Zearing, IA

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2019 Urban Forest Management Plan
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Executive Summary

Overview

This plan was developed to assist the City of Zearing 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 19% of Zearing's city owned trees (ash) will die once EAB becomes established in the community, unless preventative treatment is used. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

Inventory and Results

In 2018, a tree inventory was conducted using Global Positioning System (GPS) data collectors. The inventory was a complete inventory of street and park trees. Below are some key findings of the 313 trees inventoried.

- Zearing's trees provide $52,065 of benefits annually, an average of $166 per tree
- There are over 33 species of trees
- The top four genera are: Maple 34%, Ash 19%, and Oak and Honeylocust at 7% each
- 33% of trees are in need of some type of management
- 8 trees are recommended for removal

Recommendations

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

- Of the 8 trees needing removal, 2 trees are over 30 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*
- 16 of the 61 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
- Based on the proposed budget, we recommend requesting a budget increase to $5,891 annually and apply for grants to plant replacement trees

Introduction

This plan was developed to assist Zearing with the management, budgeting and future planning of their urban forest. Across the state, forestry budgets continue to decrease with more and more of that money spent on tree removal. With the anticipated arrival of Emerald Ash Borer (EAB), an invasive pest that kills native ash trees, it is time to prepare for the increased costs of tree removal or treatment and replacement planting. With proper planning and management of the current canopy in Zearing, these costs can be extended over years and public safety issues from dead and dying ash trees mitigated.

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

Inventory

In 2018, a tree inventory was conducted that included 100% of the city owned trees on both streets and parks. The tree data was collected using a handheld Global Positioning System (GPS) receiver. The data collector gives Geographic Information Systems (GIS) coordinates with an accuracy of 3 meters, which can be used in Arc GIS as an active GIS data layer. Because the inventory is a digital document the data can be updated with new information and become a working document.

The programming used to collect tree information on the data collectors was written to be compatible with a state-of-the-art software suite called i-Tree. i-Tree was developed by the USDA Forest Service to quantify the structure of community trees and the environmental services that trees provide. The i-Tree suite is a public domain which can be accessed for free.

To quantify the urban forest structure and benefits, specific data is collected for each tree. This data includes: location, land use, species, diameter at 4.5 ft, recommended maintenance, priority of that maintenance, leaf health, and wood condition. Additionally, signs and symptoms associated with EAB were noted for all ash trees. The signs and symptoms noted were canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

Inventory Results

The data collected for the 313 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. Zearing's trees reduce energy related costs by approximately $14,083 annually (Appendix A, Table 1). These savings are both in Electricity (66.4 MWh) and in Natural Gas (9,224.7 Therms).

Annual Stormwater Benefits

Zearing's trees intercept about 758,822 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $20,565 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 Zearing, it is estimated that trees remove 883 lbs of air pollution (ozone (O_3), particulate matter less than 10 microns (PM10), carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2)) per year with a net value of $2,502 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Zearing, trees sequester about 236,183 lbs of carbon a year with an associated value of $1,771 (Appendix A, Table 5). In addition, the trees store 2,884,685 lbs of carbon, with a yearly benefit of $21,635 (Appendix A, Table 4).

Annual Aesthetics Benefits

Social benefits of trees are hard to capture. The analysis does have a calculation for this area that includes: aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Zearing receives $13,144 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, Zearing's trees provide $52,065 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 313 trees in Zearing provide approximately $166 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Zearing 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	106	34%
Ash	61	19%
Oak	21	7%
Honeylocust	21	7%
Hackberry	19	6%
Apple	16	5%
Spruce	16	5%
Black Walnut	9	3%
Northern White Cedar	8	3%
Ginkgo	5	2%
Eastern White Pine	4	1%
Eastern Redbud	4	1%
American Basswood	3	1%
American Elm	3	1%
Callery Pear	3	1%
Northern Catalpa	3	1%
River Birch	3	1%
Kentucky Coffeetree	2	<1%
Other Species (various)	6	2%

Age Class

Nearly half of Zearing's trees (47%) are 18 inches in diameter or less 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. Zearing'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 Zearing indicate that 85% of the trees are in good health, with only 4% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 92% of Zearing'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 only about 2% of the population. This 2% 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	64	20%
Treat for Pest/Disease	16	5%
Tree Removal	8	3%
Crown Reduction	7	2%
Crown Raising	4	1%
Stake/Train	4	1%

Canopy Cover

The total canopy with both private and public trees is 7.87 acres, or 1.6% of the town's 480 acres (Appendix A, Figure 4). The City's Canopy goal is to increase canopy by 3%, in 30 years. To achieve this goal it is estimated that 35 trees need to be planted annually on public and private lands.

Land Use and Location

The majority of Zearing's city and park trees are in front yards in industrial or large commercial locations (Appendix A, Figure 6 & Appendix A, Figure7). The following describes the land use and locations for the street and park trees.

Land Use	
Industrial/Large commercial	55%
Single family residential	45%

Location	
Front yard	67%
Planting strip	33%

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

Zearing has 8 trees that need to be removed as soon as possible. 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 trees first. There are 5 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 removal trees are addressed, there should be follow up on the trees marked as needing maintenance. There are a total of 95 trees with these needs.

<u>Poor tree species</u>
After removal of necessary trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 8 removals, one is an ash trees. There are a total of 61 ash trees, and 16 of those have signs and symptoms that have been associated with EAB. In addition, there are 4 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 Zearing.

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 (34%) (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.

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 preventative treatments are not being used.

PROPOSED WORK SCHEDULE AND ESTIMATED COSTS

YEAR 1	ESTIMATED COSTS
Remove 3 immediate concern trees	$2,100
Prune 1 critical and 5 immediate concern trees	$180
Plant 7 trees in open locations	$700
Water & Maintenance	$350
Inspect ash trees for signs of Emerald Ash Borer	

YEAR 2	
Remove 5 ash trees	$3,500
Plant 7 trees in open locations	$700
Water & Maintenance	$500
Prune 1/3 of city owned trees	$3,090
Inspect ash trees for signs of Emerald Ash Borer	

YEAR 3	
Remove 5 ash trees	$3,500
Plant 7 trees in open locations	$700
Water & Maintenance	$350
Inspect ash trees for signs of EAB	

YEAR 4	
Remove 5 ash trees	$3,500
Plant 7 trees in open locations	$700

Water & Maintenance	$350
Prune 1/3 of city owned trees	$3,090
Inspect ash trees for signs of EAB	

YEAR 5

Remove 5 ash trees	$3,500
Plant 7 trees in open locations	$700
Water & Maintenance	$350
Inspect ash trees for signs of EAB	

YEAR 6

Remove 5 ash trees	$3,500
Plant 7 trees in open locations	$700
Water & Maintenance	$350
Prune 1/3 of city owned trees	$3,090

Average annual budget: $5,891

Estimated costs based on average costs of $700/tree for removal, $100/tree for planting, $50/tree for water and maintenance, and $30/tree for pruning.

This plan removes 25 ash trees, or 41% of all ash trees in the city.

Purposed Budget Increase

EAB could potentially kill all ash trees in Zearing within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $9,975 a year. Additionally, it is recommended that Zearing apply for grants to fund replacement trees. Utility Company grants are usually between $500 and $10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools.

Another option being considered by many communities is treating a number of selected trees, either to maintain those trees in the landscape or to delay their removal – to spread out the costs and number of trees needing removed all at once. Trunk injection is administered every two years for the life of the tree. If treatment is discontinued, the tree dies. For instance, in this treatment scenario, the average ash diameter is 20 inches and at $15 per inch, about 4 trees could be treated per year (every other year treatment). This would be 8 trees selected for treatment, and Zearing would still need to find $6,183 annually to remove all ash within 6 years. Alternatively, if there are 15 treatable trees, it would cost approximately $2,250 a year for treatment and leave $5,366 annually 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 Zearing. It is suggested to consider increasing the budget to plan for this.

Works Cited

Census Bureau. 2010. http://censtats.census.gov/data/IA/1601964290.pdf (April, 2013)

USDA Forest Service, et al. 2006. i-Tree Software Suite v1.0 User's Manual. Pp. 27-40.

