

Shenandoah, 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 Shenandoah 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 11.5% of Shenandoah's 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 1,435 trees inventoried.

- Shenandoah's trees provide \$304,452 of benefits annually, an average of \$212.16 per tree
- There are over 27 species of trees
- The top three genera are: Maple 40.5%, and Oak 19%, and Ash 11.5%,
- 1% of trees need some type of management
- 17 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 17 trees needing removal, 10 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*](#)
- 5 of the 165 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 11 years to remove ash. We suggest that city officials request a budget increase to \$12,000 annually and apply for grants to plant replacement trees.

Introduction

This plan was developed to assist Shenandoah 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 Shenandoah, 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 Shenandoah's 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 Shenandoah 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 Shenandoah's 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 1,435 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. Shenandoah's trees reduce energy-related costs by approximately \$81,663 annually (Appendix A, Table 1). These savings are both in electricity (386.3 MWh) and in natural gas (53,410.7 Therms).

Annual Stormwater Benefits

Shenandoah's trees intercept about 4,493,481 gallons of rainfall or snow melt per year (Appendix A, Table 2). This interception provides \$121,773 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 Shenandoah, it is estimated that trees remove 5,188.6 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 \$14,672 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Shenandoah, trees sequester about 805,570 lbs of carbon per year with an associated value of \$6,042 (Appendix A, Table 5). In addition, the trees store 17,494,175 lbs of carbon, with a yearly benefit of \$131,206 (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. Shenandoah receives \$76,105 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, Shenandoah's trees provide \$304,452 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 1,435 trees in Shenandoah provide approximately \$212.16 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Shenandoah has over 27 different tree species along city streets and parks (Appendix A, Figure 1).

The distribution of trees by genera is as follows:

Maple	582	40.5%
Oak	275	19%
Ash	165	11.5%
Broadleaf Deciduous	96	7%
Other		
Locust	51	3.5%
Linden/Basswood	49	3.5%
Pear	49	3.5%
Spruce	33	2.5%
Sycamore	28	2%
Elm	20	1%
Eastern redbud	18	1%
Pine	13	<1%
Birch	8	<1%
Hackberry	8	<1%
Southern Magnolia	8	<1%
Boxelder	7	<1%
Alder	3	<1%
Buckeye	3	<1%
Catalpa	3	<1%
Walnut	3	<1%
Cedar	2	<1%
Chokecherry	2	<1%
Conifer Evergreen	2	<1%
Ginkgo	2	<1%
Apple	1	<1%
Juniper	1	<1%
Hickory	1	<1%
Sweetgum	1	<1%
Tulip tree	1	<1%

Age Class

Most of Shenandoah’s trees (39%) are between 24 and 36 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. Shenandoah’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 urban forest’s overall health. The foliage condition results for Shenandoah indicate that 82% 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, 78% of Shenandoah’s trees are in good health for wood condition (Appendix A, Figure 4 & Appendix B, Figure 3). Three percent of the tree population’s wood condition is in poor health, dead, or dying. This 3% is an estimate of trees that need management follow up.

Management Needs

The following outlines the specific management needs of the street and park trees by number of trees and percent of canopy (Appendix B, Figure 3).

Crown Cleaning	0	0%
Crown Raising	0	0%
Tree Staking	0	0%
Tree Removal	17	1%
Crown Reduction	0	0%

Land Use and Location

The majority of Shenandoah’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.

<u>Land Use</u>	
Single family residential	92.5%
Park/vacant/other	<1%
Industrial/Large commercial	7.5%
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

Shenandoah has 17 trees that need immediate removal. These trees 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 10 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 17 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 17 removals, 5 are ash trees. There are a total of 165 ash trees, and zero of those have signs and symptoms that have been associated with EAB. In addition, there are 5 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 Proposed Work Schedule and Budget 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 Shenandoah.

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 (40.5%) (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 \$10,300/Year – (Based off \$2/Capita Calculation Due to no City Reporting)

YEAR 1

ESTIMATED COSTS

Remove 12 trees recommended for immediate removal	\$8,400
Plant 12 trees in open locations	\$1,800
Visual Survey of EAB Signs/Symptoms	

YEAR 2

Remove 3 trees recommended for immediate removal	\$2,100
Plant 6 trees in open locations	\$900
Prune 1/3 of City Owned Trees	\$7,170
Visual Survey of EAB Signs/Symptoms	

YEAR 3

Remove 2 trees recommended for immediate removal	\$1,400
Remove 10 ash trees (prioritize largest diameter)	\$7,000
Plant 12 trees in open locations	\$1,800
Visual Survey of EAB Signs/Symptoms	

YEAR 4

Remove 3 ash trees (prioritize largest diameter)	\$2,100
Plant 6 trees in open locations	\$900
Prune 1/3 of City Owned Trees	\$7,170
Visual Survey of EAB Signs/Symptoms	

YEAR 5

Remove 12 ash trees (prioritize largest diameter)	\$8,400
Plant 12 trees in open locations	\$1,800
Visual Survey of EAB Signs/Symptoms	

YEAR 6

Remove 3 ash trees (prioritize largest diameter)	\$2,100
Plant 6 trees in open locations	\$900
Prune 1/3 of City Owned Trees	\$7,170
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 \$19,250 a year. If the budget were increased to \$12,000 a year all ash could be removed in 10 years.

Proposed Work Schedule with Increased Budget

Budget Allowance of \$12,000/Year – (Budget Increase Suggested to Best Manage City Trees)

YEAR 1

ESTIMATED COSTS

Remove 15 trees recommended for immediate removal	\$10,500
Plant 10 trees in open locations	\$1,500
Visual Survey of EAB Signs/Symptoms	

YEAR 2

Remove 2 trees recommended for immediate removal	\$1,400
Remove 2 ash trees (prioritize largest diameter)	\$1,400
Plant 13 trees in open locations	\$1,950
Prune 1/3 of City Owned Trees	\$7,170
Visual Survey of EAB Signs/Symptoms	

YEAR 3

Remove 15 ash trees (prioritize largest diameter)	\$10,500
Plant 10 trees in open locations	\$1,500
Visual Survey of EAB Signs/Symptoms	

YEAR 4

Remove 4 ash trees (prioritize largest diameter)	\$2,800
Plant 13 trees in open locations	\$1,950
Prune 1/3 of City Owned Trees	\$7,170
Visual Survey of EAB Signs/Symptoms	

YEAR 5

Remove 15 ash trees (prioritize largest diameter)	\$10,500
Plant 10 trees in open locations	\$1,500
Visual Survey of EAB Signs/Symptoms	

YEAR 6

Remove 4 ash trees (prioritize largest diameter)	\$2,800
Plant 13 trees in open locations	\$1,950
Prune 1/3 of City Owned Trees	\$7,170
Visual Survey of EAB Signs/Symptoms	

Purposed Budget Increase

EAB could potentially kill all ash trees in Shenandoah within four years of its arrival. To remove all ash trees within six years, the budget would need to be increased to \$19,250 a year. If the budget were increased to \$12,000 per year all ash could be removed within 9.5 years. Additionally, we recommend that Shenandoah 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 Shenandoah would still need to find \$109,900 for removal of the remaining ash trees. Alternatively, if there are 15 treatable trees, it would cost approximately \$4,500 a year for treatment and leave \$5,800 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 Shenandoah. 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									
4/23/2020									
Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total Standard (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	50.3	3,817	7,290.7	7,145	10,962	(N/A)	12.9	13.4	59.25
Northern pin oak	57.5	4,367	8,491.5	8,322	12,689	(N/A)	12.6	15.5	70.10
Silver maple	60.9	4,623	7,985.8	7,826	12,449	(N/A)	12.5	15.2	69.55
Green ash	41.4	3,142	5,732.2	5,618	8,760	(N/A)	8.9	10.7	68.98
Sugar maple	35.5	2,696	4,759.8	4,665	7,361	(N/A)	8.6	9.0	59.85
Red maple	20.2	1,531	2,676.3	2,623	4,153	(N/A)	6.0	5.1	48.29
BroadleafDeciduous Mec	10.1	769	1,487.3	1,458	2,226	(N/A)	4.9	2.7	31.36
Honeylocust	14.7	1,114	1,963.7	1,924	3,039	(N/A)	3.5	3.7	60.77
Pear	5.1	389	799.7	784	1,172	(N/A)	3.4	1.4	23.93
Northern red oak	9.7	735	1,363.2	1,336	2,071	(N/A)	3.2	2.5	45.03
American basswood	12.7	963	1,839.6	1,803	2,766	(N/A)	2.9	3.4	65.86
White ash	13.7	1,043	1,717.9	1,684	2,727	(N/A)	2.6	3.3	71.75
American sycamore	11.0	837	1,491.4	1,462	2,298	(N/A)	2.0	2.8	82.08
Norway spruce	2.2	163	275.4	270	433	(N/A)	1.5	0.5	19.70
BroadleafDeciduous Sma	0.4	29	65.5	64	93	(N/A)	1.4	0.1	4.64
Eastern redbud	1.3	101	210.4	206	307	(N/A)	1.3	0.4	17.07
White oak	3.7	279	469.7	460	740	(N/A)	1.1	0.9	46.22
American elm	7.0	532	895.8	878	1,409	(N/A)	1.0	1.7	100.67
Swamp white oak	2.5	192	342.3	335	527	(N/A)	0.9	0.6	40.55
Bur oak	2.9	222	380.6	373	595	(N/A)	0.8	0.7	49.62
Austrian pine	1.4	109	197.6	194	302	(N/A)	0.6	0.4	33.60
River birch	1.1	87	155.3	152	239	(N/A)	0.6	0.3	29.90
Northern hackberry	3.2	241	441.1	432	673	(N/A)	0.6	0.8	84.14
Southern magnolia	1.9	145	229.1	225	370	(N/A)	0.6	0.5	46.24
Littleleaf linden	1.4	110	207.9	204	314	(N/A)	0.5	0.4	44.79
Black maple	1.8	134	236.2	231	365	(N/A)	0.5	0.4	52.17
Boxelder	0.8	61	104.4	102	163	(N/A)	0.5	0.2	23.31
Pin oak	1.5	114	190.1	186	300	(N/A)	0.4	0.4	50.04
Blue spruce	0.3	20	43.2	42	62	(N/A)	0.4	0.1	10.41
Chinese elm	1.7	127	211.5	207	334	(N/A)	0.4	0.4	55.66
Black spruce	0.4	33	62.8	62	94	(N/A)	0.3	0.1	18.86
BroadleafDeciduous Larj	1.5	113	200.2	196	309	(N/A)	0.3	0.4	61.76
Eastern white pine	0.7	52	88.4	87	139	(N/A)	0.3	0.2	34.66
Ohio buckeye	0.9	69	134.4	132	200	(N/A)	0.2	0.2	66.79
Black walnut	1.0	78	143.9	141	219	(N/A)	0.2	0.3	73.09
Northern catalpa	0.7	56	92.1	90	146	(N/A)	0.2	0.2	48.59
Alder	0.4	34	62.2	61	94	(N/A)	0.2	0.1	31.49
Ginkgo	0.3	23	41.9	41	64	(N/A)	0.1	0.1	32.00
Common chokecherry	0.4	28	49.3	48	76	(N/A)	0.1	0.1	38.13
Japanese maple	0.1	7	16.6	16	24	(N/A)	0.1	0.0	11.80
Conifer Evergreen Mediu	0.0	2	4.9	5	7	(N/A)	0.1	0.0	6.94
Conifer Evergreen Small	0.0	1	2.5	2	4	(N/A)	0.1	0.0	3.62
Sweetgum	0.3	25	46.9	46	71	(N/A)	0.1	0.1	70.91
Hickory	0.3	20	38.1	37	57	(N/A)	0.1	0.1	57.32
Eastern red cedar	0.0	1	2.5	2	4	(N/A)	0.1	0.0	3.62
Apple	0.0	2	3.8	4	5	(N/A)	0.1	0.0	5.40
Black locust	0.3	24	47.4	46	71	(N/A)	0.1	0.1	70.84
Juniper	0.1	8	16.4	16	25	(N/A)	0.1	0.0	24.57
Northern white cedar	0.1	4	9.5	9	14	(N/A)	0.1	0.0	13.58
Oak	0.3	20	38.1	37	57	(N/A)	0.1	0.1	57.32
Tulip tree	0.4	29	53.7	53	82	(N/A)	0.1	0.1	82.02
total	386.3	29,320	53,410.7	52,342	81,663	(N/A)	100.0	100.0	56.91

