Waverly, IA
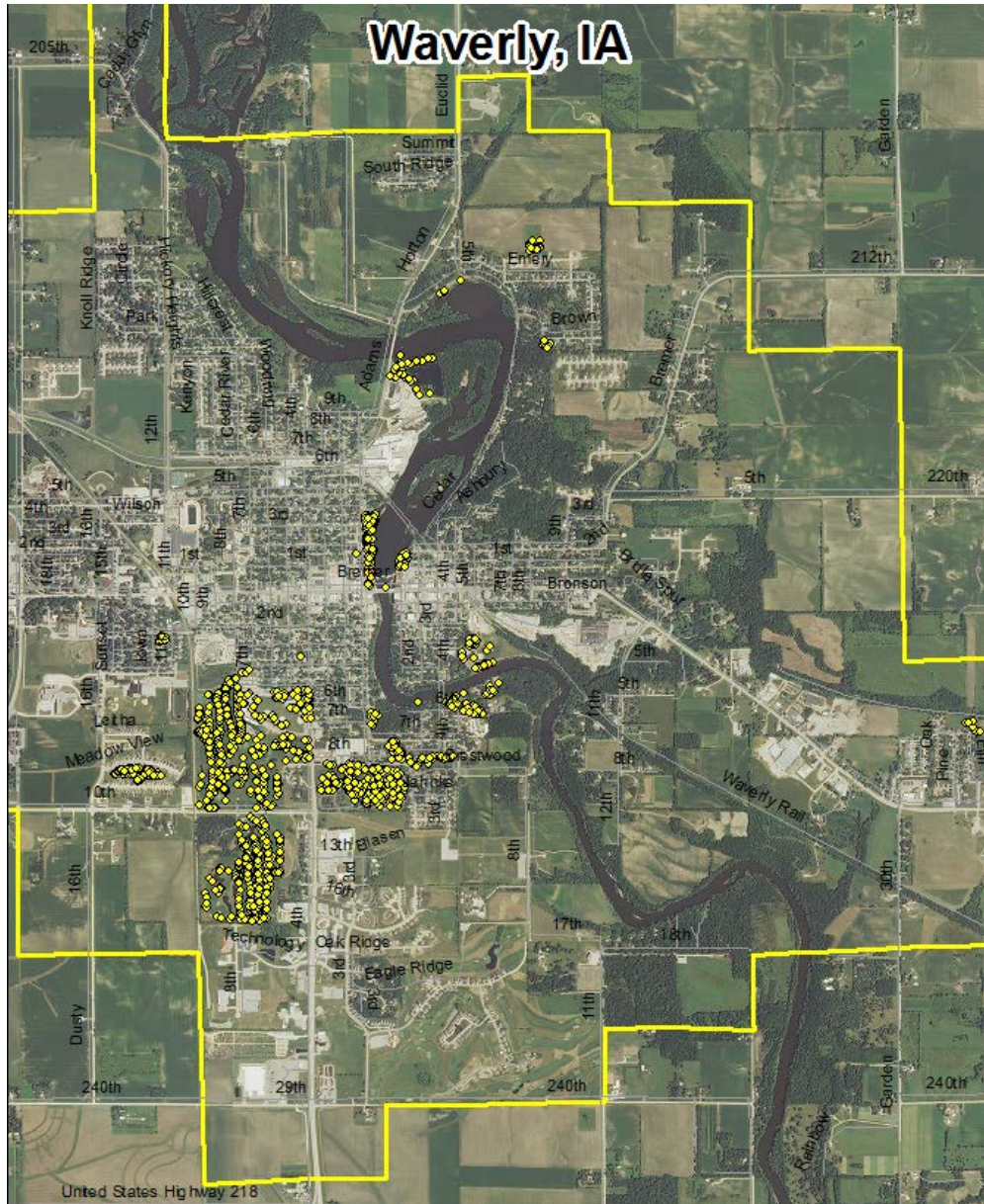

Park Inventory Map

2017 Urban Forest Management Plan
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Iowa DNR

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Executive Summary_____

Overview

This plan was developed to assist the City of Waverly 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 14% of Waverly'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 2014 and 2016, tree inventories were conducted using Global Positioning System (GPS) data collectors. The 2014 inventory was a complete inventory of streets and the 2016 inventory was of the park trees. Below are some key findings of the 3721 trees inventoried.
- Waverly's trees provide $152,420 of benefits annually, an average of $41 a tree
- There are over 64 species of trees
- The top three genera are: Maple 37%, Ash 14%, and Northern Hackberry 7%
- 36% of trees are in need of some type of management
- 164 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 164 trees needing removal, 41 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*
- 9 of the 529 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: maple, ash, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut
- Check ash trees with a visual survey yearly
- With the current budget ($5000 per year) it could take 50 years to remove ash with a contractor– Suggestion: Continue to use your Public Services, Parks and Waverly Utilities to remove the easiest ash trees and contract out the hardest trees.

Introduction _____

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

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

Inventory _____

In 2014, a tree inventory was conducted by Copper Tree Consulting on the city owned street trees. Additional data was collected in 2016 by the Iowa DNR and City of Waverly to include the park tree. 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 3721 city trees was entered into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management as part of the i-Tree suite. The following are results from the i-Tree STREETS analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Waverly's trees reduce energy related costs by approximately $152,420 annually (Appendix A, Table 1). These savings are both in Electricity (728.9 MWh) and in Natural Gas (99,076.1 Therms).

Annual Stormwater Benefits

Waverly's trees intercept about 7,618,914 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $206,473 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 mater (ozone). In Waverly, it is estimated that trees remove 8.827.7 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 $24,388 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Waverly, trees sequester about 1,453,419 lbs of carbon a year with an associated value of $10,901 (Appendix A, Table 5). In addition, the trees store 23,098,978 lbs of carbon, with a yearly benefit of $173,242 (Appendix A, Table 4).

Annual Aesthetics Benefits

Social benefits of trees are hard to capture. The analysis does have a calculation for this area that includes: aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Waverly receives $153,557 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, Waverly's trees provide $556,016 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 3721 trees in Waverly provide approximately $150 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Waverly has over 64 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	1367	37%
Ash	529	14%
Hackberry	242	7%
Apple (Crab)	225	6%
Pine	174	5%
Oak	149	4%
Spruce	121	3%
Black Walnut	120	3%
Linden	120	3%
Locust	98	3%
Others	576	15%

Age Class

Most of Waverly's trees (39%) are between 6 and 18 inches in diameter at 4.5 ft (Appendix A, Figure 2). For age, it is preferred that the highest amounts of trees are in the smallest size category (a downward slope) to prepare for natural mortality and to maintain canopy cover. Waverly's size curve is on the higher side, indicating an middle aged to older than average stand.

Condition: Wood and Foliage

Both wood condition and leaf condition are good indicators of the overall health of the urban forest. The foliage condition results for Waverly indicate that 67% of the trees are in good health, with only 6% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 57% of Waverly'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 9% of the population. This 9% 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 (Park locations can be found in Appendix B, Figure 3).

Crown Raising	833	22%
Crown Cleaning	283	8%
Crown Reduction	5	4%
Tree Staking	45	1%
Tree Removal	164	<1%

Canopy Cover

The total canopy with both private and public trees is 20% or 1459 acres. The canopy cover included in the Waverly inventory includes approximately 78 acres (Appendix A, Figure 4). Waverly is currently meeting its Canopy goal is 20%.

Land Use and Location

The majority of Waverly'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	56%
Park/vacant/other	38%
Industrial/Large commercial	6%
Small commercial	<1%
Multifamily residential	<1%

Location
Planting strip	59%
Median	2%
Cutout (surrounded by pavement)	2%
Front yard	37%

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
Waverly has 1091 critical concern trees that need immediate removal. These trees in park locations can be seen on the Location of Trees with Recommended Maintenance map (Park locations can be found in Appendix B, Figure 4). It is recommended to start with the large diameter critical concern trees first. There are 224 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 136 trees with these needs. It should be noted that this includes data for 2014, which may have been addressed but not updated.

<u>Poor tree species</u>
After the removal of the critical concern trees, ash trees in poor health should be assessed for removal (Park locations can be found in Appendix B, Figure 3 & Appendix B, Figure 4). Of the 1091 removals, 263 are ash trees. There are a total of 529 ash trees, and 9 of those have signs and symptoms that have been associated with EAB. In addition, there are 40 trees that are in poor health. *City ownership of the trees recommended for removal should be verified prior to any removal* It should be noted that this includes data for 2014, which may have been addressed but not updated.

Pruning Cycle

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

Planting

Most of the planting over the next 5 years will replace the trees that are removed. It is recommended to plant 1.2 trees for every tree removed, since survival rates will not be 100%. Please refer to the six year maintenance plan at the end of this section. It is not essential that the new trees be planted in the same location of the trees being removed. However, maintaining the same number of trees helps ensure continuation of the benefits of the existing forest in Waverly.

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 (37%) (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: Boxelder, Siberian Elm, Chinese Elm, Cottonwood, White Poplar, Lombardy Poplar, Boileana Poplar, Willows, Tree of Heaven, American Elm, Silver Maple, Catalpa, Black Locust , Weeping Birch, European Mt. Ash, Poplar, Fruit Trees (except ornamentals) as outlined in section 57.11 of the city ordinance (Appendix C). All trees planted must meet the restrictions in city ordinance 57.11 (Appendix C).

Continual Monitoring

Due to the threat of EAB, it is important to continuously check the health of ash trees. It is recommended that ash trees be checked with a visual survey every year for tree decline and for

the following signs and symptoms: canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

Six Year Maintenance Plan with <u>No Additional Funding</u> ($5000/year)

*It should be noted that this includes data for 2014, which may have been addressed but not updated.

Year 1

       Removal: 8 largest critical concern trees

       Planting and Replacement: 10 trees to be planted in open locations

       Young Tree Pruning & Maintenance:

       Visual Survey for signs and symptoms of EAB

Year 2

       Removal: 8 largest critical concern trees

       Planting and Replacement: 10 trees in open locations from year one removals

       Young Tree Pruning & Maintenance:

       Routine trimming: Contract to trim 1/3 of the city trees

       Visual Survey for signs and symptoms of EAB

Year 3

       Removal: 8 largest critical concern trees

       Planting and Replacement: 10 trees to be planted in open locations and locations from previous removals

       Young Tree Pruning & Maintenance:

       Visual Survey for signs and symptoms of EAB

Year 4

       Removal: 8 largest critical concern trees

       Planting and Replacement: 10 trees in open locations from previous removals

       Routine trimming: Contract to trim 1/3 of the city trees

       Young Tree Pruning & Maintenance:

       Visual Survey for signs and symptoms of EAB

Year 5

       Removal: 8 largest critical concern trees

       Planting and Replacement: 10 trees to be planted in open locations and locations from previous removals

       Young Tree Pruning & Maintenance:

       Visual Survey for signs and symptoms of EAB

Year 6

       Removal: 8 largest critical concern trees

       Planting and Replacement: 10 trees in open locations from previous removals

       Routine trimming: Contract to trim 1/3 of the city trees

       Young Tree Pruning & Maintenance:

       Visual Survey for signs and symptoms of EAB

*Reduction of ash over 6 years: Approximately 48 ash trees removed (approximately 10% of ash). It will take approximately 11 years to remove all ash with the current budget. EAB could potentially kill all ash within 4 to 15 years of its arrival.
** To remove all ash trees within 6 years, the budget would need to be increased to $7,350 a year.

Emerald Ash Borer Plan_____

Ash Tree Removal

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

Treatment of Ash Trees

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

EAB Quarantines

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

A regulated article under the USDA's quarantine includes any of the following items:
• emerald ash borer
• firewood of all hardwood species (for example ash, oak, maple and hickory)
• nursery stock and green lumber of ash
• any other ash material, whether living, dead, cut or fallen, including logs, stumps, roots, branches, as well as composted and not composted chips of the genus ash (Mountain ash is not included)

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

Wood Disposal

A very important aspect of planning is determining how wood infested with EAB will be handled, keeping in mind that quarantines will restrict its movement. Consider who will cut and haul the dead and dying trees? Is there an accessible, secured site big enough to store and sort the hundreds of trees and the associated brush and chips? How will wood be disposed of or utilized? Do you have equipment capable of handling the amount and size of ash trees your tree inventory has identified? Once your county is under quarantine for EAB, contact USDA-APHIS-PPQ at 515-251-4083 or visit the website http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/regulatory.shtml. Wood waste can be disposed of as you normally would if your county is not part of a quarantine.

Canopy Replacement

As budget permits, all removed trees will be replaced. All trees will meet the restrictions in city ordinance 57.11 (Appendix C). The new plantings will be a diverse mix and will not include ash, maple, Boxelder, Siberian Elm, Chinese Elm, Cottonwood, White Poplar, Lombardy Poplar, Boileana Poplar, Willows, Tree of Heaven, American Elm, Silver Maple, Catalpa, Black Locust , Weeping Birch, European Mt. Ash, Poplar, Fruit Trees (except ornamentals).

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. City Code SEC. 57.12 REMOVAL OF TREES. "The director shall remove, on the order of the council, any tree on the streets of this municipality which interferes with the making of improvements or with travel thereon. He shall additionally remove any trees on the street, not on private property, which have become diseased, or which constitutes a threat to the public, or which may otherwise be declared a nuisance by the director. The Director or his Designee has the right to determine a Hazardous tree on private property that is a threat to public safety, and issue a 30 day notice to remove to the owner. If not removed in 30 days, the city shall remove it at the owner's expense and bill accordingly on their property taxes. The owner has the right to appeal said decision in front of the Forestry Committee within the 30 day period."

Budget _____

Current Budget
Total $35,000 over 6 years ($5,000/year)

It should be noted that this includes data for 2014, which may have been addressed but not updated.

