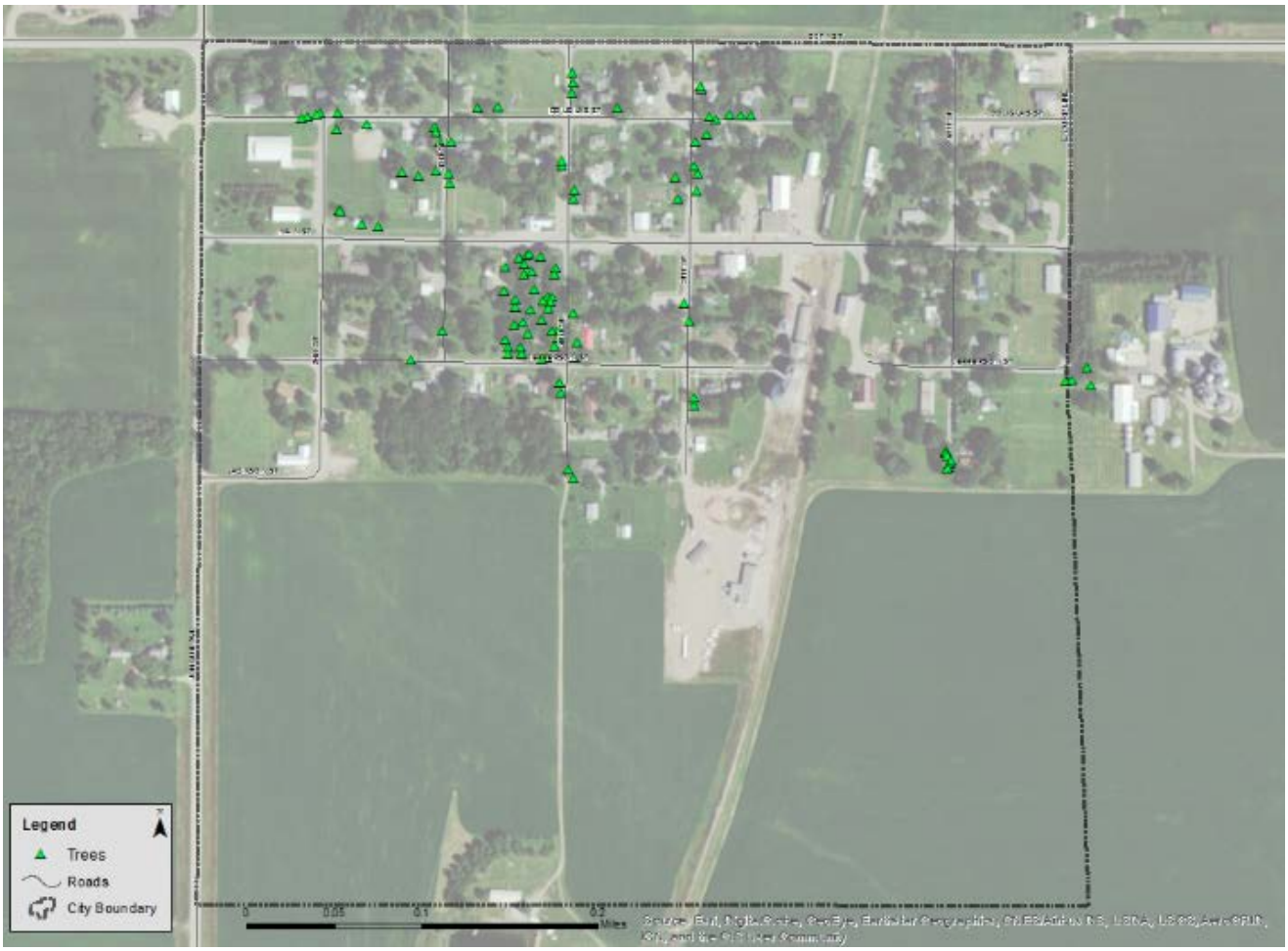
Swaledale, IA



2016 Urban Forest Management Plan
Prepared by Kittelson Consulting Arborist, LLC
In Partnership with the Iowa DNR

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Executive Summary

Overview

This plan was developed to assist the City of Swaledale 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 39% of Swaledale'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 104 trees inventoried.

- Swaledale's trees provide $24,063 of benefits annually, an average of $231 a tree
- There are 22 species of trees
- The top three genera are: Ash 39%, Maple 22%, and Apple (Crab) 3.8%%
- 61% of trees are in need of some type of management
- 34 trees (28 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 34 trees (28 ash) needing removal, 27 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*
- 7 of the 41 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 proposed current budget it could take 15 years to remove ash – Suggestion: request a budget increase to $6,000 annually and apply for grants to plant replacement trees

Introduction

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

Trees are an important component of Swaledale'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 Swaledale 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 Swaledale'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 104 city trees was entered into the USDA Forest service program STREETS, part of the i-Tree suite. The following are results from the i-Tree STREET analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Swaledale's trees reduce energy related costs by approximately $6,383 annually (Appendix A, Table 1). These savings are both in Electricity (30.1 MWh) and in Natural Gas (4,182 Therms).

Annual Stormwater Benefits

Swaledale's trees intercept about 364,724 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $9,884 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 Swaledale, it is estimated that trees remove 407 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 $1,156 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Swaledale trees sequester about 68,009 lbs. of carbon a year with an associated value of $510 (Appendix A, Table 4). In addition, the trees store 1,511,497 lbs. of carbon, with a yearly benefit of $11,336 (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. Swaledale receives $5,808 in annual social benefits from trees (Appendix A, Table 6).

Financial Summary of all Benefits

According to the USDA Forest Service i-Tree STREET analysis, Swaledale's trees provide $24,063 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 104 trees in Swaledale provide approximately $231 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Swaledale has 22 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Ash	41	39%
Maple	23	22%
Apple (Crab)	5	4.8%
Hackberry	4	3.8%
Oak	3	2.9%
Walnut	3	2.9%
Linden/Basswood	3	2.9%
Locust	2	1.9%
Spruce	2	1.9%
Others	18	17.3%

Age Class

Most of Swaledale's trees (79%) are greater than 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. Swaledale's size curve is on the larger side, indicating an older 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 Swaledale indicate that 87% of the trees are in good health, with only 1% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 34% of Swaledale'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 27% of the population. This 27% 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	25	24%
Crown Raising	4	3.8%
Tree Staking	0	0%
Tree Removal	34(28 ash)	32.7%
Crown Reduction	0	0%
Treat	12(ash)	11.5%

Canopy Cover

The total canopy with both private and public trees is 13%, 21 acres. The canopy cover included in the Swaledale inventory includes approximately 3.61 acres (Appendix A, Figure 5).

Land Use and Location

The majority of Swaledale'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	51%
Park/vacant/other	44%
Industrial/Large commercial	0%
Small commercial	5%
Multifamily residential	0%

Location	
Planting strip	71%
Front Yard	29%
Other maintained locations	0%
Cutout (surrounded by pavement)	0%
Front yard	0%

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

Swaledale has no critical concern trees that need immediate removal. Other trees 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 immediate concern trees first. There are 27 trees over 24 inches in diameter at 4.5 ft. that should be addressed immediately. Please refer to the six year maintenance plan at the end of this section. After all of the immediate concern trees are addressed, there should be follow up on the trees marked as needing maintenance. There are a total of 29 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 34 removals, 28 are ash trees. There are a total of 41 ash trees, and 7 of those have signs and symptoms that have been associated with EAB. In addition, there are 15 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 Swaledale.

