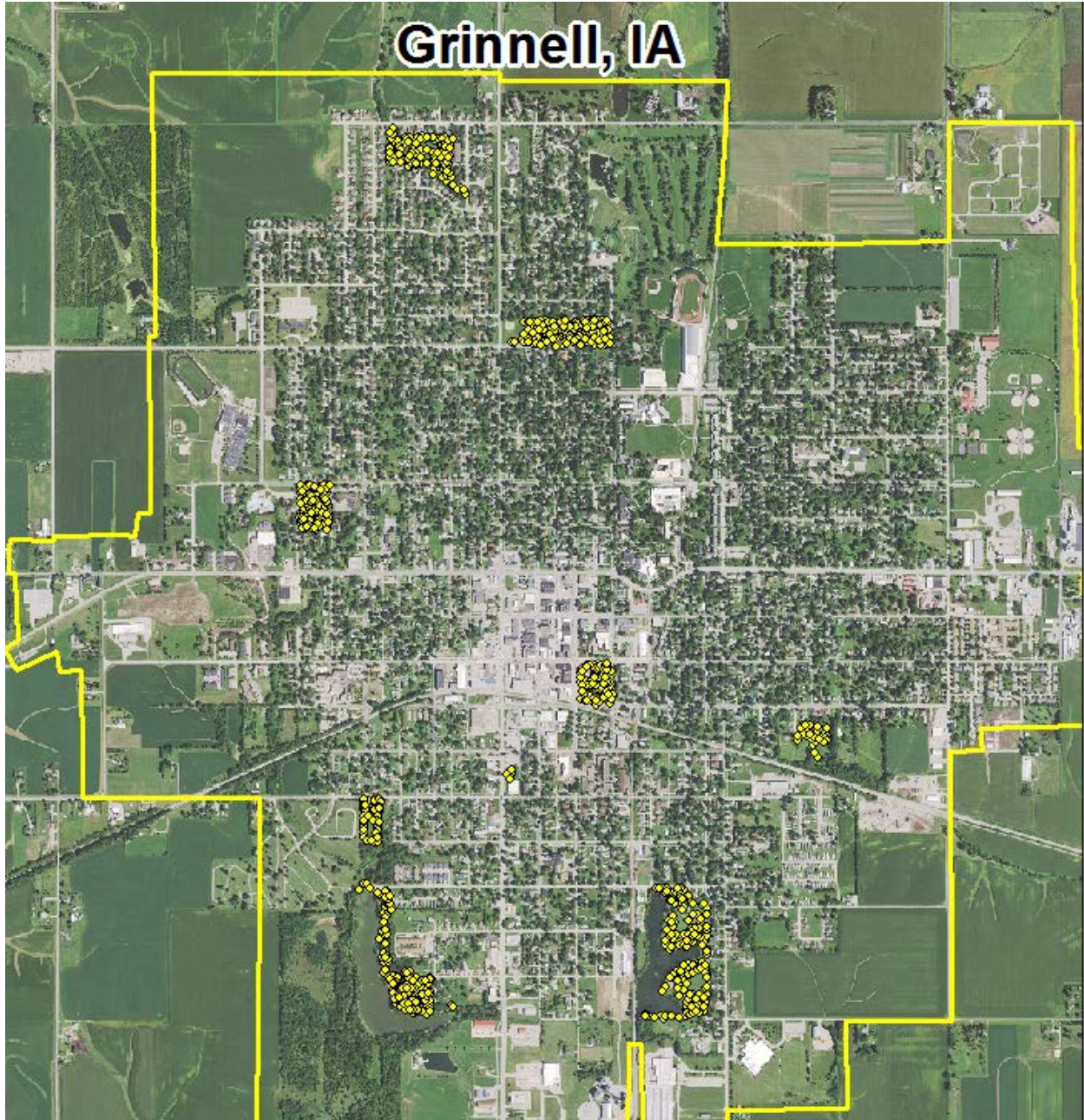


Grinnell, IA



2017 Urban Forest Management Plan
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Executive Summary

Overview

This plan was developed to assist the City of Grinnell with managing its park trees and 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 8% (77) of Grinnell's park trees (ash) will die at some point now that EAB has become established in the community (2015), unless preventative treatment is used. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

Inventory and Results

In 2015 and 2016, a tree inventory was conducted using Global Positioning System (GPS) data collectors. The inventory was a complete inventory of park trees. Below are some key findings of the 935 trees inventoried.

- Grinnell's park trees provide \$267,497 of benefits annually, an average of \$286 a tree
- There are over 59 different species of trees in the parks
- The top three genera in the parks are: Maple 20%, Oak 12%, and Apple (Crab) 8.5%
- 23% of trees are in need of some type of management in the parks
- 25 trees are recommended for removal in the parks

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 25 trees needing removal in the parks, 3 trees are ash that should be addressed immediately. 7 of the 25 trees being considered for removal are of Critical Concern. All trees suggested for removal should be evaluated as soon as possible to prioritize the order of removal. [*City ownership of the trees recommended for removal should be verified prior to any removal*](#)
- 38 of the 77 ash trees in the parks are showing some symptoms related to an EAB infestation. Check ash trees with a visual survey yearly for EAB infestations
- All park trees should be pruned on a routine schedule- one third of the city every other year
- Plant a diverse mix of trees within the parks that do not include: ash, maple, cottonwood, poplar, boxelder, Siberian elm, or willow
- With the current budget of \$30,000 for removal all park ash trees (77) could be removed just over 2 years @ a cost of \$800/tree if all funds were used for ash removal only. Also, currently there is ~\$5,000 budgeted annually for planting and care.

Introduction

This plan was developed to assist Grinnell with the management, budgeting and future planning of their park trees within their urban forest. Across the state, forestry budgets continue to decrease with more and more of that money spent on tree removal. Since Emerald Ash Borer (EAB) has already arrived in Grinnell (2015), it is now time to prepare for the increased costs of tree removal or treatment and replacement planting. Ash decline and death will most likely begin to increase over the next 3 to 10 years.

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

Inventory

In 2015 and 2016, a tree inventory was conducted that included only trees in 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 935 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. Grinnell's park trees reduce energy related costs by approximately \$70,881 annually (Appendix A, Table 1). These savings are both in Electricity (336.6 MWh) and in Natural Gas (46,255.2 Therms).

Annual Stormwater Benefits

Grinnell's park trees intercept about 3,882,057 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides \$105,204 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 Grinnell, it is estimated that park trees remove 4,120 lbs of air pollution (ozone (O₃), particulate matter less than 10 microns (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂) per year with a net value of \$11,318 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Grinnell, park trees sequester about 1,192,367 lbs of carbon a year with an associated value of \$8,943 (Appendix A, Table 5). In addition, the trees store 14,353,209 lbs of carbon, with a yearly benefit of \$107,649 (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. Grinnell receives \$71,151 in annual social benefits from park trees (Appendix A, Table 6).

Financial Summary of all Benefits

According to the USDA Forest Service i-Tree STREETS analysis, Grinnell's park trees provide \$267,497 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 935 park trees in Grinnell provide approximately \$286 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Grinnell has over 59 different tree species in city parks (Appendix A, Figure 1). The general distribution of the most common trees by genera is as follows:

Maple	186	20%
Oak	112	12%
Apple (Crab)	80	8.5%
Ash	77	8%
Spruce	75	8%
Linden/Basswood	65	7%
Hackberry	43	4.5%
Honeylocust	37	4%
Broadleaf Deciduous	28	3%
Conifer Evergreen	27	3%
Catalpa	23	2%
Austrian Pine	23	2%
Sycamore	19	2%
Hophornbeam	13	1%

Age Class

Just over 1/2 of Grinnell's park trees (53%) are between 1 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. Grinnell's size curve of park trees is about split down the middle ½ are generally young and ½ are beginning to mature.

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 Grinnell indicate that 85% of the park trees are in good health, with only 2% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 72% of Grinnell's park 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 5% of the population. This 5% is an estimate of trees that need management follow up.

Management Needs

The following outlines the specific management needs of the park trees by number of trees and percent of all park trees (Appendix B, Figure 3).

Crown Cleaning	99	11%
Tree Staking	58	6%
Crown Raising	30	3%
Tree Removal	25	3%

Canopy Cover

The total canopy with both private and public trees is 15%, 522 acres. The canopy cover included in the Grinnell inventory of park trees includes approximately 19 acres (Appendix A, Figure 4).

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

Grinnell has 7 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. There are 6 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 18 more park trees that need to be considered for removal.

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). There are 4 ash identified in poor health. Of the 25 removals, 3 are ash trees. There are a total of 77 ash park trees, and any trees that have not been treated should be observed annually for decline and symptoms related to EAB since this pest was found in the community in 2015. [*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 park and public 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 Grinnell.

It is important to plant a diverse mix of species in the parks and 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 parks have significant maple (20%) (Appendix A, Figure 1). No more maples should be planted in the parks or even potentially on any public areas 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 on the community do not plant list: cottonwood, poplar, boxelder, Chinese elm, Siberian elm, willow, catalpa, black locust, American elm, Austrian pine, mountain ash, mulberry, Russian olive, silver maple, Tree of Heaven, weeping birch, and white poplar. All trees planted must meet the restrictions in city ordinance #1237 (Appendix C).

Continual Monitoring

Since EAB was found in Grinnell in 2015, 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.

Maintenance Plan with No Additional Funding

Current Total Tree Management Annual Budget

Year 1

Tree Removal: \$30,000 @ ~\$800/tree can remove 37 trees

Tree Maintenance: \$24,000

EAB Management: \$5,000 currently treating ~75 trees @ \$60/tree=\$4,500 every 2 years

Planting & Care: \$5,000 @\$100/tree can plant 50 trees

Management: \$5,000

Year 2

Removal: Up to 37 trees/year @~800/tree

Planting and Replacement: Up to 50 trees @\$100/tree

Young Tree Pruning & Maintenance:

Routine trimming: Contract to trim 1/3 of the city trees up to \$24,000 annually

Visual Survey for signs and symptoms of EAB

Year 3

Removal: Up to 37 trees/year @~800/tree

Planting and Replacement: Up to 50 trees @\$100/tree

Young Tree Pruning & Maintenance: Begin developmental pruning when needed

Routine trimming:

Visual Survey for signs and symptoms of EAB

Year 4

Removal: Up to 37 trees/year @~800/tree

Planting and Replacement: Up to 50 trees @\$100/tree

Young Tree Pruning & Maintenance: Begin developmental pruning when needed

Routine trimming: Contract to trim 1/3 of the city trees up to \$24,000 annually

Visual Survey for signs and symptoms of EAB

Year 5

Removal: Up to 37 trees/year @~800/tree

Planting and Replacement: Up to 50 trees @\$100/tree

Young Tree Pruning & Maintenance: Begin developmental pruning when needed

Visual Survey for signs and symptoms of EAB

Year 6

Removal: Up to 37 trees/year @~800/tree

Planting and Replacement: Up to 50 trees @\$100/tree

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

Young Tree Pruning & Maintenance: Begin developmental pruning when needed

Visual Survey for signs and symptoms of EAB

*It would take 2 years of the current tree removal budget to remove the majority of the park ash trees (77). This would not include cost of removing any street ash trees or any other hazardous trees.

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). The city has determined that eventually all ash street trees will be removed, and a select number of park ash trees will be protected long-term if feasible. ***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. The city of Grinnell treated ~75 ash trees in 2015 at a cost of ~\$60/tree or a total of \$4,500. The city has determined that eventually all ash street trees will be removed, and a select number of park ash trees will be protected long-term if feasible. Currently, any street trees being treated are being done so to spread out the long-term removal costs of the ash.

