

Rudd, IA



2016 Urban Forest Management Plan
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In Partnership with the Iowa DNR



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Executive Summary

Overview

This plan was developed to assist the City of Rudd 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 31.5% of Rudd'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 2016, 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 470 trees inventoried.

- Rudd's trees provide \$45,178 of benefits annually, an average of \$97 a tree
- There are over 40 species of trees
- The top three genera are: Ash 31.5%, Maple 16%, and Spruce 13%
- 45% of trees are in need of some type of management
- 108 (95 ash) 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.

- Of the 108 (95 ash) trees needing removal, 7 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**](#)
- 8 of the 148 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: fruit bearing trees, 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 9 years to remove ash – Suggestion: request a budget increase to \$3,100 annually and apply for grants to plant replacement trees

Introduction

This plan was developed to assist Rudd 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 and replacement planting. With proper planning and management of the current canopy in Rudd these costs can be extended over years and public safety issues from dead and dying ash trees mitigated.

Trees are an important component of Rudd'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 Rudd 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 Rudd's urban forestry goals.

Inventory

In 2016, 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 470 city trees was entered into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management (STRATUM), part of the i-Tree suite. The following are results from the i-Tree STRATUM analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Rudd's trees reduce energy related costs by approximately \$12,124 annually (Appendix A, Table 1). These savings are both in Electricity (57.4 MWh) and in Natural Gas (7,929.2 Therms).

Annual Stormwater Benefits

Rudd's trees intercept about 610,562 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides \$16,546 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 Rudd it is estimated that trees remove 697.9 lbs. of air pollution (ozone (O₃), particulate matter less than 10 microns (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂)) per year with a net value of \$1,937 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Rudd trees sequester about 206,930 lbs. of carbon a year with an associated value of \$1,552 (Appendix A, Table 4). In addition, the trees store 1,975,701 lbs. of carbon, with a yearly benefit of \$14,818 (Appendix A, Table 5).

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. Rudd receives \$13,019 in annual social benefits from trees (Appendix A, Table 6).

Financial Summary of all Benefits

According to the USDA Forest Service i-Tree STRATUM analysis, Rudd's trees provide \$45,178 of benefits annually. Benefits of individual trees vary based on size, species, health and location,

but on average each of the 470 trees in Rudd provide approximately \$97 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Rudd has over 40 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Ash	148	31.5%
Maple	75	16%
Spruce	61	13%
Pine	49	10.4%
Cottonwood	31	6%
Oak	16	3.4%
Apple (Crab)	15	3.2%
Linden/Basswood	13	2.8%
Lilac	7	1.5%
Walnut	6	1.3%
Cherry	4	.9%
Birch	3	.6%
Elm	3	.6%
Aspen	3	.6%
Others	36	8.2%

Age Class

Most of Rudd's trees (75%) are between 3 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. Rudd'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 Rudd indicate that 97% of the trees are in good health, with only 3% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 88.7% of Rudd'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 11.3% of the population. This 11.3% 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	50	10.64%
Crown Raising	3	.43%
Tree Staking	4	.85%
Tree Removal	108	22.98%
Crown Reduction	4	.85%
Treat	41	8.72%

Canopy Cover

The total canopy with both private and public trees is 13%, 72 acres. The canopy cover included in the Rudd inventory includes approximately 6.15 acres (Appendix A, Figure 5).

Land Use and Location

The majority of Rudd'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.

Land Use

Single family residential	12.34%
Park/vacant/other	87.45%
Industrial/Large commercial	0.00%
Small commercial	0.21%
Multifamily residential	0.00%

Location

Planting strip	8.08%
Other maintained locations	87.45%
Cutout (surrounded by pavement)	.21%
Front yard	4.26%

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

Rudd has 1 critical concern tree that needs 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. The tree is over 24

inches in diameter at 4.5 ft. and 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 208 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 108 removals, 95 are ash trees. There are a total of 148 ash trees, and 8 of those have signs and symptoms that have been associated with EAB. In addition, there are 22 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 Rudd.

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 (31.5%) (Appendix A, Figure 1). Maples are 16% and can be planted up to 20% of the canopy. 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.

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.

Rudd has 108 trees recommended for removal, 95 of those are ash. Of the ash trees, only 13 are greater than 18 inches diameter, the balance are young ash less than 18 inches diameter that can probably be safely removed by city employees. The following proposed maintenance plan and budget will consider the 13 trees of other species recommended for removal and the 13 ash trees greater than 18 inches. A total of 26 trees professionally removed at approx. \$700 each.

Six Year Maintenance Plan with No Additional Funding

Year 1

Removal: The 1 critical concern tree and 2 trees in poor health
Planting and Replacement: 4 trees to be planted in open locations
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 2

Removal: 3 additional ash trees with poor health
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 4 trees in open locations from year one removals
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: 3 trees - 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: 4 trees to be planted in open locations and locations from previous removals
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 4

Removal: 3 trees - 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: 4 trees in open locations from previous removals
Routine trimming: Contract to trim 1/3 of the city trees
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 5

Removal: 3 trees - 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: 4 trees to be planted in open locations and locations from previous removals
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 6

Removal: 3 trees - 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: 4 trees in open locations from previous removals

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 9 ash trees removed (approximately 69% of ash). It will take approximately 9 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 26 recommended trees within 6 years, the budget would need to be increased to \$3,100 a year. If the budget were increased to \$10,000 a year all ash could be removed in 2 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 7). 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. 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 or treating ash trees on their property upon arrival of EAB.

