

Laurens, IA



2019 URBAN FOREST MANAGEMENT PLAN

IOWA DEPARTMENT OF NATURAL RESOURCES



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Executive Summary

Overview

This plan was developed to assist the City of Laurens in managing its urban forest, including budgeting and future planning. Trees bring numerous benefits to a community, and sound management helps leaders take advantage of these benefits. Management is especially important now considering the serious threats posed by forest pests like 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 except mountain ash. There is a strong possibility that 22% of Laurens' city-owned trees will die once EAB becomes established in the community, unless local leaders begin preventative treatment. 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 2019, JEO conducted a tree inventory 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 733 trees inventoried.

- Laurens' trees provide \$168,177 of benefits annually, an average of \$229.44 per tree
- There are over 21 species of trees
- The top three genera are: Maple 52.5%, Ash 22%, and Spruce 6%
- 9% of trees need some type of management
- 25 trees should be removed

Recommendations

We detail our core recommendations in the Recommendations Section. In the Emerald Ash Borer Plan, we include management recommendations. Below are some key recommendations.

- Out of the 25 trees needing removal, 19 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*](#)
- 19 of the 159 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 yearly with a visual survey.
- With the current budget it could take 44 years to remove ash. We suggest that city officials request a budget increase to \$4,500 annually and apply for grants to plant replacement trees.

Introduction

This plan was developed to assist Laurens with managing, budgeting, and future planning of their urban forest. Across the state, forestry budgets continue to decrease as a higher percentage of the budgets are devoted to 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, treatment, and replacement planting. With proper planning and management of the current canopy in Laurens, these costs can be spread out over the years and public safety issues from dead and dying ash trees can be mitigated.

Trees are an important part of Laurens' infrastructure and one of the city's greatest assets. The benefits of trees are immense. Trees improve air quality, intercept stormwater runoff, conserve energy, lower traffic speeds, increase property values, reduce crime, improve mental health, and create a desirable place to live, to name just a few. Good urban forestry management will maintain these important benefits for the people of Laurens and future generations.

Urban forestry management sets goals and develops management strategies to achieve them. To develop management strategies, a comprehensive public tree inventory must be conducted. The inventory informs maintenance, removal schedules, tree planting, and budgeting. Aligning management actions with the tree inventory results will help meet Laurens' urban forestry goals.

Inventory

In 2019, JEO conducted a tree inventory that included 100% of the city-owned trees on both streets and parks. The team collected tree data 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 data collectors' programming 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, for all ash trees, the team notes signs and symptoms associated with EAB including canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

Inventory Results

JEO entered the data collected for the 733 city trees into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management as part of the i-Tree suite. Below are results from the i-Tree STREETS analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Laurens' trees reduce energy-related costs by approximately \$42,625 annually (Appendix A, Table 1). These savings are both in electricity (203.7 MWh) and in natural gas (27,717.5 Therms).

Annual Stormwater Benefits

Laurens' trees intercept about 2,408,022 gallons of rainfall or snow melt per year (Appendix A, Table 2). This interception provides \$65,257 in benefit 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 lessens emissions of volatile organic matter (ozone). In Laurens, it is estimated that trees remove 2,679.8 lbs of air pollution (ozone (O₃), particulate matter less than 10 microns (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂)) per year with a net value of \$7,563 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Laurens, trees sequester about 514,533 lbs of carbon per year with an associated value of \$3,859 (Appendix A, Table 5). In addition, the trees store 8,878,831 lbs of carbon, with a yearly benefit of \$66,591 (Appendix A, Table 4).

Annual Aesthetics Benefits

The social benefits of trees are hard to capture. The i-Tree 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. Laurens receives \$46,646 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, Laurens' trees provide \$168,177 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 733 trees in Laurens provide approximately \$229.44 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Laurens has over 21 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	386	52.5%
Ash	159	22%
Spruce	42	6%
Hackberry	28	4%
Linden/Basswood	23	3%
Broadleaf Deciduous	16	2%
Oak	16	2%
Locust	15	2%
Walnut	11	1.5%
Buckeye	9	1%
Juniper	7	<1%
Pine	7	<1%
Elm	3	<1%
Cottonwood	2	<1%
Ginkgo	2	<1%
Sycamore	2	<1%
Apple (Crab)	1	<1%
Birch	1	<1%
Chokecherry	1	<1%
Mulberry	1	<1%
Pear	1	<1%

Age Class

Most of Laurens' trees (42.43%) are between 18 and 30 inches in diameter at 4.5 ft (Appendix A, Figure 2). To prepare for natural mortality and to maintain canopy cover, most trees should be in the smallest size category (a downward slope), indicating youth. Laurens' size curve indicates an average to mature stand.

Condition: Wood and Foliage

Both wood condition and leaf condition are good indicators of the urban forest's overall health. The foliage condition results for Laurens indicate that 72% of the trees are in good health, with only 2% of the foliage in poor health, dead, or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 66% of Laurens' trees are in good health for wood condition (Appendix A, Figure 4 & Appendix B, Figure 3). Four and a half percent of the tree population's wood condition is in poor health, dead, or dying. This 4.5% 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	0	0%
Crown Raising	0	0%
Tree Staking	0	0%
Tree Removal	25	3%
Crown Reduction	3	<1%
Treat Pest/Disease	38	5%

Land Use and Location

The majority of Laurens' 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.

<u>Land Use</u>	
Single family residential	95%
Park/vacant/other	0%
Industrial/Large commercial	5%
Small commercial	0%
Multifamily residential	0%

Recommendations

Risk Management

Hazardous trees can be a significant threat to both people and property. Trees that are dead, dying, or have large issues such as trunk cracks longer than 18 inches should be removed. Broken branches and branches that interfere with motorists' vision of pedestrians, vehicles, traffic signs and signals should be removed.

Hazardous trees

Laurens has 25 trees that need immediate removal. These trees along with other trees needing maintenance can be seen on the Location of Trees with Recommended Maintenance Map (Appendix B, Figure 4). We recommend starting with the large-diameter, critical concern trees first. There are 19 trees over 24 inches in diameter at 4.5 ft that should be addressed immediately. Please refer to the Proposed Work Schedule and Budget at the end of this section. After all the critical concern trees are addressed, there should be follow up on the trees marked as needing maintenance. There are a total of 41 trees with maintenance needs.

Poor tree species

After removing the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 25 removals, 19 are ash trees. There are a total of 159 ash trees, and nearly 23 of those have signs and symptoms that have been associated with EAB. In addition, there are 19 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 removes lower branches that are two inches in diameter or larger to provide clearance for pedestrians or vehicles. Crown reduction removes individual limbs from structures or utility wires. We recommend 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 five years will replace the trees that are removed. We recommend planting 1.2 trees for every tree removed, since survival rates will not be 100%. 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 Laurens.

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 (52.5%) (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. While the city currently has no existing City Code in reference to tree species planting restrictions, we encourage the city to work with the Iowa Department of Natural Resources to develop a plan moving forward.

Continual Monitoring

Due to the threat of EAB, it is important to continuously check the health of ash trees. We recommend 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 by first removing dead, dying, hazardous trees (Appendix B, Figure 4). Next will be all ash in poor condition that display EAB signs and symptoms (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 an effective tool for communities to spread removal costs out over several years while allowing trees to continue providing 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 normally disposed of if your county is not part of a quarantine.

Canopy Replacement

As budget permits, all removed trees will be replaced. All trees will meet the restrictions outlined by the Iowa Department of Natural Resources. While the city currently has no existing City Code in reference to tree species restrictions, we encourage the city to work with the Iowa Department of Natural Resources to develop a plan moving forward. We encourage the new plantings to be a diverse mix and 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 EAB signs and symptoms including 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. While there is no existing City Code in reference to private tree care and removal, we encourage the city to work with the Iowa Department of Natural Resources to develop a plan moving forward.