FY 2018 Budget
> Removal: $4,000
> *Or saving for ash tree treatment and/or future ash removal
> Planting: $1000
> Watering & Maintenance: $0 (City Staff)

FY 2019 Budget
> Removal: $4,000
> *Or saving for ash tree treatment and/or future ash removal
> Planting: $1000
> Routine trimming: $0 (City Staff)
> Watering & Maintenance: $0 (City Staff)

FY 2020 Budget
> Removal: $4,000
> *Or saving for ash tree treatment and/or future ash removal
> Planting: $1000
> Watering & Maintenance: $0 (City Staff)

FY 2021 Budget
> Removal: $4,000
> *Or saving for ash tree treatment and/or future ash removal
> Planting: $1000
> Routine trimming: $0 (City Staff)
> Watering & Maintenance: $0 (City Staff)

FY 2022 Budget
> Removal: $4,000
> *Or saving for ash tree treatment and/or future ash removal
> Planting: $1000
> Watering & Maintenance: $0 (City Staff)

FY 2023 Budget
> Removal: $4,000
> *Or saving for ash tree treatment and/or future ash removal
> Planting: $1000
> Routine trimming: $0 (City Staff)
> Watering & Maintenance: $0 (City Staff)

*Reduction of ash over 6 years: approximately 48 ash trees removed (approximately 10% of ash). **It will take approximately 11 years to remove all ash with the current budget.**

<u>Purposed Budget Increase</u>
EAB could potentially kill all ash trees in Waverly within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $7,350 a year.   Additionally, it is recommended that Waverly 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.

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Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Waverly

Annual Energy Benefits of Public Trees

2/6/2017

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	92.0	6,987	12,904.9	12,647	19,633	(N/A)	12.2	12.9	43.25
Green ash	86.5	6,568	11,456.4	11,227	17,795	(N/A)	10.8	11.7	44.27
Sugar maple	72.9	5,531	9,673.0	9,480	15,011	(N/A)	8.3	9.8	48.90
Silver maple	86.4	6,561	11,361.3	11,134	17,695	(N/A)	7.4	11.6	63.88
Red maple	38.3	2,906	5,237.3	5,133	8,038	(N/A)	6.8	5.3	31.65
Northern hackberry	81.0	6,144	11,512.9	11,283	17,427	(N/A)	6.5	11.4	72.01
Apple	9.3	709	1,525.0	1,494	2,204	(N/A)	6.0	1.4	9.79
Black walnut	33.3	2,527	4,511.8	4,422	6,949	(N/A)	3.2	4.6	57.90
White ash	22.0	1,669	2,723.9	2,669	4,339	(N/A)	2.7	2.8	42.96
Honeylocust	19.2	1,458	2,552.8	2,502	3,959	(N/A)	2.6	2.6	41.68
Littleleaf linden	9.6	728	1,336.7	1,310	2,038	(N/A)	2.2	1.3	25.16
Norway spruce	13.0	986	1,716.9	1,683	2,669	(N/A)	2.1	1.8	33.36
Spruce	7.0	531	926.4	908	1,439	(N/A)	2.0	0.9	19.45
Conifer Evergreen Large	8.6	653	1,115.9	1,094	1,747	(N/A)	1.6	1.1	29.60
Eastern red cedar	5.6	426	832.2	816	1,242	(N/A)	1.6	0.8	21.41
Austrian pine	8.0	606	1,080.5	1,059	1,665	(N/A)	1.5	1.1	29.73
Conifer Evergreen Medium	5.7	436	780.7	765	1,201	(N/A)	1.3	0.8	25.55
Red pine	5.5	420	693.1	679	1,099	(N/A)	1.2	0.7	24.98
Eastern white pine	4.3	329	552.0	541	870	(N/A)	1.1	0.6	20.71
Northern red oak	7.5	567	1,052.8	1,032	1,598	(N/A)	1.0	1.0	40.99
American basswood	9.3	709	1,352.1	1,325	2,034	(N/A)	1.0	1.3	53.53
Black maple	7.4	564	976.5	957	1,521	(N/A)	0.9	1.0	43.47
Amur maple	2.5	189	387.8	380	569	(N/A)	0.9	0.4	17.78
Scotch pine	4.8	364	629.4	617	980	(N/A)	0.9	0.6	30.64
Swamp white oak	1.8	133	278.9	273	407	(N/A)	0.8	0.3	14.02
Blue spruce	3.1	236	430.0	421	657	(N/A)	0.7	0.4	25.28
Ginkgo	2.4	180	311.4	305	485	(N/A)	0.7	0.3	18.66
Oak	5.1	391	689.1	675	1,066	(N/A)	0.7	0.7	42.65
Pin oak	6.9	527	914.6	896	1,423	(N/A)	0.7	0.9	56.93
Ash	6.0	455	858.0	841	1,295	(N/A)	0.6	0.8	53.97
American elm	4.2	321	561.3	550	871	(N/A)	0.6	0.6	37.88
American sycamore	7.1	536	954.0	935	1,471	(N/A)	0.6	1.0	63.96
Northern pin oak	6.2	470	902.8	885	1,355	(N/A)	0.6	0.9	58.92
Bur oak	2.6	194	346.9	340	534	(N/A)	0.5	0.4	26.70
Kentucky coffeetree	2.7	202	349.9	343	545	(N/A)	0.5	0.4	27.23
Broadleaf Evergreen Large	5.2	395	606.8	595	990	(N/A)	0.5	0.6	49.50
Broadleaf Deciduous Medium	3.2	244	467.4	458	702	(N/A)	0.5	0.5	39.00
Broadleaf Deciduous Large	4.1	311	567.8	556	867	(N/A)	0.5	0.6	48.19
River birch	1.8	136	269.1	264	400	(N/A)	0.4	0.3	26.65
Black spruce	1.9	147	264.3	259	406	(N/A)	0.4	0.3	27.08
Broadleaf Deciduous Small	0.5	40	86.6	85	125	(N/A)	0.4	0.1	8.95
White oak	2.0	150	251.6	247	396	(N/A)	0.3	0.3	30.49
Birch	2.1	157	308.8	303	459	(N/A)	0.3	0.3	41.75
Hickory	1.0	73	132.0	129	203	(N/A)	0.3	0.1	18.44
Broadleaf Evergreen Medium	2.7	204	299.8	294	498	(N/A)	0.3	0.3	49.81
Eastern redbud	0.6	46	101.5	99	145	(N/A)	0.3	0.1	14.51
Elm	0.3	22	40.4	40	61	(N/A)	0.2	0.0	6.82
Japanese tree lilac	0.2	15	35.1	34	50	(N/A)	0.2	0.0	7.11
Pear	0.4	28	62.7	61	89	(N/A)	0.2	0.1	12.71
Northern white cedar	1.3	98	172.2	169	267	(N/A)	0.2	0.2	38.17
Cottonwood	3.2	243	425.2	417	660	(N/A)	0.2	0.4	94.28
Boxelder	1.4	105	185.9	182	287	(N/A)	0.2	0.2	40.96
Cherry plum	0.1	7	16.4	16	23	(N/A)	0.2	0.0	3.89
Chinese elm	1.4	106	180.7	177	283	(N/A)	0.1	0.2	56.55
Sumac	0.9	65	132.4	130	195	(N/A)	0.1	0.1	38.95
Mulberry	0.8	57	105.6	104	161	(N/A)	0.1	0.1	40.13

Species								
Callery pear	0.3	24	51.3	50	75 (N/A)	0.1	0.0	18.63
Catalpa	0.9	68	114.6	112	180 (N/A)	0.1	0.1	45.00
Willow	1.0	73	142.2	139	213 (N/A)	0.1	0.1	70.84
Conifer Evergreen Small	0.2	16	32.3	32	48 (N/A)	0.1	0.0	15.84
Lilac	0.0	2	5.0	5	7 (N/A)	0.1	0.0	2.38
Black locust	0.3	25	49.0	48	73 (N/A)	0.1	0.0	24.35
Black cherry	0.2	17	36.0	35	52 (N/A)	0.1	0.0	17.47
Broadleaf Evergreen Small	0.0	2	4.6	4	6 (N/A)	0.1	0.0	2.12
Black ash	0.4	28	56.4	55	83 (N/A)	0.1	0.1	41.58
Tulip tree	0.1	4	7.4	7	12 (N/A)	0.1	0.0	5.82
Siberian elm	0.6	46	84.5	83	128 (N/A)	0.1	0.1	64.22
Eastern hophornbeam	0.1	6	12.8	13	18 (N/A)	0.0	0.0	18.19
Dogwood	0.0	0	0.6	1	1 (N/A)	0.0	0.0	0.87
Ohio buckeye	0.3	24	47.4	46	71 (N/A)	0.0	0.0	70.84
Basswood	0.3	25	46.9	46	71 (N/A)	0.0	0.0	70.91
Eastern cottonwood	0.2	18	27.0	26	44 (N/A)	0.0	0.0	44.23
Ponderosa pine	0.1	10	14.6	14	24 (N/A)	0.0	0.0	24.14
Southern magnolia	0.0	1	2.8	3	4 (N/A)	0.0	0.0	3.94
Amur corktree	0.1	8	16.9	17	24 (N/A)	0.0	0.0	24.47
Plum	0.0	2	3.8	4	5 (N/A)	0.0	0.0	5.40
Mountain ash	0.2	14	24.7	24	38 (N/A)	0.0	0.0	38.13
Northern catalpa	0.4	29	53.7	53	82 (N/A)	0.0	0.1	82.02
Maple	0.3	22	39.9	39	61 (N/A)	0.0	0.0	60.68
Total	728.9	55,326	99,076.1	97,095	152,420 (N/A)	100.0	100.0	40.96

Table 2: Annual Stormwater Benefits

Waverly

Annual Stormwater Benefits of Public Trees

2/6/2017

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	718,142	19,462	(N/A)	12.2	9.4	42.87
Green ash	784,375	21,257	(N/A)	10.8	10.3	52.88
Sugar maple	683,153	18,513	(N/A)	8.3	9.0	60.30
Silver maple	1,181,016	32,006	(N/A)	7.4	15.5	115.54
Red maple	305,180	8,270	(N/A)	6.8	4.0	32.56
Northern hackberry	764,554	20,719	(N/A)	6.5	10.0	85.62
Apple	35,418	960	(N/A)	6.0	0.5	4.27
Black walnut	353,525	9,581	(N/A)	3.2	4.6	79.84
White ash	229,768	6,227	(N/A)	2.7	3.0	61.65
Honeylocust	173,081	4,690	(N/A)	2.6	2.3	49.37
Littleleaf linden	76,224	2,066	(N/A)	2.2	1.0	25.50
Norway spruce	298,126	8,079	(N/A)	2.1	3.9	100.99
Spruce	118,174	3,203	(N/A)	2.0	1.6	43.28
Conifer Evergreen Large	178,140	4,828	(N/A)	1.6	2.3	81.82
Eastern red cedar	81,877	2,219	(N/A)	1.6	1.1	38.26
Austrian pine	126,542	3,429	(N/A)	1.5	1.7	61.24
Conifer Evergreen Medium	87,480	2,371	(N/A)	1.3	1.1	50.44
Red pine	91,954	2,492	(N/A)	1.2	1.2	56.64
Eastern white pine	71,172	1,929	(N/A)	1.1	0.9	45.92
Northern red oak	79,262	2,148	(N/A)	1.0	1.0	55.08
American basswood	97,446	2,641	(N/A)	1.0	1.3	69.49
Black maple	56,536	1,532	(N/A)	0.9	0.7	43.77
Amur maple	11,131	302	(N/A)	0.9	0.1	9.43
Scotch pine	96,936	2,627	(N/A)	0.9	1.3	82.09
Swamp white oak	11,076	300	(N/A)	0.8	0.1	10.35
Blue spruce	49,622	1,345	(N/A)	0.7	0.7	51.72
Ginkgo	14,369	389	(N/A)	0.7	0.2	14.98
Oak	52,033	1,410	(N/A)	0.7	0.7	56.40
Pin oak	74,429	2,017	(N/A)	0.7	1.0	80.68
Ash	54,042	1,465	(N/A)	0.6	0.7	61.02
American elm	35,534	963	(N/A)	0.6	0.5	41.87
American sycamore	85,541	2,318	(N/A)	0.6	1.1	100.79
Northern pin oak	61,807	1,675	(N/A)	0.6	0.8	72.82
Bur oak	30,603	829	(N/A)	0.5	0.4	41.47
Kentucky coffeetree	21,357	579	(N/A)	0.5	0.3	28.94
Broadleaf Evergreen Large	58,389	1,582	(N/A)	0.5	0.8	79.12
Broadleaf Deciduous Medium	29,115	789	(N/A)	0.5	0.4	43.83
Broadleaf Deciduous Large	41,669	1,129	(N/A)	0.5	0.5	62.74
River birch	14,872	403	(N/A)	0.4	0.2	26.87
Black spruce	29,724	806	(N/A)	0.4	0.4	53.70
Broadleaf Deciduous Small	2,744	74	(N/A)	0.4	0.0	5.31
White oak	15,189	412	(N/A)	0.3	0.2	31.66
Birch	17,597	477	(N/A)	0.3	0.2	43.35
Hickory	7,038	191	(N/A)	0.3	0.1	17.34
Broadleaf Evergreen Medium	27,596	748	(N/A)	0.3	0.4	74.79
Eastern redbud	2,587	70	(N/A)	0.3	0.0	7.01
Elm	1,802	49	(N/A)	0.2	0.0	5.43
Japanese tree lilac	689	19	(N/A)	0.2	0.0	2.67
Pear	1,264	34	(N/A)	0.2	0.0	4.89