McPherson EG, Simpson JR, Peper PJ, Gardner SL, Vargas KE, Ho J, Maco S, Xiao Q. 2005b. City of Charleston, South Carolina, municipal forest resource analysis. Internal Tech Rep. Davis, CA: U.S. Department of Agriculture, Center for Urban Forest Research. p. 57

Nowak, DJ and JF Dwyer. 2007. Understanding the benefits and costs of urban forest ecosystems. In: Kuser, J. (ed.) Urban and Community Forestry in the Northeast. New York: Springer. Pp. 25-46.

Peper, Paula J; McPherson, E Gregory; Simpson, James R; Vargas, Kelaine E; Xiao, Qingfu 2009. Lower Midwest community tree guide: benefits, costs, and strategic planting. Gen. Tech. Rep. PSW-GTR-219. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. p.115

Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Zearing

Annual Energy Benefits of Public Trees

9/23/2019

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	19.6	1,488	2,734.1	2,679	4,168	(N/A)	19.5	29.6	68.33
Norway maple	11.6	879	1,697.4	1,663	2,542	(N/A)	14.1	18.1	57.78
Silver maple	9.1	689	1,218.1	1,194	1,883	(N/A)	8.9	13.4	67.24
Red maple	2.3	172	299.5	294	466	(N/A)	7.0	3.3	21.17
Honeylocust	2.2	170	301.3	295	466	(N/A)	6.7	3.3	22.17
Northern hackberry	7.4	561	1,044.1	1,023	1,584	(N/A)	6.1	11.2	83.36
Apple	0.9	68	144.6	142	209	(N/A)	5.1	1.5	13.09
Blue spruce	0.7	53	97.9	96	149	(N/A)	4.8	1.1	9.91
Bur oak	0.6	43	78.5	77	119	(N/A)	4.2	0.8	9.19
Sugar maple	2.3	176	312.3	306	482	(N/A)	2.9	3.4	53.61
Black walnut	1.9	146	246.2	241	387	(N/A)	2.9	2.7	43.02
Northern white cedar	1.2	89	152.4	149	239	(N/A)	2.6	1.7	29.85
Ginkgo	0.0	2	4.6	5	7	(N/A)	1.6	0.0	1.36
Eastern redbud	0.1	8	17.9	18	25	(N/A)	1.3	0.2	6.33
Eastern white pine	0.2	19	34.3	34	52	(N/A)	1.3	0.4	13.05
American basswood	0.8	62	113.8	112	173	(N/A)	1.0	1.2	57.70
River birch	0.1	9	18.4	18	27	(N/A)	1.0	0.2	8.89
Swamp white oak	0.0	1	2.4	2	3	(N/A)	1.0	0.0	1.10
Callery pear	0.0	4	7.8	8	11	(N/A)	1.0	0.1	3.73
Northern catalpa	0.6	44	81.1	80	123	(N/A)	1.0	0.9	41.10
American elm	1.8	134	213.6	209	343	(N/A)	1.0	2.4	114.45
Northern pin oak	0.5	40	79.1	78	117	(N/A)	0.6	0.8	58.69
Boxelder	0.4	27	51.2	50	78	(N/A)	0.6	0.6	38.79
Kentucky coffeetree	0.7	51	86.0	84	135	(N/A)	0.6	1.0	67.63
Northern red oak	0.1	6	10.8	11	16	(N/A)	0.6	0.1	8.25
American sycamore	0.4	29	53.7	53	82	(N/A)	0.3	0.6	82.02
Hickory	0.2	18	27.0	26	44	(N/A)	0.3	0.3	44.23
Japanese maple	0.0	0	0.6	1	1	(N/A)	0.3	0.0	0.87
Tulip tree	0.0	0	0.5	0	1	(N/A)	0.3	0.0	0.66
Broadleaf Deciduous Large	0.5	37	63.1	62	99	(N/A)	0.3	0.7	98.63
Alder	0.0	0	0.6	1	1	(N/A)	0.3	0.0	0.87
Norway spruce	0.1	10	14.6	14	24	(N/A)	0.3	0.2	24.14
Eastern red cedar	0.1	8	16.4	16	25	(N/A)	0.3	0.2	24.57
White oak	0.0	0	0.5	0	1	(N/A)	0.3	0.0	0.66
Total	66.4	5,042	9,224.7	9,040	14,083	(N/A)	100.0	100.0	44.99

Table 2: Annual Stormwater Benefits

Zearing

Annual Stormwater Benefits of Public Trees

9/23/2019

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	233,440	6,326	(N/A)	19.5	30.8	103.71
Norway maple	124,997	3,387	(N/A)	14.1	16.5	76.99
Silver maple	126,508	3,428	(N/A)	8.9	16.7	122.44
Red maple	15,307	415	(N/A)	7.0	2.0	18.86
Honeylocust	24,864	674	(N/A)	6.7	3.3	32.09
Northern hackberry	79,100	2,144	(N/A)	6.1	10.4	112.82
Apple	3,610	98	(N/A)	5.1	0.5	6.11
Blue spruce	7,897	214	(N/A)	4.8	1.0	14.27
Bur oak	3,515	95	(N/A)	4.2	0.5	7.33
Sugar maple	32,004	867	(N/A)	2.9	4.2	96.37
Black walnut	17,515	475	(N/A)	2.9	2.3	52.74
Northern white cedar	22,528	611	(N/A)	2.6	3.0	76.31
Ginkgo	110	3	(N/A)	1.6	0.0	0.60
Eastern redbud	348	9	(N/A)	1.3	0.0	2.36
Eastern white pine	2,778	75	(N/A)	1.3	0.4	18.82
American basswood	7,930	215	(N/A)	1.0	1.0	71.64
River birch	610	17	(N/A)	1.0	0.1	5.51
Swamp white oak	37	1	(N/A)	1.0	0.0	0.33
Callery pear	187	5	(N/A)	1.0	0.0	1.69
Northern catalpa	6,706	182	(N/A)	1.0	0.9	60.58
American elm	13,653	370	(N/A)	1.0	1.8	123.33
Northern pin oak	4,959	134	(N/A)	0.6	0.7	67.19
Boxelder	3,809	103	(N/A)	0.6	0.5	51.62
Kentucky coffeetree	8,704	236	(N/A)	0.6	1.1	117.95
Northern red oak	335	9	(N/A)	0.6	0.0	4.54
American sycamore	5,491	149	(N/A)	0.3	0.7	148.79
Hickory	1,466	40	(N/A)	0.3	0.2	39.72
Japanese maple	7	0	(N/A)	0.3	0.0	0.20
Tulip tree	18	0	(N/A)	0.3	0.0	0.48
Broadleaf Deciduous Large	7,239	196	(N/A)	0.3	1.0	196.17
Alder	7	0	(N/A)	0.3	0.0	0.20
Norway spruce	1,539	42	(N/A)	0.3	0.2	41.70
Eastern red cedar	1,635	44	(N/A)	0.3	0.2	44.30
White oak	18	0	(N/A)	0.3	0.0	0.48
Citywide total	758,872	20,565	(N/A)	100.0	100.0	65.70