Proposed Work Schedule and Budget

Budget Allowance of \$2,516/Year – (Calculated at \$2/Capita, No Budget Provided)

YEAR 1

ESTIMATED COSTS

Remove 3 trees recommended for immediate removal	\$2,100
Plant 2 trees in open locations	\$450
Visual Survey of EAB Signs/Symptoms	

YEAR 2

Remove 2 trees recommended for immediate removal	\$1,400
Plant 7 trees in open locations	\$1,050
Visual Survey of EAB Signs/Symptoms	

YEAR 3

Remove 3 trees recommended for immediate removal	\$2,100
Plant 2 trees in open locations	\$450
Visual Survey of EAB Signs/Symptoms	

YEAR 4

Remove 2 trees recommended for immediate removal	\$1,400
Plant 7 trees in open locations	\$1,050
Visual Survey of EAB Signs/Symptoms	

YEAR 5

Remove 3 trees recommended for immediate removal	\$2,100
Plant 2 trees in open locations	\$450
Visual Survey of EAB Signs/Symptoms	

YEAR 6

Remove 3 trees recommended for immediate removal	\$2,100
Plant 2 trees in open locations	\$450
Visual Survey of EAB Signs/Symptoms	

Estimated costs based on average costs of \$700/tree for removal, \$150/tree for planting and maintenance, and \$15/tree for pruning.

**To remove all ash trees within 6 years alone, the budget would need to be \$18,550 a year. If the budget were increased to \$4,500 a year all ash could be removed in 25 years.

Proposed Work Schedule with Increased Budget

Budget Allowance of \$4,500/Year – (Budget Increase Suggested to Best Manage City Trees)

YEAR 1

ESTIMATED COSTS

Remove 6 trees recommended for immediate removal	\$4,200
Plant 2 trees in open locations	\$300
Visual Survey of EAB Signs/Symptoms	

YEAR 2

Plant 5 trees in open locations	\$750
Prune 1/3 of City Owned Trees	\$3,660
Visual Survey of EAB Signs/Symptoms	

YEAR 3

Remove 6 trees recommended for immediate removal	\$4,200
Plant 2 trees in open locations	\$300
Visual Survey of EAB Signs/Symptoms	

YEAR 4

Plant 5 trees in open locations	\$750
Prune 1/3 of City Owned Trees	\$3,660
Visual Survey of EAB Signs/Symptoms	

YEAR 5

Remove 6 trees recommended for immediate removal	\$4,200
Plant 2 trees in open locations	\$300
Visual Survey of EAB Signs/Symptoms	

YEAR 6

Plant 5 trees in open locations	\$750
Prune 1/3 of City Owned Trees	\$3,660
Visual Survey of EAB Signs/Symptoms	

Purposed Budget Increase

EAB could potentially kill all ash trees in Laurens within four years of its arrival. To remove all ash trees within six years, the budget would need to be increased to \$18,550 a year. If the budget were increased to \$4,500 per year all ash could be removed within 25 years. Additionally, we recommend that Laurens 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 considered by many communities is treating 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 removal 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). Eight trees would be selected for treatment, and Laurens would still need to find \$105,700 for removal of the remaining ash. Alternatively, if there are 15 treatable trees, it would cost approximately \$4,500 a year for treatment and leave no funds for removal. These are alternatives to straight removal of ash trees. However, whether the treatment option is selected, there will be an increased cost of dealing with ash trees if EAB is found in Laurens. We suggest considering an increased 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									
4/20/2020									
Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total Standard (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Silver maple	57.5	4,367	7,589.6	7,438	11,805	(N/A)	23.6	27.7	68.24
Green ash	46.8	3,550	6,393.8	6,266	9,816	(N/A)	20.9	23.0	64.16
Norway maple	33.7	2,559	4,824.9	4,728	7,287	(N/A)	17.6	17.1	56.49
Sugar maple	16.2	1,232	2,188.5	2,145	3,377	(N/A)	7.5	7.9	61.39
Northern hackberry	10.1	766	1,412.9	1,385	2,151	(N/A)	3.8	5.0	76.81
Blue spruce	2.1	157	309.2	303	460	(N/A)	3.8	1.1	16.44
Black maple	4.9	375	671.9	658	1,034	(N/A)	2.6	2.4	54.41
American basswood	4.6	349	661.4	648	997	(N/A)	2.2	2.3	62.30
Honeylocust	4.5	342	592.8	581	923	(N/A)	2.0	2.2	61.54
Broadleaf Deciduous Med	1.7	127	227.3	223	350	(N/A)	1.5	0.8	31.79
Black walnut	3.2	246	461.0	452	698	(N/A)	1.5	1.6	63.42
Red maple	1.6	125	217.8	213	338	(N/A)	1.4	0.8	33.83
Ohio buckeye	2.1	161	265.4	260	421	(N/A)	1.2	1.0	46.78
Black spruce	0.8	59	105.9	104	162	(N/A)	1.1	0.4	20.30
Northern red oak	0.8	63	101.1	99	162	(N/A)	1.0	0.4	23.21
Juniper	0.8	59	115.1	113	172	(N/A)	1.0	0.4	24.57
Littleleaf linden	0.9	70	121.6	119	189	(N/A)	1.0	0.4	27.02
Eastern white pine	0.9	66	107.9	106	172	(N/A)	0.8	0.4	28.59
White ash	3.2	241	372.8	365	606	(N/A)	0.8	1.4	100.98
Norway spruce	1.0	73	122.8	120	193	(N/A)	0.8	0.5	32.21
Broadleaf Deciduous Sma	0.1	11	24.8	24	35	(N/A)	0.7	0.1	7.05
Swamp white oak	0.8	64	115.4	113	177	(N/A)	0.5	0.4	44.18
American elm	1.6	119	199.2	195	314	(N/A)	0.4	0.7	104.79
Eastern cottonwood	0.7	50	93.7	92	142	(N/A)	0.3	0.3	70.91
Northern pin oak	0.6	44	87.0	85	130	(N/A)	0.3	0.3	64.76
White oak	0.5	36	54.0	53	88	(N/A)	0.3	0.2	44.23
American sycamore	0.7	54	100.5	99	153	(N/A)	0.3	0.4	76.46
Ginkgo	0.5	36	64.0	63	99	(N/A)	0.3	0.2	49.28
Austrian pine	0.1	10	15.2	15	25	(N/A)	0.1	0.1	24.51
White mulberry	0.2	14	24.7	24	38	(N/A)	0.1	0.1	38.13
River birch	0.1	8	16.9	17	24	(N/A)	0.1	0.1	24.47
Bur oak	0.3	25	46.9	46	71	(N/A)	0.1	0.2	70.91
Pear	0.0	2	3.8	4	5	(N/A)	0.1	0.0	5.40
Apple	0.0	2	3.8	4	5	(N/A)	0.1	0.0	5.40
Common chokecherry	0.0	2	3.8	4	5	(N/A)	0.1	0.0	5.40
Total	203.7	15,462	27,717.5	27,163	42,625	(N/A)	100.0	100.0	58.15

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees						
4/20/2020						
Species	Total rainfall interception (Gal)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Silver maple	828,595	22,455	(N/A)	23.6	34.4	129.80
Green ash	554,225	15,020	(N/A)	20.9	23.0	98.17
Norway maple	318,770	8,639	(N/A)	17.6	13.2	66.97
Sugar maple	194,933	5,283	(N/A)	7.5	8.1	96.05
Northern hackberry	98,014	2,656	(N/A)	3.8	4.1	94.86
Blue spruce	26,919	730	(N/A)	3.8	1.1	26.05
Black maple	44,937	1,218	(N/A)	2.6	1.9	64.09
American basswood	48,108	1,304	(N/A)	2.2	2.0	81.48
Honeylocust	50,965	1,381	(N/A)	2.0	2.1	92.08
Broadleaf Deciduous Medi	9,715	263	(N/A)	1.5	0.4	23.93
Black walnut	37,723	1,022	(N/A)	1.5	1.6	92.94
Red maple	10,942	297	(N/A)	1.4	0.5	29.65
Ohio buckeye	12,682	344	(N/A)	1.2	0.5	38.19
Black spruce	9,967	270	(N/A)	1.1	0.4	33.76
Northern red oak	4,979	135	(N/A)	1.0	0.2	19.27
Juniper	11,442	310	(N/A)	1.0	0.5	44.30
Littleleaf linden	5,621	152	(N/A)	1.0	0.2	21.76
Eastern white pine	15,159	411	(N/A)	0.8	0.6	68.47
White ash	47,295	1,282	(N/A)	0.8	2.0	213.62
Norway spruce	19,860	538	(N/A)	0.8	0.8	89.70
Broadleaf Deciduous Small	478	13	(N/A)	0.7	0.0	2.59
Swamp white oak	5,883	159	(N/A)	0.5	0.2	39.86
American elm	13,653	370	(N/A)	0.4	0.6	123.33
Eastern cottonwood	7,886	214	(N/A)	0.3	0.3	106.85
Northern pin oak	6,244	169	(N/A)	0.3	0.3	84.60
White oak	2,931	79	(N/A)	0.3	0.1	39.72
American sycamore	9,433	256	(N/A)	0.3	0.4	127.82
Ginkgo	3,715	101	(N/A)	0.3	0.2	50.33
Austrian pine	1,544	42	(N/A)	0.1	0.1	41.85
White mulberry	667	18	(N/A)	0.1	0.0	18.06
River birch	586	16	(N/A)	0.1	0.0	15.88
Bur oak	3,943	107	(N/A)	0.1	0.2	106.85
Pear	69	2	(N/A)	0.1	0.0	1.86
Apple	69	2	(N/A)	0.1	0.0	1.86
Common chokecherry	69	2	(N/A)	0.1	0.0	1.86
Citywide total	2,408,022	65,257	(N/A)	100.0	100.0	89.03

