Renwick, IA

2018 Urban Forest Management Plan
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Executive Summary

Overview

This plan was developed to assist the City of Renwick 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 34% of Renwick'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 2018, a tree inventory was conducted 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 323 trees inventoried.

- Renwick's trees provide $72,726 of benefits annually, an average of $228 a tree
- There are over 25 species of trees
- The top three genera are: Maple 35.6%, Ash 34.4%, and Apple 5.9%
- 27% of trees are in need of some type of immediate maintenance
- 31 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 31 trees suggested for removal, 8 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*
- 3 of the 111 ash trees should be carefully examined, as they have one or more symptoms that could be related to an EAB infestation
- All trees should be pruned on a routine schedule- one third of the city every other year
- Plant a diverse mix of trees that do not include: ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut
- Check ash trees with a visual survey yearly
- With a budget of $3,000 per year it could take nearly 30 years to remove ash – Suggestion: request a budget increase to at least $5,000 annually and apply for grants to plant replacement trees

Introduction

This plan was developed to assist Renwick 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 or treatment and replacement planting. With proper planning and management of the current canopy in Renwick, these costs can be extended over years and public safety issues from dead and dying ash trees mitigated.

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

Inventory

In 2018, a tree inventory was conducted 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 323 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. Renwick's trees reduce energy related costs by approximately $19,347 annually (Appendix A, Table 1). These savings are both in Electricity (91.7 MWh) and in Natural Gas (12,641.1 Therms).

Annual Stormwater Benefits

Renwick's trees intercept about 1,103,295 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $29,899 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 Renwick, it is estimated that trees remove 1,233.6 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 $3,507 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Renwick, trees sequester about 221,294 lbs. of carbon a year with an associated value of $2,637 (Appendix A, Table 5). In addition, the trees store 4,671,076 lbs. of carbon, with a yearly benefit of $35,033 (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. Renwick receives $18,335 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, Renwick's trees provide $73,726 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 323 trees in Renwick provide approximately $228 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Renwick has over 25 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	115	35.6%
Ash	111	34.4%
Apple	19	5.9%
Black Walnut	12	3.7%
Hackberry	12	3.7%
Spruce	12	3.7%
Oak	11	3.4%
Linden	9	2.8%
Mulberry	6	1.9%
Elm	3	<1%
Catalpa	2	<1%
Hickory	2	<1%
Black Cherry	1	<1%
Cottonwood	1	<1%
Honeylocust	1	<1%
Lilac	1	<1%
Paper Birch	1	<1%
Ohio Buckeye	1	<1%
Willow	1	<1%
White Pine	1	<1%
UNKNOWN	2	<1%

Age Class

Most of Renwick's trees (42%) are between 18 and 30 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. Renwick's size curve is on the medium side, indicating a relatively average-aged 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 Renwick indicate that 83.9% of the trees are in good health, with only 3.7% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 83.9% of Renwick's trees are in fair or 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 16.1% of the population. This 16.1% 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	171	52.9%
Crown Raising	26	8%
Crown Reduction	21	6.5%
Tree Removal	21	6.5%
Staking/Training	19	5.9%

Canopy Cover

The total canopy, including both private and public trees, is 11 acres, or 1.7% of total municipal land area (Appendix A, Figure 4).

Land Use and Location

The majority of Renwick'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	74.6%
Industrial/Large commercial	21.7%
Park/vacant/other	3.1%
Multifamily residential	0.6%

Location	
Front Yard	51.7%
Planting Strip	48.3%

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

Renwick has 8 critical concern trees that need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). It is recommended to start with the large diameter critical concern trees first. All of these trees are over 24 inches in diameter at 4.5 ft. and should therefore 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 immediate maintenance. There are a total of 62 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 33 removals, 11 are ash trees. There are a total of 111 ash trees, and 3 of those have signs and symptoms that have been associated with EAB. In addition, there are 4 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 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 Renwick.

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 (35.6%) (Appendix A, Figure 1). Maples should not be planted until this percentage can be lowered. Also, ash trees have not been recommended since 2002, due to the threat of EAB. Other species to avoid because they are public nuisances include: cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut. All trees planted must meet the restrictions set by the city ordinance.

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 (Assuming a $3,000/year budget)

Year 1

Removal: 2 critical concern trees (Including one ash tree)

Planting and Replacement: 3 trees to be planted in open locations
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 2
Removal: 3 ash trees marked for immediate removal
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 2 trees in open locations
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: 2 ash trees marked for immediate removal, plus 1 additional trees in need of removal (ash or otherwise)
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 4 trees to be planted in open locations
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 4
Removal: 3 trees - removal of any new critical concern trees and/or ash in poor health
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 4 trees in open locations
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: 3 trees - removal of any new critical concern trees and/or ash in poor health
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 2 trees in open locations
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 6
Removal: 2 trees - removal of any new critical concern trees and ash in poor health
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 3 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 6 to 15 ash trees removed (approximately 5-16% of ash). It will take approximately 30 years to remove all ash with an annual budget of $3,000. 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 nearly $15,000 per year. If the budget were increased to $10,000 per year all ash could be removed within 9 years.

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 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 any restrictions imposed in the city ordinance. The new plantings will be a diverse mix and will not include ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut.

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

Monitoring
It is recommended that ash trees be checked with a visual survey every year for tree death and for 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 if preventative treatments are not being used.