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 (39%) (Appendix A, Figure 1). 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. Also maples currently at 22% canopy should not be planted

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: 3 largest immediate concern trees
Planting and Replacement: 3 trees to be planted in open locations
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 2

Removal: 3 ash trees with poor health
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 3 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: 3 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: 3 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: 3 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: 3 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 15 ash trees removed (approximately 37% of ash). It will take approximately 17 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 $7,200 a year. If the budget were increased to $10,000 a year all ash could be removed in 3 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. 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

Current Budget
Total $15,300 over 6 years ($2,550/year)

FY 2017 Budget
Removal: $2,100
*Or saving for ash tree treatment and/or future ash removal
Planting: $300
Watering & Maintenance: $100

FY 2018 Budget
Removal: $2,100
*Or saving for ash tree treatment and/or future ash removal
Planting: $300
Routine trimming: $100
Watering & Maintenance: $100

FY 2019 Budget
R Removal: $2,100
*Or saving for ash tree treatment and/or future ash removal
Planting: $300
Watering & Maintenance: $100

FY 2020 Budget
Removal: $2,100
*Or saving for ash tree treatment and/or future ash removal
Planting: $300
Routine trimming: $100
Watering & Maintenance: $100

FY 2021 Budget
Removal: $2,100
*Or saving for ash tree treatment and/or future ash removal
Planting: $300
Watering & Maintenance: $100

FY 2022 Budget
Removal: $2,100
*Or saving for ash tree treatment and/or future ash removal
Planting: $300
Routine trimming: $100
Watering & Maintenance: $100

*Reduction of ash over 6 years: 15 ash trees removed (approximately 37% of ash). **It will take approximately 15 years to remove all ash with the proposed budget.**

Purposed Budget Increase
EAB could potentially kill all ash trees in Swaledale within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $7,200 a year. If the budget

were increased to $10,000 a year all ash could be removed within 3 years. Additionally, it is recommended that Swaledale 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 6 of 12 trees could be treated per year (every other year treatment). This would be 6 trees selected for treatment, and Swaledale would still need to find $3,700 for removal. Alternatively, if all 12 treatable trees are treated the same year (and then every other year), it would cost approximately $3,600 those years for treatment and leave $1,900 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 Swaledale 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 ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	13.18	1,000.25	1,819.47	1,783.08	2,783.33	(N/A)	37.50	43.61	71.37
Norway maple	4.38	332.69	633.92	621.25	953.94	(N/A)	14.42	14.95	63.60
Silver maple	3.73	283.42	487.92	478.16	761.58	(N/A)	10.58	11.93	69.23
Black maple	1.71	129.49	239.40	234.61	364.10	(N/A)	5.77	5.70	60.68
Apple	0.63	47.62	95.50	93.59	141.22	(N/A)	4.81	2.21	28.24
Northern hackberry	1.70	129.26	238.48	233.71	362.97	(N/A)	3.85	5.69	90.74
Black walnut	0.92	69.95	131.83	129.19	199.14	(N/A)	2.88	3.12	66.38
Northern pin oak	0.58	44.28	86.98	85.24	129.52	(N/A)	1.92	2.03	64.76
Mulberry	0.10	7.30	16.63	16.30	23.60	(N/A)	1.92	0.37	11.80
White ash	0.36	27.35	41.71	40.87	68.22	(N/A)	1.92	1.07	34.11
Honeylocust	0.67	51.13	89.73	87.94	139.07	(N/A)	1.92	2.18	69.53
Norway spruce	0.37	28.14	49.19	48.21	76.35	(N/A)	1.92	1.20	38.17
Littleleaf linden	0.25	19.16	37.75	36.99	56.15	(N/A)	1.92	0.88	28.08
American basswood	0.35	26.89	51.41	50.38	77.27	(N/A)	0.96	1.21	77.27
Austrian pine	0.14	10.52	19.52	19.13	29.65	(N/A)	0.96	0.46	29.65
Northern red oak	0.04	2.94	5.42	5.31	8.25	(N/A)	0.96	0.13	8.25
Eastern red cedar	0.11	8.45	16.44	16.11	24.57	(N/A)	0.96	0.38	24.57
Mountain ash	0.20	15.15	31.62	30.99	46.14	(N/A)	0.96	0.72	46.14
Eastern cottonwood	0.23	17.78	26.99	26.45	44.23	(N/A)	0.96	0.69	44.23
Red maple	0.04	2.73	5.22	5.12	7.85	(N/A)	0.96	0.12	7.85
Sugar maple	0.32	24.20	44.20	43.31	67.52	(N/A)	0.96	1.06	67.52
Eastern redbud	0.07	5.62	12.83	12.58	18.19	(N/A)	0.96	0.29	18.19
Total	30.10	2,284.33	4,182.17	4,098.53	6,382.86	(N/A)	100.00	100.00	61.37

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees by Species						
Species	Total Rainfall Interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	169,904.85	4,604.42	(N/A)	37.50	46.58	118.06
Norway maple	45,544.24	1,234.25	(N/A)	14.42	12.49	82.28
Silver maple	56,054.93	1,519.09	(N/A)	10.58	15.37	138.10
Black maple	17,201.88	466.17	(N/A)	5.77	4.72	77.70
Apple	3,151.92	85.42	(N/A)	4.81	0.86	17.08
Northern hackberry	18,716.46	507.22	(N/A)	3.85	5.13	126.80
Black walnut	10,476.59	283.92	(N/A)	2.88	2.87	94.64
Northern pin oak	6,243.63	169.20	(N/A)	1.92	1.71	84.60
Mulberry	333.15	9.03	(N/A)	1.92	0.09	4.51
White ash	2,276.19	61.68	(N/A)	1.92	0.62	30.84
Honeylocust	7,589.98	205.69	(N/A)	1.92	2.08	102.84
Norway spruce	9,209.30	249.57	(N/A)	1.92	2.53	124.79
Littleleaf linden	2,460.02	66.67	(N/A)	1.92	0.67	33.33
American basswood	4,608.88	124.90	(N/A)	0.96	1.26	124.90
Austrian pine	2,312.35	62.66	(N/A)	0.96	0.63	62.66
Northern red oak	167.51	4.54	(N/A)	0.96	0.05	4.54
Eastern red cedar	1,634.54	44.30	(N/A)	0.96	0.45	44.30
Mountain ash	1,174.03	31.82	(N/A)	0.96	0.32	31.82
Eastern cottonwood	1,465.55	39.72	(N/A)	0.96	0.40	39.72
Red maple	137.26	3.72	(N/A)	0.96	0.04	3.72
Sugar maple	3,795.76	102.86	(N/A)	0.96	1.04	102.86
Eastern redbud	264.49	7.17	(N/A)	0.96	0.07	7.17
Citywide total	364,723.50	9,884.01	(N/A)	100.00	100.00	95.04