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. **Currently, in Iowa the only quarantine related to this pest and associated regulated items is a Federal Quarantine that does not allow the movement of regulated items outside of Iowa into non-quarantined areas.**

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? **There is no state quarantine in Iowa that restricts the movement of ash material and/or hardwood firewood within the boundaries of the state, but with that said communities are strongly encouraged to utilize any ash material locally and limit movement outside of the county.**

Canopy Replacement

As budget permits, all removed trees will be replaced. All trees planted must meet the restrictions in city ordinance #1237 (Appendix C). The new plantings will be a diverse mix and will not include ash, maple, cottonwood, poplar, box elder, Chinese elm, Siberian elm, willow, catalpa, black locust, American elm, Austrian pine, mountain ash, mulberry, Russian olive, silver maple, Tree of Heaven, weeping birch, and white poplar.

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

Since EAB is established in Grinnell it is recommended that public 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. Currently 38 of the 77 park ash trees are showing some potential EAB infestation symptoms.

Private Ash Trees

It is strongly recommended that private property owners start removing ash trees on their property when they start to show declining health upon arrival of EAB to their area of the community if preventative treatments are not being used. City Code Sec. 21-36 (b) states: **“The duties of any person growing a tree or other plantings on private property abutting on streets or public spaces are: (2) To treat in an accepted manner, or remove any tree or plant so diseased or insect-ridden as to constitute a hazard to other trees and especially those dangerous to trees or plants in public streets or places.”**

Budget

Current Budget For All Public Trees

Tree Removal: \$30,000 @ ~\$800/tree can remove 37 trees

Tree Maintenance: \$24,000

EAB Management: \$5,000 currently treating ~75 trees @ \$60/tree=\$4,500 every 2 years

Planting & Care: \$5,000 @\$100/tree can plant 50 trees

Management: \$5,000

*It would take 2 years of the current tree removal budget to remove the majority of the park ash trees. This would not include cost of removing any street ash trees or any other hazardous trees. To remove all park ash trees (~77) within ~6 years @\$800/tree ~\$10,000 annually would allow the removal of ~12 park ash trees a year and would leave \$20,000 for removing ash and other trees of concern annually.

Purposed Budget Increase

EAB could potentially kill all non-treated ash trees in Grinnell Parks and streets within the next 3 to 10 years. To remove all park ash trees within 6 years @\$800/tree ~\$10,000 annually would allow the removal of ~12 park ash trees a year and would leave \$20,000 for removing ash and other trees of concern annually. **The number of public ash street trees will dictate the future funding needed to cover the cost of removing dead or declining public ash.** Additionally, it is recommended that Grinnell 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. The current Grinnell budget for EAB Management is \$5,000 annually which at \$60/tree would allow for treating ~83 trees. In 2015 the city treated ~75 trees (some street and some park trees), and plans are to treat those again this year.

Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Grinnell

Annual Energy Benefits of All Trees

3/3/2017

Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Apple	12.3	936	1,913.6	1,875	2,812	(N/A)	8.6	4.0	17.57
Norway maple	32.3	2,452	4,680.8	4,587	7,039	(N/A)	6.5	9.9	57.70
Green ash	32.1	2,439	4,375.7	4,288	6,727	(N/A)	6.4	9.5	56.06
American basswood	17.7	1,343	2,568.5	2,517	3,860	(N/A)	6.1	5.4	33.86
Sugar maple	23.9	1,814	3,166.1	3,103	4,917	(N/A)	5.7	6.9	46.38
Pin oak	30.2	2,289	4,109.0	4,027	6,315	(N/A)	5.4	8.9	63.15
Northern hackberry	19.1	1,450	2,640.2	2,587	4,037	(N/A)	4.6	5.7	46.94
Honeylocust	16.8	1,274	2,154.0	2,111	3,385	(N/A)	4.0	4.8	45.74
Norway spruce	8.6	653	1,106.9	1,085	1,738	(N/A)	3.3	2.5	28.03
Red maple	9.3	708	1,278.9	1,253	1,961	(N/A)	3.2	2.8	32.68
Conifer Evergreen Large	6.9	522	892.4	875	1,397	(N/A)	2.8	2.0	26.86
Austrian pine	6.3	476	830.0	813	1,290	(N/A)	2.5	1.8	28.03
Blue spruce	4.5	339	595.2	583	922	(N/A)	2.4	1.3	20.96
Spruce	6.6	505	866.8	849	1,354	(N/A)	2.4	1.9	30.78
Swamp white oak	2.4	185	343.2	336	521	(N/A)	2.1	0.7	13.02
Silver maple	14.6	1,112	1,948.8	1,910	3,022	(N/A)	2.1	4.3	75.54
American sycamore	14.2	1,079	1,909.4	1,871	2,950	(N/A)	2.0	4.2	77.64
Broadleaf Deciduous Small	0.9	65	149.7	147	212	(N/A)	1.8	0.3	6.23
Bur oak	4.6	346	589.3	578	924	(N/A)	1.7	1.3	28.86
White ash	8.3	628	1,039.0	1,018	1,646	(N/A)	1.7	2.3	51.43
Scotch pine	3.5	269	438.7	430	699	(N/A)	1.6	1.0	23.29
Catalpa	3.6	274	480.7	471	745	(N/A)	1.4	1.1	28.67
Oak	5.3	401	676.4	663	1,064	(N/A)	1.4	1.5	40.91
Eastern hophornbeam	0.1	7	16.2	16	23	(N/A)	1.4	0.0	0.87
Plum	0.1	6	15.0	15	21	(N/A)	1.3	0.0	0.87
Northern red oak	1.5	116	215.7	211	328	(N/A)	1.2	0.5	14.90
Maple	1.9	143	267.7	262	406	(N/A)	1.1	0.6	20.29
Northern catalpa	0.1	4	9.3	9	13	(N/A)	1.1	0.0	0.66
Amur maple	3.3	254	531.6	521	775	(N/A)	1.0	1.1	43.03
Eastern white pine	3.2	242	423.2	415	656	(N/A)	1.0	0.9	36.46
Dogwood	1.1	83	174.8	171	254	(N/A)	0.9	0.4	15.89
River birch	4.3	326	630.3	618	944	(N/A)	0.9	1.3	59.00
Littleleaf linden	4.1	310	605.8	594	904	(N/A)	0.9	1.3	56.51
Tulip tree	0.9	66	120.3	118	184	(N/A)	0.9	0.3	11.47
Kentucky coffeetree	0.3	21	39.5	39	59	(N/A)	0.7	0.1	4.25
Elm	2.5	193	344.7	338	531	(N/A)	0.7	0.7	37.90
Japanese tree lilac	0.6	47	107.4	105	152	(N/A)	0.7	0.2	10.88
Broadleaf Deciduous Large	3.7	277	489.6	480	757	(N/A)	0.6	1.1	63.10
Broadleaf Deciduous Medium	1.4	106	211.3	207	313	(N/A)	0.6	0.4	28.47
Cottonwood	4.5	338	593.4	581	920	(N/A)	0.5	1.3	91.99
American elm	2.5	187	311.7	305	493	(N/A)	0.5	0.7	49.25
Eastern red cedar	0.8	58	114.5	112	170	(N/A)	0.4	0.2	21.30
Siberian elm	2.6	200	361.5	354	554	(N/A)	0.4	0.8	69.23
Northern white cedar	0.9	70	117.9	116	186	(N/A)	0.3	0.3	30.93
Black walnut	1.6	123	228.5	224	347	(N/A)	0.3	0.5	57.86
Boxelder	1.6	119	217.8	213	333	(N/A)	0.3	0.5	55.44
Birch	0.9	72	146.5	144	215	(N/A)	0.3	0.3	35.88
Black cherry	1.2	91	189.7	186	277	(N/A)	0.3	0.4	46.14
Black locust	1.9	146	284.5	279	425	(N/A)	0.3	0.6	70.84
Ginkgo	0.2	16	31.6	31	47	(N/A)	0.3	0.1	7.91
White oak	1.5	116	211.7	207	324	(N/A)	0.2	0.5	80.97
Hickory	1.0	75	130.2	128	203	(N/A)	0.2	0.3	50.77
Yellowwood	0.0	1	3.2	3	4	(N/A)	0.2	0.0	1.10
Conifer Evergreen Small	0.1	7	15.9	16	23	(N/A)	0.1	0.0	11.47
Eastern hemlock	0.4	28	49.2	48	76	(N/A)	0.1	0.1	38.17
Cherry plum	0.4	30	63.2	62	92	(N/A)	0.1	0.1	46.14
Eastern redbud	0.0	3	7.6	7	11	(N/A)	0.1	0.0	5.40
Ash	0.6	49	94.8	93	142	(N/A)	0.1	0.2	70.84
Mulberry	0.4	30	63.2	62	92	(N/A)	0.1	0.1	46.14
White mulberry	0.4	30	63.2	62	92	(N/A)	0.1	0.1	46.14
Total	336.6	25,551	46,255.2	45,330	70,881	(N/A)	100.0	100.0	37.92

Table 2: Annual Stormwater Benefits

Grinnell

Annual Stormwater Benefits of All Trees

3/3/2017

Species	Total rainfall interception (Gal)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Apple	56,781	1,539	(N/A)	8.6	1.5	9.62
Norway maple	321,536	8,714	(N/A)	6.5	8.3	71.42
Green ash	344,496	9,336	(N/A)	6.4	8.9	77.80
American basswood	200,329	5,429	(N/A)	6.1	5.2	47.62
Sugar maple	267,620	7,252	(N/A)	5.7	6.9	68.42
Pin oak	314,103	8,512	(N/A)	5.4	8.1	85.12
Northern hackberry	179,872	4,875	(N/A)	4.6	4.6	56.68
Honeylocust	168,942	4,578	(N/A)	4.0	4.4	61.87
Norway spruce	159,795	4,330	(N/A)	3.3	4.1	69.85
Red maple	85,970	2,330	(N/A)	3.2	2.2	38.83
Conifer Evergreen Large	129,575	3,511	(N/A)	2.8	3.3	67.53
Austrian pine	94,016	2,548	(N/A)	2.5	2.4	55.39
Blue spruce	63,246	1,714	(N/A)	2.4	1.6	38.95
Spruce	139,526	3,781	(N/A)	2.4	3.6	85.94
Swamp white oak	13,761	373	(N/A)	2.1	0.4	9.32
Silver maple	237,873	6,446	(N/A)	2.1	6.1	161.16
American sycamore	197,928	5,364	(N/A)	2.0	5.1	141.15
Broadleaf Deciduous Small	2,946	80	(N/A)	1.8	0.1	2.35
Bur oak	53,844	1,459	(N/A)	1.7	1.4	45.60
White ash	83,219	2,255	(N/A)	1.7	2.1	70.48
Scotch pine	49,083	1,330	(N/A)	1.6	1.3	44.34
Catalpa	51,641	1,399	(N/A)	1.4	1.3	53.83
Oak	63,223	1,713	(N/A)	1.4	1.6	65.90
Eastern hophornbeam	194	5	(N/A)	1.4	0.0	0.20
Plum	179	5	(N/A)	1.3	0.0	0.20
Northern red oak	10,161	275	(N/A)	1.2	0.3	12.52
Maple	17,868	484	(N/A)	1.1	0.5	24.21
Northern catalpa	358	10	(N/A)	1.1	0.0	0.48
Amur maple	19,314	523	(N/A)	1.0	0.5	29.08
Eastern white pine	76,342	2,069	(N/A)	1.0	2.0	114.94
Dogwood	3,861	105	(N/A)	0.9	0.1	6.54
River birch	44,022	1,193	(N/A)	0.9	1.1	74.56
Littleleaf linden	48,882	1,325	(N/A)	0.9	1.3	82.79
Tulip tree	11,539	313	(N/A)	0.9	0.3	19.54
Kentucky coffeetree	1,738	47	(N/A)	0.7	0.0	3.36
Elm	36,583	991	(N/A)	0.7	0.9	70.81
Japanese tree lilac	2,136	58	(N/A)	0.7	0.1	4.14
Broadleaf Deciduous Large	41,293	1,119	(N/A)	0.6	1.1	93.25
Broadleaf Deciduous Medium	9,908	269	(N/A)	0.6	0.3	24.41
Cottonwood	65,396	1,772	(N/A)	0.5	1.7	177.22
American elm	20,999	569	(N/A)	0.5	0.5	56.91
Eastern red cedar	11,126	302	(N/A)	0.4	0.3	37.69
Siberian elm	27,687	750	(N/A)	0.4	0.7	93.79
Northern white cedar	18,225	494	(N/A)	0.3	0.5	82.32
Black walnut	20,083	544	(N/A)	0.3	0.5	90.71
Boxelder	21,215	575	(N/A)	0.3	0.5	95.82
Birch	7,302	198	(N/A)	0.3	0.2	32.98
Black cherry	7,044	191	(N/A)	0.3	0.2	31.82
Black locust	22,586	612	(N/A)	0.3	0.6	102.01
Ginkgo	930	25	(N/A)	0.3	0.0	4.20
White oak	22,364	606	(N/A)	0.2	0.6	151.51
Hickory	8,112	220	(N/A)	0.2	0.2	54.96
Yellowwood	49	1	(N/A)	0.2	0.0	0.33
Conifer Evergreen Small	1,318	36	(N/A)	0.1	0.0	17.86
Eastern hemlock	9,209	250	(N/A)	0.1	0.2	124.79
Cherry plum	2,348	64	(N/A)	0.1	0.1	31.82
Eastern redbud	137	4	(N/A)	0.1	0.0	1.86
Ash	7,529	204	(N/A)	0.1	0.2	102.01
Mulberry	2,348	64	(N/A)	0.1	0.1	31.82
White mulberry	2,348	64	(N/A)	0.1	0.1	31.82
Citywide total	3,882,057	105,204	(N/A)	100.0	100.0	56.29

