Whittemore, IA

2017 Urban Forest Management Plan
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Executive Summary

Overview

This plan was developed to assist the City of Whittemore with managing its urban forest, including budgeting and future planning. Trees can provide a multitude of benefits to the community, and sound management allows a community to best take advantage of these benefits. Management is especially important considering the serious threats posed by forest pests such as the emerald ash borer (EAB). EAB is an invasive insect imported from Eastern Asia on wood shipping crates that kills all species of ash trees (this does not include mountain ash). There is a strong possibility that 36% of Whittemore'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 537 trees inventoried.

- Whittemore's trees provide $$96,965 of benefits annually, an average of $180 a tree
- There are over 33 species of trees
- The top three genera are: Maple 39%, Ash 36%, and Apple 10%
- 9% of trees are in need of some type of management
- 5 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 5 trees needing removal, 1 tree is 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*
- 78 of the 194 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 99 years to remove ash – Suggestion: request a budget increase to $10,000 annually and apply for grants to plant replacement trees

Introduction

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

Trees are an important component of Whittemore'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 Whittemore 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 Whittemore'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 537 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. Whittemore's trees reduce energy related costs by approximately $25,249 annually (Appendix A, Table 1). These savings are both in Electricity (120.3 MWh) and in Natural Gas (16,451.3 Therms).

Annual Stormwater Benefits

Whittemore's trees intercept about 1,465,923 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $39,727 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 mater (ozone). In Whittemore, it is estimated that trees remove 1,616.7 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 $4,602 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Whittemore, trees sequester about 457,269 lbs of carbon a year with an associated value of $3,430 (Appendix A, Table 4). In addition, the trees store 6,213,227 lbs of carbon, with a yearly benefit of $46,599 (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. Whittemore receives $23,957 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, Whittemore's trees provide $96,965 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 537 trees in Whittemore provide approximately $180

Whittemore has over 33 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	212	39%
Ash	194	36%
Apple (crabapple)	52	10%
Linden	21	4%
Walnut	20	4%
Oak	8	1%
Spruce	6	1%
Birch	5	1%
Cherry	5	1%
Redbud	3	1%
Honey locust	3	1%
Cottonwood/Aspen	2	<1%
Lilac	2	<1%
Magnolia	1	<1%
Pear	1	<1%
Mountain Ash	1	<1%
Elm	1	<1%

Age Class

Most of Whittemore's trees (31%) are between 24 and 36 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. Whittemore'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 Whittemore indicate that 94% 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, 39% of Whittemore'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 8% of the population. This 8% 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	38	7%
Crown Raising	5	1%
Tree Removal	5	1%

Canopy Cover

The total canopy with both private and public trees is 14%, 398 acres. The canopy cover included in the Whittemore inventory includes approximately 14 acres (Appendix A, Figure 4). The Statewide Canopy goal is 3%, in 30 years. To achieve this goal it is estimated that 20 trees need to be planted annually on public and private lands.

Land Use and Location

The majority of Whittemore'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	88%
Park/vacant/other	8%
Small commercial	2%
Multifamily residential	1%

Location	
Planting strip	69%
Front yard	31%

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

Whittemore has 1 critical concern trees that need immediate removal and 2 tree that need pruning. These 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 critical concern

trees first. . 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 48 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 5 removals, 1 is an ash tree. There are a total of 194 ash trees, and 78 of those have signs and symptoms that have been associated with EAB. In addition, there are 32 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 Whittemore.

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 (39%) (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.

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: 1 critical concern tree and on other marked for removal
Planting and Replacement: 7 trees
Young Tree Pruning & Maintenance: 1 critical and 1 immediate
Visual Survey for signs and symptoms of EAB

Year 2

Removal: 2 marked for removal
Planting and Replacement: 7 trees
Young Tree Pruning & Maintenance: 2 trees
Visual Survey for signs and symptoms of EAB

Year 3

Removal: 1 tree marked for removal and 1 removal of any new critical concern tree, an ash in poor health or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 7 trees
Young Tree Pruning & Maintenance: 2 trees
Visual Survey for signs and symptoms of EAB

Year 4

Removal: 2 trees - removal of any new critical concern trees, ash in poor health or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 7 trees
Young Tree Pruning & Maintenance: 2 trees
Visual Survey for signs and symptoms of EAB

Year 5

Removal: 2 trees - removal of any new critical concern trees, ash in poor health or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 3 trees
Young Tree Pruning & Maintenance: 2 trees
Visual Survey for signs and symptoms of EAB

Year 6

Removal: 2 trees - removal of any new critical concern trees, ash in poor health or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 7 trees
Young Tree Pruning & Maintenance: 2 trees
Visual Survey for signs and symptoms of EAB

*Reduction of ash over 6 years: Approximately 8 of the 194 ash trees removed (approximately 4% of ash). It will take approximately 99 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 $30,550 a year.

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 ash trees on their property upon arrival of EAB if they are not already using preventative treatments.

Budget

Current Budget
$2,425 Budget

Removal: $1,600
Planting: $300
Routine trimming & Maintenance: $525

*Reduction of ash over 6 years: Approximately 8 of the 194 ash trees removed (approximately 4% of ash). It will take approximately 99 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 $30,550 a year.

Purposed Budget Increase

EAB could potentially kill all ash trees in Whittemore within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $30,550 a year. Additionally, it is recommended that Whittemore 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 $1,200, and Whittemore would still need to find $148,800 for removal. Alternatively, if there are 30 treatable trees, it would cost approximately $4,500 a year for treatment and leave $131,200 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 Whittemore. 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