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 ($)	Total (lb)	Total ($)	Standard Error	% of Total Trees	Avg. $/tree
Green ash	24.16	3.87	11.09	1.08	127.33	63.07	9.17	8.74	59.72	392.50	0.00	0.00	180.90	519.83	(N/A)	37.50	13.33
Norway maple	9.91	1.71	4.79	0.44	53.29	21.27	3.07	2.92	19.88	131.69	- 2.27	- 8.51	61.72	176.46	(N/A)	14.42	11.76
Silver maple	10.43	1.77	5.06	0.46	56.06	17.58	2.58	2.46	16.89	110.05	- 5.64	- 21.15	51.59	144.96	(N/A)	10.58	13.18
Black maple	4.49	0.77	2.06	0.20	23.82	8.19	1.19	1.13	7.73	50.88	- 1.46	- 5.46	24.29	69.24	(N/A)	5.77	11.54
Apple	1.08	0.18	0.50	0.05	5.73	3.08	0.44	0.42	2.84	18.97	- 0.01	- 0.02	8.58	24.67	(N/A)	4.81	4.93
Northern hackberry	3.63	0.63	1.77	0.16	19.59	8.19	1.19	1.13	7.72	50.90	0.00	0.00	24.43	70.49	(N/A)	3.85	17.62
Black walnut	1.25	0.20	0.60	0.06	6.69	4.45	0.64	0.61	4.18	27.60	0.00	0.00	12.00	34.29	(N/A)	2.88	11.43
Northern pin oak	1.36	0.23	0.65	0.06	7.29	2.85	0.41	0.39	2.65	17.61	- 0.31	- 1.16	8.29	23.74	(N/A)	1.92	11.87
Mulberry	0.05	0.01	0.03	0.00	0.28	0.49	0.07	0.07	0.44	2.97	0.00	0.00	1.15	3.26	(N/A)	1.92	1.63
White ash	0.13	0.02	0.09	0.01	0.77	1.65	0.25	0.24	1.63	10.46	0.00	0.00	4.01	11.22	(N/A)	1.92	5.61
Honeylocust	1.49	0.25	0.68	0.07	7.85	3.19	0.47	0.44	3.05	19.91	- 1.14	- 4.28	8.48	23.48	(N/A)	1.92	11.74
Norway spruce	1.14	0.23	0.90	0.14	7.38	1.75	0.26	0.24	1.68	10.96	- 5.73	- 21.48	0.60	- 3.15	(N/A)	1.92	- 1.58
Littleleaf linden	0.39	0.07	0.20	0.02	2.13	1.24	0.18	0.17	1.15	7.63	- 0.19	- 0.72	3.21	9.03	(N/A)	1.92	4.52
American basswood	0.68	0.12	0.32	0.03	3.63	1.72	0.25	0.24	1.61	10.65	- 0.56	- 2.10	4.40	12.18	(N/A)	0.96	12.18
Austrian pine	0.35	0.07	0.28	0.04	2.30	0.66	0.10	0.09	0.63	4.13	- 0.89	- 3.33	1.34	3.10	(N/A)	0.96	3.10
Northern red oak	0.01	0.00	0.01	0.00	0.07	0.18	0.03	0.03	0.18	1.15	- 0.02	- 0.07	0.42	1.15	(N/A)	0.96	1.15
Eastern red cedar	0.34	0.07	0.27	0.04	2.23	0.54	0.08	0.07	0.50	3.34	- 0.90	- 3.39	1.02	2.19	(N/A)	0.96	2.19
Mountain ash	0.43	0.07	0.20	0.02	2.28	0.99	0.14	0.13	0.90	6.07	0.00	- 0.01	2.89	8.35	(N/A)	0.96	8.35
Eastern cottonwood	0.11	0.02	0.07	0.00	0.62	1.07	0.16	0.15	1.06	6.80	0.00	0.00	2.65	7.42	(N/A)	0.96	7.42
Red maple	0.01	0.00	0.01	0.00	0.06	0.17	0.03	0.02	0.16	1.08	0.00	- 0.01	0.40	1.12	(N/A)	0.96	1.12
Sugar maple	0.51	0.09	0.25	0.02	2.74	1.53	0.22	0.21	1.44	9.49	- 0.39	- 1.48	3.87	10.75	(N/A)	0.96	10.75
Eastern redbud	0.05	0.01	0.03	0.00	0.26	0.38	0.05	0.05	0.34	2.29	0.00	0.00	0.90	2.55	(N/A)	0.96	2.55
Citywide Total	62.00	10.35	29.83	2.91	332.39	144.24	20.96	19.97	136.38	897.12	- 19.52	- 73.18	407.13	1,156.32	(N/A)	100.00	11.12

Table 4: Annual Carbon Stored

Stored CO2 Benefits of Public Trees by Species						
Species	Total stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	798,277.85	5,987.08	(N/A)	37.50	52.81	153.51
Norway maple	163,229.66	1,224.22	(N/A)	14.42	10.80	81.61
Silver maple	261,789.18	1,963.42	(N/A)	10.58	17.32	178.49
Black maple	47,671.72	357.54	(N/A)	5.77	3.15	59.59
Apple	16,878.17	126.59	(N/A)	4.81	1.12	25.32
Northern hackberry	58,533.90	439.00	(N/A)	3.85	3.87	109.75
Black walnut	40,003.21	300.02	(N/A)	2.88	2.65	100.01
Northern pin oak	22,225.43	166.69	(N/A)	1.92	1.47	83.35
Mulberry	1,085.70	8.14	(N/A)	1.92	0.07	4.07
White ash	4,706.36	35.30	(N/A)	1.92	0.31	17.65
Honeylocust	18,987.56	142.41	(N/A)	1.92	1.26	71.20
Norway spruce	14,980.59	112.35	(N/A)	1.92	0.99	56.18
Littleleaf linden	8,404.57	63.03	(N/A)	1.92	0.56	31.52
American basswood	24,951.71	187.14	(N/A)	0.96	1.65	187.14
Austrian pine	2,661.24	19.96	(N/A)	0.96	0.18	19.96
Northern red oak	186.59	1.40	(N/A)	0.96	0.01	1.40
Eastern red cedar	1,102.07	8.27	(N/A)	0.96	0.07	8.27
Mountain ash	6,742.71	50.57	(N/A)	0.96	0.45	50.57
Eastern cottonwood	3,671.83	27.54	(N/A)	0.96	0.24	27.54
Red maple	218.47	1.64	(N/A)	0.96	0.01	1.64
Sugar maple	14,280.15	107.10	(N/A)	0.96	0.94	107.10
Eastern redbud	907.91	6.81	(N/A)	0.96	0.06	6.81
Citywide total	1,511,496.56	11,336.22	(N/A)	100.00	100.00	109.00

