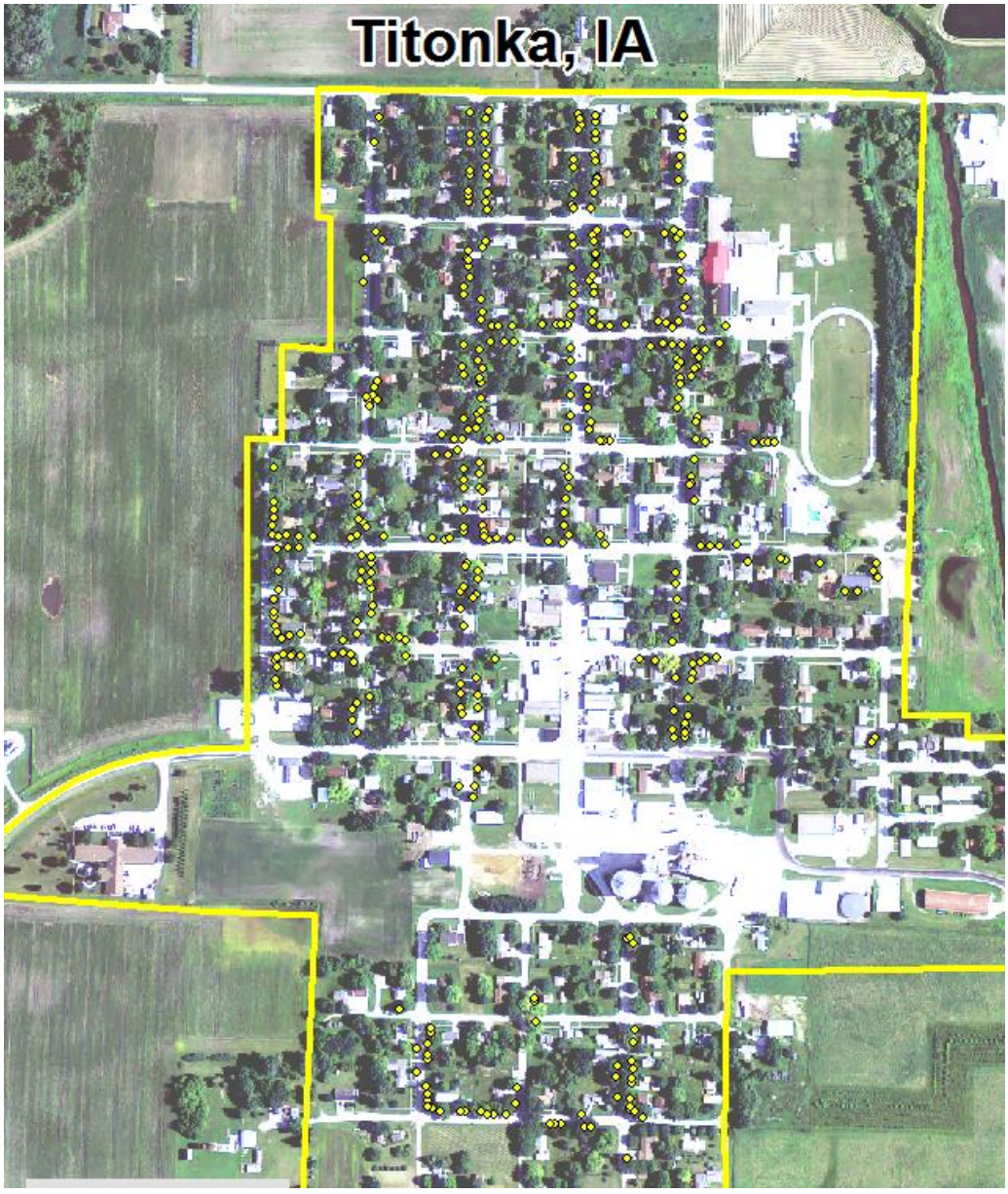
Titonka, IA



2016 Urban Forest Management Plan
Prepared by Emma Hanigan
Bureau of Forestry, Iowa DNR

Table of Contents

Executive Summary

Overview

This plan was developed to assist the City of Titonka 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 42% of Titonka's city owned trees (ash) will die once EAB becomes established in the community, unless preventative treatment is used. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

Inventory and Results

In 2015, a tree inventory was conducted 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 405 trees inventoried.

- Titonka's trees provide $84,512 of benefits annually, an average of $209 a tree
- There are over 28 species of trees
- The top three genera are: Maple 42%, Ash 42%, and Linden 3%
- 2% of trees are in need of some type of management
- 6 trees are recommended for removal

Recommendations

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

- 5 of the 170 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 113 years to remove ash – Suggestion: request a budget increase to $10,000 annually and apply for grants to plant replacement trees

Introduction

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

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

Inventory

In 2015, 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 405 city trees was entered into the USDA Forest service program i-Tree STREETS, part of the i-Tree suite. The following are results from the i-Tree STREETS analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Titonka's trees reduce energy related costs by approximately $22,865 annually (Appendix A, Table 1). These savings are both in Electricity (108.1 MWh) and in Natural Gas (14,96119 Therms).

Annual Stormwater Benefits

Titonka's trees intercept about 1,251,964 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $33,928 of benefits to the city.

Annual Air Quality Benefits

Air quality is a persistent public health issue in Iowa. The urban forest improves air quality by removing pollutants, lowering air temperature, and reducing energy consumption, which in turn reduces emissions from power plants, and emitting volatile organic mater (ozone). In Titonka, it is estimated that trees remove 1,421 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 $4,027 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Titonka, trees sequester about 231,524 lbs of carbon a year with an associated value of $1,736 (Appendix A, Table 4). In addition, the trees store 4,896,049 lbs of carbon, with a yearly benefit of $36,720 (Appendix A, Table 5).

Annual Aesthetics Benefits

Social benefits of trees are hard to capture. The analysis does have a calculation for this area that includes: aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Titonka receives $21,955 in annual social benefits from trees (Appendix A, Table 6).

Financial Summary of all Benefits

According to the USDA Forest Service i-Tree STREETS analysis, Titonka's trees provide $84,512 of benefits annually. Benefits of individual trees vary based on size, species, health and

location, but on average each of the 405 trees in Titonka provide approximately $209 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Titonka has over 28 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Ash	170	42%
Maple	169	42%
Linden/Basswood	12	3%
Locust	10	2%
Spruce	10	2%
Mountain Ash	6	1%
Walnut	5	1%
Apple (Crab)	4	1%
Arborvitea	3	1%
Birch	3	1%
Cork tree	2	<1%
Elm	2	<1%
Hickory	2	<1%
Hackberry	1	<1%
Hophornbeam	1	<1%
Kentucky	1	<1%
Lilac	1	<1%
Mulberry	1	<1%
Oak	1	<1%
Poplar	1	<1%

Age Class

Most of Titonka's trees (32%) are between 24 and 30 inches in diameter at 4.5 ft (Appendix A, Figure 2). For age, it is preferred that the highest amounts of trees are in the smallest size category (a downward slope) to prepare for natural mortality and to maintain canopy cover. Titonka'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 Titonka indicate that 98% of the trees are in good health, with only 0.25% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 68% of Titonka'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 6% of the population. This 6% is an estimate of trees that need management follow up.

Management Needs

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

Crown Cleaning	2	<1%
Tree Removal	6	1%

Canopy Cover

The total canopy with both private and public trees is 24%, 43 acres. The canopy cover included in the Titonka inventory includes approximately 12 acres (Appendix A, Figure 4).

Land Use and Location

The majority of Titonka'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	98%
Park/vacant/other	2%

Location	
Planting strip	88%
Front yard	12%

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

Titonka has 6 trees marked for removal. Of those 1 is a critical concern and 3 are marked as trees that need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). Please refer to the six year maintenance plan at the end of this section. After all of the critical concern and immediate trees are addressed, there should be follow up on the trees marked as needing maintenance.

Poor tree species

After the removal of the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 6 removals, 1 is an ash tree. There are a total of 170 ash trees, and 5 of those have signs and symptoms that have been associated with EAB. In addition, there are 5 ash trees that are in poor health. *City ownership of the trees recommended for removal should be verified prior to any removal*

Pruning Cycle

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

Planting

Most of the planting over the next 5 years will replace the trees that are removed. It is recommended to plant 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 Titonka.

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 (42%) (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 the city ordinance.