Table 3: Annual Air Quality Benefits

Annual Air Quality Benefits of Public Trees																
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							
Silver maple	141.8	24.0	69.7	6.3	765	2714	39.7	37.9	260.3	1,698	-73.0	-274	778.1	2,188 (N/A)	23.6	12.65
Green ash	73.3	11.7	34.3	3.3	388	223.3	32.5	31.0	212.0	1,391	0.0	0	621.4	1,779 (N/A)	20.9	11.63
Norway maple	65.9	11.4	32.3	2.9	356	163.1	23.6	22.5	153.0	1,011	-15.4	-58	459.2	1,309 (N/A)	17.6	10.15
Sugar maple	26.7	4.5	13.1	1.2	144	77.1	11.2	10.7	73.5	481	-20.8	-78	197.3	547 (N/A)	7.5	9.95
Northern hackberry	15.9	2.8	8.1	0.7	87	48.5	7.0	6.7	45.8	302	0.0	0	135.5	388 (N/A)	3.8	13.87
Blue spruce	3.2	0.6	2.9	0.4	22	10.1	1.5	1.4	9.4	62	-9.2	-34	20.3	50 (N/A)	3.8	1.78
Black maple	11.2	1.9	5.2	0.5	59	23.5	3.4	3.3	22.4	147	-3.7	-14	67.7	192 (N/A)	2.6	10.12
American basswood	6.3	1.1	3.1	0.3	34	22.3	3.2	3.1	20.8	138	-5.4	-20	54.7	152 (N/A)	2.2	9.47
Honeylocust	10.0	1.6	4.5	0.5	53	21.3	3.1	3.0	20.4	133	-7.8	-29	56.5	156 (N/A)	2.0	10.41
BroadleafDeciduous Med	1.3	0.2	0.7	0.1	7	8.0	1.2	1.1	7.6	50	-0.4	-1	19.9	56 (N/A)	1.5	5.08
Black walnut	4.7	0.7	2.2	0.2	25	15.6	2.3	2.2	14.7	97	0.0	0	42.5	122 (N/A)	1.5	11.06
Red maple	2.1	0.4	1.0	0.1	11	7.8	1.1	1.1	7.4	49	-0.8	-3	20.3	57 (N/A)	1.4	5.71
Ohio buckeye	2.0	0.3	1.0	0.1	11	9.9	1.5	1.4	9.6	62	-0.5	-2	25.3	71 (N/A)	1.2	7.92
Black spruce	1.2	0.2	1.0	0.1	8	3.7	0.5	0.5	3.5	23	-3.5	-13	7.4	18 (N/A)	1.1	2.24
Northern red oak	0.9	0.1	0.4	0.0	5	3.9	0.6	0.5	3.8	24	-1.2	-4	9.1	25 (N/A)	1.0	3.53
Juniper	2.4	0.5	1.9	0.3	16	3.8	0.5	0.5	3.5	23	-6.3	-24	7.1	15 (N/A)	1.0	2.19
Littleleaf linden	0.6	0.1	0.4	0.0	4	4.4	0.6	0.6	4.2	27	-0.4	-1	10.6	29 (N/A)	1.0	4.21
Eastern white pine	1.8	0.3	1.4	0.2	12	4.0	0.6	0.6	3.9	25	-7.3	-27	5.6	10 (N/A)	0.8	1.63
White ash	11.6	1.9	5.0	0.5	60	14.6	2.2	2.1	14.3	92	0.0	0	52.1	152 (N/A)	0.8	25.38
Norway spruce	2.4	0.5	1.9	0.3	16	4.5	0.7	0.6	4.4	28	-11.1	-41	4.2	2 (N/A)	0.8	0.39
BroadleafDeciduous Small	0.1	0.0	0.0	0.0	0	0.7	0.1	0.1	0.7	4	0.0	0	1.7	5 (N/A)	0.7	0.96
Swamp white oak	1.0	0.2	0.5	0.0	5	4.0	0.6	0.6	3.8	25	-0.2	-1	10.4	29 (N/A)	0.5	7.37
American elm	4.6	0.8	2.2	0.2	25	7.4	1.1	1.0	7.1	46	0.0	0	24.4	71 (N/A)	0.4	23.63
Eastern cottonwood	1.0	0.2	0.5	0.0	5	3.2	0.5	0.4	3.0	20	0.0	0	8.7	25 (N/A)	0.3	12.48
Northern pin oak	1.4	0.2	0.7	0.1	7	2.9	0.4	0.4	2.6	18	-0.3	-1	8.3	24 (N/A)	0.3	11.87
White oak	0.2	0.0	0.1	0.0	1	2.1	0.3	0.3	2.1	14	0.0	0	5.3	15 (N/A)	0.3	7.42
American sycamore	1.3	0.2	0.6	0.1	7	3.4	0.5	0.5	3.2	21	0.0	0	9.8	28 (N/A)	0.3	14.09
Ginkgo	1.1	0.2	0.5	0.0	6	2.2	0.3	0.3	2.1	14	-0.3	-1	6.5	19 (N/A)	0.3	9.29
Austrian pine	0.2	0.0	0.2	0.0	1	0.6	0.1	0.1	0.6	4	-0.6	-2	1.2	3 (N/A)	0.1	2.89
White mulberry	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.8	5	0.0	0	2.3	7 (N/A)	0.1	6.56
River birch	0.1	0.0	0.0	0.0	0	0.5	0.1	0.1	0.5	3	0.0	0	1.2	3 (N/A)	0.1	3.47
Bur oak	0.5	0.1	0.2	0.0	3	1.6	0.2	0.2	1.5	10	0.0	0	4.4	12 (N/A)	0.1	12.48
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)	0.1	0.71
Apple	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	0.0	0	0.3	1 (N/A)	0.1	0.71
Common chokecherry	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)	0.1	0.71
Citywide total	396.7	67.0	195.9	18.5	2,143	970.5	141.4	134.9	922.9	6,050	-168.1	-630	2,679.8	7,563 (N/A)	100.0	10.32

Table 4: Annual Carbon Stored

Stored CO2 Benefits of Public Trees						
4/20/2020						
Species	Total Stored CO2 (lbs)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Silver maple	3,151,480	23,636	(N/A)	23.6	35.5	136.62
Green ash	2,405,642	18,042	(N/A)	20.9	27.1	117.92
Norway maple	1,086,116	8,146	(N/A)	17.6	12.2	63.15
Sugar maple	771,661	5,787	(N/A)	7.5	8.7	105.23
Northern hackberry	243,807	1,829	(N/A)	3.8	2.7	65.31
Blue spruce	20,848	156	(N/A)	3.8	0.2	5.58
Black maple	119,987	900	(N/A)	2.6	1.4	47.36
American basswood	226,679	1,700	(N/A)	2.2	2.6	106.26
Honeylocust	128,720	965	(N/A)	2.0	1.4	64.36
Broadleaf Deciduo	22,960	172	(N/A)	1.5	0.3	15.65
Black walnut	149,843	1,124	(N/A)	1.5	1.7	102.17
Red maple	24,540	184	(N/A)	1.4	0.3	18.40
Ohio buckeye	32,617	245	(N/A)	1.2	0.4	27.18
Black spruce	7,153	54	(N/A)	1.1	0.1	6.71
Northern red oak	14,592	109	(N/A)	1.0	0.2	15.63
Juniper	7,714	58	(N/A)	1.0	0.1	8.27
Littleleaf linden	14,884	112	(N/A)	1.0	0.2	15.95
Eastern white pine	17,686	133	(N/A)	0.8	0.2	22.11
White ash	155,659	1,167	(N/A)	0.8	1.8	194.57
Norway spruce	28,154	211	(N/A)	0.8	0.3	35.19
Broadleaf Deciduo	1,455	11	(N/A)	0.7	0.0	2.18
Swamp white oak	16,294	122	(N/A)	0.5	0.2	30.55
American elm	90,346	678	(N/A)	0.4	1.0	225.86
Eastern cottonwood	31,546	237	(N/A)	0.3	0.4	118.30
Northern pin oak	22,225	167	(N/A)	0.3	0.3	83.35
White oak	7,344	55	(N/A)	0.3	0.1	27.54
American sycamore	41,716	313	(N/A)	0.3	0.5	156.43
Ginkgo	15,601	117	(N/A)	0.3	0.2	58.50
Austrian pine	1,118	8	(N/A)	0.1	0.0	8.39
White mulberry	3,037	23	(N/A)	0.1	0.0	22.78
River birch	1,101	8	(N/A)	0.1	0.0	8.26
Bur oak	15,773	118	(N/A)	0.1	0.2	118.30
Pear	178	1	(N/A)	0.1	0.0	1.33
Apple	178	1	(N/A)	0.1	0.0	1.33
Common chokeche	178	1	(N/A)	0.1	0.0	1.33
Citywide total	8,878,831	66,591	(N/A)	100.0	100.0	90.85