Whittemore

Annual Energy Benefits of Public Trees

2/9/2017

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	56.6	4,294	7,633.9	7,481	11,775	(N/A)	34.8	46.6	62.97
Silver maple	21.2	1,606	2,781.9	2,726	4,332	(N/A)	13.6	17.2	59.34
Norway maple	13.5	1,027	1,972.5	1,933	2,960	(N/A)	11.4	11.7	48.52
Apple	1.9	145	304.6	299	443	(N/A)	9.7	1.8	8.53
Sugar maple	9.4	712	1,252.1	1,227	1,939	(N/A)	6.3	7.7	57.02
Black walnut	5.2	394	713.8	700	1,094	(N/A)	3.7	4.3	54.69
Maple	0.7	56	110.1	108	164	(N/A)	3.4	0.6	9.09
American basswood	2.0	148	278.0	272	421	(N/A)	3.2	1.7	24.74
Black maple	3.1	237	438.9	430	668	(N/A)	2.0	2.6	60.68
Amur maple	1.4	103	215.3	211	314	(N/A)	1.9	1.2	31.37
White ash	1.1	82	142.1	139	222	(N/A)	1.3	0.9	31.66
Swamp white oak	0.2	14	30.8	30	45	(N/A)	0.9	0.2	8.93
Cherry plum	0.3	20	46.1	45	65	(N/A)	0.9	0.3	13.08
Red maple	0.3	20	39.0	38	58	(N/A)	0.7	0.2	14.51
Littleleaf linden	0.8	58	102.2	100	158	(N/A)	0.7	0.6	39.59
Spruce	0.2	18	33.6	33	51	(N/A)	0.6	0.2	17.10
Eastern redbud	0.0	1	1.9	2	3	(N/A)	0.6	0.0	0.87
Honeylocust	0.4	29	49.8	49	78	(N/A)	0.6	0.3	25.87
River birch	0.3	24	50.6	50	73	(N/A)	0.6	0.3	24.47
Paper birch	0.1	7	14.2	14	21	(N/A)	0.4	0.1	10.65
Black spruce	0.3	19	30.4	30	49	(N/A)	0.4	0.2	24.51
Bur oak	0.2	14	27.5	27	41	(N/A)	0.4	0.2	20.64
Lilac	0.0	0	0.6	1	1	(N/A)	0.2	0.0	0.87
Blue spruce	0.1	11	19.5	19	30	(N/A)	0.2	0.1	29.65
Eastern cottonwood	0.4	29	53.7	53	82	(N/A)	0.2	0.3	82.02
Mountain ash	0.0	2	3.8	4	5	(N/A)	0.2	0.0	5.40
Pear	0.0	2	3.8	4	5	(N/A)	0.2	0.0	5.40
Japanese tree lilac	0.1	6	12.8	13	18	(N/A)	0.2	0.1	18.19
Boxelder	0.3	20	36.3	36	55	(N/A)	0.2	0.2	55.14
Northern red oak	0.2	15	23.3	23	38	(N/A)	0.2	0.1	37.72
Quaking aspen	0.1	7	13.7	13	21	(N/A)	0.2	0.1	20.64
American elm	0.1	6	11.7	11	18	(N/A)	0.2	0.1	17.66
Southern magnolia	0.0	1	2.8	3	4	(N/A)	0.2	0.0	3.94
Total	120.3	9,127	16,451.3	16,122	25,249	(N/A)	100.0	100.0	47.02

Table 2: Annual Stormwater Benefits

Whittemore

Annual Stormwater Benefits of Public Trees

2/9/2017

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	727,792	19,723	(N/A)	34.8	49.6	105.47
Silver maple	309,049	8,375	(N/A)	13.6	21.1	114.73
Norway maple	134,481	3,644	(N/A)	11.4	9.2	59.74
Apple	8,367	227	(N/A)	9.7	0.6	4.36
Sugar maple	116,785	3,165	(N/A)	6.3	8.0	93.08
Black walnut	64,452	1,747	(N/A)	3.7	4.4	87.33
Maple	3,781	102	(N/A)	3.4	0.3	5.69
American basswood	13,684	371	(N/A)	3.2	0.9	21.81
Black maple	31,537	855	(N/A)	2.0	2.2	77.70
Amur maple	6,685	181	(N/A)	1.9	0.5	18.12
White ash	11,565	313	(N/A)	1.3	0.8	44.77
Swamp white oak	936	25	(N/A)	0.9	0.1	5.07
Cherry plum	931	25	(N/A)	0.9	0.1	5.04
Red maple	1,400	38	(N/A)	0.7	0.1	9.48
Littleleaf linden	6,724	182	(N/A)	0.7	0.5	45.55
Spruce	2,730	74	(N/A)	0.6	0.2	24.66
Eastern redbud	22	1	(N/A)	0.6	0.0	0.20
Honeylocust	4,724	128	(N/A)	0.6	0.3	42.67
River birch	1,758	48	(N/A)	0.6	0.1	15.88
Paper birch	626	17	(N/A)	0.4	0.0	8.48
Black spruce	3,089	84	(N/A)	0.4	0.2	41.85
Bur oak	1,216	33	(N/A)	0.4	0.1	16.47
Lilac	7	0	(N/A)	0.2	0.0	0.20
Blue spruce	2,312	63	(N/A)	0.2	0.2	62.66
Eastern cottonwood	5,491	149	(N/A)	0.2	0.4	148.79
Mountain ash	69	2	(N/A)	0.2	0.0	1.86
Pear	69	2	(N/A)	0.2	0.0	1.86
Japanese tree lilac	264	7	(N/A)	0.2	0.0	7.17
Boxelder	3,090	84	(N/A)	0.2	0.2	83.73
Northern red oak	1,193	32	(N/A)	0.2	0.1	32.34
Quaking aspen	608	16	(N/A)	0.2	0.0	16.47
American elm	432	12	(N/A)	0.2	0.0	11.72
Southern magnolia	56	2	(N/A)	0.2	0.0	1.53
Citywide total	1,465,923	39,727	(N/A)	100.0	100.0	73.98