**Table 3: Annual Air Quality Benefits
Grinnell**

Annual Air Quality Benefits of All Trees

3/3/2017

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							
Apple	18.0	3.0	8.4	0.8	96	60.9	8.7	8.3	55.9	374	-0.1	0	163.8	469 (N/A)	8.6	2.93
Norway maple	68.1	11.7	33.1	3.0	367	156.8	22.7	21.6	146.6	971	-15.7	-59	447.8	1,279 (N/A)	6.5	10.48
Green ash	44.2	7.1	21.2	2.0	235	153.2	22.3	21.3	145.7	955	0.0	0	416.9	1,190 (N/A)	6.4	9.92
American basswood	27.5	4.7	13.5	1.2	148	85.9	12.4	11.8	80.3	532	-23.4	-88	214.0	593 (N/A)	6.1	5.20
Sugar maple	38.2	6.5	18.8	1.7	206	113.0	16.5	15.8	108.2	707	-30.0	-112	288.9	801 (N/A)	5.7	7.55
Pin oak	52.5	9.2	27.3	2.4	289	143.6	20.9	20.0	136.6	895	-98.7	-370	313.8	814 (N/A)	5.4	8.14
Northern hackberry	30.9	5.4	15.6	1.4	168	91.6	13.3	12.7	86.6	570	0.0	0	257.5	738 (N/A)	4.6	8.58
Honeylocust	32.4	5.3	14.9	1.5	172	78.7	11.6	11.0	76.0	494	-24.9	-93	206.5	572 (N/A)	4.0	7.73
Norway spruce	18.7	3.7	15.3	2.3	123	40.4	5.9	5.7	39.0	253	-81.2	-304	49.8	72 (N/A)	3.3	1.16
Red maple	21.6	3.7	10.0	1.0	115	44.5	6.5	6.2	42.2	277	-7.1	-27	128.5	365 (N/A)	3.2	6.09
Conifer Evergreen Large	15.2	3.0	12.4	1.9	100	32.3	4.7	4.5	31.2	203	-66.7	-250	38.5	52 (N/A)	2.8	1.01
Austrian pine	14.2	2.8	11.5	1.7	93	29.6	4.3	4.1	28.4	185	-35.4	-133	61.4	146 (N/A)	2.5	3.17
Blue spruce	9.0	1.8	7.4	1.1	59	21.1	3.1	2.9	20.2	132	-23.3	-87	43.3	104 (N/A)	2.4	2.36
Spruce	16.7	3.3	13.4	2.0	109	31.3	4.6	4.4	30.1	196	-75.0	-281	30.7	23 (N/A)	2.4	0.53
Swamp white oak	1.8	0.3	1.0	0.1	10	11.7	1.7	1.6	11.0	73	-0.5	-2	28.8	81 (N/A)	2.1	2.02
Silver maple	45.6	7.7	22.0	2.0	245	69.2	10.1	9.7	66.2	433	-23.9	-90	208.7	588 (N/A)	2.1	14.69
American sycamore	35.5	5.7	15.8	1.6	186	67.6	9.9	9.4	64.4	422	0.0	0	209.8	607 (N/A)	2.0	15.98
Broadleaf Deciduous Small	0.5	0.1	0.3	0.0	3	4.4	0.6	0.6	3.9	27	0.0	0	10.3	29 (N/A)	1.8	0.86
Bur oak	10.1	1.6	4.5	0.5	53	21.5	3.1	3.0	20.7	134	0.0	0	65.0	187 (N/A)	1.7	5.86
White ash	12.5	2.0	6.0	0.6	66	38.6	5.7	5.4	37.5	243	0.0	0	108.1	309 (N/A)	1.7	9.66
Scotch pine	5.4	1.1	4.6	0.7	36	16.5	2.4	2.3	16.0	104	-19.1	-72	30.0	68 (N/A)	1.6	2.28
Catalpa	10.5	1.7	4.6	0.5	55	17.1	2.5	2.4	16.4	107	0.0	0	55.6	162 (N/A)	1.4	6.22
Oak	9.7	1.5	4.4	0.4	51	24.8	3.6	3.5	23.9	155	0.0	0	71.9	206 (N/A)	1.4	7.94
Eastern hophornbeam	0.0	0.0	0.0	0.0	0	0.5	0.1	0.1	0.4	3	0.0	0	1.0	3 (N/A)	1.4	0.11
Plum	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.4	3	0.0	0	0.9	3 (N/A)	1.3	0.11
Northern red oak	1.7	0.3	0.9	0.1	9	7.4	1.1	1.0	7.0	46	-2.4	-9	17.0	46 (N/A)	1.2	2.10
Maple	4.5	0.8	2.1	0.2	24	9.1	1.3	1.3	8.6	56	-1.5	-6	26.4	75 (N/A)	1.1	3.75
Northern catalpa	0.0	0.0	0.0	0.0	0	0.3	0.0	0.0	0.2	2	0.0	0	0.6	2 (N/A)	1.1	0.08
Amur maple	7.0	1.2	3.2	0.3	37	16.6	2.4	2.2	15.1	102	0.0	0	48.0	139 (N/A)	1.0	7.70
Eastern white pine	9.3	1.8	7.4	1.1	61	15.0	2.2	2.1	14.4	94	-45.6	-171	7.9	-16 (N/A)	1.0	-0.90
Dogwood	0.8	0.1	0.4	0.0	4	5.4	0.8	0.7	5.0	33	0.0	0	13.3	38 (N/A)	0.9	2.36
River birch	9.4	1.6	4.6	0.4	51	20.9	3.0	2.9	19.5	129	-2.2	-8	60.2	172 (N/A)	0.9	10.75
Littleleaf linden	8.9	1.5	4.3	0.4	48	20.0	2.9	2.7	18.6	123	-4.2	-16	55.1	156 (N/A)	0.9	9.72
Tulip tree	1.6	0.3	0.7	0.1	8	4.1	0.6	0.6	3.9	26	0.0	0	11.9	34 (N/A)	0.9	2.13
Kentucky coffeetree	0.1	0.0	0.1	0.0	0	1.3	0.2	0.2	1.2	8	0.0	0	3.1	9 (N/A)	0.7	0.61
Elm	6.3	1.0	2.8	0.3	33	12.1	1.8	1.7	11.5	75	0.0	0	37.5	109 (N/A)	0.7	7.76
Japanese tree lilac	0.3	0.1	0.2	0.0	2	3.2	0.4	0.4	2.8	19	0.0	0	7.4	21 (N/A)	0.7	1.50
Broadleaf Deciduous Large	5.3	0.8	2.5	0.2	28	17.4	2.5	2.4	16.6	108	0.0	0	47.7	136 (N/A)	0.6	11.36
Broadleaf Deciduous Medium	1.5	0.3	0.8	0.1	9	6.9	1.0	0.9	6.3	42	-0.4	-2	17.4	49 (N/A)	0.6	4.48
Cottonwood	12.7	2.0	5.6	0.6	66	21.1	3.1	2.9	20.2	132	0.0	0	68.2	198 (N/A)	0.5	19.81
American elm	5.0	0.9	2.4	0.2	27	11.5	1.7	1.6	11.2	72	0.0	0	34.6	99 (N/A)	0.5	9.95
Eastern red cedar	2.2	0.4	1.7	0.3	14	3.7	0.5	0.5	3.5	23	-6.1	-23	6.8	14 (N/A)	0.4	1.79
Siberian elm	4.5	0.8	2.2	0.2	24	12.6	1.8	1.7	11.9	78	0.0	0	35.8	103 (N/A)	0.4	12.83
Northern white cedar	2.2	0.4	1.7	0.3	14	4.3	0.6	0.6	4.2	27	-9.6	-36	4.8	5 (N/A)	0.3	0.90
Black walnut	2.6	0.4	1.2	0.1	14	7.8	1.1	1.1	7.4	48	0.0	0	21.8	62 (N/A)	0.3	10.39
Boxelder	3.1	0.5	1.4	0.1	16	7.5	1.1	1.0	7.1	47	-0.8	-3	21.0	60 (N/A)	0.3	9.98
Birch	1.2	0.2	0.6	0.1	7	4.7	0.7	0.6	4.3	29	-0.3	-1	12.1	34 (N/A)	0.3	5.70
Black cherry	2.6	0.4	1.2	0.1	14	5.9	0.8	0.8	5.4	36	0.0	0	17.3	50 (N/A)	0.3	8.35
Black locust	5.2	0.9	2.5	0.2	28	9.4	1.4	1.3	8.7	58	-1.2	-4	28.4	81 (N/A)	0.3	13.58
Ginkgo	0.1	0.0	0.1	0.0	0	1.0	0.2	0.1	1.0	6	0.0	0	2.4	7 (N/A)	0.3	1.13
White oak	3.3	0.5	1.5	0.1	17	7.3	1.1	1.0	7.0	46	0.0	0	21.8	63 (N/A)	0.2	15.76
Hickory	0.7	0.1	0.4	0.0	4	4.7	0.7	0.7	4.5	29	0.0	0	11.9	34 (N/A)	0.2	8.38
Yellowwood	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	0.0	0	0.2	1 (N/A)	0.2	0.14
Conifer Evergreen Small	0.1	0.0	0.1	0.0	1	0.5	0.1	0.1	0.4	3	-0.7	-3	0.6	1 (N/A)	0.1	0.62
Eastern hemlock	1.1	0.2	0.9	0.1	7	1.8	0.3	0.2	1.7	11	-5.7	-21	0.6	-3 (N/A)	0.1	-1.58
Cherry plum	0.9	0.1	0.4	0.0	5	2.0	0.3	0.3	1.8	12	0.0	0	5.8	17 (N/A)	0.1	8.35
Eastern redbud	0.0	0.0	0.0	0.0	0	0.2	0.0	0.0	0.2	1	0.0	0	0.5	1 (N/A)	0.1	0.71
Ash	1.7	0.3	0.8	0.1	9	3.1	0.5	0.4	2.9	19	-0.4	-1	9.5	27 (N/A)	0.1	13.58
Mulberry	0.9	0.1	0.4	0.0	5	2.0	0.3	0.3	1.8	12	0.0	0	5.8	17 (N/A)	0.1	8.35
White mulberry	0.9	0.1	0.4	0.0	5	2.0	0.3	0.3	1.8	12	0.0	0	5.8	17 (N/A)	0.1	8.35
Citywide total	646.7	111.3	341.6	36.3	3,576	1,608.2	234.1	223.1	1,525.5	10,015	-606.2	-2,273	4,120.4	11,318 (N/A)	100.0	6.06