Continual Monitoring

Due to the threat of EAB, it is important to continuously check the health of ash trees. It is recommended that ash trees be checked with a visual survey every year for tree decline and for the following signs and symptoms: canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

Six Year Maintenance Plan with <u>No Additional Funding</u>

Year 1

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

Year 2

Removal: 2 tree
Planting and Replacement: 2 trees in open locations from year one removals
Routine trimming: Contract to trim 1/3 of the city trees
Visual Survey for signs and symptoms of EAB

Year 3

Removal: 2 trees - removal of any new critical concern trees and ash in poor health
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 2 trees to be planted in open locations and locations from previous removals
Visual Survey for signs and symptoms of EAB

Year 4

Removal: 1 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 in open locations from previous removals
Routine trimming: Contract to trim 1/3 of the city trees
Visual Survey for signs and symptoms of EAB

Year 5

Removal: 2 trees - removal of any new critical concern trees and ash in poor health
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 2 trees to be planted in open locations and locations from previous removals
Visual Survey for signs and symptoms of EAB

Year 6

Removal: 1 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 in open locations from previous removals
Routine trimming: Contract to trim 1/3 of the city trees
Visual Survey for signs and symptoms of EAB

*Reduction of ash over 6 years: Approximately 7 ash trees removed (approximately 4% of ash). It will take approximately 113 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 $20,000 a year. If the budget were increased to $10,000 a year all ash could be removed in 13 years.

<u>Emerald Ash Borer Plan</u>

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. The new plantings will be a diverse mix and will not include ash or maple.

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 not using a treatment method.

Budget

Current Budget
Total $11,500 over 6 years (about $1,800/year)

FY 2016 Budget
Removal: $1,400
*Or saving for ash tree treatment and/or future ash removal
Planting: $200
Watering & Maintenance: $50

FY 2017 Budget
Removal: $1,400
*Or saving for ash tree treatment and/or future ash removal
Planting: $200
Routine trimming: $1,000
Watering & Maintenance: $50

FY 2018 Budget
Removal: $1,400
*Or saving for ash tree treatment and/or future ash removal
Planting: $200
Watering & Maintenance: $50

FY 2019 Budget
Removal: $700
*Or saving for ash tree treatment and/or future ash removal
Planting: $200
Routine trimming: $1,000
Watering & Maintenance: $50

FY 2020 Budget
Removal: $1,400
*Or saving for ash tree treatment and/or future ash removal
Planting: $200
Watering & Maintenance: $50

FY 2021 Budget
Removal: $700
*Or saving for ash tree treatment and/or future ash removal
Planting: $200
Routine trimming: $1,000
Watering & Maintenance: $50

*Reduction of ash over 6 years: approximately 7 ash trees removed (approximately 4% of ash).
It will take approximately 113 years to remove all ash with the current budget.

Purposed Budget Increase
EAB could potentially kill all ash trees in Titonka within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $20,000 a year. If the budget

were increased to $10,000 a year all ash could be removed within 13 years. Additionally, it is recommended that Titonka 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 Titonka would still need to find $113,400 for removal. Alternatively, if there are 15 treatable trees, it would cost approximately $2,250 a year for treatment and leave $108,500 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 Titonka. 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, D.J. and J.F. 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

Titonka

Annual Energy Benefits of Public Trees

12/30/2015

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	49.3	3,738	6,832.6	6,696	10,434	(N/A)	42.0	45.6	61.38
Norway maple	22.0	1,670	3,198.2	3,134	4,804	(N/A)	21.5	21.0	55.22
Silver maple	14.2	1,076	1,868.6	1,831	2,907	(N/A)	11.1	12.7	64.60
Sugar maple	5.5	415	709.7	695	1,110	(N/A)	5.4	4.9	50.46
American basswood	3.9	293	562.4	551	844	(N/A)	3.0	3.7	70.35
Honeylocust	2.8	209	349.5	343	552	(N/A)	2.5	2.4	55.16
Norway spruce	0.9	67	112.5	110	177	(N/A)	1.7	0.8	25.34
Mountain ash	0.4	28	64.8	63	92	(N/A)	1.5	0.4	15.31
Black walnut	1.7	128	237.7	233	361	(N/A)	1.2	1.6	72.22
Maple	0.5	39	73.7	72	111	(N/A)	1.0	0.5	27.72
Red maple	0.7	56	93.1	91	147	(N/A)	1.0	0.6	36.76
Amur maple	0.1	11	24.2	24	34	(N/A)	1.0	0.2	8.60
Apple	0.2	15	26.5	26	41	(N/A)	1.0	0.2	10.18
Northern white cedar	0.6	42	73.8	72	115	(N/A)	0.7	0.5	38.17
Paper birch	0.7	56	92.1	90	146	(N/A)	0.7	0.6	48.59
Blue spruce	0.3	24	40.6	40	64	(N/A)	0.7	0.3	21.27
Elm	0.9	66	118.0	116	182	(N/A)	0.5	0.8	91.02
Black maple	0.6	43	79.8	78	121	(N/A)	0.5	0.5	60.68
Catalpa	0.8	59	107.4	105	164	(N/A)	0.5	0.7	82.02
Amur corktree	0.5	36	59.0	58	94	(N/A)	0.5	0.4	46.78
Japanese tree lilac	0.0	2	3.8	4	5	(N/A)	0.2	0.0	5.40
Northern hackberry	0.4	33	60.8	60	92	(N/A)	0.2	0.4	92.23
Boxelder	0.3	20	36.3	36	55	(N/A)	0.2	0.2	55.14
Black poplar	0.5	37	63.1	62	99	(N/A)	0.2	0.4	98.63
Eastern hophombeam	0.0	2	3.8	4	5	(N/A)	0.2	0.0	5.40
Swamp white oak	0.2	18	29.5	29	47	(N/A)	0.2	0.2	46.78
Mulberry	0.1	6	12.8	13	18	(N/A)	0.2	0.1	18.19
Kentucky coffeetree	0.2	18	27.0	26	44	(N/A)	0.2	0.2	44.23
Total	108.1	8,203	14,961.1	14,662	22,865	(N/A)	100.0	100.0	56.46

Table 2: Annual Stormwater Benefits

Titonka

Annual Stormwater Benefits of Public Trees

12/30/2015

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	572,052	15,503	(N/A)	42.0	45.7	91.19
Norway maple	221,973	6,015	(N/A)	21.5	17.7	69.14
Silver maple	212,763	5,766	(N/A)	11.1	17.0	128.13
Sugar maple	50,426	1,367	(N/A)	5.4	4.0	62.12
American basswood	49,023	1,329	(N/A)	3.0	3.9	110.71
Honeylocust	23,093	626	(N/A)	2.5	1.8	62.58
Norway spruce	14,119	383	(N/A)	1.7	1.1	54.66
Mountain ash	1,330	36	(N/A)	1.5	0.1	6.01
Black walnut	21,658	587	(N/A)	1.2	1.7	117.39
Maple	4,129	112	(N/A)	1.0	0.3	27.98
Red maple	4,458	121	(N/A)	1.0	0.4	30.21
Amur maple	470	13	(N/A)	1.0	0.0	3.19
Apple	689	19	(N/A)	1.0	0.1	4.67
Northern white cedar	13,814	374	(N/A)	0.7	1.1	124.79
Paper birch	5,522	150	(N/A)	0.7	0.4	49.88
Blue spruce	3,844	104	(N/A)	0.7	0.3	34.72
Elm	14,478	392	(N/A)	0.5	1.2	196.17
Black maple	5,734	155	(N/A)	0.5	0.5	77.70
Catalpa	10,981	298	(N/A)	0.5	0.9	148.79
Amur corktree	2,818	76	(N/A)	0.5	0.2	38.19
Japanese tree lilac	69	2	(N/A)	0.2	0.0	1.86
Northern hackberry	4,984	135	(N/A)	0.2	0.4	135.08
Boxelder	3,090	84	(N/A)	0.2	0.2	83.73
Black poplar	7,239	196	(N/A)	0.2	0.6	196.17
Eastern hophornbeam	69	2	(N/A)	0.2	0.0	1.86
Swamp white oak	1,409	38	(N/A)	0.2	0.1	38.19
Mulberry	264	7	(N/A)	0.2	0.0	7.17
Kentucky coffeetree	1,466	40	(N/A)	0.2	0.1	39.72
Citywide total	1,251,964	33,928	(N/A)	100.0	100.0	83.77