Table 3: Annual Air Quality Benefits

Whittemore

Annual Air Quality Benefits of Public Trees

2/9/2017

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	103.7	16.6	47.5	4.6	546	269.2	39.3	37.4	256.4	1,679	0.0	0	774.6	2,225	(N/A)	34.8	11.90
Silver maple	52.7	8.9	25.9	2.3	284	99.7	14.6	13.9	95.7	624	-27.1	-102	286.6	806	(N/A)	13.6	11.04
Norway maple	28.5	4.9	13.9	1.3	153	65.8	9.5	9.0	61.4	407	-6.6	-25	187.6	536	(N/A)	11.4	8.78
Apple	2.4	0.4	1.1	0.1	13	9.5	1.4	1.3	8.6	58	0.0	0	24.8	71	(N/A)	9.7	1.36
Sugar maple	16.3	2.8	7.9	0.7	88	44.4	6.5	6.2	42.5	278	-12.7	-47	114.7	318	(N/A)	6.3	9.35
Black walnut	8.6	1.4	4.0	0.4	46	24.8	3.6	3.4	23.5	155	0.0	0	69.8	200	(N/A)	3.7	10.01
Maple	0.4	0.1	0.3	0.0	2	3.6	0.5	0.5	3.3	22	-0.2	-1	8.5	24	(N/A)	3.4	1.32
American basswood	1.3	0.2	0.8	0.1	7	9.4	1.4	1.3	8.9	59	-1.3	-5	22.0	61	(N/A)	3.2	3.59
Black maple	8.2	1.4	3.8	0.4	44	15.0	2.2	2.1	14.2	93	-2.7	-10	44.5	127	(N/A)	2.0	11.54
Amur maple	2.2	0.4	1.0	0.1	12	6.7	1.0	0.9	6.1	41	0.0	0	18.3	53	(N/A)	1.9	5.27
White ash	2.0	0.3	1.0	0.1	11	5.1	0.7	0.7	4.9	32	0.0	0	14.9	43	(N/A)	1.3	6.12
Swamp white oak	0.1	0.0	0.1	0.0	0	1.0	0.1	0.1	0.9	6	0.0	0	2.2	6	(N/A)	0.9	1.23
Cherry plum	0.1	0.0	0.1	0.0	1	1.4	0.2	0.2	1.2	8	0.0	0	3.2	9	(N/A)	0.9	1.81
Red maple	0.2	0.0	0.1	0.0	1	1.3	0.2	0.2	1.2	8	-0.1	0	3.0	9	(N/A)	0.7	2.13
Littleleaf linden	1.1	0.2	0.5	0.0	6	3.6	0.5	0.5	3.5	23	-0.5	-2	9.5	27	(N/A)	0.7	6.65
Spruce	0.3	0.1	0.3	0.0	2	1.2	0.2	0.2	1.1	7	-0.9	-3	2.3	6	(N/A)	0.6	1.92
Eastern redbud	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.0	0	0.0	0	0.1	0	(N/A)	0.6	0.11
Honeylocust	0.9	0.2	0.4	0.0	5	1.8	0.3	0.3	1.7	11	-0.8	-3	4.8	13	(N/A)	0.6	4.43
River birch	0.2	0.0	0.1	0.0	1	1.6	0.2	0.2	1.4	10	-0.1	0	3.7	10	(N/A)	0.6	3.47
Paper birch	0.0	0.0	0.0	0.0	0	0.5	0.1	0.1	0.4	3	0.0	0	1.1	3	(N/A)	0.4	1.54
Black spruce	0.4	0.1	0.3	0.0	3	1.2	0.2	0.2	1.1	7	-1.1	-4	2.4	6	(N/A)	0.4	2.89
Bur oak	0.0	0.0	0.0	0.0	0	0.9	0.1	0.1	0.9	6	0.0	0	2.1	6	(N/A)	0.4	2.99
Lilac	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)	0.2	0.11
Blue spruce	0.4	0.1	0.3	0.0	2	0.7	0.1	0.1	0.6	4	-0.9	-3	1.3	3	(N/A)	0.2	3.10
Eastern cottonwood	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)	0.2	15.71
Mountain ash	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)	0.2	0.71
Pear	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)	0.2	0.71
Japanese tree lilac	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.3	2	0.0	0	0.9	3	(N/A)	0.2	2.55
Boxelder	0.4	0.1	0.2	0.0	2	1.2	0.2	0.2	1.2	8	-0.2	-1	3.3	9	(N/A)	0.2	9.31
Northern red oak	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.9	6	-0.3	-1	2.1	6	(N/A)	0.2	5.79
Quaking aspen	0.0	0.0	0.0	0.0	0	0.5	0.1	0.1	0.4	3	0.0	0	1.1	3	(N/A)	0.2	2.99
American elm	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.4	2	0.0	0	0.9	3	(N/A)	0.2	2.54
Southern magnolia	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	0	0.0	0	0.2	0	(N/A)	0.2	0.47
Citywide total	231.5	38.3	110.1	10.4	1,235	573.8	83.6	79.7	544.8	3,575	-55.4	-208	1,616.7	4,602	(N/A)	100.0	8.57

Table 4: Annual Carbon Stored

Whittemore

Stored CO2 Benefits of Public Trees

2/9/2017

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	3,457,398	25,930	(N/A)	34.8	55.6	138.67
Silver maple	1,175,599	8,817	(N/A)	13.6	18.9	120.78
Norway maple	471,483	3,536	(N/A)	11.4	7.6	57.97
Apple	39,642	297	(N/A)	9.7	0.6	5.72
Sugar maple	471,996	3,540	(N/A)	6.3	7.6	104.12
Black walnut	285,060	2,138	(N/A)	3.7	4.6	106.90
Maple	6,529	49	(N/A)	3.4	0.1	2.72
American basswood	48,530	364	(N/A)	3.2	0.8	21.41
Black maple	87,398	655	(N/A)	2.0	1.4	59.59
Amur maple	34,548	259	(N/A)	1.9	0.6	25.91
White ash	32,150	241	(N/A)	1.3	0.5	34.45
Swamp white oak	1,571	12	(N/A)	0.9	0.0	2.36
Cherry plum	3,079	23	(N/A)	0.9	0.0	4.62
Red maple	2,437	18	(N/A)	0.7	0.0	4.57
Littleleaf linden	23,454	176	(N/A)	0.7	0.4	43.98
Spruce	1,684	13	(N/A)	0.6	0.0	4.21
Eastern redbud	41	0	(N/A)	0.6	0.0	0.10
Honeylocust	12,272	92	(N/A)	0.6	0.2	30.68
River birch	3,302	25	(N/A)	0.6	0.1	8.26
Paper birch	1,047	8	(N/A)	0.4	0.0	3.93
Black spruce	2,236	17	(N/A)	0.4	0.0	8.39
Bur oak	2,069	16	(N/A)	0.4	0.0	7.76
Lilac	14	0	(N/A)	0.2	0.0	0.10
Blue spruce	2,661	20	(N/A)	0.2	0.0	19.96
Eastern cottonwood	25,943	195	(N/A)	0.2	0.4	194.57
Mountain ash	178	1	(N/A)	0.2	0.0	1.33
Pear	178	1	(N/A)	0.2	0.0	1.33
Japanese tree lilac	908	7	(N/A)	0.2	0.0	6.81
Boxelder	14,280	107	(N/A)	0.2	0.2	107.10
Northern red oak	3,595	27	(N/A)	0.2	0.1	26.96
Quaking aspen	1,035	8	(N/A)	0.2	0.0	7.76
American elm	908	7	(N/A)	0.2	0.0	6.81
Southern magnolia	3	0	(N/A)	0.2	0.0	0.02
Citywide total	6,213,227	46,599	(N/A)	100.0	100.0	86.78