Table 4: Annual Carbon Stored

Grinnell

Stored CO2 Benefits of All Trees						
3/3/2017						
Species	Total Stored CO2 (lbs)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Apple	284,583	2,134	(N/A)	8.6	2.0	13.34
Norway maple	1,120,485	8,404	(N/A)	6.5	7.8	68.88
Green ash	1,464,340	10,983	(N/A)	6.4	10.2	91.52
American basswood	1,023,057	7,673	(N/A)	6.1	7.1	67.31
Sugar maple	1,125,573	8,442	(N/A)	5.7	7.8	79.64
Pin oak	1,346,438	10,098	(N/A)	5.4	9.4	100.98
Northern hackberry	488,892	3,667	(N/A)	4.6	3.4	42.64
Honeylocust	415,610	3,117	(N/A)	4.0	2.9	42.12
Norway spruce	201,127	1,508	(N/A)	3.3	1.4	24.33
Red maple	231,365	1,735	(N/A)	3.2	1.6	28.92
Conifer Evergreen La	165,759	1,243	(N/A)	2.8	1.2	23.91
Austrian pine	109,125	818	(N/A)	2.5	0.8	17.79
Blue spruce	64,998	487	(N/A)	2.4	0.5	11.08
Spruce	189,381	1,420	(N/A)	2.4	1.3	32.28
Swamp white oak	31,391	235	(N/A)	2.1	0.2	5.89
Silver maple	1,125,290	8,440	(N/A)	2.1	7.8	210.99
American sycamore	1,223,936	9,180	(N/A)	2.0	8.5	241.57
Broadleaf Deciduous	9,738	73	(N/A)	1.8	0.1	2.15
Bur oak	357,674	2,683	(N/A)	1.7	2.5	83.83
White ash	228,069	1,711	(N/A)	1.7	1.6	53.45
Scotch pine	42,661	320	(N/A)	1.6	0.3	10.67
Catalpa	367,656	2,757	(N/A)	1.4	2.6	106.05
Oak	330,040	2,475	(N/A)	1.4	2.3	95.20
Eastern hophornbeam	358	3	(N/A)	1.4	0.0	0.10
Plum	331	2	(N/A)	1.3	0.0	0.10
Northern red oak	30,272	227	(N/A)	1.2	0.2	10.32
Maple	48,714	365	(N/A)	1.1	0.3	18.27
Northern catalpa	243	2	(N/A)	1.1	0.0	0.09
Amur maple	109,699	823	(N/A)	1.0	0.8	45.71
Eastern white pine	118,235	887	(N/A)	1.0	0.8	49.26
Dogwood	14,404	108	(N/A)	0.9	0.1	6.75
River birch	155,472	1,166	(N/A)	0.9	1.1	72.88
Littleleaf linden	187,655	1,407	(N/A)	0.9	1.3	87.96
Tulip tree	52,403	393	(N/A)	0.9	0.4	24.56
Kentucky coffeetree	2,562	19	(N/A)	0.7	0.0	1.37
Elm	215,834	1,619	(N/A)	0.7	1.5	115.63
Japanese tree lilac	6,870	52	(N/A)	0.7	0.0	3.68
Broadleaf Deciduous	173,211	1,299	(N/A)	0.6	1.2	108.26
Broadleaf Deciduous	26,152	196	(N/A)	0.6	0.2	17.83
Cottonwood	439,665	3,297	(N/A)	0.5	3.1	329.75
American elm	104,292	782	(N/A)	0.5	0.7	78.22
Eastern red cedar	7,167	54	(N/A)	0.4	0.0	6.72
Siberian elm	110,167	826	(N/A)	0.4	0.8	103.28
Northern white cedar	24,007	180	(N/A)	0.3	0.2	30.01
Black walnut	85,501	641	(N/A)	0.3	0.6	106.88
Boxelder	125,821	944	(N/A)	0.3	0.9	157.28
Birch	20,293	152	(N/A)	0.3	0.1	25.37
Black cherry	40,456	303	(N/A)	0.3	0.3	50.57
Black locust	85,681	643	(N/A)	0.3	0.6	107.10
Ginkgo	1,258	9	(N/A)	0.3	0.0	1.57
White oak	110,063	825	(N/A)	0.2	0.8	206.37
Hickory	24,259	182	(N/A)	0.2	0.2	45.49
Yellowwood	67	1	(N/A)	0.2	0.0	0.13
Conifer Evergreen Su	554	4	(N/A)	0.1	0.0	2.08
Eastern hemlock	14,981	112	(N/A)	0.1	0.1	56.18
Cherry plum	13,485	101	(N/A)	0.1	0.1	50.57
Eastern redbud	356	3	(N/A)	0.1	0.0	1.33
Ash	28,560	214	(N/A)	0.1	0.2	107.10
Mulberry	13,485	101	(N/A)	0.1	0.1	50.57
White mulberry	13,485	101	(N/A)	0.1	0.1	50.57
Citywide total	14,353,209	107,649	(N/A)	100.0	100.0	57.60

**Table 5: Annual Carbon Sequestered
Grinnell**

Annual CO Benefits of All Trees

3/3/2017

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
Apple	18,958	142	-1,369	-183	-12	20,692	155	38,098	286 (N/A)	8.6	3.2	1.79
Norway maple	33,949	255	-5,380	-361	-43	54,189	406	82,397	618 (N/A)	6.5	6.9	5.07
Green ash	71,866	539	-7,029	-336	-55	53,907	404	118,408	888 (N/A)	6.4	9.9	7.40
American basswood	59,445	446	-4,913	-217	-38	29,678	223	83,993	630 (N/A)	6.1	7.0	5.53
Sugar maple	55,236	414	-5,404	-262	-42	40,084	301	89,655	672 (N/A)	5.7	7.5	6.34
Pin oak	123,150	924	-6,463	-314	-51	50,576	379	166,948	1,252 (N/A)	5.4	14.0	12.52
Northern hackberry	22,778	171	-2,347	-184	-19	32,040	240	52,287	392 (N/A)	4.6	4.4	4.56
Honeylocust	38,566	289	-1,996	-129	-16	28,147	211	64,588	484 (N/A)	4.0	5.4	6.55
Norway spruce	9,034	68	-965	-157	-8	14,436	108	22,347	168 (N/A)	3.3	1.9	2.70
Red maple	14,455	108	-1,112	-91	-9	15,641	117	28,893	217 (N/A)	3.2	2.4	3.61
Conifer Evergreen Large	7,598	57	-796	-126	-7	11,541	87	18,218	137 (N/A)	2.8	1.5	2.63
Austrian pine	5,081	38	-524	-115	-5	10,524	79	14,967	112 (N/A)	2.5	1.3	2.44
Blue spruce	3,479	26	-312	-80	-3	7,492	56	10,579	79 (N/A)	2.4	0.9	1.80
Spruce	7,889	59	-909	-123	-8	11,154	84	18,011	135 (N/A)	2.4	1.5	3.07
Swamp white oak	4,429	33	-153	-27	-1	4,079	31	8,327	62 (N/A)	2.1	0.7	1.56
Silver maple	73,159	549	-5,401	-176	-42	24,570	184	92,151	691 (N/A)	2.1	7.7	17.28
American sycamore	24,091	181	-5,875	-163	-45	23,844	179	41,897	314 (N/A)	2.0	3.5	8.27
Broadleaf Deciduous Smal	1,406	11	-48	-17	0	1,439	11	2,780	21 (N/A)	1.8	0.2	0.61
Bur oak	6,235	47	-1,717	-55	-13	7,649	57	12,112	91 (N/A)	1.7	1.0	2.84
White ash	14,219	107	-1,095	-75	-9	13,873	104	26,923	202 (N/A)	1.7	2.3	6.31
Scotch pine	3,520	26	-205	-59	-2	5,942	45	9,198	69 (N/A)	1.6	0.8	2.30
Catalpa	4,634	35	-1,765	-46	-14	6,061	45	8,884	67 (N/A)	1.4	0.7	2.56
Oak	9,909	74	-1,585	-57	-12	8,855	66	17,122	128 (N/A)	1.4	1.4	4.94
Eastern hophornbeam	226	2	-3	-5	0	146	1	364	3 (N/A)	1.4	0.0	0.10
Plum	208	2	-3	-5	0	135	1	336	3 (N/A)	1.3	0.0	0.10
Northern red oak	2,370	18	-146	-20	-1	2,574	19	4,779	36 (N/A)	1.2	0.4	1.63
Maple	183	1	-234	-21	-2	3,171	24	3,099	23 (N/A)	1.1	0.3	1.16
Northern catalpa	52	0	-2	-4	0	88	1	134	1 (N/A)	1.1	0.0	0.05
Amur maple	4,055	30	-527	-52	-4	5,605	42	9,081	68 (N/A)	1.0	0.8	3.78
Eastern white pine	4,334	33	-508	-60	-5	5,339	40	9,046	68 (N/A)	1.0	0.8	3.77
Dogwood	1,674	13	-69	-17	-1	1,833	14	3,421	26 (N/A)	0.9	0.3	1.60
River birch	3,840	29	-746	-50	-6	7,211	54	10,254	77 (N/A)	0.9	0.9	4.81
Littleleaf linden	13,024	98	-901	-51	-7	6,862	51	18,933	142 (N/A)	0.9	1.6	8.87
Tulip tree	2,099	16	-252	-12	-2	1,450	11	3,285	25 (N/A)	0.9	0.3	1.54
Kentucky coffeetree	592	4	-13	-5	0	459	3	1,032	8 (N/A)	0.7	0.1	0.55
Elm	4,817	36	-1,036	-30	-8	4,261	32	8,011	60 (N/A)	0.7	0.7	4.29
Japanese tree lilac	987	7	-33	-12	0	1,042	8	1,985	15 (N/A)	0.7	0.2	1.06
Broadleaf Deciduous Larg	8,352	63	-831	-37	-7	6,132	46	13,616	102 (N/A)	0.6	1.1	8.51
Broadleaf Deciduous Medi	2,680	20	-126	-15	-1	2,345	18	4,884	37 (N/A)	0.6	0.4	3.33
Cottonwood	6,712	50	-2,110	-52	-16	7,478	56	12,027	90 (N/A)	0.5	1.0	9.02
American elm	2,914	22	-501	-23	-4	4,135	31	6,525	49 (N/A)	0.5	0.5	4.89
Eastern red cedar	165	1	-34	-14	0	1,285	10	1,402	11 (N/A)	0.4	0.1	1.31
Siberian elm	5,040	38	-529	-28	-4	4,411	33	8,894	67 (N/A)	0.4	0.7	8.34
Northern white cedar	1,118	8	-115	-16	-1	1,548	12	2,534	19 (N/A)	0.3	0.2	3.17
Black walnut	4,051	30	-410	-18	-3	2,722	20	6,344	48 (N/A)	0.3	0.5	7.93
Boxelder	7,481	56	-604	-23	-5	2,635	20	9,489	71 (N/A)	0.3	0.8	11.86
Birch	1,836	14	-97	-10	-1	1,583	12	3,312	25 (N/A)	0.3	0.3	4.14
Black cherry	957	7	-194	-20	-2	2,009	15	2,752	21 (N/A)	0.3	0.2	3.44
Black locust	0	0	-411	-26	-3	3,232	24	2,795	21 (N/A)	0.3	0.2	3.49
Ginkgo	180	1	-6	-5	0	364	3	533	4 (N/A)	0.3	0.0	0.67
White oak	3,538	27	-528	-17	-4	2,573	19	5,566	42 (N/A)	0.2	0.5	10.44
Hickory	2,210	17	-116	-9	-1	1,669	13	3,753	28 (N/A)	0.2	0.3	7.04
Yellowwood	22	0	-1	-1	0	29	0	49	0 (N/A)	0.2	0.0	0.09
Conifer Evergreen Small	80	1	-3	-2	0	164	1	239	2 (N/A)	0.1	0.0	0.89
Eastern hemlock	0	0	-72	-10	-1	622	5	540	4 (N/A)	0.1	0.0	2.02
Cherry plum	0	0	-65	-7	-1	670	5	598	4 (N/A)	0.1	0.1	2.24
Eastern redbud	76	1	-2	-1	0	74	1	147	1 (N/A)	0.1	0.0	0.55
Ash	740	6	-137	-7	-1	1,077	8	1,673	13 (N/A)	0.1	0.1	6.27
Mulberry	957	7	-65	-5	-1	670	5	1,556	12 (N/A)	0.1	0.1	5.84
White mulberry	0	0	-65	-7	-1	670	5	598	4 (N/A)	0.1	0.1	2.24
Citywide total	700,654	5,255	-68,917	-4,049	-547	564,679	4,235	1,192,367	8,943 (N/A)	100.0	100.0	4.78