Table 5: Annual Carbon Sequestered

Annual CO₂ Benefits of Public Trees

4/20/2020

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
Silver maple	236,957	1,777	-15,130	-632	-118	96,515	724	317,711	2,383	(N/A)	23.6	39.2	13.77
Green ash	109,703	823	-11,547	-494	-90	78,460	588	176,122	1,321	(N/A)	20.9	21.7	8.63
Norway maple	42,978	322	-5,214	-355	-42	56,547	424	93,955	705	(N/A)	17.6	11.6	5.46
Sugar maple	38,246	287	-3,704	-178	-29	27,222	204	61,586	462	(N/A)	7.5	7.6	8.40
Northern hackberry	12,655	95	-1,170	-94	-9	16,930	127	28,321	212	(N/A)	3.8	3.5	7.59
Blue spruce	1,513	11	-100	-38	-1	3,478	26	4,853	36	(N/A)	3.8	0.6	1.30
Black maple	5,033	38	-576	-46	-5	8,295	62	12,707	95	(N/A)	2.6	1.6	5.02
American basswood	13,746	103	-1,088	-52	-9	7,706	58	20,311	152	(N/A)	2.2	2.5	9.52
Honeylocust	13,195	99	-618	-35	-5	7,560	57	20,102	151	(N/A)	2.0	2.5	10.05
Broadleaf Deciduous M	3,017	23	-112	-16	-1	2,808	21	5,697	43	(N/A)	1.5	0.7	3.88
Black walnut	8,194	61	-719	-35	-6	5,433	41	12,874	97	(N/A)	1.5	1.6	8.78
Red maple	3,238	24	-118	-15	-1	2,758	21	5,863	44	(N/A)	1.4	0.7	4.40
Ohio buckeye	3,474	26	-157	-18	-1	3,555	27	6,854	51	(N/A)	1.2	0.8	5.71
Black spruce	574	4	-34	-13	0	1,296	10	1,822	14	(N/A)	1.1	0.2	1.71
Northern red oak	1,190	9	-70	-9	-1	1,401	11	2,512	19	(N/A)	1.0	0.3	2.69
Juniper	43	0	-37	-14	0	1,308	10	1,300	10	(N/A)	1.0	0.2	1.39
Littleleaf linden	2,436	18	-71	-11	-1	1,545	12	3,899	29	(N/A)	1.0	0.5	4.18
Eastern white pine	977	7	-85	-15	-1	1,453	11	2,331	17	(N/A)	0.8	0.3	2.91
White ash	5,767	43	-747	-28	-6	5,315	40	10,307	77	(N/A)	0.8	1.3	12.88
Norway spruce	1,187	9	-135	-17	-1	1,612	12	2,647	20	(N/A)	0.8	0.3	3.31
Broadleaf Deciduous S	236	2	-7	-3	0	241	2	468	4	(N/A)	0.7	0.1	0.70
Swamp white oak	1,466	11	-78	-8	-1	1,406	11	2,786	21	(N/A)	0.5	0.3	5.22
American elm	1,945	15	-434	-15	-3	2,633	20	4,129	31	(N/A)	0.4	0.5	10.32
Eastern cottonwood	1,714	13	-151	-7	-1	1,105	8	2,660	20	(N/A)	0.3	0.3	9.97
Northern pin oak	470	4	-107	-7	-1	979	7	1,335	10	(N/A)	0.3	0.2	5.01
White oak	891	7	-35	-4	0	786	6	1,637	12	(N/A)	0.3	0.2	6.14
American sycamore	1,816	14	-200	-8	-2	1,202	9	2,811	21	(N/A)	0.3	0.3	10.54
Ginkgo	319	2	-75	-7	-1	792	6	1,029	8	(N/A)	0.3	0.1	3.86
Austrian pine	91	1	-5	-2	0	213	2	296	2	(N/A)	0.1	0.0	2.22
White mulberry	268	2	-15	-2	0	308	2	560	4	(N/A)	0.1	0.1	4.20
River birch	224	2	-5	-1	0	176	1	393	3	(N/A)	0.1	0.0	2.95
Bur oak	857	6	-76	-4	-1	552	4	1,330	10	(N/A)	0.1	0.2	9.97
Pear	38	0	-1	-1	0	37	0	74	1	(N/A)	0.1	0.0	0.55
Apple	38	0	-1	-1	0	37	0	74	1	(N/A)	0.1	0.0	0.55
Common chokecherry	38	0	-1	-1	0	37	0	74	1	(N/A)	0.1	0.0	0.55
Citywide total	514,533	3,859	-42,624	-2,183	-336	341,702	2,563	811,428	6,086	(N/A)	100.0	100.0	8.30

Table 6: Annual Social and Aesthetic Benefits

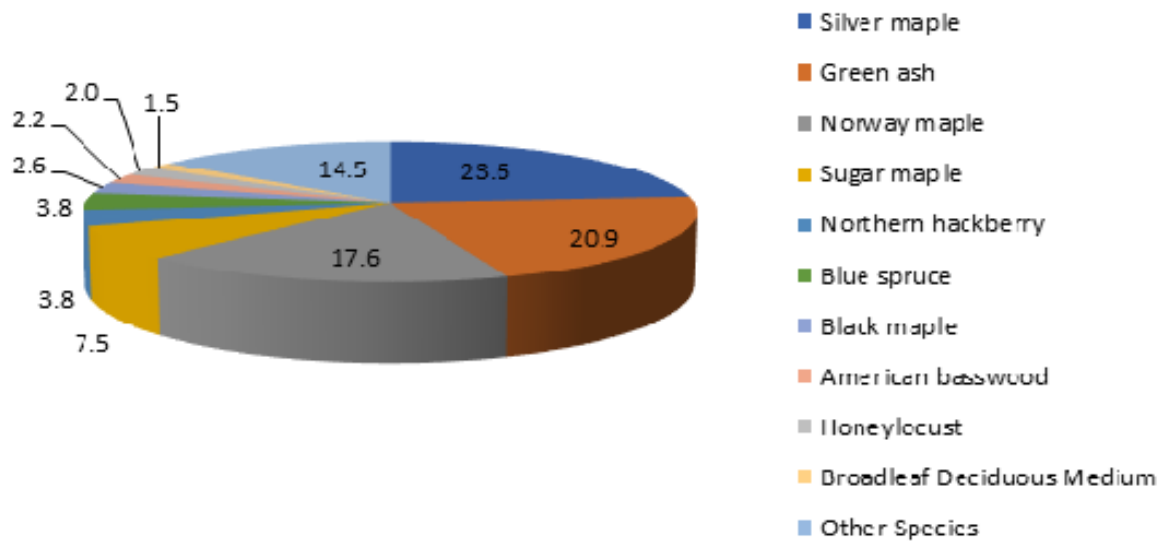
Annual Aesthetic/Other Benefits of Public Trees					
4/20/2020					
Species	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Silver maple	18,512 (N/A)		25.6	39.7	107.01
Green ash	8,681 (N/A)		20.9	18.6	56.74
Norway maple	4,072 (N/A)		17.6	8.7	31.56
Sugar maple	3,902 (N/A)		7.5	8.4	70.95
Northern hackberry	1,667 (N/A)		3.8	3.6	59.52
Blue spruce	541 (N/A)		3.8	1.2	19.33
Black maple	650 (N/A)		2.6	1.4	34.24
American basswood	1,024 (N/A)		2.2	2.2	63.97
Honeylocust	3,285 (N/A)		2.0	7.0	218.99
Broadleaf Deciduous Medi	326 (N/A)		1.5	0.7	29.68
Black walnut	655 (N/A)		1.5	1.4	59.53
Red maple	463 (N/A)		1.4	1.0	46.32
Ohio buckeye	352 (N/A)		1.2	0.8	39.16
Black spruce	180 (N/A)		1.1	0.4	22.50
Northern red oak	107 (N/A)		1.0	0.2	15.23
Juniper	14 (N/A)		1.0	0.0	1.96
Littleleaf linden	290 (N/A)		1.0	0.6	41.44
Eastern white pine	217 (N/A)		0.8	0.5	36.23
White ash	554 (N/A)		0.8	1.2	92.30
Norway spruce	190 (N/A)		0.8	0.4	31.75
Broadleaf Deciduous Small	13 (N/A)		0.7	0.0	2.52
Swamp white oak	148 (N/A)		0.5	0.3	36.90
American elm	243 (N/A)		0.4	0.5	81.16
Eastern cottonwood	131 (N/A)		0.3	0.3	65.59
Northern pin oak	43 (N/A)		0.3	0.1	21.53
White oak	92 (N/A)		0.3	0.2	45.86
American sycamore	132 (N/A)		0.3	0.3	66.10
Ginkgo	23 (N/A)		0.3	0.0	11.47
Austrian pine	25 (N/A)		0.1	0.1	25.23
White mulberry	15 (N/A)		0.1	0.0	15.48
River birch	26 (N/A)		0.1	0.1	26.22
Bur oak	66 (N/A)		0.1	0.1	65.59
Pear	2 (N/A)		0.1	0.0	2.06
Apple	2 (N/A)		0.1	0.0	2.06
Common chokecherry	2 (N/A)		0.1	0.0	2.06
Citywide total	46,646 (N/A)		100.0	100.0	63.64

