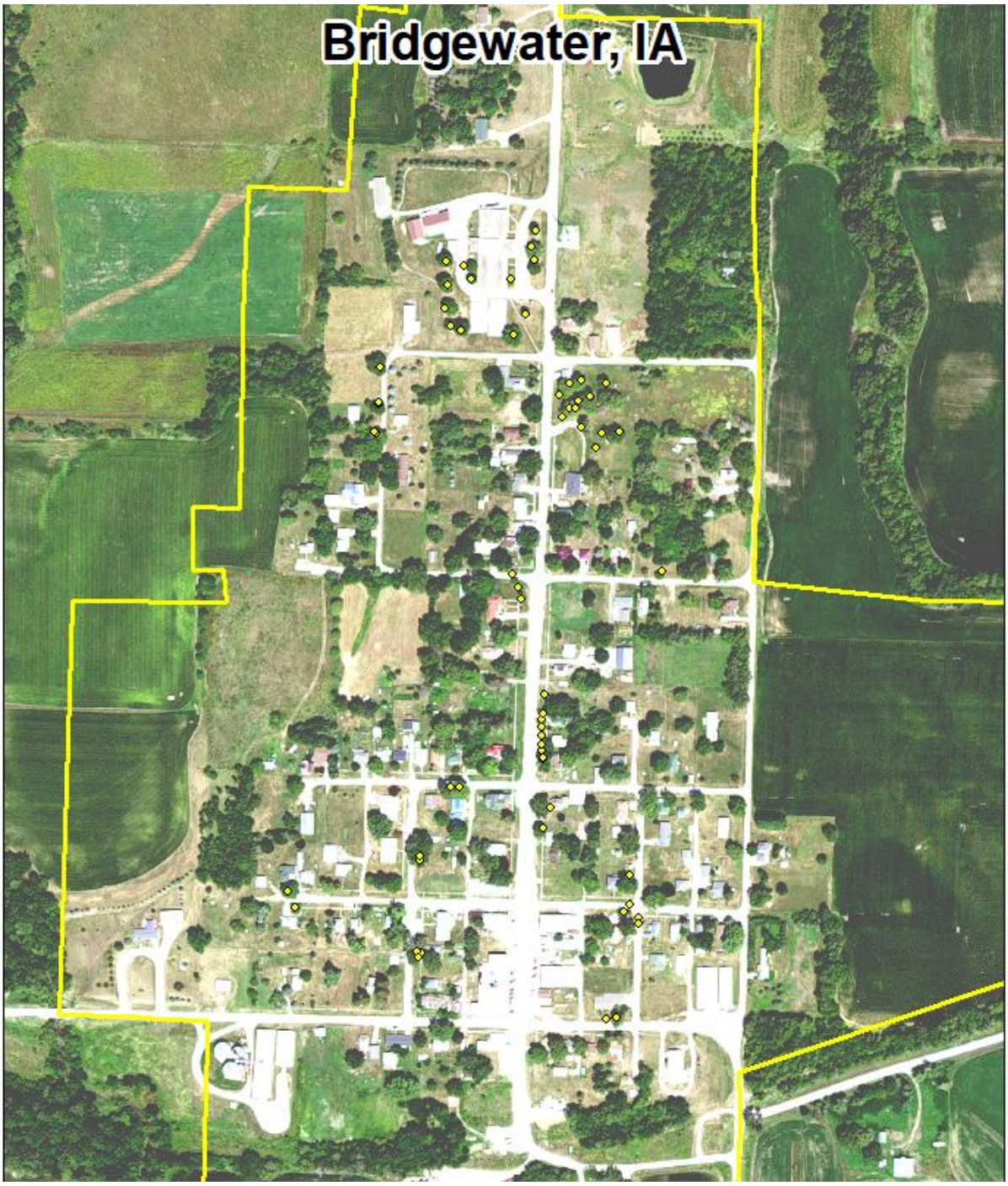
Bridgewater, IA



2019 Urban Forest Management Plan

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Executive Summary

Overview

This plan was developed to assist the City of Bridgewater 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 21% of Bridgewater'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 63 trees inventoried.

- Bridgewater's trees provide $13,544 of benefits annually, an average of $215 a tree
- There are over 22 species of trees
- The top three genera are: Maple 21%, Ash 21%, and Hackberry 10%
- 4% of trees are in need of some type of management

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.

- 13 of the 6 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 the current budget it could take 9 years to remove ash – Suggestion: request a budget increase to $480 annually and apply for grants to plant replacement trees

Introduction

This plan was developed to assist Bridgewater 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 Bridgewater, these costs can be extended over years and public safety issues from dead and dying ash trees mitigated.

Trees are an important component of Bridgewater'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 Bridgewater 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 Bridgewater'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 63 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. Bridgewater's trees reduce energy related costs by approximately $3,617 annually (Appendix A, Table 1). These savings are both in Electricity (17.1 MWh) and in Natural Gas (3,617 Therms).

Annual Stormwater Benefits

Bridgewater's trees intercept about 191,254 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $5,183 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 Bridgewater, it is estimated that trees remove 223.2 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 $631 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Bridgewater, trees sequester about 65,248lbs of carbon a year with an associated value of $489 (Appendix A, Table 5). In addition, the trees store 730,400 lbs of carbon, with a yearly benefit of $5,478 (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. Bridgewater receives $3,624in annual social benefits from trees (Appendix A, Table 6).

Financial Summary of all Benefits

According to the USDA Forest Service i-Tree STREETS analysis, Bridgewater's trees provide $13,544 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 63 trees in Bridgewater provide approximately $215 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Bridgewater has over 22 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	13	21%

Ash	13	21%
Hackberry	10	16%
Oak	6	10%
Elm	5	8%
Walnut	3	5%
Pine	3	5%
Crabapple	2	3%
Spruce	2	3%
Pear	2	3%
Hickory	1	2%
Redbud	1	2%
Mulberry	1	2%
Basswood	1	2%

Age Class

Most of Bridgewater's trees (36%) are between 30 and 36 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. Bridgewater's size curve is on the larger side, indicating an 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 Bridgewater indicate that 86% of the trees are in good health, with none of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 24% of Bridgewater'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 4% of the population. This 4% is an estimate of trees that need management follow up.

Management Needs

At this time no tree are in need of specific management beyond regular pruning (Appendix B, Figure 3).

Canopy Cover

The total canopy with both private and public trees is 14%, 26 acres. The canopy cover included in the Bridgewater inventory includes approximately 2.08 acres (Appendix A, Figure 4). The City's Canopy goal is to increase canopy by 3%, in 30 years. To achieve this goal it is estimated that 13 trees need to be planted annually on public and private lands.