Table 6: Annual Social and Aesthetic Benefits

Grinnell

Annual Aesthetic/Other Benefits of All Trees

3/3/2017

Species	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Apple	1,077	(N/A)	8.6	1.5	6.73
Norway maple	3,198	(N/A)	6.5	4.5	26.21
Green ash	6,136	(N/A)	6.4	8.6	51.13
American basswood	4,270	(N/A)	6.1	6.0	37.46
Sugar maple	5,617	(N/A)	5.7	7.9	52.99
Pin oak	9,920	(N/A)	5.4	13.9	99.20
Northern hackberry	3,210	(N/A)	4.6	4.5	37.33
Honeylocust	9,310	(N/A)	4.0	13.1	125.81
Norway spruce	1,903	(N/A)	3.3	2.7	30.69
Red maple	1,779	(N/A)	3.2	2.5	29.66
Conifer Evergreen Large	1,532	(N/A)	2.8	2.2	29.46
Austrian pine	903	(N/A)	2.5	1.3	19.63
Blue spruce	790	(N/A)	2.4	1.1	17.95
Spruce	1,485	(N/A)	2.4	2.1	33.75
Swamp white oak	536	(N/A)	2.1	0.8	13.40
Silver maple	5,194	(N/A)	2.1	7.3	129.84
American sycamore	1,725	(N/A)	2.0	2.4	45.40
Broadleaf Deciduous Small	69	(N/A)	1.8	0.1	2.03
Bur oak	648	(N/A)	1.7	0.9	20.26
White ash	1,858	(N/A)	1.7	2.6	58.05
Scotch pine	957	(N/A)	1.6	1.3	31.89
Catalpa	397	(N/A)	1.4	0.6	15.28
Oak	841	(N/A)	1.4	1.2	32.35
Eastern hophornbeam	1	(N/A)	1.4	0.0	0.03
Plum	1	(N/A)	1.3	0.0	0.03
Northern red oak	230	(N/A)	1.2	0.3	10.47
Maple	30	(N/A)	1.1	0.0	1.48
Northern catalpa	105	(N/A)	1.1	0.1	5.26
Amur maple	243	(N/A)	1.0	0.3	13.51
Eastern white pine	556	(N/A)	1.0	0.8	30.88
Dogwood	95	(N/A)	0.9	0.1	5.91
River birch	366	(N/A)	0.9	0.5	22.87
Littleleaf linden	1,288	(N/A)	0.9	1.8	80.50
Tulip tree	226	(N/A)	0.9	0.3	14.11
Kentucky coffeetree	139	(N/A)	0.7	0.2	9.94
Elm	366	(N/A)	0.7	0.5	26.12
Japanese tree lilac	55	(N/A)	0.7	0.1	3.92
Broadleaf Deciduous Large	678	(N/A)	0.6	1.0	56.49
Broadleaf Deciduous Medium	288	(N/A)	0.6	0.4	26.19
Cottonwood	438	(N/A)	0.5	0.6	43.78
American elm	395	(N/A)	0.5	0.6	39.48
Eastern red cedar	70	(N/A)	0.4	0.1	8.76
Siberian elm	359	(N/A)	0.4	0.5	44.85
Northern white cedar	211	(N/A)	0.3	0.3	35.22
Black walnut	321	(N/A)	0.3	0.5	53.58
Boxelder	429	(N/A)	0.3	0.6	71.46
Birch	191	(N/A)	0.3	0.3	31.83
Black cherry	58	(N/A)	0.3	0.1	9.60
Black locust	0	(N/A)	0.3	0.0	0.00
Ginkgo	25	(N/A)	0.3	0.0	4.10
White oak	248	(N/A)	0.2	0.3	61.96
Hickory	207	(N/A)	0.2	0.3	51.77
Yellowwood	11	(N/A)	0.2	0.0	2.74
Conifer Evergreen Small	43	(N/A)	0.1	0.1	21.34
Eastern hemlock	0	(N/A)	0.1	0.0	0.00
Cherry plum	0	(N/A)	0.1	0.0	0.00
Eastern redbud	4	(N/A)	0.1	0.0	2.06
Ash	63	(N/A)	0.1	0.1	31.46
Mulberry	58	(N/A)	0.1	0.1	28.80
White mulberry	0	(N/A)	0.1	0.0	0.00
Citywide total	71,151	(N/A)	100.0	100.0	38.07

Table 7: Summary of Benefits in Dollars

Grinnell								
Total Annual Benefits of All Trees by Species (\$)								
3/3/2017								
Species	Energy	CO ₂	Air Quality	Stormwater	Aesthetic/Other	Total (\$)	Standard Error	% of Total \$
Apple	2,812	286	469	1,539	1,077	6,183	(N/A)	2.3
Norway maple	7,039	618	1,279	8,714	3,198	20,847	(N/A)	7.8
Green ash	6,727	888	1,190	9,336	6,136	24,278	(N/A)	9.1
American basswood	3,860	630	593	5,429	4,270	14,782	(N/A)	5.5
Sugar maple	4,917	672	801	7,252	5,617	19,259	(N/A)	7.2
Pin oak	6,315	1,252	814	8,512	9,920	26,814	(N/A)	10.0
Northern hackberry	4,037	392	738	4,875	3,210	13,252	(N/A)	5.0
Honeylocust	3,385	484	572	4,578	9,310	18,329	(N/A)	6.9
Norway spruce	1,738	168	72	4,330	1,903	8,210	(N/A)	3.1
Red maple	1,961	217	365	2,330	1,779	6,652	(N/A)	2.5
Conifer Evergreen Large	1,397	137	52	3,511	1,532	6,629	(N/A)	2.5
Austrian pine	1,290	112	146	2,548	903	4,999	(N/A)	1.9
Blue spruce	922	79	104	1,714	790	3,609	(N/A)	1.3
Spruce	1,354	135	23	3,781	1,485	6,779	(N/A)	2.5
Swamp white oak	521	62	81	373	536	1,573	(N/A)	0.6
Silver maple	3,022	691	588	6,446	5,194	15,940	(N/A)	6.0
American sycamore	2,950	314	607	5,364	1,725	10,961	(N/A)	4.1
Broadleaf Deciduous Sm	212	21	29	80	69	411	(N/A)	0.2
Bur oak	924	91	187	1,459	648	3,309	(N/A)	1.2
White ash	1,646	202	309	2,255	1,858	6,270	(N/A)	2.3
Scotch pine	699	69	68	1,330	957	3,123	(N/A)	1.2
Catalpa	745	67	162	1,399	397	2,771	(N/A)	1.0
Oak	1,064	128	206	1,713	841	3,953	(N/A)	1.5
Eastern hophornbeam	23	3	3	5	1	34	(N/A)	0.0
Plum	21	3	3	5	1	32	(N/A)	0.0
Northern red oak	328	36	46	275	230	916	(N/A)	0.3
Maple	406	23	75	484	30	1,018	(N/A)	0.4
Northern catalpa	13	1	2	10	105	131	(N/A)	0.0
Amur maple	775	68	139	523	243	1,748	(N/A)	0.7
Eastern white pine	656	68	-16	2,069	556	3,333	(N/A)	1.2
Dogwood	254	26	38	105	95	517	(N/A)	0.2
River birch	944	77	172	1,193	366	2,752	(N/A)	1.0
Littleleaf linden	904	142	156	1,325	1,288	3,814	(N/A)	1.4
Tulip tree	184	25	34	313	226	781	(N/A)	0.3
Kentucky coffeetree	59	8	9	47	139	262	(N/A)	0.1
Elm	531	60	109	991	366	2,056	(N/A)	0.8
Japanese tree lilac	152	15	21	58	55	301	(N/A)	0.1
Broadleaf Deciduous La	757	102	136	1,119	678	2,793	(N/A)	1.0
Broadleaf Deciduous M	313	37	49	269	288	956	(N/A)	0.4
Cottonwood	920	90	198	1,772	438	3,418	(N/A)	1.3
American elm	493	49	99	569	395	1,605	(N/A)	0.6
Eastern red cedar	170	11	14	302	70	567	(N/A)	0.2
Siberian elm	554	67	103	750	359	1,832	(N/A)	0.7
Northern white cedar	186	19	5	494	211	915	(N/A)	0.3
Black walnut	347	48	62	544	321	1,323	(N/A)	0.5
Boxelder	333	71	60	575	429	1,467	(N/A)	0.5
Birch	215	25	34	198	191	663	(N/A)	0.2
Black cherry	277	21	50	191	58	596	(N/A)	0.2
Black locust	425	21	81	612	0	1,140	(N/A)	0.4
Ginkgo	47	4	7	25	25	108	(N/A)	0.0
White oak	324	42	63	606	248	1,283	(N/A)	0.5
Hickory	203	28	34	220	207	692	(N/A)	0.3
Yellowwood	4	0	1	1	11	18	(N/A)	0.0
Conifer Evergreen Smal	23	2	1	36	43	104	(N/A)	0.0
Eastern hemlock	76	4	-3	250	0	327	(N/A)	0.1
Cherry plum	92	4	17	64	0	177	(N/A)	0.1
Eastern redbud	11	1	1	4	4	21	(N/A)	0.0
Ash	142	13	27	204	63	448	(N/A)	0.2
Mulberry	92	12	17	64	58	242	(N/A)	0.1
White mulberry	92	4	17	64	0	177	(N/A)	0.1
Citywide Total	70,881	8,943	11,318	105,204	71,151	267,497	(N/A)	100.0