Table 5: Annual Carbon Sequestered

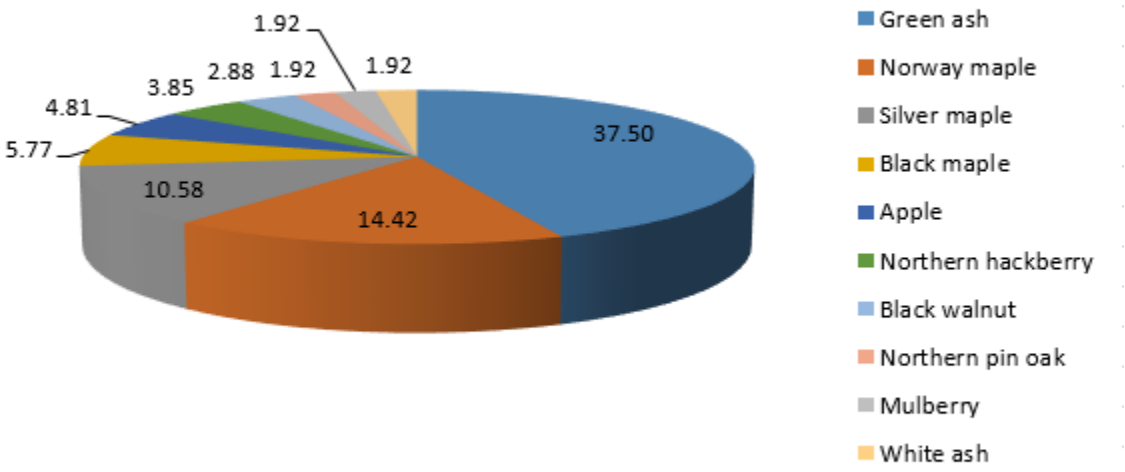
Annual CO2 Benefits of Public Trees by Species													
Species	Sequestered (lb)	Sequestered ($)	Decomposition Release(lb)	Maintenance Release (lb)	Total Release ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	Stand. Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	30,615.33	229.62	- 3,831.73	- 143.33	- 29.81	22,105.28	165.79	48,745.56	365.59	(N/A)	37.50	43.95	9.37
Norway maple	4,787.86	35.91	- 783.50	- 47.97	- 6.24	7,352.38	55.14	11,308.77	84.82	(N/A)	14.42	10.20	5.65
Silver maple	17,423.18	130.67	- 1,256.59	- 43.29	- 9.75	6,263.47	46.98	22,386.77	167.90	(N/A)	10.58	20.19	15.26
Black maple	923.35	6.93	- 228.82	- 16.38	- 1.84	2,861.78	21.46	3,539.92	26.55	(N/A)	5.77	3.19	4.42
Apple	1,300.42	9.75	- 81.02	- 8.58	- 0.67	1,052.42	7.89	2,263.25	16.97	(N/A)	4.81	2.04	3.39
Northern hackberry	2,359.77	17.70	- 280.96	- 17.16	- 2.24	2,856.62	21.42	4,918.26	36.89	(N/A)	3.85	4.43	9.22
Black walnut	2,373.44	17.80	- 192.02	- 9.75	- 1.51	1,545.90	11.59	3,717.58	27.88	(N/A)	2.88	3.35	9.29
Northern pin oak	469.91	3.52	- 106.68	- 7.02	- 0.85	978.61	7.34	1,334.82	10.01	(N/A)	1.92	1.20	5.01
Mulberry	151.81	1.14	- 5.21	- 1.76	- 0.05	161.34	1.21	306.19	2.30	(N/A)	1.92	0.28	1.15
White ash	675.74	5.07	- 22.59	- 3.12	- 0.19	604.33	4.53	1,254.36	9.41	(N/A)	1.92	1.13	4.70
Honeylocust	2,422.19	18.17	- 91.14	- 5.46	- 0.72	1,129.99	8.47	3,455.58	25.92	(N/A)	1.92	3.12	12.96
Norway spruce	256.05	1.92	- 71.91	- 7.80	- 0.60	621.91	4.66	798.25	5.99	(N/A)	1.92	0.72	2.99
Littleleaf linden	848.91	6.37	- 40.94	- 3.32	- 0.33	423.41	3.18	1,228.07	9.21	(N/A)	1.92	1.11	4.61
American basswood	1,364.80	10.24	- 119.77	- 4.29	- 0.93	594.23	4.46	1,834.98	13.76	(N/A)	0.96	1.65	13.76
Austrian pine	147.05	1.10	- 12.77	- 2.73	- 0.12	232.57	1.74	364.11	2.73	(N/A)	0.96	0.33	2.73
Northern red oak	55.13	0.41	- 0.90	- 0.59	- 0.01	64.88	0.49	118.54	0.89	(N/A)	0.96	0.11	0.89
Eastern red cedar	0.00	0.00	- 5.29	- 1.95	- 0.05	186.85	1.40	179.61	1.35	(N/A)	0.96	0.16	1.35
Mountain ash	478.45	3.59	- 32.37	- 2.73	- 0.26	334.78	2.51	778.13	5.84	(N/A)	0.96	0.70	5.84
Eastern cottonwood	445.34	3.34	- 17.62	- 1.95	- 0.15	392.87	2.95	818.63	6.14	(N/A)	0.96	0.74	6.14
Red maple	38.73	0.29	- 1.05	- 0.59	- 0.01	60.38	0.45	97.48	0.73	(N/A)	0.96	0.09	0.73
Sugar maple	757.53	5.68	- 68.54	- 3.51	- 0.54	534.87	4.01	1,220.34	9.15	(N/A)	0.96	1.10	9.15
Eastern redbud	113.87	0.85	- 4.36	- 1.17	- 0.04	124.15	0.93	232.50	1.74	(N/A)	0.96	0.21	1.74
Citywide Total	68,008.88	510.07	- 7,255.78	- 334.43	- 56.93	50,483.05	378.62	110,901.72	831.76	(N/A)	100.00	100.00	8.00

Table 6: Annual Social and Aesthetic Benefits

Annual Aesthetic/Other Benefit of Public Trees by Species					
Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	2,300.71	(N/A)	37.50	39.61	58.99
Norway maple	435.40	(N/A)	14.42	7.50	29.03
Silver maple	1,279.68	(N/A)	10.58	22.03	116.33
Black maple	109.09	(N/A)	5.77	1.88	18.18
Apple	77.20	(N/A)	4.81	1.33	15.44
Northern hackberry	281.03	(N/A)	3.85	4.84	70.26
Black walnut	188.87	(N/A)	2.88	3.25	62.96
Northern pin oak	43.06	(N/A)	1.92	0.74	21.53
Mulberry	8.46	(N/A)	1.92	0.15	4.23
White ash	97.16	(N/A)	1.92	1.67	48.58
Honeylocust	583.50	(N/A)	1.92	10.05	291.75
Norway spruce	26.26	(N/A)	1.92	0.45	13.13
Littleleaf linden	92.00	(N/A)	1.92	1.58	46.00
American basswood	94.13	(N/A)	0.96	1.62	94.13
Austrian pine	19.97	(N/A)	0.96	0.34	19.97
Northern red oak	7.21	(N/A)	0.96	0.12	7.21
Eastern red cedar	0.00	(N/A)	0.96	0.00	0.00
Mountain ash	28.80	(N/A)	0.96	0.50	28.80
Eastern cottonwood	45.86	(N/A)	0.96	0.79	45.86
Red maple	7.28	(N/A)	0.96	0.13	7.28
Sugar maple	76.42	(N/A)	0.96	1.32	76.42
Eastern redbud	6.40	(N/A)	0.96	0.11	6.40
Citywide Total	5,808.49	(N/A)	100.00	100.00	55.85