Land Use and Location

The majority of Bridgewater'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	59%
Park/vacant/other	41%

Industrial/Large commercial	0%
Small commercial	0%
Multifamily residential	0%

Location	
Planting strip	32%
Other maintained locations	0%
Cutout (surrounded by pavement)	0%
Front yard	68%

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

Bridgewater has no trees marked for immediate removal or pruning, however a decision will need to be made on the ash trees as not all trees are candidates to treat or treatment might not be the management selected by the city.

Poor tree species

There are a total of 13 ash trees, and 6 of those have signs and symptoms that have been associated with EAB. *City ownership of the trees recommended for removal should be verified prior to any removal*

Pruning Cycle

Proper pruning can extend the life and good health of trees, as well as reduce public safety issues. In the Management Needs section of the Findings there are four main maintenance issues to be addressed: routine pruning, crown cleaning, crown raising, and crown reduction. Crown cleaning removes dead, diseased, and damaged limbs. Crown raising 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 Bridgewater.

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 (21%) (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 in 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 with <u>No Additional Funding</u>

Year 1

- Removal: 2 ash trees
- Planting and Replacement: 2 trees to be planted in open locations
- Young Tree Pruning & Maintenance:
- Visual Survey for signs and symptoms of EAB

Year 2

- Removal: 1 tree
- Planting and Replacement: 1 tree
- 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 trees
- Planting and Replacement: 2 trees to be planted in open locations
- Young Tree Pruning & Maintenance:
- Visual Survey for signs and symptoms of EAB

Year 4

- Removal: 1 tree
- Planting and Replacement: 1 tree
- Young Tree Pruning & Maintenance:
- Routine trimming: Contract to trim 1/3 of the city trees
- Visual Survey for signs and symptoms of EAB

Year 5

Removal: 2 trees
Planting and Replacement: 2 trees to be planted in open locations
Young Tree Pruning & Maintenance:
Visual Survey for signs and symptoms of EAB

Year 6
Removal: 1 additional tree - 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: 2 trees
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 9 ash trees removed (approximately 70% of ash). It will take approximately 9 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 $2,100 a year.

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 the restrictions in 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 $9,600 over 6 years ($1,600/year)

FY 2019 Budget

Removal: $1400
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Watering & Maintenance: $50

FY 2020 Budget

Removal: $700
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Routine trimming: $700
Watering & Maintenance: $50

FY 2021 Budget

Removal: $1400
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Watering & Maintenance: $50

FY 2022 Budget

Removal: $700
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Routine trimming: $700
Watering & Maintenance: $50

FY 2023 Budget

Removal: $1400
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Watering & Maintenance: $50

FY 2024 Budget

Removal: $700
*Or saving for ash tree treatment and/or future ash removal
Planting: $150
Routine trimming: $700
Watering & Maintenance: $50

*Reduction of ash over 6 years: approximately 9 ash trees removed (approximately 70% of ash). **It will take approximately 9 years to remove all ash with the current budget.**

<u>Purposed Budget Increase</u>

EAB could potentially kill all ash trees in Bridgewater within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $2,100 a year. Additionally, it is recommended that Bridgewater apply for grants to fund replacement trees. Utility Company grants are usually between $500 and $10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools.

Another option being considered by many communities is treating a number of selected trees, either to maintain those trees in the landscape or to delay their removal – to spread out the costs and number of trees needing removed all at once. Trunk injection is administered every two years for the

life of the tree. If treatment is discontinued, the tree dies. For instance, in this treatment scenario, the average ash diameter is 20 inches and at $15 per inch, about 4 trees could be treated per year (every other year treatment). This would be 8 trees selected for treatment, and Bridgewater would still need to find $8,000 for removal. These are alternatives to straight removal of ash trees. However, whether or not the treatment option is selected, there will be an increased cost of dealing with ash trees if EAB is found in Bridgewater. It is suggested to consider 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

Bridgewater

Annual Energy Benefits of Public Trees

2/6/2019

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	2.7	207	373.4	366	573	(N/A)	17.5	15.8	52.06
Northern hackberry	4.2	321	597.3	585	906	(N/A)	15.9	25.1	90.60
Silver maple	1.5	114	195.8	192	306	(N/A)	9.5	8.4	50.93
Pin oak	1.6	118	207.2	203	321	(N/A)	6.3	8.9	80.25
Black cherry	0.2	17	38.5	38	55	(N/A)	4.8	1.5	18.19
Sugar maple	0.8	64	117.6	115	179	(N/A)	4.8	4.9	59.60
Chinese elm	1.2	88	161.0	158	246	(N/A)	4.8	6.8	82.02
Black walnut	1.0	79	147.4	144	224	(N/A)	4.8	6.2	74.61
Apple	0.1	7	16.6	16	24	(N/A)	3.2	0.7	11.80
Pear	0.1	11	25.7	25	36	(N/A)	3.2	1.0	18.19
Blue spruce	0.1	10	20.4	20	30	(N/A)	3.2	0.8	14.80
American elm	0.9	69	122.1	120	189	(N/A)	3.2	5.2	94.34
Maple	0.2	17	33.0	32	49	(N/A)	3.2	1.4	24.58
White ash	0.5	41	56.8	56	96	(N/A)	3.2	2.7	48.12
Hickory	0.2	18	27.0	26	44	(N/A)	1.6	1.2	44.23
Eastern redbud	0.2	14	24.7	24	38	(N/A)	1.6	1.1	38.13
Red maple	0.3	22	39.9	39	61	(N/A)	1.6	1.7	60.68
Amur maple	0.2	15	31.6	31	46	(N/A)	1.6	1.3	46.14
Mulberry	0.2	14	24.7	24	38	(N/A)	1.6	1.1	38.13
Northern red oak	0.3	20	36.4	36	55	(N/A)	1.6	1.5	55.22
American basswood	0.4	27	51.4	50	77	(N/A)	1.6	2.1	77.27
Swamp white oak	0.1	8	16.9	17	24	(N/A)	1.6	0.7	24.47
Total	17.1	1,299	2,365.3	2,318	3,617	(N/A)	100.0	100.0	57.41