Table 3: Annual Air Quality Benefits

Titonka

Annual Air Quality Benefits of Public Trees

12/30/2015

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	72.6	11.6	34.3	3.3	385	236.0	34.3	32.7	223.2	1,468	0.0	0	647.9	1,853	(N/A)	42.0	10.90
Norway maple	47.4	8.2	23.1	2.1	256	106.9	15.4	14.7	99.8	661	-11.0	-41	306.6	876	(N/A)	21.5	10.07
Silver maple	37.0	6.3	18.1	1.6	199	66.8	9.8	9.3	64.1	418	-19.0	-71	194.0	546	(N/A)	11.1	12.14
Sugar maple	6.1	1.0	3.2	0.3	33	25.7	3.8	3.6	24.7	161	-4.9	-18	63.5	176	(N/A)	5.4	8.01
American basswood	7.1	1.2	3.4	0.3	38	18.8	2.7	2.6	17.5	116	-5.9	-22	47.7	132	(N/A)	3.0	11.01
Honeylocust	4.2	0.7	2.0	0.2	22	12.9	1.9	1.8	12.5	81	-3.1	-12	33.0	92	(N/A)	2.5	9.17
Norway spruce	1.6	0.3	1.3	0.2	11	4.1	0.6	0.6	4.0	26	-5.9	-22	6.8	14	(N/A)	1.7	2.04
Mountain ash	0.2	0.0	0.1	0.0	1	1.9	0.3	0.3	1.7	12	0.0	0	4.5	13	(N/A)	1.5	2.14
Black walnut	2.9	0.5	1.3	0.1	15	8.1	1.2	1.1	7.7	50	0.0	0	22.9	66	(N/A)	1.2	13.16
Maple	0.9	0.2	0.4	0.0	5	2.5	0.4	0.3	2.3	15	-0.3	-1	6.7	19	(N/A)	1.0	4.74
Red maple	0.8	0.1	0.4	0.0	4	3.4	0.5	0.5	3.3	22	-0.3	-1	8.8	25	(N/A)	1.0	6.20
Amur maple	0.1	0.0	0.0	0.0	0	0.7	0.1	0.1	0.6	4	0.0	0	1.7	5	(N/A)	1.0	1.17
Apple	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.9	6	0.0	0	2.4	7	(N/A)	1.0	1.72
Northern white cedar	1.7	0.3	1.3	0.2	11	2.6	0.4	0.4	2.5	16	-8.6	-32	0.9	-5	(N/A)	0.7	-1.58
Paper birch	0.5	0.1	0.3	0.0	3	3.4	0.5	0.5	3.3	21	0.0	0	8.6	24	(N/A)	0.7	8.06
Blue spruce	0.5	0.1	0.4	0.1	3	1.5	0.2	0.2	1.4	9	-1.3	-5	3.0	7	(N/A)	0.7	2.44
Elm	2.3	0.4	1.0	0.1	12	4.2	0.6	0.6	4.0	26	0.0	0	13.1	38	(N/A)	0.5	19.04
Black maple	1.5	0.3	0.7	0.1	8	2.7	0.4	0.4	2.6	17	-0.5	-2	8.1	23	(N/A)	0.5	11.54
Catalpa	1.6	0.3	0.7	0.1	8	3.7	0.5	0.5	3.5	23	0.0	0	10.9	31	(N/A)	0.5	15.71
Amur corktree	0.4	0.1	0.2	0.0	2	2.2	0.3	0.3	2.1	14	-0.1	0	5.6	16	(N/A)	0.5	7.92
Japanese tree lilac	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	0.0	0	0.3	1	(N/A)	0.2	0.71
Northern hackberry	0.9	0.1	0.4	0.0	5	2.1	0.3	0.3	2.0	13	0.0	0	6.1	18	(N/A)	0.2	17.54
Boxelder	0.4	0.1	0.2	0.0	2	1.2	0.2	0.2	1.2	8	-0.2	-1	3.3	9	(N/A)	0.2	9.31
Black poplar	1.6	0.3	0.7	0.1	8	2.3	0.3	0.3	2.2	14	0.0	0	7.7	23	(N/A)	0.2	22.55
Eastern hophornbeam	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	0.0	0	0.3	1	(N/A)	0.2	0.71
Swamp white oak	0.2	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	-0.1	0	2.8	8	(N/A)	0.2	7.92
Mulberry	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.3	2	0.0	0	0.9	3	(N/A)	0.2	2.55
Kentucky coffeetree	0.1	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	0.0	0	2.6	7	(N/A)	0.2	7.42
Citywide total	192.9	32.2	94.0	8.9	1,037	517.5	75.2	71.7	489.8	3,220	-61.2	-229	1,421.0	4,027	(N/A)	100.0	9.94

Table 4: Annual Carbon Stored

Titonka

Stored CO2 Benefits of Public Trees

12/30/2015

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	2,361,918	17,714	(N/A)	42.0	48.2	104.20
Norway maple	785,440	5,891	(N/A)	21.5	16.0	67.71
Silver maple	832,497	6,244	(N/A)	11.1	17.0	138.75
Sugar maple	173,121	1,298	(N/A)	5.4	3.5	59.02
American basswood	265,157	1,989	(N/A)	3.0	5.4	165.72
Honeylocust	53,736	403	(N/A)	2.5	1.1	40.30
Norway spruce	13,796	103	(N/A)	1.7	0.3	14.78
Mountain ash	4,553	34	(N/A)	1.5	0.1	5.69
Black walnut	95,034	713	(N/A)	1.2	1.9	142.55
Maple	10,163	76	(N/A)	1.0	0.2	19.06
Red maple	9,450	71	(N/A)	1.0	0.2	17.72
Amur maple	1,441	11	(N/A)	1.0	0.0	2.70
Apple	3,079	23	(N/A)	1.0	0.1	5.77
Northern white cedar	22,471	169	(N/A)	0.7	0.5	56.18
Paper birch	15,801	119	(N/A)	0.7	0.3	39.50
Blue spruce	2,521	19	(N/A)	0.7	0.1	6.30
Elm	78,517	589	(N/A)	0.5	1.6	294.44
Black maple	15,891	119	(N/A)	0.5	0.3	59.59
Catalpa	51,886	389	(N/A)	0.5	1.1	194.57
Amur corktree	7,248	54	(N/A)	0.5	0.1	27.18
Japanese tree lilac	178	1	(N/A)	0.2	0.0	1.33
Northern hackberry	13,507	101	(N/A)	0.2	0.3	101.30
Boxelder	14,280	107	(N/A)	0.2	0.3	107.10
Black poplar	55,982	420	(N/A)	0.2	1.1	419.86
Eastern hophornbeam	178	1	(N/A)	0.2	0.0	1.33
Swamp white oak	3,624	27	(N/A)	0.2	0.1	27.18
Mulberry	908	7	(N/A)	0.2	0.0	6.81
Kentucky coffeetree	3,672	28	(N/A)	0.2	0.1	27.54
Citywide total	4,896,049	36,720	(N/A)	100.0	100.0	90.67

Table 5: Annual Carbon Sequestered

Titonka

Annual CO Benefits of Public Trees

12/30/2015

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	119,500	896	-11,337	-523	-4	0	0	107,640	807	(N/A)	42.0	46.5	4.75
Norway maple	27,636	207	-3,772	-236	-2	0	0	23,628	177	(N/A)	21.5	10.2	2.04
Silver maple	60,527	454	-3,996	-160	-1	0	0	56,371	423	(N/A)	11.1	24.3	9.40
Sugar maple	10,573	79	-832	-55	0	0	0	9,687	73	(N/A)	5.4	4.2	3.30
American basswood	14,580	109	-1,273	-47	0	0	0	13,261	99	(N/A)	3.0	5.7	8.29
Honeylocust	4,260	32	-258	-20	0	0	0	3,982	30	(N/A)	2.5	1.7	2.99
Norway spruce	961	7	-66	-15	0	0	0	880	7	(N/A)	1.7	0.4	0.94
Mountain ash	578	4	-22	-6	0	0	0	550	4	(N/A)	1.5	0.2	0.69
Black walnut	4,142	31	-456	-18	0	0	0	3,668	28	(N/A)	1.2	1.6	5.50
Maple	333	3	-49	-5	0	0	0	279	2	(N/A)	1.0	0.1	0.52
Red maple	1,297	10	-45	-6	0	0	0	1,245	9	(N/A)	1.0	0.5	2.33
Amur maple	228	2	-7	-3	0	0	0	218	2	(N/A)	1.0	0.1	0.41
Apple	294	2	-15	-3	0	0	0	276	2	(N/A)	1.0	0.1	0.52
Northern white cedar	0	0	-108	-13	0	0	0	-121	-1	(N/A)	0.7	-0.1	-0.30
Paper birch	1,550	12	-76	-7	0	0	0	1,468	11	(N/A)	0.7	0.6	3.67
Blue spruce	220	2	-12	-5	0	0	0	203	2	(N/A)	0.7	0.1	0.51
Elm	1,824	14	-377	-10	0	0	0	1,437	11	(N/A)	0.5	0.6	5.39
Black maple	1,847	14	-76	-5	0	0	0	1,765	13	(N/A)	0.5	0.8	6.62
Catalpa	1,919	14	-249	-9	0	0	0	1,662	12	(N/A)	0.5	0.7	6.23
Amur corktree	772	6	-35	-4	0	0	0	733	5	(N/A)	0.5	0.3	2.75
Japanese tree lilac	38	0	-1	-1	0	0	0	37	0	(N/A)	0.2	0.0	0.27
Northern hackberry	616	5	-65	-4	0	0	0	547	4	(N/A)	0.2	0.2	4.10
Boxelder	1,038	8	-69	-4	0	0	0	966	7	(N/A)	0.2	0.4	7.25
Black poplar	479	4	-269	-6	0	0	0	204	2	(N/A)	0.2	0.1	1.53
Eastern hophornbeam	38	0	-1	-1	0	0	0	37	0	(N/A)	0.2	0.0	0.27
Swamp white oak	386	3	-17	-2	0	0	0	367	3	(N/A)	0.2	0.2	2.75
Mulberry	114	1	-4	-1	0	0	0	108	1	(N/A)	0.2	0.0	0.81
Kentucky coffeetree	445	3	-18	-2	0	0	0	426	3	(N/A)	0.2	0.2	3.19
Citywide total	256,198	1,921	-23,503	-1,170	-9	0	0	231,524	1,736	(N/A)	100.0	100.0	4.29

