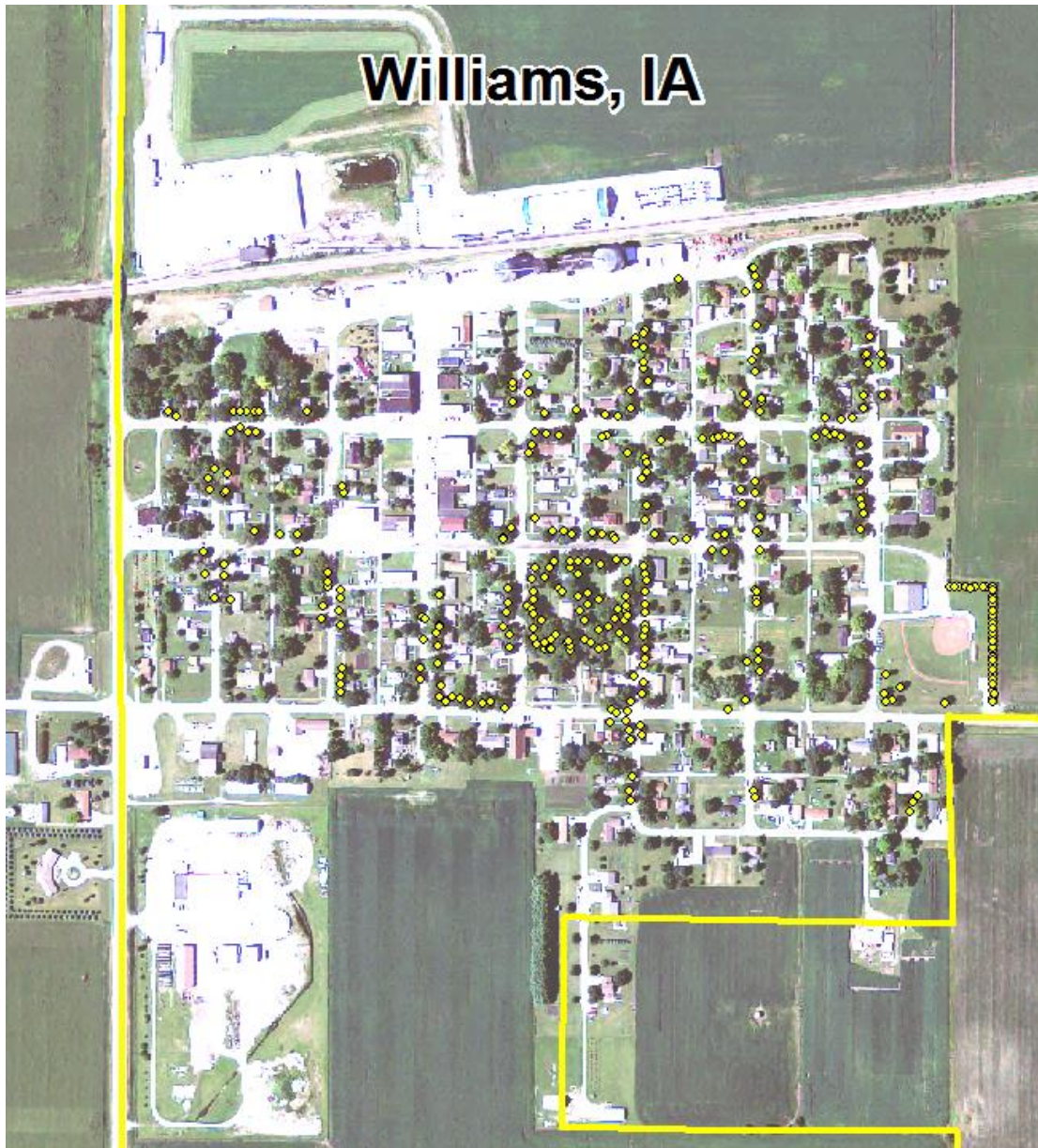# Williams

Williams, IA

2016 Urban Forest Management Plan
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Executive Summary

Overview

This plan was developed to assist the City of Williams 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 16% of Williams' 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 317 trees inventoried.
- Williams' trees provide $59,040 of benefits annually, an average of $186 a tree
- There are over 29 species of trees
- The top three genera are: Maple 46%, Ash 16%, and Spruce 14%
- 3% of trees are in need of some type of management
- 3 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.
- 7 of the 51 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

Introduction

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

Trees are an important component of Williams' 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 Williams 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 Williams' 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 317 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. Williams' trees reduce energy related costs by approximately $15,677 annually (Appendix A, Table 1). These savings are both in Electricity (74.1 MWh) and in Natural Gas (10,254.9 Therms).