Table 2: Annual Stormwater Benefits

Bridgewater

Annual Stormwater Benefits of Public Trees

2/6/2019

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	34,101	924	(N/A)	17.5	17.8	84.01
Northern hackberry	48,800	1,322	(N/A)	15.9	25.5	132.25
Silver maple	18,096	490	(N/A)	9.5	9.5	81.73
Pin oak	19,771	536	(N/A)	6.3	10.3	133.95
Black cherry	793	22	(N/A)	4.8	0.4	7.17
Sugar maple	8,728	237	(N/A)	4.8	4.6	78.85
Chinese elm	16,472	446	(N/A)	4.8	8.6	148.79
Black walnut	13,376	363	(N/A)	4.8	7.0	120.83
Apple	333	9	(N/A)	3.2	0.2	4.51
Pear	529	14	(N/A)	3.2	0.3	7.17
Blue spruce	1,511	41	(N/A)	3.2	0.8	20.47
American elm	9,102	247	(N/A)	3.2	4.8	123.33
Maple	1,251	34	(N/A)	3.2	0.7	16.95
White ash	3,325	90	(N/A)	3.2	1.7	45.05
Hickory	1,466	40	(N/A)	1.6	0.8	39.72
Eastern redbud	667	18	(N/A)	1.6	0.3	18.06
Red maple	2,867	78	(N/A)	1.6	1.5	77.70
Amur maple	1,174	32	(N/A)	1.6	0.6	31.82
Mulberry	667	18	(N/A)	1.6	0.3	18.06
Northern red oak	3,030	82	(N/A)	1.6	1.6	82.12
American basswood	4,609	125	(N/A)	1.6	2.4	124.90
Swamp white oak	586	16	(N/A)	1.6	0.3	15.88
Citywide total	191,254	5,183	(N/A)	100.0	100.0	82.27

Table 3: Annual Air Quality Benefits

Bridgewater

Annual Air Quality Benefits of Public Trees

2/6/2019

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	4.6	0.7	2.1	0.2	24	13.0	1.9	1.8	12.3	81	0.0	0	36.8	105	(N/A)	17.5	9.59
Northern hackberry	8.5	1.5	4.2	0.4	46	20.4	3.0	2.8	19.2	126	0.0	0	59.8	172	(N/A)	15.9	17.22
Silver maple	2.7	0.5	1.4	0.1	15	7.0	1.0	1.0	6.8	44	-1.5	-6	19.0	53	(N/A)	9.5	8.89
Pin oak	3.7	0.7	1.9	0.2	20	7.4	1.1	1.0	7.0	46	-6.8	-26	16.1	41	(N/A)	6.3	10.20
Black cherry	0.1	0.0	0.1	0.0	1	1.1	0.2	0.2	1.0	7	0.0	0	2.7	8	(N/A)	4.8	2.55
Sugar maple	1.1	0.2	0.6	0.0	6	4.0	0.6	0.6	3.8	25	-0.9	-3	10.0	28	(N/A)	4.8	9.22
Chinese elm	2.4	0.4	1.1	0.1	12	5.6	0.8	0.8	5.3	35	0.0	0	16.4	47	(N/A)	4.8	15.71
Black walnut	1.8	0.3	0.8	0.1	9	5.0	0.7	0.7	4.7	31	0.0	0	14.2	41	(N/A)	4.8	13.55
Apple	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)	3.2	1.63
Pear	0.1	0.0	0.1	0.0	1	0.8	0.1	0.1	0.7	5	0.0	0	1.8	5	(N/A)	3.2	2.55
Blue spruce	0.1	0.0	0.1	0.0	1	0.6	0.1	0.1	0.6	4	-0.5	-2	1.2	3	(N/A)	3.2	1.53
American elm	1.9	0.3	0.9	0.1	10	4.3	0.6	0.6	4.1	27	0.0	0	12.9	37	(N/A)	3.2	18.52
Maple	0.2	0.0	0.1	0.0	1	1.1	0.2	0.1	1.0	7	-0.1	0	2.6	7	(N/A)	3.2	3.64
White ash	0.2	0.0	0.1	0.0	1	2.4	0.4	0.3	2.4	15	0.0	0	5.9	17	(N/A)	3.2	8.32
Hickory	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)	1.6	7.42
Eastern redbud	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)	1.6	6.56
Red 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)	1.6	11.54
Amur maple	0.4	0.1	0.2	0.0	2	1.0	0.1	0.1	0.9	6	0.0	0	2.9	8	(N/A)	1.6	8.35
Mulberry	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)	1.6	6.56
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)	1.6	7.65
American basswood	0.7	0.1	0.3	0.0	4	1.7	0.2	0.2	1.6	11	-0.6	-2	4.4	12	(N/A)	1.6	12.18
Swamp white oak	0.1	0.0	0.0	0.0	0	0.5	0.1	0.1	0.5	3	0.0	0	1.2	3	(N/A)	1.6	3.47
Citywide total	30.5	5.1	14.9	1.4	164	81.9	11.9	11.3	77.5	510	-11.5	-43	223.2	631	(N/A)	100.0	10.02

Table 4: Annual Carbon Stored

Bridgewater

Stored CO2 Benefits of Public Trees

2/6/2019

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	154,280	1,157	(N/A)	17.5	21.1	105.19
Northern hackberry	132,713	995	(N/A)	15.9	18.2	99.53
Silver maple	57,192	429	(N/A)	9.5	7.8	71.49
Pin oak	99,807	749	(N/A)	6.3	13.7	187.14
Black cherry	2,724	20	(N/A)	4.8	0.4	6.81
Sugar maple	30,171	226	(N/A)	4.8	4.1	75.43
Chinese elm	77,829	584	(N/A)	4.8	10.7	194.57
Black walnut	57,489	431	(N/A)	4.8	7.9	143.72
Apple	1,086	8	(N/A)	3.2	0.1	4.07
Pear	1,816	14	(N/A)	3.2	0.2	6.81
Blue spruce	568	4	(N/A)	3.2	0.1	2.13
American elm	39,456	296	(N/A)	3.2	5.4	147.96
Maple	2,201	17	(N/A)	3.2	0.3	8.26
White ash	7,344	55	(N/A)	3.2	1.0	27.54
Hickory	3,672	28	(N/A)	1.6	0.5	27.54
Eastern redbud	3,037	23	(N/A)	1.6	0.4	22.78
Red maple	7,945	60	(N/A)	1.6	1.1	59.59
Amur maple	6,743	51	(N/A)	1.6	0.9	50.57
Mulberry	3,037	23	(N/A)	1.6	0.4	22.78
Northern red oak	15,239	114	(N/A)	1.6	2.1	114.29
American basswood	24,952	187	(N/A)	1.6	3.4	187.14
Swamp white oak	1,101	8	(N/A)	1.6	0.2	8.26
Citywide total	730,400	5,478	(N/A)	100.0	100.0	86.95

