Delhi, 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 Delhi 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 8% of Delhi'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 161 trees inventoried.

- Delhi's trees provide $30,179 of benefits annually, an average of $187 per tree
- There are over 30 species of trees
- The top three genera are: Maple 42%, Spruce 21%, and Ash 8%
- 19% of trees need some type of management
- 4 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 4 trees needing removal, 1 tree is 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*
- The ash trees should be watched carefully for symptoms related to 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 24 years to remove ash. We suggest that city officials request a budget increase to $10,000 annually and apply for grants to plant replacement trees.

Introduction

This plan was developed to assist Delhi 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 Delhi, 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 Delhi'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 Delhi 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 Delhi'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 161 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. Fin

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Delhi's trees reduce energy-related costs by approximately $7,816 annually (Appendix A, Table 1). These savings are both in electricity (38 MWh) and in natural gas (5,067 Therms).

Annual Stormwater Benefits

Delhi's trees intercept about 425,250 gallons of rainfall or snow melt per year (Appendix A, Table 2). This interception provides $11,524 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 Delhi, it is estimated that trees remove 4,519 lbs of air pollution (ozone (O_3), particulate matter less than 10 microns (PM10), carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2)) per year with a net value of $1,245 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Delhi, trees sequester about 86,254 lbs of carbon per year with an associated value of $647 (Appendix A, Table 5). In addition, the trees store 1,494,099 lbs of carbon, with a yearly benefit of $11,206 (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. Delhi receives $8,530 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, Delhi's trees provide $30,179 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 161 trees in Delhi provide approximately $187 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Delhi has over 30 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	68	42%
Spruce	21	13%
Ash	13	8%
Oak	8	5%
Pine	7	4%
Locust	7	4%
Hackberry	6	4%
Elm	5	3%
Catalpa	5	3%
Walnut	5	3%
Hickory	3	2%
Cottonwood	3	2%
Basswood/Linden	2	1%
Boxelder	1	<1%
Apple	1	<1%
Pear	1	<1%
Other Deciduous	1	<1%
Other Evergreen	1	<1%

Age Class

Most of Delhi's trees (25%) are between 6 and 18 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. Delhi'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 Delhi indicate that 75% of the trees are in good health, with only 3% of the foliage in poor health, dead, or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 60% of Delhi'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	13	8%
Crown Reduction	8	5%
Tree Removal	4	2%
Tree Staking	3	2%
Crown Raising	3	2%

Land Use and Location

The majority of Delhi's city and park trees are in planting strips in single family residential neighborhoods (Appendix A, Figure 6 & Appendix A, Figure7). The following describes the land use and locations for the street and park trees.

Land Use	
Single family residential	79%
Industrial/Large commercial	21%
Park/vacant/other	0%
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

Delhi has 9 critical concern 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 6 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 31 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 4 removals, zero are ash trees. There are a total of 13 ash trees, which should be carefully watched for signs and symptoms that are associated with EAB. *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 Delhi.

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 (42%) (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 $920/Year – (Based off $2/Capita Calculation Due to no City Reporting)

YEAR 1	**ESTIMATED COSTS**
Remove 1 tree recommended for immediate removal	$700
Plant 1 trees in open locations	$150
Visual Survey of EAB Signs/Symptoms	

YEAR 2	
Remove 1 tree recommended for immediate removal	$700
Plant 1 trees in open locations	$150
Visual Survey of EAB Signs/Symptoms	

YEAR 3	
Remove 1 tree recommended for immediate removal	$700
Plant 1 trees in open locations	$150
Visual Survey of EAB Signs/Symptoms	

YEAR 4	
Remove 1 tree recommended for immediate removal	$700
Plant 1 trees in open locations	$150
Visual Survey of EAB Signs/Symptoms	

YEAR 5	
Remove 1 ash tree (prioritize largest diameter)	$700
Plant 1 trees in open locations	$150
Visual Survey of EAB Signs/Symptoms	

YEAR 6

Remove 1 ash tree (prioritize largest diameter)	$700
Plant 1 trees in open locations	$150
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 $1,500 a year. If the budget were increased to $1,000 a year all ash could be removed in 9 years.

Proposed Work Schedule with Increased Budget

Budget Allowance of $1,500/Year – (Budget Increase Suggested to Best Manage City Trees)

YEAR 1	**ESTIMATED COSTS**
Remove 2 trees recommended for immediate removal	$1,400
Visual Survey of EAB Signs/Symptoms	

YEAR 2

Plant 4 trees in open locations	$600
Prune 1/3 of City Owned Trees	$810
Visual Survey of EAB Signs/Symptoms	

YEAR 3

Remove 2 trees recommended for immediate removal	$1,400
Visual Survey of EAB Signs/Symptoms	

YEAR 4

Plant 4 trees in open locations	$600
Prune 1/3 of City Owned Trees	$810
Visual Survey of EAB Signs/Symptoms	

YEAR 5

Remove 2 ash trees (prioritize largest diameter)	$1,400
Visual Survey of EAB Signs/Symptoms	

YEAR 6

Plant 4 trees in open locations	$600
Prune 1/3 of City Owned Trees	$810
Visual Survey of EAB Signs/Symptoms	

Purposed Budget Increase

EAB could potentially kill all ash trees in Delhi within four years of its arrival. To remove all ash trees within six years, the budget would need to be increased to $1,500 a year. If the budget were increased to $1,000 per year all ash could be removed within 9 years. Additionally, we recommend that Delhi 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 Delhi would still need to find $3,500 for removal. Alternatively, if there are 3 treatable trees, it would cost approximately $900 a year for treatment and leave $600 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 Delhi. 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

4/21/2020

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Sugar maple	13.2	1,002	1,762.0	1,727	2,728	(N/A)	28.6	34.9	59.31
Green ash	3.3	253	452.8	444	697	(N/A)	8.1	8.9	53.61
Silver maple	3.8	286	497.8	488	774	(N/A)	7.5	9.9	64.46
Black spruce	0.0	4	9.6	9	13	(N/A)	5.0	0.2	1.65
Norway maple	2.0	152	289.4	284	436	(N/A)	5.0	5.6	54.47
Blue spruce	0.5	36	63.7	62	98	(N/A)	4.3	1.3	14.06
Norway spruce	1.0	76	132.9	130	206	(N/A)	3.7	2.6	34.32
Northern hackberry	2.3	174	330.6	324	498	(N/A)	3.7	6.4	82.97
Catalpa	0.1	11	18.5	18	29	(N/A)	3.1	0.4	5.82
Black locust	1.2	93	167.6	164	258	(N/A)	3.1	3.3	51.54
Black walnut	1.0	80	141.7	139	218	(N/A)	3.1	2.8	43.69
Siberian elm	1.7	130	234.0	229	359	(N/A)	3.1	4.6	71.80
Pin oak	1.6	121	210.1	206	327	(N/A)	2.5	4.2	81.68
Eastern white pine	0.7	50	88.6	87	137	(N/A)	2.5	1.8	34.32
Cottonwood	0.7	53	81.0	79	133	(N/A)	1.9	1.7	44.23
Hickory	1.0	75	140.6	138	213	(N/A)	1.9	2.7	70.91
Red pine	0.4	29	43.9	43	72	(N/A)	1.9	0.9	24.14
Apple	0.3	20	37.5	37	56	(N/A)	1.2	0.7	28.16
Northern white cedar	0.0	3	7.9	8	11	(N/A)	1.2	0.1	5.61
Bur oak	0.6	45	85.0	83	128	(N/A)	1.2	1.6	64.12
Red maple	0.3	24	45.1	44	69	(N/A)	1.2	0.9	34.27
Honeylocust	0.6	44	75.7	74	119	(N/A)	1.2	1.5	59.28
Northern red oak	0.0	0	1.2	1	2	(N/A)	0.6	0.0	1.67
Pear	0.0	2	3.8	4	5	(N/A)	0.6	0.1	5.40
American basswood	0.0	0	0.5	0	1	(N/A)	0.6	0.0	0.69
Conifer Evergreen Mediu	0.0	2	4.9	5	7	(N/A)	0.6	0.1	6.94
Broadleaf Deciduous Med	0.2	18	29.5	29	47	(N/A)	0.6	0.6	46.78
Littleleaf linden	0.2	15	23.9	23	39	(N/A)	0.6	0.5	38.70
White oak	0.5	37	63.1	62	99	(N/A)	0.6	1.3	98.63
Boxelder	0.2	15	23.9	23	39	(N/A)	0.6	0.5	38.63
Total	37.6	2,851	5,066.8	4,965	7,816	(N/A)	100.0	100.0	48.55