Annual Stormwater Benefits

Williams' trees intercept about 848,495 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $22,994 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 Williams, it is estimated that trees remove 964 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 $2,719 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Williams, trees sequester about 161,769 lbs of carbon a year with an associated value of $1,213 (Appendix A, Table 4). In addition, the trees store 3,140,085 lbs of carbon, with a yearly benefit of $23,551 (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. Williams receives $16,436 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, Williams' trees provide $59,040 of benefits annually. Benefits of individual trees vary based on size, species, health and

location, but on average each of the 317 trees in Williams provide approximately $186 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Williams has over 29 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	146	46%
Ash	51	16%
Spruce	43	14%
Walnut	21	7%
Linden/Basswood	12	4%
Hackberry	10	3%
Apple (Crab)	8	3%
Oak	8	3%
Locust	5	2%
Juniper	3	1%
Pear	2	1%
Sycamore	2	1%
Elm	1	<1%
Hickory	1	<1%
Kentucky Coffeetree	1	<1%
Plum/Cherry	1	<1%
Redbud	1	<1%
		<1%
Other	1	<1%

Age Class

Most of Williams' trees (76%) are between 6 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. Williams' size curve is moderate, indicating a middle aged stand.

Condition: Wood and Foliage

Both wood condition and leaf condition are good indicators of the overall health of the urban forest. The foliage condition results for Williams indicate that 99% of the trees are in good health, with only 1% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 66% of Williams' 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 7% of the population. This 7% 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	5	2%
Tree Removal	3	1%

Canopy Cover

The total canopy with both private and public trees is 4%, 23 acres. The canopy cover included in the Williams inventory includes approximately 8.5 acres (Appendix A, Figure 4).

Land Use and Location

The majority of Williams' 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	69%
Park/vacant/other	31%

Location
Front yard	51%
Planting strip	49%

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
Williams has 3 trees marked for removal and 2 of those need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). An additional 5 trees are marked to clean (prune). Only 1 of the 5 marked for cleaning needs to be addressed immediately.

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 3 removals, 1 is an ash tree. There are a total of 51 ash trees, and 7 of those have signs and symptoms that have been associated with EAB. In addition, there are 6 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 Williams.

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 (46%) (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.

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: 1 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 14% of ash). It will take approximately 35 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 $6,000 a year. If the budget were increased to $3,000 a year all ash could be removed in 13 years.

Emerald Ash Borer Plan_____

Ash Tree Removal

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

Treatment of Ash Trees

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

EAB Quarantines

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

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

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

Wood Disposal

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

Canopy Replacement

As budget permits, all removed trees will be replaced. All trees will meet the restrictions in city ordinance). The new plantings will be a diverse mix.

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.

Budget _____

Current Budget
Total $10,800 over 6 years ($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: $700
      *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 7ash trees removed (approximately 14% of ash).
It will take approximately 35 years to remove all ash with the current budget.

