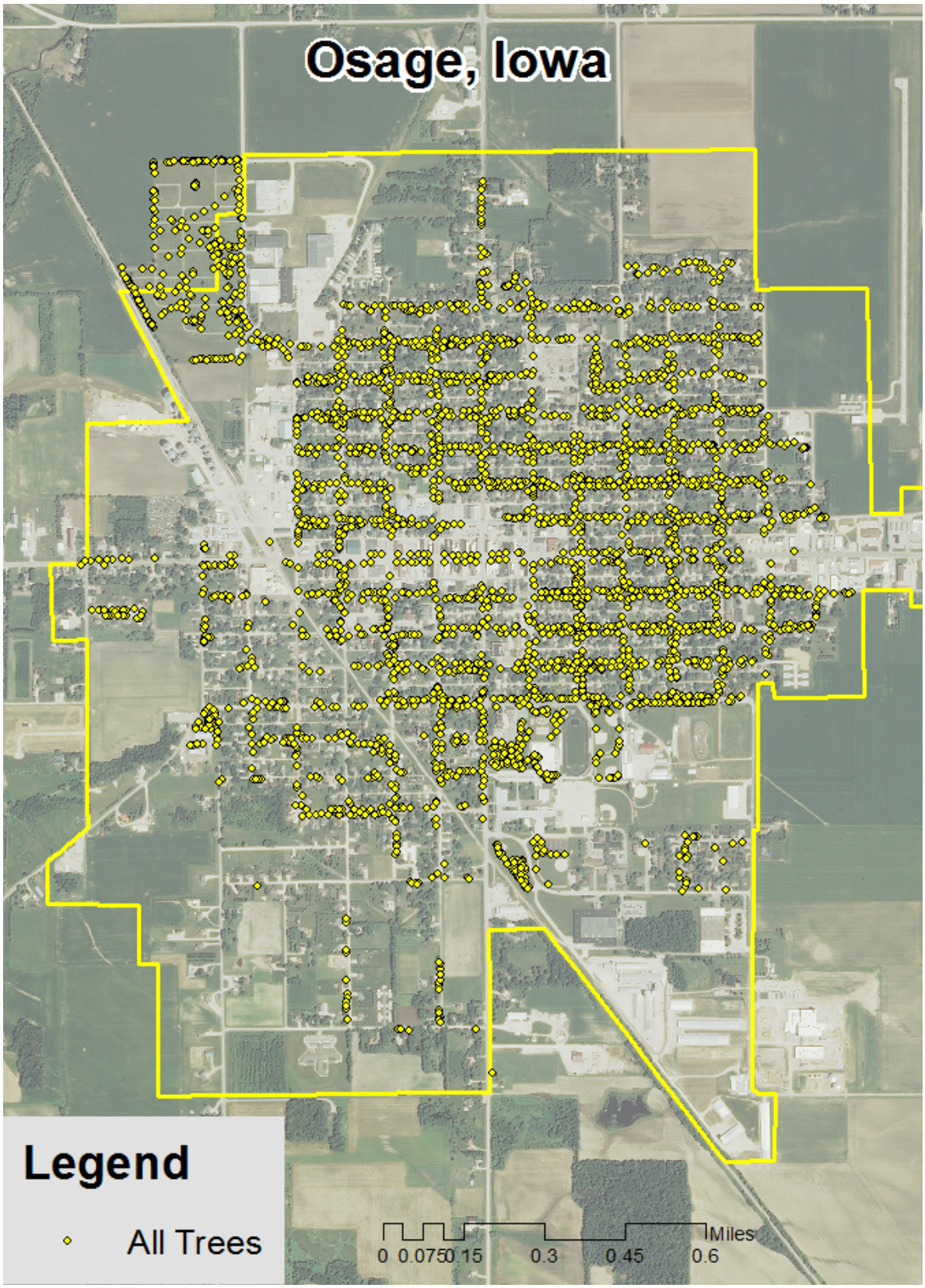
Osage, IA

2016 Urban Forest Management Plan
Prepared by Matt Brewer
Bureau of Forestry, Iowa DNR


Osage, Iowa
Legend
All Trees
0 0.075 0.15 0.3 0.45 0.6
Miles

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Executive Summary

Overview

This plan was developed to assist the City of Osage with managing its urban forest, including budgeting and future planning. Trees can provide a multitude of benefits to the community, and sound management allows a community to best take advantage of these benefits. Management is especially important considering the serious threats posed by forest pests such as the emerald ash borer (EAB). EAB is an invasive insect imported from Eastern Asia on wood shipping crates that kills all species of ash trees (this does not include mountain ash). There is a strong possibility that 11% of Osage's city owned trees (ash) will die once EAB becomes established in the community, unless preventative treatment is used. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

Inventory and Results

In 2015, a tree inventory was conducted by Matt Brewer, Iowa DNR, 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 3,298 trees inventoried.

- Osage's trees provide $580,197 of benefits annually, an average of $175 a tree
- There are over 55 species of trees
- The top three genera are: Maple 66%, Ash 11%, and Spruce 6%
- 10% of trees are in need of some type of management
- 37 trees are recommended for removal

Recommendations

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

- Of the 37 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*
- 94 of the 354 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, any fruit bearing tree or any tree of the kinds commonly known as cottonwood, poplar, boxelder, Chinese elm, or evergreens
- Check ash trees with a visual survey yearly
- With the current budget it could take 10 years to remove ash – Suggestion: request a budget increase to $53,100 annually and apply for grants to plant replacement trees

Introduction

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

Trees are an important component of Osage's infrastructure and one of the greatest assets to the community. The benefits of trees are immense. Trees provide the community with improved air quality, stormwater runoff interception, energy conservation, lower traffic speeds, increased property values, reduced crime, improved mental health and create a desirable place to live, to name just a few benefits. It is essential that these benefits be maintained for the people of Osage and future generations through good urban forestry management.

Good urban forestry management involves setting goals and developing management strategies to achieve these goals. An essential part of developing management strategies is a comprehensive public tree inventory. The inventory supplies information that will be used for maintenance, removal schedules, tree planting and budgeting. Basing actions on this information will help meet Osage's urban forestry goals.

Inventory

In 2015, a tree inventory was conducted by Matt Brewer, Iowa DNR, that included 100% of the city owned trees on both streets and parks. The tree data was collected using a handheld Global Positioning System (GPS) receiver. The data collector gives Geographic Information Systems (GIS) coordinates with an accuracy of 3 meters, which can be used in Arc GIS as an active GIS data layer. Because the inventory is a digital document the data can be updated with new information and become a working document.

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

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

Inventory Results

The data collected for the 3,298 city trees was entered into the USDA Forest Service program i-Tree Streets, part of the i-Tree suite. The following are results from the i-Tree Streets analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Osage's trees reduce energy related costs by approximately $151,653 annually (Appendix A, Table 1). These savings are both in Electricity (722.1 MWh) and in Natural Gas (98,823.9 Therms).

Annual Stormwater Benefits

Osage's trees intercept about 8,576,365 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $232,419 of benefits to the city.

Annual Air Quality Benefits

Air quality is a persistent public health issue in Iowa. The urban forest improves air quality by removing pollutants, lowering air temperature, and reducing energy consumption, which in turn reduces emissions from power plants, and emitting volatile organic matter (ozone). In Osage, it is estimated that trees remove 8,899.3 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 $24,571 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Osage, trees sequester about 1,563,224 lbs of carbon a year with an associated value of $11,724 (Appendix A, Table 4). In addition, the trees store 31,651,232 lbs of carbon, with a yearly benefit of $237,384 (Appendix A, Table 5).

Annual Aesthetics Benefits

Social benefits of trees are hard to capture. The analysis does have a calculation for this area that includes: aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Osage receives $151,947 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, Osage's trees provide $580,197 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 3,298 trees in Osage provides approximately $175 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Osage has over 55 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	2,192	66%
Ash	354	11%
Spruce	184	6%
Oak	80	2%
Northern White Cedar	66	2%
Linden/Basswood	55	2%
Elm	51	2%
Apple/Crabapple	50	2%
Pine	37	1%
Black Walnut	30	1%
Hackberry	25	1%
Eastern Red Cedar	25	1%
Ginkgo	24	1%
Honeylocust	18	1%
Birch	13	<1%
Ohio Buckeye	12	<1%
Lilac	10	<1%
Hickory	6	<1%
Kentucky Coffeetree	6	<1%
Aspen/Cottonwood	6	<1%
Mountain Ash	6	<1%
Pear	5	<1%
Alder	3	<1%
Cherry/Plum	3	<1%
Black Locust	3	<1%
Eastern Redbud	2	<1%
Eastern Hophornbeam	2	<1%
Dogwood	1	<1%
Willow	1	<1%
Other Small Deciduous	12	<1%
Other Large Evergreen	12	<1%
Other Large Deciduous	1	<1%
Other Medium Deciduous	1	<1%
Other Medium Evergreen	1	<1%
Other Small Evergreen	1	<1%

Age Class

Just under half of Osage's trees (44%) are between 18 and 36 inches in diameter at 4.5 ft (Appendix A, Figure 2). For age, it is preferred that a large number of trees are in the smallest size categories (a downward slope) to prepare for natural mortality and to maintain canopy cover. Osage will have an aging tree population as this 44% matures, and should consider new plantings (currently only 16% are under 6 inches in diameter) to develop the next generation of trees.

Condition: Wood and Foliage

Both wood condition and leaf condition are good indicators of the overall health of the urban forest. The foliage condition results for Osage indicate that 94% 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). Additionally, 58% of Osage's trees are in good health for wood condition (Appendix A, Figure 4 & Appendix B, Figure 3). Wood condition that is in poor health, dead or dying is about 10% of the population. This 10% 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	201	6%
Tree Staking	105	3%
Tree Removal	37	1%

Canopy Cover

The total canopy with both private and public trees is 17% (242 acres). The canopy cover included in the Osage inventory includes approximately 82 acres (Appendix A, Figure 4).

Land Use and Location

The majority of Osage'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	80%
Park/vacant/other	17%
Small commercial	3%
Multifamily residential	<1%
Industrial/Large commercial	<1%

Location	
Planting strip	52%
Front yard	47%
Cutout (surrounded by pavement)	1%

Recommendations

Risk Management

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

Hazardous trees

Osage has 11 critical concern trees, 4 of which need immediate removal and 6 that need immediate cleaning. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). It is recommended to start with the large diameter critical concern trees first. There are 7 trees over 24 inches in diameter at 4.5 ft that should be addressed immediately. Please refer to the six year maintenance plan at the end of this section. After all of the critical concern trees are addressed, there should be follow up on the trees marked as needing maintenance. There are a total of 343 trees with these needs.

Poor tree species

After the removal of the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 37 removals, 2 are ash trees. There are a total of 354 ash trees, and 94 of those have signs and symptoms that have been associated with EAB. In addition, there are 27 ash trees that are in poor health. *City ownership of the trees recommended for removal should be verified prior to any removal*

Pruning Cycle

Proper pruning can extend the life and good health of trees, as well as reduce public safety issues. In the Management Needs section of the Findings there are four main maintenance issues to be addressed: routine pruning, crown cleaning, crown raising, and crown reduction. Crown cleaning removes dead, diseased, and damaged limbs. Crown raising is the removal of lower branches that are 2 inches in diameter or larger in the case of providing clearance for pedestrians or vehicles. Crown reduction is removing individual limbs from structures or utility wires. It is recommended that all trees be pruned on a routine schedule every five to seven years. Please refer to the six year maintenance plan for further information.

Planting

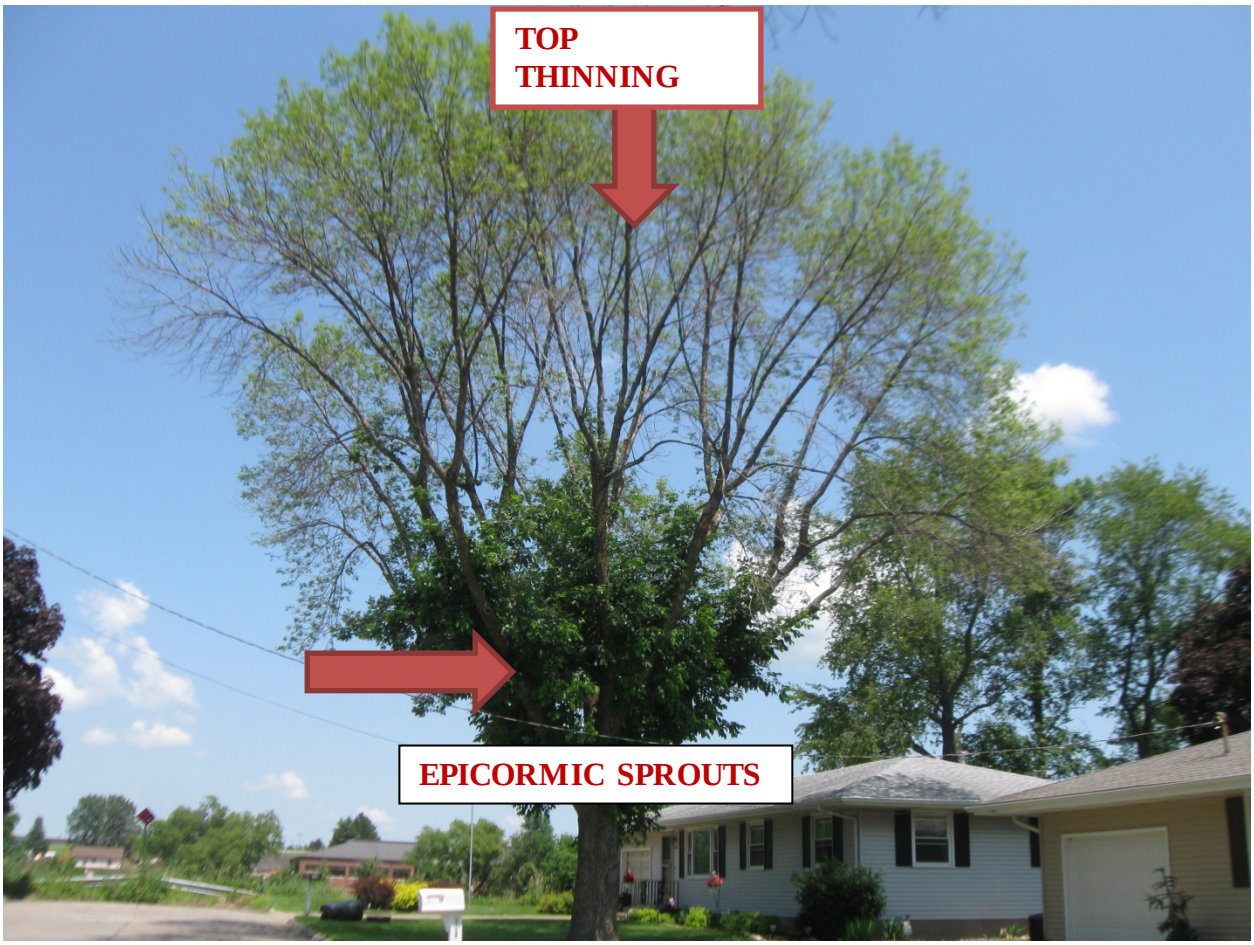
Most of the planting over the next 5 years will replace the trees that are removed. It is recommended to plant at least 1.2 trees for every tree removed, since survival rates will not be

100%. Please refer to the six year maintenance plan at the end of this section. It is not essential that the new trees be planted in the same location of the trees being removed. However, maintaining the same or greater number of trees helps ensure continuation of the benefits of the existing forest in Osage.