Table 7: Summary of Benefits in Dollars

Annual Benefits of Public Trees by Species (\$/tree)						
4/20/2020						
Species	Energy	CO ₂	Air Quality	Stormwater	Aesthetic/Other	Total (\$) Standard Error
Silver maple	68.24	13.77	12.65	129.80	107.01	331.47 (N/A)
Green ash	64.16	8.63	11.63	98.17	56.74	239.32 (N/A)
Norway maple	56.49	5.46	10.15	66.97	31.56	170.63 (N/A)
Sugar maple	61.39	8.40	9.95	96.05	70.95	246.73 (N/A)
Northern hackberry	76.81	7.59	13.87	94.86	59.52	252.65 (N/A)
Blue spruce	16.44	1.30	1.78	26.05	19.33	64.91 (N/A)
Black maple	54.41	5.02	10.12	64.09	34.24	167.88 (N/A)
American basswood	62.30	9.52	9.47	81.48	63.97	226.75 (N/A)
Honeylocust	61.54	10.05	10.41	92.08	218.99	393.06 (N/A)
Broadleaf Deciduous	31.79	3.88	5.08	23.93	29.68	94.37 (N/A)
Black walnut	63.42	8.78	11.06	92.94	59.53	235.73 (N/A)
Red maple	33.83	4.40	5.71	29.65	46.32	119.91 (N/A)
Ohio buckeye	46.78	5.71	7.92	38.19	39.16	137.75 (N/A)
Black spruce	20.30	1.71	2.24	33.76	22.50	80.51 (N/A)
Northern red oak	23.21	2.69	3.53	19.27	15.23	63.94 (N/A)
Juniper	24.57	1.39	2.19	44.30	1.96	74.40 (N/A)
Littleleaf linden	27.02	4.18	4.21	21.76	41.44	98.60 (N/A)
Eastern white pine	28.59	2.91	1.63	68.47	36.23	137.83 (N/A)
White ash	100.98	12.88	25.38	213.62	92.30	445.16 (N/A)
Norway spruce	32.21	3.31	0.39	89.70	31.75	157.36 (N/A)
Broadleaf Deciduous	7.05	0.70	0.96	2.59	2.52	13.82 (N/A)
Swamp white oak	44.18	5.22	7.37	39.86	36.90	133.52 (N/A)
American elm	104.79	10.32	23.63	123.33	81.16	343.24 (N/A)
Eastern cottonwood	70.91	9.97	12.48	106.85	65.59	265.81 (N/A)
Northern pin oak	64.76	5.01	11.87	84.60	21.53	187.77 (N/A)
White oak	44.23	6.14	7.42	39.72	45.86	143.36 (N/A)
American sycamore	76.46	10.54	14.09	127.82	66.10	295.02 (N/A)
Ginkgo	49.28	3.86	9.29	50.33	11.47	124.23 (N/A)
Austrian pine	24.51	2.22	2.89	41.85	25.23	96.70 (N/A)
White mulberry	38.13	4.20	6.56	18.06	15.48	82.43 (N/A)
River birch	24.47	2.95	3.47	15.88	26.22	72.99 (N/A)
Bur oak	70.91	9.97	12.48	106.85	65.59	265.81 (N/A)
Pear	5.40	0.55	0.71	1.86	2.06	10.58 (N/A)
Apple	5.40	0.55	0.71	1.86	2.06	10.58 (N/A)
Common chokecherry	5.40	0.55	0.71	1.86	2.06	10.58 (N/A)
Citywide Total	58.15	8.30	10.32	89.03	63.64	229.44 (N/A)

Species Distribution of Public Trees

4/20/2020

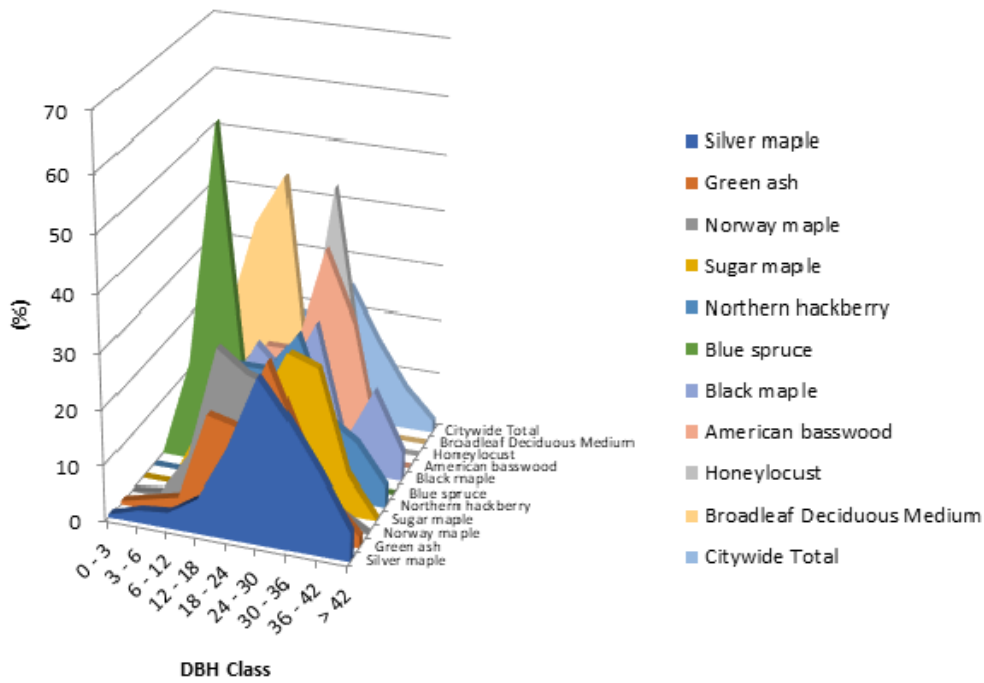


Species	Percent
Silver maple	23.6
Green ash	20.9
Norway maple	17.6
Sugar maple	7.5
Northern hackberry	3.8
Blue spruce	3.8
Black maple	2.6
American basswood	2.2
Honeylocust	2.0
Broadleaf Deciduous Me	1.5
Other Species	14.5
Total	100.0