Budget

Current Budget
Total $18,000 over 6 years ($3,000/year)

FY 2020 Budget
Removal: $1,600
*Or saving for ash tree treatment and/or future ash removal
Planting: $300
Watering & Maintenance: $200 (2100)

FY 2021 Budget
Removal: $2,400
*Or saving for ash tree treatment and/or future ash removal
Planting: $200
Routine trimming: $400
Watering & Maintenance: $250 (3250)

FY 2022 Budget
Removal: $2,400
*Or saving for ash tree treatment and/or future ash removal
Planting: $400
Watering & Maintenance: $300 (3100)

FY 2023 Budget
Removal: $2,400
*Or saving for ash tree treatment and/or future ash removal

Planting: $400
Routine trimming: $400
Watering & Maintenance: $400 (3600)

FY 2024 Budget
Removal: $2,400
*Or saving for ash tree treatment and/or future ash removal
Planting: $200
Watering & Maintenance: $450 (3050)

FY 2025 Budget
Removal: $1,600
*Or saving for ash tree treatment and/or future ash removal
Planting: $300
Routine trimming: $400
Watering & Maintenance: $600 (2900)

*Reduction of ash over 6 years: approximately 30 to 38 ash trees removed (approximately 25% of ash). **It will take approximately 24 years to remove all ash with the current budget.**

Proposed Budget Increase

EAB could potentially kill all ash trees in Renwick within 4 years of its arrival. To remove all ash trees within 10 years the budget would need to be nearly $9,000 per year. Additionally, it is recommended that Renwick 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. Trunk injection is administered every two years for the life of the tree. If treatment is discontinued, the tree dies. For instance, in this treatment scenario, the average ash diameter is 28 inches and at $14 per inch, approximately 7-8 trees per year could be treated (every other year treatment) with an annual budget of $3,000; Renwick would still need to find additional funding for tree removal. Alternatively, if the city decided to forgo treatment of any of its ash trees, it would cost approximately $89,000 in total for removal. Whether the city decides to treat or remove its ash trees, there will be an increased cost of dealing with ash trees if EAB is found in Renwick, and it is therefore suggested that consideration be given to increasing the budget to plan for this.

Works Cited

Census Bureau. 2010. http://censtats.census.gov/data/IA/1601964290.pdf (April, 2013)

USDA Forest Service, et al. 2006. i-Tree Software Suite v1.0 User's Manual. Pp. 27-40.

McPherson EG, Simpson JR, Peper PJ, Gardner SL, Vargas KE, Ho J, Maco S, Xiao Q. 2005b. City of Charleston, South Carolina, municipal forest resource analysis. Internal Tech Rep. Davis, CA: U.S. Department of Agriculture, Center for Urban Forest Research. p. 57

Nowak, DJ and JF Dwyer. 2007. Understanding the benefits and costs of urban forest ecosystems. In: Kuser, J. (ed.) Urban and Community Forestry in the Northeast. New York: Springer. Pp. 25-46.

Peper, Paula J; McPherson, E Gregory; Simpson, James R; Vargas, Kelaine E; Xiao, Qingfu 2009. Lower Midwest community tree guide: benefits, costs, and strategic planting. Gen. Tech. Rep. PSW-GTR-219. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. p.115

Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Renwick

Annual Energy Benefits of Public Trees

3/29/2018

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	37.4	2,839	5,127.0	5,024	7,864	(N/A)	34.4	40.6	70.84
Norway maple	14.7	1,115	2,099.7	2,058	3,173	(N/A)	18.0	16.4	54.71
Silver maple	13.1	996	1,723.3	1,689	2,685	(N/A)	11.1	13.9	74.58
Apple	1.2	89	185.5	182	270	(N/A)	5.9	1.4	14.23
Northern hackberry	4.9	370	679.7	666	1,036	(N/A)	3.7	5.4	86.36
Black walnut	3.4	261	481.5	472	733	(N/A)	3.4	3.8	66.61
Spruce	1.0	73	131.3	129	202	(N/A)	2.8	1.0	22.41
Sugar maple	2.2	169	306.3	300	469	(N/A)	2.5	2.4	58.66
Black maple	1.9	141	230.1	225	366	(N/A)	2.2	1.9	52.30
Mulberry	0.5	40	84.3	83	122	(N/A)	1.9	0.6	20.36
American basswood	1.7	129	245.1	240	369	(N/A)	1.5	1.9	73.74
Pin oak	1.7	126	226.4	222	348	(N/A)	1.5	1.8	69.55
Red maple	0.6	47	89.4	88	134	(N/A)	1.2	0.7	33.60
Littleleaf linden	0.8	62	122.0	120	182	(N/A)	1.2	0.9	45.40
Blue spruce	0.4	29	45.6	45	74	(N/A)	0.9	0.4	24.51
Elm	1.3	100	176.9	173	273	(N/A)	0.9	1.4	91.02
Bur oak	1.1	84	154.2	151	235	(N/A)	0.9	1.2	78.32
UNKNOWN	0.0	0	0.0	0	0	(N/A)	0.6	0.0	0.00
Catalpa	0.6	43	73.8	72	115	(N/A)	0.6	0.6	57.57
Hickory	0.6	45	85.0	83	128	(N/A)	0.6	0.7	64.12
Northern red oak	0.3	20	36.4	36	55	(N/A)	0.3	0.3	55.22
Ohio buckeye	0.2	18	29.5	29	47	(N/A)	0.3	0.2	46.78
Amur maple	0.0	2	3.8	4	5	(N/A)	0.3	0.0	5.40
Honeylocust	0.4	28	47.4	46	74	(N/A)	0.3	0.4	74.28
Maple	0.3	22	39.9	39	61	(N/A)	0.3	0.3	60.68
Paper birch	0.0	2	3.7	4	6	(N/A)	0.3	0.0	5.82
Northern pin oak	0.1	8	16.9	17	24	(N/A)	0.3	0.1	24.47
Lilac	0.2	14	24.7	24	38	(N/A)	0.3	0.2	38.13
Black cherry	0.1	6	12.8	13	18	(N/A)	0.3	0.1	18.19
Eastern white pine	0.1	11	19.7	19	30	(N/A)	0.3	0.2	30.47
Willow	0.3	24	47.4	46	71	(N/A)	0.3	0.4	70.84
Oak	0.3	20	38.1	37	57	(N/A)	0.3	0.3	57.32
Cottonwood	0.4	29	53.7	53	82	(N/A)	0.3	0.4	82.02
Total	91.7	6,959	12,641.1	12,388	19,347	(N/A)	100.0	100.0	59.90