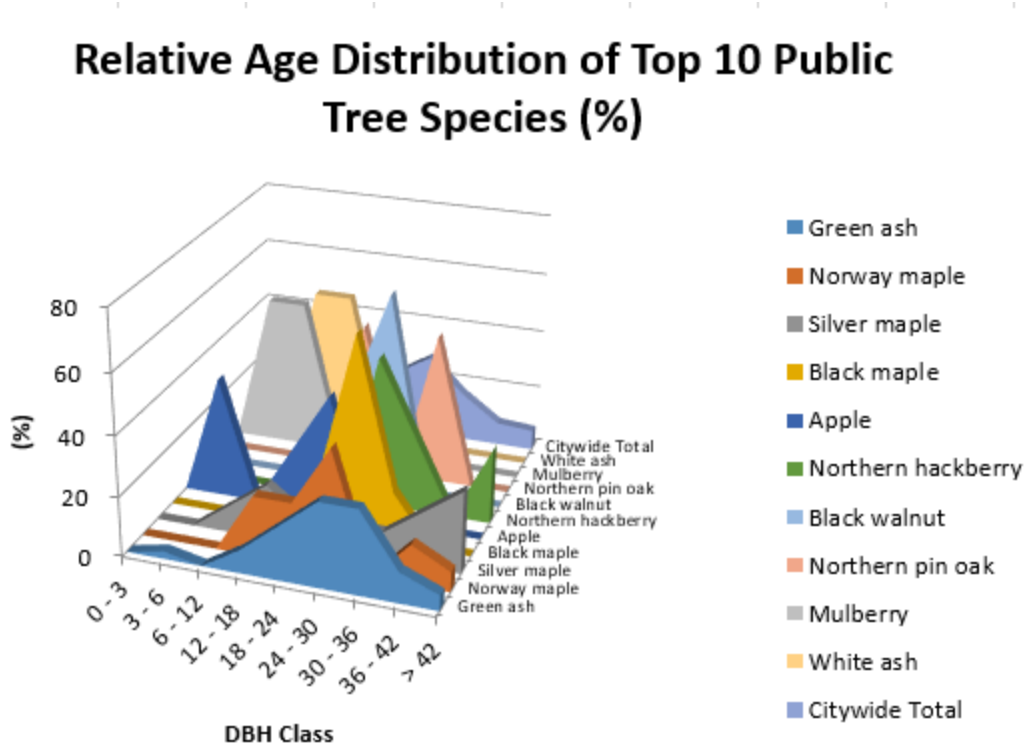
Table 7: Summary of Benefits in Dollars

Average Annual Benefits of Public Trees by Species ($/tree)							
Species	Energy	CO2	Air Quality	Stormwater	Aesthetic/Other	Total	Stand.
Green ash	71.37	9.37	13.33	118.06	58.99	271.13	(N/A)
Norway maple	63.60	5.65	11.76	82.28	29.03	192.32	(N/A)
Silver maple	69.23	15.26	13.18	138.10	116.33	352.11	(N/A)
Black maple	60.68	4.42	11.54	77.70	18.18	172.53	(N/A)
Apple	28.24	3.39	4.93	17.08	15.44	69.10	(N/A)
Northern hackberry	90.74	9.22	17.62	126.80	70.26	314.65	(N/A)
Black walnut	66.38	9.29	11.43	94.64	62.96	244.70	(N/A)
Northern pin oak	64.76	5.01	11.87	84.60	21.53	187.77	(N/A)
Mulberry	11.80	1.15	1.63	4.51	4.23	23.32	(N/A)
White ash	34.11	4.70	5.61	30.84	48.58	123.85	(N/A)
Honeylocust	69.53	12.96	11.74	102.84	291.75	488.83	(N/A)
Norway spruce	38.17	2.99	- 1.58	124.79	13.13	177.51	(N/A)
Littleleaf linden	28.08	4.61	4.52	33.33	46.00	116.53	(N/A)
American basswood	77.27	13.76	12.18	124.90	94.13	322.23	(N/A)
Austrian pine	29.65	2.73	3.10	62.66	19.97	118.11	(N/A)
Northern red oak	8.25	0.89	1.15	4.54	7.21	22.03	(N/A)
Eastern red cedar	24.57	1.35	2.19	44.30	0.00	72.40	(N/A)
Mountain ash	46.14	5.84	8.35	31.82	28.80	120.94	(N/A)
Eastern cottonwood	44.23	6.14	7.42	39.72	45.86	143.36	(N/A)
Red maple	7.85	0.73	1.12	3.72	7.28	20.71	(N/A)
Sugar maple	67.52	9.15	10.75	102.86	76.42	266.71	(N/A)
Eastern redbud	18.19	1.74	2.55	7.17	6.40	36.05	(N/A)
Citywide Total	61.37	8.00	11.12	95.04	55.85	231.38	(N/A)



Species Distribution of Public Trees	
12/21/2016	
Species	Percent
Green ash	37.50
Norway maple	14.42
Silver maple	10.58
Black maple	5.77
Apple	4.81
Northern hackberry	3.85
Black walnut	2.88
Northern pin oak	1.92
Mulberry	1.92
White ash	1.92
Other Species	14.42

Figure 1: Species Distribution



Relative Age Distribution of Top 10 Public Tree Species (%)									
	DBH class (in)								
Species	0 - 3	3 - 6	6 - 12	12 - 18	18 - 24	24 - 30	30 - 36	36 - 42	>42
Green ash	0.00	2.56	0.00	7.69	17.95	28.21	28.21	10.26	5.13
Norway maple	0.00	0.00	0.00	20.00	20.00	40.00	0.00	13.33	6.67
Silver maple	0.00	0.00	9.09	18.18	9.09	9.09	9.09	18.18	27.27
Black maple	0.00	0.00	0.00	0.00	16.67	66.67	16.67	0.00	0.00
Apple	0.00	40.00	0.00	20.00	40.00	0.00	0.00	0.00	0.00
Northern hackberry	0.00	0.00	0.00	0.00	0.00	50.00	25.00	0.00	25.00
Black walnut	0.00	0.00	0.00	0.00	33.33	66.67	0.00	0.00	0.00
Northern pin oak	0.00	0.00	0.00	0.00	50.00	0.00	50.00	0.00	0.00
Mulberry	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00
White ash	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00
Citywide Total	0.00	6.73	3.85	10.58	20.19	27.88	16.35	7.69	6.73