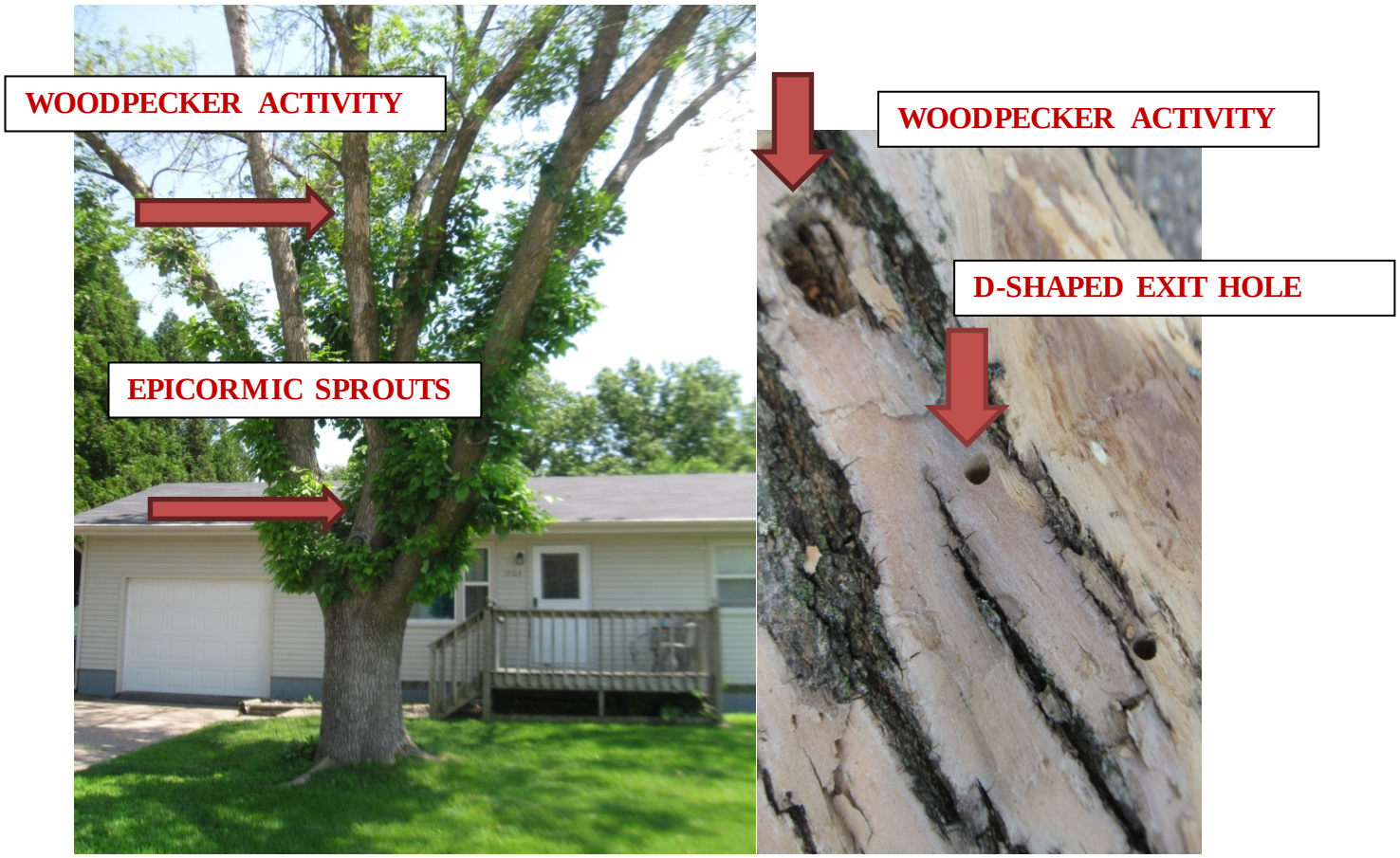
It is important to plant a diverse mix of species in the urban forest to maintain canopy health, since most insects and diseases target a genus (ash) or species (green ash) of trees. Current diversity recommendations advise that a genus (i.e. maple, oak) not make up more than 10% of the urban forest and a single species (i.e. silver maple, sugar maple, white oak, bur oak) not make up more than 5-10% of the total urban forest. Presently, the forest is heavily planted with maple (66%) (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: any fruit bearing tree or any tree of the kinds commonly known as cottonwood, poplar, boxelder, Chinese elm, or evergreens, as outlined in section 151.02 of the city ordinance (Appendix C). All trees planted must meet the restrictions in city ordinance 151.02 (Appendix C).

Continual Monitoring For EAB

Due to the threat of EAB, it is important to continuously check the health of ash trees. It is recommended that ash trees be checked with a visual survey every year for tree decline and for the following signs and symptoms: canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage (See examples below). Once EAB arrives in Osage, it could potentially kill all ash within 4 to 10 years of its arrival.



EAB infested tree in Muscatine with top thinning and many new green epicormic sprouts



EAB infested tree in Muscatine with sprouting, wood pecker activity, and D-shaped exit holes

Emerald Ash Borer Plan

Ash Tree Removal

Tree removal will be prioritized with dead, dying, hazardous trees to be removed first (Appendix B, Figure 4). Next will be all ash in poor condition and displaying signs and symptoms of EAB (Appendix B, Figure 2 & Appendix B, Figure 3). *City ownership of the tree recommended for removal should be verified prior to any removal*

Treatment of Ash Trees

Chemical treatment can be an effective tool for communities to spread removal costs out over several years while allowing trees to continue to provide benefits. However, treatment is not recommended if EAB is more than 15 miles away from the community. For more information on the cost of treatment strategies visit http://extension.entm.purdue.edu/treecomputer/

EAB Quarantines

EAB is an extremely destructive plant pest and it is responsible for the death and decline of millions of ash trees. Ash in both forested and urban settings constitute a significant portion of the canopy cover in the United States. Current tools to detect, control, suppress and eradicate this pest are not as robust as the USDA would desire. In order to stay ahead of this hard to detect beetle, the USDA is attempting to contain the beetle before it spreads beyond its known positions by regulating articles.

A regulated article under the USDA's quarantine includes any of the following items:

- emerald ash borer
- firewood of all hardwood species (for example ash, oak, maple and hickory)
- nursery stock and green lumber of ash
- any other ash material, whether living, dead, cut or fallen, including logs, stumps, roots, branches, as well as composted and not composted chips of the genus ash (Mountain ash is not included)

In addition, any other article, product or means of conveyance not listed above may be designated as a regulated article if a USDA inspector determines that it presents a risk of spreading EAB once a quarantine is in effect.

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? The entire state of Iowa is under quarantine, so regulated articles may not be moved into non-quarantined states. For more information, please visit http://www.emeraldashborer.info/.

Canopy Replacement

As budget permits, all removed trees will be replaced. All trees will meet the restrictions in city ordinance 151.02 (Appendix C). The new plantings will be a diverse mix and will not include ash, maple, any fruit bearing tree or any tree of the kinds commonly known as cottonwood, poplar, boxelder, Chinese elm, or evergreens.

Postponed Work

While finances, staffing and equipment are focused on the management of ash, usual services may be delayed. Tree removal requests on genera other than ash will be prioritized by hazardous or emergency situations only.

Monitoring

It is recommended that ash trees be checked with a visual survey every year for tree death and for the following signs and symptoms: canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

Private Ash Trees

It is strongly recommended that private property owners start removing ash trees on their property upon arrival of EAB. It is recommended to update City Code 152.05, which states "If it is determined with reasonable certainty that any condition as herein defined exists in or upon private premises and that the danger to other elm trees within the City is imminent, the Council shall immediately notify by certified mail the owner, occupant or person in charge of such property to correct such condition within fourteen (14) days of said notification. If such owner, occupant or person in charge of said property fails to comply within fourteen (14) days of receipt of notice, the Council may cause the nuisance to be removed and the cost assessed against the property.".

Six Year Maintenance Plan and Cost Estimates

Year 1 (FY 2016)

Remove 4 critical concern trees that need immediate attention	$3,600
Maintain 7 critical concern trees that need immediate attention (6 cleaning, 1 other)	$2,100
Remove 15 trees (marked for removal)	$13,500
Plant and Maintain 30 trees in open locations (pursue grants)	$3,000
Ash tree treatment (if elected), 248 trees in good condition, average 18–24"	avg. $315/tree
-$15 per inch, treated every two years, see note	
*Or saving for future ash removal	
Visual Survey for signs and symptoms of EAB	

Year 2 (FY 2017)

Remove 18 trees (marked for removal)	$16,200
Plant and Maintain 30 trees in open locations (pursue grants)	$3,000
Ash tree treatment (if elected) or saving for future ash removal	
Routine trimming: Contract to trim 1/3 of the city trees (~$300 per tree)	
Visual Survey for signs and symptoms of EAB	

Year 3 (FY 2018)

Remove any new critical concern trees and ash in poor health	$900/tree
Plant and Maintain 30 trees in open locations (pursue grants)	$3,000
Ash tree treatment (if elected) or saving for future ash removal	
Visual Survey for signs and symptoms of EAB	

Year 4 (FY 2019)

Remove any new critical concern trees and ash in poor health	$900/tree
Plant and Maintain 30 trees in open locations (pursue grants)	$3,000
Ash tree treatment (if elected) or saving for future ash removal	
Routine trimming: Contract to trim 1/3 of the city trees (~$300 per tree)	
Visual Survey for signs and symptoms of EAB	

Year 5 (FY 2020)

Remove any new critical concern trees and ash in poor health	$900/tree
Plant and Maintain 30 trees in open locations (pursue grants)	$3,000
Ash tree treatment (if elected) or saving for future ash removal	
Visual Survey for signs and symptoms of EAB	

Year 6 (FY 2021)

Remove any new critical concern trees and ash in poor health	$900/tree
Plant and Maintain 30 trees in open locations (pursue grants)	$3,000
Ash tree treatment (if elected) or saving for future ash removal	
Routine trimming: Contract to trim 1/3 of the city trees (~$300 per tree)	
Visual Survey for signs and symptoms of EAB	

*****Reduction of ash in poor health will reduce exposure to Emerald Ash Borer over time. EAB could potentially kill all ash within 4-15 years of its arrival.
******Assuming a cost of $900 per tree for removal, the budget would need to be increased to $53,100 a year to remove all ash trees within 6 years.
*******Suggest setting aside additional funds to prepare for the expected arrival of EAB. Planting would be at least partially dependent on receiving grant funds annually.

Proposed Budget Increase

EAB could potentially kill all ash trees in Osage within 4-15 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $53,100 a year. Additionally, it is recommended that Osage apply for grants to fund replacement trees. Utility Company grants are usually between $500 and $10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools.

Another option being considered by many communities is treating a number of selected trees, either to maintain those trees in the landscape or to delay their removal – to spread out the costs and number of trees needing removed all at once. Trunk injection is administered every two years for the life of the tree. If treatment is discontinued, the tree dies. For an example, if the average ash diameter is 20 inches and treatment costs $15 per inch, then treating 10 trees would cost about $3,000 (every other year treatment). This would be 10 trees selected for treatment, and Osage would still need to find $900 per tree for removal. Alternatively, if there are 15 treatable trees, it would cost approximately $4,500 every two years for treatment and leave five less trees for removal (for at least two more years). These are alternatives to straight removal of ash trees. However, whether or not the treatment option is selected, there will be an increased cost of dealing with ash trees if EAB is found in Osage. It is suggested to consider increasing the budget to plan for this.