Figure 1: Species Distribution

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

4/20/2020



Species	DBH class (in)								
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42
Silver maple	0.58	2.31	2.89	6.36	16.18	29.48	22.54	14.45	5.20
Green ash	0.65	1.96	3.27	18.95	17.65	30.07	17.65	7.84	1.96
Norway maple	0.00	0.78	8.53	28.68	24.81	23.26	10.85	3.10	0.00
Sugar maple	0.00	0.00	10.91	12.73	16.36	27.27	25.45	7.27	0.00
Northern hackberry	0.00	0.00	0.00	21.43	21.43	28.57	14.29	10.71	3.57
Blue spruce	0.00	17.86	60.71	10.71	3.57	7.14	0.00	0.00	0.00
Black maple	0.00	0.00	10.53	21.05	15.79	26.32	5.26	15.79	5.26
American basswood	0.00	0.00	0.00	18.75	18.75	37.50	25.00	0.00	0.00
Honeylocust	0.00	6.67	13.33	6.67	13.33	46.67	13.33	0.00	0.00
Broadleaf Deciduous M	0.00	18.18	36.36	45.45	0.00	0.00	0.00	0.00	0.00
Citywide Total	0.68	3.27	9.41	19.10	17.33	25.10	15.55	7.50	2.05

Figure 2: Relative Age Class

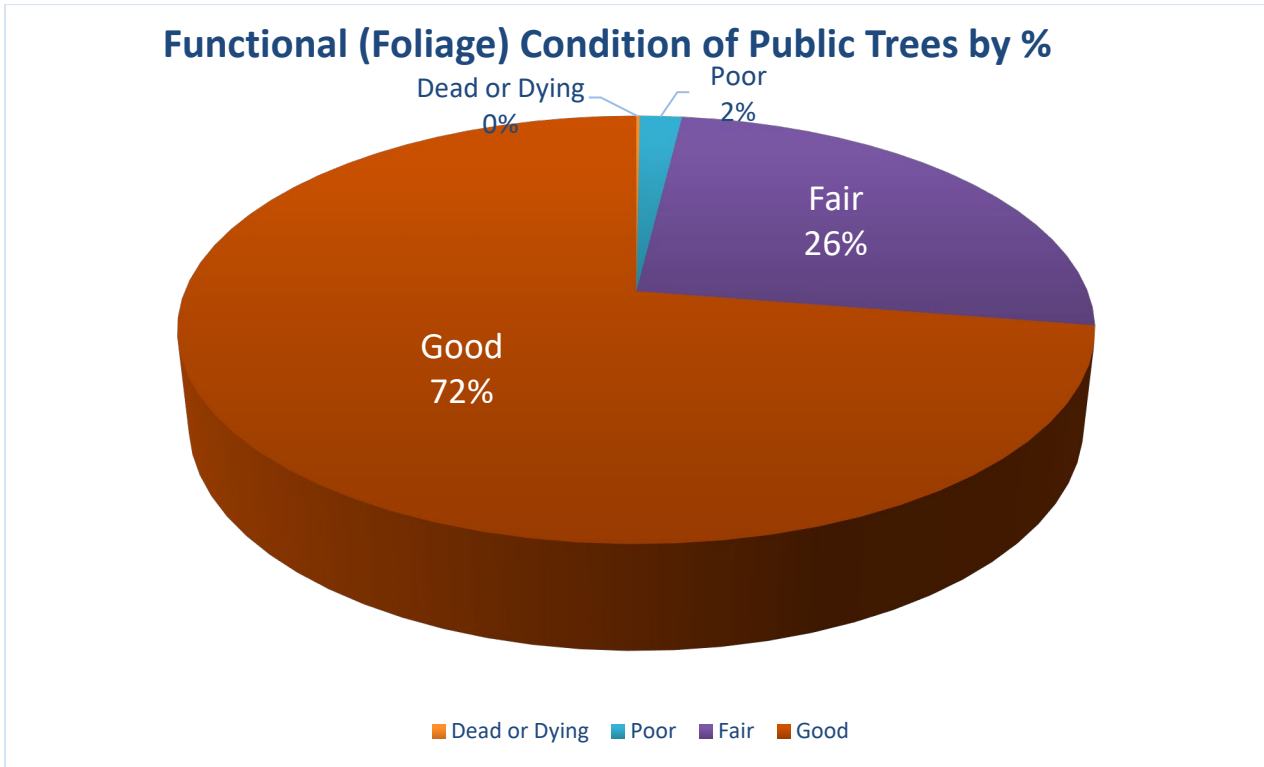


Figure 3: Foliage Condition

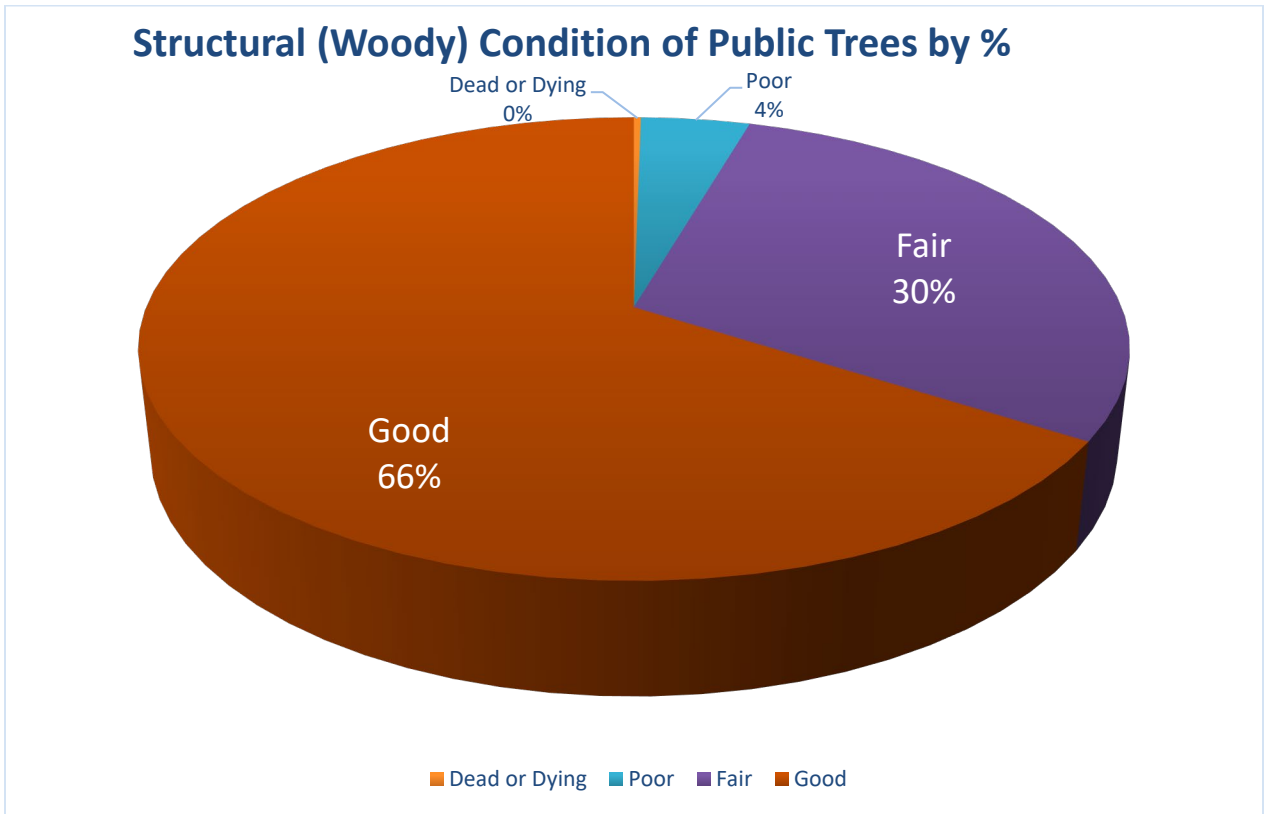
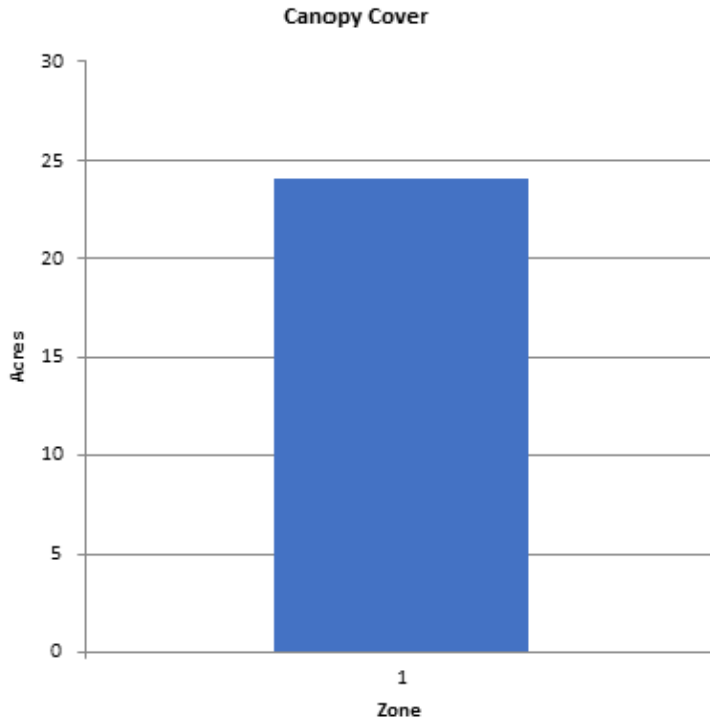