Northern white cedar	32,233	874	(N/A)	0.2	0.4	124.79
Cottonwood	50,672	1,373	(N/A)	0.2	0.7	196.17
Boxelder	12,565	341	(N/A)	0.2	0.2	48.64
Cherry plum	290	8	(N/A)	0.2	0.0	1.31
Chinese elm	17,159	465	(N/A)	0.1	0.2	93.00
Sumac	4,453	121	(N/A)	0.1	0.1	24.14
Mulberry	3,174	86	(N/A)	0.1	0.0	21.50
Callery pear	1,770	48	(N/A)	0.1	0.0	11.99
Catalpa	7,482	203	(N/A)	0.1	0.1	50.69
Willow	11,293	306	(N/A)	0.1	0.1	102.01
Conifer Evergreen Small	2,953	80	(N/A)	0.1	0.0	26.68
Lilac	84	2	(N/A)	0.1	0.0	0.75
Black locust	3,789	103	(N/A)	0.1	0.0	34.23
Black cherry	1,250	34	(N/A)	0.1	0.0	11.29
Broadleaf Evergreen Small	71	2	(N/A)	0.1	0.0	0.64
Black ash	3,065	83	(N/A)	0.1	0.0	41.53
Tulip tree	343	9	(N/A)	0.1	0.0	4.65
Siberian elm	5,649	153	(N/A)	0.1	0.1	76.55
Eastern hophornbeam	264	7	(N/A)	0.0	0.0	7.17
Dogwood	7	0	(N/A)	0.0	0.0	0.20
Ohio buckeye	3,764	102	(N/A)	0.0	0.0	102.01
Basswood	3,943	107	(N/A)	0.0	0.1	106.85
Eastern cottonwood	1,466	40	(N/A)	0.0	0.0	39.72
Ponderosa pine	1,539	42	(N/A)	0.0	0.0	41.70
Southern magnolia	56	2	(N/A)	0.0	0.0	1.53
Amur corktree	586	16	(N/A)	0.0	0.0	15.88
Plum	69	2	(N/A)	0.0	0.0	1.86
Mountain ash	667	18	(N/A)	0.0	0.0	18.06
Northern catalpa	5,491	149	(N/A)	0.0	0.1	148.79
Maple	2,867	78	(N/A)	0.0	0.0	77.70
Citywide total	7,618,914	206,473	(N/A)	100.0	100.0	55.49

Table 3: Annual Air Quality Benefits

Waverly

Species	Deposition (lb) O₃	NO₂	PM₁₀	SO₂	Total Depos. ($)	Avoided (lb) NO₂	PM₁₀	VOC	SO₂	Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($) Standard Error	% of Total Trees	Avg. $/tree
Norway maple	130.8	22.6	66.5	5.8	713	443.1	64.3	61.2	417.7	2,753	-32.1	-120	1,179.9	3,345 (N/A)	12.2	7.37
Green ash	82.9	13.3	42.5	3.7	450	409.6	59.9	57.2	392.2	2,561	0.0	0	1,061.3	3,010 (N/A)	10.8	7.49
Sugar maple	83.0	14.1	43.3	3.7	455	344.9	50.4	48.1	330.1	2,156	-66.7	-250	850.9	2,360 (N/A)	8.3	7.69
Silver maple	198.9	33.7	98.5	8.8	1,075	407.5	59.7	57.0	391.1	2,550	-106.3	-399	1,148.8	3,226 (N/A)	7.4	11.65
Red maple	69.0	11.8	32.8	3.1	369	182.5	26.6	25.3	173.4	1,137	-23.6	-88	500.8	1,418 (N/A)	6.8	5.58
Northern hackberry	120.6	20.9	61.6	5.4	659	391.0	56.6	53.9	367.2	2,425	0.0	0	1,077.3	3,084 (N/A)	6.5	12.74
Apple	7.8	1.3	4.1	0.4	43	46.7	6.6	6.3	42.3	286	0.0	0	115.6	329 (N/A)	6.0	1.46
Black walnut	42.7	6.8	20.7	1.9	228	158.6	23.1	22.0	150.9	989	0.0	0	426.8	1,217 (N/A)	3.2	10.14
White ash	37.6	6.0	17.6	1.7	199	102.3	15.1	14.4	99.6	644	0.0	0	294.2	842 (N/A)	2.7	8.34
Honeylocust	31.9	5.3	14.9	1.5	170	90.8	13.3	12.7	87.0	568	-23.7	-89	233.7	649 (N/A)	2.6	6.83
Littleleaf linden	11.0	1.9	5.8	0.5	60	46.1	6.7	6.4	43.5	287	-5.7	-21	116.2	326 (N/A)	2.2	4.02
Norway spruce	36.3	7.2	28.9	4.5	236	61.3	9.0	8.6	58.9	384	-177.6	-666	37.0	-46 (N/A)	2.1	-0.57
Spruce	13.3	2.6	11.1	1.6	88	33.0	4.8	4.6	31.7	207	-54.9	-206	48.0	89 (N/A)	2.0	1.20
Conifer Evergreen Large	21.3	4.2	17.1	2.6	139	40.4	5.9	5.7	39.0	253	-97.5	-366	38.8	27 (N/A)	1.6	0.46
Eastern red cedar	16.8	3.3	13.3	2.1	109	27.3	3.9	3.7	25.4	169	-45.1	-169	50.6	108 (N/A)	1.6	1.87
Austrian pine	19.8	3.9	16.0	2.4	130	37.9	5.5	5.3	36.1	236	-48.3	-181	78.7	185 (N/A)	1.5	3.31
Conifer Evergreen Medium	13.5	2.7	10.9	1.7	88	27.3	4.0	3.8	26.0	170	-32.9	-123	56.9	135 (N/A)	1.3	2.88
Red pine	10.6	2.1	8.8	1.3	70	25.8	3.8	3.6	25.1	162	-44.1	-166	36.9	67 (N/A)	1.2	1.51
Eastern white pine	8.1	1.6	6.8	1.0	54	20.3	3.0	2.8	19.6	127	-35.0	-131	28.2	50 (N/A)	1.1	1.18
Northern red oak	17.0	2.9	8.2	0.8	91	35.9	5.2	5.0	33.8	223	-24.4	-92	84.3	222 (N/A)	1.0	7.49
American basswood	12.7	2.2	6.4	0.6	69	45.3	6.6	6.2	42.4	281	-11.0	-41	111.3	308 (N/A)	1.0	8.11
Black maple	12.5	2.1	6.0	0.6	67	35.1	5.1	4.9	33.7	220	-4.4	-16	95.7	270 (N/A)	0.9	7.72
Amur maple	3.4	0.6	1.6	0.2	18	12.3	1.8	1.7	11.3	76	0.0	0	32.7	94 (N/A)	0.9	2.92
Scotch pine	11.4	2.3	9.2	1.4	75	22.6	3.3	3.2	21.7	141	-49.1	-184	26.0	32 (N/A)	0.9	1.00
Swamp white oak	1.4	0.2	0.9	0.1	8	8.7	1.2	1.2	8.0	54	-0.4	-2	21.3	60 (N/A)	0.8	2.08
Blue spruce	8.1	1.6	6.5	1.0	53	14.8	2.2	2.1	14.1	92	-18.9	-71	31.4	75 (N/A)	0.7	2.87
Ginkgo	3.4	0.6	1.7	0.2	19	11.2	1.6	1.6	10.7	70	-1.1	-4	29.9	84 (N/A)	0.7	3.25
Oak	6.5	1.0	3.1	0.3	35	24.4	3.6	3.4	23.3	153	0.0	0	65.7	187 (N/A)	0.7	7.49
Pin oak	13.1	2.3	6.7	0.6	72	32.8	4.8	4.6	31.4	205	-24.5	-92	71.9	185 (N/A)	0.7	7.40
Ash	10.8	1.9	5.3	0.5	58	29.0	4.2	4.0	27.2	180	-2.6	-10	80.3	229 (N/A)	0.6	9.52
American elm	8.1	1.4	4.0	0.4	44	20.0	2.9	2.8	19.2	125	0.0	0	58.8	169 (N/A)	0.6	7.35
American sycamore	13.3	2.1	6.1	0.6	70	33.6	4.9	4.7	32.0	210	0.0	0	97.2	280 (N/A)	0.6	12.15
Northern pin oak	13.1	2.3	6.4	0.6	70	30.1	4.4	4.1	28.1	186	-3.0	-11	86.0	246 (N/A)	0.6	10.67
Bur oak	4.5	0.7	2.1	0.2	24	12.2	1.8	1.7	11.6	76	0.0	0	34.7	100 (N/A)	0.5	4.98
Kentucky coffeetree	1.9	0.3	1.1	0.1	11	12.6	1.8	1.8	12.0	79	0.0	0	31.5	89 (N/A)	0.5	4.46
Broadleaf Evergreen Large	5.9	1.2	5.4	0.7	40	23.9	3.5	3.4	23.5	151	-24.9	-94	42.5	98 (N/A)	0.5	4.88
Broadleaf Deciduous Medium	5.8	1.0	2.9	0.3	31	15.6	2.3	2.1	14.6	97	-1.4	-5	43.2	123 (N/A)	0.5	6.83
Broadleaf Deciduous Large	4.6	0.7	2.3	0.2	25	19.6	2.9	2.7	18.6	122	0.0	0	51.7	147 (N/A)	0.5	8.17
River birch	2.7	0.5	1.4	0.1	15	8.8	1.3	1.2	8.1	54	-0.7	-3	23.4	67 (N/A)	0.4	4.44
Black spruce	4.4	0.9	3.6	0.5	29	9.2	1.3	1.3	8.8	57	-11.2	-42	18.9	45 (N/A)	0.4	2.97
Broadleaf Deciduous Small	0.9	0.1	0.4	0.0	5	2.7	0.4	0.4	2.4	16	0.0	0	7.3	21 (N/A)	0.4	1.50
White oak	1.3	0.2	0.7	0.1	7	9.3	1.4	1.3	8.9	58	0.0	0	23.2	66 (N/A)	0.3	5.04
Birch	3.3	0.6	1.7	0.1	18	10.1	1.5	1.4	9.4	62	-0.8	-3	27.2	77 (N/A)	0.3	7.02
Hickory	0.5	0.1	0.3	0.0	3	4.6	0.7	0.6	4.4	29	0.0	0	11.2	32 (N/A)	0.3	2.86
Broadleaf Evergreen Medium	5.2	1.0	4.5	0.6	35	12.2	1.8	1.7	12.1	77	-7.4	-28	31.9	85 (N/A)	0.3	8.46
Eastern redbud	0.7	0.1	0.3	0.0	4	3.0	0.4	0.4	2.7	19	0.0	0	7.7	22 (N/A)	0.3	2.21
Elm	0.1	0.0	0.1	0.0	0	1.4	0.2	0.2	1.3	9	0.0	0	3.2	9 (N/A)	0.2	0.99
Japanese tree lilac	0.1	0.0	0.1	0.0	1	1.0	0.1	0.1	0.9	6	0.0	0	2.4	7 (N/A)	0.2	0.98
Pear	0.2	0.0	0.1	0.0	1	1.8	0.3	0.2	1.6	11	0.0	0	4.3	12 (N/A)	0.2	1.76
Northern white cedar	4.0	0.8	3.1	0.5	26	6.1	0.9	0.9	5.9	38	-20.1	-75	2.1	-11 (N/A)	0.2	-1.58
Cottonwood	9.4	1.5	4.1	0.4	49	15.2	2.2	2.1	14.5	95	0.0	0	49.5	144 (N/A)	0.2	20.54
Boxelder	1.4	0.2	0.7	0.1	8	6.5	1.0	0.9	6.2	41	-0.6	-2	16.5	46 (N/A)	0.2	6.60
Cherry plum	0.0	0.0	0.0	0.0	0	0.5	0.1	0.1	0.4	3	0.0	0	1.1	3 (N/A)	0.2	0.51
Chinese elm	3.3	0.5	1.5	0.1	17	6.6	1.0	0.9	6.3	41	0.0	0	20.2	59 (N/A)	0.1	11.70
Sumac	1.6	0.3	0.7	0.1	8	4.2	0.6	0.6	3.9	26	0.0	0	11.9	34 (N/A)	0.1	6.83
Mulberry	1.1	0.2	0.5	0.0	6	3.6	0.5	0.5	3.4	22	0.0	0	9.8	28 (N/A)	0.1	7.00
Callery pear	0.2	0.0	0.1	0.0	1	1.6	0.2	0.2	1.4	10	-0.1	0	3.7	11 (N/A)	0.1	2.63
Catalpa	0.7	0.1	0.4	0.0	4	4.2	0.6	0.6	4.0	26	0.0	0	10.7	30 (N/A)	0.1	7.58
Willow	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
Conifer Evergreen Small	0.5	0.1	0.4	0.1	3	1.0	0.1	0.1	0.9	6	-1.6	-6	1.7	3 (N/A)	0.1	1.14
Lilac	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	0.0	0	0.3	1 (N/A)	0.1	0.31
Black locust	0.9	0.1	0.4	0.0	5	1.6	0.2	0.2	1.5	10	-0.2	-1	4.8	14 (N/A)	0.1	4.62
Black cherry	0.4	0.1	0.2	0.0	2	1.1	0.2	0.2	1.0	7	0.0	0	3.2	9 (N/A)	0.1	3.05
Broadleaf Evergreen Small	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	0.0	0	0.3	1 (N/A)	0.1	0.27
Black ash	0.5	0.1	0.3	0.0	3	1.8	0.3	0.2	1.7	11	-0.1	-1	4.8	14 (N/A)	0.1	6.81
Tulip tree	0.0	0.0	0.0	0.0	0	0.3	0.0	0.0	0.3	2	0.0	0	0.6	2 (N/A)	0.1	0.87
Siberian elm	0.8	0.1	0.4	0.0	4	2.9	0.4	0.4	2.7	18	0.0	0	7.8	22 (N/A)	0.1	11.10
Eastern hophornbeam	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
Dogwood	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	0.11
Ohio buckeye	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

Basswood	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
Eastern cottonwood	0.1	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	0.0	0	2.6	7 (N/A)	0.0	7.42
Ponderosa pine	0.2	0.0	0.1	0.0	1	0.6	0.1	0.1	0.6	4	-0.5	-2	1.2	3 (N/A)	0.0	2.82
Southern magnolia	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)	0.0	0.47
Amur corktree	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
Plum	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)	0.0	0.71
Mountain ash	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.8	5	0.0	0	2.3	7 (N/A)	0.0	6.56
Northern catalpa	0.8	0.1	0.4	0.0	4	1.9	0.3	0.3	1.8	12	0.0	0	5.5	16 (N/A)	0.0	15.71
Maple	0.7	0.1	0.3	0.0	4	1.4	0.2	0.2	1.3	8	-0.2	-1	4.0	12 (N/A)	0.0	11.54
Citywide total	1,163.8	201.4	635.8	65.9	6,501	3,472.5	506.1	482.7	3,303.0	21,650	-1,003.4	-3,763	8,827.7	24,388 (N/A)	100.0	6.55