Table 5: Annual Carbon Sequestered

Whittemore

Annual CO Benefits of Public Trees

2/9/2017

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	126,205	947	-16,596	-614	-129	94,900	712	203,895	1,529 (N/A)	34.8	44.6	8.18
Silver maple	87,736	658	-5,644	-237	-44	35,485	266	117,341	880 (N/A)	13.6	25.7	12.06
Norway maple	14,963	112	-2,266	-152	-18	22,691	170	35,236	264 (N/A)	11.4	7.7	4.33
Apple	3,271	25	-191	-35	-2	3,201	24	6,246	47 (N/A)	9.7	1.4	0.90
Sugar maple	22,715	170	-2,266	-104	-18	15,726	118	36,071	271 (N/A)	6.3	7.9	7.96
Black walnut	12,267	92	-1,368	-57	-11	8,715	65	19,557	147 (N/A)	3.7	4.3	7.33
Maple	1,007	8	-32	-10	0	1,231	9	2,195	16 (N/A)	3.4	0.5	0.91
American basswood	3,719	28	-233	-23	-2	3,273	25	6,736	51 (N/A)	3.2	1.5	2.97
Black maple	923	7	-420	-30	-3	5,247	39	5,720	43 (N/A)	2.0	1.3	3.90
Amur maple	2,272	17	-166	-20	-1	2,268	17	4,355	33 (N/A)	1.9	1.0	3.27
White ash	3,015	23	-154	-11	-1	1,819	14	4,669	35 (N/A)	1.3	1.0	5.00
Swamp white oak	426	3	-9	-3	0	319	2	734	6 (N/A)	0.9	0.2	1.10
Cherry plum	418	3	-15	-5	0	447	3	845	6 (N/A)	0.9	0.2	1.27
Red maple	372	3	-12	-3	0	438	3	796	6 (N/A)	0.7	0.2	1.49
Littleleaf linden	1,252	9	-113	-9	-1	1,285	10	2,415	18 (N/A)	0.7	0.5	4.53
Spruce	221	2	-8	-4	0	405	3	614	5 (N/A)	0.6	0.1	1.53
Eastern redbud	26	0	0	-1	0	17	0	42	0 (N/A)	0.6	0.0	0.10
Honeylocust	1,507	11	-59	-3	0	637	5	2,082	16 (N/A)	0.6	0.5	5.20
River birch	672	5	-16	-4	0	528	4	1,180	9 (N/A)	0.6	0.3	2.95
Paper birch	211	2	-5	-1	0	163	1	368	3 (N/A)	0.4	0.1	1.38
Black spruce	181	1	-11	-4	0	426	3	592	4 (N/A)	0.4	0.1	2.22
Bur oak	418	3	-10	-2	0	318	2	723	5 (N/A)	0.4	0.2	2.71
Lilac	9	0	0	0	0	6	0	14	0 (N/A)	0.2	0.0	0.10
Blue spruce	147	1	-13	-3	0	233	2	364	3 (N/A)	0.2	0.1	2.73
Eastern cottonwood	960	7	-125	-4	-1	650	5	1,481	11 (N/A)	0.2	0.3	11.11
Mountain ash	38	0	-1	-1	0	37	0	74	1 (N/A)	0.2	0.0	0.55
Pear	38	0	-1	-1	0	37	0	74	1 (N/A)	0.2	0.0	0.55
Japanese tree lilac	114	1	-4	-1	0	124	1	232	2 (N/A)	0.2	0.1	1.74
Boxelder	1,038	8	-69	-4	-1	433	3	1,399	10 (N/A)	0.2	0.3	10.49
Northern red oak	281	2	-17	-2	0	329	2	591	4 (N/A)	0.2	0.1	4.43
Quaking aspen	209	2	-5	-1	0	159	1	361	3 (N/A)	0.2	0.1	2.71
American elm	111	1	-4	-1	0	137	1	242	2 (N/A)	0.2	0.1	1.82
Southern magnolia	1	0	0	0	0	26	0	27	0 (N/A)	0.2	0.0	0.20
Citywide total	286,743	2,151	-29,832	-1,350	-234	201,708	1,513	457,269	3,430 (N/A)	100.0	100.0	6.39

Table 6: Annual Social and Aesthetic Benefits

Whittemore

Annual Aesthetic/Other Benefits of Public Trees

2/9/2017

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	9,761	(N/A)	34.8	40.7	52.20
Silver maple	6,968	(N/A)	13.6	29.1	95.46
Norway maple	1,453	(N/A)	11.4	6.1	23.82
Apple	179	(N/A)	9.7	0.7	3.43
Sugar maple	2,272	(N/A)	6.3	9.5	66.82
Black walnut	990	(N/A)	3.7	4.1	49.49
Maple	179	(N/A)	3.4	0.7	9.92
American basswood	330	(N/A)	3.2	1.4	19.41
Black maple	109	(N/A)	2.0	0.5	9.92
Amur maple	134	(N/A)	1.9	0.6	13.39
White ash	385	(N/A)	1.3	1.6	55.02
Swamp white oak	57	(N/A)	0.9	0.2	11.49
Cherry plum	23	(N/A)	0.9	0.1	4.66
Red maple	67	(N/A)	0.7	0.3	16.75
Littleleaf linden	141	(N/A)	0.7	0.6	35.35
Spruce	63	(N/A)	0.6	0.3	21.05
Eastern redbud	0	(N/A)	0.6	0.0	0.03
Honeylocust	390	(N/A)	0.6	1.6	129.89
River birch	79	(N/A)	0.6	0.3	26.22
Paper birch	34	(N/A)	0.4	0.1	16.91
Black spruce	50	(N/A)	0.4	0.2	25.23
Bur oak	57	(N/A)	0.4	0.2	28.56
Lilac	0	(N/A)	0.2	0.0	0.03
Blue spruce	20	(N/A)	0.2	0.1	19.97
Eastern cottonwood	67	(N/A)	0.2	0.3	66.60
Mountain ash	2	(N/A)	0.2	0.0	2.06
Pear	2	(N/A)	0.2	0.0	2.06
Japanese tree lilac	6	(N/A)	0.2	0.0	6.40
Boxelder	65	(N/A)	0.2	0.3	65.43
Northern red oak	24	(N/A)	0.2	0.1	24.08
Quaking aspen	29	(N/A)	0.2	0.1	28.56
American elm	20	(N/A)	0.2	0.1	19.89
Southern magnolia	0	(N/A)	0.2	0.0	0.01
Citywide total	23,957	(N/A)	100.0	100.0	44.61

Table 7: Summary of Benefits in Dollars

Whittemore

Total Annual Benefits of Public Trees by Species ($)