Table 2: Annual Stormwater Benefits

Renwick

Annual Stormwater Benefits of Public Trees

3/29/2018

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	472,529	12,806	(N/A)	34.4	42.8	115.37
Norway maple	138,122	3,743	(N/A)	18.0	12.5	64.54
Silver maple	200,688	5,439	(N/A)	11.1	18.2	151.07
Apple	5,414	147	(N/A)	5.9	0.5	7.72
Northern hackberry	55,153	1,495	(N/A)	3.7	5.0	124.55
Black walnut	40,134	1,088	(N/A)	3.4	3.6	98.88
Spruce	16,002	434	(N/A)	2.8	1.5	48.18
Sugar maple	22,620	613	(N/A)	2.5	2.1	76.62
Black maple	13,753	373	(N/A)	2.2	1.2	53.24
Mulberry	2,757	75	(N/A)	1.9	0.2	12.45
American basswood	22,392	607	(N/A)	1.5	2.0	121.37
Pin oak	18,270	495	(N/A)	1.5	1.7	99.02
Red maple	4,743	129	(N/A)	1.2	0.4	32.13
Littleleaf linden	8,937	242	(N/A)	1.2	0.8	60.55
Blue spruce	4,633	126	(N/A)	0.9	0.4	41.85
Elm	21,717	589	(N/A)	0.9	2.0	196.17
Bur oak	14,924	404	(N/A)	0.9	1.4	134.81
UNKNOWN	0	0	(N/A)	0.6	0.0	0.00
Catalpa	5,409	147	(N/A)	0.6	0.5	73.29
Hickory	6,534	177	(N/A)	0.6	0.6	88.53
Northern red oak	3,030	82	(N/A)	0.3	0.3	82.12
Ohio buckeye	1,409	38	(N/A)	0.3	0.1	38.19
Amur maple	69	2	(N/A)	0.3	0.0	1.86
Honeylocust	4,685	127	(N/A)	0.3	0.4	126.96
Maple	2,867	78	(N/A)	0.3	0.3	77.70
Paper birch	172	5	(N/A)	0.3	0.0	4.65
Northern pin oak	586	16	(N/A)	0.3	0.1	15.88
Lilac	667	18	(N/A)	0.3	0.1	18.06
Black cherry	264	7	(N/A)	0.3	0.0	7.17
Eastern white pine	2,969	80	(N/A)	0.3	0.3	80.46
Willow	3,764	102	(N/A)	0.3	0.3	102.01
Oak	2,591	70	(N/A)	0.3	0.2	70.21
Cottonwood	5,491	149	(N/A)	0.3	0.5	148.79
Citywide total	1,103,295	29,899	(N/A)	100.0	100.0	92.57

Table 3: Annual Air Quality Benefits

Renwick

Annual Air Quality Benefits of Public Trees

3/29/2018

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							
Green ash	67.8	10.9	31.2	3.0	358	178.7	26.0	24.8	169.5	1,113	0.0	0	511.9	1,470 (N/A)	34.4	13.25
Norway maple	28.5	4.9	14.0	1.3	154	71.1	10.3	9.8	66.7	441	-6.7	-25	199.8	570 (N/A)	18.0	9.82
Silver maple	36.7	6.2	17.8	1.6	197	61.8	9.1	8.6	59.4	387	-18.9	-71	182.4	514 (N/A)	11.1	14.27
Apple	1.6	0.3	0.8	0.1	9	5.8	0.8	0.8	5.3	36	0.0	0	15.4	44 (N/A)	5.9	2.32
Northern hackberry	10.9	1.9	5.3	0.5	59	23.4	3.4	3.2	22.1	146	0.0	0	70.8	205 (N/A)	3.7	17.05
Black walnut	5.0	0.8	2.4	0.2	27	16.5	2.4	2.3	15.6	103	0.0	0	45.2	129 (N/A)	3.4	11.76
Spruce	1.8	0.4	1.5	0.2	12	4.6	0.7	0.6	4.4	29	-7.4	-28	6.8	13 (N/A)	2.8	1.43
Sugar maple	2.8	0.5	1.4	0.1	15	10.6	1.5	1.5	10.1	66	-2.2	-8	26.4	73 (N/A)	2.5	9.15
Black maple	3.1	0.5	1.5	0.1	17	8.6	1.3	1.2	8.4	54	-1.1	-4	23.7	67 (N/A)	2.2	9.55
Mulberry	0.9	0.2	0.4	0.0	5	2.6	0.4	0.4	2.4	16	0.0	0	7.2	21 (N/A)	1.9	3.46
American basswood	3.3	0.6	1.6	0.1	18	8.2	1.2	1.1	7.7	51	-2.8	-10	21.1	58 (N/A)	1.5	11.69
Pin oak	3.2	0.6	1.6	0.1	17	7.9	1.2	1.1	7.5	49	-5.9	-22	17.3	45 (N/A)	1.5	8.90
Red maple	1.0	0.2	0.5	0.0	5	3.0	0.4	0.4	2.8	18	-0.3	-1	7.9	22 (N/A)	1.2	5.62
Littleleaf linden	1.5	0.3	0.8	0.1	8	4.0	0.6	0.5	3.7	25	-0.7	-3	10.7	30 (N/A)	1.2	7.55
Blue spruce	0.6	0.1	0.5	0.1	4	1.8	0.3	0.2	1.7	11	-1.7	-6	3.6	9 (N/A)	0.9	2.89
Elm	3.5	0.6	1.5	0.2	18	6.2	0.9	0.9	6.0	39	0.0	0	19.7	57 (N/A)	0.9	19.04
Bur oak	2.1	0.3	0.9	0.1	11	5.3	0.8	0.7	5.0	33	0.0	0	15.3	44 (N/A)	0.9	14.63
UNKNOWN	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0 (N/A)	0.6	0.00
Catalpa	0.6	0.1	0.3	0.0	3	2.7	0.4	0.4	2.6	17	0.0	0	7.0	20 (N/A)	0.6	9.95
Hickory	0.8	0.1	0.4	0.0	4	2.9	0.4	0.4	2.7	18	0.0	0	7.6	22 (N/A)	0.6	10.91
Northern red oak	0.7	0.1	0.3	0.0	4	1.2	0.2	0.2	1.2	8	-1.0	-4	2.9	8 (N/A)	0.3	7.65
Ohio buckeye	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)	0.3	7.92
Amur maple	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)	0.3	0.71
Honeylocust	0.9	0.2	0.4	0.0	5	1.7	0.3	0.2	1.7	11	-0.8	-3	4.7	13 (N/A)	0.3	12.87
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)	0.3	11.54
Paper birch	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)	0.3	0.87
Northern pin 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)	0.3	3.47
Lilac	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)	0.3	6.56
Black cherry	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)	0.3	2.55
Eastern white pine	0.3	0.1	0.3	0.0	2	0.7	0.1	0.1	0.7	4	-1.4	-5	0.9	1 (N/A)	0.3	1.45
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)	0.3	13.58
Oak	0.3	0.0	0.1	0.0	1	1.3	0.2	0.2	1.2	8	0.0	0	3.3	9 (N/A)	0.3	9.34
Cottonwood	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)	0.3	15.71
Citywide total	181.0	30.1	86.9	8.3	969	438.5	63.8	60.8	415.5	2,730	-51.2	-192	1,233.6	3,507 (N/A)	100.0	10.86