Table 4: Annual Carbon Stored

Waverly

Stored CO2 Benefits of Public Trees

2/6/2017

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	2,165,302	16,240	(N/A)	12.2	9.4	35.77
Green ash	2,740,153	20,551	(N/A)	10.8	11.9	51.12
Sugar maple	2,364,844	17,736	(N/A)	8.3	10.2	57.77
Silver maple	4,581,641	34,362	(N/A)	7.4	19.8	124.05
Red maple	764,784	5,736	(N/A)	6.8	3.3	22.58
Northern hackberry	1,818,837	13,641	(N/A)	6.5	7.9	56.37
Apple	141,783	1,063	(N/A)	6.0	0.6	4.73
Black walnut	1,397,909	10,484	(N/A)	3.2	6.1	87.37
White ash	646,618	4,850	(N/A)	2.7	2.8	48.02
Honeylocust	406,174	3,046	(N/A)	2.6	1.8	32.07
Littleleaf linden	245,594	1,842	(N/A)	2.2	1.1	22.74
Norway spruce	459,152	3,444	(N/A)	2.1	2.0	43.05
Spruce	130,942	982	(N/A)	2.0	0.6	13.27
Conifer Evergreen La	246,851	1,851	(N/A)	1.6	1.1	31.38
Eastern red cedar	54,185	406	(N/A)	1.6	0.2	7.01
Austrian pine	157,135	1,179	(N/A)	1.5	0.7	21.04
Conifer Evergreen Me	106,588	799	(N/A)	1.3	0.5	17.01
Red pine	107,086	803	(N/A)	1.2	0.5	18.25
Eastern white pine	84,974	637	(N/A)	1.1	0.4	15.17
Northern red oak	374,684	2,810	(N/A)	1.0	1.6	72.05
American basswood	466,617	3,500	(N/A)	1.0	2.0	92.10
Black maple	138,893	1,042	(N/A)	0.9	0.6	29.76
Amur maple	54,316	407	(N/A)	0.9	0.2	12.73
Scotch pine	122,052	915	(N/A)	0.9	0.5	28.61
Swamp white oak	26,926	202	(N/A)	0.8	0.1	6.96
Blue spruce	67,616	507	(N/A)	0.7	0.3	19.50
Ginkgo	48,997	367	(N/A)	0.7	0.2	14.13
Oak	215,594	1,617	(N/A)	0.7	0.9	64.68
Pin oak	349,933	2,625	(N/A)	0.7	1.5	104.98
Ash	177,914	1,334	(N/A)	0.6	0.8	55.60
American elm	171,430	1,286	(N/A)	0.6	0.7	55.90
American sycamore	447,792	3,358	(N/A)	0.6	1.9	146.02
Northern pin oak	215,116	1,613	(N/A)	0.6	0.9	70.15
Bur oak	153,017	1,148	(N/A)	0.5	0.7	57.38
Kentucky coffeetree	62,138	466	(N/A)	0.5	0.3	23.30
Broadleaf Evergreen l	88,167	661	(N/A)	0.5	0.4	33.06
Broadleaf Deciduous	96,299	722	(N/A)	0.5	0.4	40.12
Broadleaf Deciduous	149,012	1,118	(N/A)	0.5	0.6	62.09
River birch	46,339	348	(N/A)	0.4	0.2	23.17
Black spruce	33,457	251	(N/A)	0.4	0.1	16.73
Broadleaf Deciduous	14,471	109	(N/A)	0.4	0.1	7.75
White oak	43,793	328	(N/A)	0.3	0.2	25.27
Birch	54,307	407	(N/A)	0.3	0.2	37.03
Hickory	16,848	126	(N/A)	0.3	0.1	11.49
Broadleaf Evergreen l	50,244	377	(N/A)	0.3	0.2	37.68
Eastern redbud	11,501	86	(N/A)	0.3	0.0	8.63
Elm	2,674	20	(N/A)	0.2	0.0	2.23
Japanese tree lilac	2,213	17	(N/A)	0.2	0.0	2.37
Pear	4,165	31	(N/A)	0.2	0.0	4.46
Northern white cedar	52,432	393	(N/A)	0.2	0.2	56.18
Cottonwood	324,980	2,437	(N/A)	0.2	1.4	348.19
Boxelder	40,130	301	(N/A)	0.2	0.2	43.00
Cherry plum	739	6	(N/A)	0.2	0.0	0.92
Chinese elm	117,705	883	(N/A)	0.1	0.5	176.56
Sumac	24,173	181	(N/A)	0.1	0.1	36.26

Mulberry	15,854	119	(N/A)	0.1	0.1	29.73
Callery pear	3,319	25	(N/A)	0.1	0.0	6.22
Catalpa	24,151	181	(N/A)	0.1	0.1	45.28
Willow	42,840	321	(N/A)	0.1	0.2	107.10
Conifer Evergreen Sn	1,656	12	(N/A)	0.1	0.0	4.14
Lilac	205	2	(N/A)	0.1	0.0	0.51
Black locust	14,314	107	(N/A)	0.1	0.1	35.78
Black cherry	6,934	52	(N/A)	0.1	0.0	17.34
Broadleaf Evergreen !	41	0	(N/A)	0.1	0.0	0.10
Black ash	9,046	68	(N/A)	0.1	0.0	33.92
Tulip tree	371	3	(N/A)	0.1	0.0	1.39
Siberian elm	18,988	142	(N/A)	0.1	0.1	71.20
Eastern hophornbeam	908	7	(N/A)	0.0	0.0	6.81
Dogwood	14	0	(N/A)	0.0	0.0	0.10
Ohio buckeye	14,280	107	(N/A)	0.0	0.1	107.10
Basswood	15,773	118	(N/A)	0.0	0.1	118.30
Eastern cottonwood	3,672	28	(N/A)	0.0	0.0	27.54
Ponderosa pine	1,170	9	(N/A)	0.0	0.0	8.78
Southern magnolia	3	0	(N/A)	0.0	0.0	0.02
Amur corktree	1,101	8	(N/A)	0.0	0.0	8.26
Plum	178	1	(N/A)	0.0	0.0	1.33
Mountain ash	3,037	23	(N/A)	0.0	0.0	22.78
Northern catalpa	25,943	195	(N/A)	0.0	0.1	194.57
Maple	7,945	60	(N/A)	0.0	0.0	59.59
Citywide total	23,098,978	173,242	(N/A)	100.0	100.0	46.56

Table 5: Annual Carbon Sequestered

Waverly

Annual CO Benefits of Public Trees

2/6/2017

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total Standard ($) Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	149,486	1,121	-10,410	-902	-85	154,402	1,158	292,576	2,194 (N/A)	12.2	11.4	4.83
Green ash	192,204	1,442	-13,153	-870	-105	145,140	1,089	323,321	2,425 (N/A)	10.8	12.6	6.03
Sugar maple	143,668	1,078	-11,356	-747	-91	122,243	917	253,809	1,904 (N/A)	8.3	9.9	6.20
Silver maple	347,895	2,609	-21,996	-939	-172	145,004	1,088	469,964	3,525 (N/A)	7.4	18.4	12.72
Red maple	60,168	451	-3,673	-373	-30	64,215	482	120,338	903 (N/A)	6.8	4.7	3.55
Northern hackberry	100,978	757	-8,731	-759	-71	135,789	1,018	227,277	1,705 (N/A)	6.5	8.9	7.04
Apple	14,570	109	-683	-169	-6	15,673	118	29,391	220 (N/A)	6.0	1.1	0.98
Black walnut	77,284	580	-6,710	-341	-53	55,845	419	126,079	946 (N/A)	3.2	4.9	7.88
White ash	48,477	364	-3,116	-199	-25	36,890	277	82,052	615 (N/A)	2.7	3.2	6.09
Honeylocust	41,393	310	-1,958	-156	-16	32,213	242	71,493	536 (N/A)	2.6	2.8	5.64
Littleleaf linden	23,256	174	-1,189	-123	-10	16,088	121	38,031	285 (N/A)	2.2	1.5	3.52
Norway spruce	7,125	53	-2,204	-287	-19	21,793	163	26,427	198 (N/A)	2.1	1.0	2.48
Spruce	7,292	55	-629	-129	-6	11,738	88	18,274	137 (N/A)	2.0	0.7	1.85
Conifer Evergreen Large	7,379	55	-1,185	-170	-10	14,434	108	20,458	153 (N/A)	1.6	0.8	2.60
Eastern red cedar	728	5	-260	-101	-3	9,414	71	9,781	73 (N/A)	1.6	0.4	1.26
Austrian pine	7,405	56	-754	-152	-7	13,391	100	19,889	149 (N/A)	1.5	0.8	2.66
Conifer Evergreen Medium	3,736	28	-512	-108	-5	9,632	72	12,748	96 (N/A)	1.3	0.5	2.03
Red pine	5,761	43	-514	-95	-5	9,283	70	14,434	108 (N/A)	1.2	0.6	2.46
Eastern white pine	3,372	25	-408	-80	-4	7,264	54	10,148	76 (N/A)	1.1	0.4	1.81
Northern red oak	5,454	41	-1,799	-99	-14	12,524	94	16,080	121 (N/A)	1.0	0.6	3.09
American basswood	28,373	213	-2,240	-108	-18	15,673	118	41,698	313 (N/A)	1.0	1.6	8.23
Black maple	15,525	116	-667	-66	-5	12,472	94	27,264	204 (N/A)	0.9	1.1	5.84
Amur maple	2,766	21	-261	-39	-2	4,175	31	6,640	50 (N/A)	0.9	0.3	1.56
Scotch pine	5,215	39	-586	-91	-5	8,035	60	12,572	94 (N/A)	0.9	0.5	2.95
Swamp white oak	3,571	27	-138	-22	-1	2,946	22	6,356	48 (N/A)	0.8	0.2	1.64
Blue spruce	2,739	21	-325	-61	-3	5,211	39	7,565	57 (N/A)	0.7	0.3	2.18
Ginkgo	1,301	10	-235	-36	-2	3,979	30	5,008	38 (N/A)	0.7	0.2	1.44
Oak	11,271	85	-1,035	-54	-8	8,638	65	18,820	141 (N/A)	0.7	0.7	5.65
Pin oak	22,565	169	-1,680	-73	-13	11,645	87	32,459	243 (N/A)	0.7	1.3	9.74
Ash	8,243	62	-854	-62	-7	10,044	75	17,371	130 (N/A)	0.6	0.7	5.43
American elm	5,222	39	-823	-44	-7	7,096	53	11,450	86 (N/A)	0.6	0.4	3.73
American sycamore	14,266	107	-2,149	-76	-17	11,848	89	23,888	179 (N/A)	0.6	0.9	7.79
Northern pin oak	8,241	62	-1,033	-66	-8	10,398	78	17,541	132 (N/A)	0.6	0.7	5.72
Bur oak	5,254	39	-735	-31	-6	4,285	32	8,774	66 (N/A)	0.5	0.3	3.29
Kentucky coffeetree	5,900	44	-299	-27	-2	4,458	33	10,033	75 (N/A)	0.5	0.4	3.76
Broadleaf Evergreen Large	9,101	68	-423	-41	-3	8,738	66	17,374	130 (N/A)	0.5	0.7	6.52
Broadleaf Deciduous Medi	4,595	34	-462	-34	-4	5,392	40	9,490	71 (N/A)	0.5	0.4	3.95
Broadleaf Deciduous Large	9,992	75	-715	-42	-6	6,871	52	16,106	121 (N/A)	0.5	0.6	6.71
River birch	2,279	17	-225	-21	-2	3,007	23	5,039	38 (N/A)	0.4	0.2	2.52
Black spruce	1,846	14	-161	-36	-1	3,252	24	4,901	37 (N/A)	0.4	0.2	2.45
Broadleaf Deciduous Small	250	2	-70	-11	-1	895	7	1,064	8 (N/A)	0.4	0.0	0.57
White oak	4,219	32	-210	-19	-2	3,310	25	7,300	55 (N/A)	0.3	0.3	4.21
Birch	3,627	27	-261	-22	-2	3,462	26	6,806	51 (N/A)	0.3	0.3	4.64
Hickory	2,168	16	-81	-12	-1	1,624	12	3,699	28 (N/A)	0.3	0.2	2.52
Broadleaf Evergreen Medi	1,721	13	-241	-25	-2	4,514	34	5,969	45 (N/A)	0.3	0.2	4.48
Eastern redbud	633	5	-55	-11	0	1,010	8	1,577	12 (N/A)	0.3	0.1	1.18
Elm	651	5	-13	-5	0	481	4	1,114	8 (N/A)	0.2	0.0	0.93
Japanese tree lilac	330	2	-11	-4	0	340	3	654	5 (N/A)	0.2	0.0	0.70
Pear	569	4	-20	-6	0	608	5	1,151	9 (N/A)	0.2	0.0	1.23
Northern white cedar	256	2	-252	-34	-2	2,177	16	2,147	16 (N/A)	0.2	0.1	2.30
Cottonwood	5,085	38	-1,560	-38	-12	5,376	40	8,863	66 (N/A)	0.2	0.3	9.50
Boxelder	3,795	28	-193	-16	-2	2,310	17	5,896	44 (N/A)	0.2	0.2	6.32
Cherry plum	169	1	-4	-3	0	160	1	323	2 (N/A)	0.2	0.0	0.40
Chinese elm	1,821	14	-565	-16	-4	2,336	18	3,576	27 (N/A)	0.1	0.1	5.36
Sumac	1,817	14	-116	-11	-1	1,437	11	3,127	23 (N/A)	0.1	0.1	4.69
Mulberry	1,281	10	-76	-9	-1	1,260	9	2,457	18 (N/A)	0.1	0.1	4.61
Callery pear	677	5	-16	-4	0	535	4	1,192	9 (N/A)	0.1	0.0	2.24
Catalpa	1,956	15	-116	-9	-1	1,497	11	3,329	25 (N/A)	0.1	0.1	6.24
Willow	0	0	-206	-13	-2	1,616	12	1,397	10 (N/A)	0.1	0.1	3.49
Conifer Evergreen Small	80	1	-8	-4	0	351	3	418	3 (N/A)	0.1	0.0	1.05
Lilac	55	0	-1	-1	0	48	0	102	1 (N/A)	0.1	0.0	0.25
Black locust	11	0	-69	-5	-1	553	4	490	4 (N/A)	0.1	0.0	1.23
Black cherry	47	0	-33	-4	0	378	3	387	3 (N/A)	0.1	0.0	0.97
Broadleaf Evergreen Small	13	0	0	-1	0	42	0	54	0 (N/A)	0.1	0.0	0.13
Black ash	694	5	-43	-4	0	616	5	1,262	9 (N/A)	0.1	0.0	4.73
Tulip tree	148	1	-2	-1	0	97	1	243	2 (N/A)	0.1	0.0	0.91
Siberian elm	1,124	8	-91	-6	-1	1,009	8	2,036	15 (N/A)	0.1	0.1	7.63