Table 3: Annual Air Quality Benefits

Annual Air Quality Benefits of Public Trees

9/23/2019

Species	Deposition (lb) O₃	NO₂	PM₁₀	SO₂	Total Depos. ($)	Avoided (lb) NO₂	PM₁₀	VOC	SO₂	Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($) Standard Error	% of Total Trees	Avg. $/tree
Green ash	30.3	4.8	14.2	1.4	161	94.1	13.7	13.0	88.9	585	0.0	0	260.4	745 (N/A)	19.5	12.22
Norway maple	27.6	4.8	13.3	1.2	148	56.4	8.1	7.7	52.5	349	-6.3	-24	165.4	473 (N/A)	14.1	10.76
Silver maple	21.7	3.7	10.7	1.0	117	43.0	6.3	6.0	41.1	269	-11.7	-44	121.8	342 (N/A)	8.9	12.22
Red maple	3.1	0.5	1.5	0.1	17	10.7	1.6	1.5	10.3	67	-1.1	-4	28.2	80 (N/A)	7.0	3.62
Honeylocust	4.8	0.8	2.2	0.2	25	10.6	1.6	1.5	10.2	66	-3.8	-14	27.9	77 (N/A)	6.7	3.68
Northern hackberry	13.6	2.4	6.8	0.6	74	35.6	5.2	4.9	33.5	221	0.0	0	102.6	295 (N/A)	6.1	15.53
Apple	0.9	0.2	0.5	0.0	5	4.5	0.6	0.6	4.0	27	0.0	0	11.3	32 (N/A)	5.1	2.01
Blue spruce	0.8	0.2	0.8	0.1	6	3.3	0.5	0.5	3.1	21	-2.6	-10	6.7	17 (N/A)	4.8	1.11
Bur oak	0.1	0.0	0.1	0.0	1	2.7	0.4	0.4	2.5	17	0.0	0	6.2	17 (N/A)	4.2	1.34
Sugar maple	5.1	0.9	2.4	0.2	27	11.0	1.6	1.5	10.5	69	-3.9	-15	29.3	81 (N/A)	2.9	9.03
Black walnut	1.9	0.3	1.0	0.1	10	9.0	1.3	1.3	8.7	57	0.0	0	23.6	67 (N/A)	2.9	7.45
Northern white cedar	2.6	0.5	2.1	0.3	17	5.5	0.8	0.8	5.3	35	-10.8	-41	7.2	11 (N/A)	2.6	1.41
Ginkgo	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)	1.6	0.18
Eastern redbud	0.0	0.0	0.0	0.0	0	0.5	0.1	0.1	0.5	3	0.0	0	1.2	3 (N/A)	1.3	0.87
Eastern white pine	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)	1.3	1.46
American basswood	1.0	0.2	0.5	0.0	5	3.9	0.6	0.5	3.7	24	-0.9	-3	9.5	26 (N/A)	1.0	8.80
River birch	0.1	0.0	0.0	0.0	0	0.6	0.1	0.1	0.5	3	0.0	0	1.3	4 (N/A)	1.0	1.25
Swamp white oak	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	0	0.0	0	0.1	0 (N/A)	1.0	0.14
Callery pear	0.0	0.0	0.0	0.0	0	0.2	0.0	0.0	0.2	1	0.0	0	0.5	1 (N/A)	1.0	0.49
Northern catalpa	0.8	0.1	0.4	0.0	4	2.8	0.4	0.4	2.6	17	0.0	0	7.6	22 (N/A)	1.0	7.23
American elm	6.6	1.1	3.0	0.3	35	8.2	1.2	1.2	8.0	52	0.0	0	29.6	87 (N/A)	1.0	28.89
Northern pin oak	1.0	0.2	0.5	0.0	5	2.6	0.4	0.4	2.4	16	-0.2	-1	7.1	20 (N/A)	0.6	10.16
Boxelder	0.5	0.1	0.2	0.0	3	1.7	0.3	0.2	1.6	11	-0.2	-1	4.5	13 (N/A)	0.6	6.29
Kentucky coffeetree	1.3	0.2	0.6	0.1	7	3.2	0.5	0.4	3.0	20	0.0	0	9.2	26 (N/A)	0.6	13.23
Northern red oak	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.4	2	0.0	0	0.8	2 (N/A)	0.6	1.15
American sycamore	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)	0.3	15.71
Hickory	0.1	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	0.0	0	2.6	7 (N/A)	0.3	7.42
Japanese maple	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0 (N/A)	0.3	0.11
Tulip tree	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)	0.3	0.08
Broadleaf Deciduous Large	1.6	0.3	0.7	0.1	8	2.3	0.3	0.3	2.2	14	0.0	0	7.7	23 (N/A)	0.3	22.55
Alder	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)	0.3	0.11
Norway spruce	0.2	0.0	0.1	0.0	1	0.6	0.1	0.1	0.6	4	-0.5	-2	1.2	3 (N/A)	0.3	2.82
Eastern red cedar	0.3	0.1	0.3	0.0	2	0.5	0.1	0.1	0.5	3	-0.9	-3	1.0	2 (N/A)	0.3	2.19
White oak	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)	0.3	0.08

Species	Deposition (lb) O₃	NO₂	PM₁₀	SO₂	Total Depos. ($)	Avoided (lb) NO₂	PM₁₀	VOC	SO₂	Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($) Standard Error	% of Total Trees	Avg. $/tree
Citywide total	127.2	21.4	62.7	6.0	687	318.3	46.3	44.1	301.1	1,980	-44.0	-165	883.1	2,502 (N/A)	100.0	7.99

Table 4: Annual Carbon Stored

Zearing

Stored CO2 Benefits of Public Trees

9/23/2019

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	983,322	7,375	(N/A)	19.5	34.1	120.90
Norway maple	456,479	3,424	(N/A)	14.1	15.8	77.81
Silver maple	507,475	3,806	(N/A)	8.9	17.6	135.93
Red maple	35,723	268	(N/A)	7.0	1.2	12.18
Honeylocust	62,593	469	(N/A)	6.7	2.2	22.35
Northern hackberry	214,131	1,606	(N/A)	6.1	7.4	84.53
Apple	15,666	117	(N/A)	5.1	0.5	7.34
Blue spruce	4,349	33	(N/A)	4.8	0.2	2.17
Bur oak	5,287	40	(N/A)	4.2	0.2	3.05
Sugar maple	152,210	1,142	(N/A)	2.9	5.3	126.84
Black walnut	65,507	491	(N/A)	2.9	2.3	54.59
Northern white cedar	26,544	199	(N/A)	2.6	0.9	24.89
Ginkgo	96	1	(N/A)	1.6	0.0	0.14
Eastern redbud	1,113	8	(N/A)	1.3	0.0	2.09
Eastern white pine	1,686	13	(N/A)	1.3	0.1	3.16
American basswood	36,765	276	(N/A)	1.0	1.3	91.91
River birch	1,134	9	(N/A)	1.0	0.0	2.84
Swamp white oak	51	0	(N/A)	1.0	0.0	0.13
Callery pear	252	2	(N/A)	1.0	0.0	0.63
Northern catalpa	28,012	210	(N/A)	1.0	1.0	70.03
American elm	123,794	928	(N/A)	1.0	4.3	309.48
Northern pin oak	15,891	119	(N/A)	0.6	0.6	59.59
Boxelder	15,381	115	(N/A)	0.6	0.5	57.68
Kentucky coffeetree	42,930	322	(N/A)	0.6	1.5	160.99
Northern red oak	373	3	(N/A)	0.6	0.0	1.40
American sycamore	25,943	195	(N/A)	0.3	0.9	194.57
Hickory	3,672	28	(N/A)	0.3	0.1	27.54
Japanese maple	14	0	(N/A)	0.3	0.0	0.10
Tulip tree	12	0	(N/A)	0.3	0.0	0.09
Broadleaf Deciduous	55,982	420	(N/A)	0.3	1.9	419.86
Alder	14	0	(N/A)	0.3	0.0	0.10
Norway spruce	1,170	9	(N/A)	0.3	0.0	8.78
Eastern red cedar	1,102	8	(N/A)	0.3	0.0	8.27
White oak	12	0	(N/A)	0.3	0.0	0.09
Citywide total	2,884,685	21,635	(N/A)	100.0	100.0	69.12