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees						
4/23/2020						
Species	Total rainfall interception (Gal)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	510,854	13,844	(N/A)	12.9	11.4	74.83
Northern pin oak	667,641	18,093	(N/A)	12.6	14.9	99.96
Silver maple	921,473	24,972	(N/A)	12.5	20.5	139.51
Green ash	512,626	13,892	(N/A)	8.9	11.4	109.39
Sugar maple	424,613	11,507	(N/A)	8.6	9.4	93.55
Red maple	171,820	4,656	(N/A)	6.0	3.8	54.14
BroadleafDeciduous Medi	77,735	2,107	(N/A)	4.9	1.7	29.67
Honeylocust	156,147	4,232	(N/A)	3.5	3.5	84.63
Pear	22,861	620	(N/A)	3.4	0.5	12.64
Northern red oak	107,627	2,917	(N/A)	3.2	2.4	63.41
American basswood	150,592	4,081	(N/A)	2.9	3.4	97.17
White ash	168,483	4,566	(N/A)	2.6	3.7	120.15
American sycamore	161,267	4,370	(N/A)	2.0	3.6	156.08
Norway spruce	36,049	977	(N/A)	1.5	0.8	44.41
BroadleafDeciduous Smal	1,214	33	(N/A)	1.4	0.0	1.64
Eastern redbud	5,634	153	(N/A)	1.3	0.1	8.48
White oak	28,711	778	(N/A)	1.1	0.6	48.63
American elm	61,944	1,679	(N/A)	1.0	1.4	119.91
Swamp white oak	16,743	454	(N/A)	0.9	0.4	34.90
Bur oak	29,962	812	(N/A)	0.8	0.7	67.66
Austrian pine	24,329	659	(N/A)	0.6	0.5	73.26
River birch	8,492	230	(N/A)	0.6	0.2	28.77
Northern hackberry	35,881	972	(N/A)	0.6	0.8	121.55
Southern magnolia	18,893	512	(N/A)	0.6	0.4	64.00
Littleleaflinden	16,789	455	(N/A)	0.5	0.4	65.00
Black maple	15,301	415	(N/A)	0.5	0.3	59.24
Boxelder	5,625	152	(N/A)	0.5	0.1	21.78
Pin oak	16,320	442	(N/A)	0.4	0.4	73.71
Blue spruce	3,098	84	(N/A)	0.4	0.1	13.99
Chinese elm	17,734	481	(N/A)	0.4	0.4	80.10
Black spruce	6,899	187	(N/A)	0.3	0.2	37.39
BroadleafDeciduous Large	18,746	508	(N/A)	0.3	0.4	101.60
Eastern white pine	15,353	416	(N/A)	0.3	0.3	104.01
Ohio buckeye	10,008	271	(N/A)	0.2	0.2	90.41
Black walnut	13,773	373	(N/A)	0.2	0.3	124.41
Northern catalpa	5,522	150	(N/A)	0.2	0.1	49.88
Alder	1,598	43	(N/A)	0.2	0.0	14.43
Ginkgo	2,159	59	(N/A)	0.1	0.0	29.25
Common chokecherry	1,333	36	(N/A)	0.1	0.0	18.06
Japanese maple	333	9	(N/A)	0.1	0.0	4.51
Conifer Evergreen Medium	256	7	(N/A)	0.1	0.0	6.95
Conifer Evergreen Small	183	5	(N/A)	0.1	0.0	4.97
Sweetgum	3,943	107	(N/A)	0.1	0.1	106.85
Hickory	2,591	70	(N/A)	0.1	0.1	70.21
Eastern red cedar	183	5	(N/A)	0.1	0.0	4.97
Apple	69	2	(N/A)	0.1	0.0	1.86
Black locust	3,764	102	(N/A)	0.1	0.1	102.01
Juniper	1,635	44	(N/A)	0.1	0.0	44.30
Northern white cedar	596	16	(N/A)	0.1	0.0	16.14
Oak	2,591	70	(N/A)	0.1	0.1	70.21
Tulip tree	5,491	149	(N/A)	0.1	0.1	148.79
Citywide total	4,493,481	121,773	(N/A)	100.0	100.0	84.86