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

were increased to $3,000 a year all ash could be removed within 13 years. Additionally, it is recommended that Williams 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 Williams would still need to find $30,100 for removal. Alternatively, if there are 15 treatable trees, it would cost approximately $2,250 a year for treatment and leave $25,200 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 Williams. 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

Williams

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
Norway maple	13.5	1,022	1,940.5	1,902	2,924	(N/A)	17.7	18.7	52.22
Silver maple	17.3	1,311	2,255.4	2,210	3,521	(N/A)	17.0	22.5	65.21
Green ash	14.6	1,110	2,001.8	1,962	3,071	(N/A)	16.1	19.6	60.22
Blue spruce	2.3	173	367.1	360	533	(N/A)	11.4	3.4	14.80
Black walnut	6.3	481	877.8	860	1,341	(N/A)	6.6	8.6	63.88
Sugar maple	5.1	388	688.1	674	1,062	(N/A)	5.4	6.8	62.49
Northern hackberry	2.9	220	417.8	409	630	(N/A)	3.2	4.0	62.97
Apple	1.1	82	170.9	167	249	(N/A)	2.5	1.6	31.17
Red maple	0.5	35	68.2	67	101	(N/A)	2.2	0.6	14.48
Northern red oak	1.0	78	139.7	137	215	(N/A)	2.2	1.4	30.73
Littleleaf linden	1.1	86	156.6	153	239	(N/A)	1.9	1.5	39.88
Maple	0.3	23	44.9	44	67	(N/A)	1.9	0.4	11.15
American basswood	1.4	110	206.7	203	312	(N/A)	1.9	2.0	52.08
Honeylocust	1.8	135	232.0	227	362	(N/A)	1.6	2.3	72.38
Norway spruce	0.2	17	38.0	37	54	(N/A)	1.3	0.3	13.58
Eastern red cedar	0.3	25	49.3	48	74	(N/A)	0.9	0.5	24.57
Spruce	0.3	23	43.6	43	65	(N/A)	0.9	0.4	21.78
Boxelder	0.6	44	81.3	80	124	(N/A)	0.6	0.8	62.01
Pear	0.2	16	28.5	28	44	(N/A)	0.6	0.3	21.77
Black maple	0.4	30	56.4	55	85	(N/A)	0.6	0.5	42.63
Kentucky coffeetree	0.3	25	40.7	40	65	(N/A)	0.6	0.4	32.43
American sycamore	0.8	62	110.0	108	170	(N/A)	0.6	1.1	84.77
Hickory	0.1	7	13.7	13	21	(N/A)	0.3	0.1	20.64
Broadleaf Deciduous Small	0.2	14	24.7	24	38	(N/A)	0.3	0.2	38.13
Chinese elm	0.5	37	63.1	62	99	(N/A)	0.3	0.6	98.63
Eastern redbud	0.2	14	24.7	24	38	(N/A)	0.3	0.2	38.13
Plum	0.1	6	12.8	13	18	(N/A)	0.3	0.1	18.19
Bur oak	0.4	29	53.7	53	82	(N/A)	0.3	0.5	82.02
Eastern cottonwood	0.3	25	46.9	46	71	(N/A)	0.3	0.5	70.91
Total	74.1	5,627	10,254.9	10,050	15,677	(N/A)	100.0	100.0	49.45

Table 2: Annual Stormwater Benefits

Williams

Annual Stormwater Benefits of Public Trees

12/30/2015

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	129,735	3,516 (N/A)		17.7	15.3	62.78
Silver maple	240,686	6,523 (N/A)		17.0	28.4	120.79
Green ash	164,856	4,468 (N/A)		16.1	19.4	87.60
Blue spruce	27,195	737 (N/A)		11.4	3.2	20.47
Black walnut	73,402	1,989 (N/A)		6.6	8.7	94.72
Sugar maple	63,006	1,707 (N/A)		5.4	7.4	100.44
Northern hackberry	26,564	720 (N/A)		3.2	3.1	71.99
Apple	5,247	142 (N/A)		2.5	0.6	17.77
Red maple	2,536	69 (N/A)		2.2	0.3	9.82
Northern red oak	7,532	204 (N/A)		2.2	0.9	29.16
Littleleaf linden	10,928	296 (N/A)		1.9	1.3	49.36
Maple	1,548	42 (N/A)		1.9	0.2	6.99
American basswood	16,126	437 (N/A)		1.9	1.9	72.83
Honeylocust	21,644	587 (N/A)		1.6	2.6	117.31
Norway spruce	2,382	65 (N/A)		1.3	0.3	16.14
Eastern red cedar	4,904	133 (N/A)		0.9	0.6	44.30
Spruce	5,796	157 (N/A)		0.9	0.7	52.35
Boxelder	8,047	218 (N/A)		0.6	0.9	109.04
Pear	735	20 (N/A)		0.6	0.1	9.96
Black maple	3,492	95 (N/A)		0.6	0.4	47.32
Kentucky coffeetree	2,073	56 (N/A)		0.6	0.2	28.09
American sycamore	11,182	303 (N/A)		0.6	1.3	151.51
Hickory	608	16 (N/A)		0.3	0.1	16.47
Broadleaf Deciduous Small	667	18 (N/A)		0.3	0.1	18.06
Chinese elm	7,239	196 (N/A)		0.3	0.9	196.17
Eastern redbud	667	18 (N/A)		0.3	0.1	18.06
Plum	264	7 (N/A)		0.3	0.0	7.17
Bur oak	5,491	149 (N/A)		0.3	0.6	148.79
Eastern cottonwood	3,943	107 (N/A)		0.3	0.5	106.85
Citywide total	848,495	22,994 (N/A)		100.0	100.0	72.54