Table 4: Annual Carbon Stored

Renwick

Stored CO2 Benefits of Public Trees

3/29/2018

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	2,252,726	16,895	(N/A)	34.4	48.2	152.21
Norway maple	471,468	3,536	(N/A)	18.0	10.1	60.97
Silver maple	851,774	6,388	(N/A)	11.1	18.2	177.45
Apple	26,662	200	(N/A)	5.9	0.6	10.52
Northern hackberry	179,640	1,347	(N/A)	3.7	3.8	112.28
Black walnut	162,940	1,222	(N/A)	3.4	3.5	111.10
Spruce	17,543	132	(N/A)	2.8	0.4	14.62
Sugar maple	78,246	587	(N/A)	2.5	1.7	73.36
Black maple	34,011	255	(N/A)	2.2	0.7	36.44
Mulberry	14,763	111	(N/A)	1.9	0.3	18.45
American basswood	126,827	951	(N/A)	1.5	2.7	190.24
Pin oak	81,578	612	(N/A)	1.5	1.7	122.37
Red maple	11,247	84	(N/A)	1.2	0.2	21.09
Littleleaf linden	32,700	245	(N/A)	1.2	0.7	61.31
Blue spruce	3,355	25	(N/A)	0.9	0.1	8.39
Elm	117,776	883	(N/A)	0.9	2.5	294.44
Bur oak	67,659	507	(N/A)	0.9	1.4	169.15
UNKNOWN	0	0	(N/A)	0.6	0.0	0.00
Catalpa	19,445	146	(N/A)	0.6	0.4	72.92
Hickory	24,230	182	(N/A)	0.6	0.5	90.86
Northern red oak	15,239	114	(N/A)	0.3	0.3	114.29
Ohio buckeye	3,624	27	(N/A)	0.3	0.1	27.18
Amur maple	178	1	(N/A)	0.3	0.0	1.33
Honeylocust	12,245	92	(N/A)	0.3	0.3	91.84
Maple	7,945	60	(N/A)	0.3	0.2	59.59
Paper birch	185	1	(N/A)	0.3	0.0	1.39
Northern pin oak	1,101	8	(N/A)	0.3	0.0	8.26
Lilac	3,037	23	(N/A)	0.3	0.1	22.78
Black cherry	908	7	(N/A)	0.3	0.0	6.81
Eastern white pine	3,343	25	(N/A)	0.3	0.1	25.07
Willow	14,280	107	(N/A)	0.3	0.3	107.10
Oak	8,458	63	(N/A)	0.3	0.2	63.43
Cottonwood	25,943	195	(N/A)	0.3	0.6	194.57
Citywide total	4,671,076	35,033	(N/A)	100.0	100.0	108.46

Table 5: Annual Social and Aesthetic Benefits

Renwick

Annual Aesthetic/Other Benefits of Public Trees

3/29/2018

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	6,418	(N/A)	34.4	35.0	57.82
Norway maple	1,793	(N/A)	18.0	9.8	30.91
Silver maple	4,389	(N/A)	11.1	23.9	121.93
Apple	137	(N/A)	5.9	0.7	7.22
Northern hackberry	802	(N/A)	3.7	4.4	66.82
Black walnut	671	(N/A)	3.4	3.7	60.98
Spruce	247	(N/A)	2.8	1.3	27.42
Sugar maple	503	(N/A)	2.5	2.7	62.89
Black maple	439	(N/A)	2.2	2.4	62.65
Mulberry	11	(N/A)	1.9	0.1	1.76
American basswood	459	(N/A)	1.5	2.5	91.75
Pin oak	597	(N/A)	1.5	3.3	119.33
Red maple	199	(N/A)	1.2	1.1	49.65
Littleleaf linden	300	(N/A)	1.2	1.6	75.05
Blue spruce	76	(N/A)	0.9	0.4	25.23
Elm	175	(N/A)	0.9	1.0	58.34
Bur oak	199	(N/A)	0.9	1.1	66.26
UNKNOWN	0	(N/A)	0.6	0.0	0.00
Catalpa	111	(N/A)	0.6	0.6	55.72
Hickory	123	(N/A)	0.6	0.7	61.64
Northern red oak	24	(N/A)	0.3	0.1	23.84
Ohio buckeye	39	(N/A)	0.3	0.2	39.16
Amur maple	2	(N/A)	0.3	0.0	2.06
Honeylocust	389	(N/A)	0.3	2.1	388.90
Maple	0	(N/A)	0.3	0.0	0.00
Paper birch	15	(N/A)	0.3	0.1	14.73
Northern pin oak	26	(N/A)	0.3	0.1	26.22
Lilac	15	(N/A)	0.3	0.1	15.48
Black cherry	6	(N/A)	0.3	0.0	6.40
Eastern white pine	47	(N/A)	0.3	0.3	47.08
Willow	0	(N/A)	0.3	0.0	0.00
Oak	58	(N/A)	0.3	0.3	57.69
Cottonwood	67	(N/A)	0.3	0.4	66.60
Citywide total	18,335	(N/A)	100.0	100.0	56.77