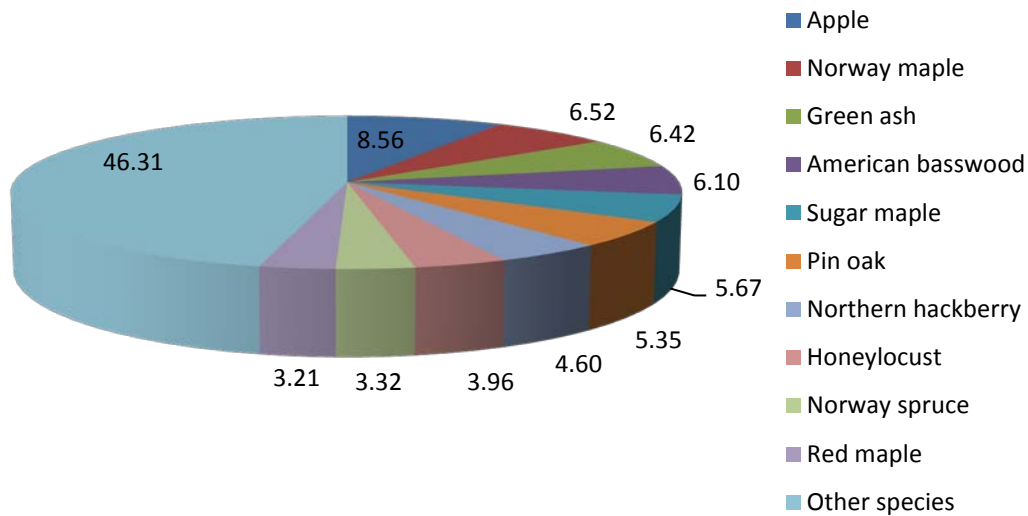


Figure 1: Species Distribution

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

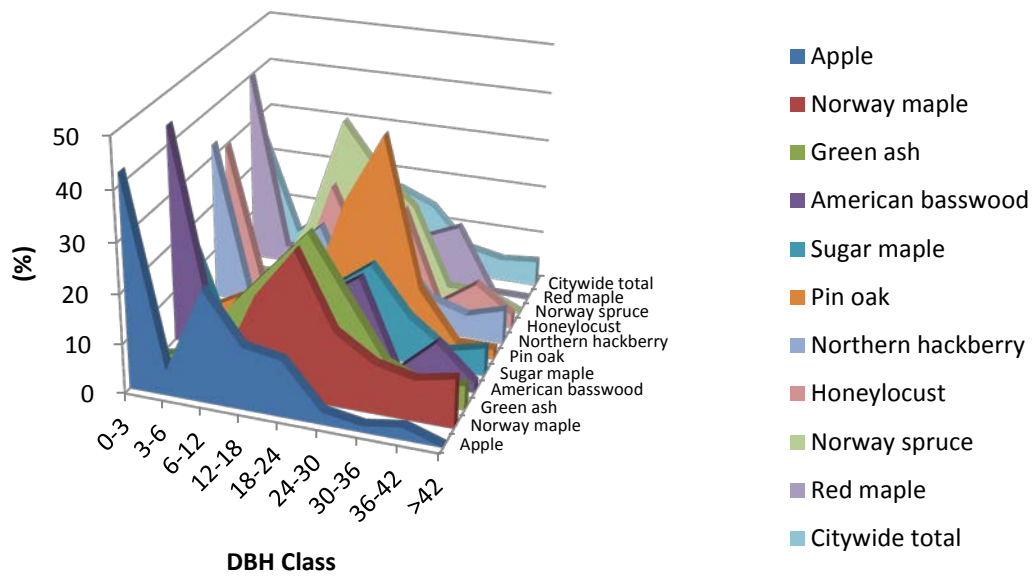


Figure 2: Relative Age Class

Leaf Condition

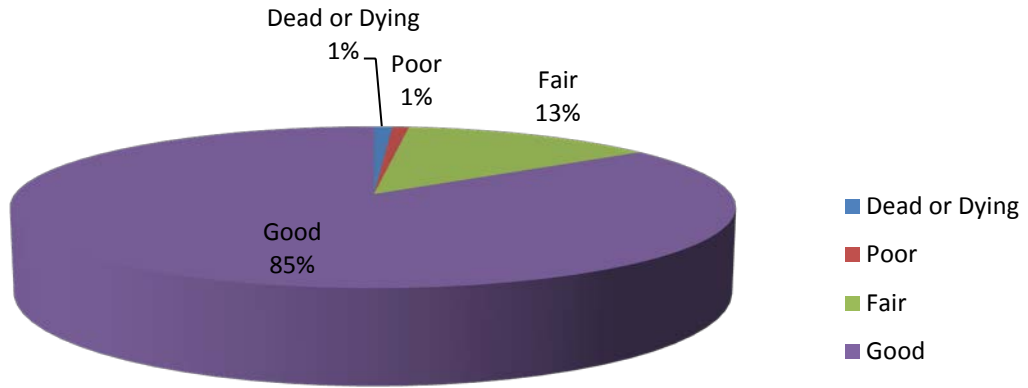


Figure 3: Foliage Condition

Wood Condition

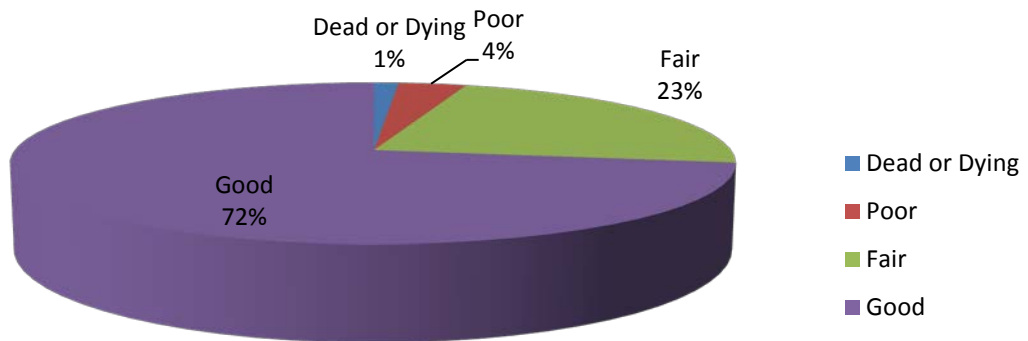


Figure 4: Wood Condition

Canopy Cover

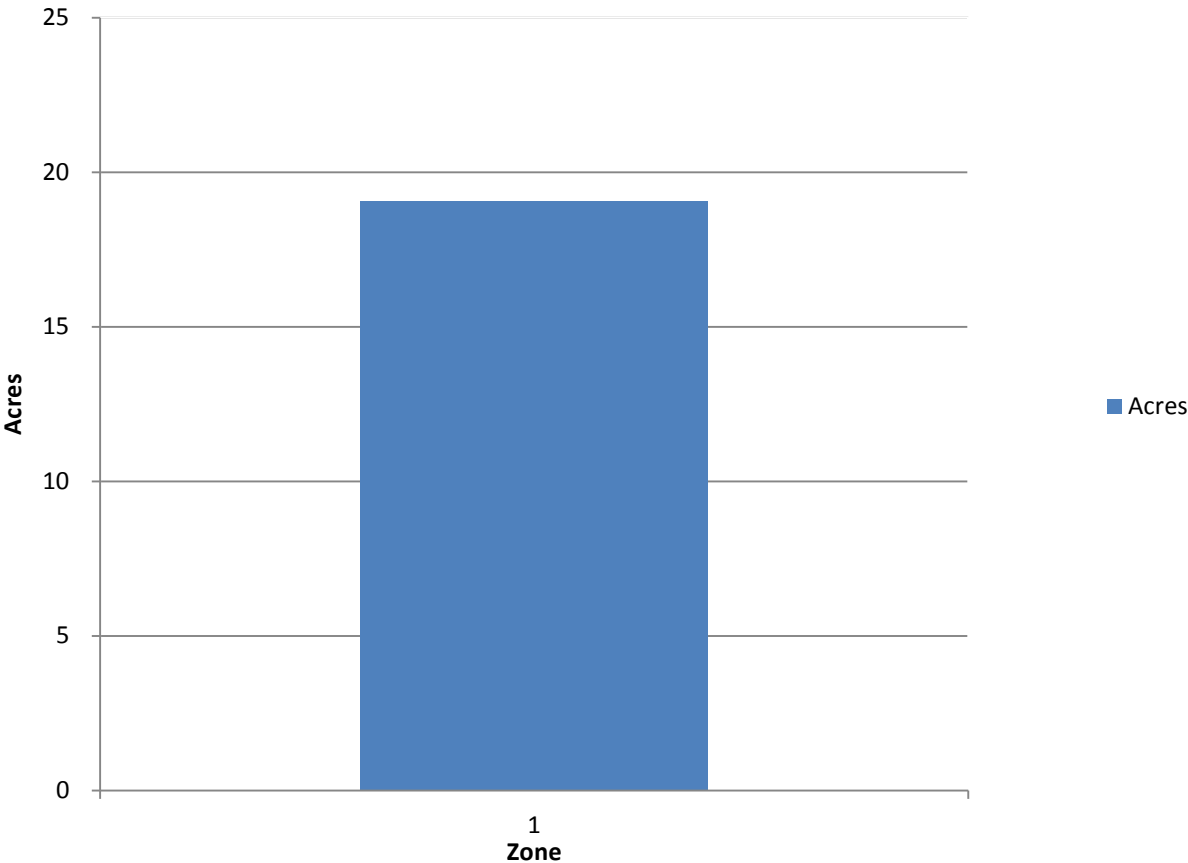


Figure 5: Canopy Cover in Acres

Appendix B: ArcGIS Mapping

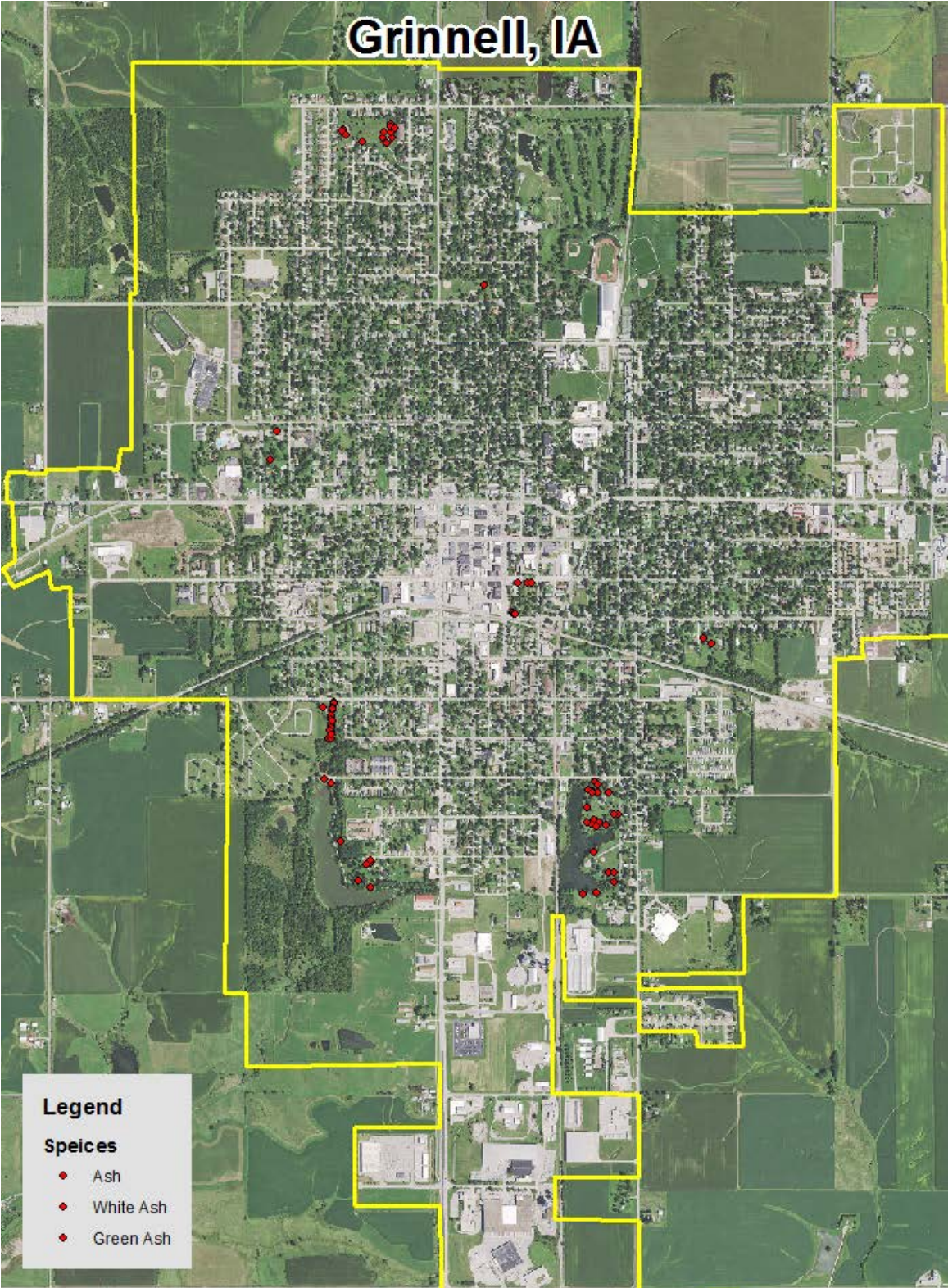


Figure 1: Location of Ash Trees

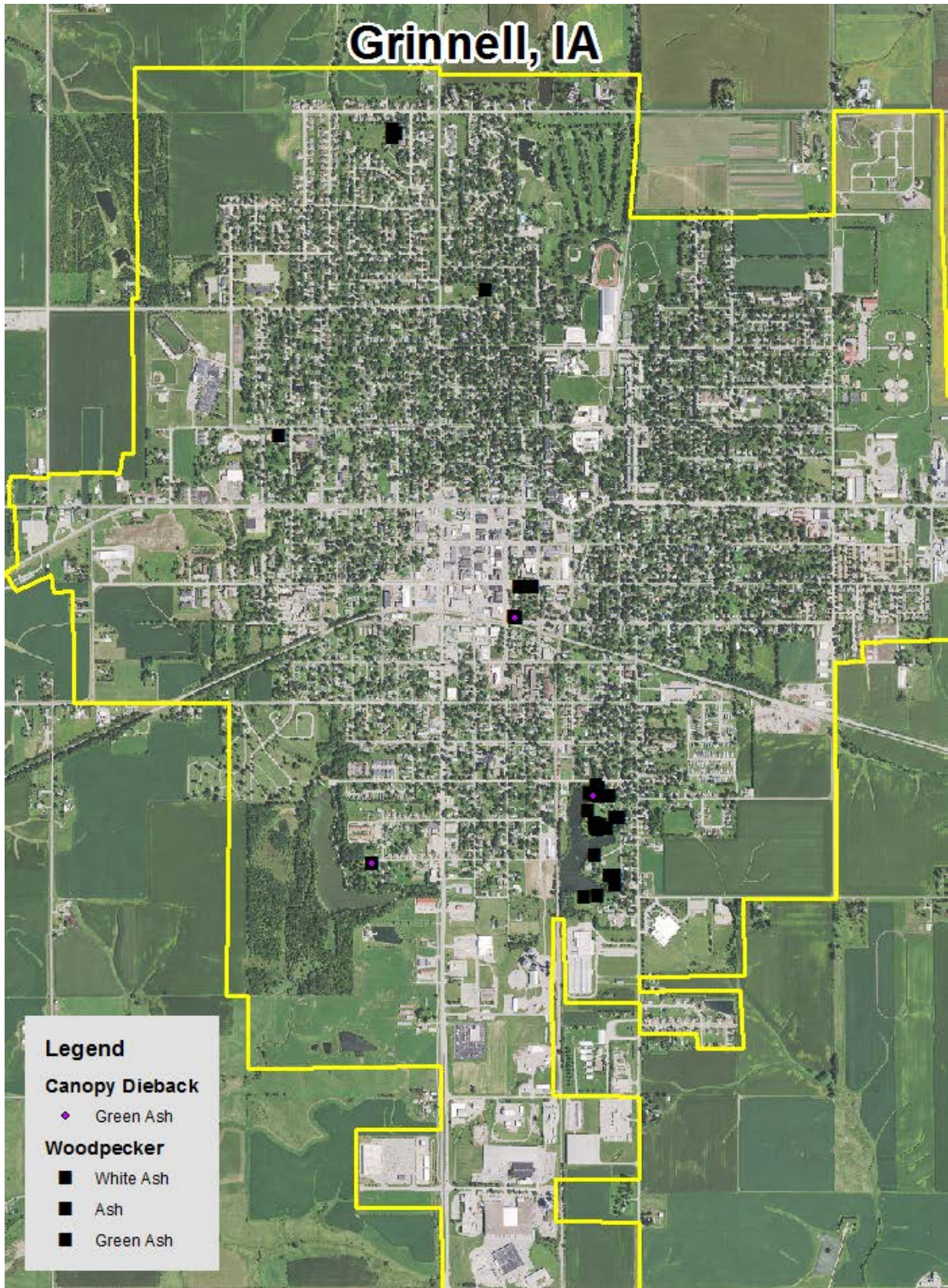


Figure 2: Location of EAB symptoms

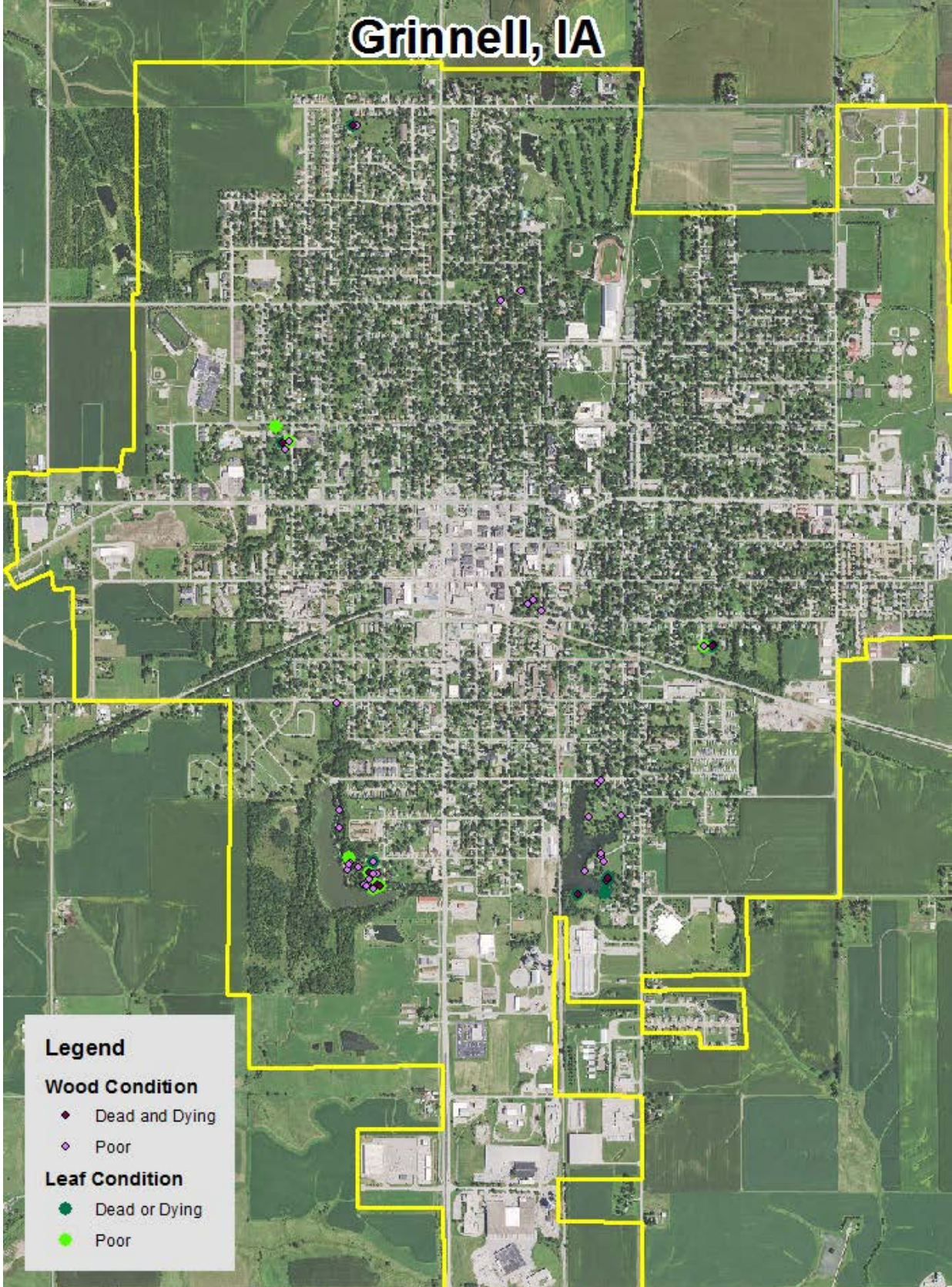


Figure 3: Location of Poor Condition Trees

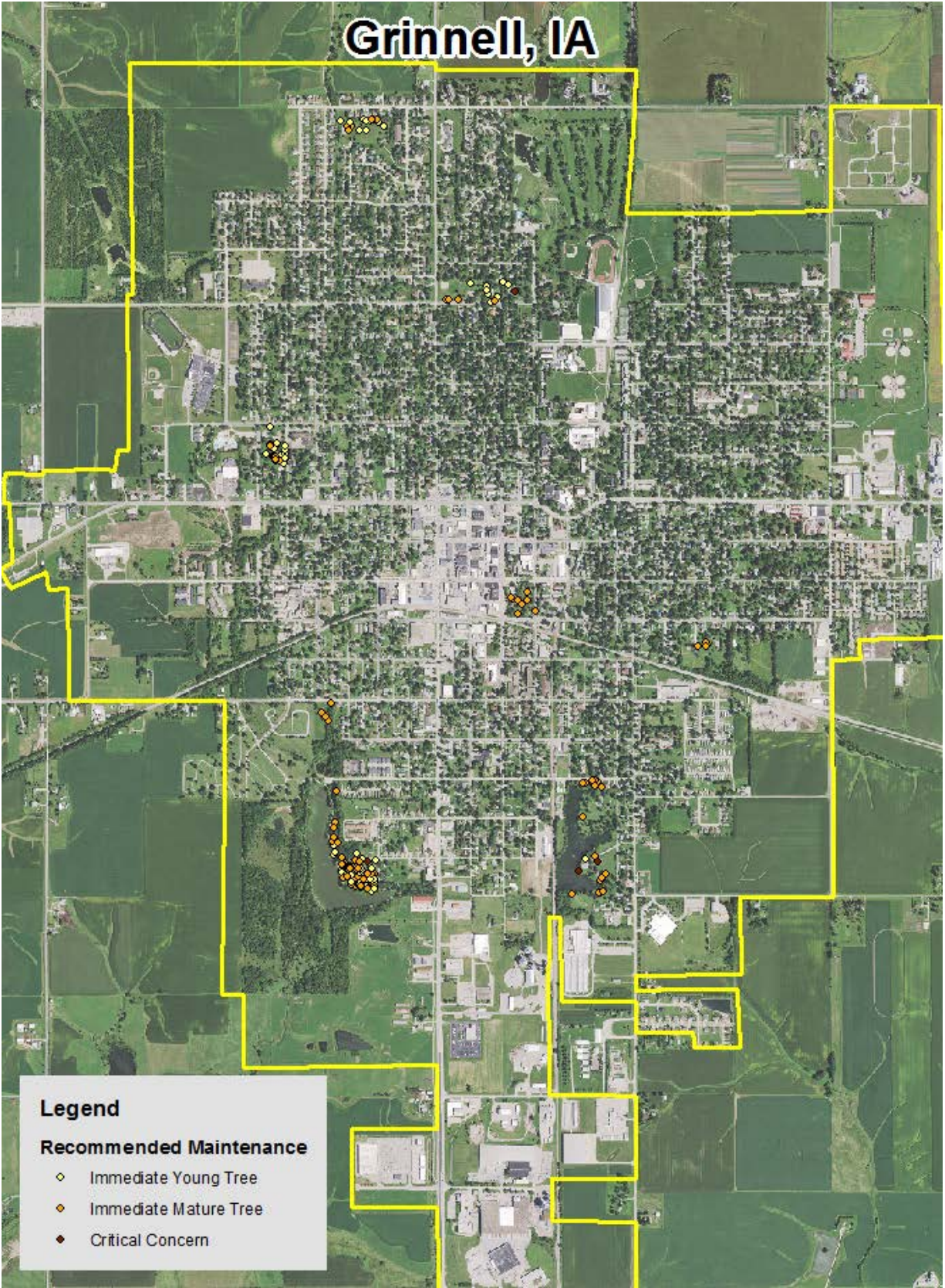


Figure 4: Location of Trees with Recommended Maintenance

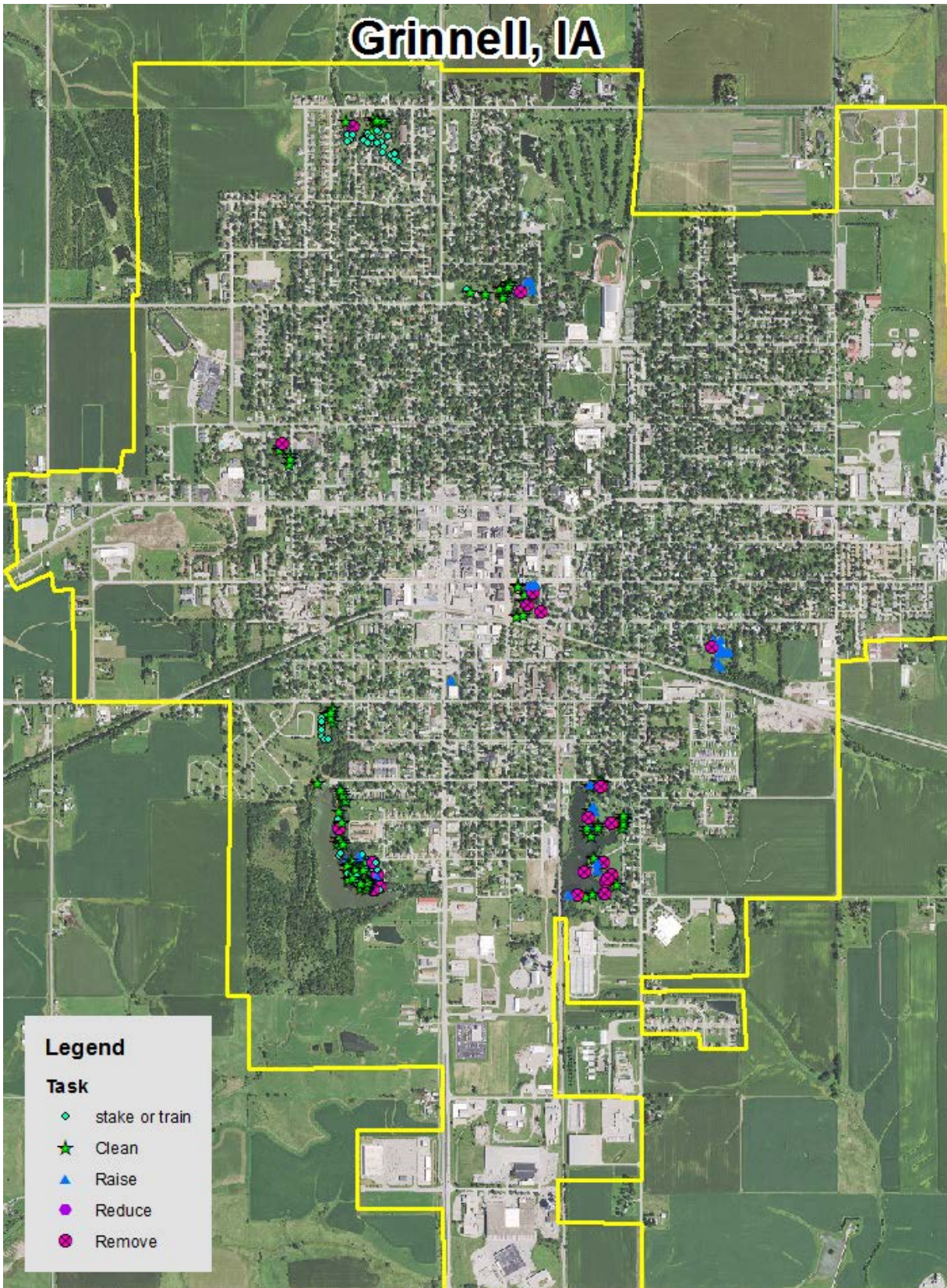


Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

ORDINANCE NO. 1237

"AN ORDINANCE AMENDING THE " MUNICIPAL CODE OF THE CITY OF GRINNELL, IOWA BY AMENDING PROVISIONS PERTAINING TO CHAPTER 21, ARTICLE II, (TREES IN AND ADJOINING PUBLIC WAYS.)"

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF GRINNELL, IOWA:

SECTION 1. SECTION MODIFIED. Chapter 21, Article II, be amended by repealing the existing article and adopting the following article in its place:

ARTICLE II. TREES IN AND ADJOINING PUBLIC WAYS

Sec. 21-31. Purpose.

The purpose of these regulations is to establish and maintain a healthy urban forest within the city. Rules for planting or removal, care and maintenance of trees are included to ensure proper treatment and to avoid interference with infrastructure. (Ord. No. 1051, § 1, 9-7-93)

Sec. 21-32. Authority.

The director of building and planning will have the authority to issue permits for planting or removal of trees and other plantings in the right-of-way. The supervisor of public services will have responsibility for care and maintenance of trees and plantings on public property. (Ord. No. 1051, § 1, 9-7-93)

Sec. 21-33. Tree planting permits.

Before planting trees or shrubs in the right-of-way, a tree planting permit application must be received from the director of building and planning for review. The permit fee (as established by Resolution) shall be paid for with the application. The applicant shall demonstrate that all plantings will be done in accordance with all the rules and regulations as set out in Chapter 21 of the Grinnell Municipal Code. (Ord. No. 1051, § 1, 9-7-93)

Sec. 21-34. Conditions and planting specifications for the right-of way, public property and/or private property adjacent to the right-of-way.

- (a) Any tree within street right-of-way shall have a single trunk with a minimum of four (4) feet from grade to the first branch at the time of planting.
- (b) No conifers of any sort shall be planted in the right-of-way. Trees that are not on the list of trees recommended trees for right-of-way planting shall not be planted in the right-of-way.
- (c) Trees shall be planted a minimum of four and one-half (4 1/2) feet from the edge of a sidewalk, curb, or alley right-of-way to the center of the tree. Trees shall be planted a minimum of five (5) feet from water service stop boxes or water valve boxes. Trees shall be planted a minimum of ten (10) feet from any hydrant,

transformers, telephone junction boxes, manholes, and driveway approaches. No tree shall be planted in a right-of-way less than twelve (12) feet in width.