Figure 2: Relative Age Class

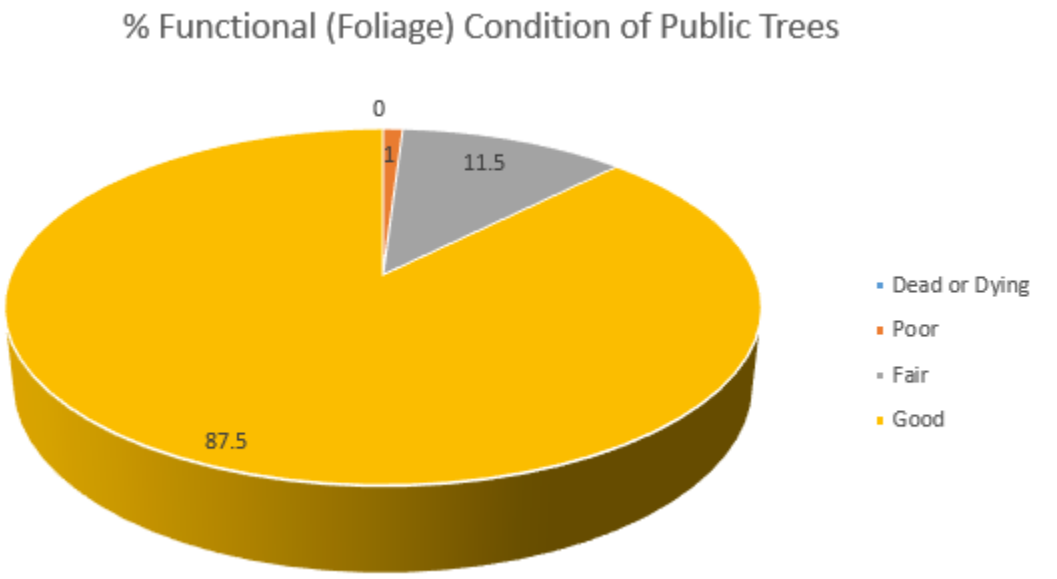


Figure 3: Foliage Condition

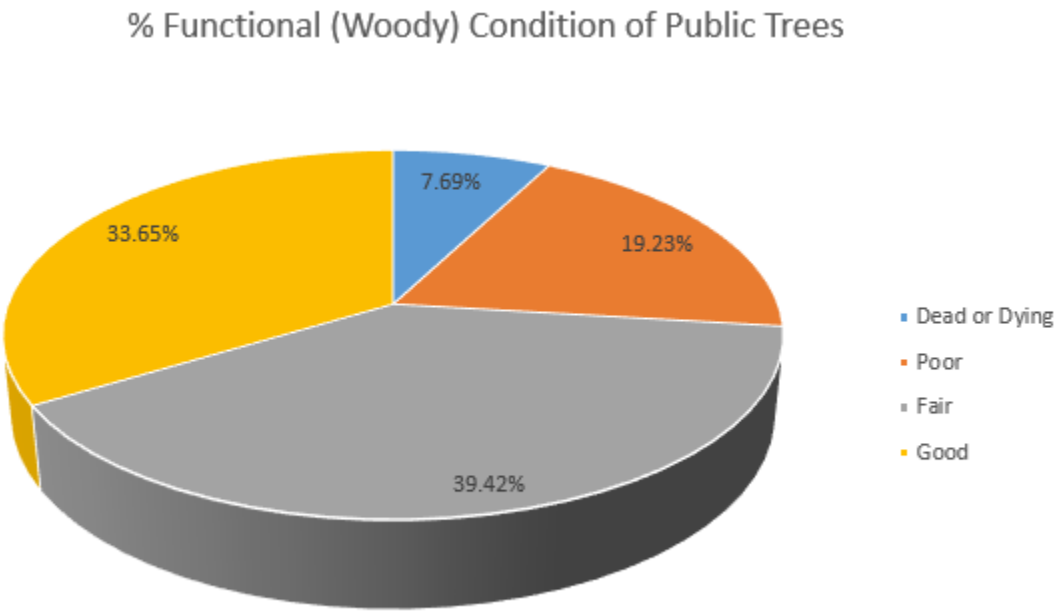
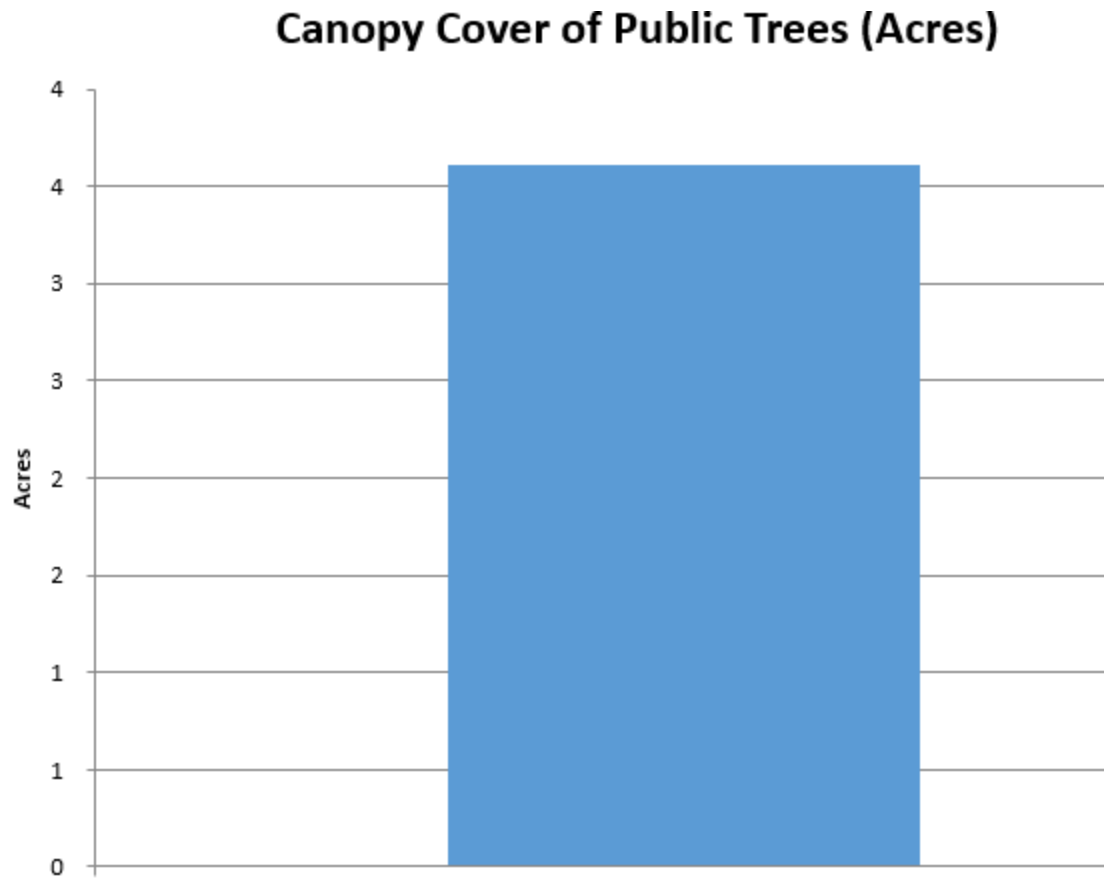