Table 6: Summary of Benefits in Dollars

Renwick

Total Annual Benefits of Public Trees by Species ($)

3/29/2018

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Green ash	7,864	1,019	1,470	12,806	6,418	29,576	(N/A)	40.1
Norway maple	3,173	307	570	3,743	1,793	9,585	(N/A)	13.0
Silver maple	2,685	578	514	5,439	4,389	13,605	(N/A)	18.5
Apple	270	31	44	147	137	629	(N/A)	0.9
Northern hackberry	1,036	105	205	1,495	802	3,642	(N/A)	4.9
Black walnut	733	101	129	1,088	671	2,721	(N/A)	3.7
Spruce	202	19	13	434	247	914	(N/A)	1.2
Sugar maple	469	60	73	613	503	1,719	(N/A)	2.3
Black maple	366	47	67	373	439	1,291	(N/A)	1.8
Mulberry	122	7	21	75	11	236	(N/A)	0.3
American basswood	369	68	58	607	459	1,560	(N/A)	2.1
Pin oak	348	75	45	495	597	1,559	(N/A)	2.1
Red maple	134	18	22	129	199	502	(N/A)	0.7
Littleleaf linden	182	31	30	242	300	785	(N/A)	1.1
Blue spruce	74	7	9	126	76	290	(N/A)	0.4
Elm	273	33	57	589	175	1,126	(N/A)	1.5
Bur oak	235	32	44	404	199	914	(N/A)	1.2
UNKNOWN	0	0	0	0	0	0	(N/A)	0.0
Catalpa	115	16	20	147	111	409	(N/A)	0.6
Hickory	128	18	22	177	123	468	(N/A)	0.6
Northern red oak	55	5	8	82	24	174	(N/A)	0.2
Ohio buckeye	47	6	8	38	39	138	(N/A)	0.2
Amur maple	5	1	1	2	2	11	(N/A)	0.0
Honeylocust	74	15	13	127	389	618	(N/A)	0.8
Maple	61	3	12	78	0	153	(N/A)	0.2
Paper birch	6	1	1	5	15	27	(N/A)	0.0
Northern pin oak	24	3	3	16	26	73	(N/A)	0.1
Lilac	38	4	7	18	15	82	(N/A)	0.1
Black cherry	18	2	3	7	6	36	(N/A)	0.0
Eastern white pine	30	3	1	80	47	163	(N/A)	0.2
Willow	71	3	14	102	0	190	(N/A)	0.3
Oak	57	8	9	70	58	202	(N/A)	0.3
Cottonwood	82	11	16	149	67	324	(N/A)	0.4
Citywide Total	19,347	2,637	3,507	29,899	18,335	73,726	(N/A)	100.0