2/9/2017

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Green ash	11,775	1,529	2,225	19,723	9,761	45,014	(N/A)	46.4
Silver maple	4,332	880	806	8,375	6,968	21,362	(N/A)	22.0
Norway maple	2,960	264	536	3,644	1,453	8,857	(N/A)	9.1
Apple	443	47	71	227	179	966	(N/A)	1.0
Sugar maple	1,939	271	318	3,165	2,272	7,964	(N/A)	8.2
Black walnut	1,094	147	200	1,747	990	4,177	(N/A)	4.3
Maple	164	16	24	102	179	485	(N/A)	0.5
American basswood	421	51	61	371	330	1,233	(N/A)	1.3
Black maple	668	43	127	855	109	1,801	(N/A)	1.9
Amur maple	314	33	53	181	134	714	(N/A)	0.7
White ash	222	35	43	313	385	998	(N/A)	1.0
Swamp white oak	45	6	6	25	57	139	(N/A)	0.1
Cherry plum	65	6	9	25	23	129	(N/A)	0.1
Red maple	58	6	9	38	67	177	(N/A)	0.2
Littleleaf linden	158	18	27	182	141	527	(N/A)	0.5
Spruce	51	5	6	74	63	199	(N/A)	0.2
Eastern redbud	3	0	0	1	0	4	(N/A)	0.0
Honeylocust	78	16	13	128	390	624	(N/A)	0.6
River birch	73	9	10	48	79	219	(N/A)	0.2
Paper birch	21	3	3	17	34	78	(N/A)	0.1
Black spruce	49	4	6	84	50	193	(N/A)	0.2
Bur oak	41	5	6	33	57	143	(N/A)	0.1
Lilac	1	0	0	0	0	1	(N/A)	0.0
Blue spruce	30	3	3	63	20	118	(N/A)	0.1
Eastern cottonwood	82	11	16	149	67	324	(N/A)	0.3
Mountain ash	5	1	1	2	2	11	(N/A)	0.0
Pear	5	1	1	2	2	11	(N/A)	0.0
Japanese tree lilac	18	2	3	7	6	36	(N/A)	0.0
Boxelder	55	10	9	84	65	224	(N/A)	0.2
Northern red oak	38	4	6	32	24	104	(N/A)	0.1
Quaking aspen	21	3	3	16	29	71	(N/A)	0.1
American elm	18	2	3	12	20	54	(N/A)	0.1
Southern magnolia	4	0	0	2	0	6	(N/A)	0.0
Citywide Total	25,249	3,430	4,602	39,727	23,957	96,965	(N/A)	100.0