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees

4/21/2020

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Sugar maple	152,169	4,124	(N/A)	28.6	35.8	89.65
Green ash	31,252	847	(N/A)	8.1	7.3	65.15
Silver maple	46,680	1,265	(N/A)	7.5	11.0	105.42
Black spruce	305	8	(N/A)	5.0	0.1	1.03
Norway maple	18,371	498	(N/A)	5.0	4.3	62.23
Blue spruce	6,271	170	(N/A)	4.3	1.5	24.28
Norway spruce	22,722	616	(N/A)	3.7	5.3	102.63
Northern hackberry	23,082	626	(N/A)	3.7	5.4	104.25
Catalpa	858	23	(N/A)	3.1	0.2	4.65
Black locust	9,186	249	(N/A)	3.1	2.2	49.79
Black walnut	11,525	312	(N/A)	3.1	2.7	62.46
Siberian elm	18,411	499	(N/A)	3.1	4.3	99.79
Pin oak	21,357	579	(N/A)	2.5	5.0	144.69
Eastern white pine	15,148	411	(N/A)	2.5	3.6	102.63
Cottonwood	4,397	119	(N/A)	1.9	1.0	39.72
Hickory	11,829	321	(N/A)	1.9	2.8	106.85
Red pine	4,616	125	(N/A)	1.9	1.1	41.70
Apple	931	25	(N/A)	1.2	0.2	12.62
Northern white cedar	426	12	(N/A)	1.2	0.1	5.77
Bur oak	6,534	177	(N/A)	1.2	1.5	88.53
Red maple	3,004	81	(N/A)	1.2	0.7	40.71
Honeylocust	4,462	121	(N/A)	1.2	1.0	60.46
Northern red oak	19	1	(N/A)	0.6	0.0	0.51
Pear	69	2	(N/A)	0.6	0.0	1.86
American basswood	8	0	(N/A)	0.6	0.0	0.22
Conifer Evergreen Medium	256	7	(N/A)	0.6	0.1	6.95
Broadleaf Deciduous Medi	1,409	38	(N/A)	0.6	0.3	38.19
Littleleaf linden	1,260	34	(N/A)	0.6	0.3	34.14
White oak	7,239	196	(N/A)	0.6	1.7	196.17
Boxelder	1,456	39	(N/A)	0.6	0.3	39.46
Citywide total	425,250	11,524	(N/A)	100.0	100.0	71.58

Table 3: Annual Air Quality Benefits

Annual Air Quality Benefits of Public Trees

4/21/2020

Species	Deposition (lb) O_3	NO_2	PM_{10}	SO_2	Total Depos ($)	Avoided (lb) NO_2	PM_{10}	VOC	SO_2	Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($)	Standard Error	% of Total Trees	Avg $/tree
Sugar maple	20.9	3.6	10.3	0.9	115	62.5	9.1	8.7	59.8	391	-16.4	-62	159.5	442	(N/A)	28.6	9.62
Green ash	3.3	0.5	1.7	0.1	18	15.9	2.3	2.2	15.1	99	0.0	0	41.1	117	(N/A)	8.1	8.99
Silver maple	7.4	1.3	3.7	0.3	40	17.8	2.6	2.5	17.0	111	-4.1	-15	48.5	136	(N/A)	7.5	11.33
Black spruce	0.0	0.0	0.0	0.0	0	0.3	0.0	0.0	0.2	2	-0.1	0	0.5	1	(N/A)	5.0	0.18
Norway maple	3.7	0.6	1.8	0.2	20	9.7	1.4	1.3	9.1	60	-0.9	-3	27.0	77	(N/A)	5.0	9.62
Blue spruce	0.8	0.2	0.7	0.1	5	2.2	0.3	0.3	2.1	14	-2.3	-8	4.5	11	(N/A)	4.3	1.56
Norway spruce	2.7	0.5	2.2	0.3	18	4.7	0.7	0.7	4.5	29	-12.7	-48	3.7	0	(N/A)	3.7	-0.06
Northern hackberry	3.6	0.6	1.8	0.2	20	11.1	1.6	1.5	10.4	69	0.0	0	30.9	89	(N/A)	3.7	14.76
Catalpa	0.0	0.0	0.0	0.0	0	0.7	0.1	0.1	0.7	4	0.0	0	1.6	4	(N/A)	3.1	0.87
Black locust	1.6	0.3	0.8	0.1	9	5.9	0.9	0.8	5.6	37	-0.4	-2	15.6	44	(N/A)	3.1	8.81
Black walnut	1.4	0.2	0.7	0.1	8	5.0	0.7	0.7	4.8	31	0.0	0	13.6	39	(N/A)	3.1	7.74
Siberian elm	3.1	0.5	1.5	0.1	17	8.2	1.2	1.1	7.7	51	0.0	0	23.5	67	(N/A)	3.1	13.48
Pin oak	4.2	0.7	2.1	0.2	23	7.5	1.1	1.0	7.2	47	-7.6	-29	16.4	41	(N/A)	2.5	10.29
Eastern white pine	1.8	0.4	1.5	0.2	12	3.1	0.5	0.4	3.0	20	-8.5	-32	2.4	0	(N/A)	2.5	-0.06
Cottonwood	0.3	0.1	0.2	0.0	2	3.2	0.5	0.5	3.2	20	0.0	0	7.9	22	(N/A)	1.9	7.42
Hickory	1.5	0.2	0.7	0.1	8	4.8	0.7	0.7	4.5	30	0.0	0	13.1	37	(N/A)	1.9	12.48
Red pine	0.5	0.1	0.4	0.1	3	1.8	0.3	0.3	1.8	11	-1.6	-6	3.5	8	(N/A)	1.9	2.82
Apple	0.3	0.0	0.1	0.0	1	1.3	0.2	0.2	1.2	8	0.0	0	3.2	9	(N/A)	1.2	4.55
Northern white cedar	0.0	0.0	0.0	0.0	0	0.2	0.0	0.0	0.2	1	-0.1	0	0.4	1	(N/A)	1.2	0.56
Bur oak	0.8	0.1	0.4	0.0	4	2.9	0.4	0.4	2.7	18	0.0	0	7.6	22	(N/A)	1.2	10.91
Red maple	0.8	0.1	0.4	0.0	4	1.5	0.2	0.2	1.5	10	-0.2	-1	4.4	13	(N/A)	1.2	6.33
Honeylocust	0.8	0.1	0.4	0.0	4	2.7	0.4	0.4	2.6	17	-0.5	-2	7.0	20	(N/A)	1.2	9.76
Northern red oak	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0	0.1	0	(N/A)	0.6	0.21
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)	0.6	0.71
American basswood	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)	0.6	0.08
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)	0.6	0.75
Broadleaf Deciduous Medi	0.2	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	-0.1	0	2.8	8	(N/A)	0.6	7.92
Littleleaf linden	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.9	6	-0.1	0	2.3	6	(N/A)	0.6	6.42
White oak	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)	0.6	22.55
Boxelder	0.1	0.0	0.1	0.0	1	0.9	0.1	0.1	0.9	6	-0.1	0	2.3	6	(N/A)	0.6	6.37
Citywide total	61.7	10.6	32.4	3.2	340	178.5	26.0	24.8	170.2	1,114	-55.7	-209	451.9	1,245	(N/A)	100.0	7.74