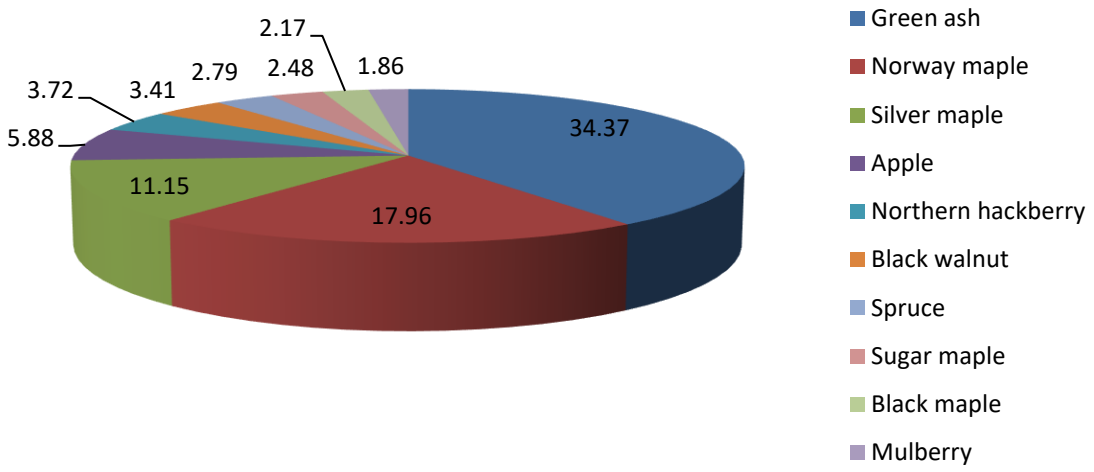

Figure 1: Species Distribution

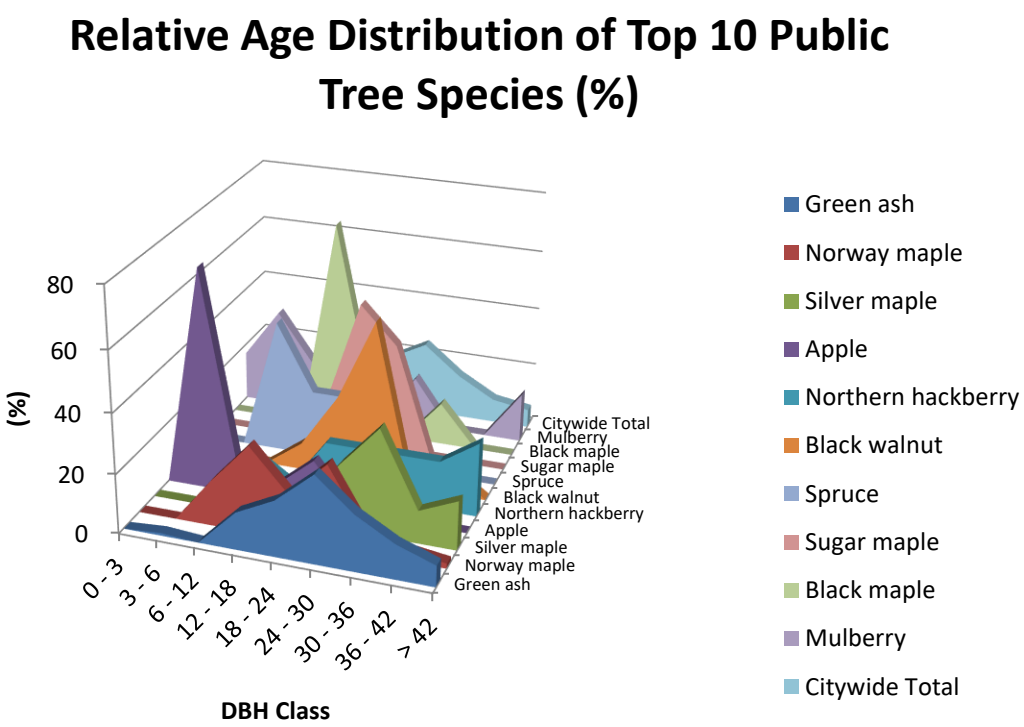

Figure 2: Relative Age Class

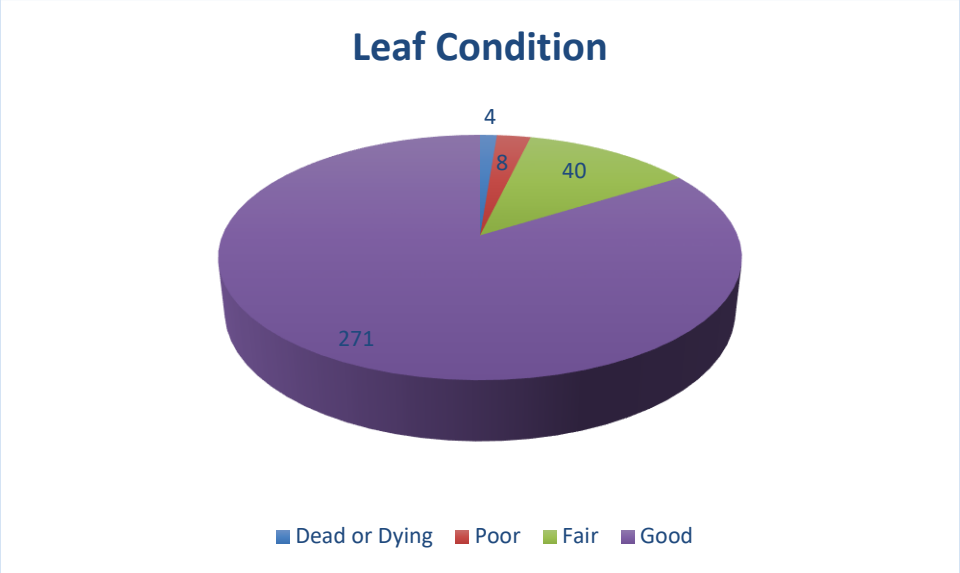

Figure 3: Foliage Condition

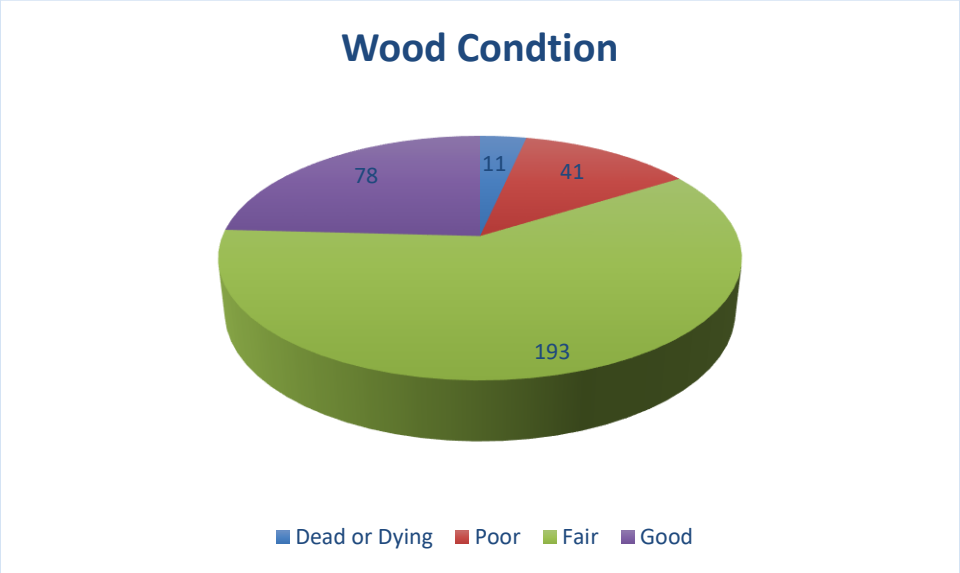