Table 6: Annual Social and Aesthetic Benefits

Titonka

Annual Aesthetic/Other Benefits of Public Trees

12/30/2015

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	9,610	(N/A)	42.0	43.8	56.53
Norway maple	2,592	(N/A)	21.5	11.8	29.80
Silver maple	4,717	(N/A)	11.1	21.5	104.82
Sugar maple	1,154	(N/A)	5.4	5.3	52.44
American basswood	1,010	(N/A)	3.0	4.6	84.17
Honeylocust	965	(N/A)	2.5	4.4	96.54
Norway spruce	254	(N/A)	1.7	1.2	36.23
Mountain ash	32	(N/A)	1.5	0.1	5.34
Black walnut	313	(N/A)	1.2	1.4	62.56
Maple	60	(N/A)	1.0	0.3	14.93
Red maple	191	(N/A)	1.0	0.9	47.86
Amur maple	13	(N/A)	1.0	0.1	3.14
Apple	16	(N/A)	1.0	0.1	3.90
Northern white cedar	0	(N/A)	0.7	0.0	0.00
Paper birch	149	(N/A)	0.7	0.7	49.80
Blue spruce	72	(N/A)	0.7	0.3	23.85
Elm	117	(N/A)	0.5	0.5	58.34
Black maple	218	(N/A)	0.5	1.0	109.08
Catalpa	133	(N/A)	0.5	0.6	66.60
Amur corktree	78	(N/A)	0.5	0.4	39.16
Japanese tree lilac	2	(N/A)	0.2	0.0	2.06
Northern hackberry	73	(N/A)	0.2	0.3	72.66
Boxelder	65	(N/A)	0.2	0.3	65.43
Black poplar	29	(N/A)	0.2	0.1	28.57
Eastern hophornbeam	2	(N/A)	0.2	0.0	2.06
Swamp white oak	39	(N/A)	0.2	0.2	39.16
Mulberry	6	(N/A)	0.2	0.0	6.40
Kentucky coffeetree	46	(N/A)	0.2	0.2	45.86
Citywide total	21,955	(N/A)	100.0	100.0	54.21

Table 7: Summary of Benefits in Dollars

Titonka

Total Annual Benefits of Public Trees by Species ($)

12/30/201

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Green ash	10,434	807	1,853	15,503	9,610	38,207	(N/A)	45.2
Norway maple	4,804	177	876	6,015	2,592	14,464	(N/A)	17.1
Silver maple	2,907	423	546	5,766	4,717	14,358	(N/A)	17.0
Sugar maple	1,110	73	176	1,367	1,154	3,879	(N/A)	4.6
American basswood	844	99	132	1,329	1,010	3,414	(N/A)	4.0
Honeylocust	552	30	92	626	965	2,264	(N/A)	2.7
Norway spruce	177	7	14	383	254	835	(N/A)	1.0
Mountain ash	92	4	13	36	32	177	(N/A)	0.2
Black walnut	361	28	66	587	313	1,354	(N/A)	1.6
Maple	111	2	19	112	60	304	(N/A)	0.4
Red maple	147	9	25	121	191	493	(N/A)	0.6
Amur maple	34	2	5	13	13	66	(N/A)	0.1
Apple	41	2	7	19	16	84	(N/A)	0.1
Northern white cedar	115	-1	-5	374	0	483	(N/A)	0.6
Paper birch	146	11	24	150	149	480	(N/A)	0.6
Blue spruce	64	2	7	104	72	248	(N/A)	0.3
Elm	182	11	38	392	117	740	(N/A)	0.9
Black maple	121	13	23	155	218	531	(N/A)	0.6
Catalpa	164	12	31	298	133	639	(N/A)	0.8
Amur corktree	94	5	16	76	78	270	(N/A)	0.3
Japanese tree lilac	5	0	1	2	2	10	(N/A)	0.0
Northern hackberry	92	4	18	135	73	322	(N/A)	0.4
Boxelder	55	7	9	84	65	221	(N/A)	0.3
Black poplar	99	2	23	196	29	347	(N/A)	0.4
Eastern hophornbeam	5	0	1	2	2	10	(N/A)	0.0
Swamp white oak	47	3	8	38	39	135	(N/A)	0.2
Mulberry	18	1	3	7	6	35	(N/A)	0.0
Kentucky coffeetree	44	3	7	40	46	140	(N/A)	0.2
Citywide Total	22,865	1,736	4,027	33,928	21,955	84,512	(N/A)	100.0