Table 4: Annual Carbon Stored

Stored CO2 Benefits of Public Trees

4/21/2020

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Sugar maple	609,464	4,571	(N/A)	28.6	40.8	99.37
Green ash	105,329	790	(N/A)	8.1	7.0	60.77
Silver maple	165,976	1,245	(N/A)	7.5	11.1	103.73
Black spruce	18	0	(N/A)	5.0	0.0	0.02
Norway maple	60,745	456	(N/A)	5.0	4.1	56.95
Blue spruce	5,189	39	(N/A)	4.3	0.3	5.56
Norway spruce	32,499	244	(N/A)	3.7	2.2	40.62
Northern hackberry	53,744	403	(N/A)	3.7	3.6	67.18
Catalpa	927	7	(N/A)	3.1	0.1	1.39
Black locust	26,763	201	(N/A)	3.1	1.8	40.14
Black walnut	46,434	348	(N/A)	3.1	3.1	69.65
Siberian elm	74,811	561	(N/A)	3.1	5.0	112.22
Pin oak	115,423	866	(N/A)	2.5	7.7	216.42
Eastern white pine	21,666	162	(N/A)	2.5	1.5	40.62
Cottonwood	11,016	83	(N/A)	1.9	0.7	27.54
Hickory	47,318	355	(N/A)	1.9	3.2	118.30
Red pine	3,511	26	(N/A)	1.9	0.2	8.78
Apple	3,945	30	(N/A)	1.2	0.3	14.79
Northern white ceda	76	1	(N/A)	1.2	0.0	0.29
Bur oak	24,230	182	(N/A)	1.2	1.6	90.86
Red maple	8,164	61	(N/A)	1.2	0.5	30.61
Honeylocust	9,780	73	(N/A)	1.2	0.7	36.67
Northern red oak	13	0	(N/A)	0.6	0.0	0.09
Pear	178	1	(N/A)	0.6	0.0	1.33
American basswood	13	0	(N/A)	0.6	0.0	0.09
Conifer Evergreen M	43	0	(N/A)	0.6	0.0	0.32
Broadleaf Deciduou	3,624	27	(N/A)	0.6	0.2	27.18
Littleleaf linden	3,595	27	(N/A)	0.6	0.2	26.96
White oak	55,982	420	(N/A)	0.6	3.7	419.86
Boxelder	3,624	27	(N/A)	0.6	0.2	27.18
Citywide total	1,494,099	11,206	(N/A)	100.0	100.0	69.60

Table 5: Annual Carbon Sequestered

Annual CO_2 Benefits of Public Trees

4/21/2020

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
Sugar maple	30,420	228	-2,926	-143	-23	22,135	166	49,487	371	(N/A)	28.6	34.9	8.07
Green ash	7,859	59	-506	-33	-4	5,594	42	12,914	97	(N/A)	8.1	9.1	7.45
Silver maple	13,840	104	-797	-39	-6	6,313	47	19,318	145	(N/A)	7.5	13.6	12.07
Black spruce	14	0	0	-2	0	83	1	95	1	(N/A)	5.0	0.1	0.09
Norway maple	3,146	24	-292	-20	-2	3,363	25	6,197	46	(N/A)	5.0	4.4	5.81
Blue spruce	372	3	-25	-8	0	796	6	1,135	9	(N/A)	4.3	0.8	1.22
Norway spruce	1,330	10	-156	-19	-1	1,672	13	2,828	21	(N/A)	3.7	2.0	3.53
Northern hackberry	3,112	23	-258	-22	-2	3,841	29	6,674	50	(N/A)	3.7	4.7	8.34
Catalpa	371	3	-4	-3	0	243	2	607	5	(N/A)	3.1	0.4	0.91
Black locust	2,098	16	-128	-11	-1	2,065	15	4,023	30	(N/A)	3.1	2.8	6.03
Black walnut	2,473	19	-223	-11	-2	1,758	13	3,997	30	(N/A)	3.1	2.8	6.00
Siberian elm	3,317	25	-359	-18	-3	2,867	22	5,806	44	(N/A)	3.1	4.1	8.71
Pin oak	6,599	49	-554	-18	-4	2,669	20	8,696	65	(N/A)	2.5	6.1	16.30
Eastern white pine	887	7	-104	-12	-1	1,115	8	1,885	14	(N/A)	2.5	1.3	3.53
Cottonwood	1,336	10	-53	-6	0	1,179	9	2,456	18	(N/A)	1.9	1.7	6.14
Hickory	2,571	19	-227	-11	-2	1,657	12	3,990	30	(N/A)	1.9	2.8	9.97
Red pine	347	3	-17	-6	0	649	5	973	7	(N/A)	1.9	0.7	2.43
Apple	382	3	-19	-3	0	433	3	792	6	(N/A)	1.2	0.6	2.97
Northern white cedar	36	0	0	-1	0	76	1	110	1	(N/A)	1.2	0.1	0.41
Bur oak	1,517	11	-116	-6	-1	994	7	2,388	18	(N/A)	1.2	1.7	8.95
Red maple	962	7	-39	-3	0	537	4	1,457	11	(N/A)	1.2	1.0	5.46
Honeylocust	1,411	11	-47	-5	0	981	7	2,340	18	(N/A)	1.2	1.7	8.78
Northern red oak	5	0	0	0	0	11	0	15	0	(N/A)	0.6	0.0	0.12
Pear	38	0	-1	-1	0	37	0	74	1	(N/A)	0.6	0.1	0.55
American basswood	3	0	0	0	0	4	0	8	0	(N/A)	0.6	0.0	0.06
Conifer Evergreen Medi	12	0	0	-1	0	48	0	60	0	(N/A)	0.6	0.0	0.45
Broadleaf Deciduous Me	386	3	-17	-2	0	395	3	762	6	(N/A)	0.6	0.5	5.71
Littleleaf linden	514	4	-17	-2	0	337	3	832	6	(N/A)	0.6	0.6	6.24
White oak	479	4	-269	-6	-2	813	6	1,017	8	(N/A)	0.6	0.7	7.63
Boxelder	418	3	-17	-2	0	336	3	735	6	(N/A)	0.6	0.5	5.51
Citywide total	86,254	647	-7,173	-414	-57	63,002	473	141,670	1,063	(N/A)	100.0	100.0	6.60