Table 3: Annual Air Quality Benefits

Annual Air Quality Benefits of Public Trees																
4/23/2020																
Species	Deposition (lb)				Total Depos. (\$)	Avoided (lb)				Total Avoided (\$)	BVOC Emissions (lb)	BVOC Emissions (\$)	Total (lb)	Total Standard (\$)	% of Total Error	Avg. Trees \$/tree
	O ₃	NO ₂	PM ₁₀	SO ₂		NO ₂	PM ₁₀	VOC	SO ₂							
Norway maple	109.6	18.9	53.2	4.9	590	244.1	35.3	33.6	228.1	1,511	-25.2	-95	702.3	2,007 (N/A)	12.9	10.85
Northern pin oak	152.5	26.3	72.9	6.7	818	280.6	40.4	38.5	261.0	1,734	-34.4	-129	844.5	2,423 (N/A)	12.6	13.39
Silver maple	164.2	27.8	80.0	7.3	884	286.8	42.0	40.1	275.5	1,795	-84.6	-317	839.1	2,361 (N/A)	12.5	13.19
Green ash	68.4	10.9	31.8	3.1	362	198.3	28.8	27.5	187.6	1,234	0.0	0	556.4	1,595 (N/A)	8.9	12.56
Sugar maple	60.6	10.3	29.6	2.7	326	168.5	24.6	23.5	160.9	1,052	-47.2	-177	433.4	1,201 (N/A)	8.6	9.77
Red maple	41.5	7.1	19.3	1.8	221	95.4	14.0	13.3	91.3	596	-13.9	-52	269.8	765 (N/A)	6.0	8.90
Broadleaf Deciduous Med	13.5	2.3	7.0	0.6	74	49.4	7.1	6.8	46.0	305	-3.4	-13	129.3	367 (N/A)	4.9	5.16
Honeylocust	30.2	5.0	13.8	1.4	160	69.5	10.2	9.7	66.4	434	-22.8	-85	183.5	509 (N/A)	3.5	10.17
Pear	6.9	1.1	3.3	0.3	37	25.3	3.6	3.4	23.2	156	0.0	0	67.2	192 (N/A)	3.4	3.92
Northern red oak	23.5	4.0	11.3	1.0	126	46.5	6.8	6.4	43.9	289	-33.8	-127	109.6	288 (N/A)	3.2	6.27
American basswood	21.2	3.6	10.3	0.9	114	61.6	8.9	8.5	57.6	381	-17.9	-67	154.8	429 (N/A)	2.9	10.20
White ash	32.2	5.2	14.6	1.4	169	64.1	9.4	9.0	62.2	403	0.0	0	198.1	572 (N/A)	2.6	15.05
American sycamore	25.6	4.1	11.4	1.1	134	52.5	7.7	7.3	49.9	327	0.0	0	159.6	461 (N/A)	2.0	16.47
Norway spruce	4.1	0.8	3.4	0.5	27	10.1	1.5	1.4	9.8	63	-17.9	-67	13.7	24 (N/A)	1.5	1.07
Broadleaf Deciduous Smal	0.1	0.0	0.1	0.0	1	1.9	0.3	0.3	1.7	12	0.0	0	4.4	12 (N/A)	1.4	0.62
Eastern redbud	1.6	0.3	0.8	0.1	8	6.6	0.9	0.9	6.0	41	0.0	0	17.1	49 (N/A)	1.3	2.72
White oak	2.6	0.4	1.4	0.1	14	17.3	2.5	2.4	16.7	108	0.0	0	43.4	123 (N/A)	1.1	7.66
American elm	20.0	3.4	9.4	0.9	107	32.9	4.8	4.6	31.7	206	0.0	0	107.8	313 (N/A)	1.0	22.36
Swamp white oak	2.7	0.5	1.4	0.1	15	12.1	1.8	1.7	11.5	75	-0.7	-3	30.9	87 (N/A)	0.9	6.72
Bur oak	3.6	0.6	1.8	0.2	19	13.8	2.0	1.9	13.3	86	0.0	0	37.2	106 (N/A)	0.8	8.82
Austrian pine	4.3	0.8	3.4	0.5	28	6.8	1.0	0.9	6.5	43	-9.4	-35	14.9	35 (N/A)	0.6	3.90
River birch	1.5	0.3	0.8	0.1	8	5.5	0.8	0.8	5.2	34	-0.4	-1	14.5	41 (N/A)	0.6	5.14
Northern hackberry	6.2	1.1	3.1	0.3	34	15.2	2.2	2.1	14.4	95	0.0	0	44.6	128 (N/A)	0.6	16.06
Southern magnolia	1.8	0.4	1.8	0.2	13	8.8	1.3	1.2	8.6	55	-5.4	-20	18.7	48 (N/A)	0.6	6.01
Littleleaf linden	3.1	0.5	1.5	0.1	17	7.0	1.0	1.0	6.6	43	-1.5	-5	19.3	55 (N/A)	0.5	7.80
Black maple	3.7	0.6	1.7	0.2	20	8.4	1.2	1.2	8.0	52	-1.2	-5	23.7	67 (N/A)	0.5	9.62
Boxelder	0.5	0.1	0.3	0.0	3	3.8	0.6	0.5	3.6	24	-0.3	-1	9.0	25 (N/A)	0.5	3.61
Pin oak	3.0	0.5	1.5	0.1	16	7.0	1.0	1.0	6.8	44	-5.6	-21	15.4	40 (N/A)	0.4	6.58
Blue spruce	0.3	0.1	0.3	0.0	2	1.3	0.2	0.2	1.2	8	-1.0	-4	2.6	6 (N/A)	0.4	1.08
Chinese elm	2.7	0.4	1.3	0.1	14	7.8	1.1	1.1	7.6	49	0.0	0	22.2	64 (N/A)	0.4	10.59
Black spruce	1.2	0.2	0.9	0.1	8	2.1	0.3	0.3	2.0	13	-2.6	-10	4.5	11 (N/A)	0.3	2.16
Broadleaf Deciduous Larg	2.6	0.4	1.2	0.1	14	7.1	1.0	1.0	6.7	44	0.0	0	20.1	58 (N/A)	0.3	11.53
Eastern white pine	1.9	0.4	1.5	0.2	12	3.2	0.5	0.5	3.1	20	-9.1	-34	2.1	-2 (N/A)	0.3	-0.48
Ohio buckeye	2.2	0.4	1.1	0.1	12	4.4	0.6	0.6	4.1	27	-0.5	-2	13.0	37 (N/A)	0.2	12.44
Black walnut	1.9	0.3	0.9	0.1	10	4.9	0.7	0.7	4.7	31	0.0	0	14.2	41 (N/A)	0.2	13.62
Northern catalpa	0.5	0.1	0.3	0.0	3	3.4	0.5	0.5	3.3	21	0.0	0	8.6	24 (N/A)	0.2	8.06
Alder	0.5	0.1	0.2	0.0	2	2.1	0.3	0.3	2.0	13	0.0	0	5.5	16 (N/A)	0.2	5.22
Ginkgo	0.6	0.1	0.3	0.0	3	1.4	0.2	0.2	1.4	9	-0.2	-1	4.0	11 (N/A)	0.1	5.71
Common chokecherry	0.4	0.1	0.2	0.0	2	1.7	0.3	0.2	1.7	11	0.0	0	4.6	13 (N/A)	0.1	6.56
Japanese maple	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)	0.1	1.63
Conifer Evergreen Medium	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	-0.1	0	0.3	1 (N/A)	0.1	0.75
Conifer Evergreen Small	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	0	-0.1	0	0.1	0 (N/A)	0.1	0.20
Sweetgum	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
Hickory	0.3	0.0	0.1	0.0	1	1.3	0.2	0.2	1.2	8	0.0	0	3.3	9 (N/A)	0.1	9.34
Eastern red cedar	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	0	-0.1	0	0.1	0 (N/A)	0.1	0.20
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
Black locust	0.9	0.1	0.4	0.0	5	1.6	0.2	0.2	1.5	10	-0.2	-1	4.7	14 (N/A)	0.1	13.58
Juniper	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)	0.1	2.19
Northern white cedar	0.1	0.0	0.1	0.0	0	0.3	0.0	0.0	0.3	2	-0.2	-1	0.6	1 (N/A)	0.1	1.48
Oak	0.3	0.0	0.1	0.0	1	1.3	0.2	0.2	1.2	8	0.0	0	3.3	9 (N/A)	0.1	9.34
Tulip tree	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)	0.1	15.71
Citywide total	826.6	140.1	400.4	37.8	4,444	1,848.6	268.8	256.2	1,750.3	11,504	-340.4	-1,276	5,188.6	14,672 (N/A)	100.0	10.22

Table 4: Annual Carbon Stored

Stored CO2 Benefits of Public Trees						
4/23/2020						
Species	Total Stored CO2 (lbs)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	1,806,803	13,551	(N/A)	12.9	10.3	73.25
Northern pin oak	2,519,051	18,893	(N/A)	12.6	14.4	104.38
Silver maple	3,781,228	28,359	(N/A)	12.5	21.6	158.43
Green ash	2,233,742	16,753	(N/A)	8.9	12.8	131.91
Sugar maple	1,768,441	13,263	(N/A)	8.6	10.1	107.83
Red maple	448,566	3,364	(N/A)	6.0	2.6	39.12
Broadleaf Deciduou	227,560	1,707	(N/A)	4.9	1.3	24.04
Honeylocust	383,543	2,877	(N/A)	3.5	2.2	57.53
Pear	110,944	832	(N/A)	3.4	0.6	16.98
Northern red oak	522,322	3,917	(N/A)	3.2	3.0	85.16
American basswood	789,501	5,921	(N/A)	2.9	4.5	140.98
White ash	506,856	3,801	(N/A)	2.6	2.9	100.04
American sycamore	863,139	6,474	(N/A)	2.0	4.9	231.20
Norway spruce	43,375	325	(N/A)	1.5	0.2	14.79
Broadleaf Deciduou	3,540	27	(N/A)	1.4	0.0	1.33
Eastern redbud	25,937	195	(N/A)	1.3	0.1	10.81
White oak	84,719	635	(N/A)	1.1	0.5	39.71
American elm	392,282	2,942	(N/A)	1.0	2.2	210.15
Swamp white oak	44,780	336	(N/A)	0.9	0.3	25.83
Bur oak	121,065	908	(N/A)	0.8	0.7	75.67
Austrian pine	38,034	285	(N/A)	0.6	0.2	31.69
River birch	25,825	194	(N/A)	0.6	0.1	24.21
Northern hackberry	100,061	750	(N/A)	0.6	0.6	93.81
Southern magnolia	25,004	188	(N/A)	0.6	0.1	23.44
Littleleaf linden	65,762	493	(N/A)	0.5	0.4	70.46
Black maple	40,130	301	(N/A)	0.5	0.2	43.00
Boxelder	10,987	82	(N/A)	0.5	0.1	11.77
Pin oak	83,633	627	(N/A)	0.4	0.5	104.54
Blue spruce	1,141	9	(N/A)	0.4	0.0	1.43
Chinese elm	93,975	705	(N/A)	0.4	0.5	117.47
Black spruce	10,116	76	(N/A)	0.3	0.1	15.17
Broadleaf Deciduou	85,681	643	(N/A)	0.3	0.5	128.52
Eastern white pine	23,641	177	(N/A)	0.3	0.1	44.33
Ohio buckeye	36,506	274	(N/A)	0.2	0.2	91.26
Black walnut	63,489	476	(N/A)	0.2	0.4	158.72
Northern catalpa	15,801	119	(N/A)	0.2	0.1	39.50
Alder	6,982	52	(N/A)	0.2	0.0	17.46
Ginkgo	8,274	62	(N/A)	0.1	0.0	31.03
Common chokecher	6,074	46	(N/A)	0.1	0.0	22.78
Japanese maple	1,086	8	(N/A)	0.1	0.0	4.07
Conifer Evergreen N	43	0	(N/A)	0.1	0.0	0.32
Conifer Evergreen S	43	0	(N/A)	0.1	0.0	0.32
Sweetgum	15,773	118	(N/A)	0.1	0.1	118.30
Hickory	8,458	63	(N/A)	0.1	0.0	63.43
Eastern red cedar	43	0	(N/A)	0.1	0.0	0.32
Apple	178	1	(N/A)	0.1	0.0	1.33
Black locust	14,280	107	(N/A)	0.1	0.1	107.10
Juniper	1,102	8	(N/A)	0.1	0.0	8.27
Northern white ceda	257	2	(N/A)	0.1	0.0	1.93
Oak	8,458	63	(N/A)	0.1	0.0	63.43
Tulip tree	25,943	195	(N/A)	0.1	0.1	194.57
Citywide total	17,494,175	131,206	(N/A)	100.0	100.0	91.43