Eastern hophornbeam	114	1	-4	-1	0	124	1	232	2 (N/A)	0.0	0.0	1.74
Dogwood	9	0	0	0	0	6	0	14	0 (N/A)	0.0	0.0	0.10
Ohio buckeye	370	3	-69	-4	-1	539	4	837	6 (N/A)	0.0	0.0	6.27
Basswood	857	6	-76	-4	-1	552	4	1,330	10 (N/A)	0.0	0.1	9.97
Eastern cottonwood	445	3	-18	-2	0	393	3	819	6 (N/A)	0.0	0.0	6.14
Ponderosa pine	116	1	-6	-2	0	216	2	324	2 (N/A)	0.0	0.0	2.43
Southern magnolia	1	0	0	0	0	26	0	27	0 (N/A)	0.0	0.0	0.20
Amur corktree	224	2	-5	-1	0	176	1	393	3 (N/A)	0.0	0.0	2.95
Plum	38	0	-1	-1	0	37	0	74	1 (N/A)	0.0	0.0	0.55
Mountain ash	268	2	-15	-2	0	308	2	560	4 (N/A)	0.0	0.0	4.20
Northern catalpa	960	7	-125	-4	-1	650	5	1,481	11 (N/A)	0.0	0.1	11.11
Maple	923	7	-38	-3	0	477	4	1,359	10 (N/A)	0.0	0.1	10.20
Citywide total	1,453,419	10,901	-110,952	-8,146	-893	1,222,681	9,170	2,557,002	19,178 (N/A)	100.0	100.0	5.15

Table 6: Annual Social and Aesthetic Benefits

Waverly

Annual Aesthetic/Other Benefits of Public Trees

2/6/2017

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	14,941	(N/A)	12.2	9.7	32.91
Green ash	18,128	(N/A)	10.8	11.8	45.09
Sugar maple	15,768	(N/A)	8.3	10.3	51.36
Silver maple	27,538	(N/A)	7.4	17.9	99.42
Red maple	8,249	(N/A)	6.8	5.4	32.48
Northern hackberry	13,588	(N/A)	6.5	8.8	56.15
Apple	796	(N/A)	6.0	0.5	3.54
Black walnut	6,517	(N/A)	3.2	4.2	54.31
White ash	5,741	(N/A)	2.7	3.7	56.84
Honeylocust	9,255	(N/A)	2.6	6.0	97.42
Littleleaf linden	2,734	(N/A)	2.2	1.8	33.76
Norway spruce	1,152	(N/A)	2.1	0.8	14.40
Spruce	1,801	(N/A)	2.0	1.2	24.34
Conifer Evergreen Large	1,502	(N/A)	1.6	1.0	25.46
Eastern red cedar	312	(N/A)	1.6	0.2	5.37
Austrian pine	1,059	(N/A)	1.5	0.7	18.90
Conifer Evergreen Medium	764	(N/A)	1.3	0.5	16.26
Red pine	1,274	(N/A)	1.2	0.8	28.95
Eastern white pine	833	(N/A)	1.1	0.5	19.83
Northern red oak	430	(N/A)	1.0	0.3	11.03
American basswood	2,075	(N/A)	1.0	1.4	54.61
Black maple	2,065	(N/A)	0.9	1.3	58.99
Amur maple	155	(N/A)	0.9	0.1	4.83
Scotch pine	1,177	(N/A)	0.9	0.8	36.77
Swamp white oak	441	(N/A)	0.8	0.3	15.22
Blue spruce	394	(N/A)	0.7	0.3	15.15
Ginkgo	124	(N/A)	0.7	0.1	4.78
Oak	1,024	(N/A)	0.7	0.7	40.96
Pin oak	1,824	(N/A)	0.7	1.2	72.96
Ash	792	(N/A)	0.6	0.5	32.98
American elm	739	(N/A)	0.6	0.5	32.14
American sycamore	1,125	(N/A)	0.6	0.7	48.93
Northern pin oak	762	(N/A)	0.6	0.5	33.14
Bur oak	504	(N/A)	0.5	0.3	25.20
Kentucky coffeetree	613	(N/A)	0.5	0.4	30.63
Broadleaf Evergreen Large	2,002	(N/A)	0.5	1.3	100.12
Broadleaf Deciduous Medium	457	(N/A)	0.5	0.3	25.38
Broadleaf Deciduous Large	864	(N/A)	0.5	0.6	47.99
River birch	260	(N/A)	0.4	0.2	17.35
Black spruce	308	(N/A)	0.4	0.2	20.57
Broadleaf Deciduous Small	11	(N/A)	0.4	0.0	0.75
White oak	429	(N/A)	0.3	0.3	32.97
Birch	361	(N/A)	0.3	0.2	32.78
Hickory	272	(N/A)	0.3	0.2	24.77
Broadleaf Evergreen Medium	276	(N/A)	0.3	0.2	27.60
Eastern redbud	34	(N/A)	0.3	0.0	3.42
Elm	122	(N/A)	0.2	0.1	13.60
Japanese tree lilac	17	(N/A)	0.2	0.0	2.43

Pear	32 (N/A)	0.2	0.0	4.54
Northern white cedar	26 (N/A)	0.2	0.0	3.75
Cottonwood	319 (N/A)	0.2	0.2	45.58
Boxelder	312 (N/A)	0.2	0.2	44.62
Cherry plum	8 (N/A)	0.2	0.0	1.38
Chinese elm	160 (N/A)	0.1	0.1	32.02
Sumac	108 (N/A)	0.1	0.1	21.66
Mulberry	75 (N/A)	0.1	0.0	18.81
Callery pear	81 (N/A)	0.1	0.1	20.35
Catalpa	186 (N/A)	0.1	0.1	46.46
Willow	0 (N/A)	0.1	0.0	0.00
Conifer Evergreen Small	43 (N/A)	0.1	0.0	14.23
Lilac	2 (N/A)	0.1	0.0	0.71
Black locust	5 (N/A)	0.1	0.0	1.82
Black cherry	2 (N/A)	0.1	0.0	0.70
Broadleaf Evergreen Small	1 (N/A)	0.1	0.0	0.50
Black ash	69 (N/A)	0.1	0.0	34.64
Tulip tree	29 (N/A)	0.1	0.0	14.73
Siberian elm	86 (N/A)	0.1	0.1	42.97
Eastern hophornbeam	6 (N/A)	0.0	0.0	6.40
Dogwood	0 (N/A)	0.0	0.0	0.03
Ohio buckeye	31 (N/A)	0.0	0.0	31.46
Basswood	66 (N/A)	0.0	0.0	65.59
Eastern cottonwood	46 (N/A)	0.0	0.0	45.86
Ponderosa pine	32 (N/A)	0.0	0.0	32.32
Southern magnolia	0 (N/A)	0.0	0.0	0.01
Amur corktree	26 (N/A)	0.0	0.0	26.22
Plum	2 (N/A)	0.0	0.0	2.06
Mountain ash	15 (N/A)	0.0	0.0	15.48
Northern catalpa	67 (N/A)	0.0	0.0	66.60
Maple	109 (N/A)	0.0	0.1	109.08
Citywide total	153,557 (N/A)	100.0	100.0	41.27

Table 7: Summary of Benefits in Dollars

Waverly

Total Annual Benefits of Public Trees by Species ($)

2/6/2017

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Norway maple	19,633	2,194	3,345	19,462	14,941	59,575	(N/A)	10.7
Green ash	17,795	2,425	3,010	21,257	18,128	62,614	(N/A)	11.3
Sugar maple	15,011	1,904	2,360	18,513	15,768	53,556	(N/A)	9.6
Silver maple	17,695	3,525	3,226	32,006	27,538	83,990	(N/A)	15.1
Red maple	8,038	903	1,418	8,270	8,249	26,878	(N/A)	4.8
Northern hackberry	17,427	1,705	3,084	20,719	13,588	56,523	(N/A)	10.2
Apple	2,204	220	329	960	796	4,509	(N/A)	0.8
Black walnut	6,949	946	1,217	9,581	6,517	25,208	(N/A)	4.5
White ash	4,339	615	842	6,227	5,741	17,764	(N/A)	3.2
Honeylocust	3,959	536	649	4,690	9,255	19,089	(N/A)	3.4
Littleleaf linden	2,038	285	326	2,066	2,734	7,449	(N/A)	1.3
Norway spruce	2,669	198	-46	8,079	1,152	12,053	(N/A)	2.2
Spruce	1,439	137	89	3,203	1,801	6,669	(N/A)	1.2
Conifer Evergreen Large	1,747	153	27	4,828	1,502	8,257	(N/A)	1.5
Eastern red cedar	1,242	73	108	2,219	312	3,954	(N/A)	0.7
Austrian pine	1,665	149	185	3,429	1,059	6,487	(N/A)	1.2
Conifer Evergreen Medi	1,201	96	135	2,371	764	4,567	(N/A)	0.8
Red pine	1,099	108	67	2,492	1,274	5,040	(N/A)	0.9
Eastern white pine	870	76	50	1,929	833	3,757	(N/A)	0.7
Northern red oak	1,598	121	222	2,148	430	4,520	(N/A)	0.8
American basswood	2,034	313	308	2,641	2,075	7,371	(N/A)	1.3
Black maple	1,521	204	270	1,532	2,065	5,593	(N/A)	1.0
Amur maple	569	50	94	302	155	1,169	(N/A)	0.2
Scotch pine	980	94	32	2,627	1,177	4,910	(N/A)	0.9
Swamp white oak	407	48	60	300	441	1,256	(N/A)	0.2
Blue spruce	657	57	75	1,345	394	2,527	(N/A)	0.5
Ginkgo	485	38	84	389	124	1,121	(N/A)	0.2
Oak	1,066	141	187	1,410	1,024	3,829	(N/A)	0.7
Pin oak	1,423	243	185	2,017	1,824	5,693	(N/A)	1.0
Ash	1,295	130	229	1,465	792	3,910	(N/A)	0.7
American elm	871	86	169	963	739	2,828	(N/A)	0.5
American sycamore	1,471	179	280	2,318	1,125	5,373	(N/A)	1.0
Northern pin oak	1,355	132	246	1,675	762	4,169	(N/A)	0.7
Bur oak	534	66	100	829	504	2,033	(N/A)	0.4
Kentucky coffeetree	545	75	89	579	613	1,900	(N/A)	0.3
Broadleaf Evergreen Lar	990	130	98	1,582	2,002	4,803	(N/A)	0.9
Broadleaf Deciduous M	702	71	123	789	457	2,142	(N/A)	0.4
Broadleaf Deciduous La	867	121	147	1,129	864	3,128	(N/A)	0.6
River birch	400	38	67	403	260	1,167	(N/A)	0.2
Black spruce	406	37	45	806	308	1,602	(N/A)	0.3
Broadleaf Deciduous Sn	125	8	21	74	11	239	(N/A)	0.0
White oak	396	55	66	412	429	1,357	(N/A)	0.2
Birch	459	51	77	477	361	1,425	(N/A)	0.3
Hickory	203	28	32	191	272	725	(N/A)	0.1
Broadleaf Evergreen Me	498	45	85	748	276	1,651	(N/A)	0.3
Eastern redbud	145	12	22	70	34	283	(N/A)	0.1
Elm	61	8	9	49	122	250	(N/A)	0.0
Japanese tree lilac	50	5	7	19	17	97	(N/A)	0.0