Budget

Proposed Budget

Total \$16,500 over 6 years (\$2,750/year)

FY 2017 Budget

Removal: \$2,100

*Or saving for ash tree treatment and/or future ash removal

Planting: \$400

Watering & Maintenance: \$100

FY 2018 Budget

Removal: \$2,100

*Or saving for ash tree treatment and/or future ash removal

Planting: \$400

Routine trimming: \$300

Watering & Maintenance: \$100

FY 2019 Budget

Removal: \$2,100

*Or saving for ash tree treatment and/or future ash removal

Planting: \$400

Watering & Maintenance: \$100

FY 2020 Budget

Removal: \$2,100

*Or saving for ash tree treatment and/or future ash removal

Planting: \$400

Routine trimming: \$300

Watering & Maintenance: \$100

FY 2021 Budget

Removal: \$2,100

*Or saving for ash tree treatment and/or future ash removal

Planting: \$400

Watering & Maintenance: \$100

FY 2022 Budget

Removal: \$2,100

*Or saving for ash tree treatment and/or future ash removal

Planting: \$400

Routine trimming: \$300

Watering & Maintenance: \$100

*Reduction of ash over 6 years: approximately 9 ash trees removed (approximately 69% of ash). **It will take approximately 9 years to remove all ash with the current budget.**

Proposed Budget Increase

EAB could potentially kill all ash trees in Rudd within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to \$3,100 a year. If the budget

were increased to \$10,000 a year all ash could be removed within 2 years. Additionally, it is recommended that Rudd 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 less than 18 inches and at \$15 per inch, about 20 trees could be treated per year (every other year treatment). This would be 20 of 41 trees selected for treatment at \$5,400, and Rudd would still need to find \$2,100 for removal. Alternatively, if all 41 treatable trees are treated the same year (and then every other year), it would cost approximately \$11,000 those years for treatment and leave \$0 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 Rudd. 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

Annual Energy Benefits of Public Trees by Species									
Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total (\$)	Stand. Error	% of Total Trees	% of Total \$	Avg. \$/tree
Green ash	14.66	1,113.00	2,014.44	1,974.15	3,087.15	(N/A)	30.77	25.46	21.44
Blue spruce	0.80	61.10	116.05	113.73	174.82	(N/A)	8.76	1.44	4.26
Silver maple	7.41	562.18	994.15	974.26	1,536.45	(N/A)	6.84	12.67	48.01
Eastern cottonwood	9.62	730.24	1,327.35	1,300.81	2,031.05	(N/A)	6.62	16.75	65.52
Scotch pine	2.58	195.75	338.30	331.53	527.28	(N/A)	5.56	4.35	20.28
Norway maple	5.52	419.32	797.91	781.95	1,201.27	(N/A)	5.56	9.91	46.20
Eastern white pine	1.28	97.04	176.01	172.49	269.53	(N/A)	4.06	2.22	14.19
Norway spruce	0.90	68.60	129.25	126.66	195.26	(N/A)	3.63	1.61	11.49
Apple	0.64	48.85	101.51	99.48	148.33	(N/A)	3.21	1.22	9.89
Littleleaf linden	1.15	87.33	153.54	150.46	237.80	(N/A)	2.35	1.96	21.62
Sugar maple	2.16	164.14	290.21	284.41	448.55	(N/A)	1.50	3.70	64.08
Lilac	1.26	95.32	195.62	191.70	287.02	(N/A)	1.50	2.37	41.00
Swamp white oak	0.03	2.28	5.54	5.43	7.71	(N/A)	1.50	0.06	1.10
Bur oak	1.19	90.58	161.59	158.36	248.94	(N/A)	1.28	2.05	41.49
Black walnut	0.02	1.19	2.79	2.74	3.93	(N/A)	1.28	0.03	0.66
River birch	0.41	30.86	61.38	60.15	91.01	(N/A)	1.07	0.75	18.20
Black maple	1.11	84.55	150.49	147.48	232.03	(N/A)	1.07	1.91	46.41
Black cherry	0.53	40.34	81.95	80.31	120.66	(N/A)	0.85	1.00	30.16
White ash	0.47	35.49	64.81	63.51	99.00	(N/A)	0.85	0.82	24.75
Quaking aspen	0.01	0.60	1.40	1.37	1.97	(N/A)	0.64	0.02	0.66
Other City Trees	5.59	424.37	764.96	749.66	1,174.03	(N/A)	11.11	9.68	585.68
Total	57.35	4,353.14	7,929.24	7,770.65	12,123.79	(N/A)	100.00	100.00	25.91

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees by Species						
Species	Total Rainfall Interception (Gal)	Total (\$)	Stand. Error	% of Total Trees	% of Total \$	Avg. \$/tree
Green ash	119,965.86	3,251.07	(N/A)	30.77	19.65	22.58
Blue spruce	8,242.83	223.38	(N/A)	8.76	1.35	5.45
Silver maple	96,474.47	2,614.46	(N/A)	6.84	15.80	81.70
Eastern cottonwood	116,249.90	3,150.37	(N/A)	6.62	19.04	101.62
Scotch pine	35,866.80	971.99	(N/A)	5.56	5.87	37.38
Norway maple	48,356.43	1,310.46	(N/A)	5.56	7.92	50.40
Eastern white pine	22,002.49	596.27	(N/A)	4.06	3.60	31.38
Norway spruce	15,230.44	412.74	(N/A)	3.63	2.49	24.28
Apple	2,696.32	73.07	(N/A)	3.21	0.44	4.87
Littleleaf linden	10,016.87	271.46	(N/A)	2.35	1.64	24.68
Sugar maple	26,727.61	724.32	(N/A)	1.50	4.38	103.47
Lilac	6,801.19	184.31	(N/A)	1.50	1.11	26.33
Swamp white oak	85.43	2.32	(N/A)	1.50	0.01	0.33
Bur oak	17,122.18	464.01	(N/A)	1.28	2.80	77.34
Black walnut	107.31	2.91	(N/A)	1.28	0.02	0.48
River birch	4,114.16	111.49	(N/A)	1.07	0.67	22.30
Black maple	10,216.48	276.87	(N/A)	1.07	1.67	55.37
Black cherry	2,369.54	64.21	(N/A)	0.85	0.39	16.05
White ash	4,165.52	112.89	(N/A)	0.85	0.68	28.22
Quaking aspen	53.65	1.45	(N/A)	0.64	0.01	0.48
Other City Trees	63,696.37	1,726.17	(N/A)	11.11	10.43	831.00
Citywide total	610,561.87	16,546.23	(N/A)	100.00	100.00	35.36