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Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Annual Energy Benefits of Public Trees

1/27/2016

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Sugar maple	255.0	19,352	34,130.3	33,448	52,800	(N/A)	25.8	34.8	61.97
Norway maple	156.2	11,857	22,743.2	22,288	34,146	(N/A)	23.0	22.5	45.11
Green ash	85.8	6,515	11,567.5	11,336	17,851	(N/A)	10.0	11.8	54.09
Red maple	23.8	1,809	3,238.6	3,174	4,983	(N/A)	7.1	3.3	21.20
Silver maple	59.5	4,512	7,770.4	7,615	12,127	(N/A)	5.5	8.0	66.27
Spruce	25.3	1,919	3,328.7	3,262	5,181	(N/A)	5.0	3.4	31.21
Maple	6.0	455	843.3	826	1,281	(N/A)	4.2	0.8	9.28
Northern white cedar	9.1	690	1,238.7	1,214	1,903	(N/A)	2.0	1.3	28.84
Apple	5.8	443	908.8	891	1,333	(N/A)	1.5	0.9	26.66
Elm	5.6	428	751.3	736	1,164	(N/A)	1.5	0.8	24.25
Littleleaf linden	6.5	490	869.2	852	1,342	(N/A)	1.1	0.9	37.28
Pin oak	11.2	853	1,490.2	1,460	2,313	(N/A)	0.9	1.5	74.61
Black walnut	10.0	757	1,367.5	1,340	2,098	(N/A)	0.9	1.4	69.92
Northern red oak	3.1	238	445.6	437	675	(N/A)	0.8	0.4	25.96
Eastern red cedar	2.5	190	371.6	364	554	(N/A)	0.8	0.4	22.16
Northern hackberry	8.4	638	1,158.4	1,135	1,773	(N/A)	0.8	1.2	70.94
Ginkgo	1.3	98	187.5	184	282	(N/A)	0.7	0.2	11.74
Scotch pine	3.0	226	381.9	374	600	(N/A)	0.7	0.4	27.26
Bur oak	4.2	315	554.8	544	859	(N/A)	0.6	0.6	40.90
American basswood	5.3	403	781.8	766	1,169	(N/A)	0.6	0.8	61.55
Honeylocust	5.8	437	753.6	739	1,176	(N/A)	0.5	0.8	65.33
Blue spruce	1.6	121	216.0	212	332	(N/A)	0.5	0.2	19.55
White ash	5.1	386	633.5	621	1,006	(N/A)	0.5	0.7	59.20
Amur maple	0.8	60	129.0	126	186	(N/A)	0.5	0.1	11.63
Conifer Evergreen Large	2.1	156	270.5	265	421	(N/A)	0.4	0.3	35.08
Broadleaf Deciduous Small	0.7	52	108.7	106	159	(N/A)	0.4	0.1	13.21
Ohio buckeye	2.6	195	360.4	353	548	(N/A)	0.4	0.4	45.68
Boxelder	1.3	95	164.1	161	256	(N/A)	0.3	0.2	23.27
Paper birch	2.4	183	336.7	330	513	(N/A)	0.3	0.3	51.30
Japanese tree lilac	0.1	4	9.4	9	13	(N/A)	0.3	0.0	1.32
Eastern white pine	1.4	105	181.9	178	284	(N/A)	0.2	0.2	35.46
Black ash	1.4	106	200.7	197	303	(N/A)	0.2	0.2	43.30
Red pine	0.9	71	122.5	120	191	(N/A)	0.2	0.1	27.35
Hickory	1.4	105	193.2	189	294	(N/A)	0.2	0.2	49.02
Mountain ash	0.8	59	110.0	108	167	(N/A)	0.2	0.1	27.80
Kentucky coffeetree	0.0	1	2.8	3	4	(N/A)	0.2	0.0	0.66
Quaking aspen	0.1	7	12.0	12	19	(N/A)	0.2	0.0	3.75
Pear	0.3	20	46.1	45	65	(N/A)	0.2	0.0	13.08
Alder	0.3	25	50.3	49	75	(N/A)	0.1	0.0	24.84
Black locust	1.0	73	142.2	139	213	(N/A)	0.1	0.1	70.84
River birch	0.5	40	81.1	79	120	(N/A)	0.1	0.1	39.93
Black cherry	0.3	22	48.3	47	70	(N/A)	0.1	0.0	23.25
Siberian elm	1.3	101	173.7	170	272	(N/A)	0.1	0.2	90.54
Eastern hophornbeam	0.4	28	49.3	48	76	(N/A)	0.1	0.1	38.13
Eastern redbud	0.2	14	25.3	25	39	(N/A)	0.1	0.0	19.50
Conifer Evergreen Medium	0.1	10	15.2	15	25	(N/A)	0.0	0.0	24.51
Norway spruce	0.2	14	24.6	24	38	(N/A)	0.0	0.0	38.17
Broadleaf Deciduous Mediu	0.2	18	29.5	29	47	(N/A)	0.0	0.0	46.78
White oak	0.3	25	46.9	46	71	(N/A)	0.0	0.0	70.91
Swamp white oak	0.1	8	16.9	17	24	(N/A)	0.0	0.0	24.47
Broadleaf Deciduous Large	0.0	0	0.5	0	1	(N/A)	0.0	0.0	0.66
Conifer Evergreen Small	0.1	8	16.4	16	25	(N/A)	0.0	0.0	24.57
Eastern cottonwood	0.5	37	63.1	62	99	(N/A)	0.0	0.1	98.63
Willow	0.3	24	47.4	46	71	(N/A)	0.0	0.0	70.84
Dogwood	0.1	6	12.8	13	18	(N/A)	0.0	0.0	18.19
Total	722.1	54,806	98,823.9	96,847	151,653	(N/A)	100.0	100.0	45.98

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees

1/27/2016

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Sugar maple	3,239,915	87,802	(N/A)	25.8	37.8	103.05
Norway maple	1,495,292	40,522	(N/A)	23.0	17.4	53.53
Green ash	907,229	24,586	(N/A)	10.0	10.6	74.50
Red maple	166,943	4,524	(N/A)	7.1	1.9	19.25
Silver maple	886,188	24,016	(N/A)	5.5	10.3	131.23
Spruce	549,286	14,886	(N/A)	5.0	6.4	89.67
Maple	35,501	962	(N/A)	4.2	0.4	6.97
Northern white cedar	199,260	5,400	(N/A)	2.0	2.3	81.82
Apple	27,758	752	(N/A)	1.5	0.3	15.05
Elm	44,122	1,196	(N/A)	1.5	0.5	24.91
Littleleaf linden	54,577	1,479	(N/A)	1.1	0.6	41.08
Pin oak	138,970	3,766	(N/A)	0.9	1.6	121.49
Black walnut	131,851	3,573	(N/A)	0.9	1.5	119.10
Northern red oak	31,837	863	(N/A)	0.8	0.4	33.18
Eastern red cedar	36,486	989	(N/A)	0.8	0.4	39.55
Northern hackberry	79,107	2,144	(N/A)	0.8	0.9	85.75
Ginkgo	6,518	177	(N/A)	0.7	0.1	7.36
Scotch pine	53,298	1,444	(N/A)	0.7	0.6	65.65
Bur oak	45,865	1,243	(N/A)	0.6	0.5	59.19
American basswood	61,604	1,669	(N/A)	0.6	0.7	87.87
Honeylocust	64,507	1,748	(N/A)	0.5	0.8	97.12
Blue spruce	20,035	543	(N/A)	0.5	0.2	31.94
White ash	47,501	1,287	(N/A)	0.5	0.6	75.72
Amur maple	2,761	75	(N/A)	0.5	0.0	4.68
Conifer Evergreen Large	47,283	1,281	(N/A)	0.4	0.6	106.78
Broadleaf Deciduous Small	2,870	78	(N/A)	0.4	0.0	6.48
Ohio buckeye	23,511	637	(N/A)	0.4	0.3	53.09
Boxelder	8,798	238	(N/A)	0.3	0.1	21.68
Paper birch	25,985	704	(N/A)	0.3	0.3	70.42
Japanese tree lilac	136	4	(N/A)	0.3	0.0	0.37
Eastern white pine	32,136	871	(N/A)	0.2	0.4	108.86
Black ash	11,005	298	(N/A)	0.2	0.1	42.60
Red pine	17,185	466	(N/A)	0.2	0.2	66.53
Hickory	12,436	337	(N/A)	0.2	0.1	56.17
Mountain ash	3,250	88	(N/A)	0.2	0.0	14.68
Kentucky coffeetree	107	3	(N/A)	0.2	0.0	0.48
Quaking aspen	551	15	(N/A)	0.2	0.0	2.98
Pear	931	25	(N/A)	0.2	0.0	5.04
Alder	1,196	32	(N/A)	0.1	0.0	10.80
Black locust	11,293	306	(N/A)	0.1	0.1	102.01
River birch	4,936	134	(N/A)	0.1	0.1	44.59
Black cherry	1,507	41	(N/A)	0.1	0.0	13.61
Siberian elm	17,822	483	(N/A)	0.1	0.2	161.00
Eastern hophornbeam	1,333	36	(N/A)	0.1	0.0	18.06
Eastern redbud	674	18	(N/A)	0.1	0.0	9.13
Conifer Evergreen Medium	1,544	42	(N/A)	0.0	0.0	41.85
Norway spruce	4,605	125	(N/A)	0.0	0.1	124.79
Broadleaf Deciduous Medium	1,409	38	(N/A)	0.0	0.0	38.19
White oak	3,943	107	(N/A)	0.0	0.0	106.85
Swamp white oak	586	16	(N/A)	0.0	0.0	15.88
Broadleaf Deciduous Large	18	0	(N/A)	0.0	0.0	0.48
Conifer Evergreen Small	1,635	44	(N/A)	0.0	0.0	44.30
Eastern cottonwood	7,239	196	(N/A)	0.0	0.1	196.17
Willow	3,764	102	(N/A)	0.0	0.0	102.01
Dogwood	264	7	(N/A)	0.0	0.0	7.17
Citywide total	8,576,365	232,419	(N/A)	100.0	100.0	70.47