Figure 4: Wood Condition

Canopy Cover of Public Trees (Acres)

4/20/2020



Zone	Acres	% of Total Canopy Cover
1	24	100.0
Citywide total	24	100.0

	Total Land Area	Total Street and Sidewalk Area	Total Canopy Cover	Canopy Cover as % of Total Land Area	Canopy Cover as % of Total Streets and Sidewalks
Citywide Total	0	0	24	0.00	0.00

Figure 5: Canopy Cover in Acres

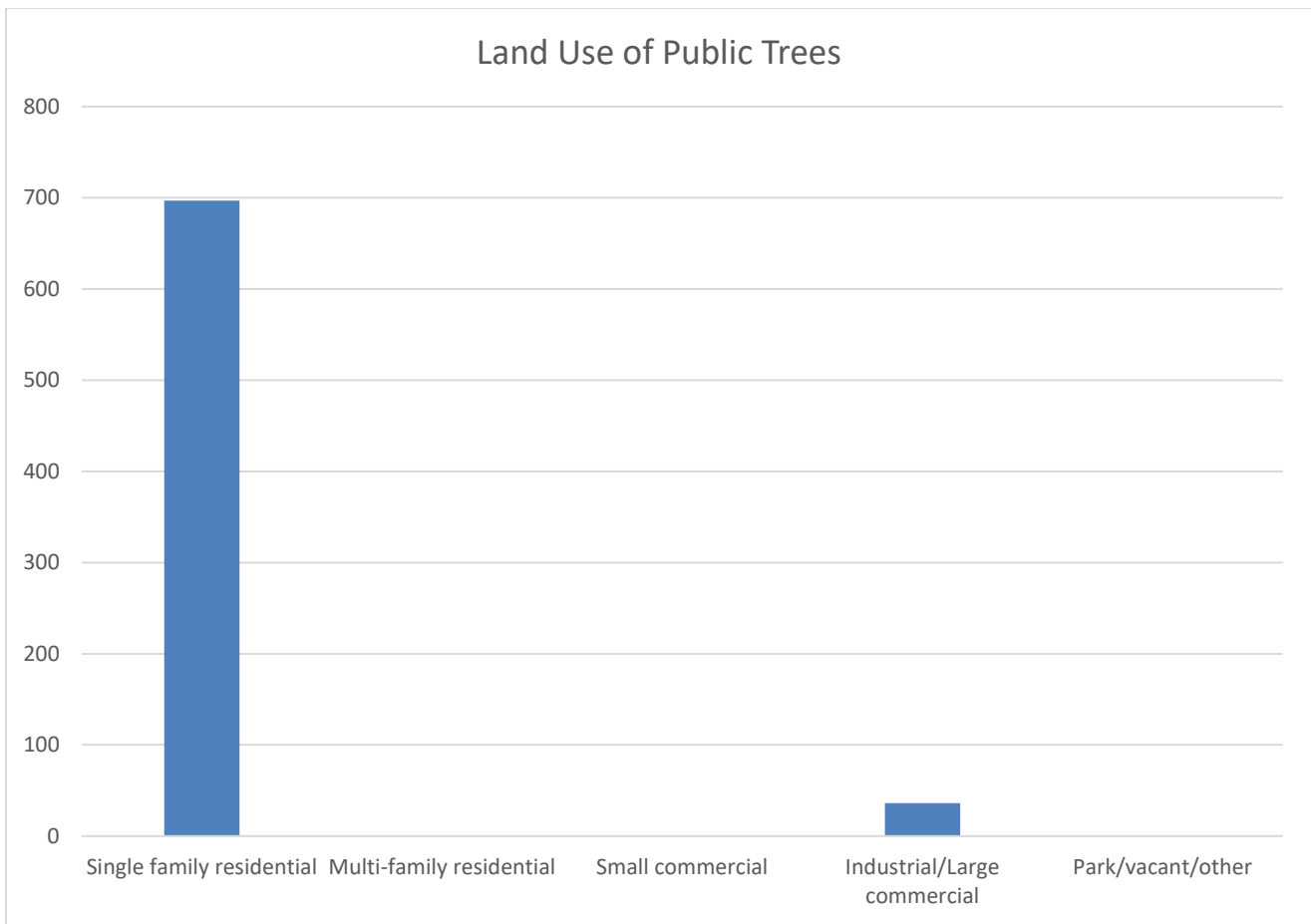


Figure 6: Land Use of city/park trees