Table 5: Annual Carbon Sequestered

Zearing

Annual CO Benefits of Public Trees

9/23/2019

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total Standard ($) Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	47,996	360	-4,720	-208	-37	32,893	247	75,961	570 (N/A)	19.5	32.2	9.34
Norway maple	9,132	68	-2,195	-137	-17	19,424	146	26,223	197 (N/A)	14.1	11.1	4.47
Silver maple	37,892	284	-2,436	-101	-19	15,229	114	50,585	379 (N/A)	8.9	21.4	13.55
Red maple	3,712	28	-172	-23	-1	3,805	29	7,322	55 (N/A)	7.0	3.1	2.50
Honeylocust	3,381	25	-305	-20	-2	3,763	28	6,820	51 (N/A)	6.7	2.9	2.44
Northern hackberry	9,899	74	-1,028	-72	-8	12,389	93	21,188	159 (N/A)	6.1	9.0	8.36
Apple	1,557	12	-75	-14	-1	1,496	11	2,964	22 (N/A)	5.1	1.3	1.39
Blue spruce	434	3	-21	-12	0	1,165	9	1,566	12 (N/A)	4.8	0.7	0.78
Bur oak	1,288	10	-25	-9	0	940	7	2,194	16 (N/A)	4.2	0.9	1.27
Sugar maple	6,399	48	-731	-28	-6	3,899	29	9,539	72 (N/A)	2.9	4.0	7.95
Black walnut	3,980	30	-314	-19	-3	3,223	24	6,869	52 (N/A)	2.9	2.9	5.72
Northern white cedar	1,424	11	-127	-21	-1	1,976	15	3,251	24 (N/A)	2.6	1.4	3.05
Ginkgo	25	0	-1	-1	0	50	0	73	1 (N/A)	1.6	0.0	0.11
Eastern redbud	169	1	-5	-2	0	173	1	334	3 (N/A)	1.3	0.1	0.63
Eastern white pine	224	2	-8	-4	0	411	3	623	5 (N/A)	1.3	0.3	1.17
American basswood	2,278	17	-176	-9	-1	1,360	10	3,452	26 (N/A)	1.0	1.5	8.63
River birch	235	2	-6	-2	0	190	1	418	3 (N/A)	1.0	0.2	1.04
Swamp white oak	16	0	0	-1	0	22	0	37	0 (N/A)	1.0	0.0	0.09
Callery pear	106	1	-2	-1	0	79	1	182	1 (N/A)	1.0	0.1	0.46
Northern catalpa	1,377	10	-134	-7	-1	968	7	2,204	17 (N/A)	0.9	0.9	5.51
American elm	2,173	16	-594	-18	-5	2,961	22	4,522	34 (N/A)	1.0	1.9	11.31
Northern pin oak	940	7	-76	-5	-1	880	7	1,738	13 (N/A)	0.6	0.7	6.52
Boxelder	1,219	9	-74	-5	-1	606	5	1,746	13 (N/A)	0.6	0.7	6.55
Kentucky coffeetree	1,357	10	-206	-7	-2	1,127	8	2,272	17 (N/A)	0.6	1.0	8.52
Northern red oak	110	1	-2	-1	0	130	1	237	2 (N/A)	0.6	0.1	0.89
American sycamore	960	7	-125	-4	-1	650	5	1,481	11 (N/A)	0.3	0.6	11.11
Hickory	445	3	-18	-2	0	393	3	819	6 (N/A)	0.3	0.3	6.14
Japanese maple	9	0	0	0	0	6	0	14	0 (N/A)	0.3	0.0	0.10
Tulip tree	3	0	0	0	0	4	0	7	0 (N/A)	0.3	0.0	0.05
Broadleaf Deciduous Large	479	4	-269	-6	-2	813	6	1,017	8 (N/A)	0.3	0.4	7.63
Alder	9	0	0	0	0	6	0	14	0 (N/A)	0.3	0.0	0.10
Norway spruce	116	1	-6	-2	0	216	2	324	2 (N/A)	0.3	0.1	2.43

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
Eastern red cedar	0	0	-5	-2	0	187	1	180	1 (N/A)	0.3	0.1	1.35
White oak	3	0	0	0	0	4	0	7	0 (N/A)	0.3	0.0	0.05
Citywide total	139,346	1,045	-13,858	-742	-110	111,437	836	236,183	1,771 (N/A)	100.0	100.0	5.66

Table 6: Annual Social and Aesthetic Benefits

Zearing

Annual Aesthetic/Other Benefits of Public Trees

9/23/2019

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	3,738	(N/A)	19.5	28.4	61.29
Norway maple	853	(N/A)	14.1	6.5	19.39
Silver maple	2,951	(N/A)	8.9	22.4	105.38
Red maple	528	(N/A)	7.0	4.0	23.99
Honeylocust	835	(N/A)	6.7	6.3	39.74
Northern hackberry	1,232	(N/A)	6.1	9.4	64.82
Apple	87	(N/A)	5.1	0.7	5.44
Blue spruce	206	(N/A)	4.8	1.6	13.74
Bur oak	218	(N/A)	4.2	1.7	16.80
Sugar maple	609	(N/A)	2.9	4.6	67.72
Black walnut	385	(N/A)	2.9	2.9	42.79
Northern white cedar	326	(N/A)	2.6	2.5	40.79
Ginkgo	4	(N/A)	1.6	0.0	0.85
Eastern redbud	9	(N/A)	1.3	0.1	2.13
Eastern white pine	69	(N/A)	1.3	0.5	17.23
American basswood	170	(N/A)	1.0	1.3	56.79
River birch	32	(N/A)	1.0	0.2	10.56
Swamp white oak	8	(N/A)	1.0	0.1	2.74
Callery pear	18	(N/A)	1.0	0.1	6.12
Northern catalpa	124	(N/A)	1.0	0.9	41.24
American elm	260	(N/A)	1.0	2.0	86.69
Northern pin oak	86	(N/A)	0.6	0.7	43.05
Boxelder	93	(N/A)	0.6	0.7	46.27
Kentucky coffeetree	104	(N/A)	0.6	0.8	52.10
Northern red oak	14	(N/A)	0.6	0.1	7.21
American sycamore	67	(N/A)	0.3	0.5	66.60
Hickory	46	(N/A)	0.3	0.3	45.86
Japanese maple	0	(N/A)	0.3	0.0	0.03
Tulip tree	5	(N/A)	0.3	0.0	5.26
Broadleaf Deciduous Large	29	(N/A)	0.3	0.2	28.57
Alder	0	(N/A)	0.3	0.0	0.03
Norway spruce	32	(N/A)	0.3	0.2	32.32
Eastern red cedar	0	(N/A)	0.3	0.0	0.00
White oak	5	(N/A)	0.3	0.0	5.26
Citywide total	13,144	(N/A)	100.0	100.0	41.99

Table 7: Summary of Benefits in Dollars

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

9/23/2019

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Green ash	4,168	570	745	6,326	3,738	15,548	(N/A)	29.9
Norway maple	2,542	197	473	3,387	853	7,453	(N/A)	14.3
Silver maple	1,883	379	342	3,428	2,951	8,983	(N/A)	17.3
Red maple	466	55	80	415	528	1,543	(N/A)	3.0
Honeylocust	466	51	77	674	835	2,102	(N/A)	4.0
Northern hackberry	1,584	159	295	2,144	1,232	5,413	(N/A)	10.4
Apple	209	22	32	98	87	449	(N/A)	0.9
Blue spruce	149	12	17	214	206	597	(N/A)	1.1
Bur oak	119	16	17	95	218	467	(N/A)	0.9
Sugar maple	482	72	81	867	609	2,112	(N/A)	4.1
Black walnut	387	52	67	475	385	1,366	(N/A)	2.6
Northern white cedar	239	24	11	611	326	1,211	(N/A)	2.3
Ginkgo	7	1	1	3	4	15	(N/A)	0.0
Eastern redbud	25	3	3	9	9	49	(N/A)	0.1
Eastern white pine	52	5	6	75	69	207	(N/A)	0.4
American basswood	173	26	26	215	170	611	(N/A)	1.2
River birch	27	3	4	17	32	82	(N/A)	0.2
Swamp white oak	3	0	0	1	8	13	(N/A)	0.0
Callery pear	11	1	1	5	18	37	(N/A)	0.1
Northern catalpa	123	17	22	182	124	467	(N/A)	0.9
American elm	343	34	87	370	260	1,094	(N/A)	2.1
Northern pin oak	117	13	20	134	86	371	(N/A)	0.7
Boxelder	78	13	13	103	93	299	(N/A)	0.6
Kentucky coffeetree	135	17	26	236	104	519	(N/A)	1.0
Northern red oak	16	2	2	9	14	44	(N/A)	0.1
American sycamore	82	11	16	149	67	324	(N/A)	0.6
Hickory	44	6	7	40	46	143	(N/A)	0.3
Japanese maple	1	0	0	0	0	1	(N/A)	0.0
Tulip tree	1	0	0	0	5	7	(N/A)	0.0
Broadleaf Deciduous La	99	8	23	196	29	354	(N/A)	0.7
Alder	1	0	0	0	0	1	(N/A)	0.0
Norway spruce	24	2	3	42	32	103	(N/A)	0.2
Eastern red cedar	25	1	2	44	0	72	(N/A)	0.1
White oak	1	0	0	0	5	7	(N/A)	0.0
Citywide Total	14,083	1,771	2,502	20,565	13,144	52,065	(N/A)	100.0