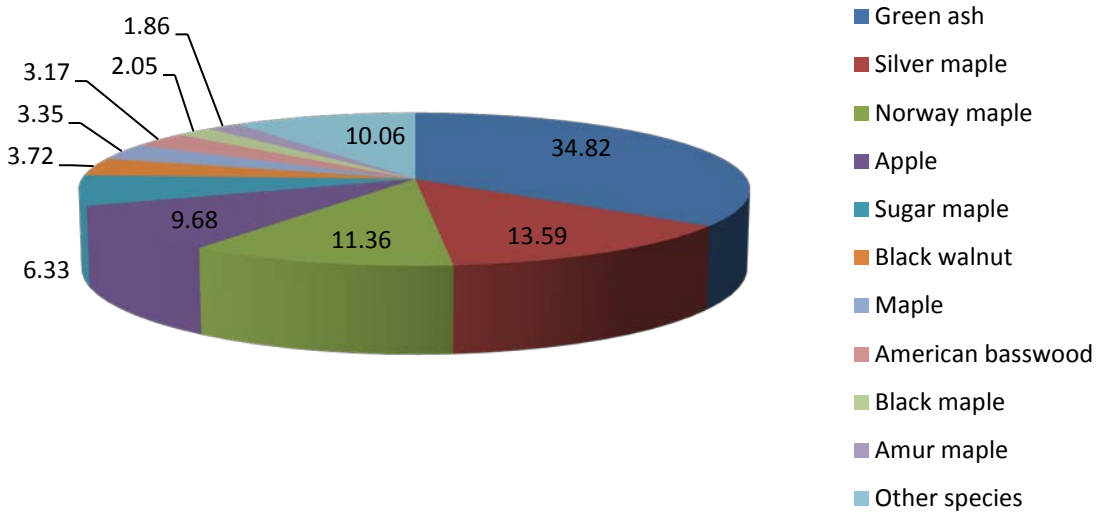

Figure 1: Species Distribution

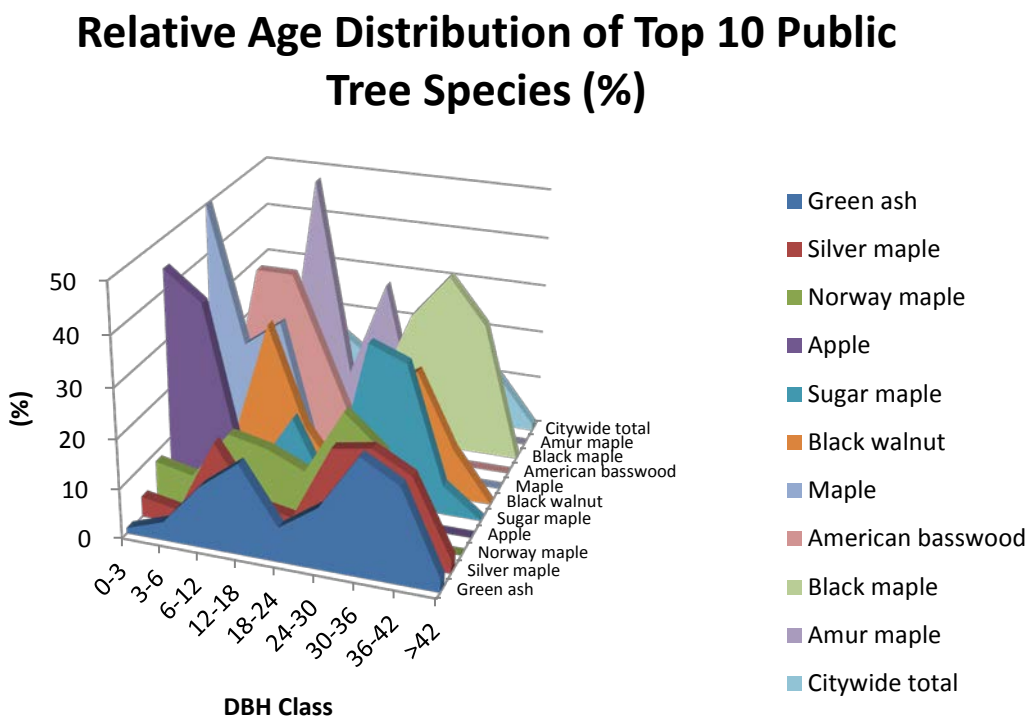

Figure 2: Relative Age Class

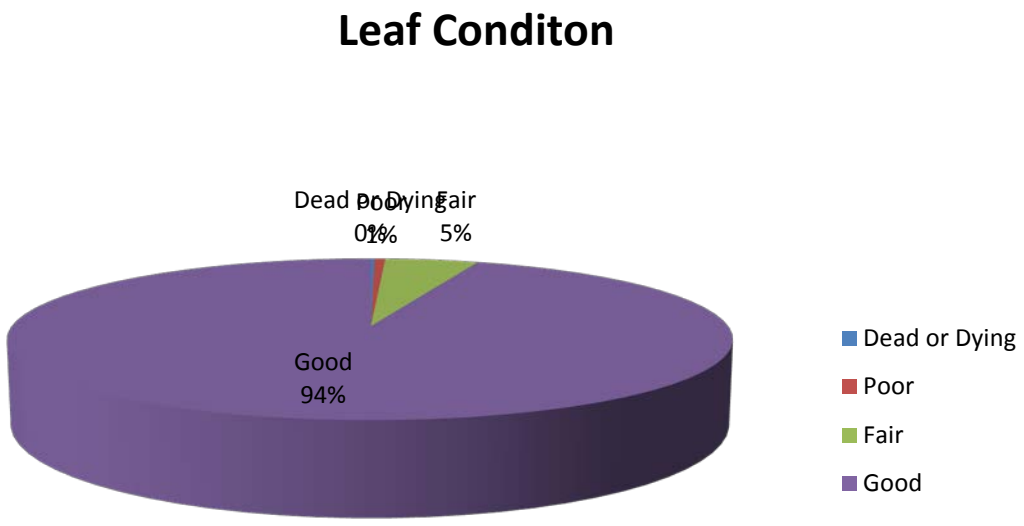

Figure 3: Foliage Condition

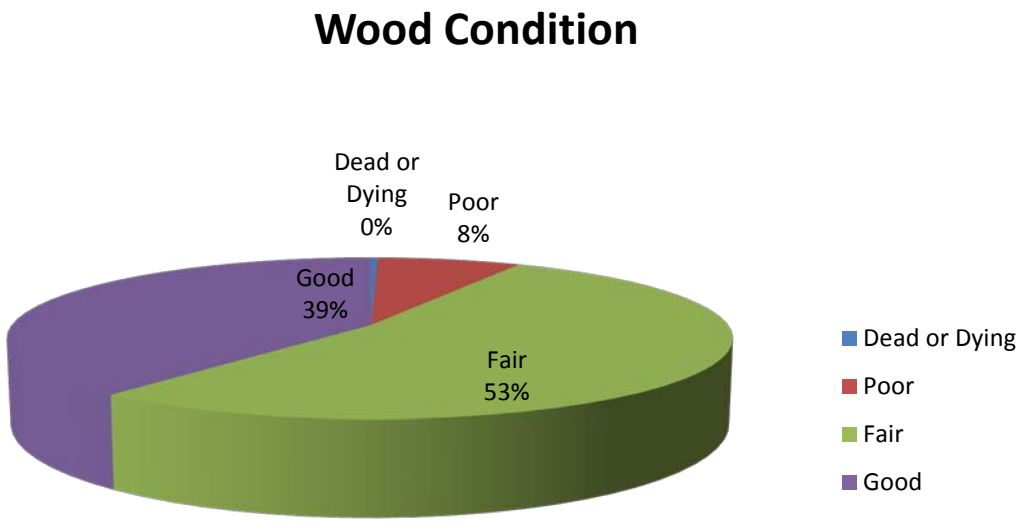

Figure 4: Wood Condition