Table 3: Annual Air Quality Benefits

Annual Air Quality Benefits of Public Trees

1/27/2016

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							
Sugar maple	472.7	80.5	228.4	20.9	2,539	1,209.0	176.6	168.5	1,154.7	7,550	-366.8	-1,376	3,144.5	8,714 (N/A)	25.8	10.23
Norway maple	309.5	53.4	151.9	13.7	1,672	759.3	109.6	104.3	708.8	4,699	-72.3	-271	2,138.3	6,099 (N/A)	23.0	8.06
Green ash	110.6	17.7	53.4	5.0	590	408.2	59.6	56.8	389.1	2,547	0.0	0	1,100.3	3,137 (N/A)	10.0	9.51
Red maple	33.9	5.8	16.6	1.5	183	113.4	16.5	15.8	108.0	707	-12.1	-45	299.4	845 (N/A)	7.1	3.59
Silver maple	157.3	26.7	76.7	7.0	847	279.8	41.0	39.1	268.9	1,752	-81.6	-306	814.9	2,292 (N/A)	5.5	12.53
Spruce	66.0	13.1	52.8	8.1	431	119.2	17.5	16.7	114.5	746	-308.1	-1,155	99.7	22 (N/A)	5.0	0.13
Maple	6.1	1.0	3.2	0.3	33	28.7	4.2	4.0	27.1	179	-2.2	-8	72.4	204 (N/A)	4.2	1.48
Northern white cedar	23.9	4.7	19.2	2.9	156	43.2	6.3	6.0	41.2	270	-114.6	-430	32.9	-4 (N/A)	2.0	-0.06
Apple	9.0	1.5	4.2	0.4	48	28.8	4.1	3.9	26.4	177	0.0	0	78.2	224 (N/A)	1.5	4.49
Elm	3.7	0.6	2.1	0.2	21	26.7	3.9	3.7	25.5	167	0.0	0	66.5	188 (N/A)	1.5	3.91
Littleleaf linden	8.4	1.4	4.3	0.4	46	30.8	4.5	4.3	29.3	192	-4.2	-16	79.1	222 (N/A)	1.1	6.17
Pin oak	26.1	4.6	13.2	1.2	142	53.2	7.8	7.4	50.9	332	-47.9	-180	116.3	295 (N/A)	0.9	9.51
Black walnut	18.9	3.0	8.6	0.8	100	47.7	6.9	6.6	45.2	297	0.0	0	137.9	396 (N/A)	0.9	13.21
Northern red oak	6.7	1.2	3.3	0.3	36	15.1	2.2	2.1	14.2	94	-9.6	-36	35.4	94 (N/A)	0.8	3.61
Eastern red cedar	7.4	1.5	5.9	0.9	48	12.2	1.8	1.7	11.3	75	-20.1	-75	22.5	48 (N/A)	0.8	1.92
Northern hackberry	12.9	2.2	6.5	0.6	70	40.3	5.9	5.6	38.1	251	0.0	0	112.0	321 (N/A)	0.8	12.83
Ginkgo	1.0	0.2	0.6	0.0	6	6.2	0.9	0.9	5.8	39	-0.4	-1	15.2	43 (N/A)	0.7	1.78
Scotch pine	6.2	1.2	5.1	0.8	41	13.9	2.0	2.0	13.5	87	-26.0	-97	18.7	31 (N/A)	0.7	1.40
Bur oak	6.2	1.0	2.9	0.3	33	19.7	2.9	2.7	18.8	123	0.0	0	54.6	156 (N/A)	0.6	7.44
American basswood	8.5	1.4	4.1	0.4	46	25.9	3.7	3.6	24.1	160	-7.2	-27	64.5	179 (N/A)	0.6	9.41
Honeylocust	12.6	2.1	5.8	0.6	67	27.1	4.0	3.8	26.1	170	-9.8	-37	72.2	200 (N/A)	0.5	11.10
Blue spruce	2.4	0.5	2.1	0.3	16	7.6	1.1	1.1	7.2	47	-7.0	-26	15.3	37 (N/A)	0.5	2.20
White ash	5.7	0.9	2.9	0.3	31	23.7	3.5	3.3	23.0	149	0.0	0	63.3	180 (N/A)	0.5	10.58
Amur maple	0.5	0.1	0.3	0.0	3	3.9	0.6	0.5	3.6	24	0.0	0	9.5	27 (N/A)	0.5	1.69
Conifer Evergreen Large	5.7	1.1	4.6	0.7	37	9.7	1.4	1.4	9.3	61	-27.6	-103	6.3	-5 (N/A)	0.4	-0.45
Broadleaf Deciduous Small	0.8	0.1	0.4	0.0	4	3.4	0.5	0.5	3.1	21	0.0	0	8.8	25 (N/A)	0.4	2.09
Ohio buckeye	4.8	0.8	2.4	0.2	26	12.4	1.8	1.7	11.7	77	-1.1	-4	34.7	99 (N/A)	0.4	8.23
Boxelder	0.7	0.1	0.4	0.0	4	5.9	0.9	0.8	5.7	37	-0.4	-1	14.2	40 (N/A)	0.3	3.59
Paper birch	3.1	0.5	1.5	0.1	16	11.6	1.7	1.6	10.9	72	0.0	0	31.0	88 (N/A)	0.3	8.83
Japanese tree lilac	0.0	0.0	0.0	0.0	0	0.3	0.0	0.0	0.2	2	0.0	0	0.6	2 (N/A)	0.3	0.17
Eastern white pine	3.9	0.8	3.1	0.5	26	6.5	1.0	0.9	6.3	41	-19.1	-72	3.9	-5 (N/A)	0.2	-0.65
Black ash	2.0	0.3	1.0	0.1	11	6.8	1.0	0.9	6.4	42	-0.5	-2	18.0	51 (N/A)	0.2	7.28
Red pine	2.0	0.4	1.6	0.2	13	4.4	0.6	0.6	4.3	28	-8.3	-31	6.0	10 (N/A)	0.2	1.41
Hickory	1.2	0.2	0.6	0.1	7	6.6	1.0	0.9	6.3	41	0.0	0	16.9	48 (N/A)	0.2	7.96
Mountain ash	1.1	0.2	0.5	0.0	6	3.7	0.5	0.5	3.5	23	0.0	0	10.1	29 (N/A)	0.2	4.80
Kentucky coffeetree	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	0	0.0	0	0.2	0 (N/A)	0.2	0.08
Quaking aspen	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.4	3	0.0	0	1.0	3 (N/A)	0.2	0.56
Pear	0.1	0.0	0.1	0.0	1	1.4	0.2	0.2	1.2	8	0.0	0	3.2	9 (N/A)	0.2	1.81
Alder	0.3	0.0	0.2	0.0	2	1.6	0.2	0.2	1.5	10	0.0	0	4.1	12 (N/A)	0.1	3.88
Black locust	2.6	0.4	1.2	0.1	14	4.7	0.7	0.6	4.4	29	-0.6	-2	14.2	41 (N/A)	0.1	13.58
River birch	1.0	0.2	0.5	0.0	5	2.6	0.4	0.4	2.4	16	-0.2	-1	7.2	21 (N/A)	0.1	6.84
Black cherry	0.5	0.1	0.2	0.0	3	1.5	0.2	0.2	1.3	9	0.0	0	4.0	12 (N/A)	0.1	3.87
Siberian elm	3.7	0.6	1.7	0.2	20	6.3	0.9	0.9	6.0	39	0.0	0	20.4	59 (N/A)	0.1	19.71
Eastern hophornbeam	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
Eastern redbud	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.8	6	0.0	0	2.3	7 (N/A)	0.1	3.33
Conifer Evergreen Medium	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)	0.0	2.89
Norway spruce	0.6	0.1	0.4	0.1	4	0.9	0.1	0.1	0.8	5	-2.9	-11	0.3	-2 (N/A)	0.0	-1.58
Broadleaf Deciduous Medium	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)	0.0	7.92
White 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)	0.0	12.48
Swamp white oak	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)	0.0	3.47
Broadleaf Deciduous Large	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)	0.0	0.08
Conifer Evergreen Small	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)	0.0	2.19
Eastern cottonwood	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)	0.0	22.55
Willow	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)	0.0	13.58
Dogwood	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.3	2	0.0	0	0.9	3 (N/A)	0.0	2.55
Citywide total	1,354.7	233.1	696.9	69.4	7,425	3,445.5	501.8	478.4	3,271.8	21,467	-1,152.3	-4,321	8,899.3	24,571 (N/A)	100.0	7.45

Table 4: Annual Carbon Stored

Stored CO2 Benefits of Public Trees

1/27/2016

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Sugar maple	13,907,396	104,305	(N/A)	25.8	43.9	122.42
Norway maple	5,135,913	38,519	(N/A)	23.0	16.2	50.88
Green ash	3,637,979	27,285	(N/A)	10.0	11.5	82.68
Red maple	389,787	2,923	(N/A)	7.1	1.2	12.44
Silver maple	3,636,936	27,277	(N/A)	5.5	11.5	149.05
Spruce	785,500	5,891	(N/A)	5.0	2.5	35.49
Maple	76,649	575	(N/A)	4.2	0.2	4.17
Northern white cedar	293,145	2,199	(N/A)	2.0	0.9	33.31
Apple	141,666	1,062	(N/A)	1.5	0.4	21.25
Elm	131,279	985	(N/A)	1.5	0.4	20.51
Littleleaf linden	183,375	1,375	(N/A)	1.1	0.6	38.20
Pin oak	706,460	5,298	(N/A)	0.9	2.2	170.92
Black walnut	627,207	4,704	(N/A)	0.9	2.0	156.80
Northern red oak	146,179	1,096	(N/A)	0.8	0.5	42.17
Eastern red cedar	24,018	180	(N/A)	0.8	0.1	7.21
Northern hackberry	199,487	1,496	(N/A)	0.8	0.6	59.85
Ginkgo	14,665	110	(N/A)	0.7	0.0	4.58
Scotch pine	63,492	476	(N/A)	0.7	0.2	21.65
Bur oak	211,102	1,583	(N/A)	0.6	0.7	75.39
American basswood	312,391	2,343	(N/A)	0.6	1.0	123.31
Honeylocust	162,250	1,217	(N/A)	0.5	0.5	67.60
Blue spruce	15,037	113	(N/A)	0.5	0.0	6.63
White ash	124,802	936	(N/A)	0.5	0.4	55.06
Amur maple	9,995	75	(N/A)	0.5	0.0	4.69
Conifer Evergreen La	71,121	533	(N/A)	0.4	0.2	44.45
Broadleaf Deciduous	13,092	98	(N/A)	0.4	0.0	8.18
Ohio buckeye	80,016	600	(N/A)	0.4	0.3	50.01
Boxelder	17,031	128	(N/A)	0.3	0.1	11.61
Paper birch	99,808	749	(N/A)	0.3	0.3	74.86
Japanese tree lilac	302	2	(N/A)	0.3	0.0	0.23
Eastern white pine	49,455	371	(N/A)	0.2	0.2	46.36
Black ash	32,403	243	(N/A)	0.2	0.1	34.72
Red pine	20,116	151	(N/A)	0.2	0.1	21.55
Hickory	38,537	289	(N/A)	0.2	0.1	48.17
Mountain ash	16,046	120	(N/A)	0.2	0.1	20.06
Kentucky coffeetree	73	1	(N/A)	0.2	0.0	0.09
Quaking aspen	581	4	(N/A)	0.2	0.0	0.87
Pear	3,079	23	(N/A)	0.2	0.0	4.62
Alder	4,853	36	(N/A)	0.1	0.0	12.13
Black locust	42,840	321	(N/A)	0.1	0.1	107.10
River birch	16,481	124	(N/A)	0.1	0.1	41.20
Black cherry	7,828	59	(N/A)	0.1	0.0	19.57
Siberian elm	90,346	678	(N/A)	0.1	0.3	225.86
Eastern hophornbeam	6,074	46	(N/A)	0.1	0.0	22.78
Eastern redbud	3,051	23	(N/A)	0.1	0.0	11.44
Conifer Evergreen Mi	1,118	8	(N/A)	0.0	0.0	8.39
Norway spruce	7,490	56	(N/A)	0.0	0.0	56.18
Broadleaf Deciduous	3,624	27	(N/A)	0.0	0.0	27.18
White oak	15,773	118	(N/A)	0.0	0.0	118.30
Swamp white oak	1,101	8	(N/A)	0.0	0.0	8.26
Broadleaf Deciduous	12	0	(N/A)	0.0	0.0	0.09
Conifer Evergreen Sn	1,102	8	(N/A)	0.0	0.0	8.27
Eastern cottonwood	55,982	420	(N/A)	0.0	0.2	419.86
Willow	14,280	107	(N/A)	0.0	0.0	107.10
Dogwood	908	7	(N/A)	0.0	0.0	6.81
Citywide total	31,651,232	237,384	(N/A)	100.0	100.0	71.98

Table 5: Annual Carbon Sequestered

Annual CO Benefits of Public Trees

1/27/2016

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	637,735	4,783	-66,771	-2,867	-522	427,685	3,208	995,782	7,468 (N/A)	25.8	38.1	8.77
Norway maple	180,263	1,352	-24,719	-1,746	-198	262,044	1,965	415,841	3,119 (N/A)	23.0	15.9	4.12
Green ash	196,281	1,472	-17,462	-885	-138	143,985	1,080	321,918	2,414 (N/A)	10.0	12.3	7.32
Red maple	38,197	286	-1,875	-242	-16	39,974	300	76,054	570 (N/A)	7.1	2.9	2.43
Silver maple	258,918	1,942	-17,460	-670	-136	99,721	748	340,509	2,554 (N/A)	5.5	13.0	13.96
Spruce	20,436	153	-3,770	-510	-32	42,398	318	58,554	439 (N/A)	5.0	2.2	2.65
Maple	8,605	65	-371	-79	-3	10,049	75	18,204	137 (N/A)	4.2	0.7	0.99
Northern white cedar	7,389	55	-1,407	-192	-12	15,239	114	21,029	158 (N/A)	2.0	0.8	2.39
Apple	6,195	46	-680	-89	-6	9,783	73	15,208	114 (N/A)	1.5	0.6	2.28
Elm	12,052	90	-630	-63	-5	9,454	71	20,813	156 (N/A)	1.5	0.8	3.25
Littleleaf linden	18,553	139	-881	-74	-7	10,834	81	28,431	213 (N/A)	1.1	1.1	5.92
Pin oak	52,100	391	-3,391	-123	-26	18,843	141	67,430	506 (N/A)	0.9	2.6	16.31
Black walnut	22,956	172	-3,011	-109	-23	16,738	126	36,574	274 (N/A)	0.9	1.4	9.14
Northern red oak	2,798	21	-702	-42	-6	5,264	39	7,318	55 (N/A)	0.8	0.3	2.11
Eastern red cedar	390	3	-115	-45	-1	4,196	31	4,426	33 (N/A)	0.8	0.2	1.33
Northern hackberry	10,011	75	-958	-78	-8	14,105	106	23,081	173 (N/A)	0.8	0.9	6.92
Ginkgo	897	7	-70	-24	-1	2,165	16	2,967	22 (N/A)	0.7	0.1	0.93
Scotch pine	3,162	24	-305	-53	-3	4,984	37	7,788	58 (N/A)	0.7	0.3	2.65
Bur oak	8,705	65	-1,013	-45	-8	6,966	52	14,612	110 (N/A)	0.6	0.6	5.22
American basswood	18,098	136	-1,499	-64	-12	8,911	67	25,446	191 (N/A)	0.6	1.0	10.04
Honeylocust	13,070	98	-779	-45	-6	9,666	72	21,913	164 (N/A)	0.5	0.8	9.13
Blue spruce	1,144	9	-72	-27	-1	2,668	20	3,713	28 (N/A)	0.5	0.1	1.64
White ash	12,653	95	-599	-42	-5	8,520	64	20,532	154 (N/A)	0.5	0.8	9.06
Amur maple	1,222	9	-48	-13	0	1,317	10	2,478	19 (N/A)	0.5	0.1	1.16
Conifer Evergreen Large	1,446	11	-341	-45	-3	3,443	26	4,502	34 (N/A)	0.4	0.2	2.81
Broadleaf Deciduous Smal	1,236	9	-63	-11	-1	1,150	9	2,312	17 (N/A)	0.4	0.1	1.45
Ohio buckeye	3,320	25	-386	-27	-3	4,311	32	7,219	54 (N/A)	0.4	0.3	4.51
Boxelder	2,329	17	-84	-13	-1	2,102	16	4,334	33 (N/A)	0.3	0.2	2.95
Paper birch	5,827	44	-479	-26	-4	4,046	30	9,368	70 (N/A)	0.3	0.4	7.03
Japanese tree lilac	116	1	-2	-2	0	88	1	200	1 (N/A)	0.3	0.0	0.15
Eastern white pine	1,071	8	-237	-30	-2	2,329	17	3,132	23 (N/A)	0.2	0.1	2.94
Black ash	2,501	19	-156	-14	-1	2,350	18	4,682	35 (N/A)	0.2	0.2	5.02
Red pine	1,102	8	-97	-17	-1	1,578	12	2,566	19 (N/A)	0.2	0.1	2.75
Hickory	3,293	25	-185	-14	-1	2,317	17	5,411	41 (N/A)	0.2	0.2	6.76
Mountain ash	1,328	10	-77	-9	-1	1,303	10	2,545	19 (N/A)	0.2	0.1	3.18
Kentucky coffeetree	16	0	-1	-1	0	26	0	40	0 (N/A)	0.2	0.0	0.05
Quaking aspen	228	2	-3	-2	0	155	1	377	3 (N/A)	0.2	0.0	0.57
Pear	418	3	-15	-5	0	447	3	845	6 (N/A)	0.2	0.0	1.27
Alder	495	4	-23	-4	0	557	4	1,025	8 (N/A)	0.1	0.0	2.56
Black locust	370	3	-206	-12	-2	1,616	12	1,768	13 (N/A)	0.1	0.1	4.42
River birch	448	3	-79	-7	-1	890	7	1,252	9 (N/A)	0.1	0.0	3.13
Black cherry	152	1	-38	-5	0	496	4	605	5 (N/A)	0.1	0.0	1.51
Siberian elm	2,691	20	-434	-15	-3	2,240	17	4,482	34 (N/A)	0.1	0.2	11.21
Eastern hophornbeam	535	4	-29	-4	0	617	5	1,119	8 (N/A)	0.1	0.0	4.20
Eastern redbud	276	2	-15	-2	0	314	2	574	4 (N/A)	0.1	0.0	2.15
Conifer Evergreen Mediun	91	1	-5	-2	0	213	2	296	2 (N/A)	0.0	0.0	2.22
Norway spruce	0	0	-36	-4	0	311	2	271	2 (N/A)	0.0	0.0	2.03
Broadleaf Deciduous Medi	386	3	-17	-2	0	395	3	762	6 (N/A)	0.0	0.0	5.71
White oak	857	6	-76	-4	-1	552	4	1,330	10 (N/A)	0.0	0.1	9.97
Swamp white oak	224	2	-5	-1	0	176	1	393	3 (N/A)	0.0	0.0	2.95
Broadleaf Deciduous Larg	3	0	0	0	0	4	0	7	0 (N/A)	0.0	0.0	0.05
Conifer Evergreen Small	43	0	-5	-2	0	187	1	222	2 (N/A)	0.0	0.0	1.67
Eastern cottonwood	479	4	-269	-6	-2	813	6	1,017	8 (N/A)	0.0	0.0	7.63
Willow	0	0	-69	-4	-1	539	4	466	3 (N/A)	0.0	0.0	3.49
Dogwood	114	1	-4	-1	0	124	1	232	2 (N/A)	0.0	0.0	1.74
Citywide total	1,563,224	11,724	-152,027	-8,418	-1,203	1,211,197	9,084	2,613,976	19,605 (N/A)	100.0	100.0	5.94