(d) Plantings shall be in compliance with the General Visibility Requirements, Appendix A, Section 15.

(e) The minimum spacing for a tree from a street light standard or transmission pole shall be one-half (1/2) of the normal spread for that species of tree, or thirty (30) feet, whichever is less. No tree shall be planted under transmission lines unless the tree at maturity will not be tall enough to interfere with the lines. (See list of recommended trees to be planted under overhead utilities)

(f) Trees and other plantings shall not be planted directly over an underground water line, sewer line, transmission line or other utility. Trees and other plantings shall be planted a minimum of two (2) feet from the underground utility. The applicant shall be responsible for contacting the statewide "One Call" notification system prior to any type of excavation. The Iowa "One Call" toll free number is: 1-800-292-8989. If a living or healthy tree or any other planting is damaged, or has to be removed, to repair an underground utility, the city or any other approved franchise holder, shall not be held responsible for the tree or the replacement of the tree or other planting. The cost associated with the removal may be passed onto the adjacent property owner.

(g) Species of trees that are noted as undesirable on the List of Recommended Trees, available from the director of building and planning, shall not be planted within the city limits.

(h) In the central business district, plantings shall be done only with prior approval of the Grinnell City Council, and where the sidewalk abuts the curb four (4) square feet of ground with permeable surface shall be maintained for each tree.

(i) The applicant proposing the plantings in city parks must receive approval by the park board prior to the issuance of a permit.
(Ord. No. 1051, § 1, 9-7-93)

Sec. 21-35. Tree removal permits.

(a) No person shall remove trees from right-of-ways or any other public property without receiving a permit from the director of building and planning. The director of building and planning may waive the permit for conditions such as storm damage.

Sec. 21-36. Trimming, care and maintenance of trees.

(a) Duties of the supervisor of public services are as follows:

- (1) The supervisor of public services shall have jurisdiction over trees and other plantings on public property within the city in order to protect the health of all trees from disease and to require trees and plantings to be maintained so they are not dangerous to public safety.
 - (2) The supervisor of public services shall supervise all work by city employees or contractors in the trimming, preservation, planting or removal of trees or other plantings within the right-of-ways and all other city properties. The supervisor of public services shall have the authority to order private persons to comply with duties placed upon them by this section.
- (b) The duties of any person growing a tree or other plantings on private property abutting on streets or public places are:
- (1) To trim trees or plantings so that they shall not cause a hazard to the public or block public walks or ways or interfere with proper lighting of public streets or places. The minimum clearance of any overhanging portion shall be eight (8) feet over walks and sixteen (16) feet above the surface of the traveled portion of the street.