Table 5: Annual Carbon Sequestered

Bridgewater

Annual CO Benefits of Public Trees

2/6/2019

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
Green ash	6,209	47	-741	-30	-6	4,569	34	10,007	75 (N/A)	17.5	15.3	6.82
Northern hackberry	5,995	45	-637	-42	-5	7,086	53	12,402	93 (N/A)	15.9	19.0	9.30
Silver maple	5,159	39	-275	-16	-2	2,512	19	7,381	55 (N/A)	9.5	11.3	9.23
Pin oak	8,782	66	-479	-17	-4	2,608	20	10,894	82 (N/A)	6.3	16.7	20.43
Black cherry	342	3	-13	-4	0	372	3	697	5 (N/A)	4.8	1.1	1.74
Sugar maple	1,803	14	-145	-9	-1	1,405	11	3,054	23 (N/A)	4.8	4.7	7.64
Chinese elm	2,879	22	-374	-13	-3	1,950	15	4,442	33 (N/A)	4.8	6.8	11.11
Black walnut	2,673	20	-276	-11	-2	1,755	13	4,141	31 (N/A)	4.8	6.3	10.35
Apple	152	1	-5	-2	0	161	1	306	2 (N/A)	3.2	0.5	1.15
Pear	228	2	-9	-2	0	248	2	465	3 (N/A)	3.2	0.7	1.74
Blue spruce	77	1	-3	-2	0	212	2	285	2 (N/A)	3.2	0.4	1.07
American elm	1,132	8	-189	-9	-1	1,525	11	2,459	18 (N/A)	3.2	3.8	9.22
Maple	331	2	-11	-2	0	371	3	689	5 (N/A)	3.2	1.1	2.58
White ash	987	7	-35	-4	0	898	7	1,846	14 (N/A)	3.2	2.8	6.92
Hickory	445	3	-18	-2	0	393	3	819	6 (N/A)	1.6	1.3	6.14
Eastern redbud	268	2	-15	-2	0	308	2	560	4 (N/A)	1.6	0.9	4.20
Red maple	923	7	-38	-3	0	477	4	1,359	10 (N/A)	1.6	2.1	10.20
Amur maple	0	0	-32	-4	0	335	3	299	2 (N/A)	1.6	0.5	2.24
Mulberry	268	2	-15	-2	0	308	2	560	4 (N/A)	1.6	0.9	4.20
Northern red oak	0	0	-73	-4	-1	432	3	355	3 (N/A)	1.6	0.5	2.67
American basswood	1,365	10	-120	-4	-1	594	4	1,835	14 (N/A)	1.6	2.8	13.76
Swamp white oak	224	2	-5	-1	0	176	1	393	3 (N/A)	1.6	0.6	2.95
Citywide total	40,240	302	-3,506	-184	-28	28,698	215	65,248	489 (N/A)	100.0	100.0	7.77

Table 6: Annual Social and Aesthetic Benefits

Bridgewater

Annual Aesthetic/Other Benefits of Public Trees

2/6/2019

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	512	(N/A)	17.5	14.1	46.50
Northern hackberry	712	(N/A)	15.9	19.6	71.20
Silver maple	457	(N/A)	9.5	12.6	76.11
Pin oak	628	(N/A)	6.3	17.3	157.02
Black cherry	19	(N/A)	4.8	0.5	6.40
Sugar maple	194	(N/A)	4.8	5.3	64.53
Chinese elm	200	(N/A)	4.8	5.5	66.60
Black walnut	198	(N/A)	4.8	5.5	65.93
Apple	8	(N/A)	3.2	0.2	4.23
Pear	13	(N/A)	3.2	0.4	6.40
Blue spruce	42	(N/A)	3.2	1.2	21.08
American elm	149	(N/A)	3.2	4.1	74.47
Maple	60	(N/A)	3.2	1.6	29.84
White ash	127	(N/A)	3.2	3.5	63.74
Hickory	46	(N/A)	1.6	1.3	45.86
Eastern redbud	15	(N/A)	1.6	0.4	15.48
Red maple	109	(N/A)	1.6	3.0	109.08
Amur maple	0	(N/A)	1.6	0.0	0.00
Mulberry	15	(N/A)	1.6	0.4	15.48
Northern red oak	0	(N/A)	1.6	0.0	0.00
American basswood	94	(N/A)	1.6	2.6	94.13
Swamp white oak	26	(N/A)	1.6	0.7	26.22
Citywide total	3,624	(N/A)	100.0	100.0	57.53

Table 7: Summary of Benefits in Dollars

Bridgewater

Total Annual Benefits of Public Trees by Species ($)

2/6/2019

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Green ash	573	75	105	924	512	2,189	(N/A)	16.2
Northern hackberry	906	93	172	1,322	712	3,206	(N/A)	23.7
Silver maple	306	55	53	490	457	1,361	(N/A)	10.1
Pin oak	321	82	41	536	628	1,607	(N/A)	11.9
Black cherry	55	5	8	22	19	108	(N/A)	0.8
Sugar maple	179	23	28	237	194	660	(N/A)	4.9
Chinese elm	246	33	47	446	200	973	(N/A)	7.2
Black walnut	224	31	41	363	198	856	(N/A)	6.3
Apple	24	2	3	9	8	47	(N/A)	0.3
Pear	36	3	5	14	13	72	(N/A)	0.5
Blue spruce	30	2	3	41	42	118	(N/A)	0.9
American elm	189	18	37	247	149	640	(N/A)	4.7
Maple	49	5	7	34	60	155	(N/A)	1.1
White ash	96	14	17	90	127	344	(N/A)	2.5
Hickory	44	6	7	40	46	143	(N/A)	1.1
Eastern redbud	38	4	7	18	15	82	(N/A)	0.6
Red maple	61	10	12	78	109	269	(N/A)	2.0
Amur maple	46	2	8	32	0	89	(N/A)	0.7
Mulberry	38	4	7	18	15	82	(N/A)	0.6
Northern red oak	55	3	8	82	0	148	(N/A)	1.1
American basswood	77	14	12	125	94	322	(N/A)	2.4
Swamp white oak	24	3	3	16	26	73	(N/A)	0.5
Citywide Total	3,617	489	631	5,183	3,624	13,544	(N/A)	100.0