Table 6: Annual Social and Aesthetic Benefits

Annual Aesthetic/Other Benefits of Public Trees

4/21/2020

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Sugar maple	3,114	(N/A)	28.6	36.5	67.69
Green ash	697	(N/A)	8.1	8.2	53.63
Silver maple	1,137	(N/A)	7.5	13.3	94.71
Black spruce	40	(N/A)	5.0	0.5	5.03
Norway maple	297	(N/A)	5.0	3.5	37.08
Blue spruce	107	(N/A)	4.3	1.2	15.23
Norway spruce	220	(N/A)	3.7	2.6	36.67
Northern hackberry	390	(N/A)	3.7	4.6	65.08
Catalpa	74	(N/A)	3.1	0.9	14.73
Black locust	204	(N/A)	3.1	2.4	40.72
Black walnut	212	(N/A)	3.1	2.5	42.37
Siberian elm	230	(N/A)	3.1	2.7	46.01
Pin oak	479	(N/A)	2.5	5.6	119.79
Eastern white pine	147	(N/A)	2.5	1.7	36.67
Cottonwood	138	(N/A)	1.9	1.6	45.86
Hickory	197	(N/A)	1.9	2.3	65.59
Red pine	97	(N/A)	1.9	1.1	32.32
Apple	22	(N/A)	1.2	0.3	10.94
Northern white cedar	14	(N/A)	1.2	0.2	6.83
Bur oak	123	(N/A)	1.2	1.4	61.64
Red maple	116	(N/A)	1.2	1.4	58.18
Honeylocust	297	(N/A)	1.2	3.5	148.65
Northern red oak	2	(N/A)	0.6	0.0	1.54
Pear	2	(N/A)	0.6	0.0	2.06
American basswood	2	(N/A)	0.6	0.0	1.78
Conifer Evergreen Medium	12	(N/A)	0.6	0.1	12.31
Broadleaf Deciduous Medi	39	(N/A)	0.6	0.5	39.16
Littleleaf linden	55	(N/A)	0.6	0.6	55.09
White oak	29	(N/A)	0.6	0.3	28.57
Boxelder	39	(N/A)	0.6	0.5	39.36
Citywide total	8,530	(N/A)	100.0	100.0	52.98

Table 7: Summary of Benefits in Dollars

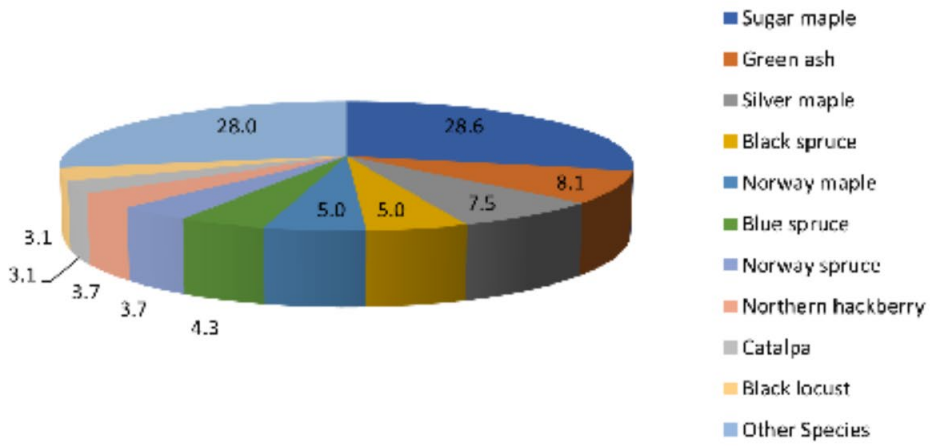
Annual Benefits of Public Trees by Species ($/tree)

4/21/2020

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error
Sugar maple	59.31	8.07	9.62	89.65	67.69	234.34	(N/A)
Green ash	53.61	7.45	8.99	65.15	53.63	188.82	(N/A)
Silver maple	64.46	12.07	11.33	105.42	94.71	287.99	(N/A)
Black spruce	1.65	0.09	0.18	1.03	5.03	7.97	(N/A)
Norway maple	54.47	5.81	9.62	62.23	37.08	169.21	(N/A)
Blue spruce	14.06	1.22	1.56	24.28	15.23	56.34	(N/A)
Norway spruce	34.32	3.53	-0.06	102.63	36.67	177.09	(N/A)
Northern hackberry	82.97	8.34	14.76	104.25	65.08	275.41	(N/A)
Catalpa	5.82	0.91	0.87	4.65	14.73	26.98	(N/A)
Black locust	51.54	6.03	8.81	49.79	40.72	156.89	(N/A)
Black walnut	43.69	6.00	7.74	62.46	42.37	162.26	(N/A)
Siberian elm	71.80	8.71	13.48	99.79	46.01	239.80	(N/A)
Pin oak	81.68	16.30	10.29	144.69	119.79	372.75	(N/A)
Eastern white pine	34.32	3.53	-0.06	102.63	36.67	177.09	(N/A)
Cottonwood	44.23	6.14	7.42	39.72	45.86	143.36	(N/A)
Hickory	70.91	9.97	12.48	106.85	65.59	265.81	(N/A)
Red pine	24.14	2.43	2.82	41.70	32.32	103.40	(N/A)
Apple	28.16	2.97	4.55	12.62	10.94	59.24	(N/A)
Northern white cedar	5.61	0.41	0.56	5.77	6.83	19.18	(N/A)
Bur oak	64.12	8.95	10.91	88.53	61.64	234.15	(N/A)
Red maple	34.27	5.46	6.33	40.71	58.18	144.95	(N/A)
Honeylocust	59.28	8.78	9.76	60.46	148.65	286.93	(N/A)
Northern red oak	1.67	0.12	0.21	0.51	1.54	4.04	(N/A)
Pear	5.40	0.55	0.71	1.86	2.06	10.58	(N/A)
American basswood	0.69	0.06	0.08	0.22	1.78	2.83	(N/A)
Conifer Evergreen M.	6.94	0.45	0.75	6.95	12.31	27.41	(N/A)
Broadleaf Deciduous	46.78	5.71	7.92	38.19	39.16	137.75	(N/A)
Littleleaf linden	38.70	6.24	6.42	34.14	55.09	140.59	(N/A)
White oak	98.63	7.63	22.55	196.17	28.57	353.55	(N/A)
Boxelder	38.63	5.51	6.37	39.46	39.36	129.33	(N/A)
Citywide Total	48.55	6.60	7.74	71.58	52.98	187.44	(N/A)