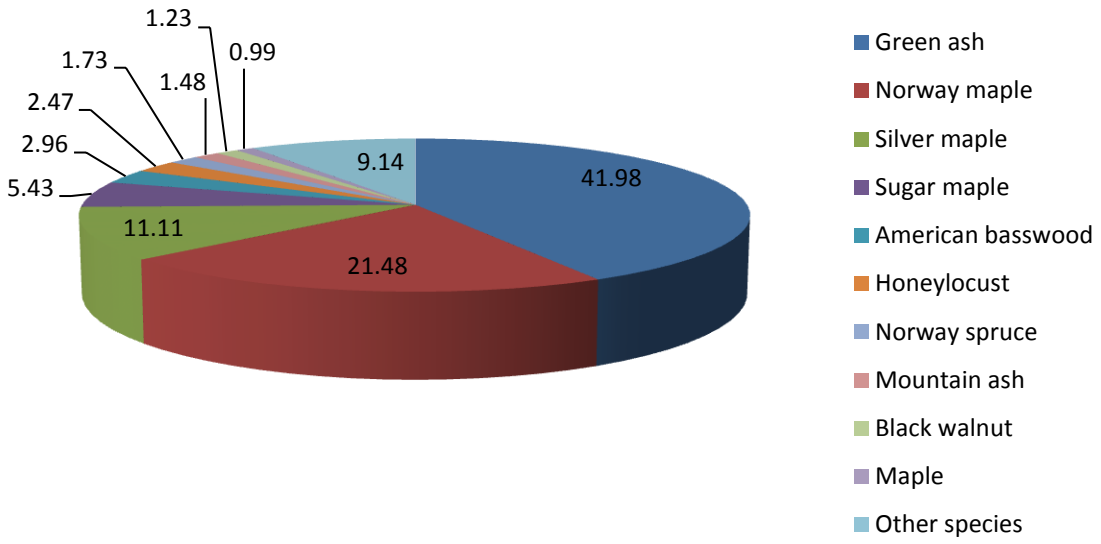


Figure 1: Species Distribution

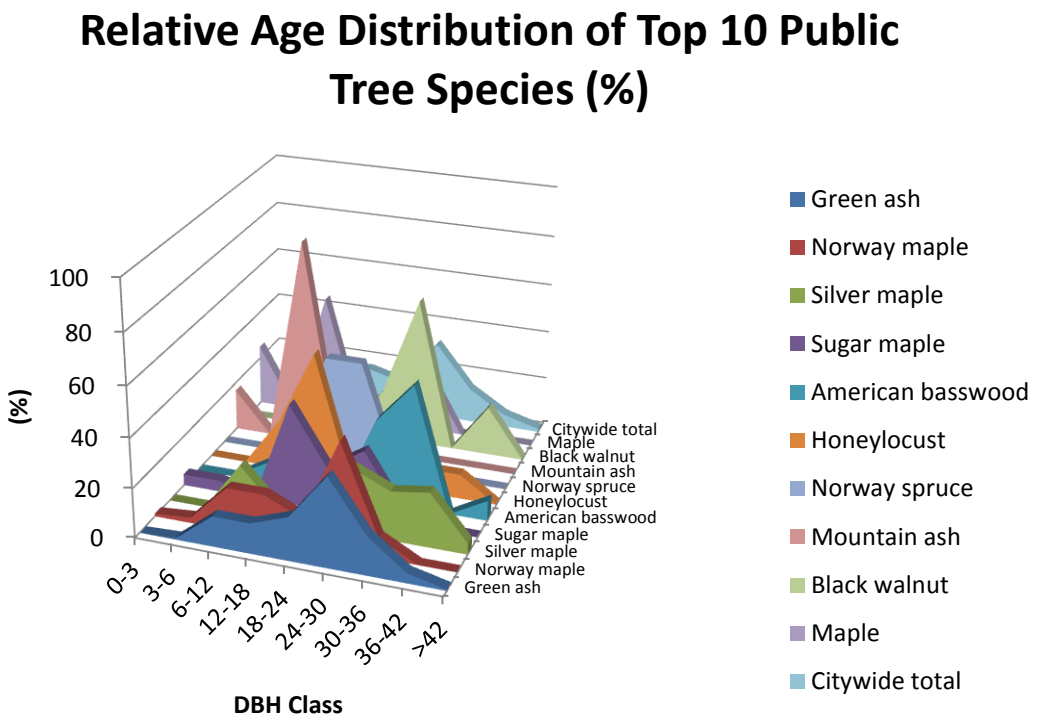


Figure 2: Relative Age Class

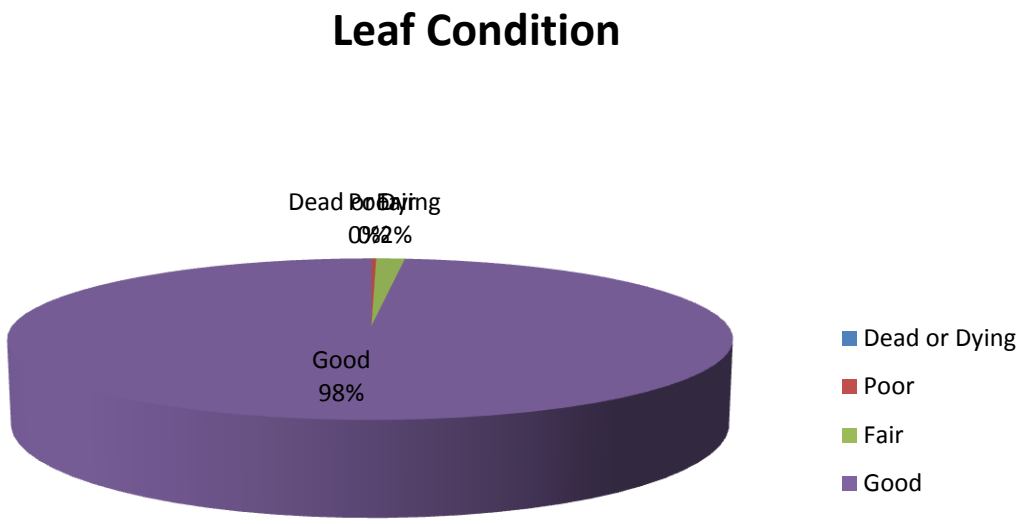


Figure 3: Foliage Condition

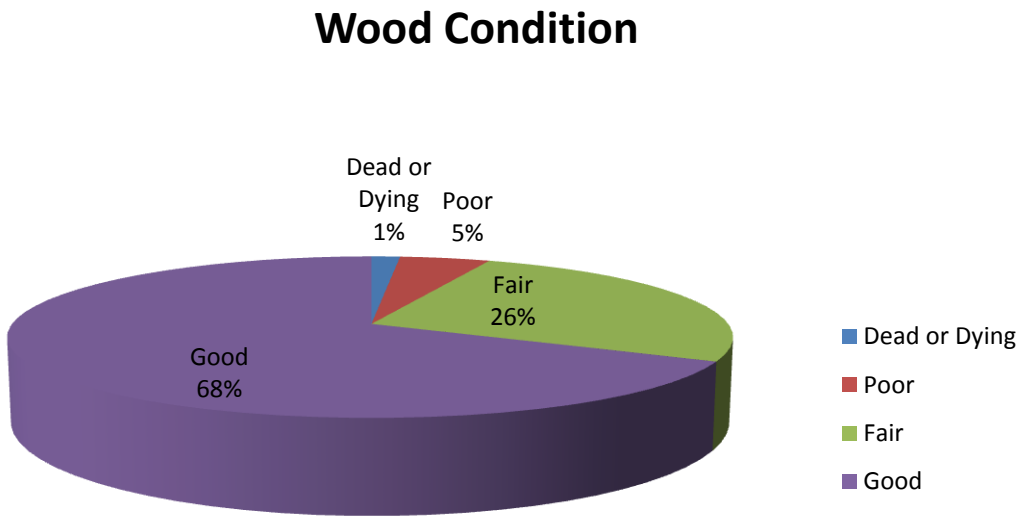


Figure 4: Wood Condition