Pear	89	9	12	34	32	176 (N/A)	0.0
Northern white cedar	267	16	-11	874	26	1,172 (N/A)	0.2
Cottonwood	660	66	144	1,373	319	2,563 (N/A)	0.5
Boxelder	287	44	46	341	312	1,030 (N/A)	0.2
Cherry plum	23	2	3	8	8	45 (N/A)	0.0
Chinese elm	283	27	59	465	160	993 (N/A)	0.2
Sumac	195	23	34	121	108	481 (N/A)	0.1
Mulberry	161	18	28	86	75	368 (N/A)	0.1
Callery pear	75	9	11	48	81	223 (N/A)	0.0
Catalpa	180	25	30	203	186	624 (N/A)	0.1
Willow	213	10	41	306	0	570 (N/A)	0.1
Conifer Evergreen Smal	48	3	3	80	43	177 (N/A)	0.0
Lilac	7	1	1	2	2	13 (N/A)	0.0
Black locust	73	4	14	103	5	199 (N/A)	0.0
Black cherry	52	3	9	34	2	100 (N/A)	0.0
Broadleaf Evergreen Sm	6	0	1	2	1	11 (N/A)	0.0
Black ash	83	9	14	83	69	259 (N/A)	0.0
Tulip tree	12	2	2	9	29	54 (N/A)	0.0
Siberian elm	128	15	22	153	86	405 (N/A)	0.1
Eastern hophornbeam	18	2	3	7	6	36 (N/A)	0.0
Dogwood	1	0	0	0	0	1 (N/A)	0.0
Ohio buckeye	71	6	14	102	31	224 (N/A)	0.0
Basswood	71	10	12	107	66	266 (N/A)	0.0
Eastern cottonwood	44	6	7	40	46	143 (N/A)	0.0
Ponderosa pine	24	2	3	42	32	103 (N/A)	0.0
Southern magnolia	4	0	0	2	0	6 (N/A)	0.0
Amur corktree	24	3	3	16	26	73 (N/A)	0.0
Plum	5	1	1	2	2	11 (N/A)	0.0
Mountain ash	38	4	7	18	15	82 (N/A)	0.0
Northern catalpa	82	11	16	149	67	324 (N/A)	0.1
Maple	61	10	12	78	109	269 (N/A)	0.0
Citywide Total	**152,420**	**19,178**	**24,388**	**206,473**	**153,557**	**556,016 (N/A)**	**100.0**
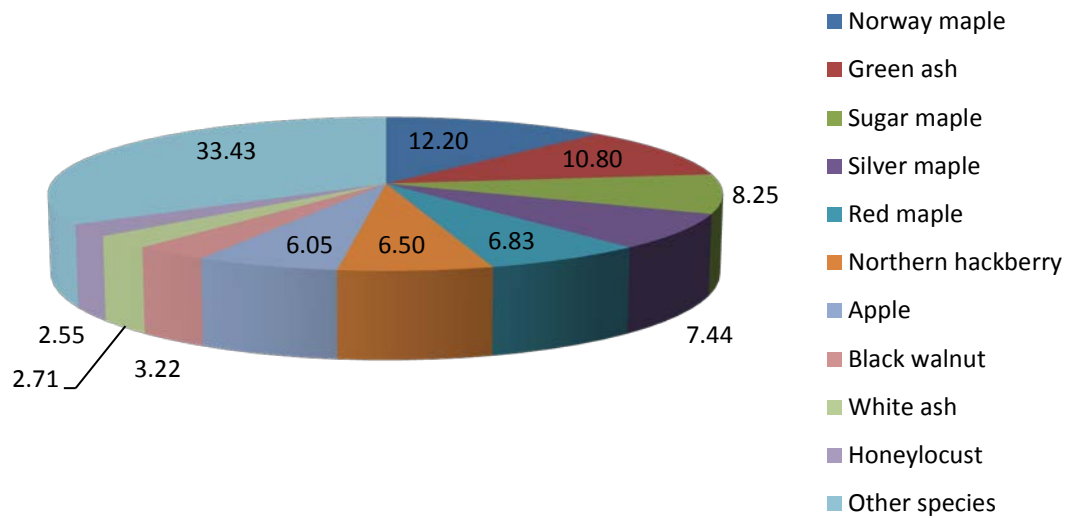
Figure 1: Species Distribution

Relative Age Distribution of Top 10 Public Tree Species (%)
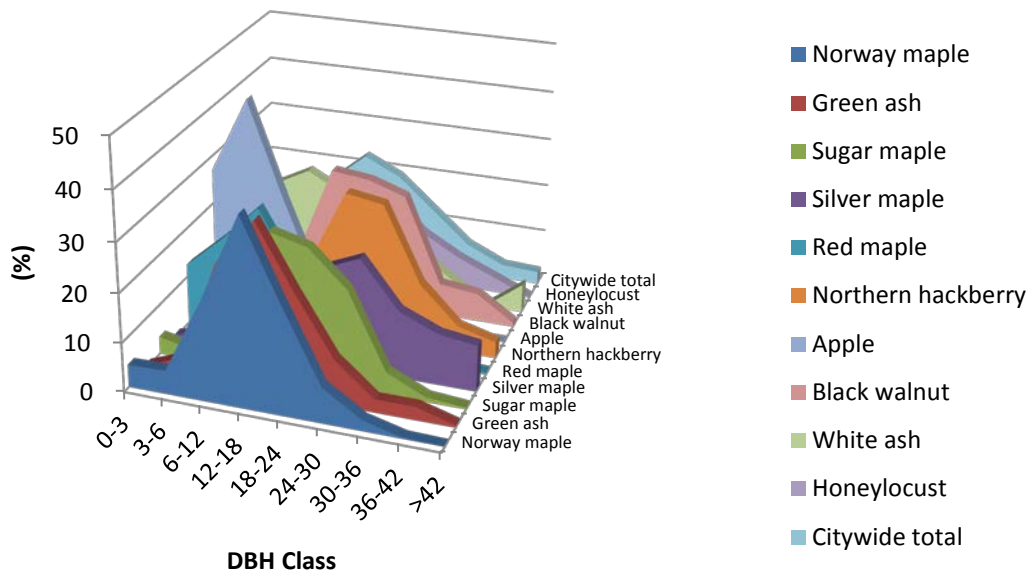
Figure 2: Relative Age Class

Leaf Condition

Dead or Dying 1%
Poor 5%
Fair 27%
Good 67%

- Dead or Dying
- Poor
- Fair
- Good
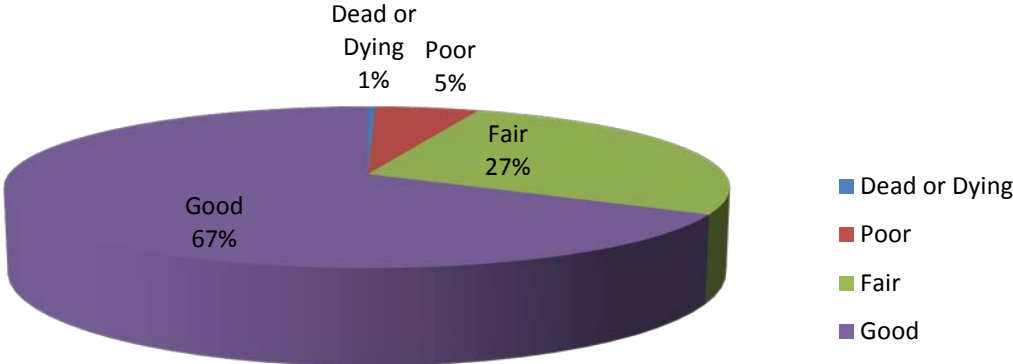
Figure 3: Foliage Condition

Wood Condition

Dead or Dying 1%
Poor 8%
Fair 34%
Good 57%

- Dead or Dying
- Poor
- Fair
- Good
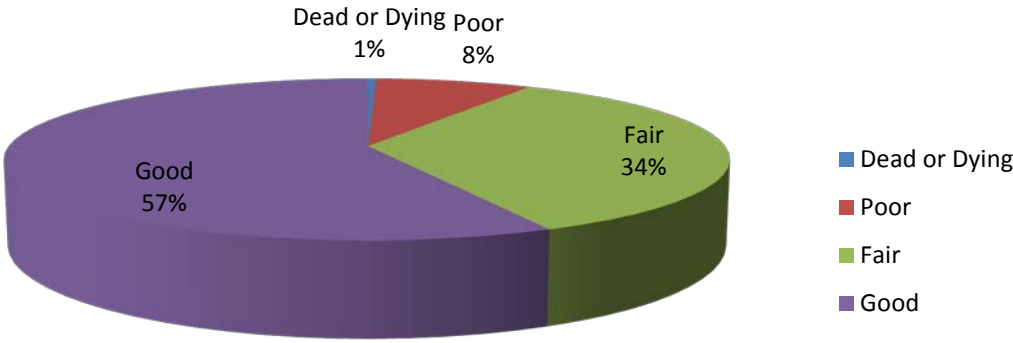
Figure 4: Wood Condition

Canopy Cover
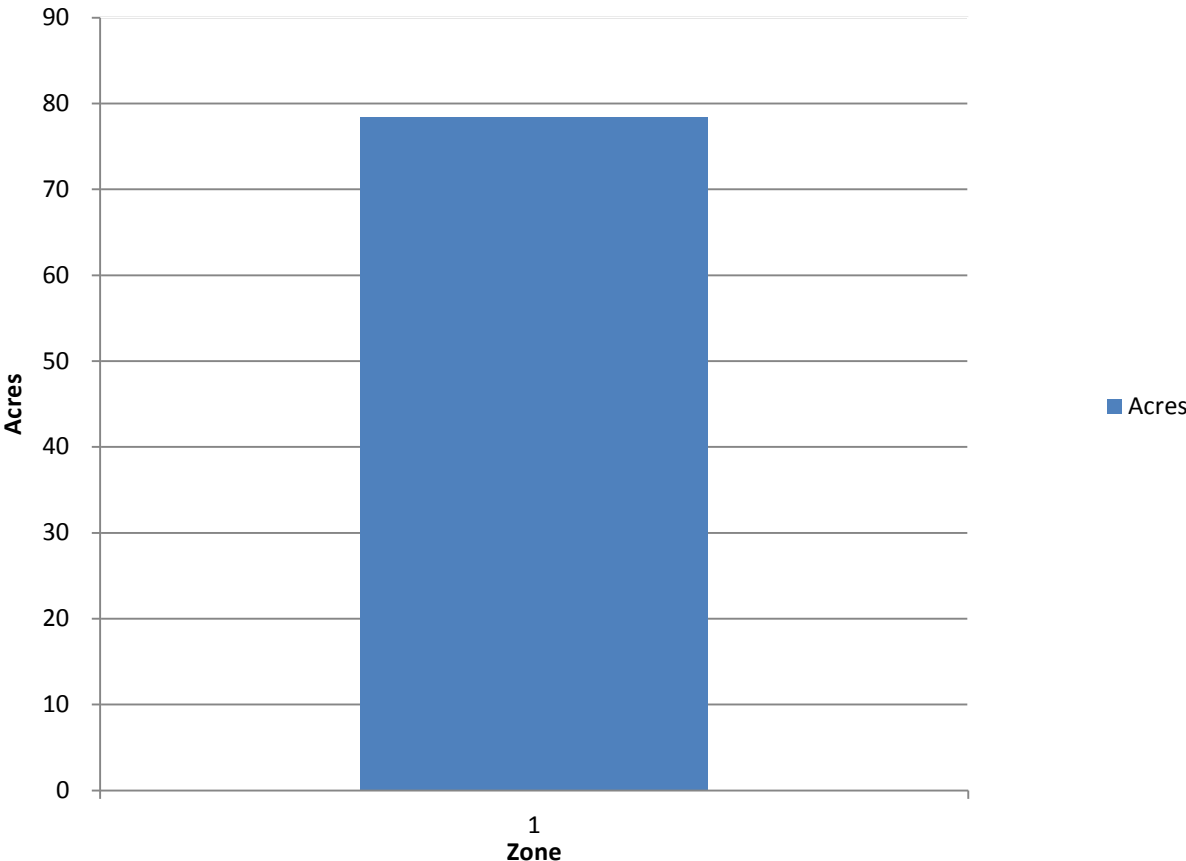
Figure 5: Canopy Cover in Acres

Land use Public Trees by Zone (%)
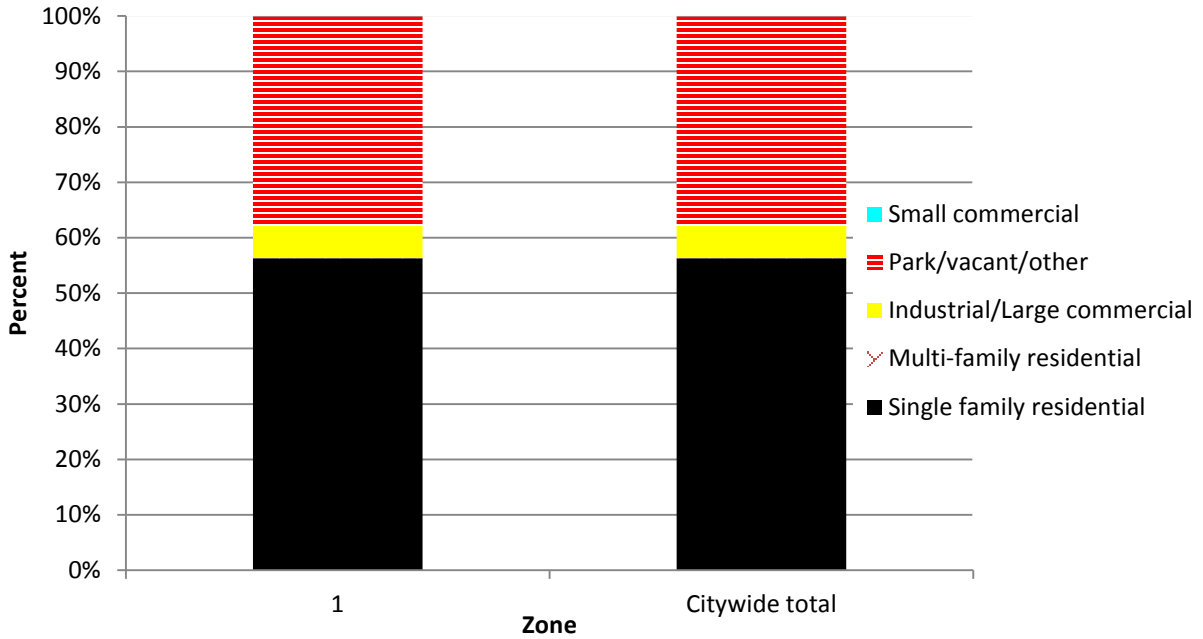
Figure 6: Land Use of city/park trees