Table 3: Annual Air Quality Benefits

Annual Air Quality Benefits of Public Trees by Species																	
Species	Deposition O3 (lb)	Deposition NO2 (lb)	Deposition PM10 (lb)	Deposition SO2 (lb)	Total Deposition (\$)	Avoided NO2 (lb)	Avoided PM10 (lb)	Avoided VOC (lb)	Avoided SO2 (lb)	Total Avoided (\$)	BVOC Emissions (lb)	BVOC Emissions (\$)	Total (lb)	Total (\$)	Stand. Error	% of Total Trees	Avg. \$/tree
Green ash	10.13	1.62	5.71	0.45	56.40	69.96	10.19	9.71	66.44	435.90	0.00	0.00	174.22	492.30	(N/A)	30.77	3.42
Blue spruce	0.82	0.16	0.78	0.10	5.73	3.89	0.56	0.54	3.65	24.13	- 2.68	- 10.03	7.84	19.83	(N/A)	8.76	0.48
Silver maple	15.26	2.59	7.66	0.68	82.74	35.09	5.12	4.89	33.51	219.11	- 8.21	- 30.78	96.58	271.07	(N/A)	6.84	8.47
Eastern cottonwood	16.59	2.65	7.69	0.74	87.65	46.03	6.69	6.38	43.60	286.51	0.00	0.00	130.39	374.15	(N/A)	6.62	12.07
Scotch pine	3.91	0.77	3.39	0.48	26.26	12.15	1.78	1.70	11.68	76.09	- 15.00	- 56.23	20.87	46.12	(N/A)	5.56	1.77
Norway maple	9.42	1.62	4.69	0.42	51.06	26.80	3.87	3.69	25.07	165.97	- 2.25	- 8.42	73.33	208.61	(N/A)	5.56	8.02
Eastern white pine	2.40	0.48	2.02	0.29	15.94	6.10	0.89	0.85	5.79	38.00	- 10.14	- 38.01	8.68	15.93	(N/A)	4.06	0.84
Norway spruce	1.65	0.33	1.40	0.20	11.00	4.35	0.63	0.60	4.09	27.02	- 7.07	- 26.51	6.19	11.51	(N/A)	3.63	0.68
Apple	0.75	0.12	0.36	0.03	4.02	3.19	0.46	0.43	2.92	19.58	0.00	- 0.02	8.26	23.58	(N/A)	3.21	1.57
Littleleaf linden	1.59	0.27	0.80	0.07	8.67	5.47	0.80	0.76	5.22	34.15	- 0.79	- 2.97	14.21	39.86	(N/A)	2.35	3.62
Sugar maple	3.72	0.63	1.82	0.16	20.05	10.26	1.50	1.43	9.79	64.07	- 2.90	- 10.88	26.42	73.23	(N/A)	1.50	10.46
Lilac	2.42	0.40	1.10	0.11	12.77	6.20	0.89	0.84	5.69	38.11	- 0.01	- 0.05	17.64	50.84	(N/A)	1.50	7.26
Swamp white oak	0.00	0.00	0.00	0.00	0.01	0.16	0.02	0.02	0.14	0.94	0.00	0.00	0.34	0.96	(N/A)	1.50	0.14
Bur oak	3.01	0.48	1.34	0.13	15.73	5.68	0.83	0.79	5.41	35.44	0.00	0.00	17.67	51.17	(N/A)	1.28	8.53
Black walnut	0.00	0.00	0.00	0.00	0.01	0.08	0.01	0.01	0.07	0.49	0.00	0.00	0.18	0.50	(N/A)	1.28	0.08
River birch	0.88	0.15	0.43	0.04	4.73	2.00	0.29	0.27	1.85	12.30	- 0.20	- 0.76	5.69	16.28	(N/A)	1.07	3.26
Black maple	2.57	0.44	1.18	0.11	13.64	5.29	0.77	0.74	5.05	33.03	- 0.85	- 3.18	15.31	43.50	(N/A)	1.07	8.70
Black cherry	0.73	0.12	0.35	0.03	3.90	2.62	0.38	0.36	2.41	16.11	0.00	- 0.01	6.99	19.99	(N/A)	0.85	5.00
White ash	0.39	0.06	0.21	0.02	2.16	2.23	0.32	0.31	2.12	13.91	0.00	0.00	5.67	16.07	(N/A)	0.85	4.02
Quaking aspen	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.01	0.04	0.24	0.00	0.00	0.09	0.25	(N/A)	0.64	0.08
Other City Trees	9.99	1.81	6.29	0.79	58.91	26.68	3.89	3.70	25.34	166.23	- 17.12	- 64.20	61.37	160.94	(N/A)	11.11	85.35
Citywide Total	86.23	14.72	47.24	4.88	481.40	274.28	39.90	38.03	259.87	1,707.34	- 67.22	- 252.06	697.93	1,936.68	(N/A)	100.00	4.14