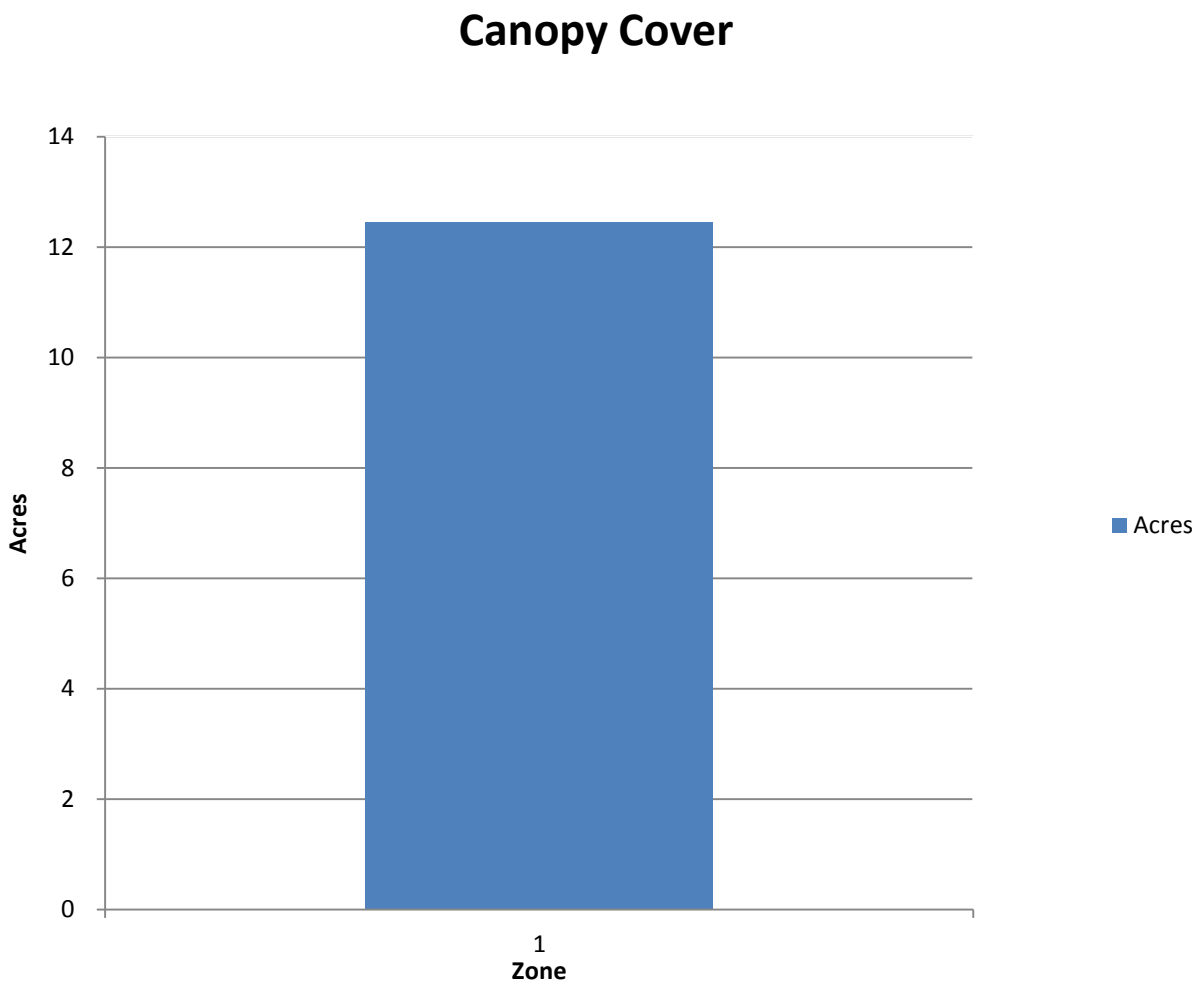


Figure 5: Canopy Cover in Acres

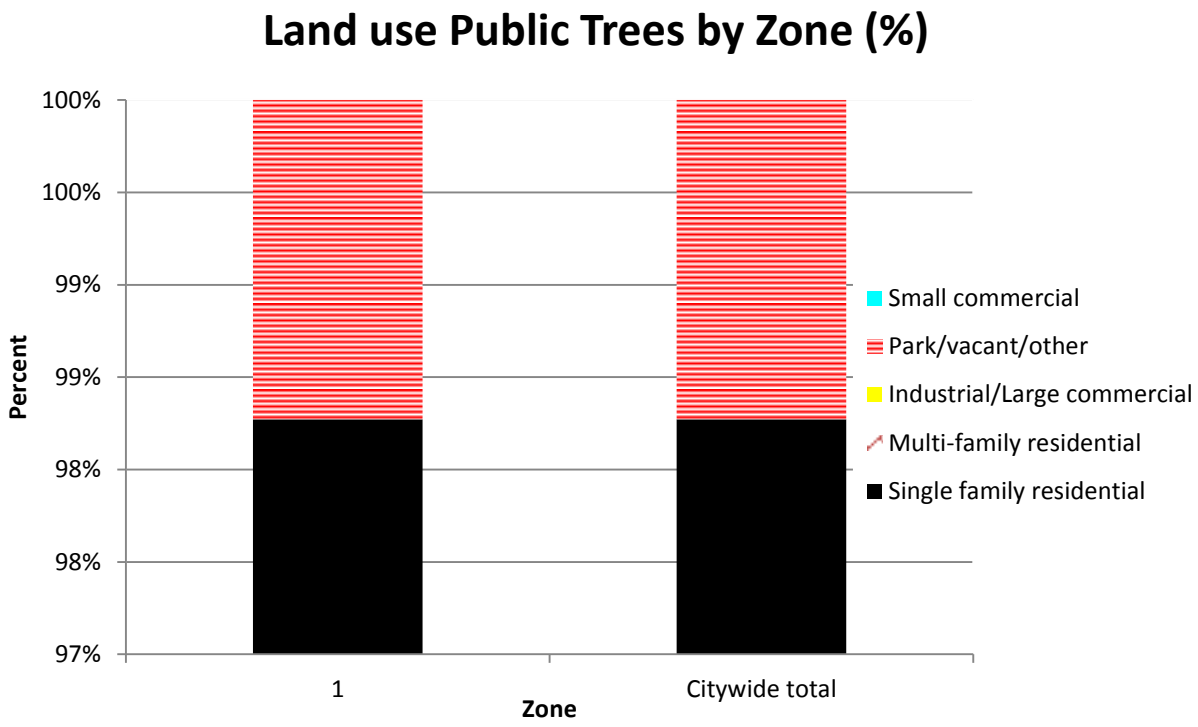


Figure 6: Land Use of city/park trees

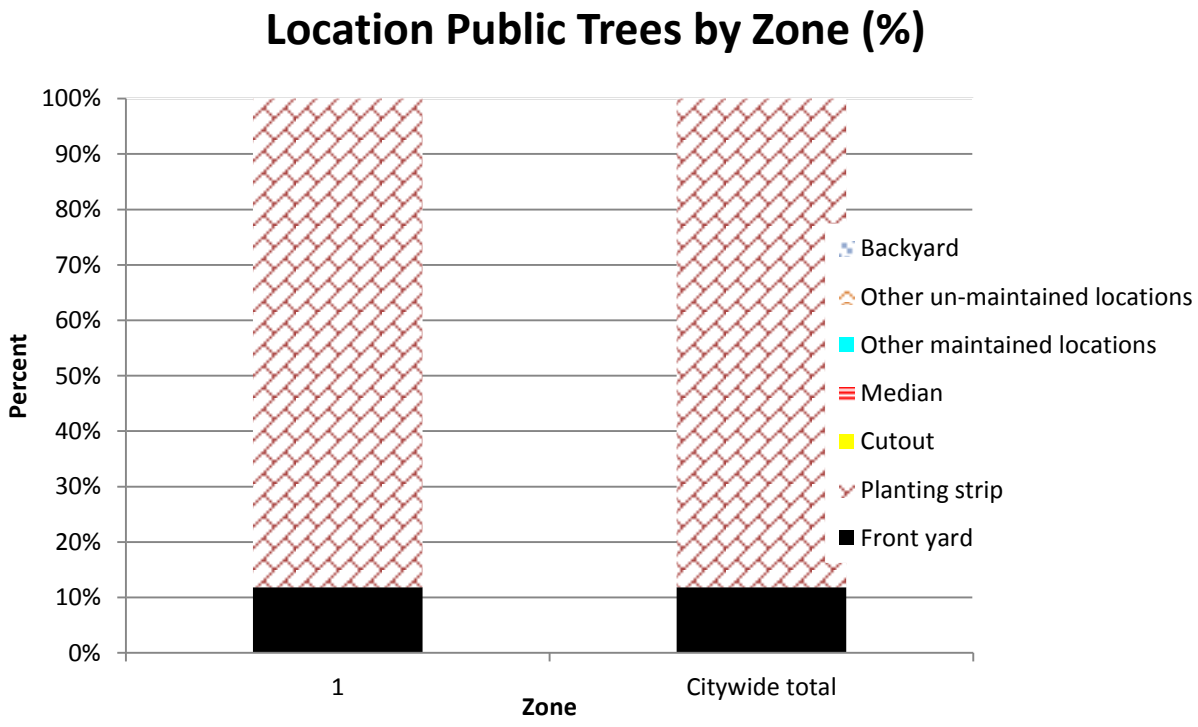


Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

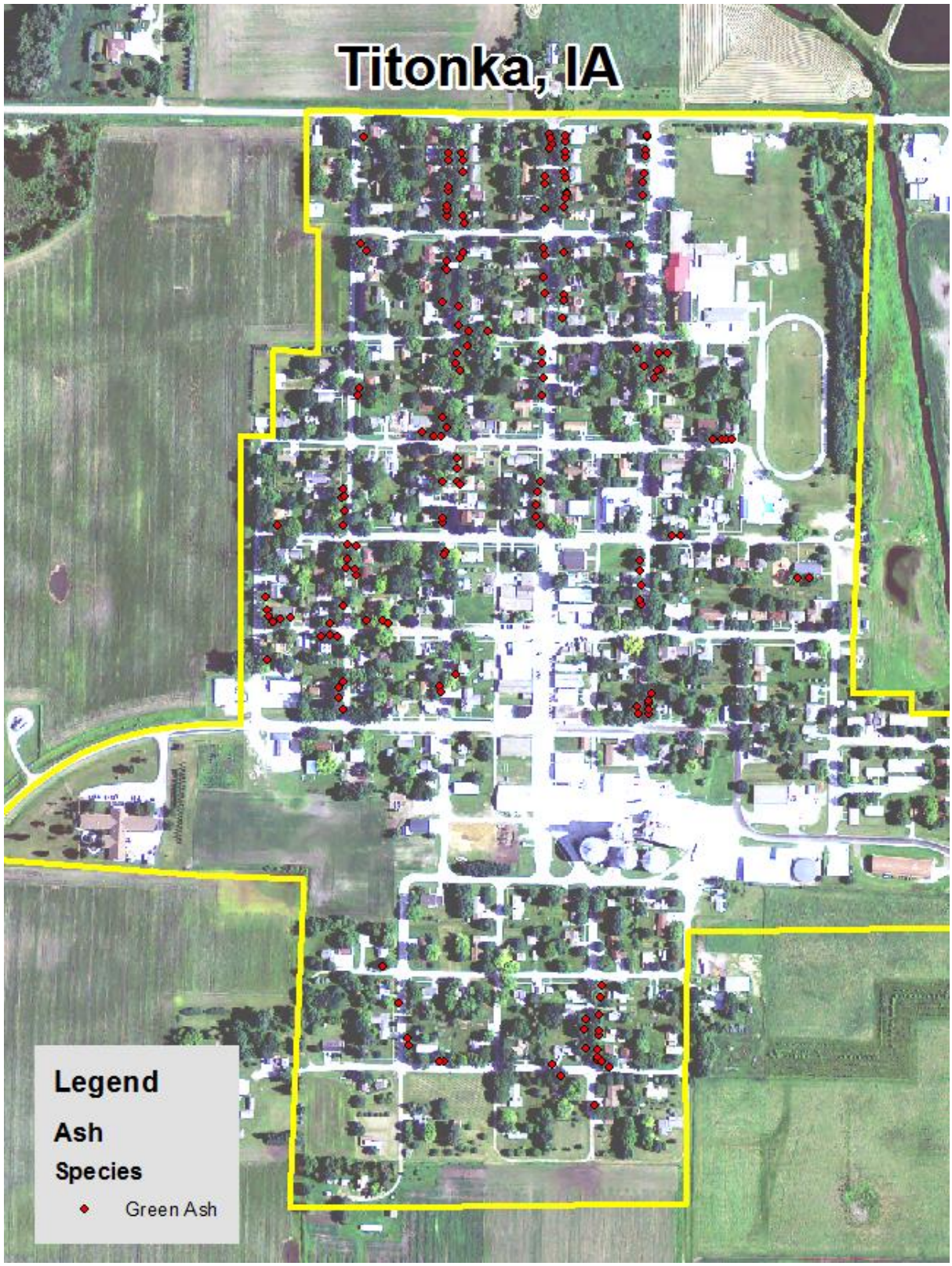