Table 5: Annual Carbon Sequestered

Annual CO ₂ Benefits of Public Trees													
4/23/2020													
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
Norway maple	58,687	440	-8,674	-547	-69	84,348	633	133,815	1,004	(N/A)	12.9	9.8	5.42
Northern pin oak	11,462	86	-12,091	-745	-96	96,507	724	95,133	713	(N/A)	12.6	7.0	3.94
Silver maple	267,455	2,006	-18,152	-688	-141	102,158	766	350,774	2,631	(N/A)	12.5	25.7	14.70
Green ash	100,223	752	-10,722	-443	-84	69,448	521	158,506	1,189	(N/A)	8.9	11.6	9.36
Sugar maple	85,142	639	-8,491	-392	-67	59,591	447	135,850	1,019	(N/A)	8.6	10.0	8.28
Red maple	41,221	309	-2,153	-182	-18	33,824	254	72,709	545	(N/A)	6.0	5.3	6.34
Broadleaf Deciduous Me	17,602	132	-1,104	-107	-9	16,991	127	33,383	250	(N/A)	4.9	2.4	3.53
Honeylocust	42,389	318	-1,843	-121	-15	24,623	185	65,047	488	(N/A)	3.5	4.8	9.76
Pear	8,558	64	-533	-73	-5	8,589	64	16,542	124	(N/A)	3.4	1.2	2.53
Northern red oak	5,394	40	-2,507	-130	-20	16,251	122	19,007	143	(N/A)	3.2	1.4	3.10
American basswood	44,811	336	-3,790	-151	-30	21,287	160	62,157	466	(N/A)	2.9	4.6	11.10
White ash	32,899	247	-2,433	-119	-19	23,053	173	53,399	400	(N/A)	2.6	3.9	10.54
American sycamore	23,070	173	-4,143	-124	-32	18,490	139	37,293	280	(N/A)	2.0	2.7	9.99
Norway spruce	1,826	14	-208	-41	-2	3,612	27	5,189	39	(N/A)	1.5	0.4	1.77
Broadleaf Deciduous Spr	647	5	-17	-9	0	634	5	1,254	9	(N/A)	1.4	0.1	0.47
Eastern redbud	1,913	14	-125	-21	-1	2,234	17	4,002	30	(N/A)	1.3	0.3	1.67
White oak	7,921	59	-407	-34	-3	6,171	46	13,651	102	(N/A)	1.1	1.0	6.40
American elm	8,647	65	-1,883	-68	-15	11,747	88	18,443	138	(N/A)	1.0	1.4	9.88
Swamp white oak	4,409	33	-216	-23	-2	4,237	32	8,407	63	(N/A)	0.9	0.6	4.85
Bur oak	6,344	48	-581	-30	-5	4,916	37	10,650	80	(N/A)	0.8	0.8	6.66
Austrian pine	1,180	9	-183	-29	-2	2,405	18	3,373	25	(N/A)	0.6	0.2	2.81
River birch	1,450	11	-126	-12	-1	1,924	14	3,236	24	(N/A)	0.6	0.2	3.03
Northern hackberry	4,245	32	-480	-31	-4	5,322	40	9,055	68	(N/A)	0.6	0.7	8.49
Southern magnolia	1,567	12	-120	-18	-1	3,212	24	4,641	35	(N/A)	0.6	0.3	4.35
Littleleaf linden	3,034	23	-316	-19	-3	2,425	18	5,123	38	(N/A)	0.5	0.4	5.49
Black maple	3,902	29	-193	-16	-2	2,955	22	6,648	50	(N/A)	0.5	0.5	7.12
Boxelder	1,492	11	-54	-9	0	1,344	10	2,773	21	(N/A)	0.5	0.2	2.97
Pin oak	1,162	9	-401	-16	-3	2,518	19	3,263	24	(N/A)	0.4	0.2	4.08
Blue spruce	158	1	-5	-5	0	446	3	593	4	(N/A)	0.4	0.0	0.74
Chinese elm	2,983	22	-451	-17	-4	2,800	21	5,315	40	(N/A)	0.4	0.4	6.64
Black spruce	429	3	-49	-9	0	725	5	1,097	8	(N/A)	0.3	0.1	1.65
Broadleaf Deciduous Lar	3,383	25	-411	-16	-3	2,488	19	5,444	41	(N/A)	0.3	0.4	8.17
Eastern white pine	116	1	-113	-16	-1	1,149	9	1,135	9	(N/A)	0.3	0.1	2.13
Ohio buckeye	840	6	-175	-11	-1	1,517	11	2,171	16	(N/A)	0.2	0.2	5.43
Black walnut	2,429	18	-305	-11	-2	1,728	13	3,841	29	(N/A)	0.2	0.3	9.60
Northern catalpa	1,550	12	-76	-7	-1	1,227	9	2,695	20	(N/A)	0.2	0.2	6.74
Alder	649	5	-34	-5	0	741	6	1,352	10	(N/A)	0.2	0.1	3.38
Ginkgo	58	0	-40	-5	0	507	4	521	4	(N/A)	0.1	0.0	1.95
Common chokecherry	535	4	-29	-4	0	617	5	1,119	8	(N/A)	0.1	0.1	4.20
Japanese maple	152	1	-5	-2	0	161	1	306	2	(N/A)	0.1	0.0	1.15
Conifer Evergreen Medin	12	0	0	-1	0	48	0	60	0	(N/A)	0.1	0.0	0.45
Conifer Evergreen Small	13	0	0	-1	0	26	0	39	0	(N/A)	0.1	0.0	0.29
Sweetgum	857	6	-76	-4	-1	552	4	1,330	10	(N/A)	0.1	0.1	9.97
Hickory	660	5	-41	-3	0	441	3	1,058	8	(N/A)	0.1	0.1	7.93
Eastern red cedar	13	0	0	-1	0	26	0	39	0	(N/A)	0.1	0.0	0.29
Apple	38	0	-1	-1	0	37	0	74	1	(N/A)	0.1	0.0	0.55
Black locust	370	3	-69	-4	-1	539	4	837	6	(N/A)	0.1	0.1	6.27
Juniper	0	0	-5	-2	0	187	1	180	1	(N/A)	0.1	0.0	1.35
Northern white cedar	53	0	-1	-1	0	94	1	145	1	(N/A)	0.1	0.0	1.08
Oak	660	5	-41	-3	0	441	3	1,058	8	(N/A)	0.1	0.1	7.93
Tulip tree	960	7	-125	-4	-1	650	5	1,481	11	(N/A)	0.1	0.1	11.11
Citywide total	805,570	6,042	-83,997	-4,329	-662	647,967	4,860	1,365,212	10,239	(N/A)	100.0	100.0	7.14

Table 6: Annual Social and Aesthetic Benefits

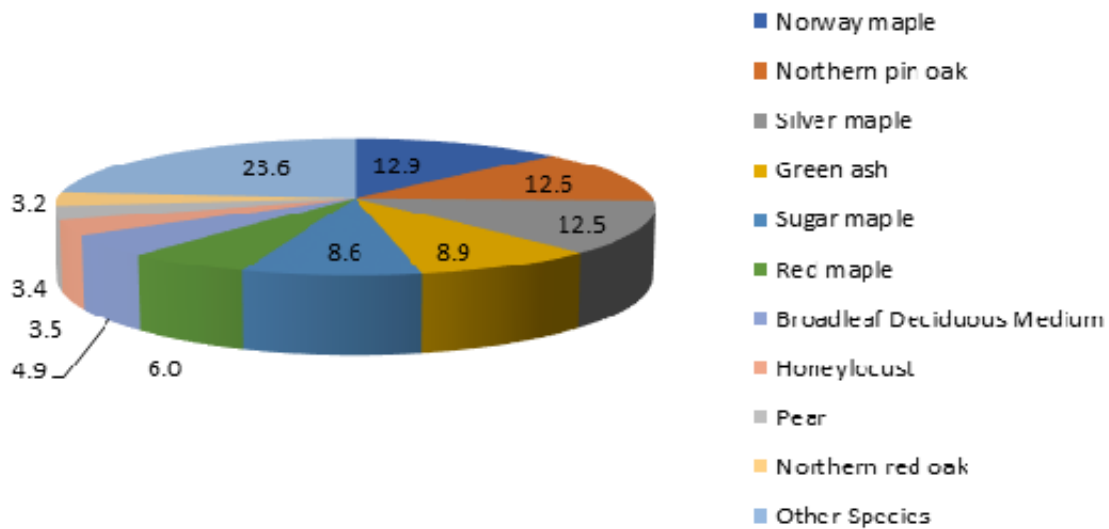
Annual Aesthetic/Other Benefits of Public Trees					
4/23/2020					
Species	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	5,430	(N/A)	12.9	7.1	29.35
Northern pin oak	1,009	(N/A)	12.6	1.3	5.58
Silver maple	20,217	(N/A)	12.5	26.6	112.95
Green ash	7,683	(N/A)	8.9	10.1	60.49
Sugar maple	8,576	(N/A)	8.6	11.3	69.72
Red maple	5,195	(N/A)	6.0	6.8	60.41
BroadleafDeciduous Medi	1,853	(N/A)	4.9	2.4	26.10
Honeylocust	9,768	(N/A)	3.5	12.8	195.37
Pear	499	(N/A)	3.4	0.7	10.18
Northern red oak	396	(N/A)	3.2	0.5	8.62
American basswood	3,126	(N/A)	2.9	4.1	74.43
White ash	3,568	(N/A)	2.6	4.7	93.88
American sycamore	1,598	(N/A)	2.0	2.1	57.09
Norway spruce	435	(N/A)	1.5	0.6	19.76
BroadleafDeciduous Small	32	(N/A)	1.4	0.0	1.58
Eastern redbud	109	(N/A)	1.3	0.1	6.03
White oak	766	(N/A)	1.1	1.0	47.88
American elm	1,094	(N/A)	1.0	1.4	78.12
Swamp white oak	452	(N/A)	0.9	0.6	34.75
Bur oak	564	(N/A)	0.8	0.7	47.01
Austrian pine	109	(N/A)	0.6	0.1	12.14
River birch	159	(N/A)	0.6	0.2	19.86
Northern hackberry	521	(N/A)	0.6	0.7	65.16
Southern magnolia	283	(N/A)	0.6	0.4	35.34
Littleleaflinden	309	(N/A)	0.5	0.4	44.13
Black maple	489	(N/A)	0.5	0.6	69.83
Boxelder	198	(N/A)	0.5	0.3	28.31
Pin oak	126	(N/A)	0.4	0.2	21.03
Blue spruce	94	(N/A)	0.4	0.1	15.73
Chinese elm	261	(N/A)	0.4	0.3	43.55
Black spruce	64	(N/A)	0.3	0.1	12.81
BroadleafDeciduous Large	265	(N/A)	0.3	0.3	52.99
Eastern white pine	32	(N/A)	0.3	0.0	8.08
Ohio buckeye	75	(N/A)	0.2	0.1	24.84
Black walnut	182	(N/A)	0.2	0.2	60.54
Northern catalpa	149	(N/A)	0.2	0.2	49.80
Alder	37	(N/A)	0.2	0.0	12.46
Ginkgo	7	(N/A)	0.1	0.0	3.39
Common chokecherry	31	(N/A)	0.1	0.0	15.48
Japanese maple	8	(N/A)	0.1	0.0	4.23
Conifer Evergreen Medium	12	(N/A)	0.1	0.0	12.31
Conifer Evergreen Small	13	(N/A)	0.1	0.0	13.37
Sweetgum	66	(N/A)	0.1	0.1	65.59
Hickory	58	(N/A)	0.1	0.1	57.69
Eastern red cedar	13	(N/A)	0.1	0.0	13.37
Apple	2	(N/A)	0.1	0.0	2.06
Black locust	31	(N/A)	0.1	0.0	31.46
Juniper	0	(N/A)	0.1	0.0	0.00
Northern white cedar	15	(N/A)	0.1	0.0	15.42
Oak	58	(N/A)	0.1	0.1	57.69
Tulip tree	67	(N/A)	0.1	0.1	66.60
Citywide total	76,105	(N/A)	100.0	100.0	53.04