Table 4: Annual Carbon Stored

Stored CO2 Benefits of Public Trees by Species						
Species	Total stored CO2 (lbs)	Total (\$)	Stand. Error	% of Total Trees	% of Total \$	Avg. \$/tree
Green ash	352,381.38	2,642.86	(N/A)	30.77	17.84	18.35
Blue spruce	4,677.94	35.08	(N/A)	8.76	0.24	0.86
Silver maple	333,947.95	2,504.61	(N/A)	6.84	16.90	78.27
Eastern cottonwood	552,197.96	4,141.48	(N/A)	6.62	27.95	133.60
Scotch pine	34,057.68	255.43	(N/A)	5.56	1.72	9.82
Norway maple	155,027.94	1,162.71	(N/A)	5.56	7.85	44.72
Eastern white pine	23,771.26	178.28	(N/A)	4.06	1.20	9.38
Norway spruce	16,466.45	123.50	(N/A)	3.63	0.83	7.26
Apple	12,403.34	93.03	(N/A)	3.21	0.63	6.20
Littleleaf linden	34,491.25	258.68	(N/A)	2.35	1.75	23.52
Sugar maple	109,088.80	818.17	(N/A)	1.50	5.52	116.88
Lilac	37,658.63	282.44	(N/A)	1.50	1.91	40.35
Swamp white oak	117.87	0.88	(N/A)	1.50	0.01	0.13
Bur oak	103,734.68	778.01	(N/A)	1.28	5.25	129.67
Black walnut	72.99	0.55	(N/A)	1.28	0.00	0.09
River birch	14,750.76	110.63	(N/A)	1.07	0.75	22.13
Black maple	27,476.86	206.08	(N/A)	1.07	1.39	41.22
Black cherry	11,595.68	86.97	(N/A)	0.85	0.59	21.74
White ash	9,863.13	73.97	(N/A)	0.85	0.50	18.49
Quaking aspen	36.49	0.27	(N/A)	0.64	0.00	0.09
Other City Trees	141,881.58	1,064.11	(N/A)	11.11	7.18	581.49
Citywide total	1,975,700.61	14,817.75	(N/A)	100.00	100.00	31.66

Table 5: Annual Carbon Sequestered

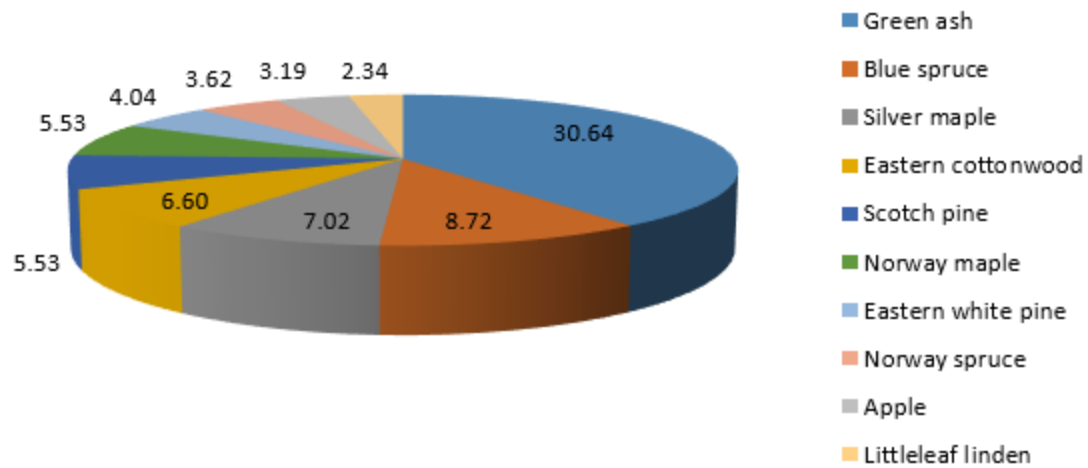
Annual CO2 Benefits of Public Trees by Species													
Species	Sequestered (lb)	Sequestered (\$)	Decomposition Release (lb)	Maintenance Release (lb)	Total Release (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total (\$)	Stand. Error	% of Total Trees	% of Total \$	Avg. \$/tree
Green ash	33,461.05	250.96	- 1,691.51	- 176.87	- 14.01	24,596.90	184.48	56,189.58	421.42	(N/A)	30.77	27.15	2.93
Blue spruce	457.32	3.43	- 22.70	- 16.19	- 0.29	1,350.21	10.13	1,768.65	13.26	(N/A)	8.76	0.85	0.32
Silver maple	27,770.59	208.28	- 1,606.55	- 80.93	- 12.66	12,424.14	93.18	38,507.24	288.80	(N/A)	6.84	18.61	9.03
Eastern cottonwood	21,438.76	160.79	- 2,650.55	- 104.13	- 20.66	16,138.16	121.04	34,822.24	261.17	(N/A)	6.62	16.83	8.42
Scotch pine	2,567.36	19.26	- 163.48	- 44.66	- 1.56	4,326.03	32.45	6,685.26	50.14	(N/A)	5.56	3.23	1.93
Norway maple	9,027.34	67.71	- 744.94	- 55.97	- 6.01	9,266.93	69.50	17,493.36	131.20	(N/A)	5.56	8.45	5.05
Eastern white pine	1,443.86	10.83	- 114.13	- 24.77	- 1.04	2,144.55	16.08	3,449.52	25.87	(N/A)	4.06	1.67	1.36
Norway spruce	1,017.59	7.63	- 79.09	- 18.14	- 0.73	1,515.99	11.37	2,436.35	18.27	(N/A)	3.63	1.18	1.07
Apple	1,186.38	8.90	- 59.84	- 10.73	- 0.53	1,079.63	8.10	2,195.44	16.47	(N/A)	3.21	1.06	1.10
Littleleaf linden	3,600.51	27.00	- 166.36	- 13.65	- 1.35	1,930.03	14.48	5,350.53	40.13	(N/A)	2.35	2.59	3.65
Sugar maple	5,211.68	39.09	- 523.63	- 23.79	- 4.11	3,627.48	27.21	8,291.75	62.19	(N/A)	1.50	4.01	8.88
Lilac	2,295.32	17.21	- 180.76	- 17.55	- 1.49	2,106.52	15.80	4,203.54	31.53	(N/A)	1.50	2.03	4.50
Swamp white oak	37.93	0.28	- 0.94	- 1.37	- 0.02	50.33	0.38	85.96	0.64	(N/A)	1.50	0.04	0.09
Bur oak	2,058.46	15.44	- 498.04	- 14.24	- 3.84	2,001.84	15.01	3,548.02	26.61	(N/A)	1.28	1.71	4.44
Black walnut	15.56	0.12	- 0.58	- 1.17	- 0.01	26.37	0.20	40.18	0.30	(N/A)	1.28	0.02	0.05
River birch	572.11	4.29	- 72.31	- 5.07	- 0.58	682.01	5.12	1,176.74	8.83	(N/A)	1.07	0.57	1.77
Black maple	486.02	3.65	- 131.94	- 10.34	- 1.07	1,868.53	14.01	2,212.27	16.59	(N/A)	1.07	1.07	3.32
Black cherry	973.84	7.30	- 55.66	- 7.02	- 0.47	891.57	6.69	1,802.73	13.52	(N/A)	0.85	0.87	3.38
White ash	1,157.76	8.68	- 48.53	- 5.07	- 0.40	784.38	5.88	1,888.54	14.16	(N/A)	0.85	0.91	3.54
Quaking aspen	7.78	0.06	- 0.29	- 0.59	- 0.01	13.19	0.10	20.09	0.15	(N/A)	0.64	0.01	0.05
Other City Trees	6,140.55	46.05	- 683.07	- 73.71	- 5.68	9,378.38	70.34	14,762.14	110.72	(N/A)	11.11	7.13	55.44
Citywide Total	120,927.77	906.96	- 9,494.91	- 705.91	- 76.51	96,203.17	721.52	206,930.12	1,551.98	(N/A)	100.00	100.00	3.32