Figure 1: Location of Ash Trees

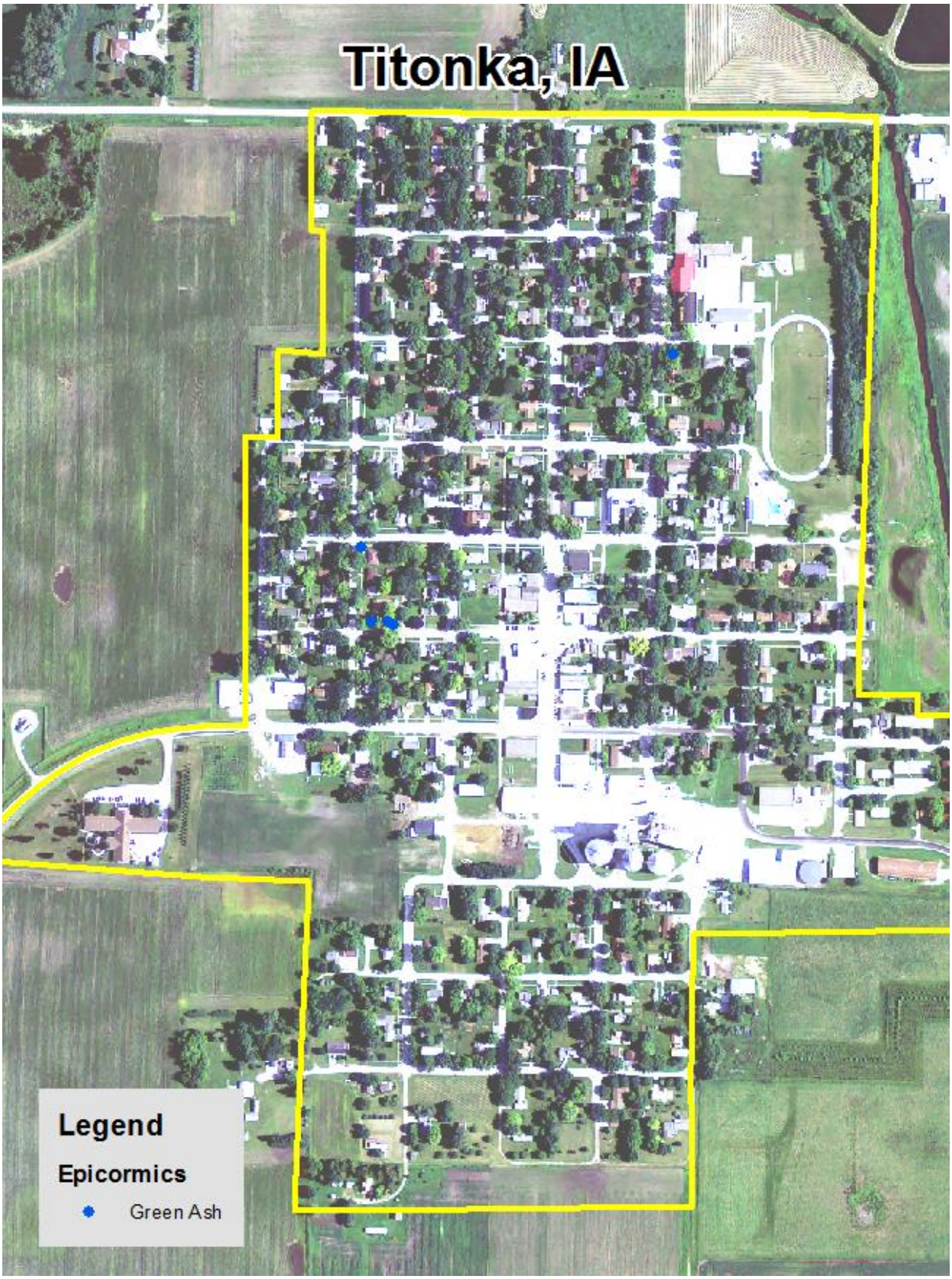


Figure 2: Location of EAB symptoms

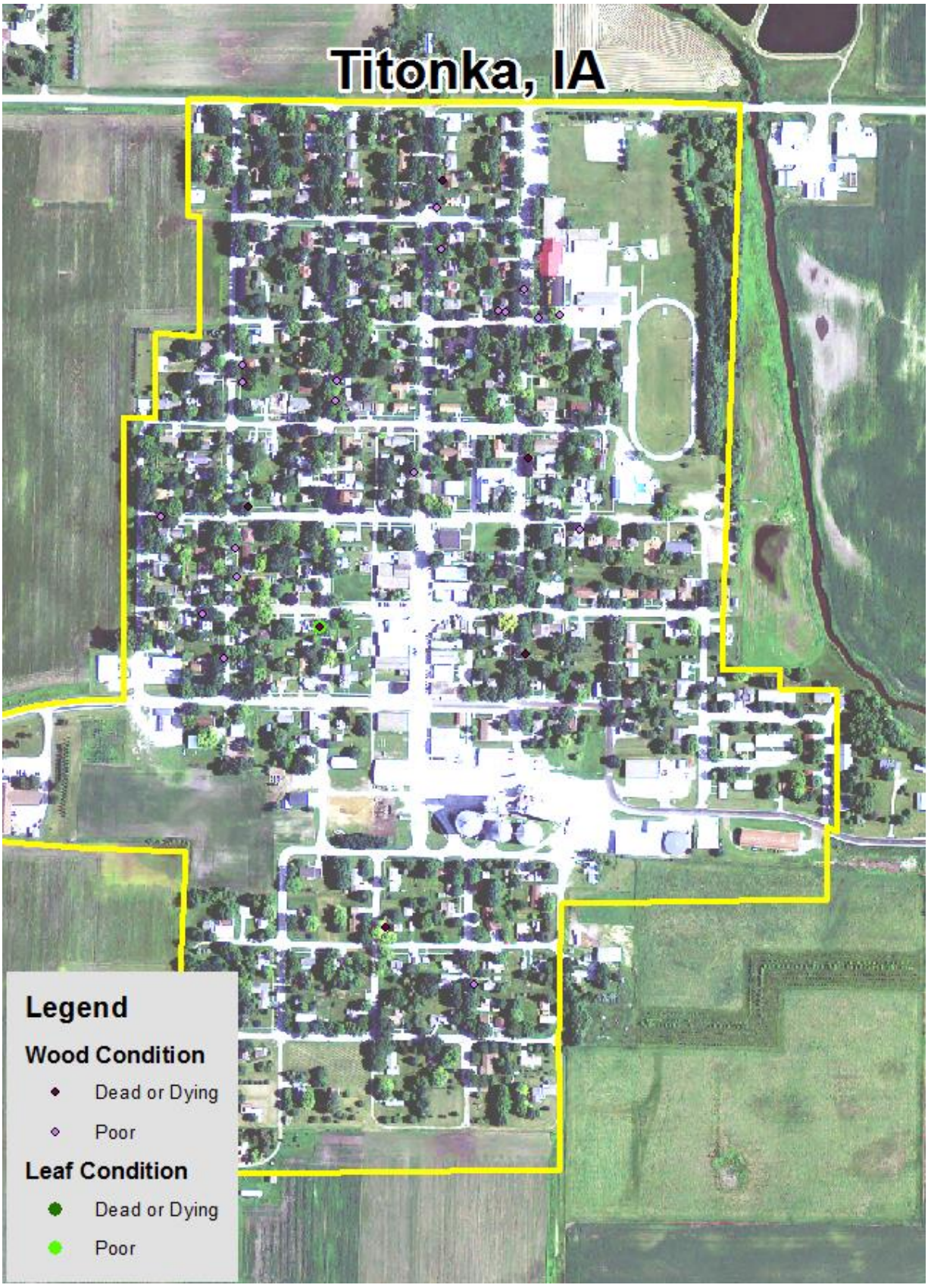


Figure 3: Location of Poor Condition Trees

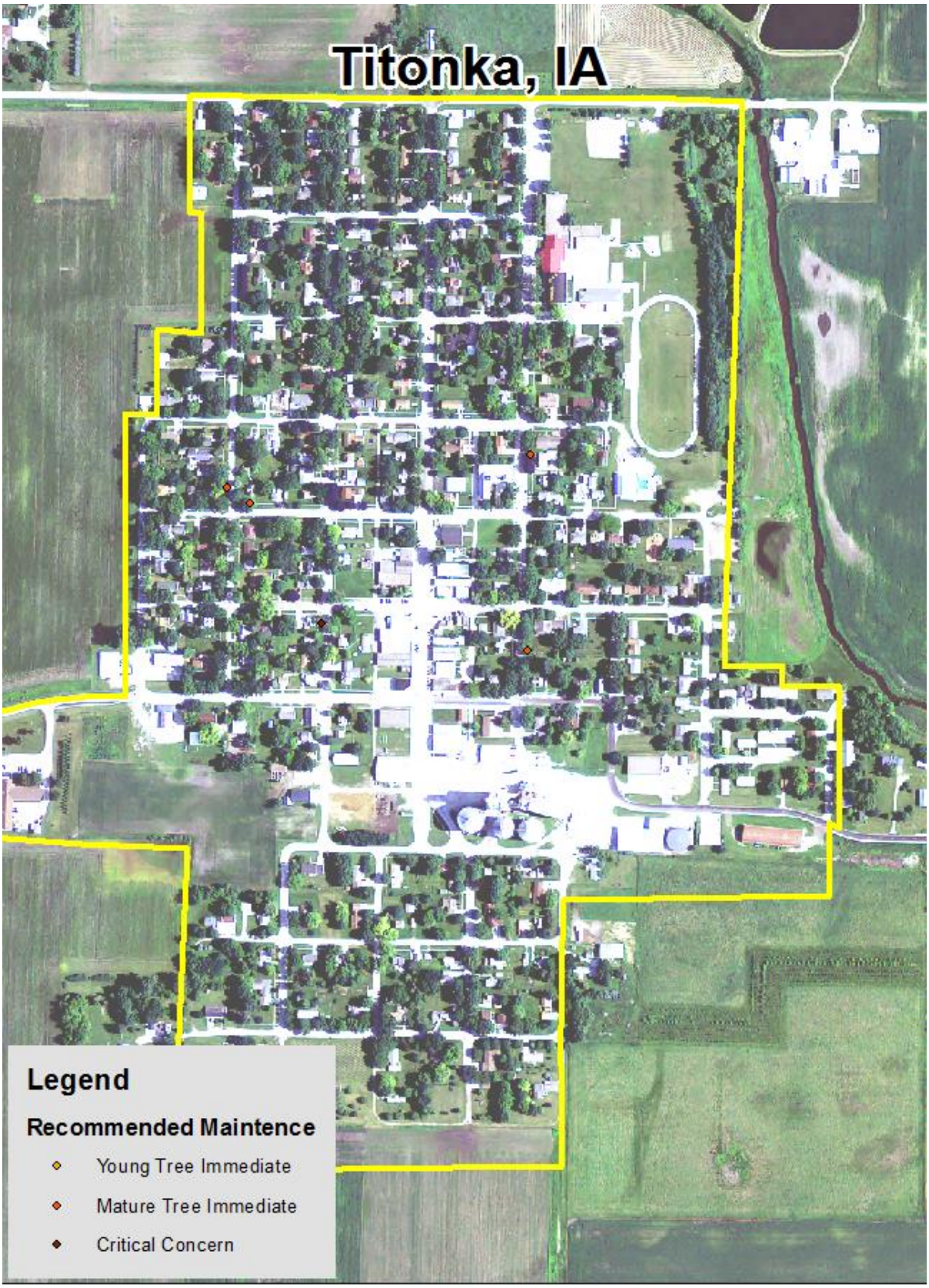


Figure 4: Location of Trees with Recommended Maintenance