Table 6: Annual Social and Aesthetic Benefits

Annual Aesthetic/Other Benefits of Public Trees

1/27/2016

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Sugar maple	63,219	(N/A)	25.8	41.6	74.20
Norway maple	17,914	(N/A)	23.0	11.8	23.66
Green ash	16,842	(N/A)	10.0	11.1	51.04
Red maple	5,524	(N/A)	7.1	3.6	23.50
Silver maple	19,710	(N/A)	5.5	13.0	107.70
Spruce	3,997	(N/A)	5.0	2.6	24.08
Maple	1,317	(N/A)	4.2	0.9	9.54
Northern white cedar	1,266	(N/A)	2.0	0.8	19.18
Apple	356	(N/A)	1.5	0.2	7.13
Elm	1,416	(N/A)	1.5	0.9	29.50
Littleleaf linden	1,984	(N/A)	1.1	1.3	55.10
Pin oak	3,854	(N/A)	0.9	2.5	124.33
Black walnut	1,717	(N/A)	0.9	1.1	57.25
Northern red oak	232	(N/A)	0.8	0.2	8.94
Eastern red cedar	160	(N/A)	0.8	0.1	6.38
Northern hackberry	1,371	(N/A)	0.8	0.9	54.83
Ginkgo	113	(N/A)	0.7	0.1	4.72
Scotch pine	713	(N/A)	0.7	0.5	32.42
Bur oak	787	(N/A)	0.6	0.5	37.49
American basswood	1,286	(N/A)	0.6	0.8	67.69
Honeylocust	3,123	(N/A)	0.5	2.1	173.52
Blue spruce	370	(N/A)	0.5	0.2	21.79
White ash	1,467	(N/A)	0.5	1.0	86.28
Amur maple	67	(N/A)	0.5	0.0	4.16
Conifer Evergreen Large	252	(N/A)	0.4	0.2	21.03
Broadleaf Deciduous Small	70	(N/A)	0.4	0.0	5.82
Ohio buckeye	323	(N/A)	0.4	0.2	26.88
Boxelder	311	(N/A)	0.3	0.2	28.26
Paper birch	503	(N/A)	0.3	0.3	50.34
Japanese tree lilac	2	(N/A)	0.3	0.0	0.24
Eastern white pine	158	(N/A)	0.2	0.1	19.77
Black ash	247	(N/A)	0.2	0.2	35.23
Red pine	248	(N/A)	0.2	0.2	35.36
Hickory	305	(N/A)	0.2	0.2	50.86
Mountain ash	77	(N/A)	0.2	0.1	12.89
Kentucky coffeetree	32	(N/A)	0.2	0.0	5.26
Quaking aspen	55	(N/A)	0.2	0.0	10.94
Pear	23	(N/A)	0.2	0.0	4.66
Alder	28	(N/A)	0.1	0.0	9.43
Black locust	31	(N/A)	0.1	0.0	10.49
River birch	52	(N/A)	0.1	0.0	17.48
Black cherry	8	(N/A)	0.1	0.0	2.82
Siberian elm	158	(N/A)	0.1	0.1	52.74
Eastern hophornbeam	31	(N/A)	0.1	0.0	15.48
Eastern redbud	16	(N/A)	0.1	0.0	7.76
Conifer Evergreen Medium	25	(N/A)	0.0	0.0	25.23
Norway spruce	0	(N/A)	0.0	0.0	0.00
Broadleaf Deciduous Medium	39	(N/A)	0.0	0.0	39.16
White oak	66	(N/A)	0.0	0.0	65.59
Swamp white oak	26	(N/A)	0.0	0.0	26.22
Broadleaf Deciduous Large	5	(N/A)	0.0	0.0	5.26
Conifer Evergreen Small	14	(N/A)	0.0	0.0	13.68
Eastern cottonwood	29	(N/A)	0.0	0.0	28.57
Willow	0	(N/A)	0.0	0.0	0.00
Dogwood	6	(N/A)	0.0	0.0	6.40
Citywide total	151,947	(N/A)	100.0	100.0	46.07

Table 7: Summary of Benefits in Dollars

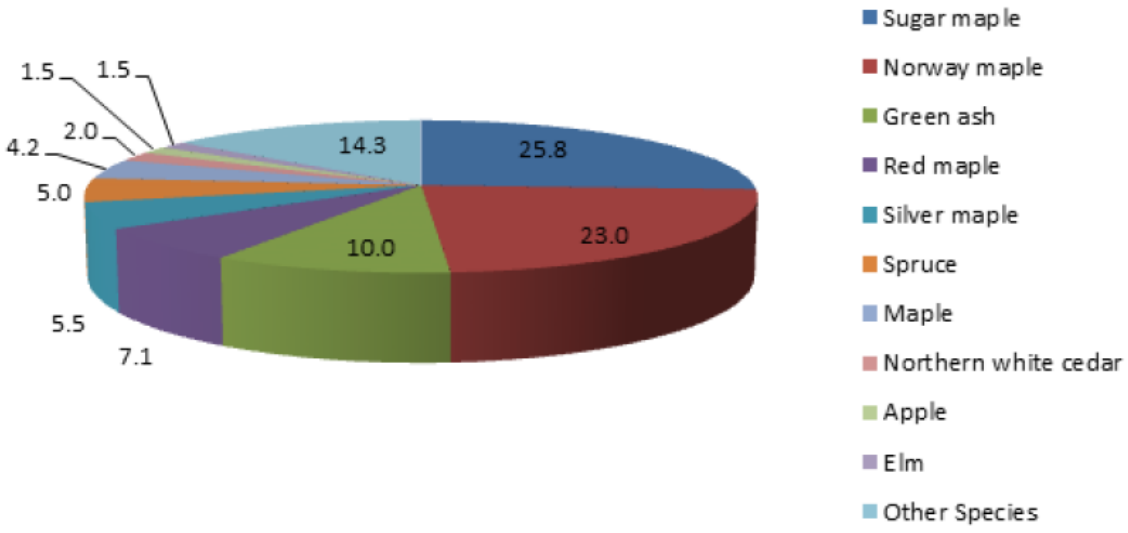
Total Annual Benefits of Public Trees by Species ($)

1/27/2016

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Sugar maple	52,800	7,468	8,714	87,802	63,219	220,004	(N/A)	37.9
Norway maple	34,146	3,119	6,099	40,522	17,914	101,801	(N/A)	17.5
Green ash	17,851	2,414	3,137	24,586	16,842	64,831	(N/A)	11.2
Red maple	4,983	570	845	4,524	5,524	16,446	(N/A)	2.8
Silver maple	12,127	2,554	2,292	24,016	19,710	60,699	(N/A)	10.5
Spruce	5,181	439	22	14,886	3,997	24,524	(N/A)	4.2
Maple	1,281	137	204	962	1,317	3,900	(N/A)	0.7
Northern white cedar	1,903	158	-4	5,400	1,266	8,723	(N/A)	1.5
Apple	1,333	114	224	752	356	2,780	(N/A)	0.5
Elm	1,164	156	188	1,196	1,416	4,120	(N/A)	0.7
Littleleaf linden	1,342	213	222	1,479	1,984	5,240	(N/A)	0.9
Pin oak	2,313	506	295	3,766	3,854	10,734	(N/A)	1.9
Black walnut	2,098	274	396	3,573	1,717	8,059	(N/A)	1.4
Northern red oak	675	55	94	863	232	1,919	(N/A)	0.3
Eastern red cedar	554	33	48	989	160	1,783	(N/A)	0.3
Northern hackberry	1,773	173	321	2,144	1,371	5,782	(N/A)	1.0
Ginkgo	282	22	43	177	113	637	(N/A)	0.1
Scotch pine	600	58	31	1,444	713	2,847	(N/A)	0.5
Bur oak	859	110	156	1,243	787	3,155	(N/A)	0.5
American basswood	1,169	191	179	1,669	1,286	4,495	(N/A)	0.8
Honeylocust	1,176	164	200	1,748	3,123	6,412	(N/A)	1.1
Blue spruce	332	28	37	543	370	1,311	(N/A)	0.2
White ash	1,006	154	180	1,287	1,467	4,094	(N/A)	0.7
Amur maple	186	19	27	75	67	373	(N/A)	0.1
Conifer Evergreen Large	421	34	-5	1,281	252	1,983	(N/A)	0.3
Broadleaf Deciduous Sn	159	17	25	78	70	349	(N/A)	0.1
Ohio buckeye	548	54	99	637	323	1,661	(N/A)	0.3
Boxelder	256	33	40	238	311	877	(N/A)	0.2
Paper birch	513	70	88	704	503	1,879	(N/A)	0.3
Japanese tree lilac	13	1	2	4	2	22	(N/A)	0.0
Eastern white pine	284	23	-5	871	158	1,331	(N/A)	0.2
Black ash	303	35	51	298	247	934	(N/A)	0.2
Red pine	191	19	10	466	248	934	(N/A)	0.2
Hickory	294	41	48	337	305	1,025	(N/A)	0.2
Mountain ash	167	19	29	88	77	380	(N/A)	0.1
Kentucky coffeetree	4	0	0	3	32	39	(N/A)	0.0
Quaking aspen	19	3	3	15	55	94	(N/A)	0.0
Pear	65	6	9	25	23	129	(N/A)	0.0
Alder	75	8	12	32	28	155	(N/A)	0.0
Black locust	213	13	41	306	31	604	(N/A)	0.1
River birch	120	9	21	134	52	336	(N/A)	0.1
Black cherry	70	5	12	41	8	135	(N/A)	0.0
Siberian elm	272	34	59	483	158	1,006	(N/A)	0.2
Eastern hophornbeam	76	8	13	36	31	165	(N/A)	0.0
Eastern redbud	39	4	7	18	16	84	(N/A)	0.0
Conifer Evergreen Medi	25	2	3	42	25	97	(N/A)	0.0
Norway spruce	38	2	-2	125	0	163	(N/A)	0.0
Broadleaf Deciduous M	47	6	8	38	39	138	(N/A)	0.0
White oak	71	10	12	107	66	266	(N/A)	0.0
Swamp white oak	24	3	3	16	26	73	(N/A)	0.0
Broadleaf Deciduous La	1	0	0	0	5	7	(N/A)	0.0
Conifer Evergreen Smal	25	2	2	44	14	86	(N/A)	0.0
Eastern cottonwood	99	8	23	196	29	354	(N/A)	0.1
Willow	71	3	14	102	0	190	(N/A)	0.0
Dogwood	18	2	3	7	6	36	(N/A)	0.0
Citywide Total	151,653	19,605	24,571	232,419	151,947	580,197	(N/A)	100.0