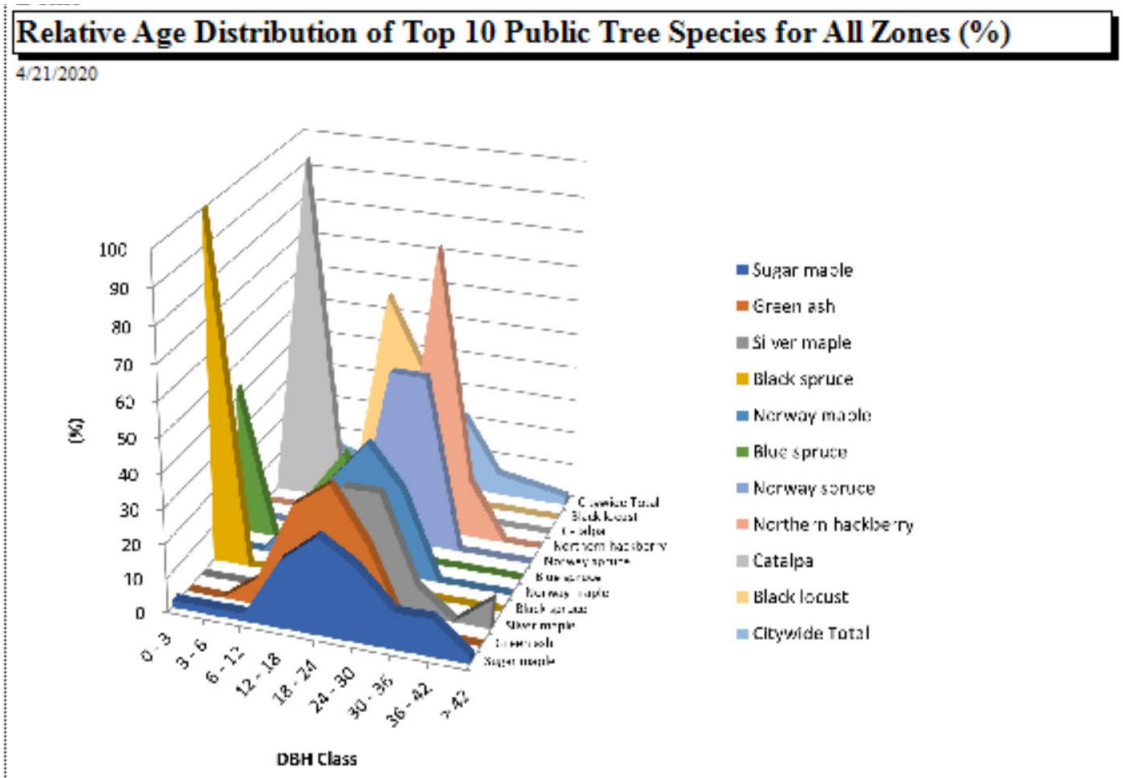
Species Distribution of Public Trees

4/21/2020



Species	Percent
Sugar maple	28.6
Green ash	8.1
Silver maple	7.5
Black spruce	5.0
Norway maple	5.0
Blue spruce	4.3
Norway spruce	3.7
Northern hackberry	3.7
Catalpa	3.1
Black locust	3.1
Other Species	28.0
Total	100.0

Figure 1: Species Distribution



	DBH class (in)								
Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Sugar maple	2.17	2.17	2.17	19.57	28.26	21.74	10.87	10.87	2.17
Green ash	0.00	0.00	7.69	30.77	38.46	23.08	0.00	0.00	0.00
Silver maple	0.00	0.00	0.00	16.67	33.33	33.33	8.33	0.00	8.33
Black spruce	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Norway maple	0.00	0.00	12.50	25.00	37.50	25.00	0.00	0.00	0.00
Blue spruce	42.86	0.00	14.29	28.57	14.29	0.00	0.00	0.00	0.00
Norway spruce	0.00	0.00	0.00	0.00	50.00	50.00	0.00	0.00	0.00
Northern hackberry	0.00	0.00	0.00	0.00	0.00	83.33	16.67	0.00	0.00
Catalpa	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black locust	0.00	0.00	0.00	60.00	40.00	0.00	0.00	0.00	0.00
Citywide Total	9.32	6.83	3.73	21.12	23.60	22.36	6.21	4.35	2.48