Figure 4: Wood Condition

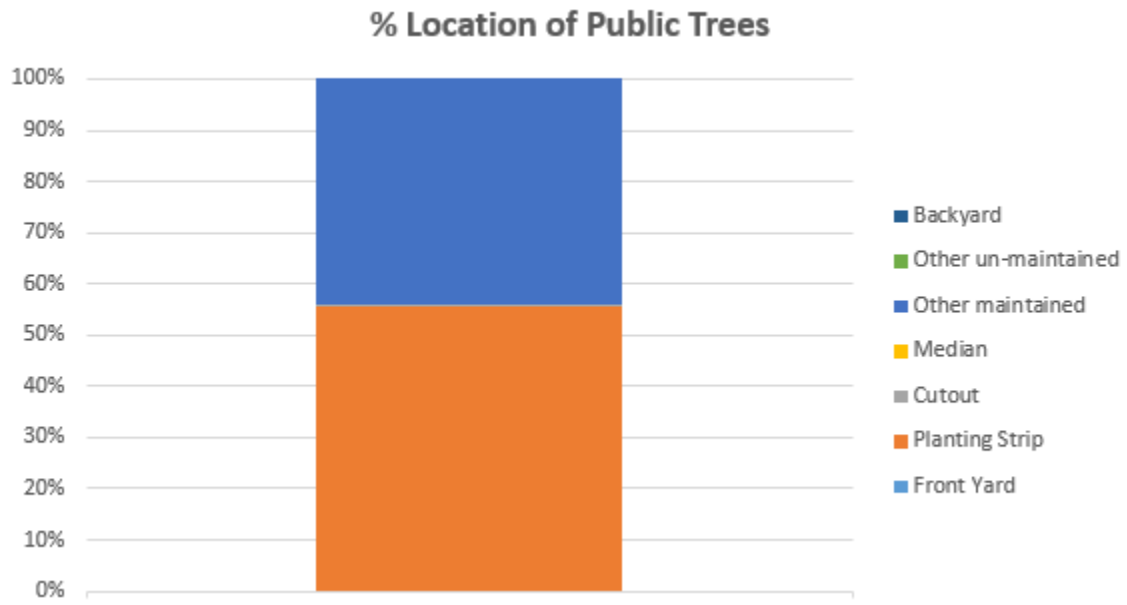


Canopy Cover of Public Trees (Acres)		
12/21/2016		
Zone	Acres	% of Total Canopy
1	3.61	100.00
Citywide Total	3.61	100.00

Figure 5: Canopy Cover in Acres

Citywide	Single family residential	53	(N/A)	50.96	50.96
	Multi-family residential	0	(N/A)	0.00	0.00
	Industrial/Large commercial	0	(N/A)	0.00	0.00
	Park/vacant/other	46	(N/A)	44.23	44.23
	Small Commercial	5	(N/A)	4.81	4.81
	Total	104	(N/A)	100.00	100.00

Figure 6: Land Use of city/park trees



Citywide	Front yard	0	(N/A)	0.00
	Planting strip	58	(N/A)	55.77
	Cutout	0	(N/A)	0.00
	Median	0	(N/A)	0.00
	Other maintained locations	46	(N/A)	44.23
	Other un-maintained locations	0	(N/A)	0.00
	Backyard	0	(N/A)	0.00
	Total	104	(N/A)	100.00