Table 6: Annual Social and Aesthetic Benefits

Annual Aesthetic/Other Benefit of Public Trees by Species					
Species	Total (\$)	Stand. Error	% of Total Trees	% of Total \$	Avg. \$/tree
Green ash	4,000.38	(N/A)	30.77	30.73	27.78
Blue spruce	308.88	(N/A)	8.76	2.37	7.53
Silver maple	2,406.40	(N/A)	6.84	18.48	75.20
Eastern cottonwood	1,694.42	(N/A)	6.62	13.02	54.66
Scotch pine	631.55	(N/A)	5.56	4.85	24.29
Norway maple	871.51	(N/A)	5.56	6.69	33.52
Eastern white pine	366.58	(N/A)	4.06	2.82	19.29
Norway spruce	268.41	(N/A)	3.63	2.06	15.79
Apple	65.55	(N/A)	3.21	0.50	4.37
Littleleaf linden	376.99	(N/A)	2.35	2.90	34.27
Sugar maple	524.35	(N/A)	1.50	4.03	74.91
Lilac	137.09	(N/A)	1.50	1.05	19.58
Swamp white oak	19.15	(N/A)	1.50	0.15	2.74
Bur oak	160.38	(N/A)	1.28	1.23	26.73
Black walnut	31.57	(N/A)	1.28	0.24	5.26
River birch	62.70	(N/A)	1.07	0.48	12.54
Black maple	65.93	(N/A)	1.07	0.51	13.19
Black cherry	57.09	(N/A)	0.85	0.44	14.27
White ash	160.30	(N/A)	0.85	1.23	40.07
Quaking aspen	15.79	(N/A)	0.64	0.12	5.26
Other City Trees	793.92	(N/A)	11.11	6.10	402.89
Citywide Total	13,018.94	(N/A)	100.00	100.00	27.82

Table 7: Summary of Benefits in Dollars

Average Annual Benefits of Public Trees by Species (\$/tree)							
Species	Energy	CO2	Air Quality	Stormwater	Aesthetic/Other	Total	Stand. Error
Green ash	21.44	2.93	3.42	22.58	27.78	78.14	(N/A)
Blue spruce	4.26	0.32	0.48	5.45	7.53	18.05	(N/A)
Silver maple	48.01	9.03	8.47	81.70	75.20	222.41	(N/A)
Eastern cottonwood	65.52	8.42	12.07	101.62	54.66	242.30	(N/A)
Scotch pine	20.28	1.93	1.77	37.38	24.29	85.66	(N/A)
Norway maple	46.20	5.05	8.02	50.40	33.52	143.19	(N/A)
Eastern white pine	14.19	1.36	0.84	31.38	19.29	67.06	(N/A)
Norway spruce	11.49	1.07	0.68	24.28	15.79	53.31	(N/A)
Apple	9.89	1.10	1.57	4.87	4.37	21.80	(N/A)
Littleleaf linden	21.62	3.65	3.62	24.68	34.27	87.84	(N/A)
Sugar maple	64.08	8.88	10.46	103.47	74.91	261.80	(N/A)
Lilac	41.00	4.50	7.26	26.33	19.58	98.68	(N/A)
Swamp white oak	1.10	0.09	0.14	0.33	2.74	4.40	(N/A)
Bur oak	41.49	4.44	8.53	77.34	26.73	158.52	(N/A)
Black walnut	0.66	0.05	0.08	0.48	5.26	6.53	(N/A)
River birch	18.20	1.77	3.26	22.30	12.54	58.06	(N/A)
Black maple	46.41	3.32	8.70	55.37	13.19	126.98	(N/A)
Black cherry	30.16	3.38	5.00	16.05	14.27	68.87	(N/A)
White ash	24.75	3.54	4.02	28.22	40.07	100.60	(N/A)
Quaking aspen	0.66	0.05	0.08	0.48	5.26	6.53	(N/A)
Other City Trees	585.68	55.44	85.35	831.00	402.89	1,960.35	(N/A)
Citywide Total	25.91	3.32	4.14	35.36	27.82	96.53	(N/A)