Figure 2: Relative Age Class

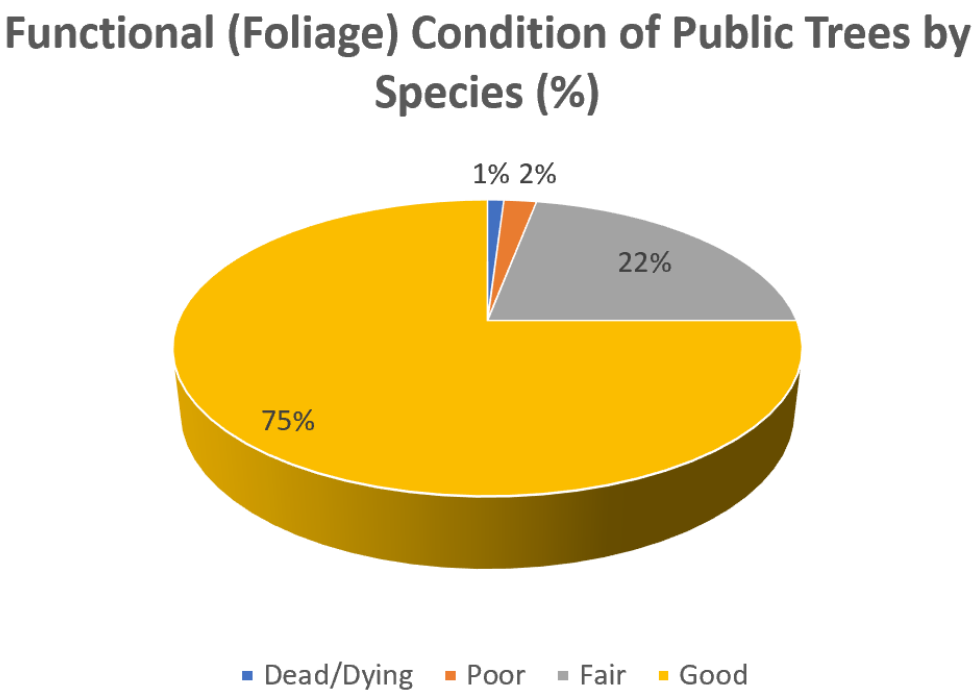


Figure 3: Foliage Condition

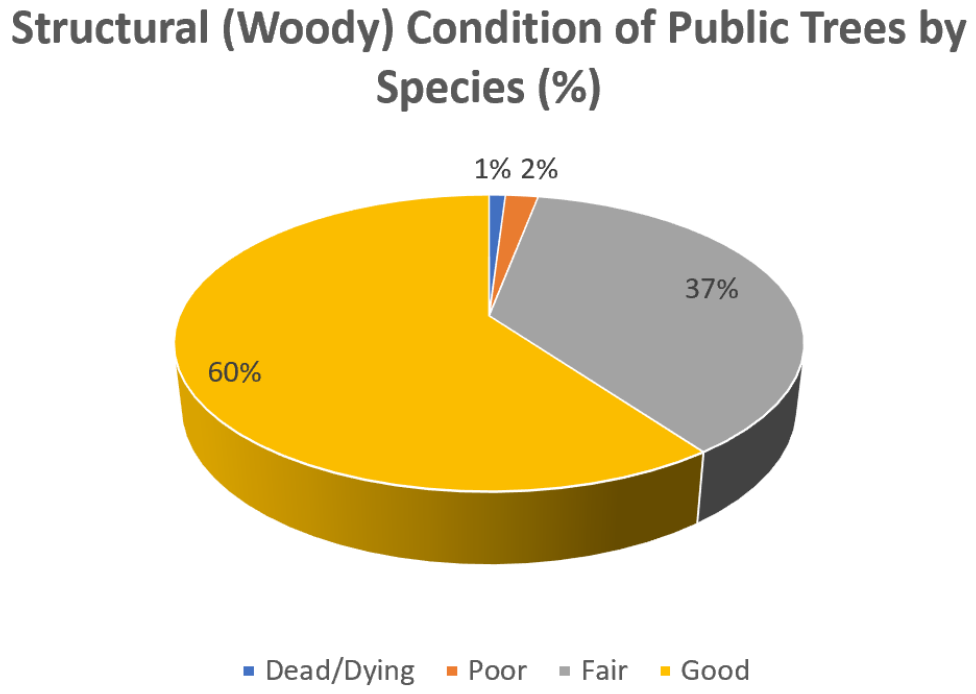
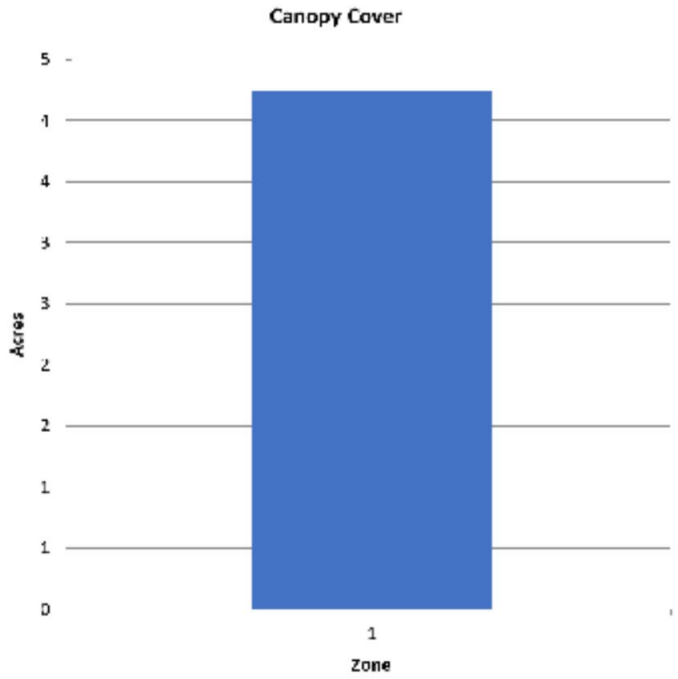


Figure 4: Wood Condition

Canopy Cover of Public Trees (Acres)

4/21/2020



Zone	Acres	% of Total Canopy Cover
1	4	100.0
Citywide total	4	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	4	0.00	0.00