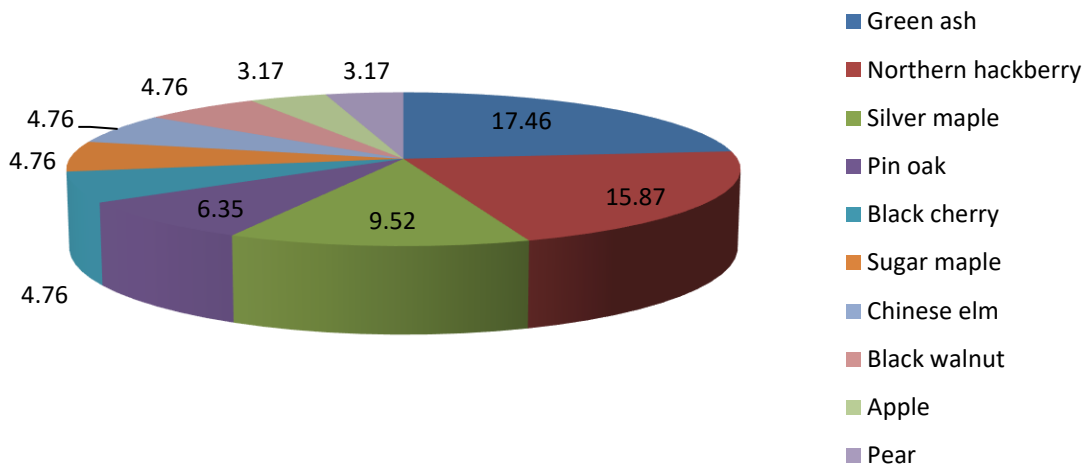

Figure 1: Species Distribution

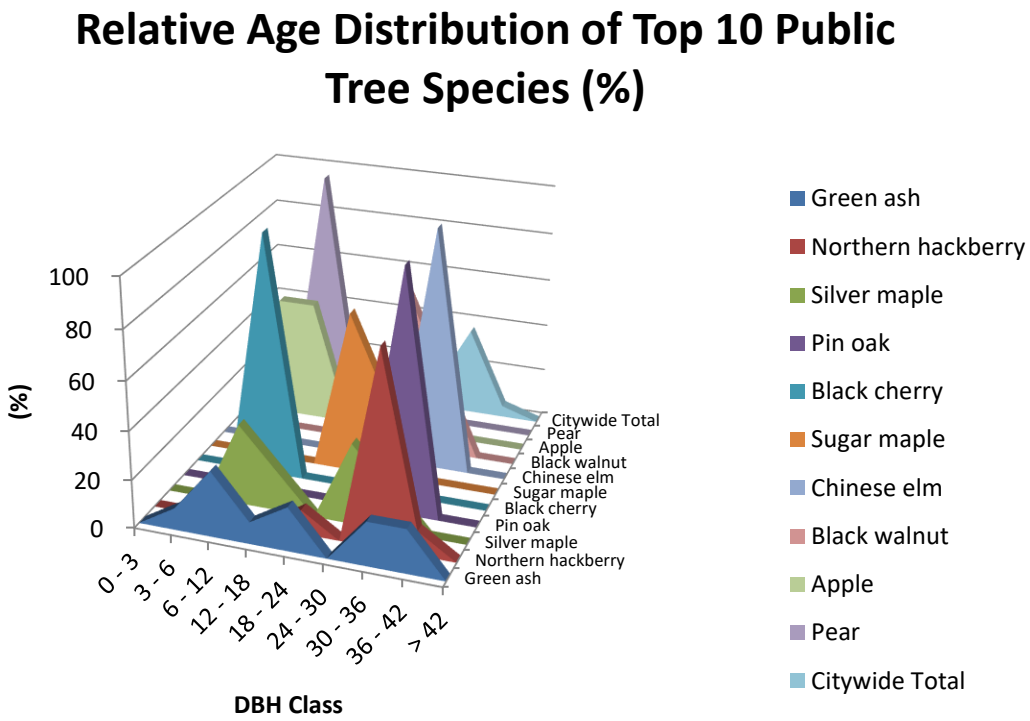

Figure 2: Relative Age Class

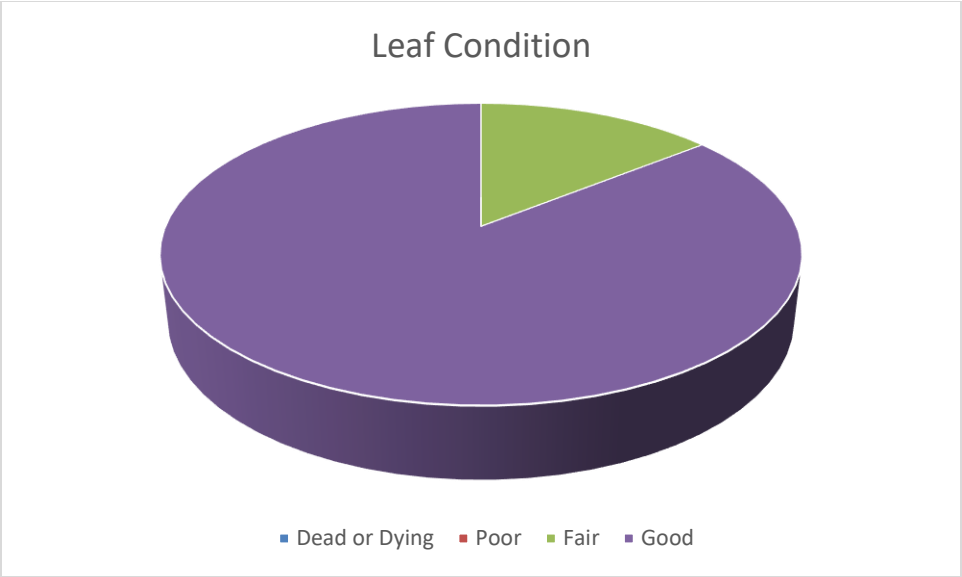

Figure 3: Foliage Condition

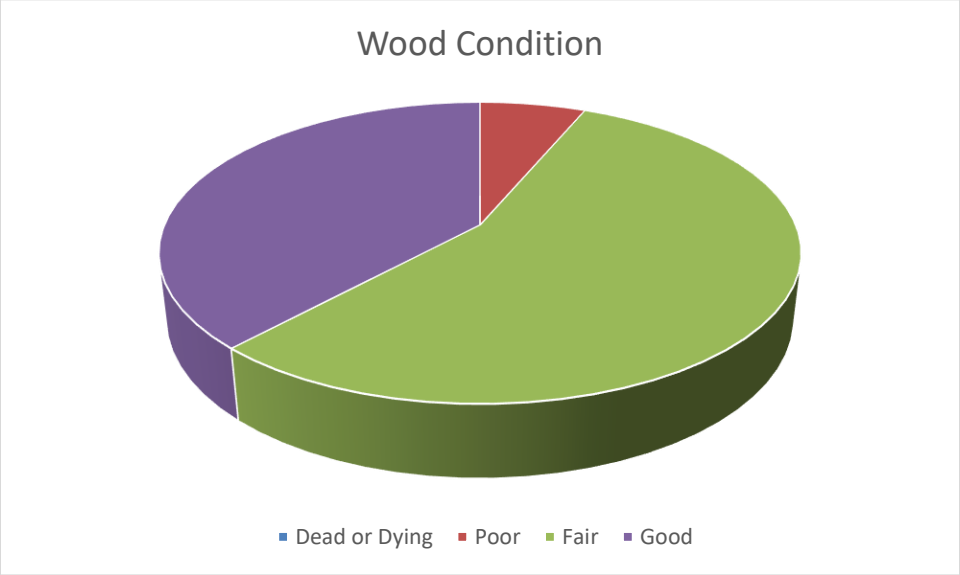