Species Distribution of Public Trees

1/27/2016

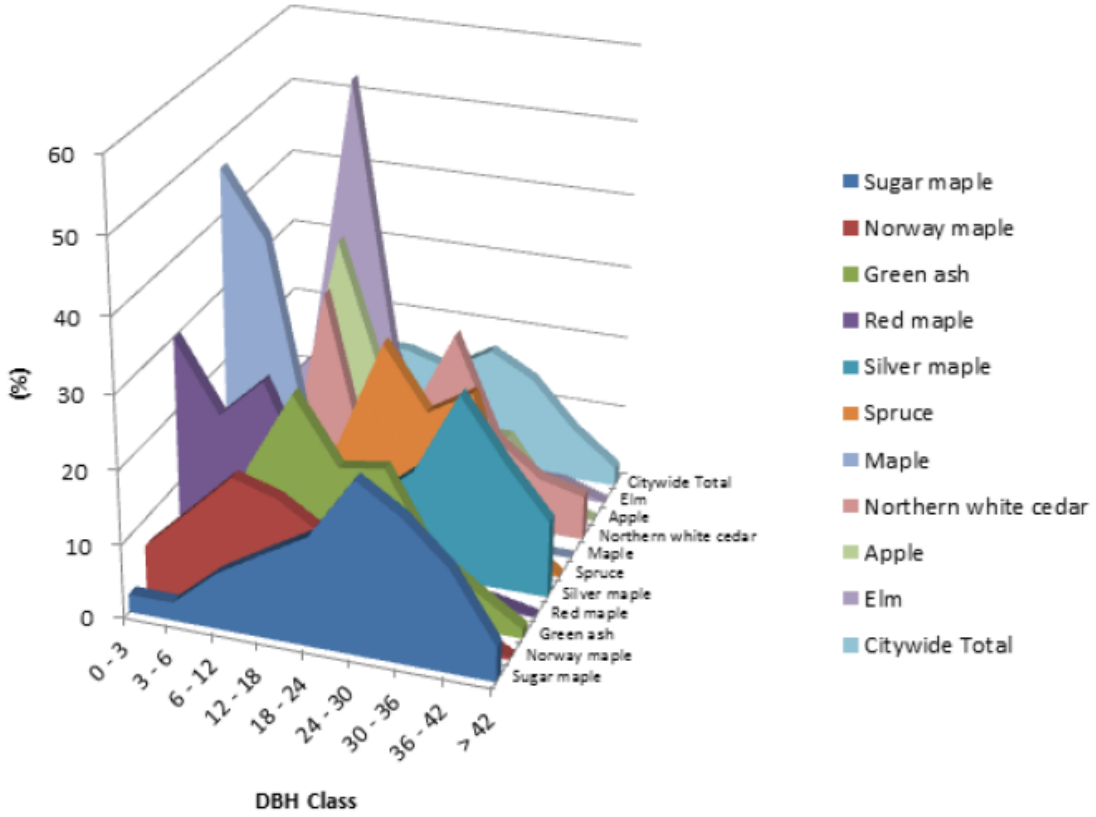


Species	Percent
Sugar maple	25.8
Norway maple	23.0
Green ash	10.0
Red maple	7.1
Silver maple	5.5
Spruce	5.0
Maple	4.2
Northern white cedar	2.0
Apple	1.5
Elm	1.5
Other Species	14.3
Total	100.0

Figure 1: Species Distribution

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

1/27/2016



	DBH class (in)								
Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42
Sugar maple	2.46	2.46	7.63	11.27	14.79	23.36	19.48	13.85	4.69
Norway maple	6.47	12.15	17.97	16.12	12.29	17.83	13.47	3.43	0.26
Green ash	0.00	1.21	16.97	27.58	18.79	19.70	9.39	5.15	1.21
Red maple	29.79	20.43	25.96	13.19	5.11	3.40	0.85	1.28	0.00
Silver maple	2.73	2.19	7.10	10.93	9.29	14.21	25.68	17.49	10.38
Spruce	1.81	3.01	4.82	13.86	28.31	19.88	23.49	4.82	0.00
Maple	46.38	37.68	9.42	3.62	1.45	1.45	0.00	0.00	0.00
Northern white cedar	1.52	0.00	28.79	4.55	13.64	25.76	12.12	7.58	6.06
Apple	12.00	8.00	34.00	16.00	8.00	10.00	10.00	2.00	0.00
Elm	8.33	14.58	54.17	16.67	2.08	0.00	2.08	2.08	0.00
Citywide Total	8.16	8.22	15.16	15.10	13.31	16.80	13.55	7.16	2.55

Figure 2: Relative Age Class

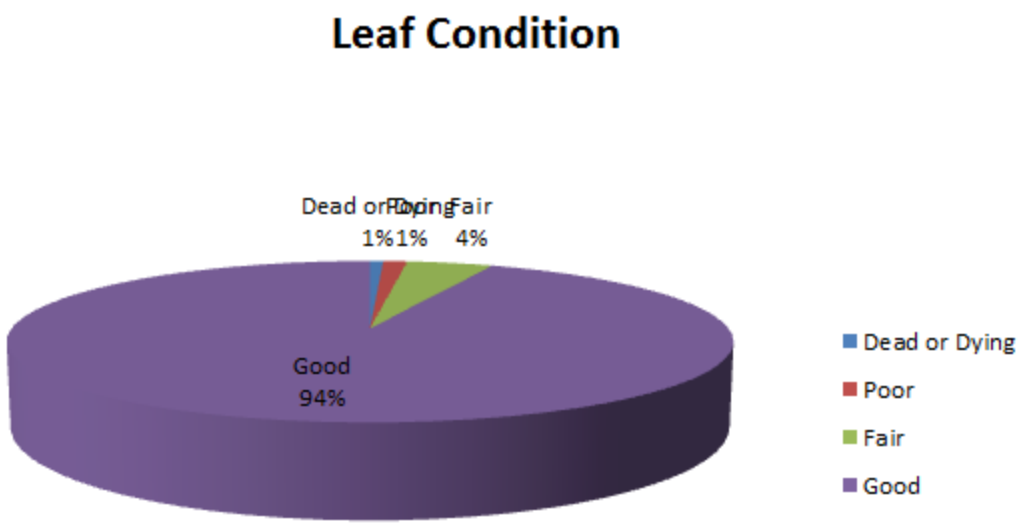


Figure 3: Foliage Condition

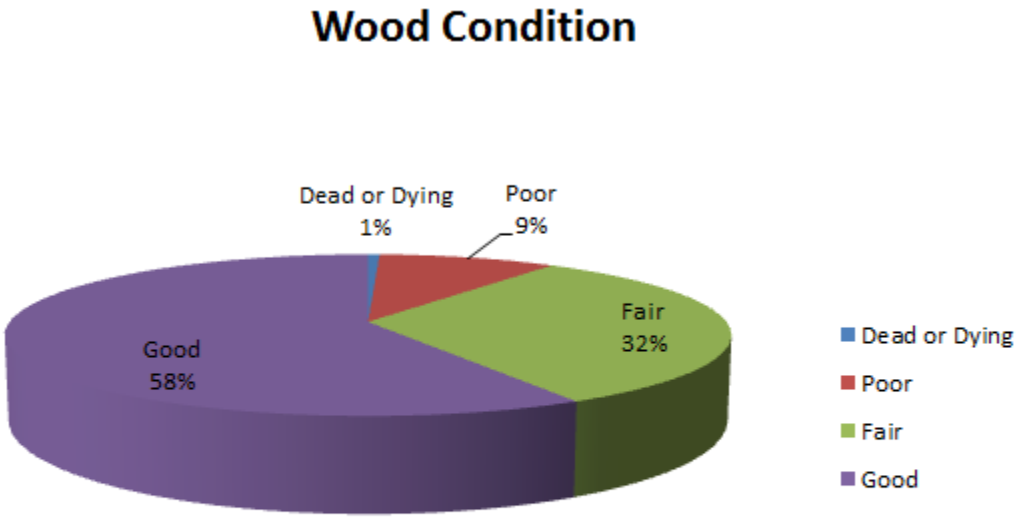
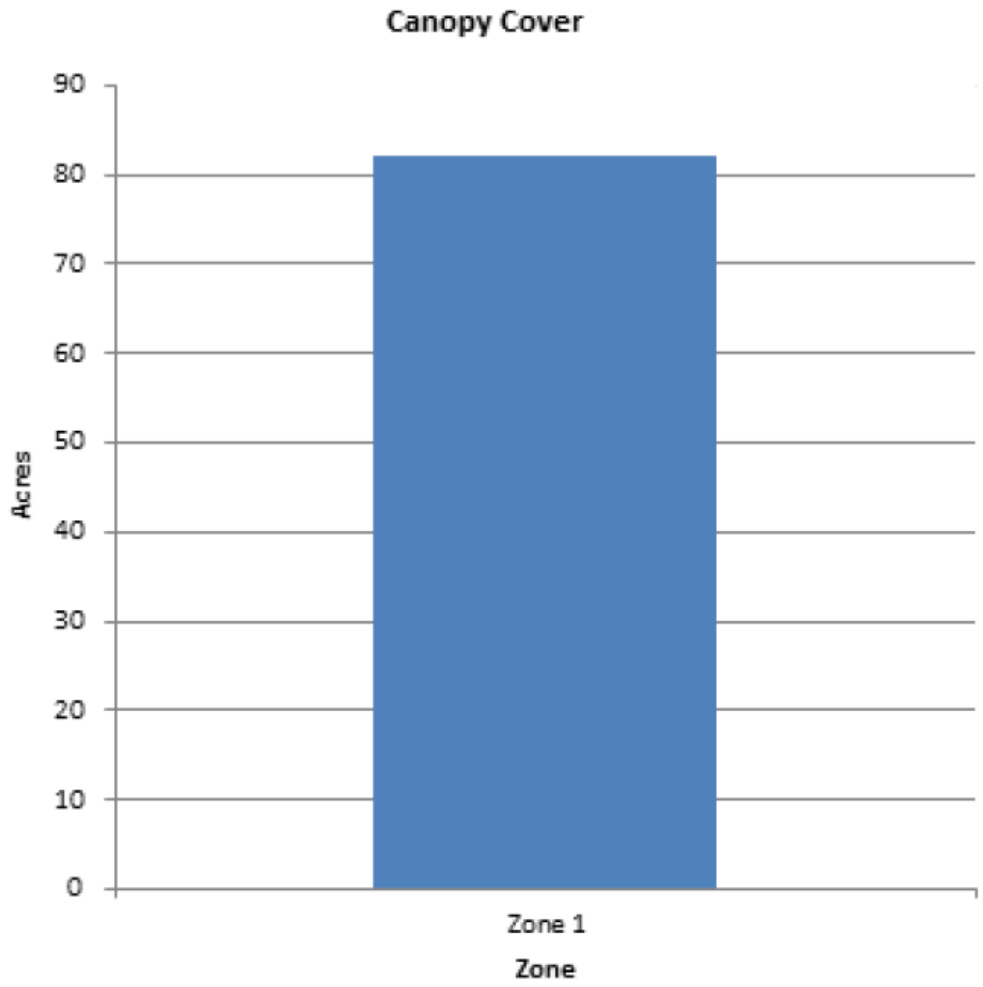


Figure 4: Wood Condition

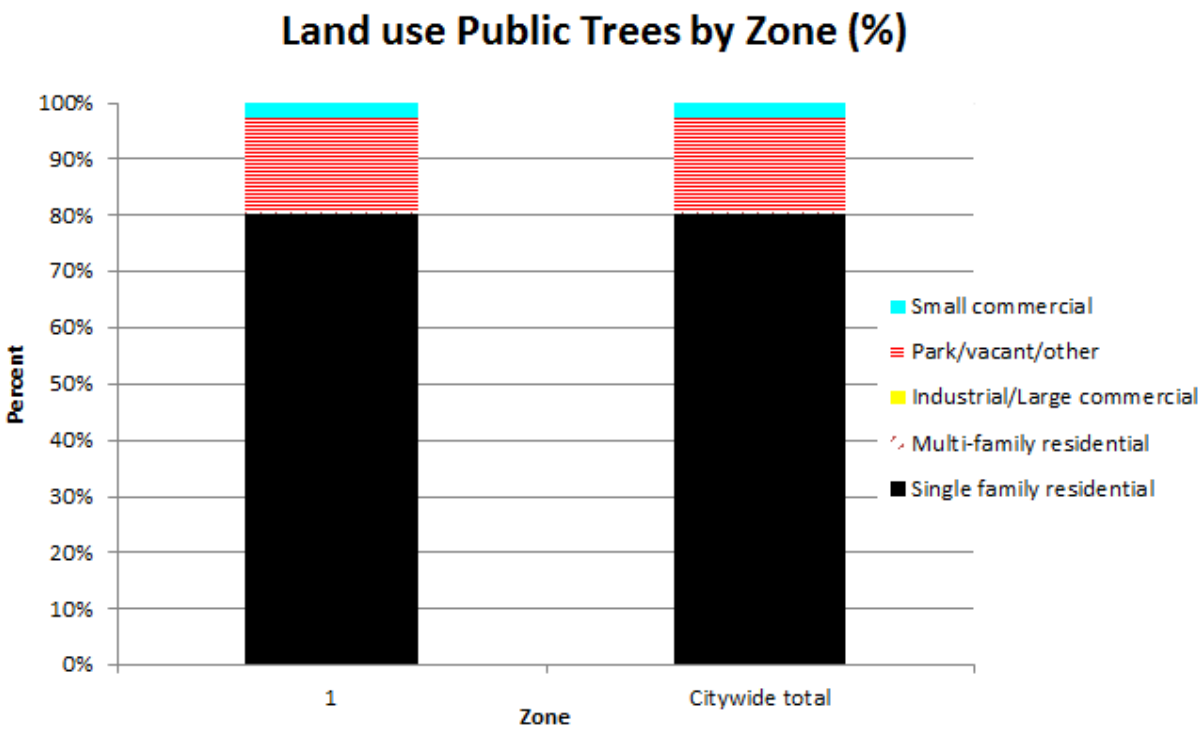
Canopy Cover of Public Trees (Acres)