Figure 4: Wood Condition

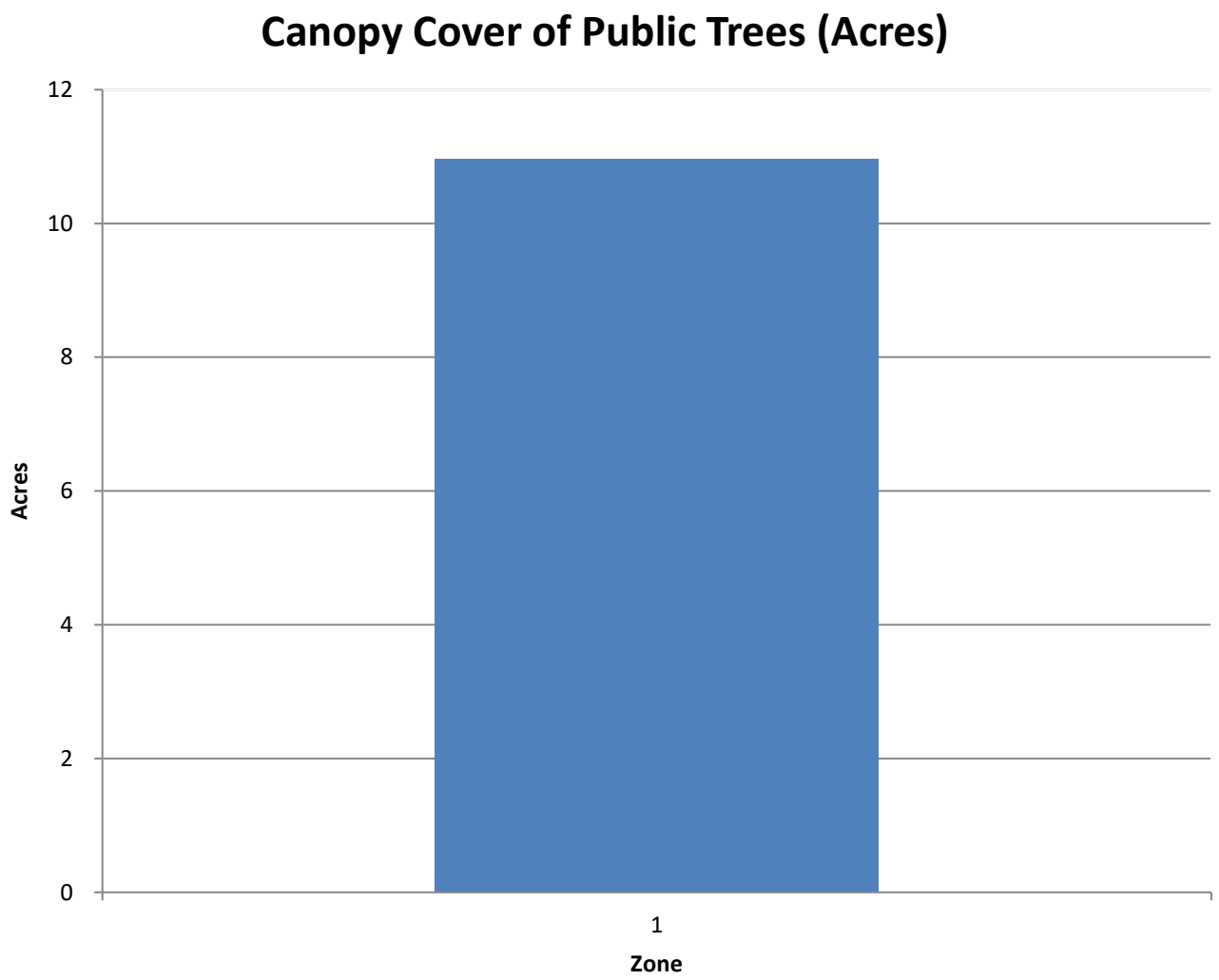

Figure 5: Canopy Cover in Acres

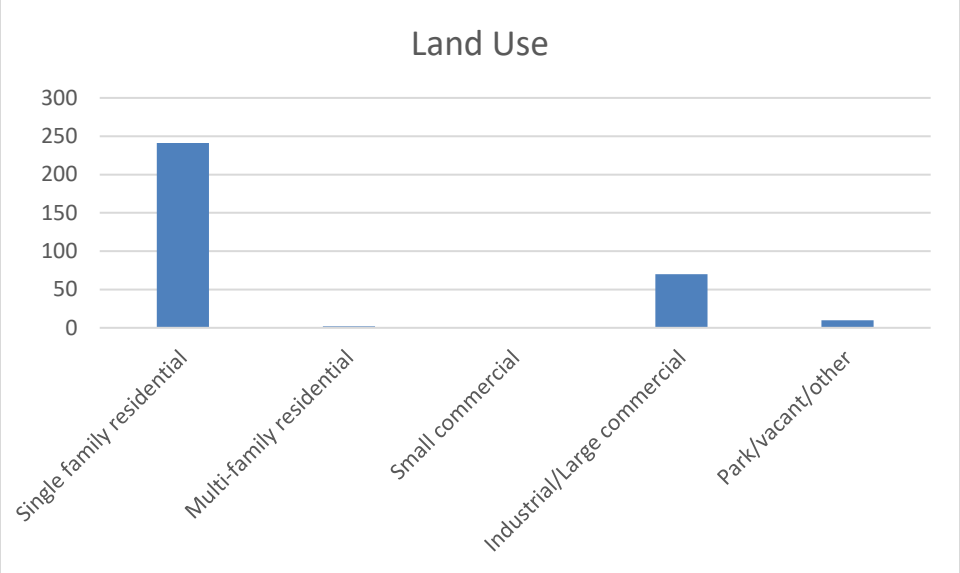

Figure 6: Land Use of city/park trees

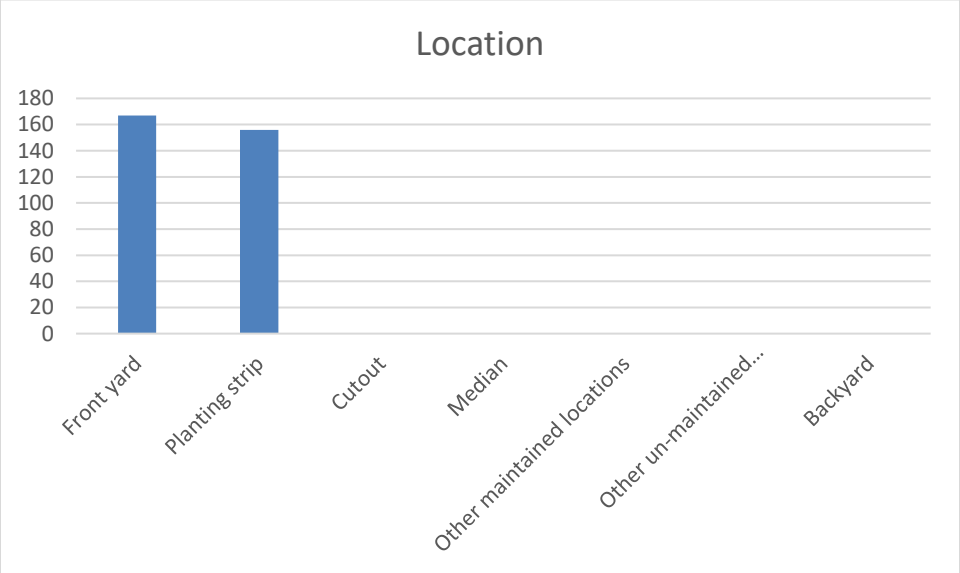

Figure 7: Location of city/park trees