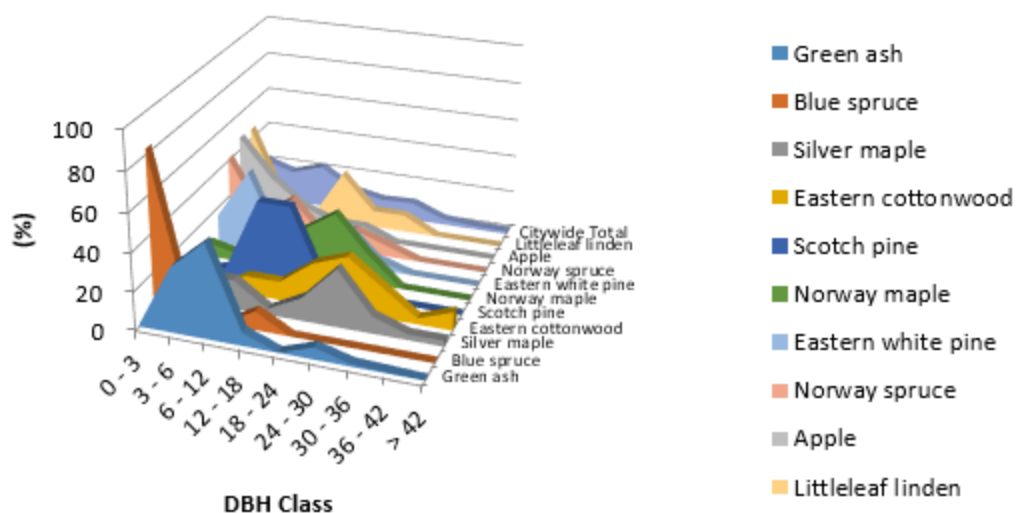


Species Distribution of Public Trees

Species	Percent
Green ash	30.64
Blue spruce	8.72
Silver maple	7.02
Eastern cottonwood	6.60
Scotch pine	5.53
Norway maple	5.53
Eastern white pine	4.04
Norway spruce	3.62
Apple	3.19
Littleleaf linden	2.34
Other Species	22.77

Figure 1: Species Distribution

Relative Age Distribution of Top 10 Public Tree Species (%)



Relative Age Distribution of Top 10 Public Tree Species (%)									
Species	0 - 3	3 - 6	6 - 12	12 - 18	18 - 24	24 - 30	30 - 36	36 - 42	> 42
Green ash	1.39	34.03	49.31	6.94	0.00	6.25	1.39	0.69	0.00
Blue spruce	82.93	7.32	0.00	9.76	0.00	0.00	0.00	0.00	0.00
Silver maple	6.06	15.15	15.15	3.03	12.12	30.30	9.09	3.03	3.03
Eastern cottonwood	0.00	0.00	9.68	9.68	22.58	29.03	16.13	3.23	9.68
Scotch pine	0.00	3.85	42.31	42.31	3.85	7.69	0.00	0.00	0.00
Norway maple	7.69	3.85	15.38	23.08	34.62	15.38	0.00	0.00	0.00
Eastern white pine	15.79	42.11	5.26	10.53	21.05	5.26	0.00	0.00	0.00
Norway spruce	41.18	11.76	23.53	5.88	11.76	5.88	0.00	0.00	0.00
Apple	46.67	26.67	13.33	6.67	6.67	0.00	0.00	0.00	0.00
Littleleaf linden	45.45	9.09	0.00	27.27	9.09	9.09	0.00	0.00	0.00
Citywide Total	22.55	17.45	22.77	12.13	8.94	9.57	2.98	1.70	1.49

Figure 2: Relative Age Class

% Functional (Foliage) Condition of Public Trees

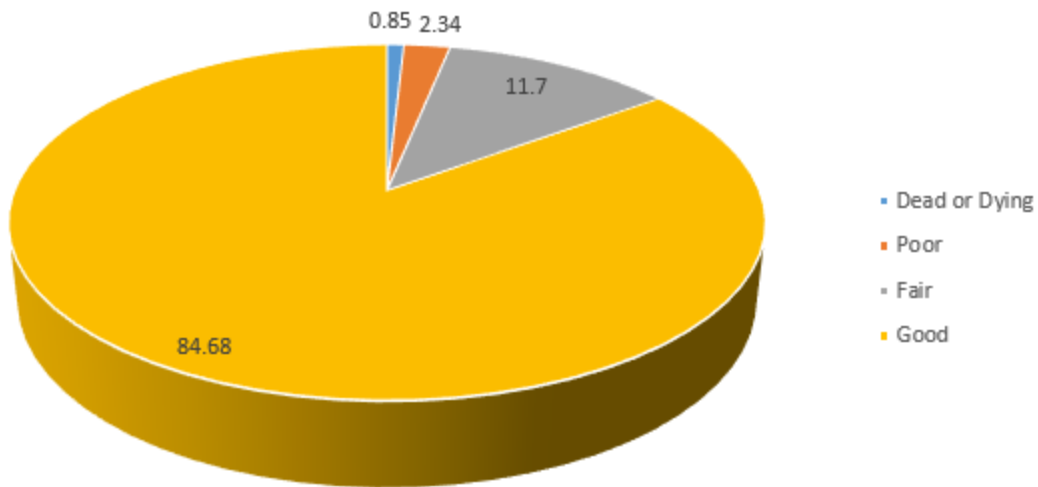


Figure 3: Foliage Condition

Structural (Woody) Condition of Public Trees (%)