Figure 5: Canopy Cover in Acres

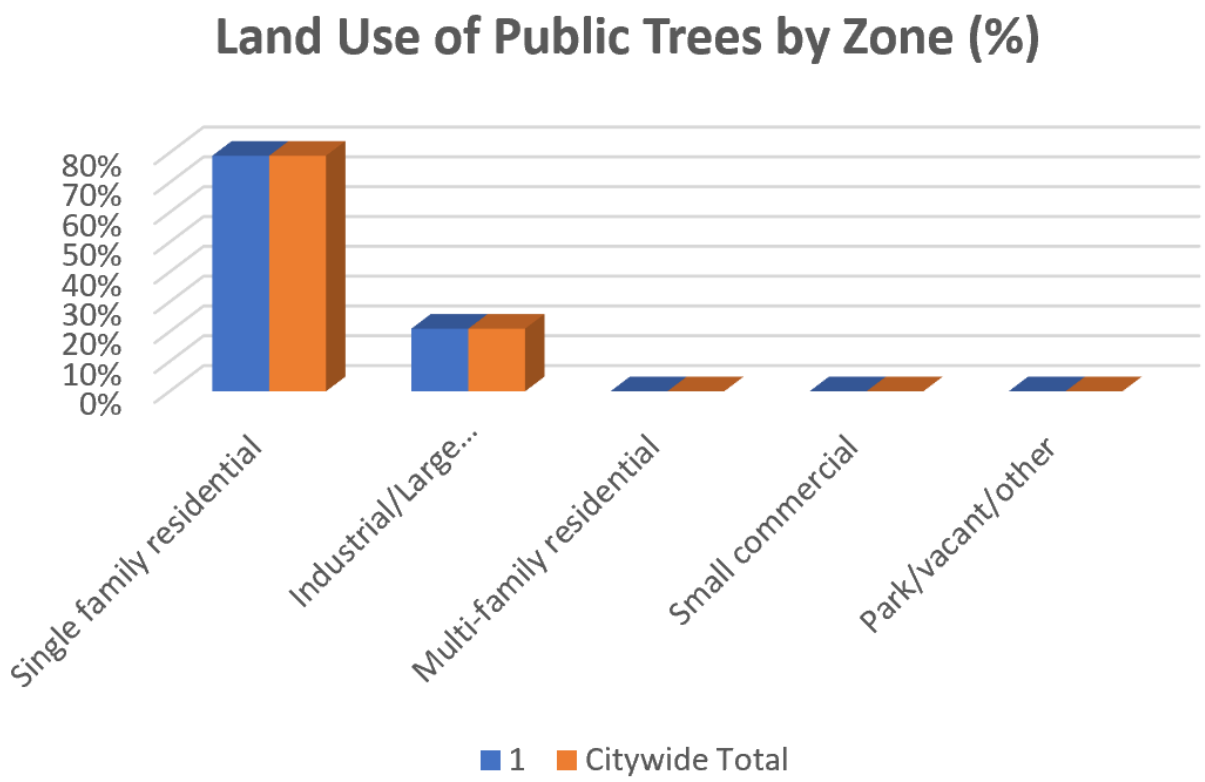


Figure 6: Land Use of city/park trees

Appendix B: ArcGIS Mapping

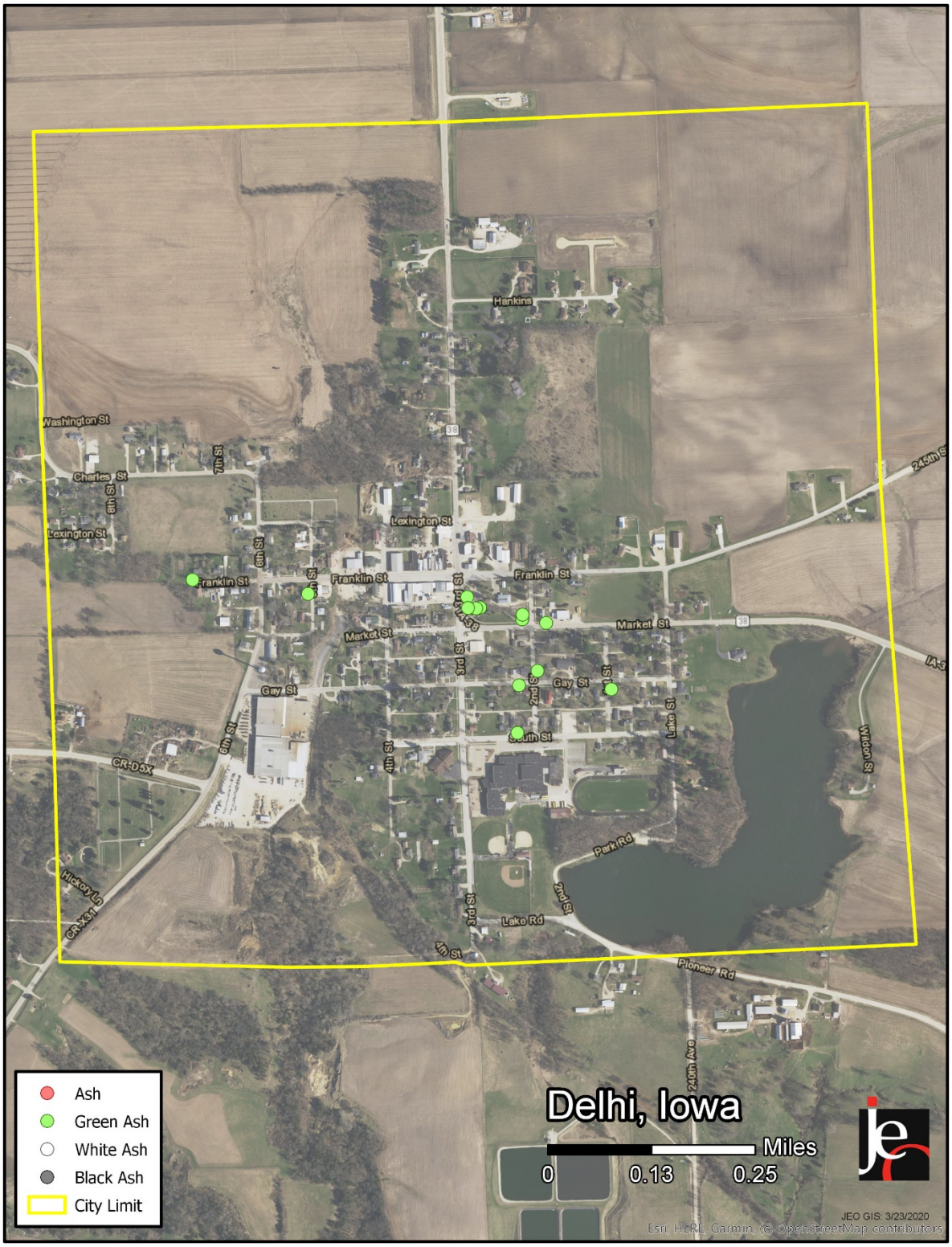


Figure 1: Location of Ash Trees

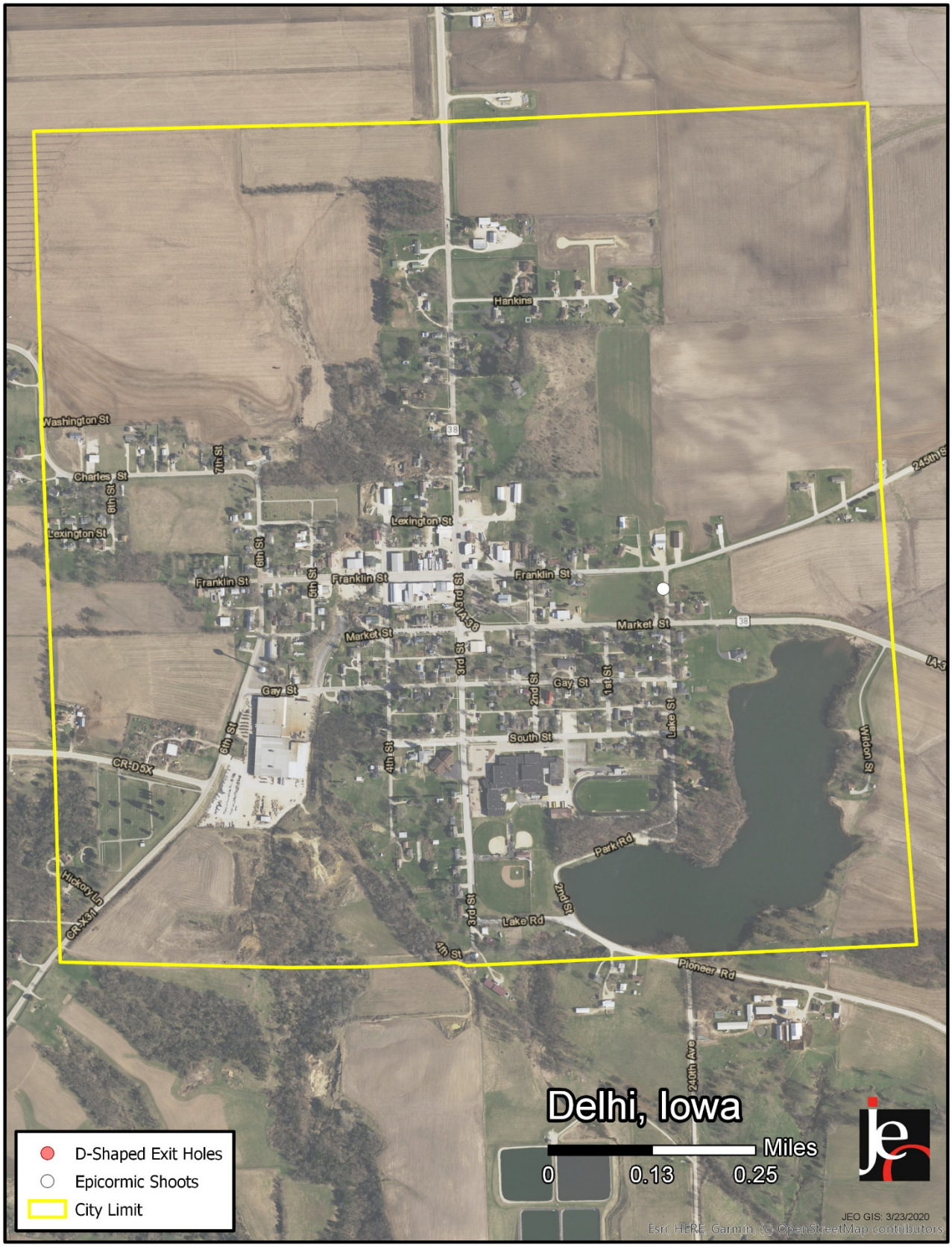


Figure 2: Location of EAB symptoms