Location Public Trees by Zone (%)
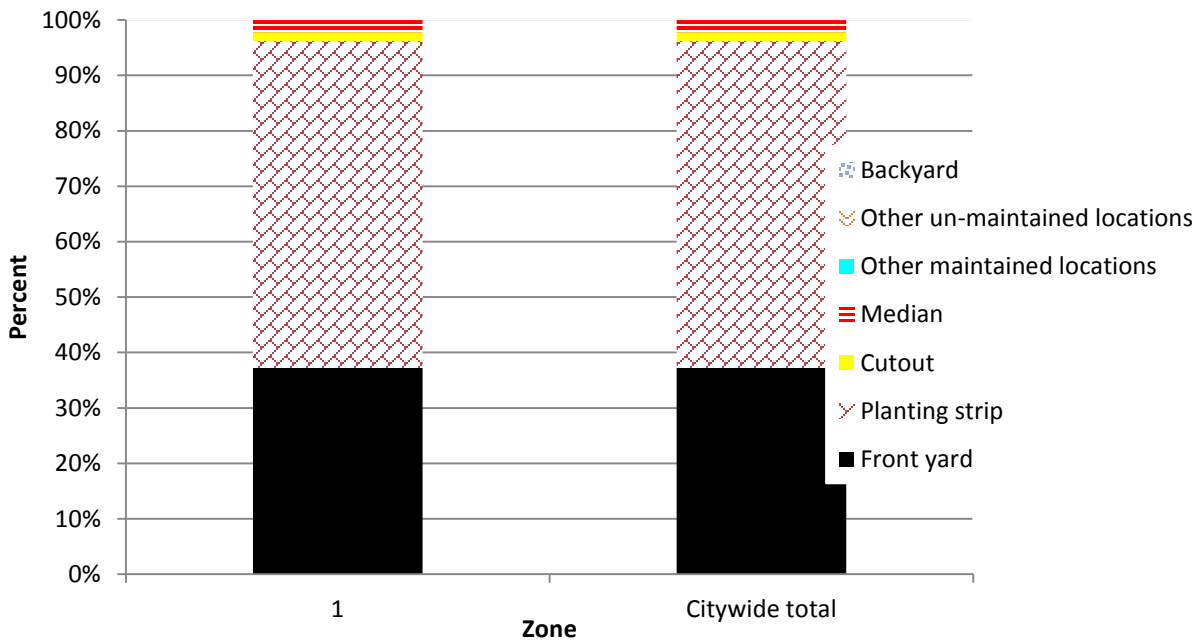
Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping
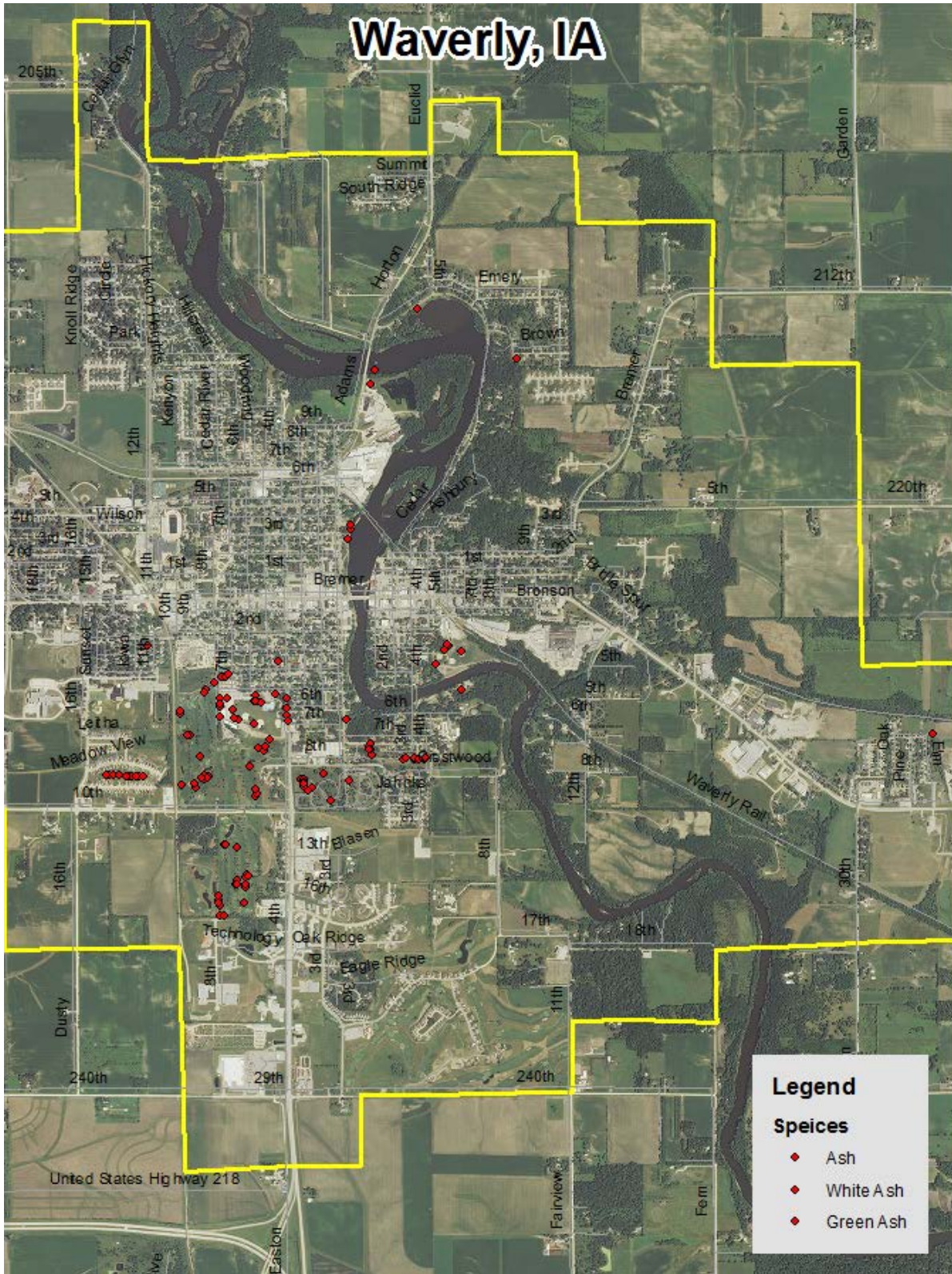
Figure 1: Park Location of Ash Trees
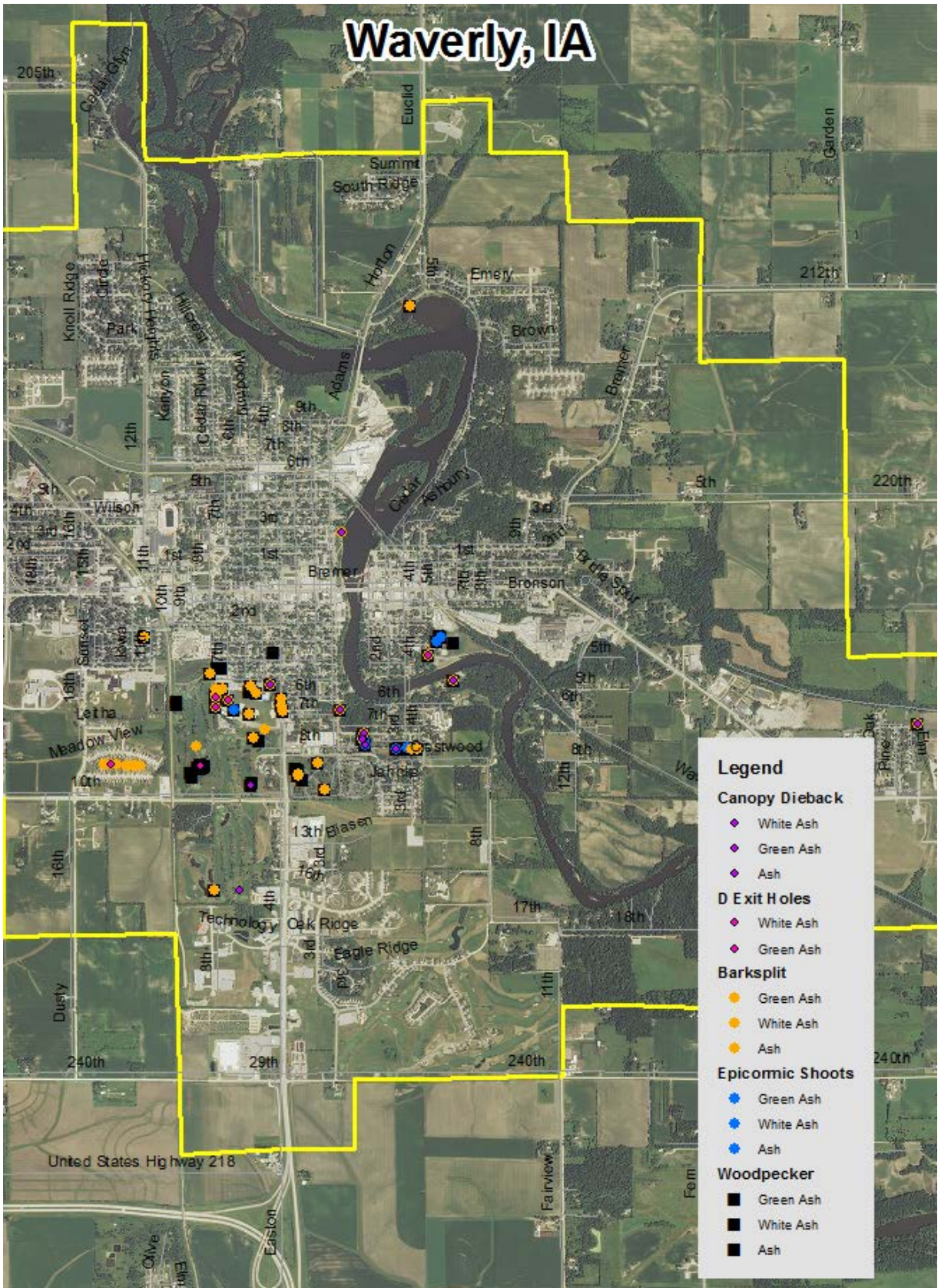
Figure 2: Park Location of EAB symptoms
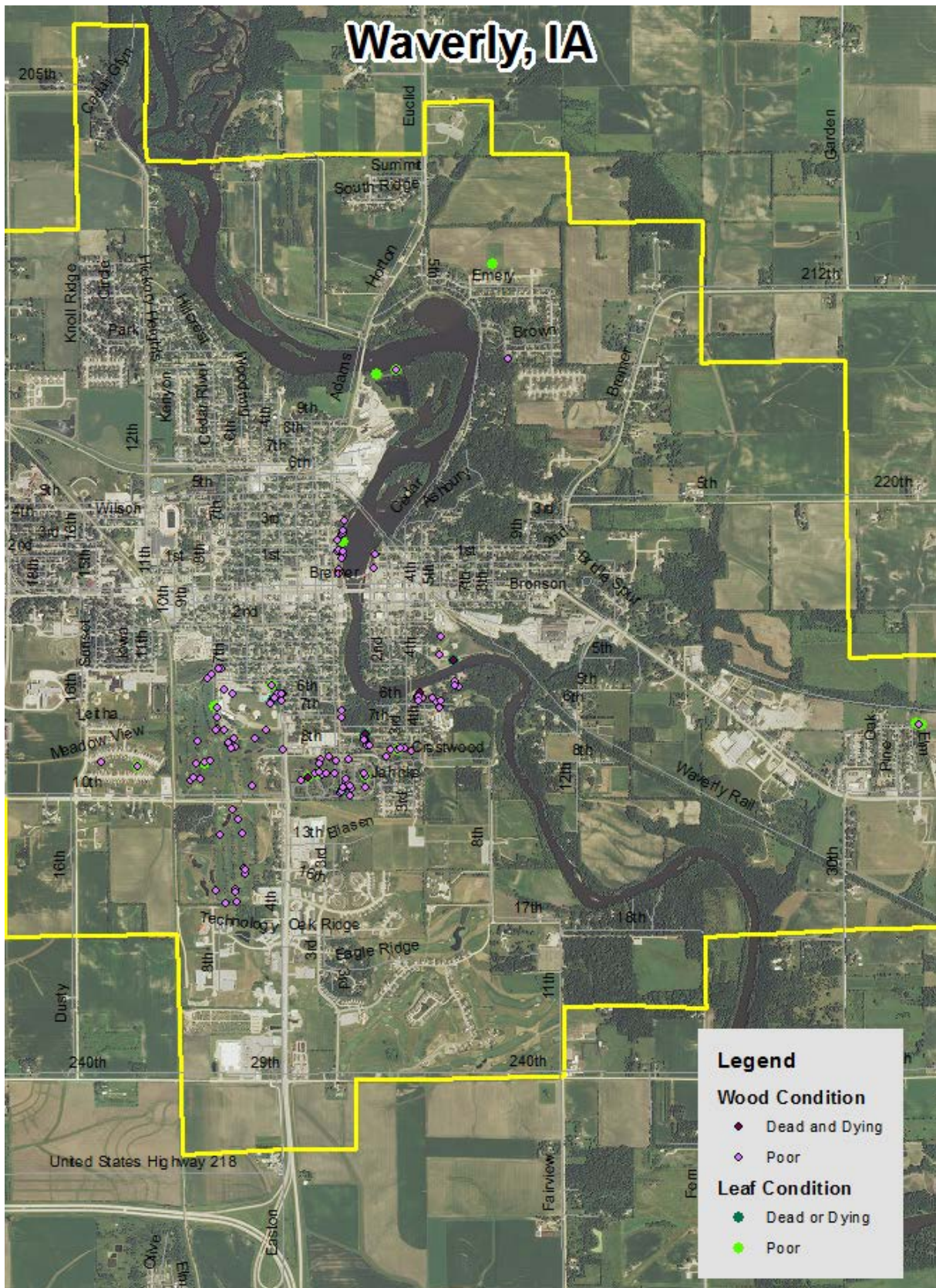
Figure 3: Park Location of Poor Condition Trees