Figure 1: Species Distribution
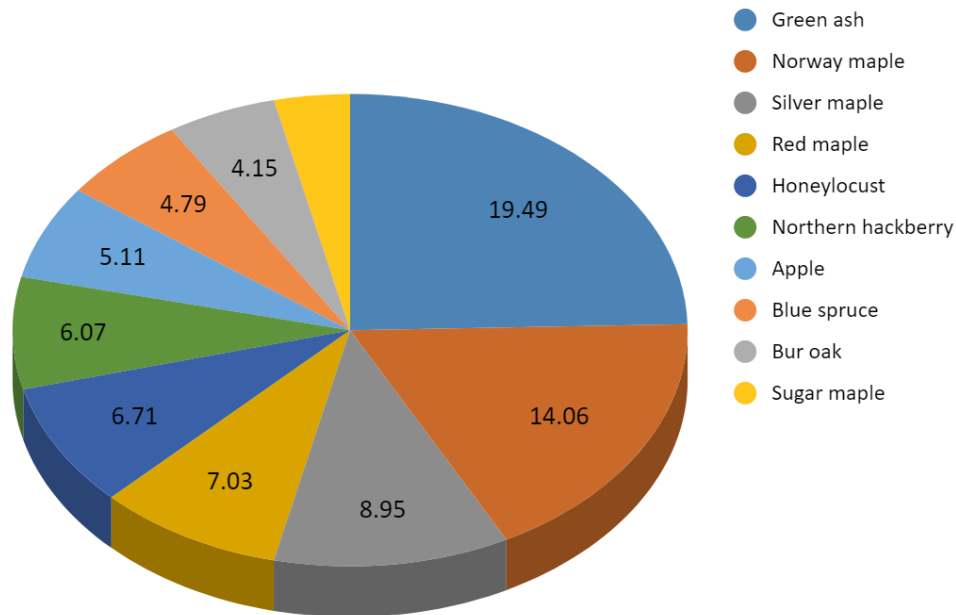
Figure 2: Relative Age Class

Relative Age Distribution of Top 10 Public Tree Species (%)
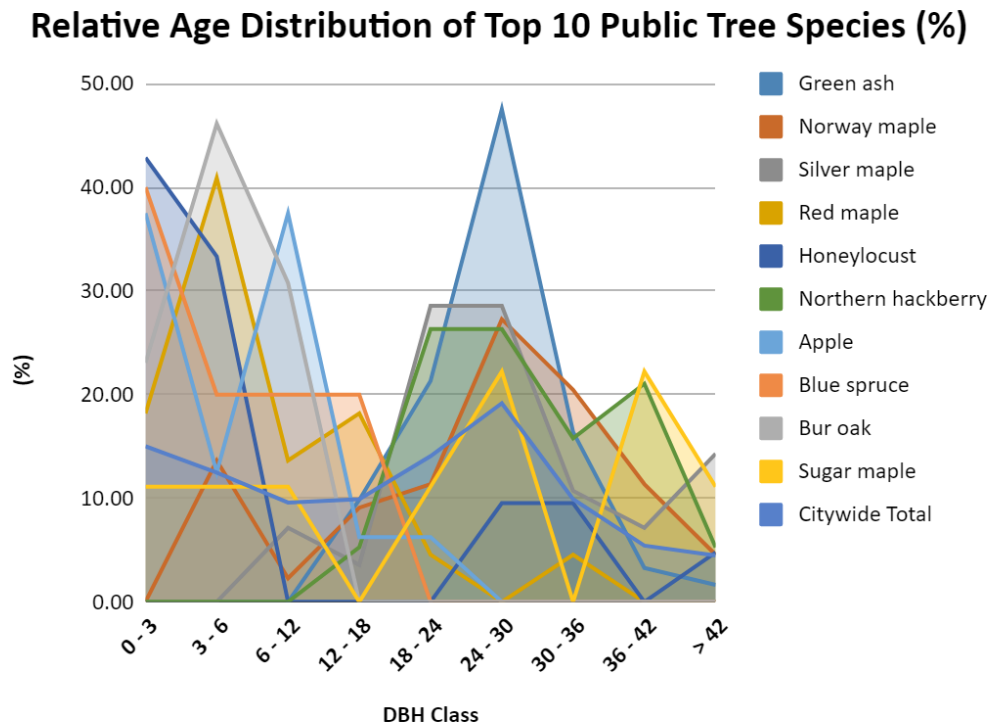
Figure 3: Foliage Condition

Leaf Condition

Dead or Dying ● Poor ● Fair ● Good

Figure 4: Wood Condition


Wood Condition

Dead or Dying ● Poor ● Fair ● Good
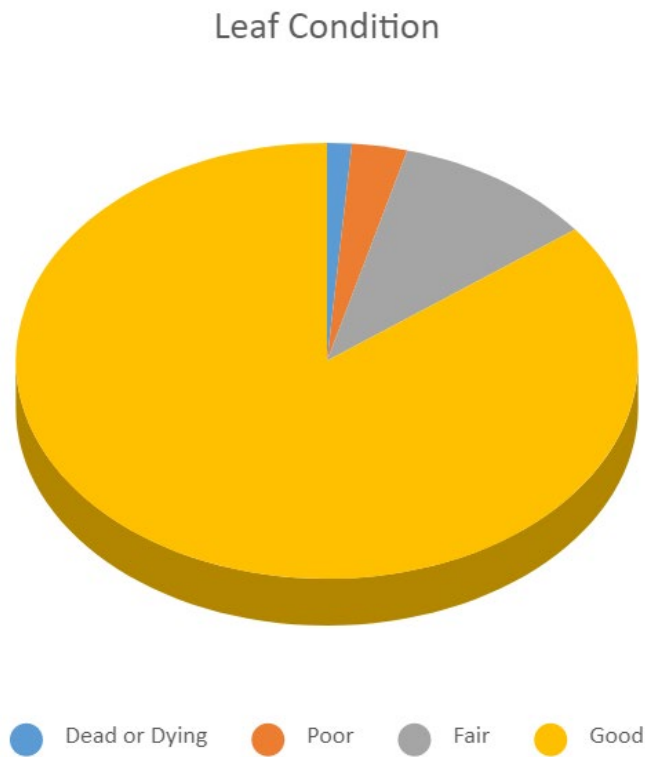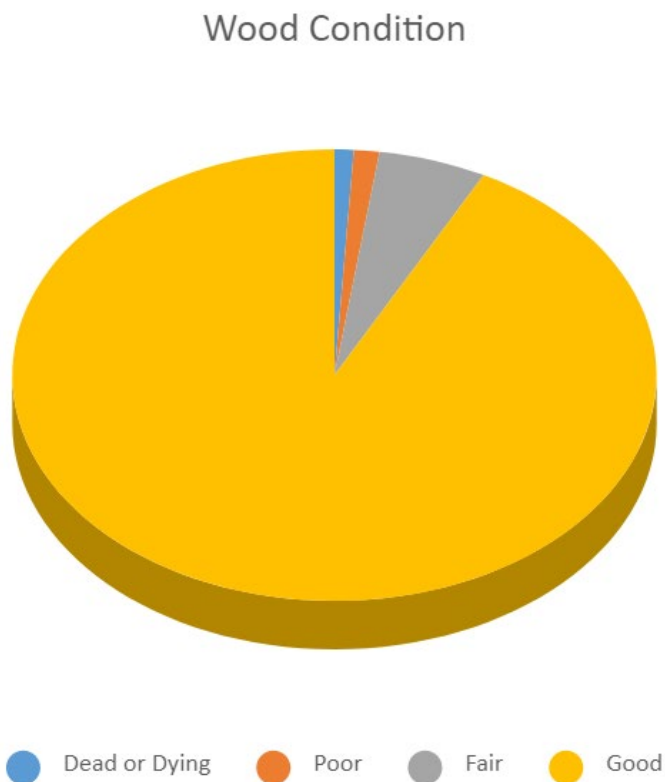
Figure 5: Canopy Cover in Acres