Table 3: Annual Air Quality Benefits

Williams

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							
Norway maple	27.1	4.7	13.3	1.2	146	65.3	9.4	9.0	61.1	404	-6.3	-24	184.8	527 (N/A)	17.7	9.41
Silver maple	40.4	6.9	20.0	1.8	218	81.3	11.9	11.4	78.1	509	-20.9	-78	230.8	649 (N/A)	17.0	12.01
Green ash	21.0	3.4	10.0	0.9	112	69.8	10.2	9.7	66.3	435	0.0	0	191.2	546 (N/A)	16.1	10.71
Blue spruce	2.5	0.5	2.5	0.3	18	11.3	1.6	1.5	10.3	69	-8.5	-32	22.1	55 (N/A)	11.4	1.53
Black walnut	9.3	1.5	4.4	0.4	49	30.4	4.4	4.2	28.7	189	0.0	0	83.2	238 (N/A)	6.6	11.34
Sugar maple	8.7	1.5	4.3	0.4	47	24.3	3.5	3.4	23.1	151	-6.8	-25	62.4	173 (N/A)	5.4	10.18
Northern hackberry	3.9	0.7	2.0	0.2	22	14.1	2.0	1.9	13.2	87	0.0	0	38.0	109 (N/A)	3.2	10.87
Apple	1.7	0.3	0.8	0.1	9	5.4	0.8	0.7	4.9	33	0.0	0	14.6	42 (N/A)	2.5	5.22
Red maple	0.3	0.1	0.2	0.0	2	2.2	0.3	0.3	2.1	14	-0.1	-1	5.3	15 (N/A)	2.2	2.14
Northern red oak	1.4	0.2	0.7	0.1	7	4.9	0.7	0.7	4.7	31	-1.9	-7	11.4	31 (N/A)	2.2	4.40
Littleleaf linden	1.8	0.3	0.9	0.1	10	5.4	0.8	0.8	5.1	34	-0.9	-3	14.4	40 (N/A)	1.9	6.73
Maple	0.2	0.0	0.1	0.0	1	1.5	0.2	0.2	1.4	9	-0.1	0	3.5	10 (N/A)	1.9	1.63
American basswood	2.2	0.4	1.1	0.1	12	7.0	1.0	1.0	6.6	43	-1.9	-7	17.5	48 (N/A)	1.9	8.06
Honeylocust	4.3	0.7	1.9	0.2	23	8.3	1.2	1.2	8.0	52	-3.4	-13	22.5	62 (N/A)	1.6	12.42
Norway spruce	0.2	0.0	0.2	0.0	1	1.1	0.2	0.2	1.0	7	-0.7	-2	2.3	6 (N/A)	1.3	1.48
Eastern red cedar	1.0	0.2	0.8	0.1	7	1.6	0.2	0.2	1.5	10	-2.7	-10	3.1	7 (N/A)	0.9	2.19
Spruce	0.7	0.1	0.6	0.1	4	1.4	0.2	0.2	1.3	9	-3.2	-12	1.4	1 (N/A)	0.9	0.46
Boxelder	1.2	0.2	0.5	0.1	6	2.8	0.4	0.4	2.6	17	-0.4	-1	7.9	22 (N/A)	0.6	11.20
Pear	0.2	0.0	0.1	0.0	1	1.0	0.1	0.1	0.9	6	0.0	0	2.6	7 (N/A)	0.6	3.63
Black maple	0.8	0.1	0.4	0.0	4	1.9	0.3	0.3	1.8	12	-0.3	-1	5.3	15 (N/A)	0.6	7.59
Kentucky coffeetree	0.1	0.0	0.1	0.0	1	1.5	0.2	0.2	1.5	10	0.0	0	3.7	10 (N/A)	0.6	5.21
American sycamore	2.1	0.3	0.9	0.1	11	3.9	0.6	0.5	3.7	24	0.0	0	12.1	35 (N/A)	0.6	17.51
Hickory	0.0	0.0	0.0	0.0	0	0.5	0.1	0.1	0.4	3	0.0	0	1.1	3 (N/A)	0.3	2.99
Broadleaf Deciduous Small	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.8	5	0.0	0	2.3	7 (N/A)	0.3	6.56
Chinese elm	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)	0.3	22.55
Eastern redbud	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.8	5	0.0	0	2.3	7 (N/A)	0.3	6.56
Plum	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.3	2	0.0	0	0.9	3 (N/A)	0.3	2.55
Bur oak	0.8	0.1	0.4	0.0	4	1.9	0.3	0.3	1.8	12	0.0	0	5.5	16 (N/A)	0.3	15.71
Eastern cottonwood	0.5	0.1	0.2	0.0	3	1.6	0.2	0.2	1.5	10	0.0	0	4.4	12 (N/A)	0.3	12.48
Citywide total	134.6	22.7	67.2	6.3	729	354.7	51.6	49.2	335.9	2,207	-58.1	-218	964.1	2,719 (N/A)	100.0	8.58