Table 7: Summary of Benefits in Dollars

Annual Benefits of Public Trees by Species (\$/tree)						
Species	Energy	CO ₂	AirQuality	Stormwater	AestheticOther	Total (\$) Standard Error
Norway maple	59.25	5.42	10.85	74.83	29.35	179.71 (N/A)
Northern pin oak	70.10	3.94	13.39	99.96	5.58	192.97 (N/A)
Silver maple	69.55	14.70	13.19	139.51	112.95	349.89 (N/A)
Green ash	68.98	9.36	12.56	109.39	60.49	260.78 (N/A)
Sugar maple	59.85	8.28	9.77	93.55	69.72	241.17 (N/A)
Red maple	48.29	6.34	8.90	54.14	60.41	178.08 (N/A)
BroadleafDeciduou	31.36	3.53	5.16	29.67	26.10	95.82 (N/A)
Honeylocust	60.77	9.76	10.17	84.63	195.37	360.70 (N/A)
Pear	23.93	2.53	3.92	12.64	10.18	53.20 (N/A)
Northern red oak	45.03	3.10	6.27	63.41	8.62	126.42 (N/A)
American basswood	65.86	11.10	10.20	97.17	74.43	258.76 (N/A)
White ash	71.75	10.54	15.05	120.15	93.88	311.38 (N/A)
American sycamore	82.08	9.99	16.47	156.08	57.09	321.71 (N/A)
Norway spruce	19.70	1.77	1.07	44.41	19.76	86.70 (N/A)
BroadleafDeciduou	4.64	0.47	0.62	1.64	1.58	8.96 (N/A)
Eastern redbud	17.07	1.67	2.72	8.48	6.03	35.97 (N/A)
White oak	46.22	6.40	7.66	48.63	47.88	156.80 (N/A)
American elm	100.67	9.88	22.36	119.91	78.12	330.94 (N/A)
Swamp white oak	40.55	4.85	6.72	34.90	34.75	121.78 (N/A)
Bur oak	49.62	6.66	8.82	67.66	47.01	179.78 (N/A)
Austrian pine	33.60	2.81	3.90	73.26	12.14	125.71 (N/A)
River birch	29.90	3.03	5.14	28.77	19.86	86.70 (N/A)
Northern hackberry	84.14	8.49	16.06	121.55	65.16	295.39 (N/A)
Southern magnolia	46.24	4.35	6.01	64.00	35.34	155.94 (N/A)
Littleleaflinden	44.79	5.49	7.80	65.00	44.13	167.20 (N/A)
Black maple	52.17	7.12	9.62	59.24	69.83	197.98 (N/A)
Boxelder	23.31	2.97	3.61	21.78	28.31	79.98 (N/A)
Pin oak	50.04	4.08	6.58	73.71	21.03	155.44 (N/A)
Blue spruce	10.41	0.74	1.08	13.99	15.73	41.96 (N/A)
Chinese elm	55.66	6.64	10.59	80.10	43.55	196.54 (N/A)
Black spruce	18.86	1.65	2.16	37.39	12.81	72.87 (N/A)
BroadleafDeciduou	61.76	8.17	11.53	101.60	52.99	236.05 (N/A)
Eastern white pine	34.66	2.13	-0.48	104.01	8.08	148.41 (N/A)
Ohio buckeye	66.79	5.43	12.44	90.41	24.84	199.90 (N/A)
Black walnut	73.09	9.60	13.62	124.41	60.54	281.26 (N/A)
Northern catalpa	48.59	6.74	8.06	49.88	49.80	163.07 (N/A)
Alder	31.49	3.38	5.22	14.43	12.46	66.97 (N/A)
Ginkgo	32.00	1.95	5.71	29.25	3.39	72.30 (N/A)
Common chokechen	38.13	4.20	6.56	18.06	15.48	82.43 (N/A)
Japanese maple	11.80	1.15	1.63	4.51	4.23	23.32 (N/A)
Conifer Evergreen N	6.94	0.45	0.75	6.95	12.31	27.41 (N/A)
Conifer Evergreen S	3.62	0.29	0.20	4.97	13.37	22.45 (N/A)
Sweetgum	70.91	9.97	12.48	106.85	65.59	265.81 (N/A)
Hickory	57.32	7.93	9.34	70.21	57.69	202.49 (N/A)
Eastern red cedar	3.62	0.29	0.20	4.97	13.37	22.45 (N/A)
Apple	5.40	0.55	0.71	1.86	2.06	10.58 (N/A)
Black locust	70.84	6.27	13.58	102.01	31.46	224.17 (N/A)
Juniper	24.57	1.35	2.19	44.30	0.00	72.40 (N/A)
Northern white ceda	13.58	1.08	1.48	16.14	15.42	47.70 (N/A)
Oak	57.32	7.93	9.34	70.21	57.69	202.49 (N/A)
Tulip tree	82.02	11.11	15.71	148.79	66.60	324.23 (N/A)
Citywide total	56.91	7.14	10.22	84.86	53.04	212.16 (N/A)

Species Distribution of Public Trees

4/23/2020

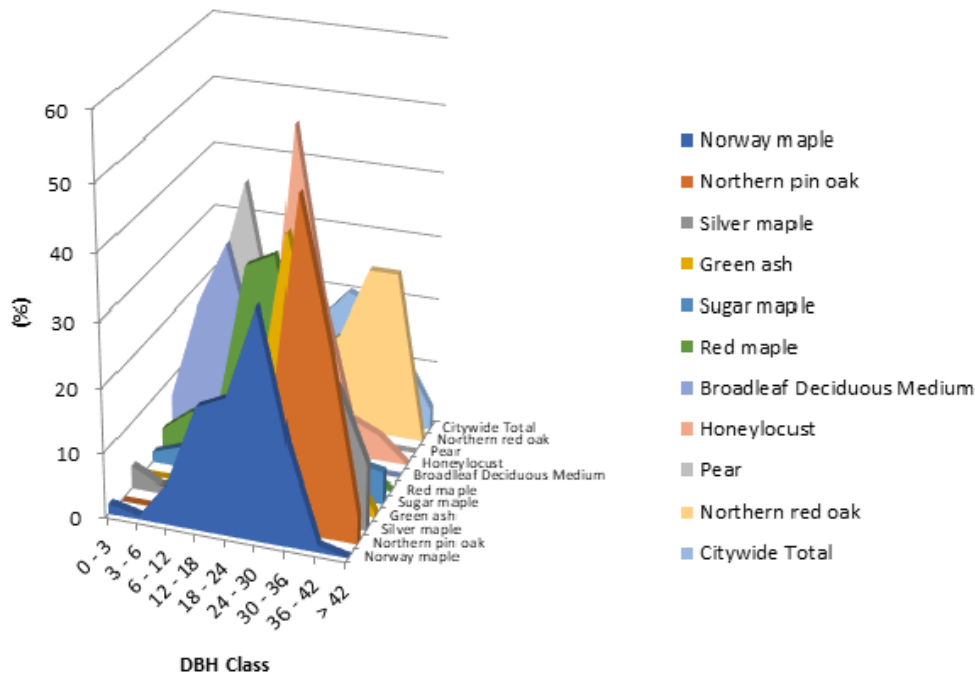


Species	Percent
Norway maple	12.9
Northern pin oak	12.6
Silver maple	12.5
Green ash	8.9
Sugar maple	8.6
Red maple	6.0
Broadleaf Deciduous Me	4.9
Honeylocust	3.5
Pear	3.4
Northern red oak	3.2
Other Species	23.6
Total	100.0