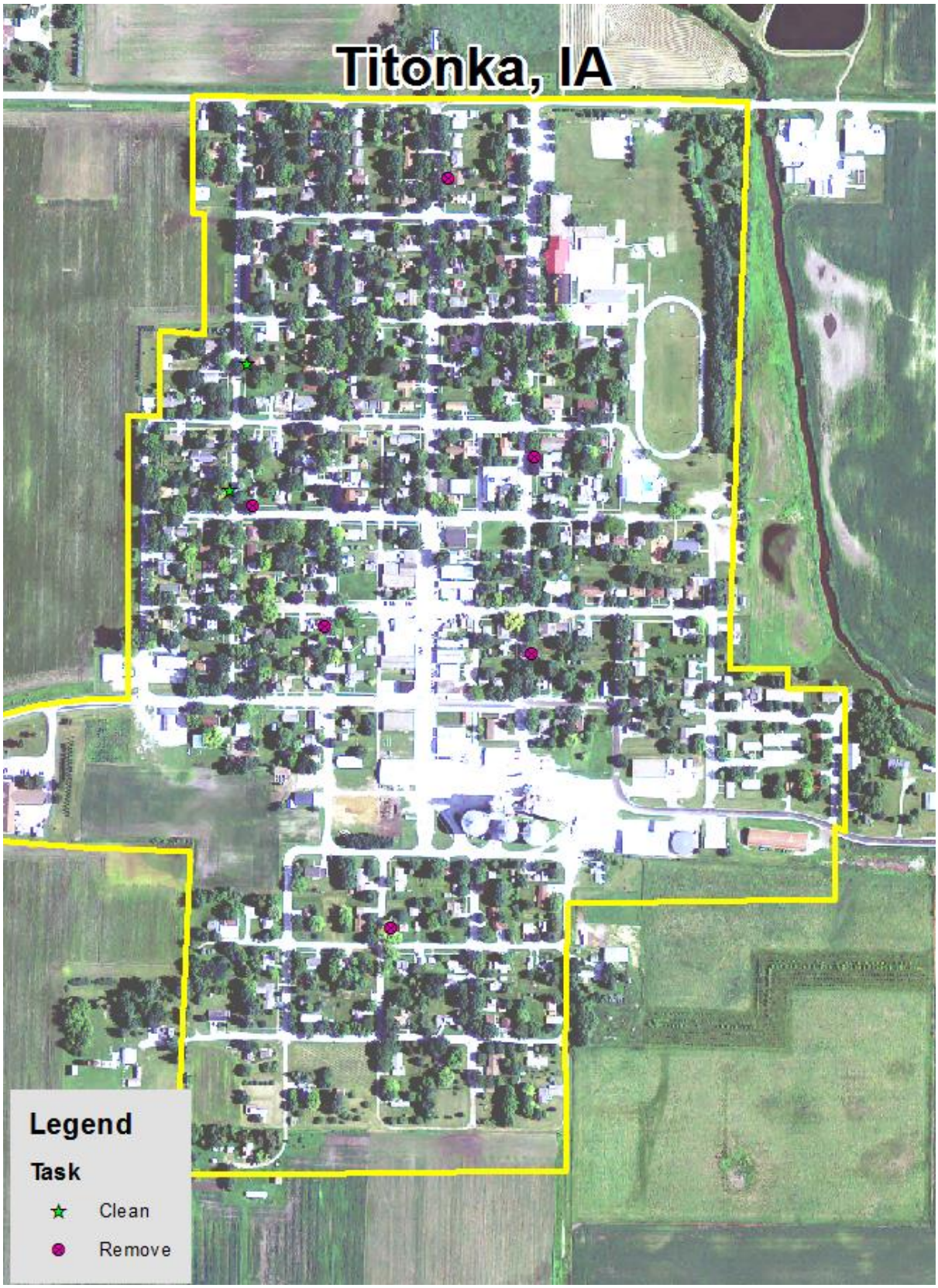


Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

The State of Iowa is an Equal Opportunity Employer and provider of ADA services.

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

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