Canopy Cover of Public Trees (Acres)
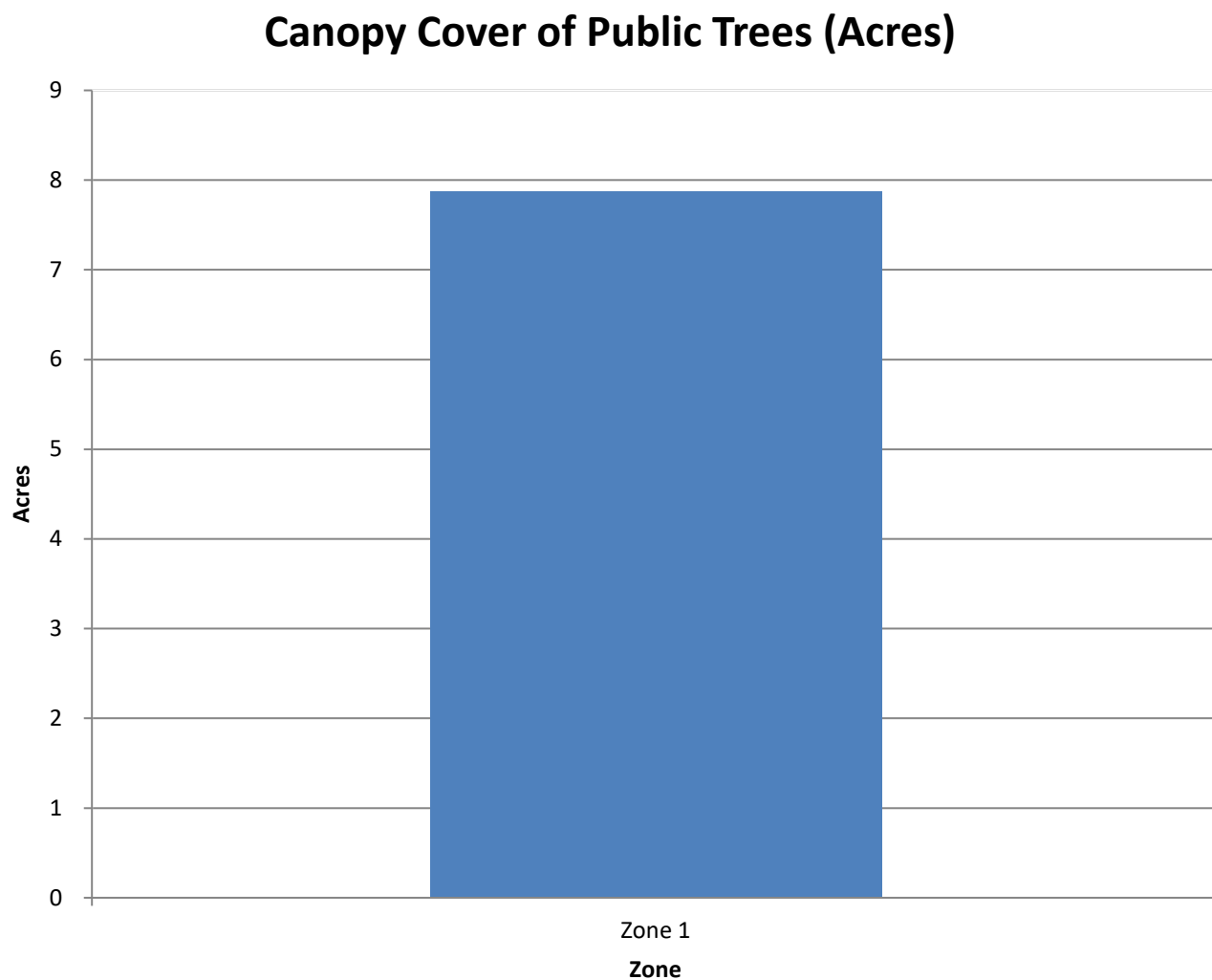
Figure 6: Land Use of city/park trees

Land Use
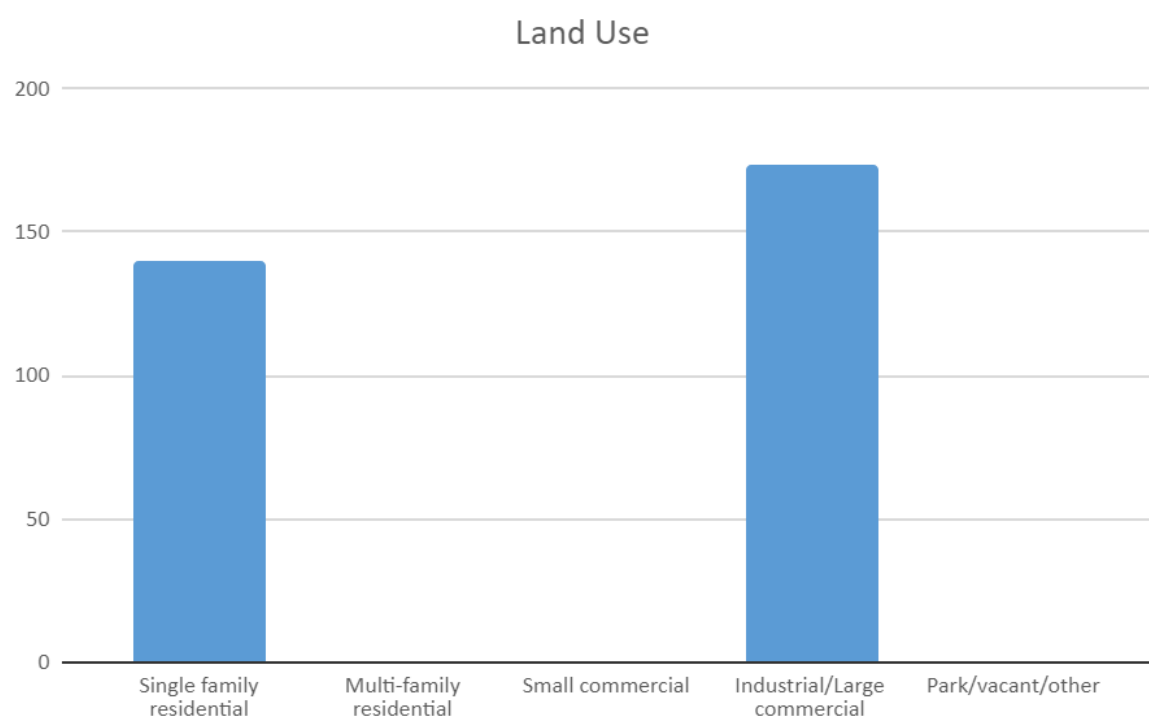
Figure 7: Location of city/park trees