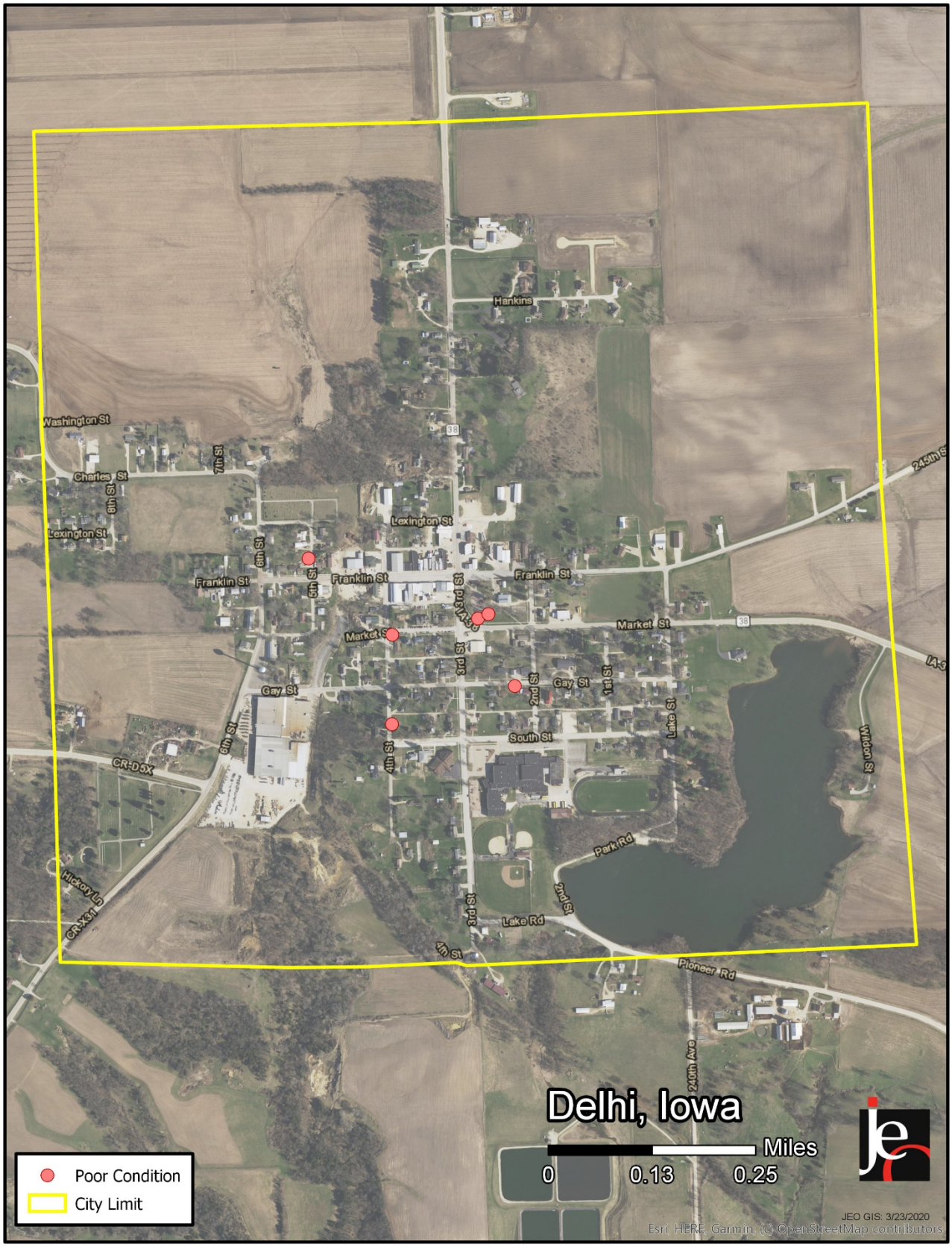


Figure 3: Location of Poor Condition Trees

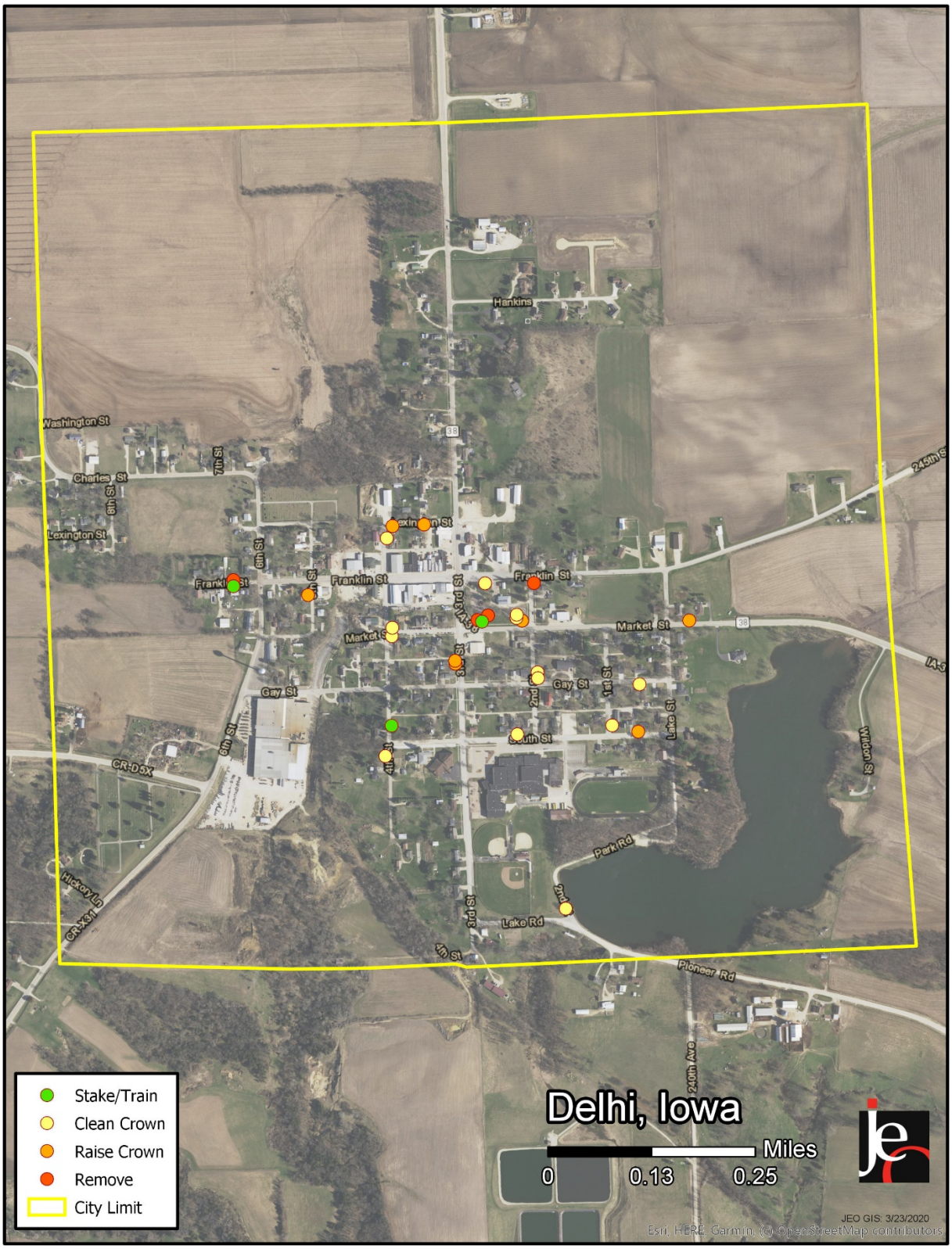


Figure 4: Location of Trees with Recommended Maintenance ***City ownership of the trees recommended for removal should be verified prior to any removal***

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