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

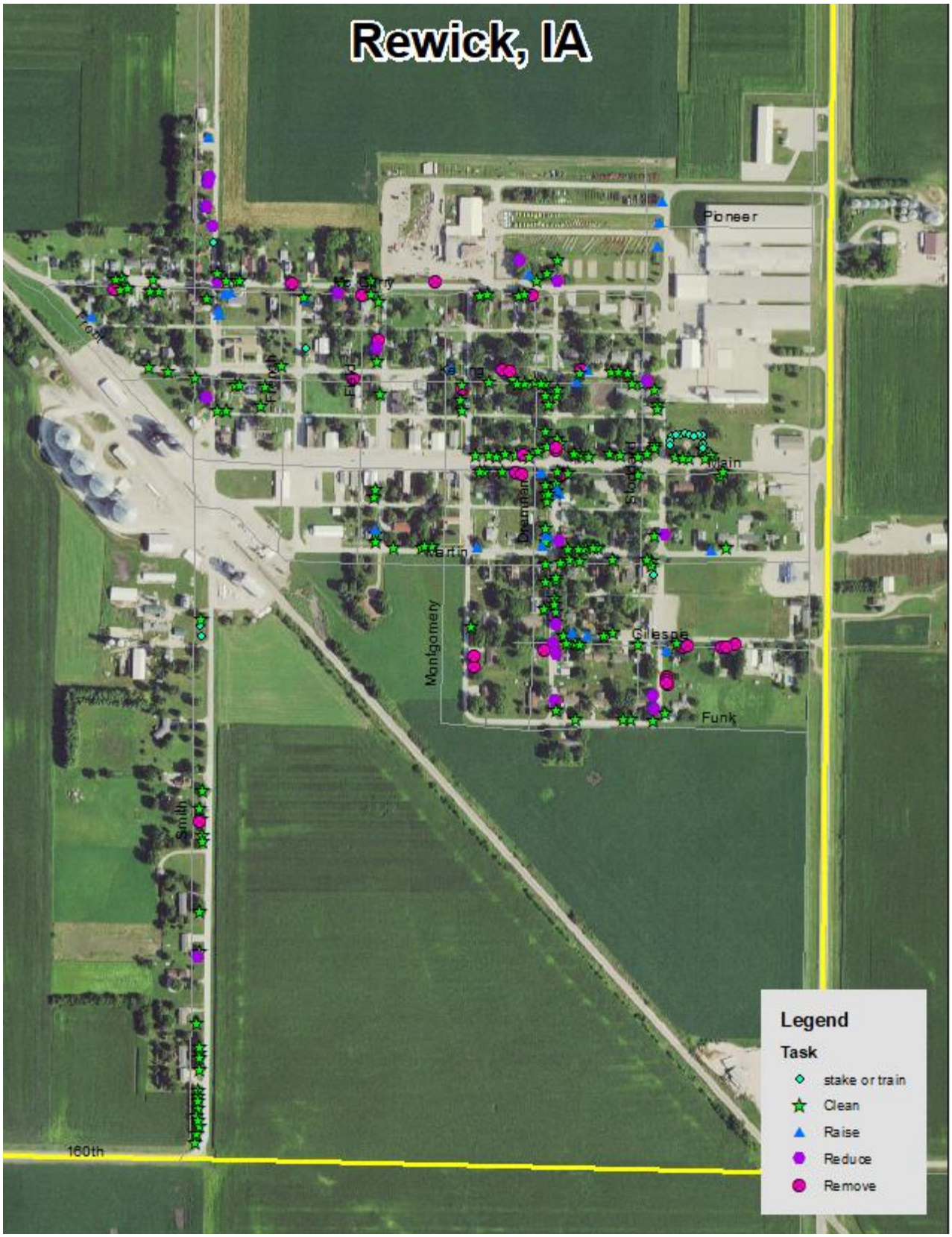

Figure 5: Maintenance Tasks ***City ownership of the trees recommended for removal should be verified prior to any removal***

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