Location

A bar chart showing the number of city/park trees by location. The y-axis ranges from 0 to 250. The categories along the x-axis are: Front yard (~210), Planting strip (~102), Cutout (0), Median (0), Other maintained lo... (0), Other un-maintaine... (0), Backyard (0).
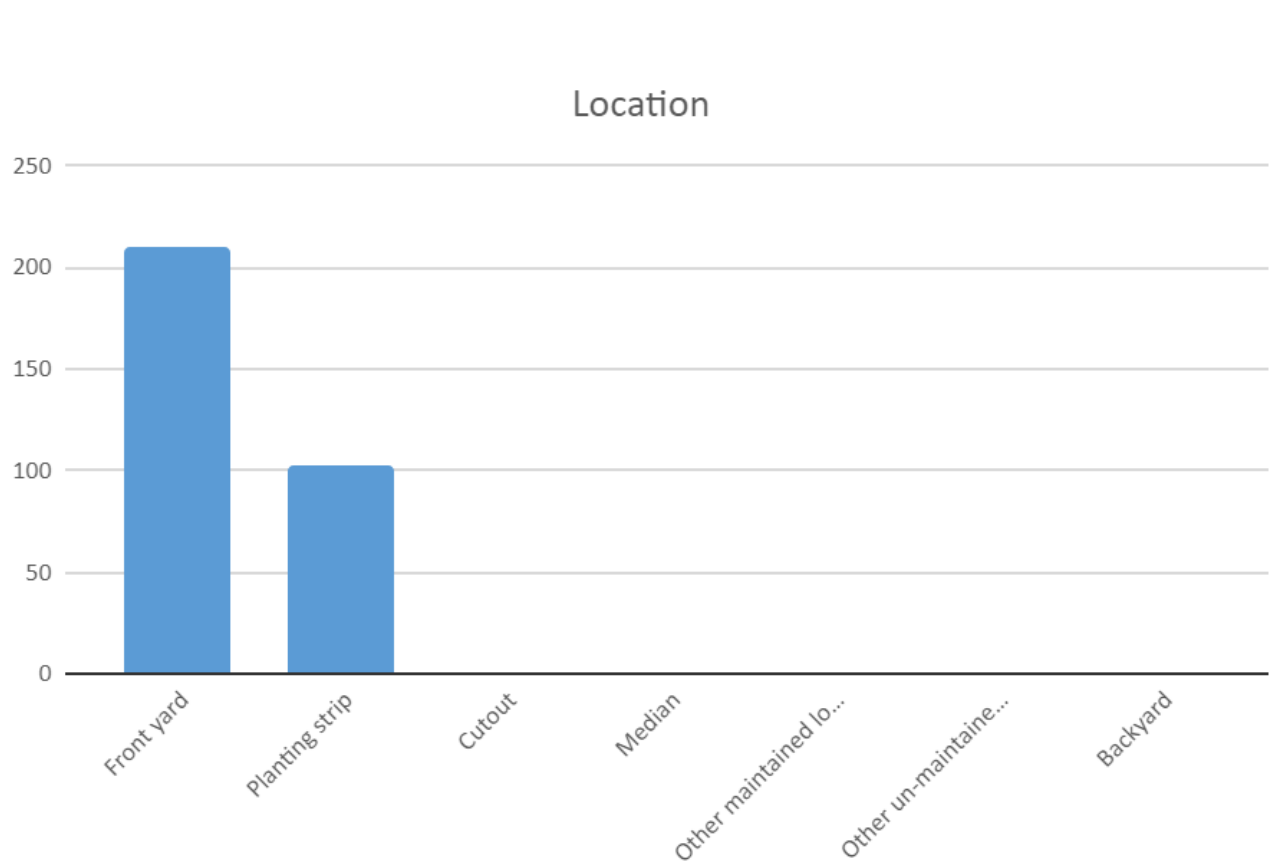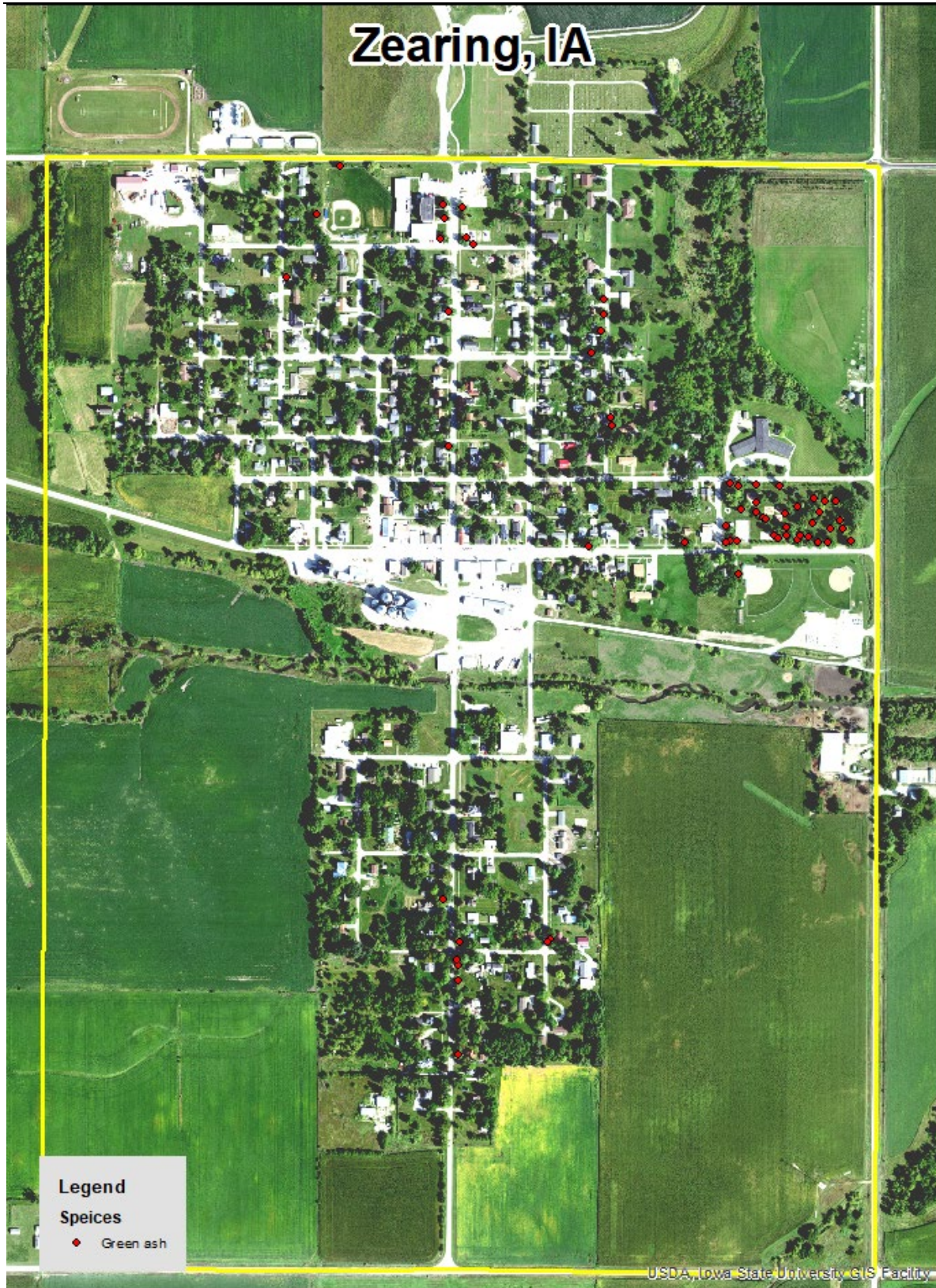
Figure 1: Location of Ash Trees
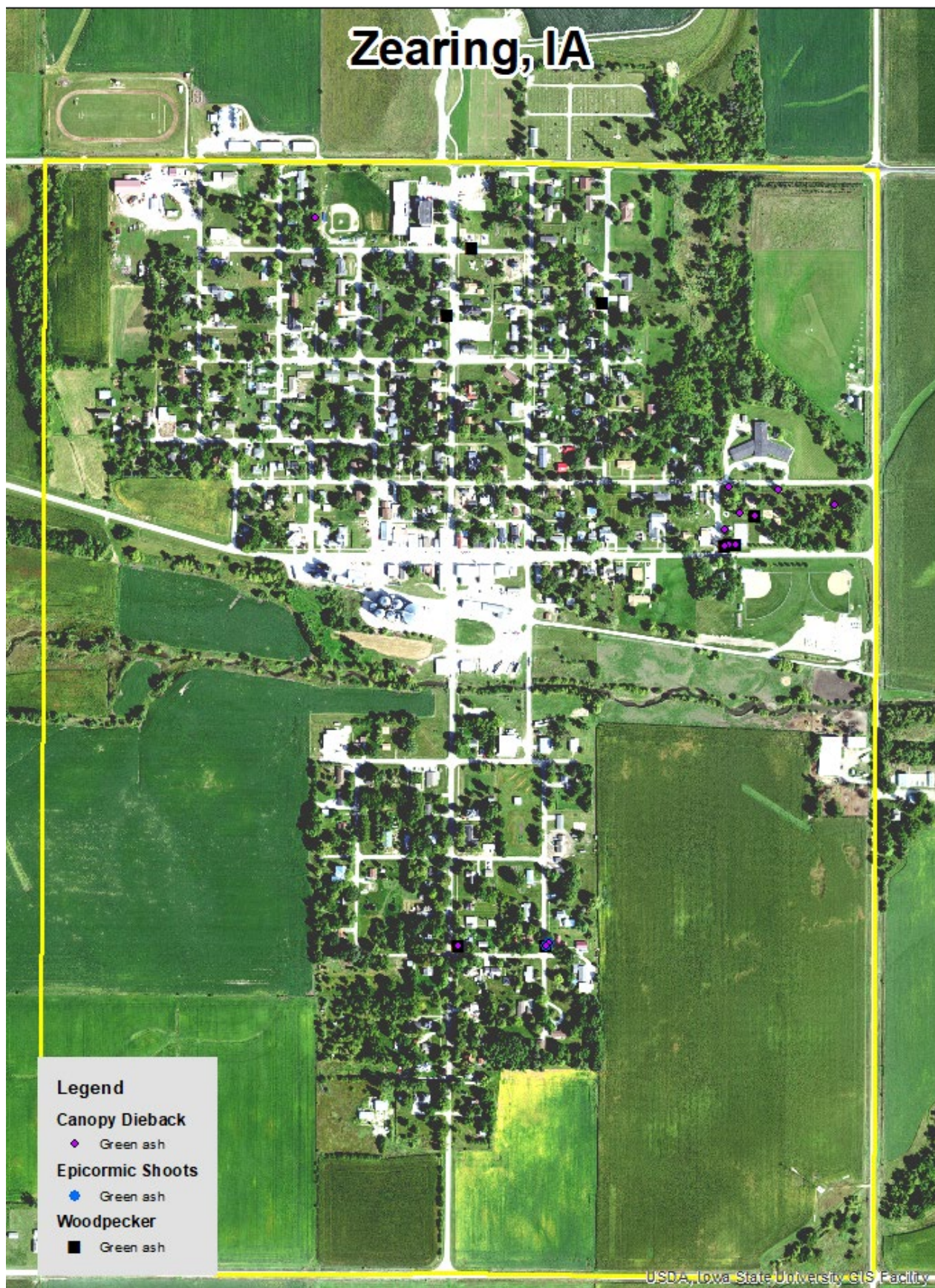
Figure 2: Location of EAB symptoms
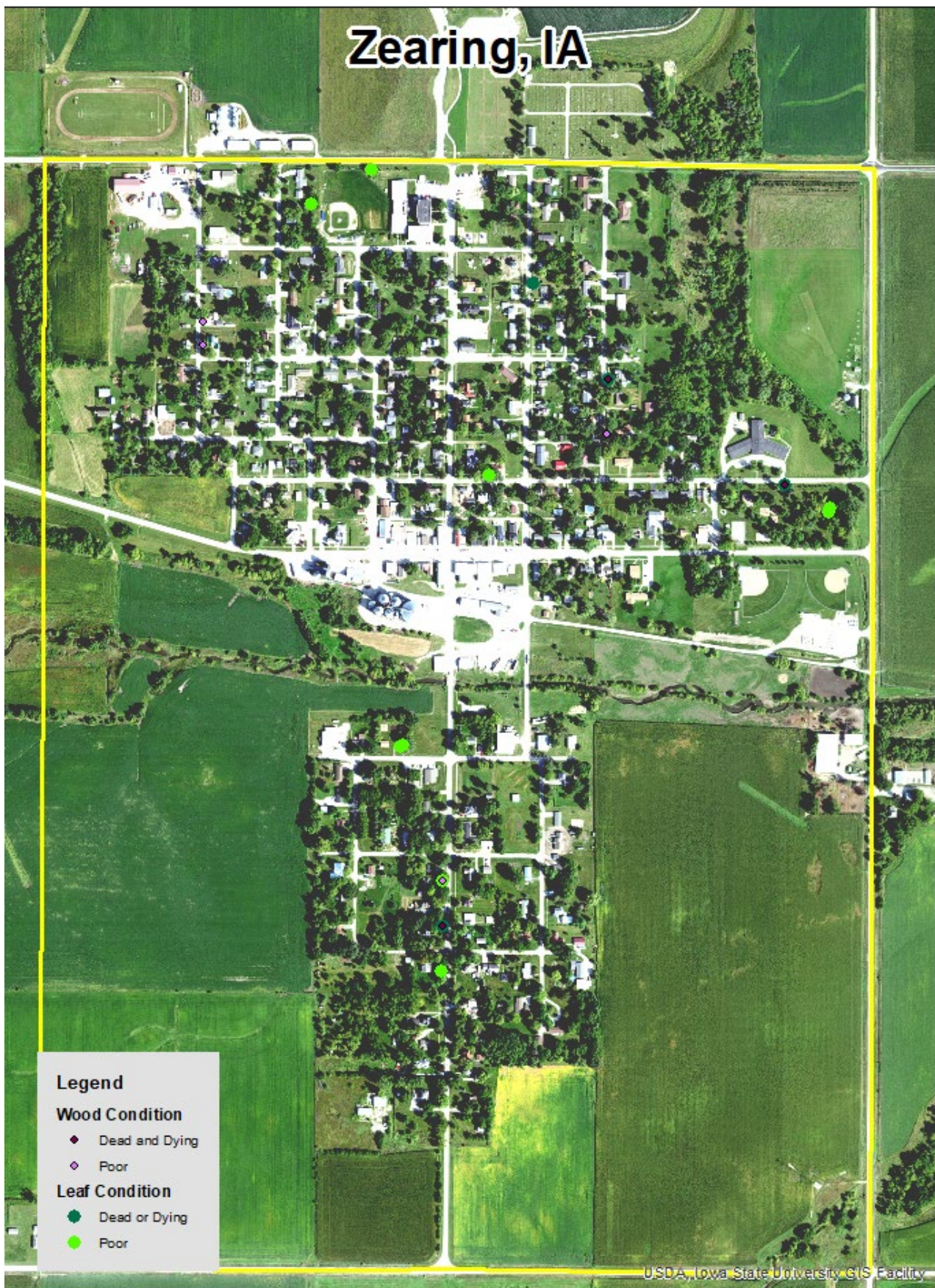
Figure 3: Location of Poor Condition Trees