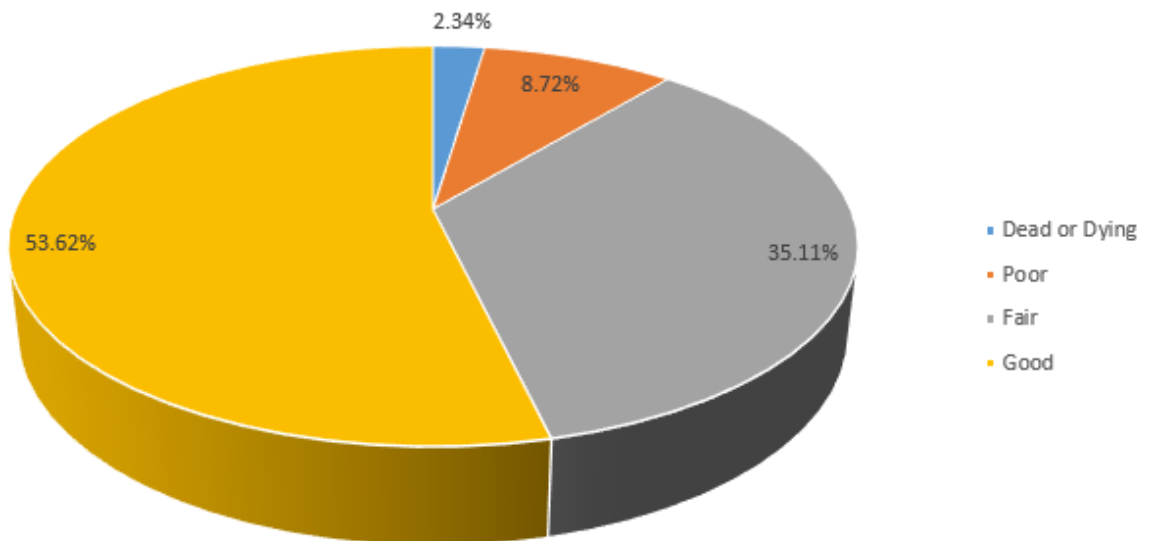


Figure 4: Wood Condition

Canopy Cover of Public Trees (Acres)