Appendix B: ArcGIS Mapping

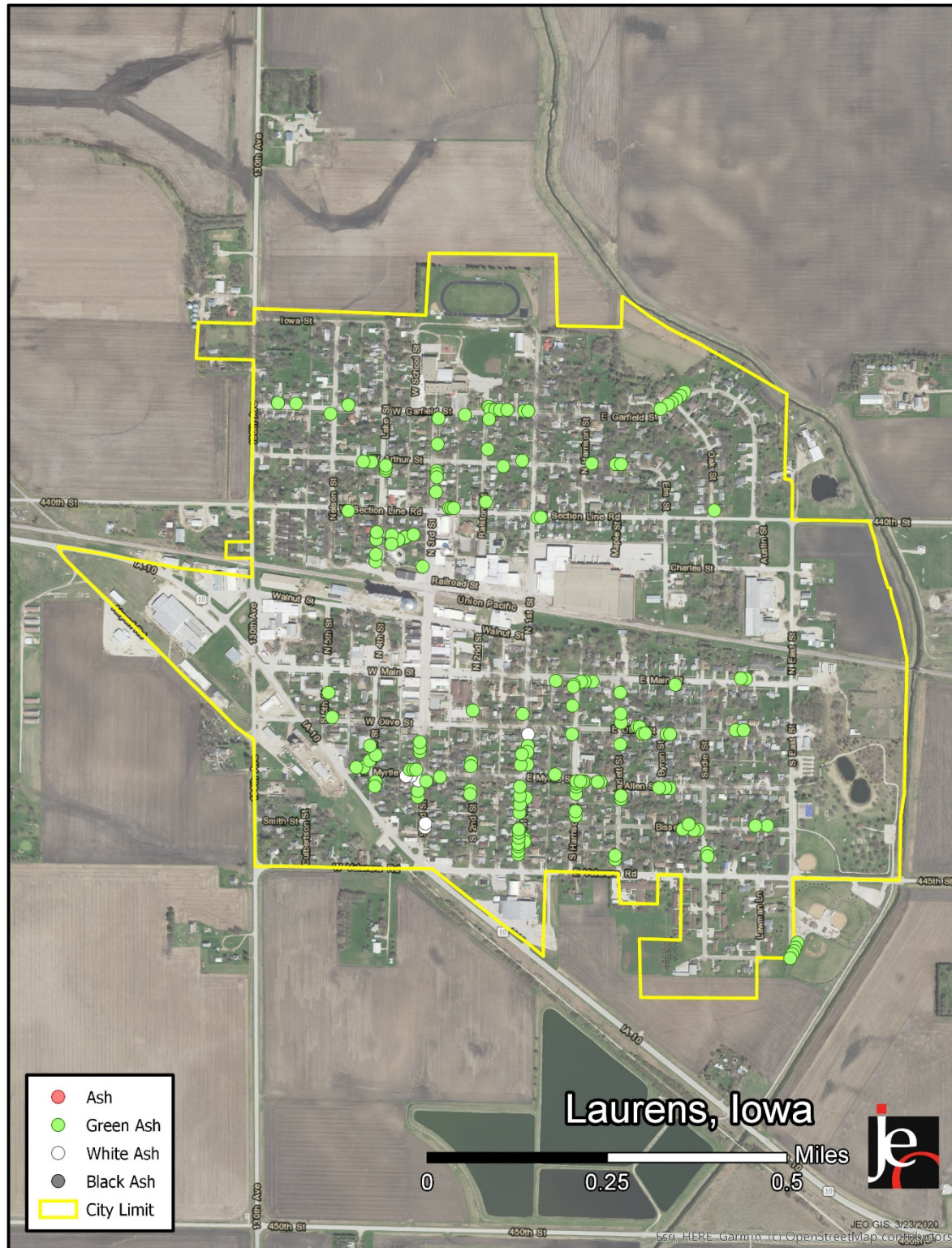


Figure 1: Location of Ash Trees



Figure 2: Location of EAB symptoms

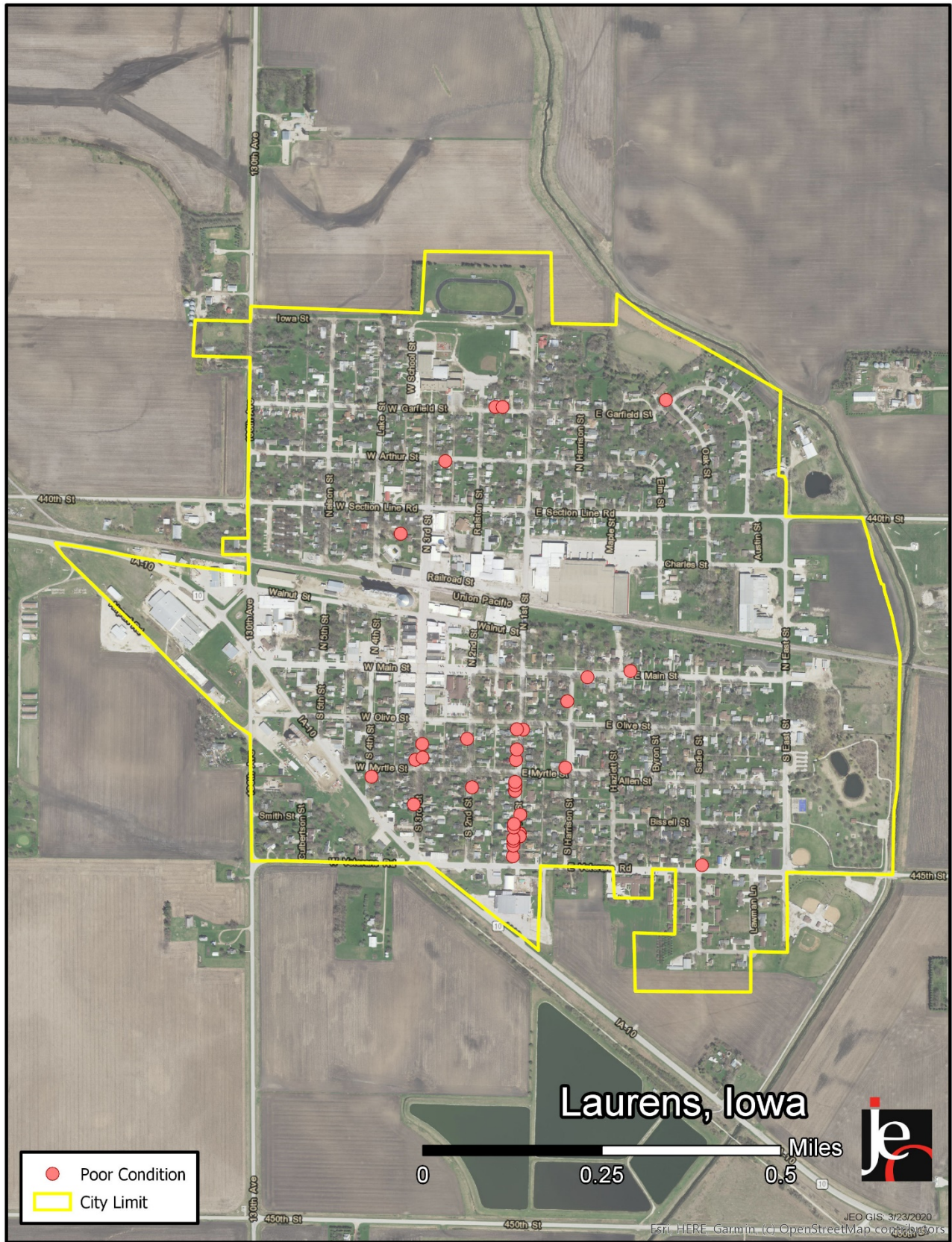


Figure 3: Location of Poor Condition Trees

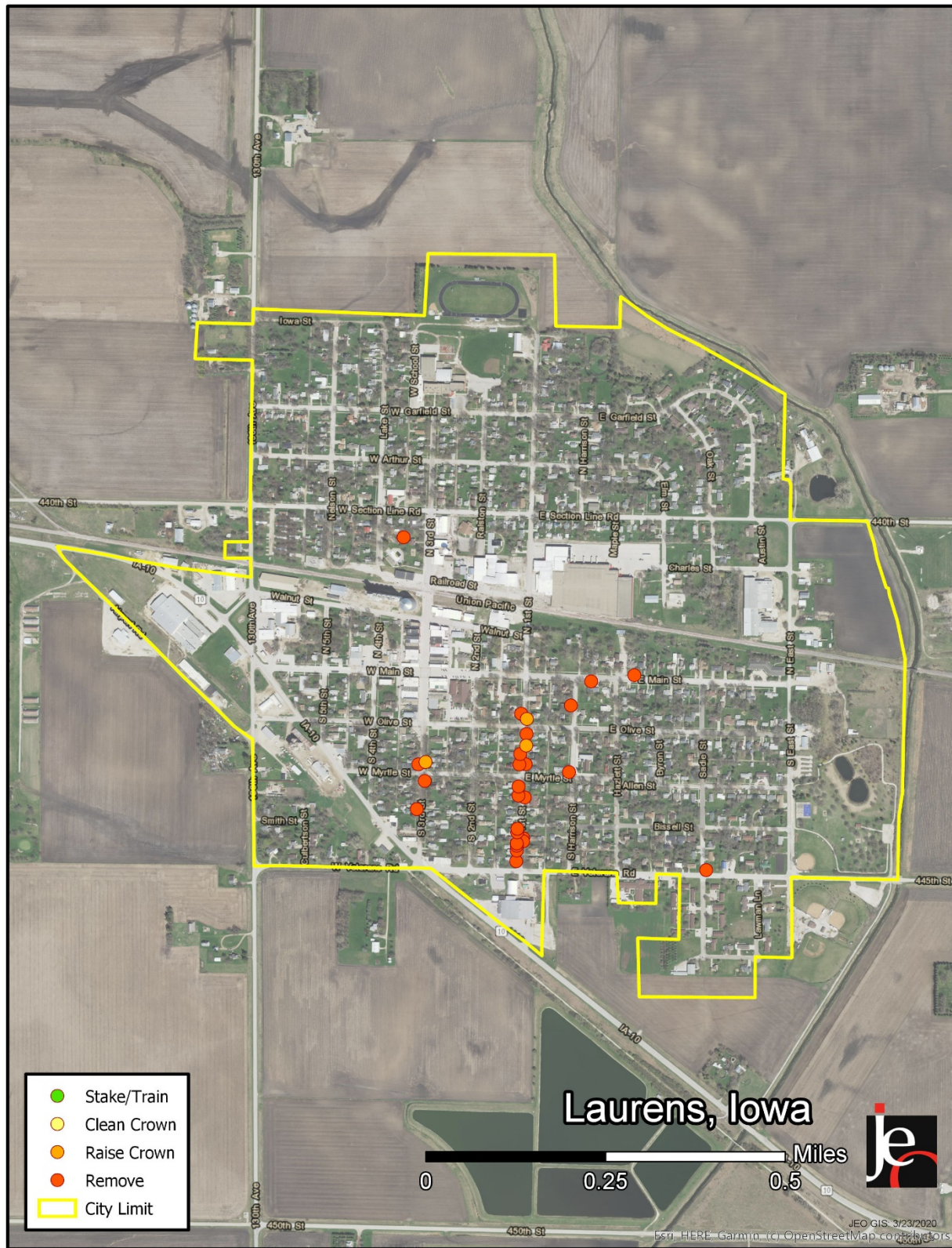


Figure 4: Location of Trees with Recommended Maintenance *City ownership of the trees recommended for removal should be verified prior to any removal*

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