Figure 4: Location of Trees with Recommended Maintenance
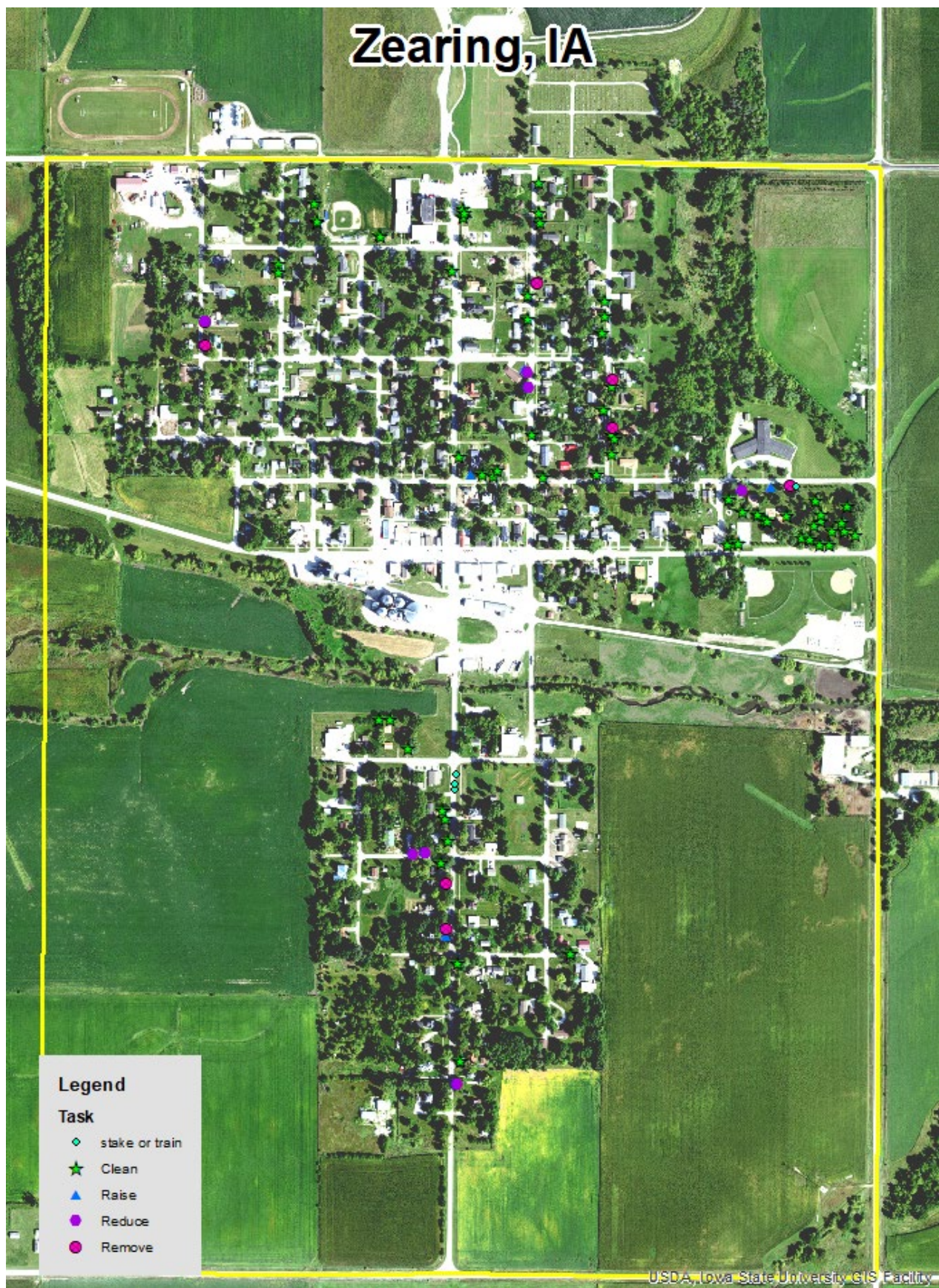
Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

Appendix C: Zearing Tree Ordinances

None