1/27/2016



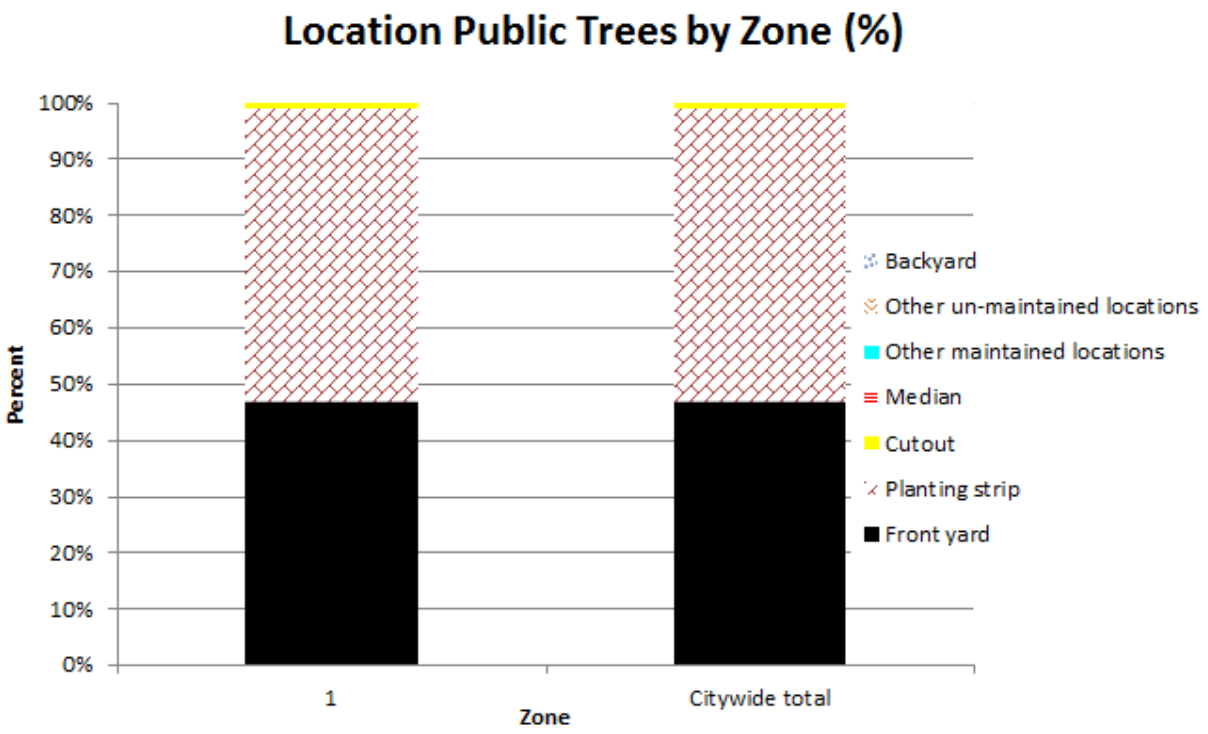
Zone	Acres	% of Total Canopy Cover
Zone 1	82	100.0
Citywide total	82	100.0

Figure 5: Canopy Cover in Acres



Zone	Single family residential	Multi-family residential	Industrial/Large commercial	Park/vacant /other	Small commercial
1	80.17	0.24	0.03	16.95	2.61
Citywide total	80.17	0.24	0.03	16.95	2.61

Figure 6: Land Use of city/park trees



Zone	Front yard	Planting strip	Cutout	Median	Other maintained locations	Other un-maintained locations	Backyard
1	46.66	52.24	1.09	0.00	0.00	0.00	0.00
Citywide total	46.66	52.24	1.09	0.00	0.00	0.00	0.00

Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

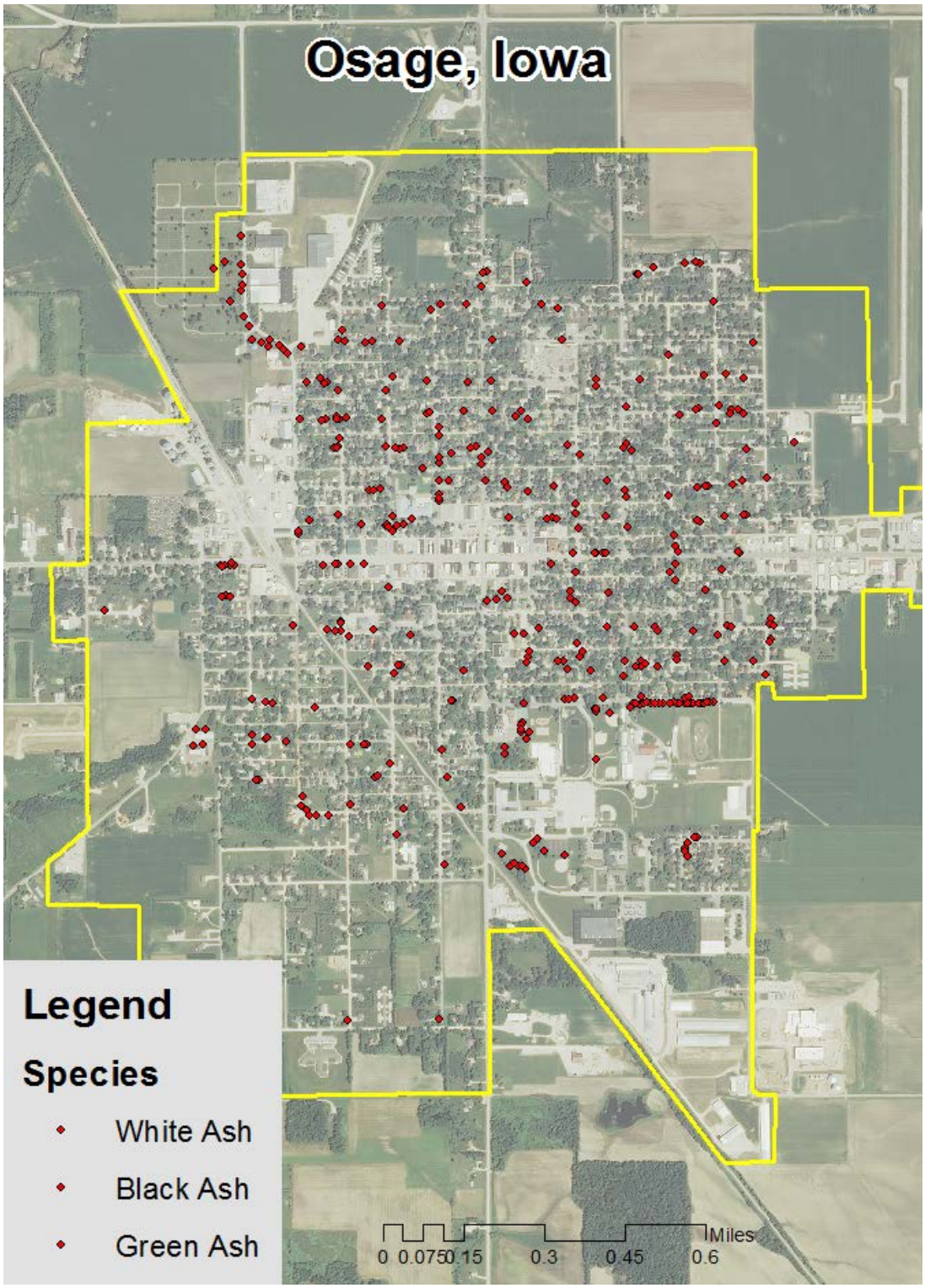


Figure 1: Location of Ash Trees

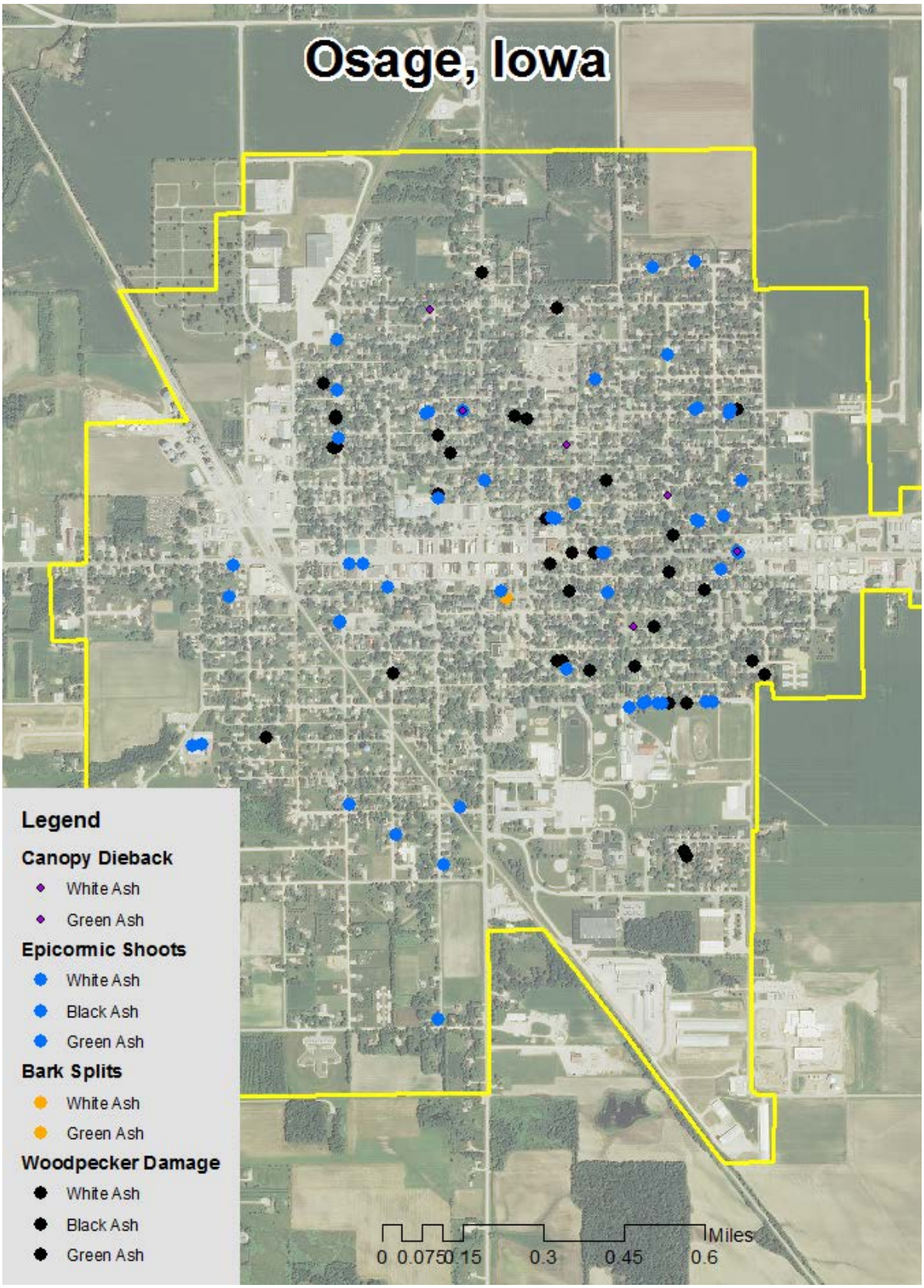


Figure 2: Location of EAB symptoms

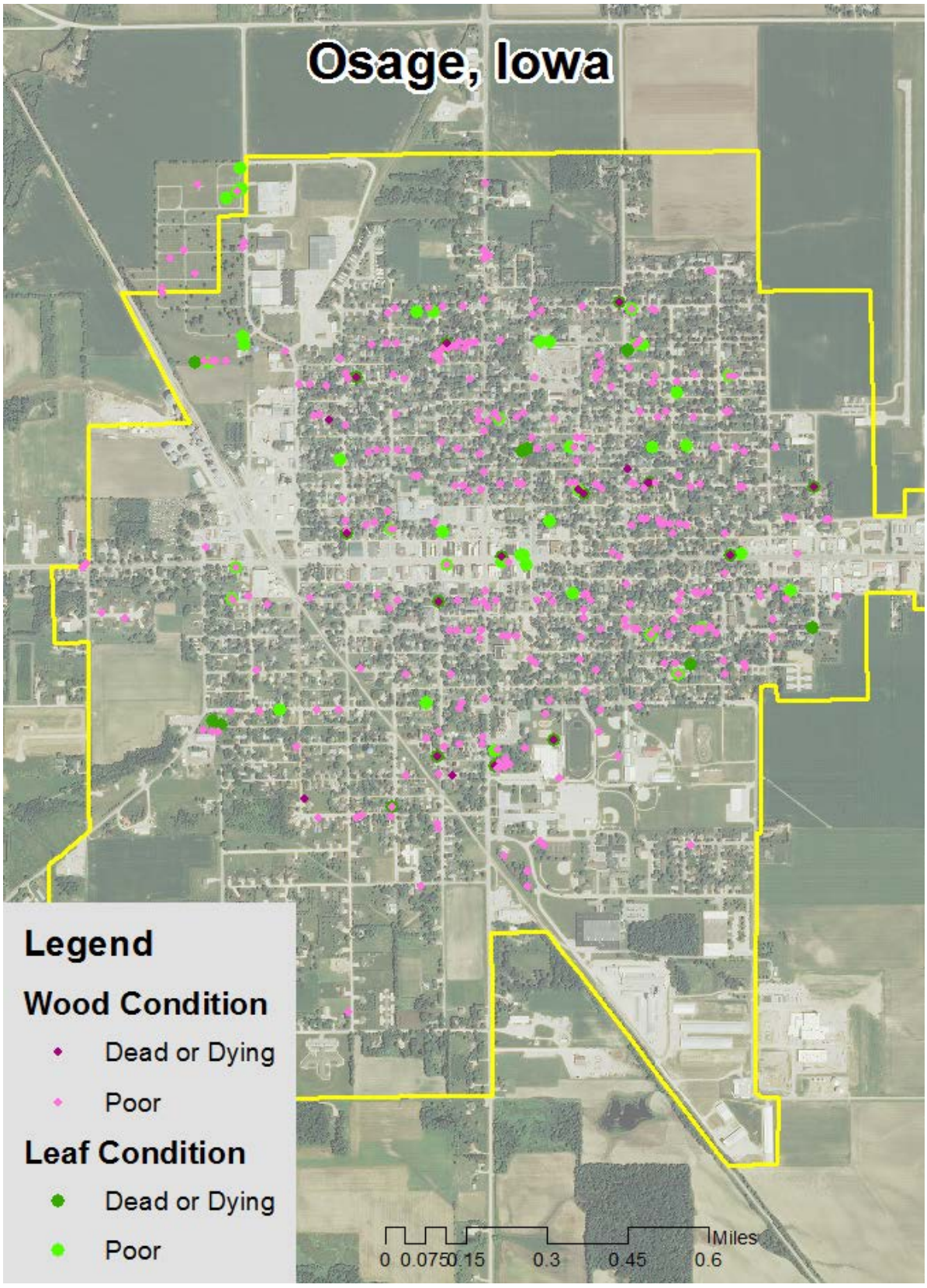


Figure 3: Location of Poor Condition Trees

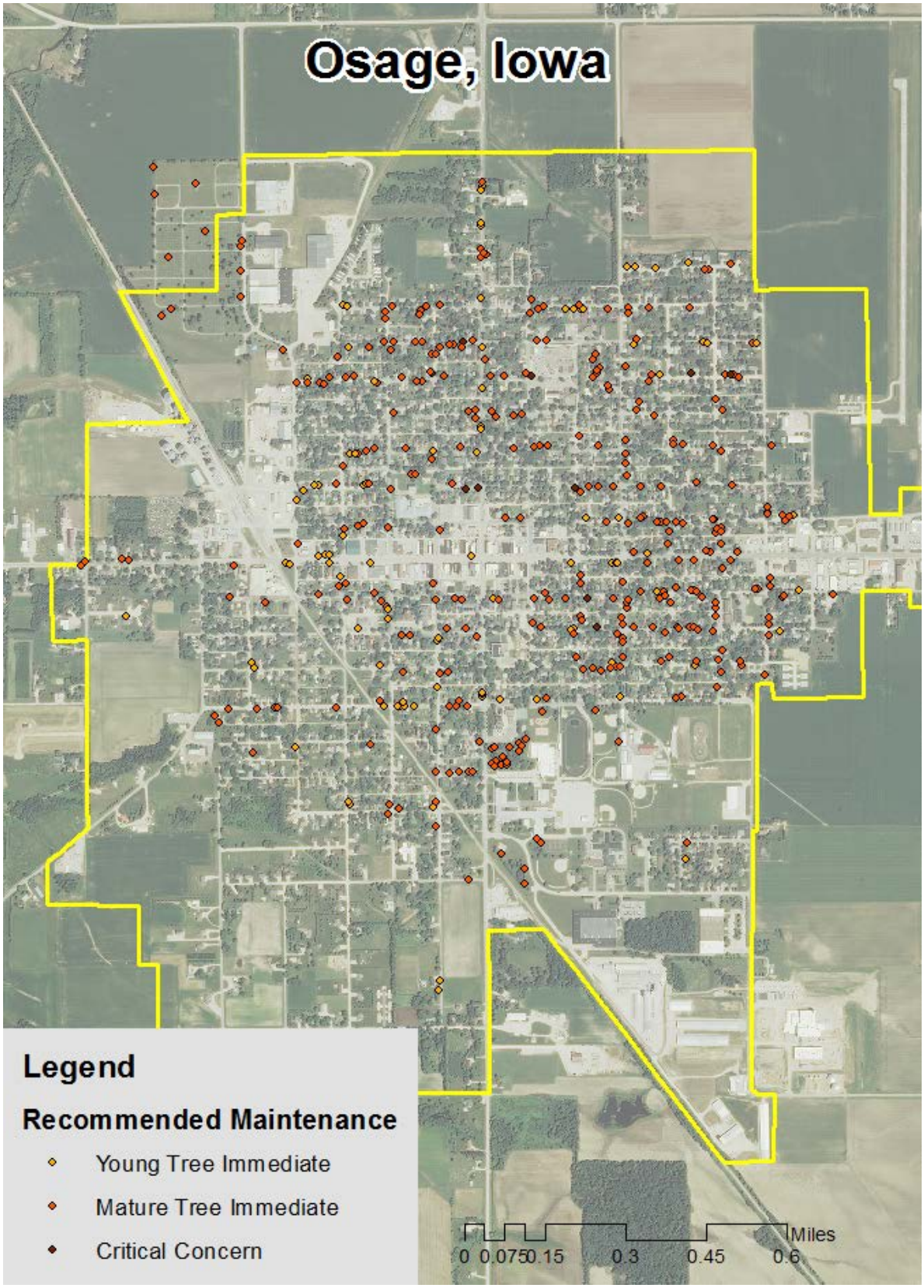


Figure 4: Location of Trees with Recommended Maintenance

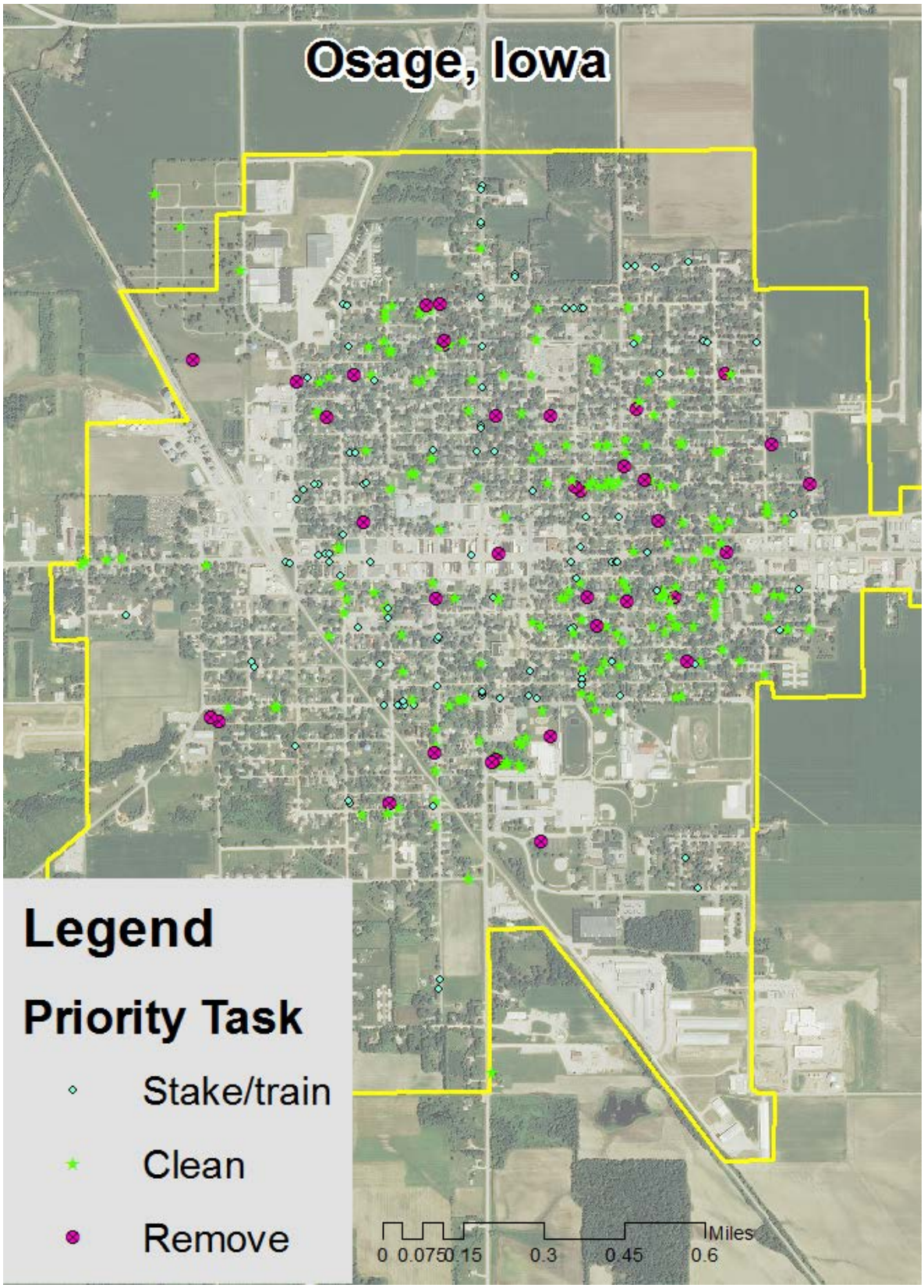


Figure 5: Maintenance Tasks ***City ownership of the trees recommended for removal should be verified prior to any removal***

Appendix C: Osage Tree Ordinances

CHAPTER 151

TREES

151.01 DEFINITIONS. For use in this chapter, the following terms are defined:

1. "Parking" means that part of the street, avenue or highway in the City not covered by sidewalk and lying between the lot line and the curb line; or, on unpaved streets, that part of the street, avenue or highway lying between the lot line and that portion of the street usually traveled by vehicular traffic.

2. "Superintendent" means the Public Works Supervisor.

151.02 PLANTING RESTRICTIONS. No tree shall be planted in any street or parking except in accordance with the following:

1. Alignment. All trees hereafter planted in any street shall be planted in the parking midway between the outer line of the sidewalk and the curb. In the event a curb line is not established, trees shall be planted on a line ten (10) feet from the property line.

2. Spacing. Trees shall not be planted on any parking which is less than nine (9) feet in width, or contains less than eighty-one (81) square feet of exposed soil surface per tree. Trees shall not be planted closer than twenty (20) feet from street intersections (property lines extended) and ten (10) feet from driveways. If it is at all possible trees should be planted inside the property lines and not between the sidewalk and the curb.

3. Prohibited Trees. No person shall plant in any street any fruit-bearing tree or any tree of the kinds commonly known as cottonwood, poplar, boxelder, chinese elm, or evergreens.

151.03 DUTY TO TRIM TREES. The owner or agent of the abutting property shall keep the trees on, or overhanging the street, trimmed so that all branches will be at least fifteen (15) feet above the surface of the street and eight (8) feet above the sidewalks.

(Code of Iowa, Sec. 364.12[2c])

151.04 ASSESSMENT. If the abutting property owner fails to trim the trees as required in this chapter, the City may serve notice on the abutting property owner requiring that such action be taken within five (5) days. If such action is not taken within that time, the City may perform the required action and assess the costs against the abutting property for collection in the same manner as a property tax.

(Code of Iowa, Sec. 364.12[2d & e])

151.05 TRIMMING TREES TO BE SUPERVISED. It is unlawful for any person to trim or cut any tree in a street or public place unless the work is done under the supervision of the City.

151.06 REMOVAL OF TREES. The superintendent shall remove, on order of the Council, any tree on the streets of the City which interferes with the making of improvements or with travel thereon. The superintendent shall additionally remove any trees on the street, not on private property, which are dead or have become diseased, or which constitute a danger to the public, or which may otherwise be declared a nuisance.

(Code of Iowa, Sec. 364.12 [2c] & 372.13 [4])

CHAPTER 152

DUTCH ELM DISEASE CONTROL

152.01 TREES SUBJECT TO REMOVAL. The Council, having determined that the health of the elm trees within the City is threatened by a fatal disease known as the Dutch Elm Disease, hereby declares the following shall be removed:
(Code of Iowa, Sec. 364.12[3b])

1. Living or Standing Trees. Any living or standing elm tree or part thereof infected with the Dutch Elm Disease fungus or which harbors any of the elm bark beetles, that is scolytus multistriatus (eichb.) or hylurgopinus rufipes (marsh.).

2. Dead Trees. Any dead elm tree or part thereof including logs, branches, stumps, firewood or other elm material from which the bark has not been removed and burned or sprayed with an effective elm bark beetle destroying insecticide.

152.02 DUTY TO REMOVE. No person or entity shall permit any tree or material as defined in Section 152.01 to remain on the premises owned, controlled or occupied by such person or entity within the City.
(Code of Iowa, Sec. 364.12[3b])

152.03 INSPECTION. The Council shall inspect or cause to be inspected any elm trees reported or suspected to be infected with the Dutch Elm Disease or any elm bark bearing material reported or suspected to be infected with the elm bark beetles.

152.04 REMOVAL FROM CITY PROPERTY. If it is determined that any condition as herein defined exists in or upon any public street, alley, park or any public place, including the strip between the curb and the lot line of private property, within the City and that danger to other elm trees within the City is imminent, the Council shall immediately cause such condition to be corrected so as to destroy or prevent as fully as possible the spread of Dutch Elm Disease or the insect pests or vectors known to carry such disease fungus.

152.05 REMOVAL FROM PRIVATE PROPERTY. If it is determined with reasonable certainty that any condition as herein defined exists in or upon private premises and that the danger to other elm trees within the City is imminent, the Council shall immediately notify by certified mail the owner, occupant or person in charge of such property to correct such condition within fourteen (14) days of said notification. If such owner, occupant or person in charge of said property fails to comply within fourteen (14) days of receipt of notice, the Council may cause the nuisance to be removed and the cost assessed against the property.
(Code of Iowa, Sec. 364.12[3b & h])

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Federal law prohibits employment discrimination on the basis of race, color, age, religion, national origin, sex or disability. State law prohibits employment discrimination on the basis of race, color, creed, age, sex, sexual orientation, gender identity, national origin, religion, pregnancy, or disability. State law also prohibits public accommodation (such as access to services or physical facilities) discrimination on the basis of race, color, creed, religion, sex, sexual orientation, gender identity, religion, national origin, or disability. If you believe you have been discriminated against in any program, activity or facility as described above, or if you desire further information, please contact the Iowa Civil Rights Commission, 1-800-457-4416, or write to the Iowa Department of Natural Resources, Wallace State Office Bldg., 502 E. 9th St., Des Moines, IA 50319.

If you need accommodations because of disability to access the services of this Agency, please contact the Director at 515-725-8200.