Figure 1: Species Distribution

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

4/23/2020



Species	DBH class (m)								
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42
Norway maple	1.62	0.54	6.49	18.92	21.08	35.14	15.14	1.08	0.00
Northern pin oak	0.00	0.00	0.00	1.10	3.87	11.05	50.28	29.28	4.42
Silver maple	3.35	1.12	2.23	8.38	11.73	18.44	23.46	21.23	10.06
Green ash	0.00	0.00	3.15	11.02	13.39	40.94	22.05	8.66	0.79
Sugar maple	1.63	3.25	8.13	14.63	10.57	34.96	16.26	5.69	4.88
Red maple	3.49	6.98	8.14	31.40	33.72	10.47	3.49	2.33	0.00
Broadleaf Deciduous Medium	7.04	22.54	32.39	15.49	15.49	5.63	1.41	0.00	0.00
Honeylocust	4.00	8.00	0.00	4.00	50.00	24.00	6.00	4.00	0.00
Pear	2.04	22.45	38.78	16.33	16.33	4.08	0.00	0.00	0.00
Northern red oak	8.70	6.52	2.17	4.35	10.87	15.22	26.09	26.09	0.00
Citywide Total	3.07	5.57	8.50	14.08	15.40	20.28	18.40	11.36	3.34

Figure 2: Relative Age Class

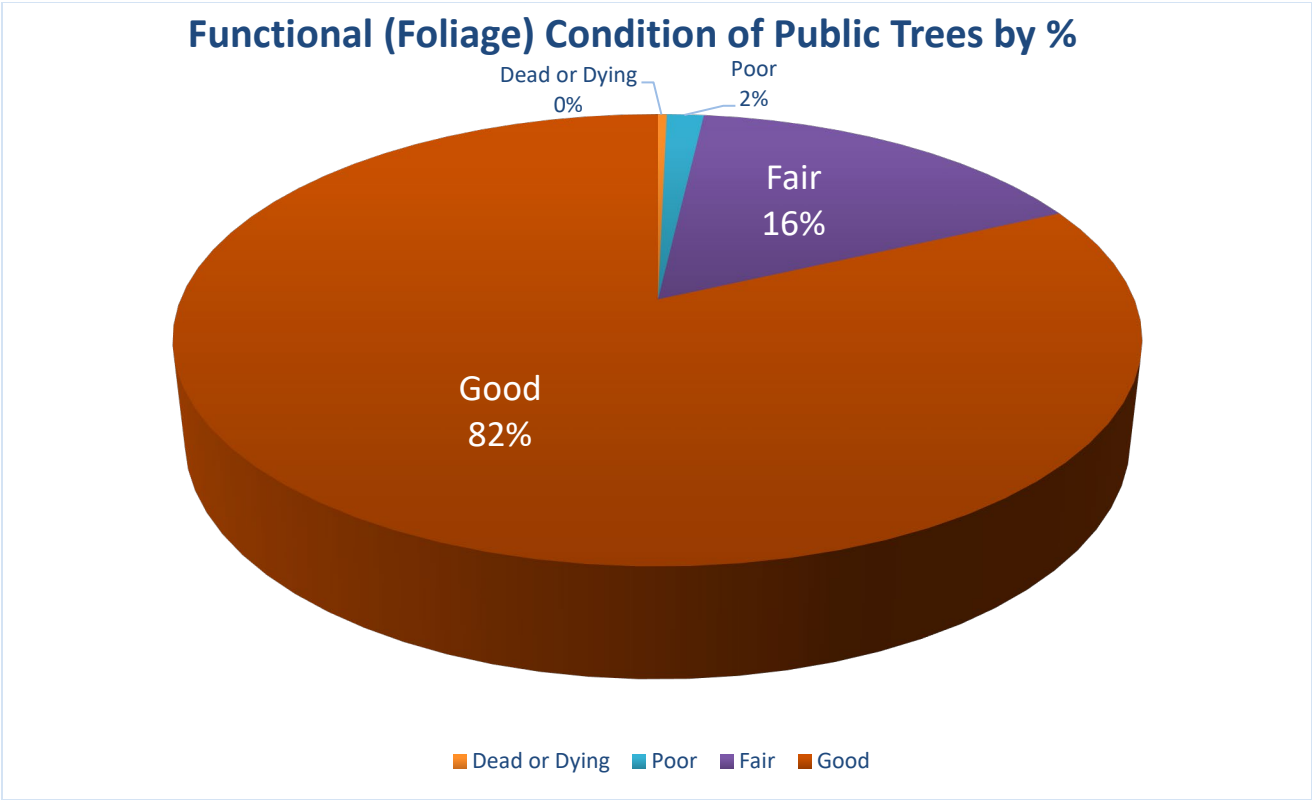


Figure 3: Foliage Condition

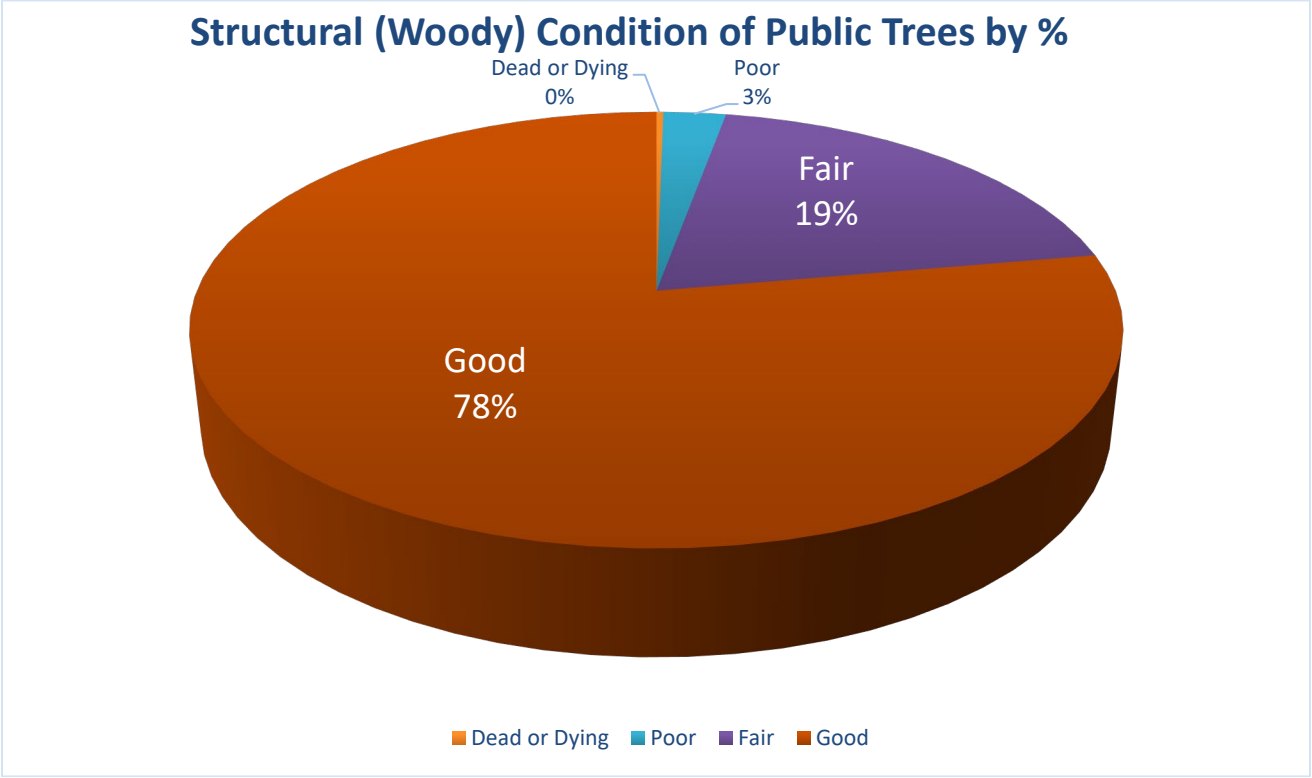
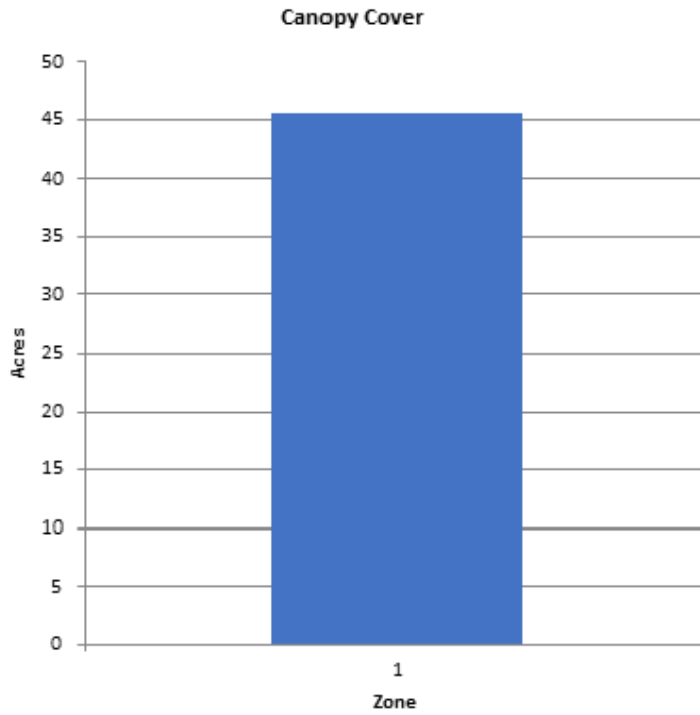


