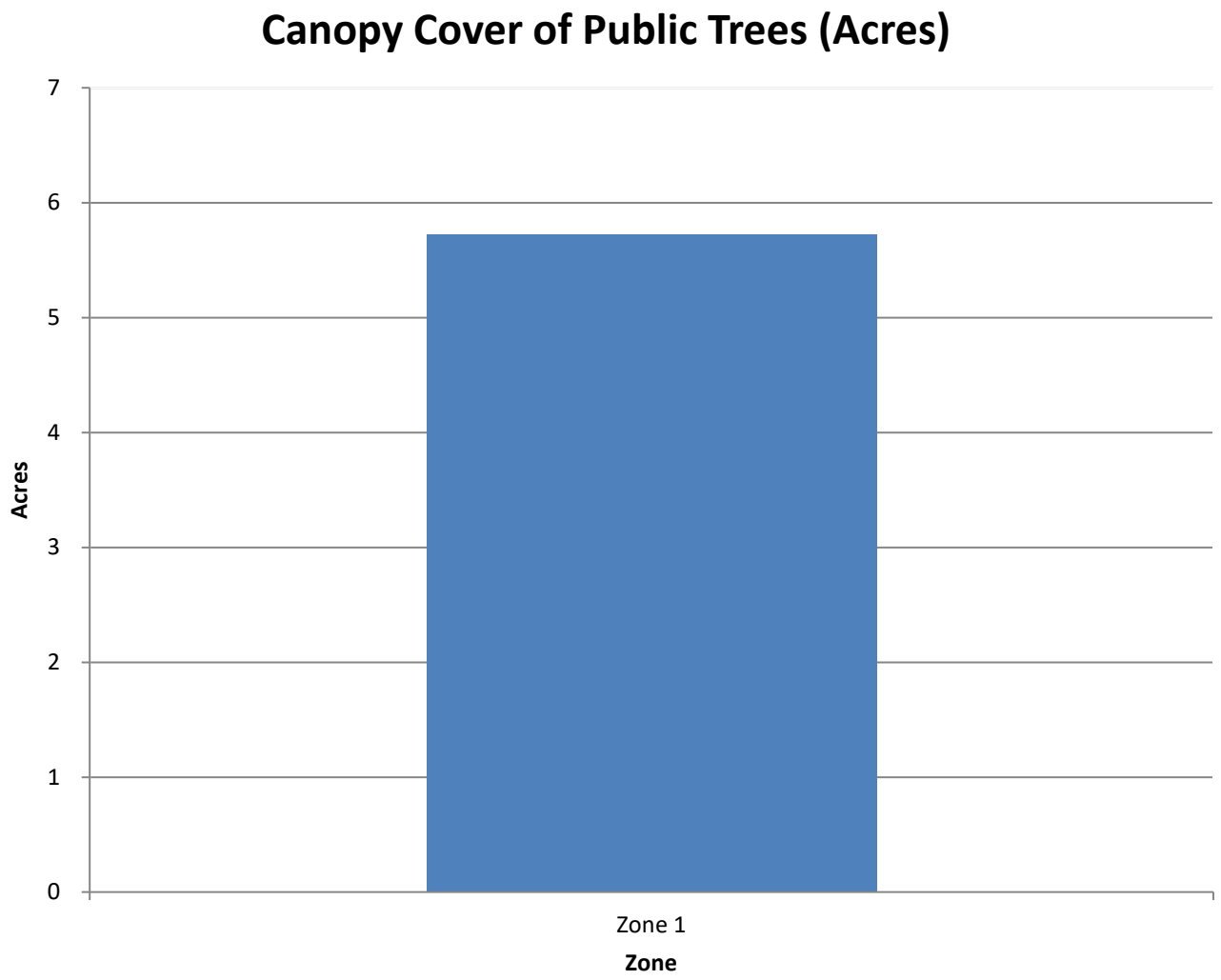

Figure 5: Canopy Cover in Acres

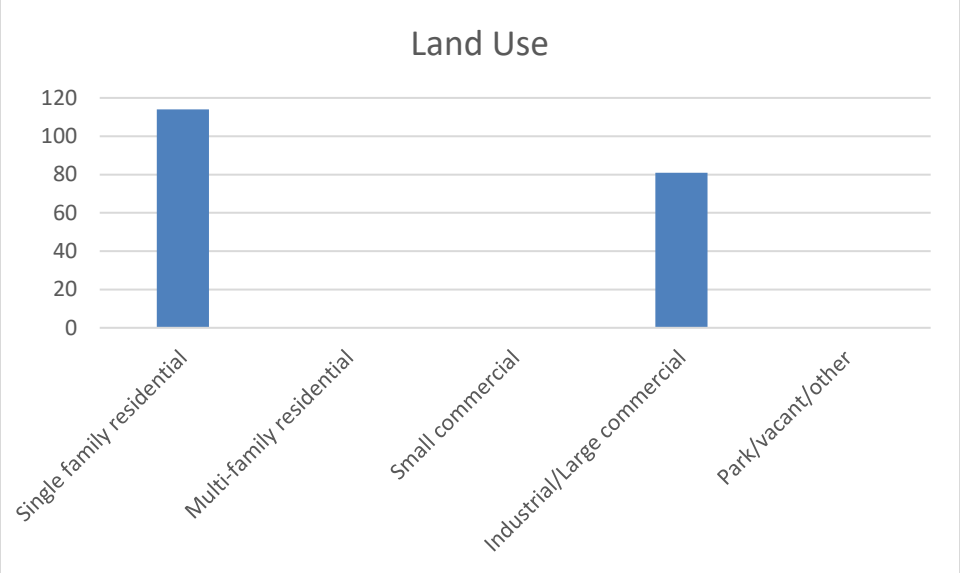

Figure 6: Land Use of city/park trees

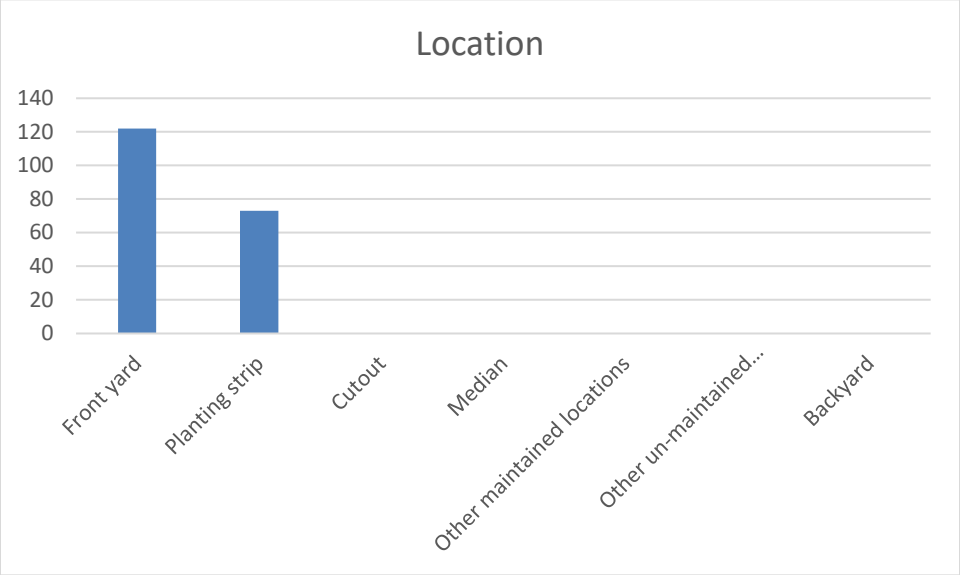

Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

Figure 1: Location of Ash Trees

Figure 2: Location of EAB symptoms

Figure 3: Location of Poor Condition Trees

Figure 4: Location of Trees with Recommended Maintenance

Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

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