 - (2) To treat in an accepted manner, or remove any tree or plant so diseased or insect-ridden as to constitute a hazard to other trees and especially those dangerous to trees or plants in public streets or places.
- (c) Utility companies may operate under an annual or semi-annual permit issued by the director of building and planning with programmed trimming under conditions agreed upon by the supervisor of public services. Exception: If the utility company hires an outside contractor to perform work on trees within the right-of-way, Section 21-37 must be met by the contractor.
- (d) Mutilation of trees; trimming practices generally. No person shall willfully damage, cut, carve, or injure the bark of any tree or plant on the streets or public places of the city. Tree trimming shall be done in accordance with good practices and regulations of the city.

Topping of any tree on the right-of-way shall not be a normal practice for any person, firm, or city department. Topping is defined as the severe cutting back of limbs to stubs within the tree's crown to such a degree so as to remove the normal canopy and disfigure the tree. Trees severely damaged by storms or other causes, or certain trees under utility wires or other obstructions where other pruning practices are impractical may be exempted from the ordinance at the determination of the supervisor of public services.

(Ord. No. 1051, § 1, 9-7-93)

Sec. 21-37. License and bond.

Before engaging in the business or occupation of pruning, treating, or removing trees located in the right-of-ways or parks within the city, any person or firm must procure a license from the director of building and planning. Before any license shall be issued, each applicant shall provide a one thousand dollar (\$1,000) bond to the city to work within the right-of-way and provide evidence of possession of liability insurance in the minimum amounts of one million dollars (\$1,000,000.00) for bodily injury and property damage indemnifying the city or any person injured or damaged resulting from the pursuit of such endeavors as herein described. A license shall not be required of any city employee doing such work in the pursuit of their public service endeavors.

(Ord. No. 1051, § 1, 9-7-93)

Sec. 21-38. Penalty.

Any violation of this article shall be a municipal infraction.

(Ord. No. 1051, § 1, 9-7-93)

SECTION 2. REPEALER. All ordinances or parts of ordinances in conflict with the provisions of this ordinance are hereby repealed.

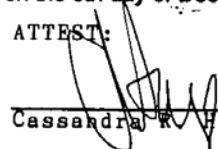
SECTION 3. SEVERABILITY CLAUSE. If any section, provision or part of this ordinance shall be adjudged invalid or unconstitutional, such as adjudication shall not affect the validity of the ordinance as a whole or any section, provision or part thereof not adjudged invalid or unconstitutional.

SECTION 4. WHEN EFFECTIVE. This ordinance shall be in effect from and after its final passage, approval and publication as provided by law.

Passed and Approved by the City Council on the 6th day of December, 2004.

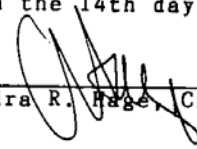
ATTEST:


Gordon Canfield, Mayor


Cassandra R. Page, City Clerk

First Reading: Monday, November 1, 2004.
Second Reading: Monday, November 15, 2004.
Third Reading: Monday, December 6, 2004.

I certify that the foregoing was published as Ordinance No. 1237 on the 14th day of February, 2005.


Cassandra R. Page, City Clerk

Works Cited

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