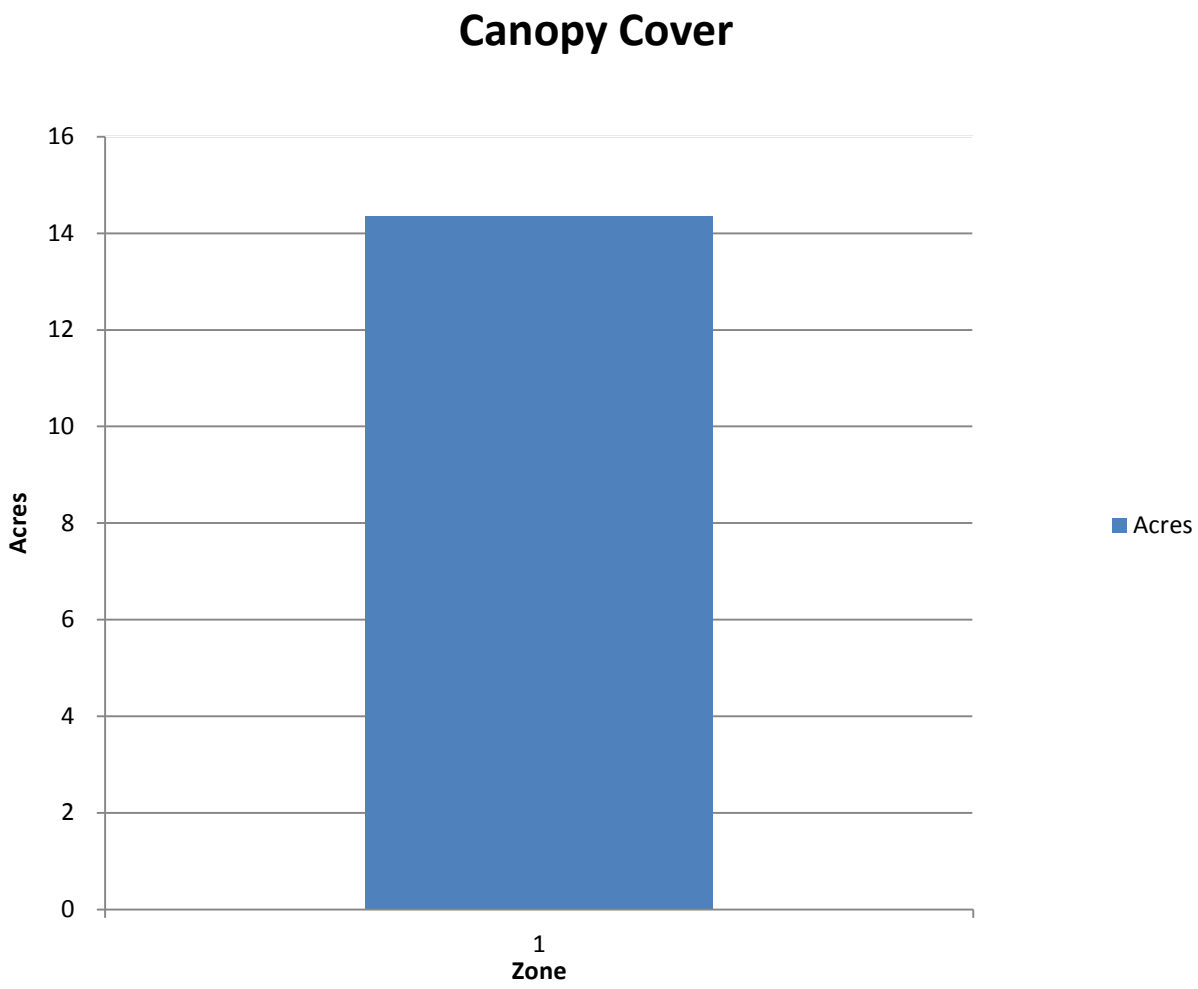

Figure 5: Canopy Cover in Acres

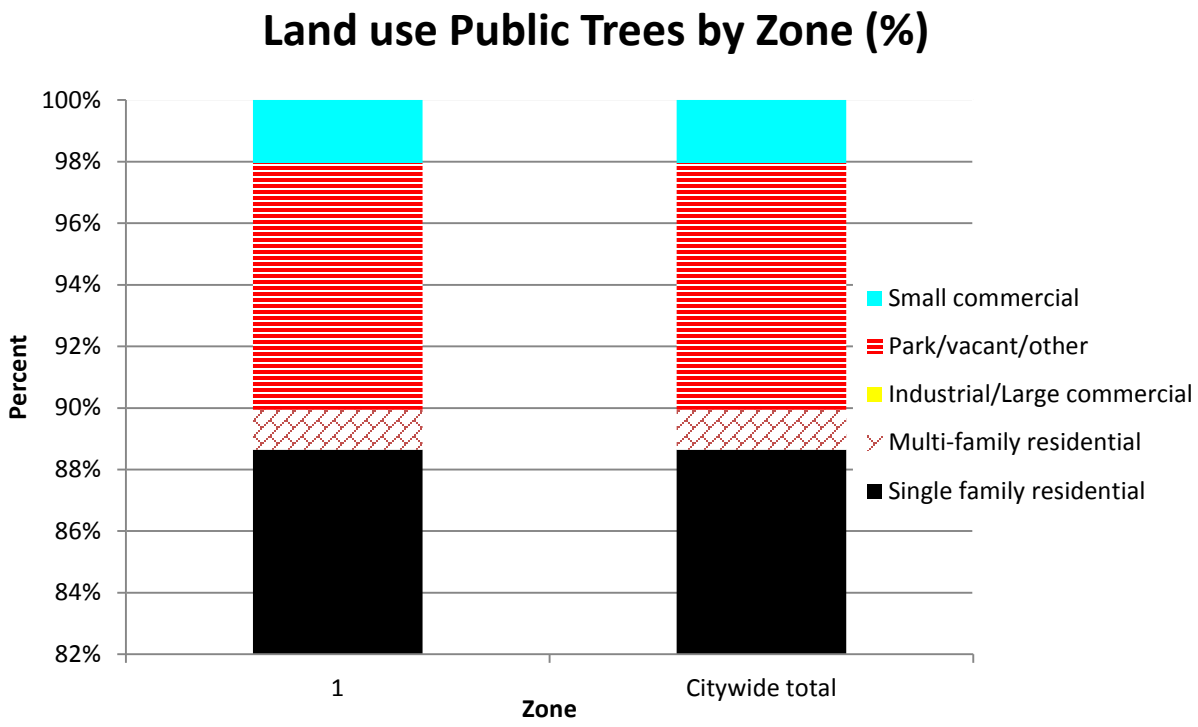

Figure 6: Land Use of city/park trees

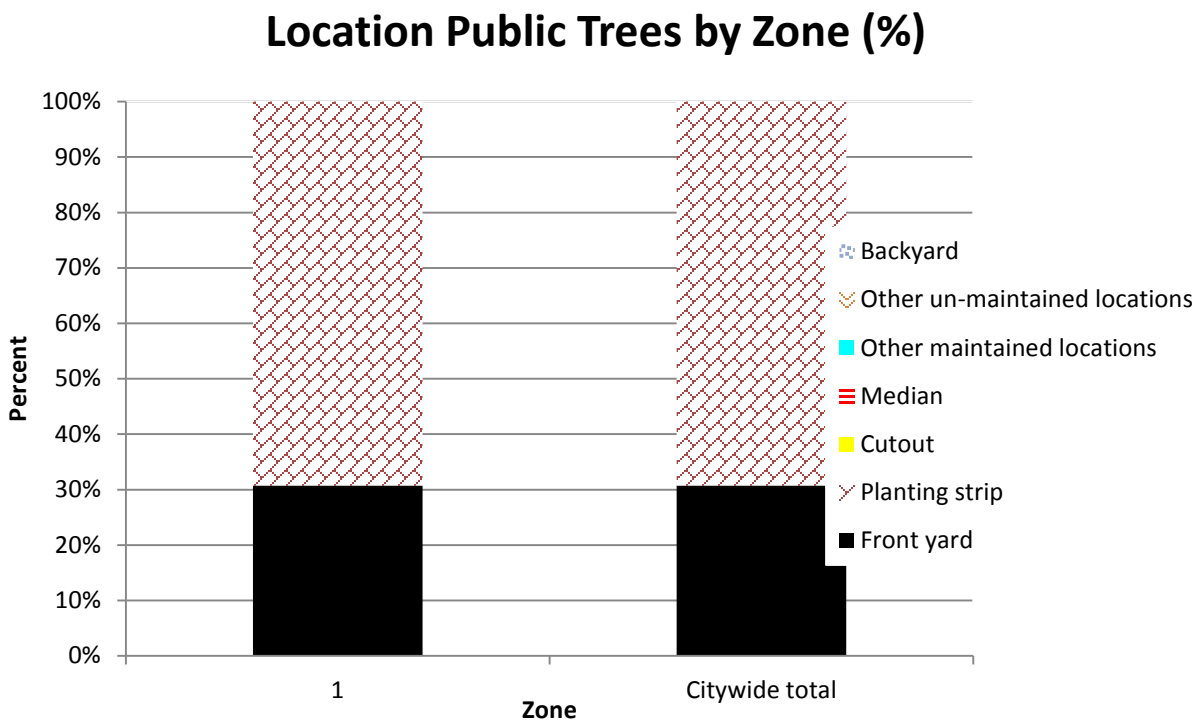

Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

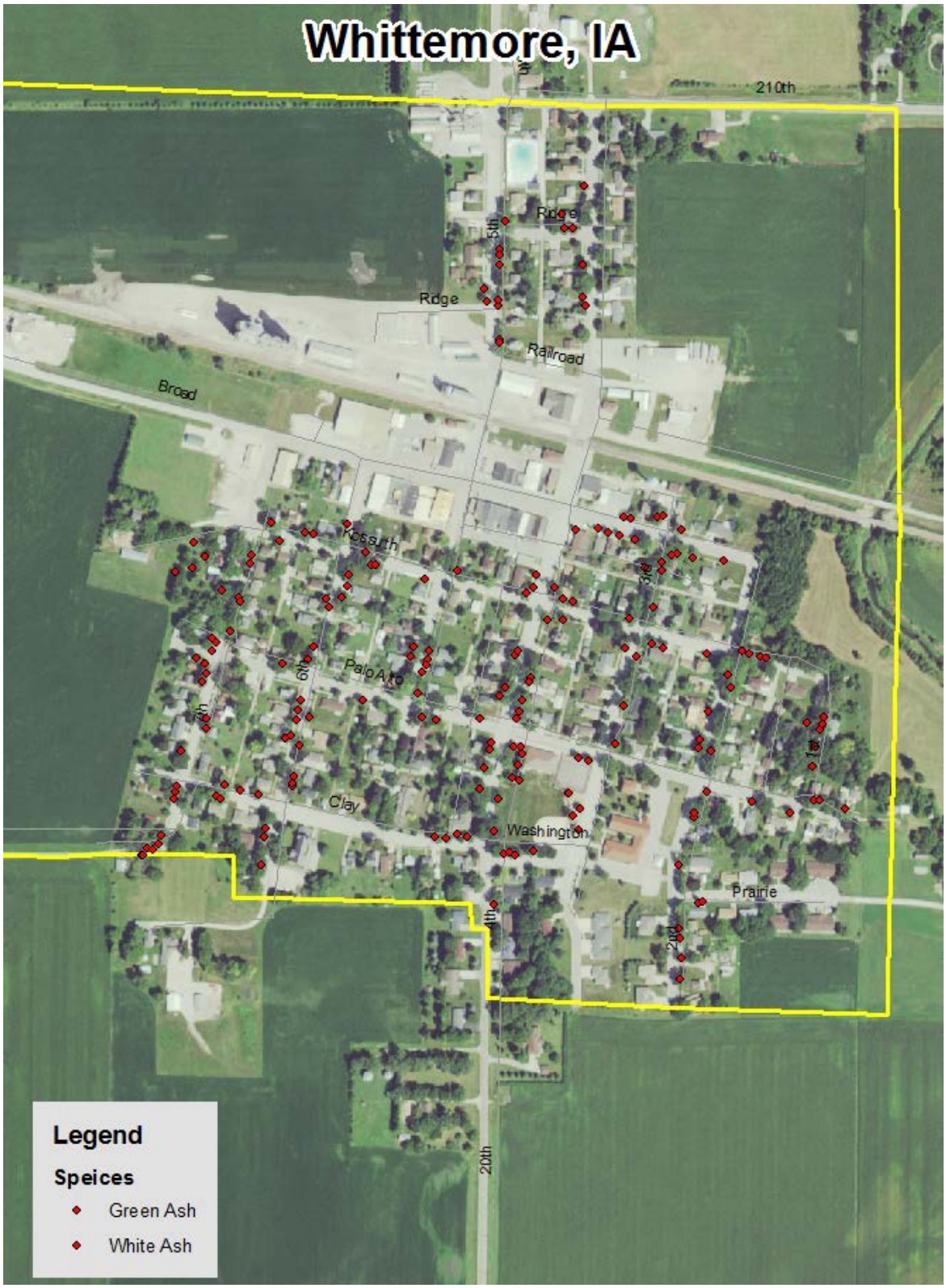

Figure 1: Location of Ash Trees