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 Ash with Canopy Dieback

Figure 4: Location of Ash with Epicormic Shoots

U


Legend
Epicormic Shoots
Roads
City Boundary

Figure 5: Location of Treatable Ash in Good Condition

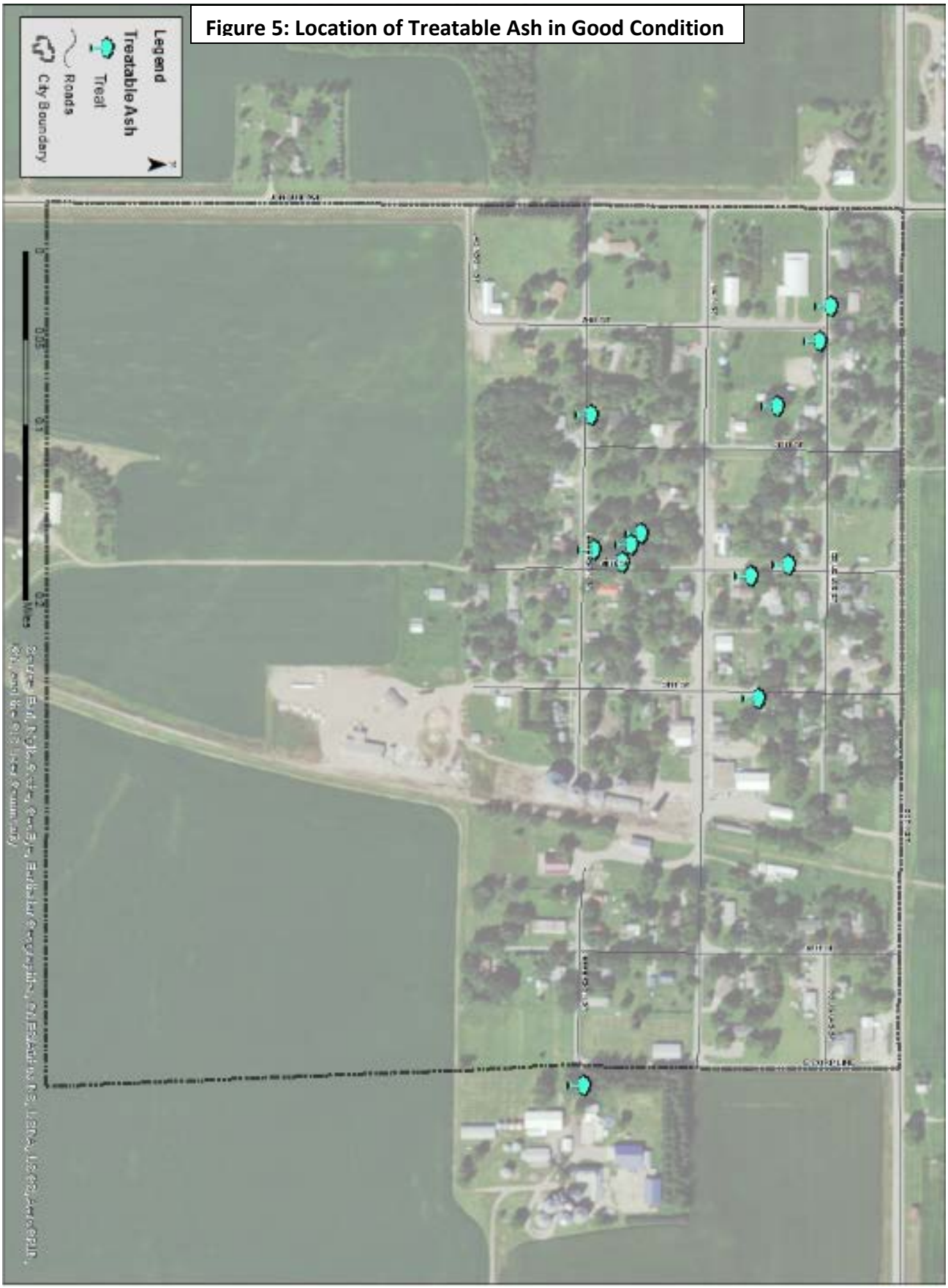


Figure 6: Location of Trees with Recommended Maintenance

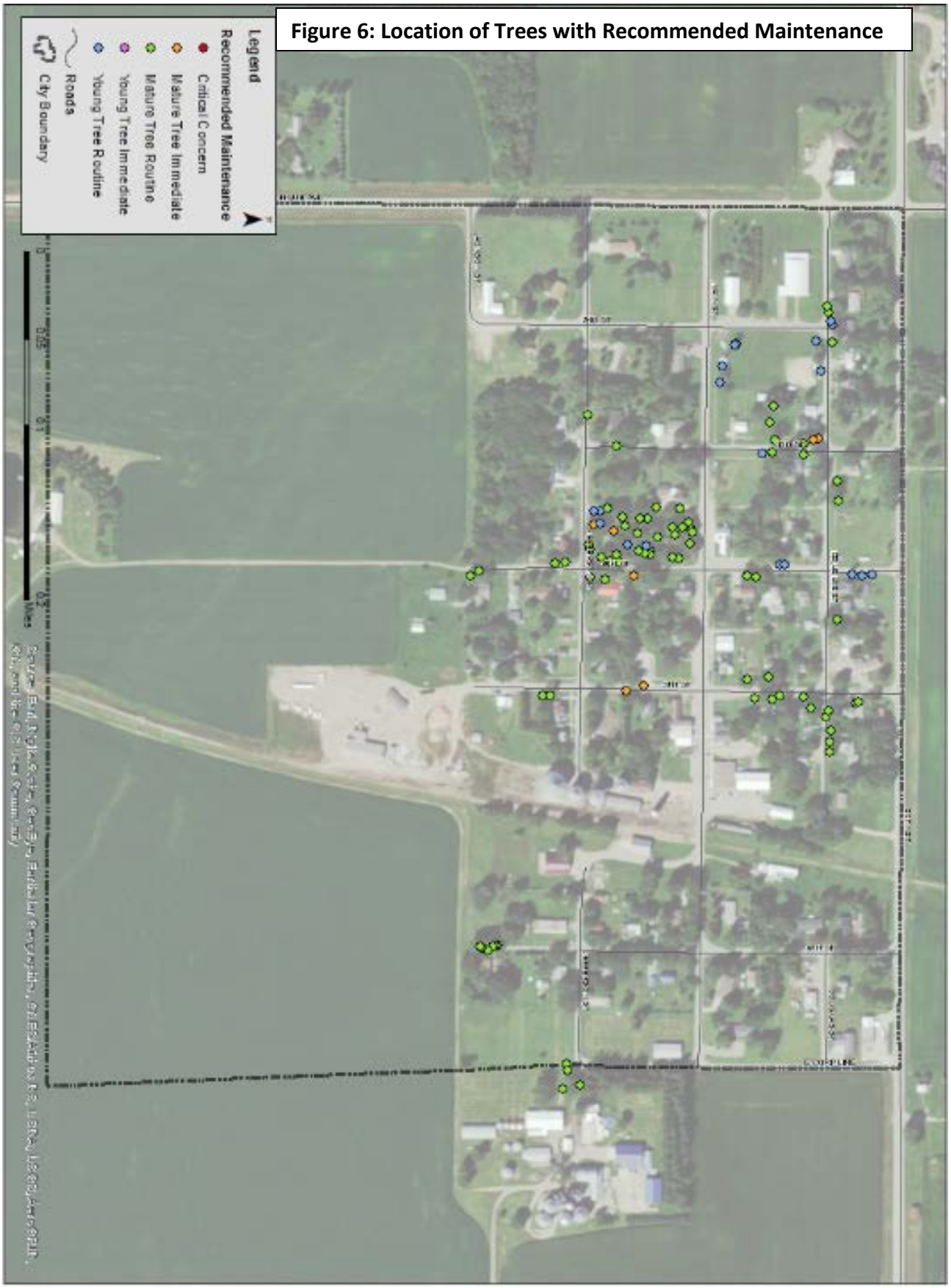
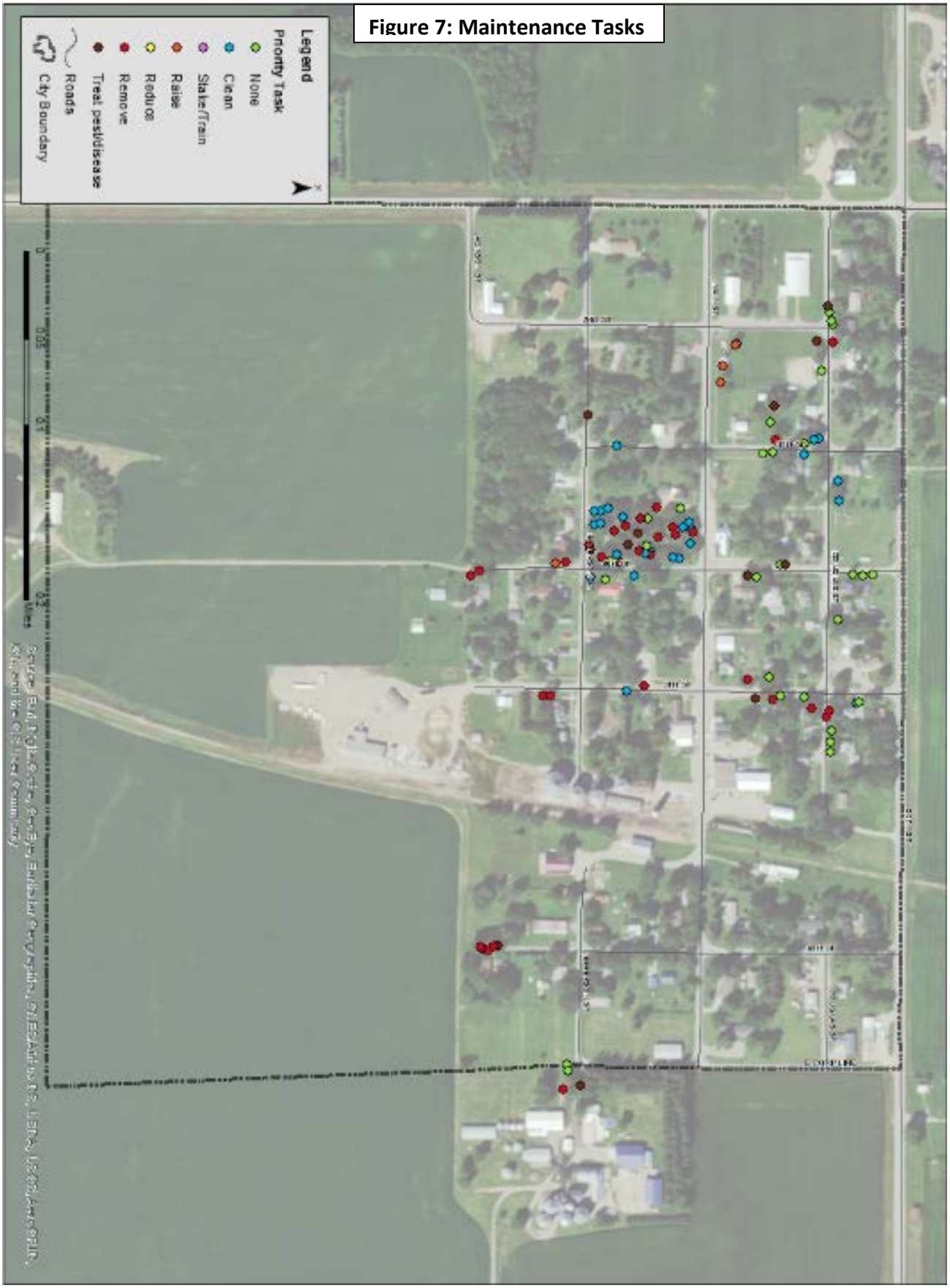


Figure 7: Maintenance Tasks



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