Figure 4: Wood Condition

Canopy Cover of Public Trees (Acres)

4/23/2020



Zone	Acres	% of Total Canopy Cover
1	46	100.0
Citywide total	46	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	46	0.00	0.00

Figure 5: Canopy Cover in Acres

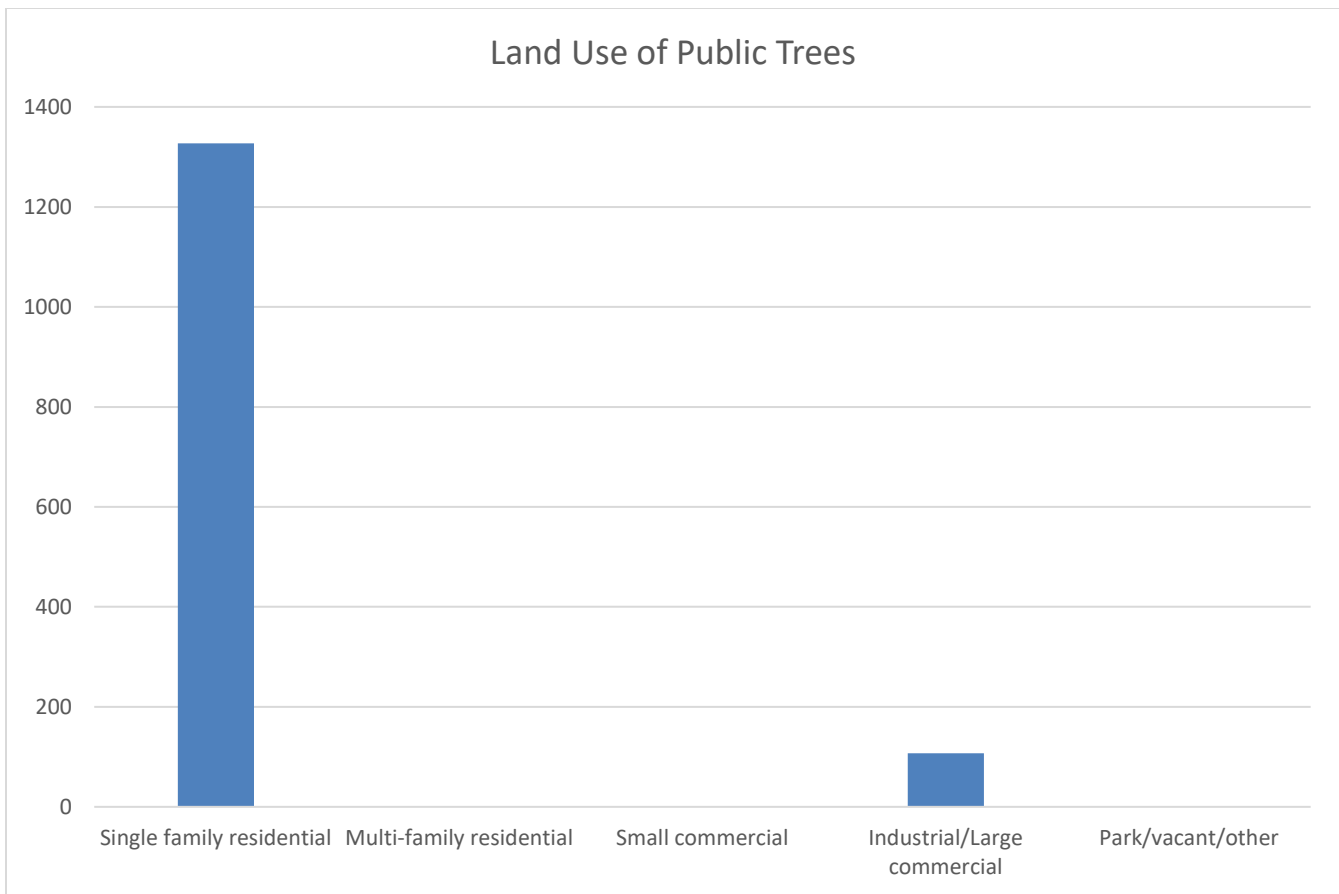


Figure 6: Land Use of city/park trees

Appendix B: ArcGIS Mapping

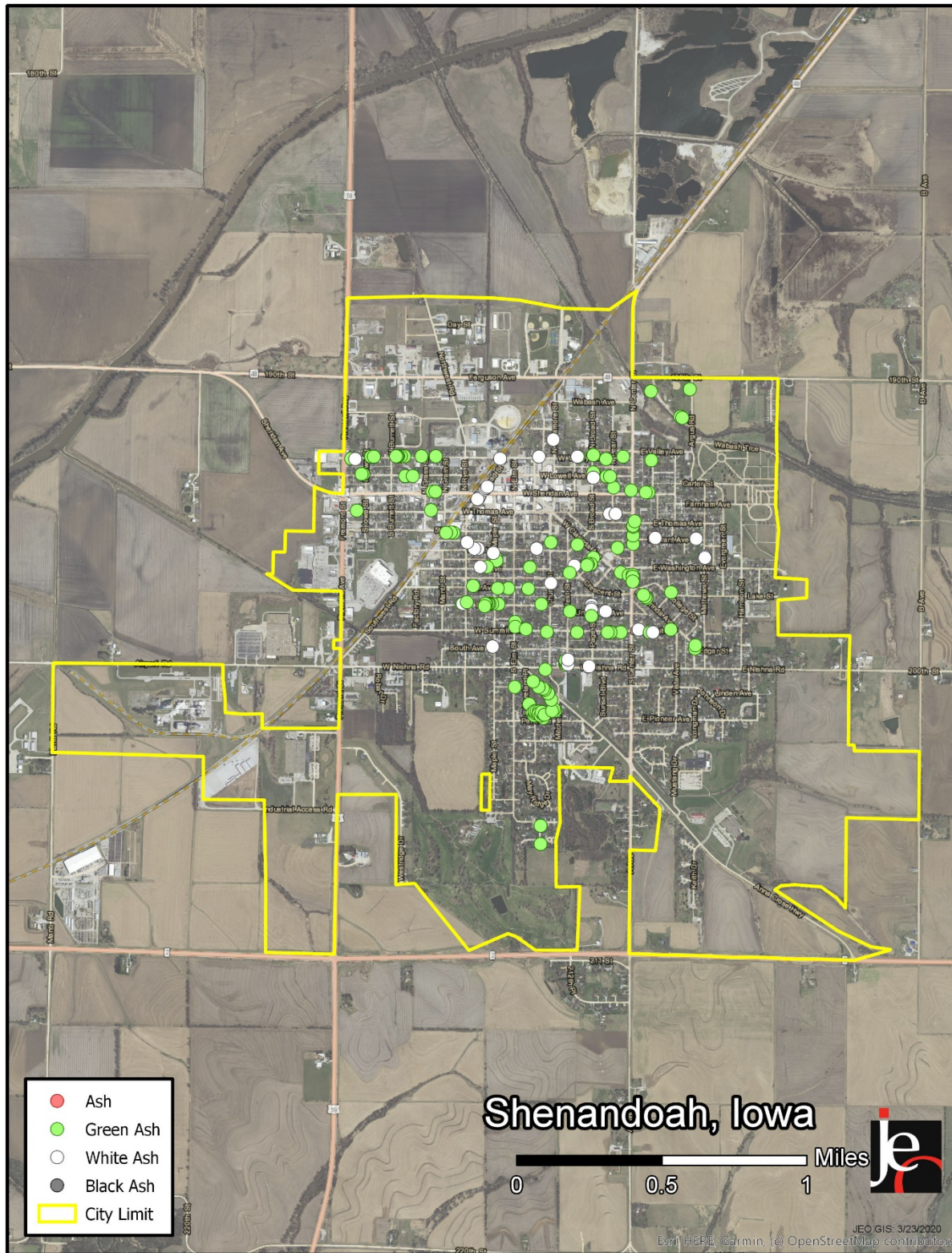


Figure 1: Location of Ash Trees