Figure 2: Location of EAB symptoms

Figure 3: Location of Poor Condition Trees

Figure 4: Location of Trees with Recommended Maintenance

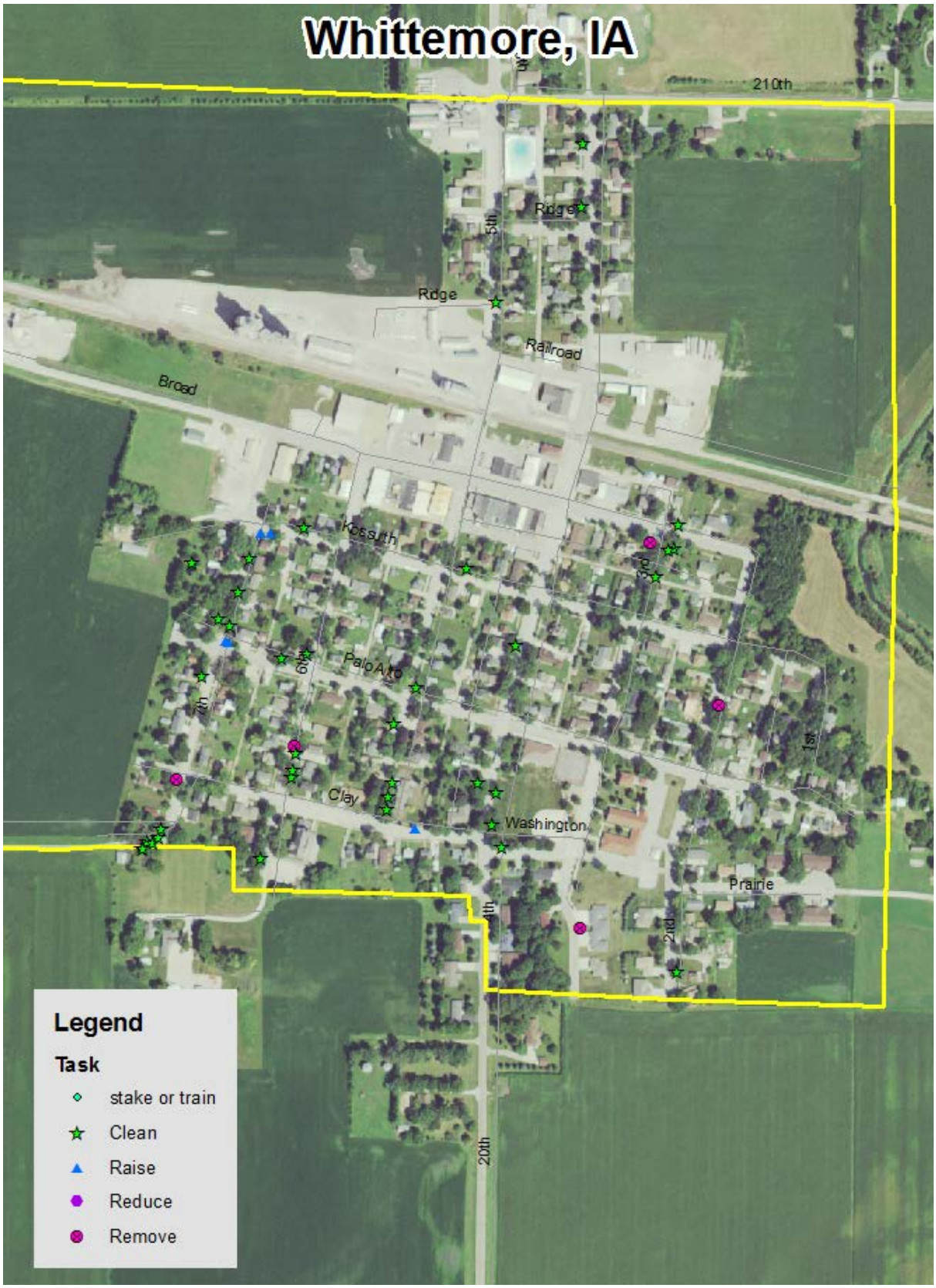

Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

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