Figure 4: Wood Condition

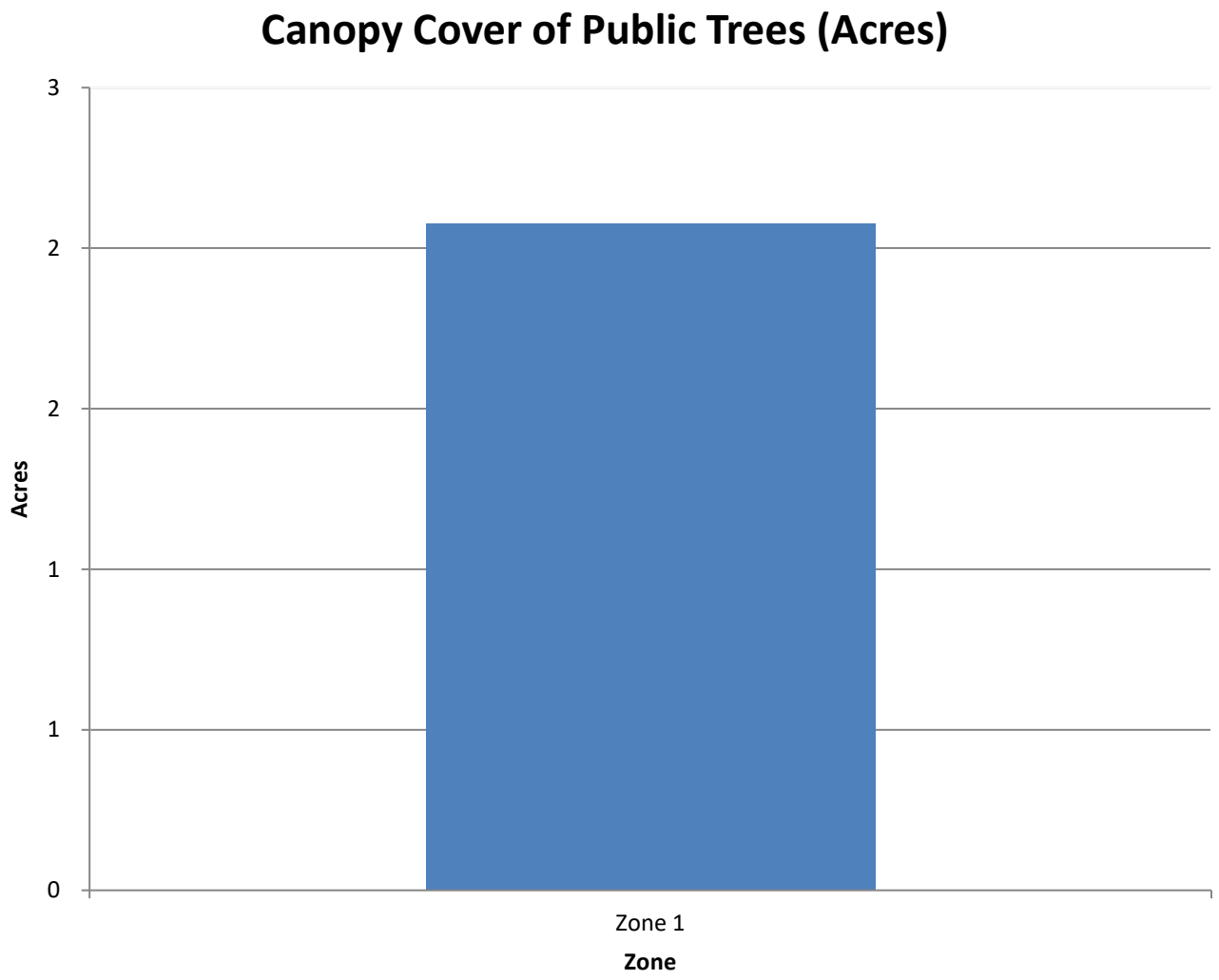

Figure 5: Canopy Cover in Acres

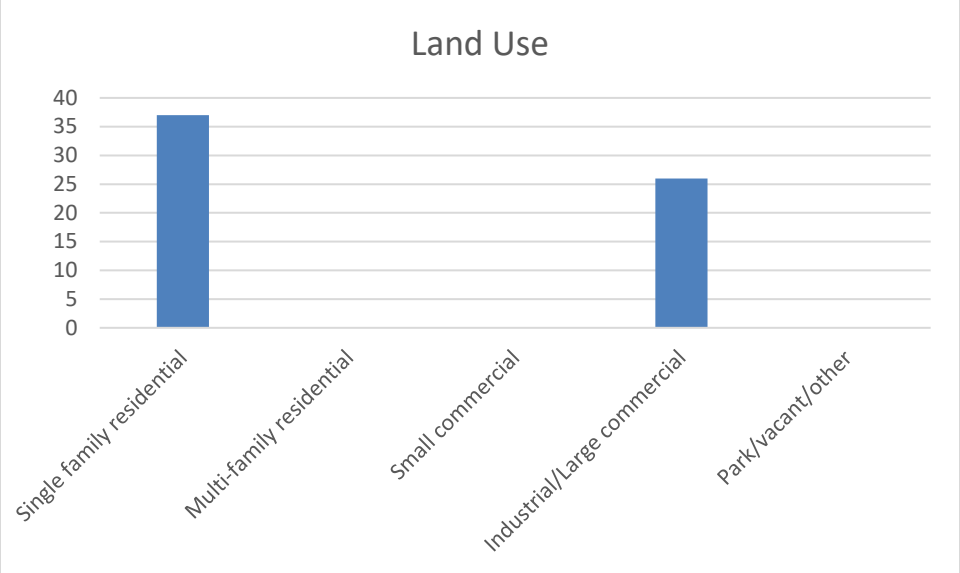

Figure 6: Land Use of city/park trees

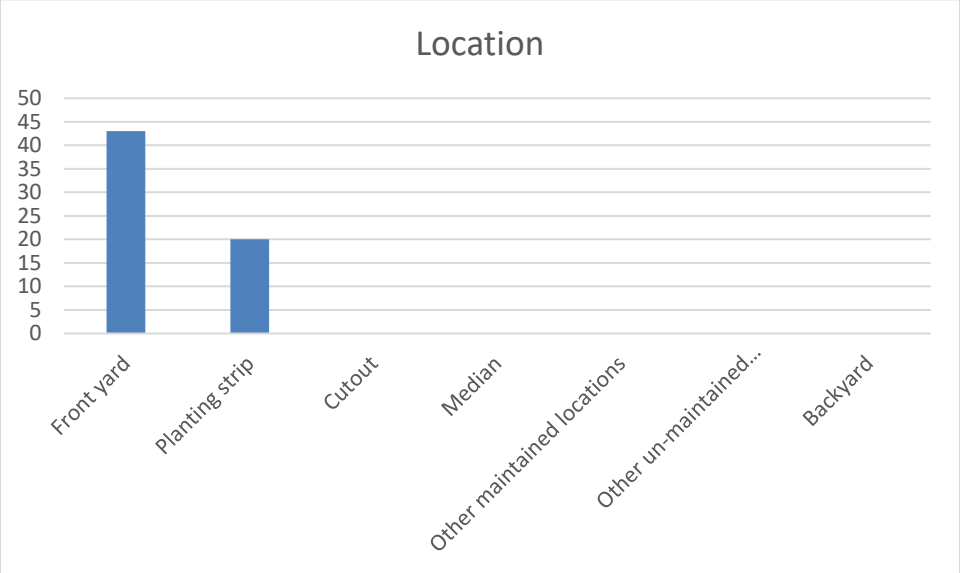

Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

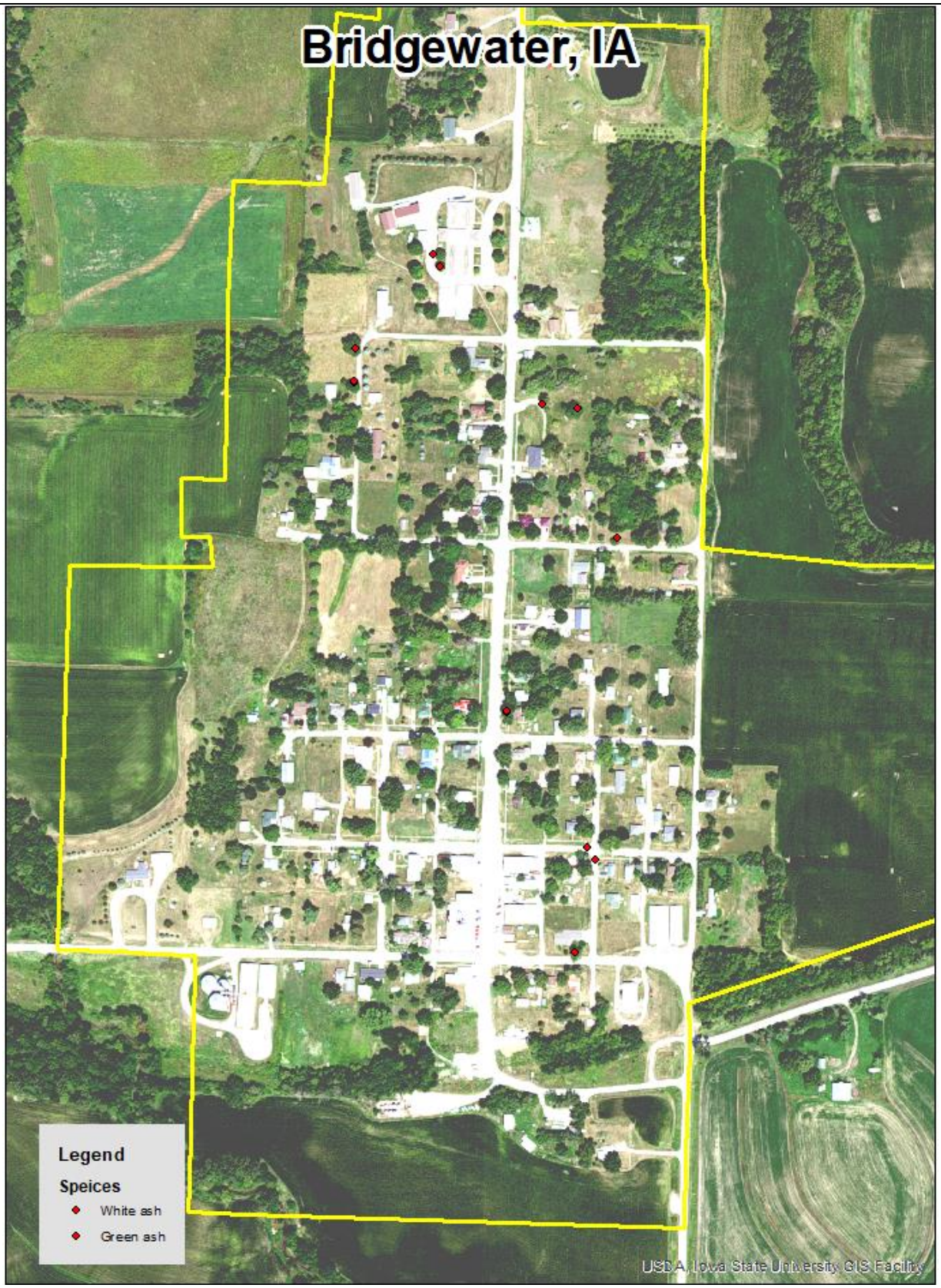

Figure 1: Location of Ash Trees

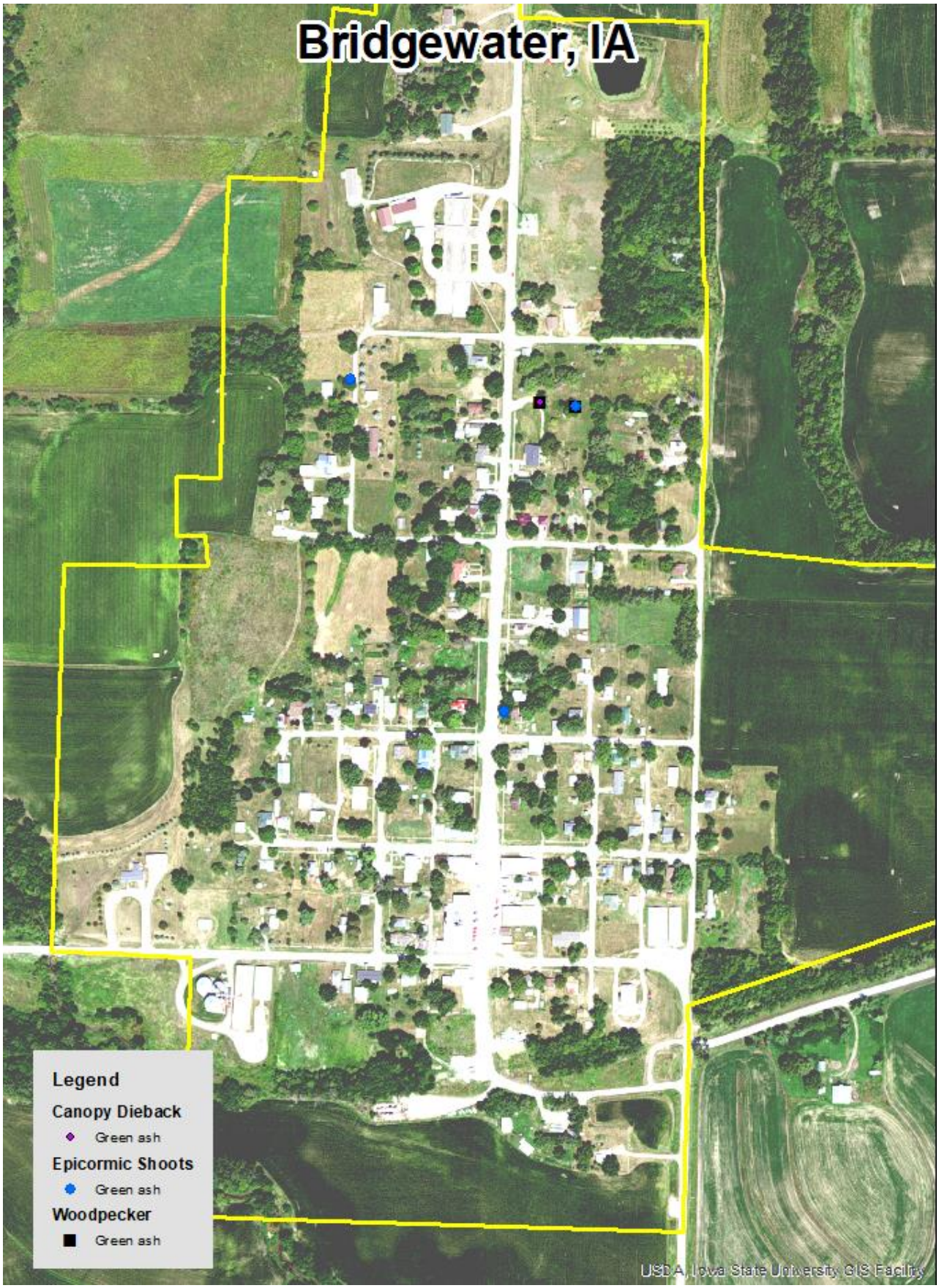

Figure 2: Location of EAB symptoms

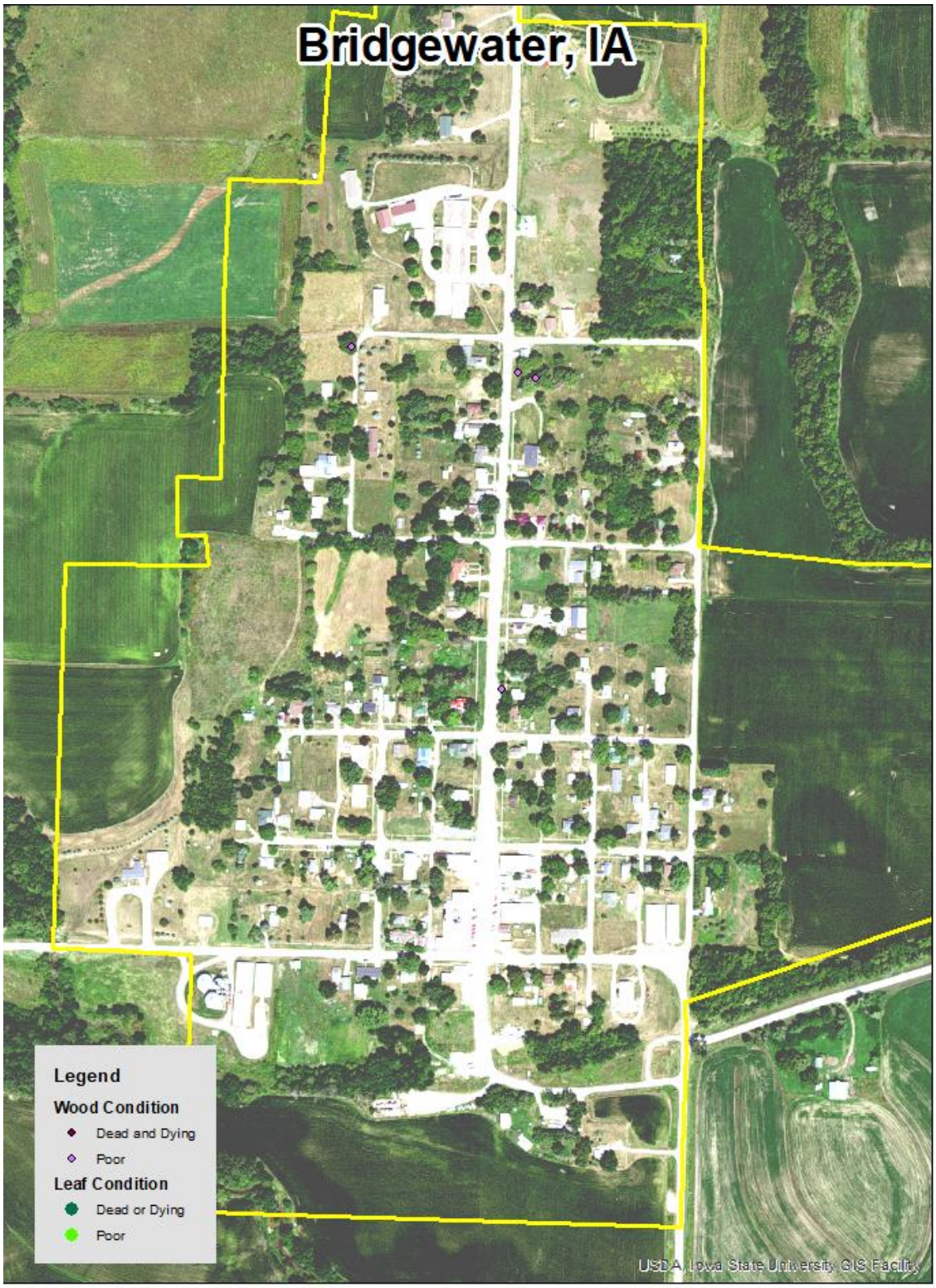

Figure 3: Location of Poor Condition Trees

None

Figure 4: Location of Trees with Recommended Maintenance

None

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

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