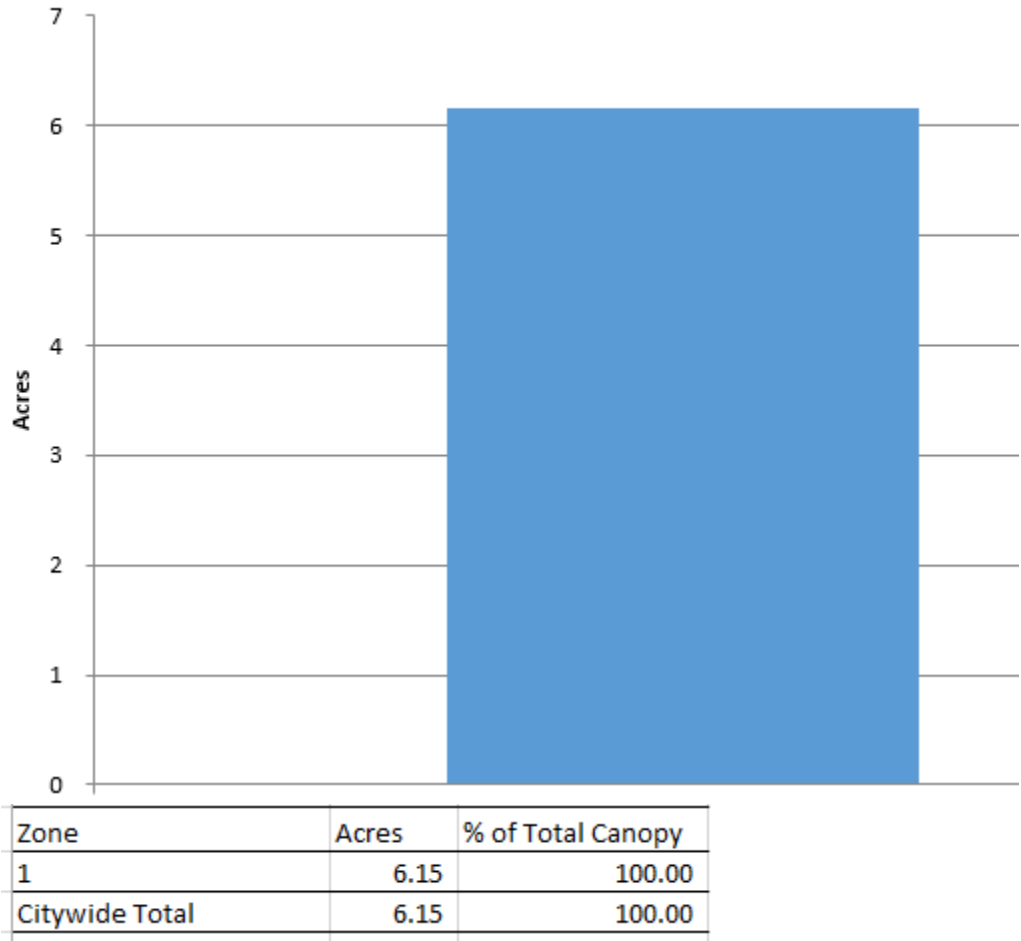


Figure 5: Canopy Cover in Acres

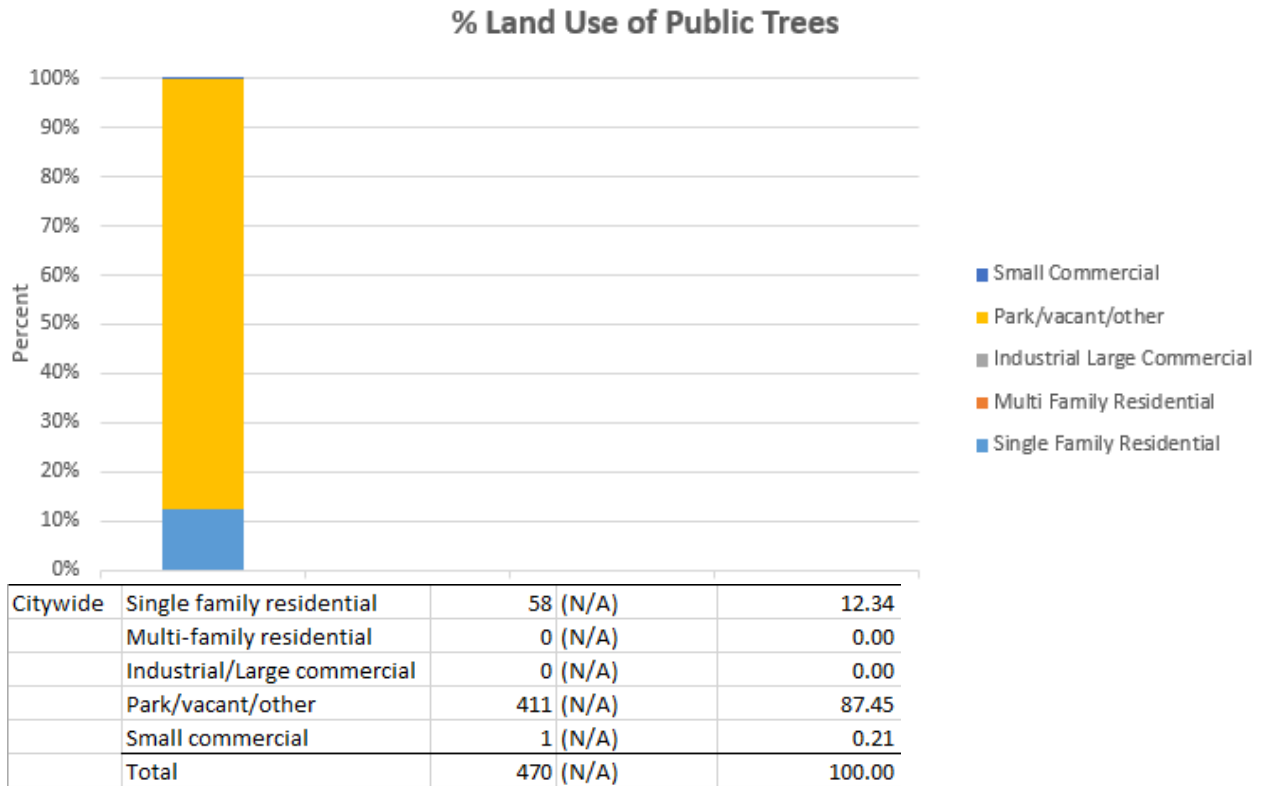


Figure 6: Land Use of city/park trees

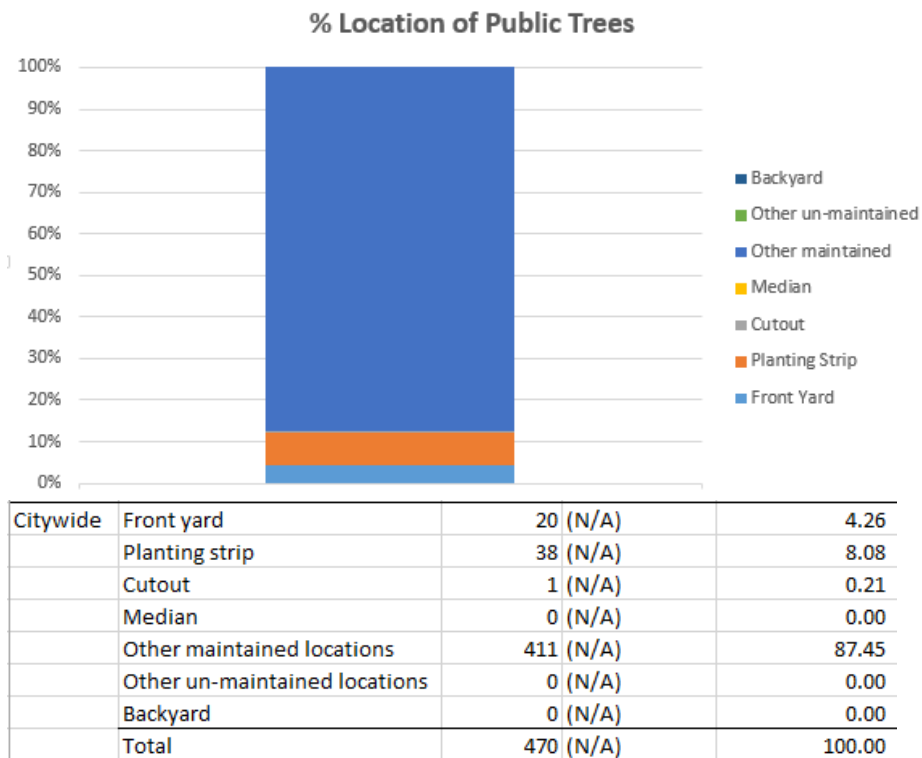


Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping



Figure 1: Location of Ash Trees













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