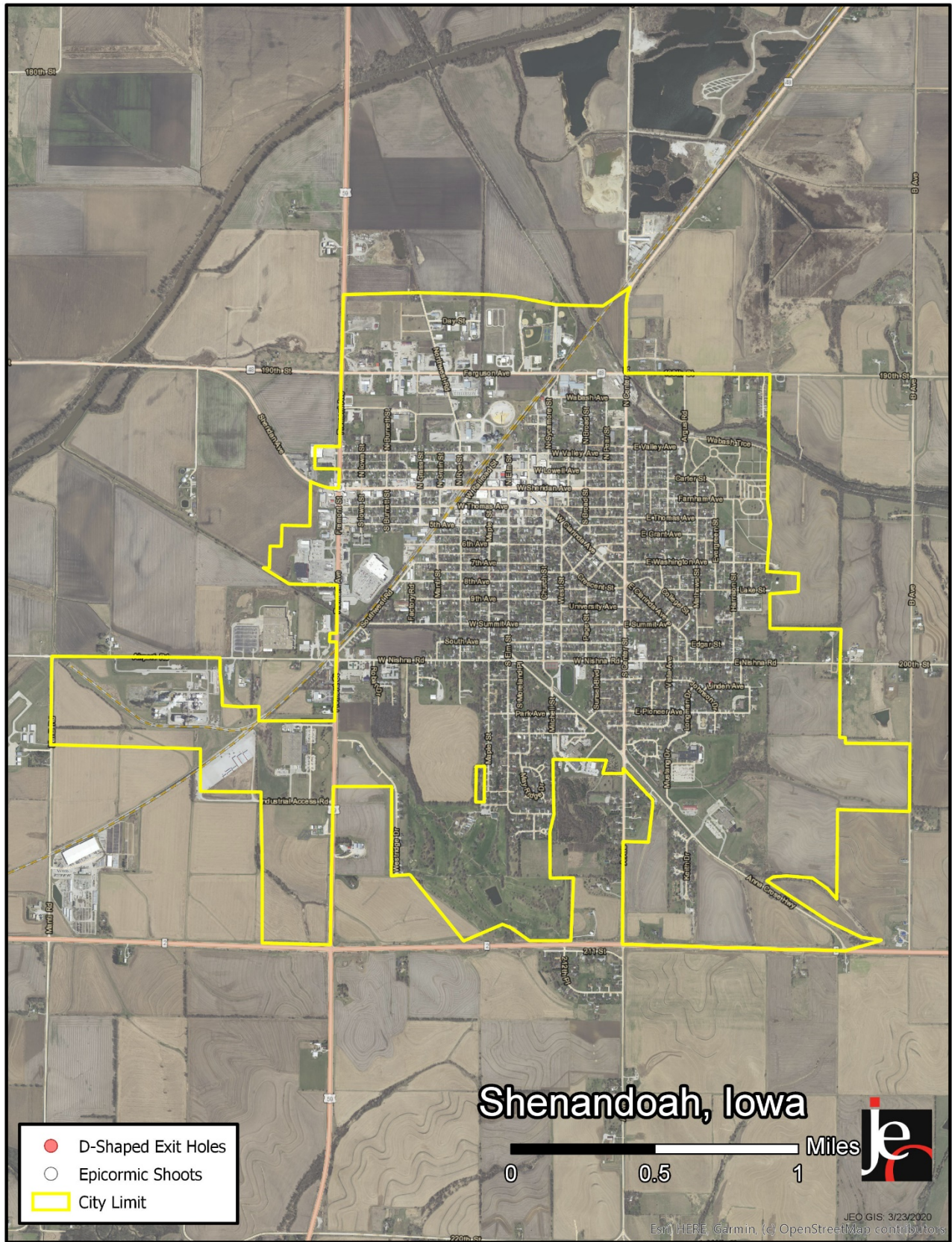


Figure 2: Location of EAB symptoms

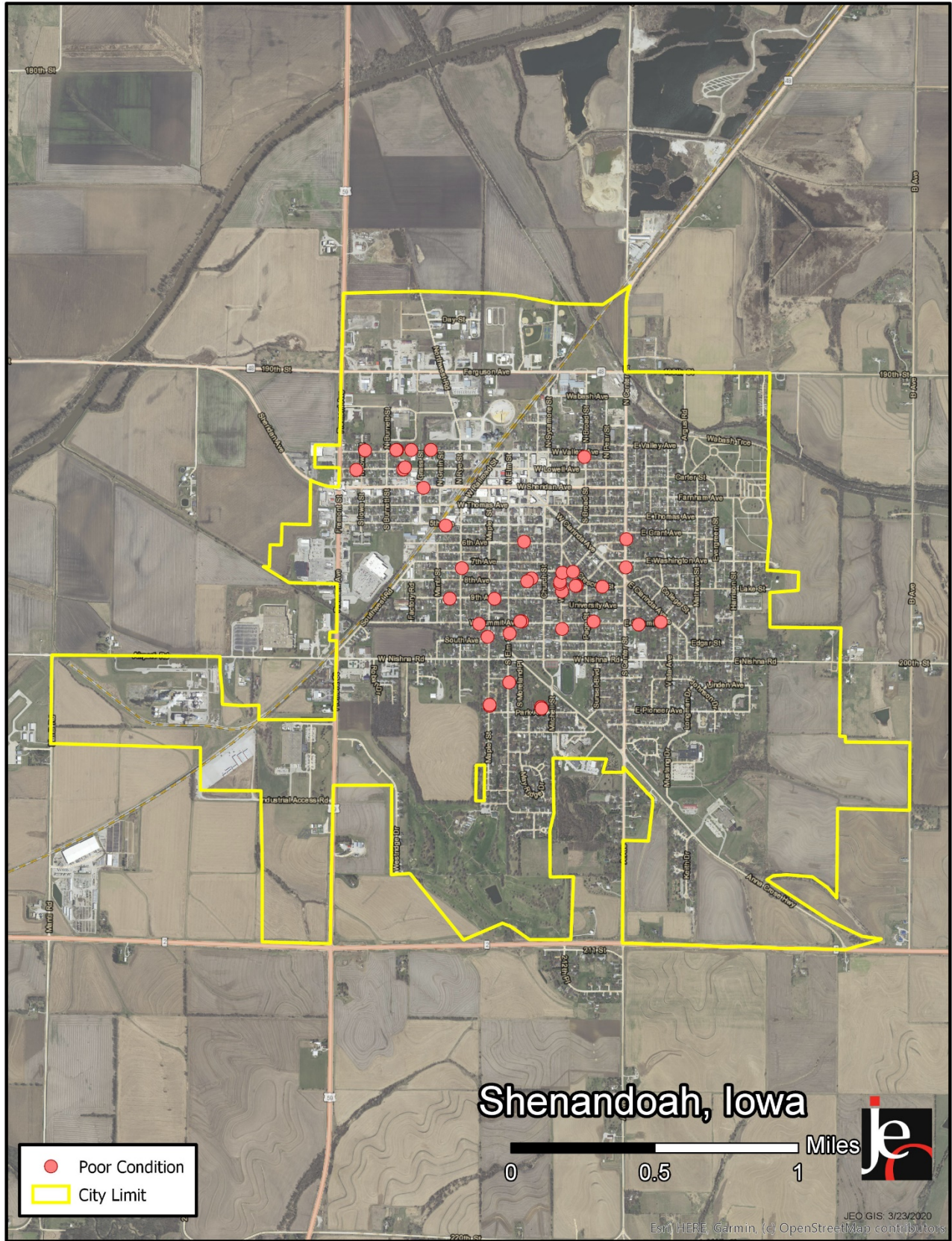


Figure 3: Location of Poor Condition Trees

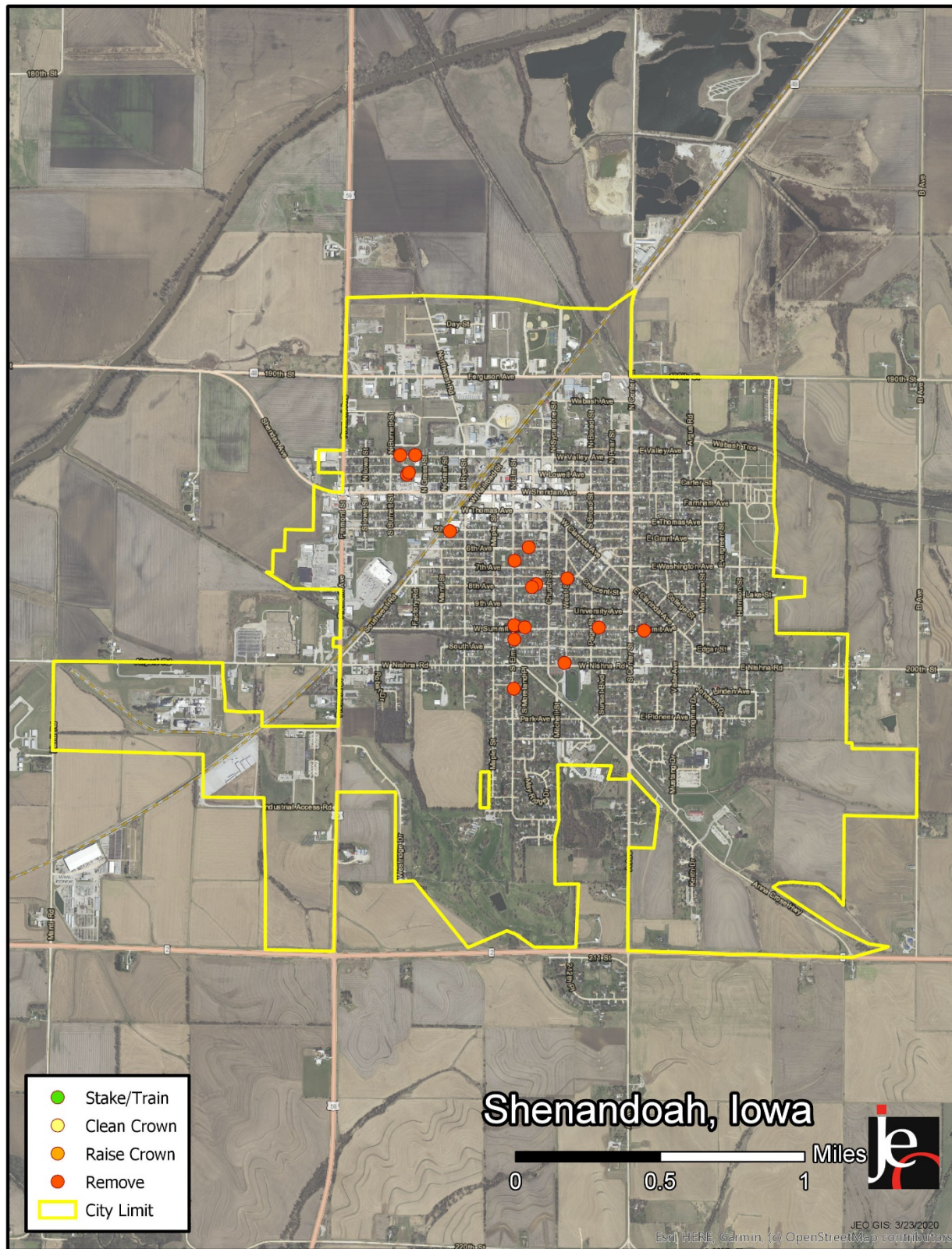


Figure 4: Location of Trees with Recommended Maintenance *City ownership of the trees recommended for removal should be verified prior to any removal*

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