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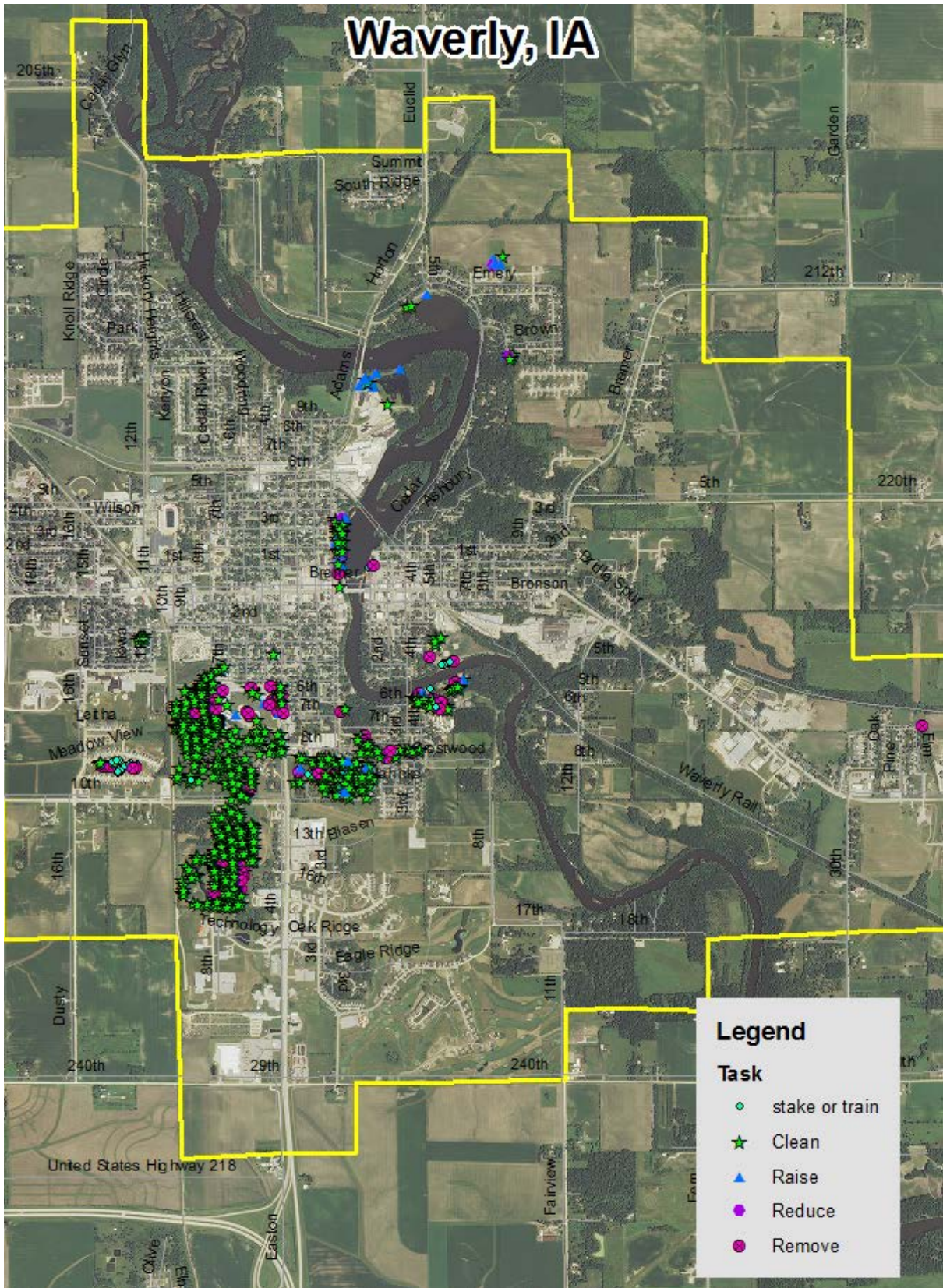
Figure 5: Park Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

Appendix C: Waverly Tree Ordinances

CHAPTER 57 TREE ORDINANCE

Sections:
57.1 Purpose.
57.2 Definitions.
57.3 Permit Required.
57.4 Business of Removing, Cutting, Trimming to be Licensed, Fees.
57.5 Permits and Licenses--Exemptions.
57.6 Bond or Evidence of Insurance.
57.7 Worker's Compensation Policy.
57.8 Felling of Trees/Limbs Onto Streets.
57.9 Materials Used on Trees Needs Permit.
57.10 Pollutants to Trees Not Allowed.
57.11 Arboricultural Specifications and Standards of Practice.
57.12 Removal of Trees.
57.13 Duty to Trim Trees.
57.14 Container Planting.
57.15 Erect Barriers for Protection of Trees.
57.16 Destroying of Trees.
57.17 Penalty.

SEC. 57.1 PURPOSE. The purpose of this chapter is to beautify and preserve the appearance of the city by requiring street trees to be uniformly located and maintained. The primary responsibility for maintaining street trees is placed upon the abutting property owner or his designated agent, and the director shall personally supervise any extensive trimming or cutting of said trees.

SEC. 57.2 DEFINITIONS. For use in this chapter, the following terms are defined:
    1. The term "person" shall mean any individual, firm, corporation, trust, association or any other organized group.
    2. The term "street" shall mean the entire width between property lines of avenues or highways.
    3. The term "parking" shall mean 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.
    4. The term "property owner" shall mean a person owning private property in the city as shown by the county auditor's plats of the city.
    5. The term "public property" shall mean any and all property located within the confines of the city and owned by the city or held in the name of the city by any of the departments, commissions or agencies within the city government.
    6. The term "director" shall mean the leisure services director.

SEC. 57.3 PERMIT REQUIRED.

        1.   Except as allowed in Section 57.13, no person shall cut or remove any plant, tree or shrub
on the streets or on public property without first obtaining a permit from the director, who
shall issue said permit if the proposed work is necessary and the proposed methods and workmanship are satisfactory.

        2. The director may demand the posting of bond or insurance before the permit is granted. Such bond or insurance shall be of sufficient amount to reasonably cover any damages that may occur to life or property while the provisions of the permit are being carried out.

        3. Every permit granted in accordance with this section by the director shall describe the work to be done, the estimated cost, define the species, sizes and location of all trees and shrubs concerned and contain a definite date of expiration.

        4. Any permit may be declared void if the terms are violated.

SEC. 57.4 BUSINESS OF REMOVING, CUTTING, TRIMMING TO BE LICENSED, FEES.

        1. No person shall engage in the business of removing, cutting or trimming of trees or shrubbery in the city without first obtaining a license therefor. The applicant shall submit written application to the director setting forth his experience and qualifications. Upon determination by the director that he is qualified he shall be granted a license which shall allow the removal, cutting and trimming of trees and shrubbery in the city, which shall be an annual license commencing January 1, and terminating December 31, of each year. The license fee shall be established by resolution of the city council and shall be paid prior to the issuance of the license. No trimming, cutting or removal shall be done until the license has been obtained.

        2. In addition, applicants may be required to pass a test designed and administered by the director.

SEC. 57.5 PERMITS AND LICENSES--EXEMPTIONS. The preceding section relating to permits and licenses shall not apply to the following:

        1. The United States of America, the State of Iowa, any county, municipality or political subdivisions of the State, any department, bureau or agency of any of the foregoing or any official representative of any of the forgoing in pursuit of official duties.

        2. Any person with reference to trees and shrubs on his own premises;

        3. Any individual performing labor or services on or in connection with trees at the direction and under the personal supervision of a licensed tree trimmer while in the performance of such functions;

        4. Any public utility engaged in tree trimming and/or tree removal for the purpose of line clearance in order to insure the continuity of utility service to the public.

        5. Trimming or cutting which is in compliance with Section 57.13.

SEC. 57.6 BOND OR EVIDENCE OF INSURANCE. Any person, before engaging in the business or occupation of removing, cutting or trimming trees or shrubbery in the city, shall deposit with the director a good and sufficient bond or evidence of insurance in the sum of not less than ten thousand dollars ($10,000.00), provide evidence of liability insurance in the sum of One hundred thousand dollars

($100,000.00), conditioned that such person shall faithfully comply with the provisions of this chapter and shall indemnify, save and keep harmless the city and its officers from any and all claims, damages and losses and actions by reason of any acts or things done under or by authority or permission granted herein.

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SEC. 57.7 WORKER'S COMPENSATION POLICY. Any person, before engaging in the business or occupation of removing, cutting or trimming trees in the city shall furnish satisfactory evidence to the director that the workers employed by that person are covered by a suitable worker's compensation policy according to the laws of that State.

SEC. 57.8 FELLING OF TREES/LIMBS ONTO STREETS. If a tree or limb will fall on any street, alley or sidewalk, the director must be notified prior to felling.
      1. Safety requirements. The person to whom the permit is issued shall be responsible for placing such signs, flags, flares and barricades as are needed to warn persons of the danger of using the street, sidewalk or alley.
      2. Trees or branches which are felled or trimmed onto public property must be removed immediately unless an extension of time is granted by the director in writing.
      3. Stump removal cavities must be cleared and refilled with soil in the same operation. At no time shall a cavity remain unfilled overnight.

SEC. 57.9 MATERIALS USED ON TREES NEED PERMIT. No person shall fasten any sign, box, wire, rope or other material to, around or through any tree or shrub in any street, park or public place in the city except by the permission of the director or when such materials are designed to preserve such tree or shrub and have been placed under a permit granted by the director.

SEC. 57.10 POLLUTANTS TO TREES NOT ALLOWED. No person shall deposit, place, store or maintain upon any street, park or public place in the city any stone, brick, sand, concrete or other material which shall impede the free passage of water, air and fertilizer to the roots of any tree or shrub growing therein except by permission of the director or when such materials are designed for the construction of sidewalks, pavement, gutters or other public improvements under a permit granted by the city or some department thereof.

SEC. 57.11 ARBORICULTURAL SPECIFICATIONS AND STANDARDS OF PRACTICE.
      1. Location.
            a. Whenever possible trees should be planted inside the property lines and not between the sidewalk and the curb.
            b. All trees and shrubs hereafter planted in any street shall be planted midway between the outer line of the sidewalk and the curb. In the event a curb line is not established, trees shall not be planted within 10 feet from the near edge of the road.
            c. Trees shall not be planted on the parking if said parking is less than 12' in length and 4 feet 9 inches in depth (sidewalk to curb), or contains less than 50 square feet of exposed soil or grass surface.
            d. Trees shall not be planted closer than 20 feet to the street intersections (property lines extended) and 4 feet 9 inches from any driveway.

e. No tree that will attain a mature height of 30' tall may be planted under existing utility lines.

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2. Nuisance. The following trees are not permitted to be planted in any street or public place in the city:

Boxelder	Siberian Elm	Chinese Elm
Cottonwood White	Poplar	Lombardy Poplar
Boileana Poplar	Willows	Tree of Heaven
American Elm	Silver Maple	Catalpa
Black Locust	Weeping Birch	European Mt. Ash
Poplar	Fruit Trees (except ornamentals)	
or any species of Ash.		

**No conifers or evergreens should be planted between the sidewalk and the curb of any city street for safety and visibility considerations. See director for trees recommended for planting.

3. Method of support. Trees may be guyed or supported in an upright position according to accepted arboricultural practices. The guys or supports shall be fastened in such a way that they will not girdle or cause serious injury to the trees or endanger public safety.

4. Trimming or pruning.

a. All public tree trimming or pruning shall utilize Natural Target Puning Practice now commonly accepted by the United States Forest Service. All efforts to protect the Branch Collar will be the responsibility of the tree trimmer or pruner.

b. All limbs over 1 inch in diameter must be bottom cut first to prevent striping of bark as limbs fall. Any limbs which endanger other limbs, trees or property shall be lowered to the ground - not felled.

c. To avoid the spreading of disease, tools shall be disinfected with alcohol before use on another tree.

SEC. 57.12 REMOVAL OF TREES. The director shall remove, on the order of the council, any tree on the streets of this municipality which interferes with the making of improvements or with travel thereon. He shall additionally remove any trees on the street, not on private property, which have become diseased, or which constitutes a threat to the public, or which may otherwise be declared a nuisance by the director. The Director or his Designee has the right to determine a Hazardous tree on private property that is a threat to public safety, and issue a 30 day notice to remove to the owner. If not removed in 30 days, the city shall remove it at the owner's expense and bill accordingly on their property taxes. The owner has the right to appeal said decision in front of the Forestry Committee within the 30 day period.

SEC. 57.13 DUTY TO TRIM TREES. The owner of property abutting a street shall keep the trees on his property or on the parking and overhanging the street, trimmed so that all branches will be at least (16) feet above the surface of the street and at least (8) eight feet above the sidewalks.

SEC. 57.14 CONTAINER PLANTING. No individual or firm shall establish a container either above or below ground for plants or trees on public property without a permit from the director. The petitioner shall submit a request complete with a design detail to the director prior to the issuance of said permit.

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    1. Requirements.
        a. Provisions in Section 57.11. Arboricultural specifications and standards of practice, must be met.
        b. The planting medium must be of sufficient size to support and sustain the plants and the container shall not be less than 24 inches in depth and 30 inches in diameter, inside dimensions.
        c. All costs arising from the establishment, maintenance or removal of plants or plant containers will be born by the abutting property owner.
        d. Plants, containers and their contents must be maintained in the conditions specified by original design at all times. Any planter not serving its designed aesthetic function shall be replanted or removed.
    2. Notice to replant or remove. Any container and plant material not maintained to quality and designed standard as required by the director is hereby declared a nuisance, and must be abated by abutting property owner.
    3. Freedom from liability. Any individual or firm granted the right to place or establish containers on public property pursuant to this section shall execute an indemnification agreement, which indemnifies and holds harmless the City of Waverly from any and all liability which may be incurred as a result of the placement of said containers and their contents.

SEC. 57.15 ERECT BARRIERS FOR PROTECTION OF TREES. During all building and construction operations, the contractor or builder shall erect suitable protective barriers around all trees and shrubs in any street, park or public place in the city in order to prevent said trees from being injured.

SEC. 57.16 DESTROYING OF TREES. No person shall break, deface, injure, kill or destroy any tree or shrub or set fire or permit any fire to burn where such fire or heat thereof will injure any portion of any tree or shrub in any street, park or public place in the city. Topping of any city owned tree is prohibited except when authorized.

SEC. 57.17 PENALTY. Anyone violating any of the provisions of this ordinance shall, upon conviction, be subject to imprisonment not exceeding thirty (30) days, or a fine not exceeding $100.00.

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Revised December, 2010