Table 4: Annual Carbon Stored

Williams

Stored CO2 Benefits of Public Trees

12/30/2015

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	448,970	3,367	(N/A)	17.7	14.3	60.13
Silver maple	890,761	6,681	(N/A)	17.0	28.4	123.72
Green ash	687,510	5,156	(N/A)	16.1	21.9	101.10
Blue spruce	10,230	77	(N/A)	11.4	0.3	2.13
Black walnut	300,174	2,251	(N/A)	6.6	9.6	107.21
Sugar maple	252,970	1,897	(N/A)	5.4	8.1	111.60
Northern hackberry	57,645	432	(N/A)	3.2	1.8	43.23
Apple	26,897	202	(N/A)	2.5	0.9	25.22
Red maple	4,453	33	(N/A)	2.2	0.1	4.77
Northern red oak	26,528	199	(N/A)	2.2	0.8	28.42
Littleleaf linden	39,717	298	(N/A)	1.9	1.3	49.65
Maple	2,672	20	(N/A)	1.9	0.1	3.34
American basswood	83,451	626	(N/A)	1.9	2.7	104.31
Honeylocust	55,722	418	(N/A)	1.6	1.8	83.58
Norway spruce	1,027	8	(N/A)	1.3	0.0	1.93
Eastern red cedar	3,306	25	(N/A)	0.9	0.1	8.27
Spruce	8,004	60	(N/A)	0.9	0.3	20.01
Boxelder	45,612	342	(N/A)	0.6	1.5	171.04
Pear	3,215	24	(N/A)	0.6	0.1	12.06
Black maple	9,046	68	(N/A)	0.6	0.3	33.92
Kentucky coffeetree	4,706	35	(N/A)	0.6	0.1	17.65
American sycamore	71,755	538	(N/A)	0.6	2.3	269.08
Hickory	1,035	8	(N/A)	0.3	0.0	7.76
Broadleaf Deciduous	3,037	23	(N/A)	0.3	0.1	22.78
Chinese elm	55,982	420	(N/A)	0.3	1.8	419.86
Eastern redbud	3,037	23	(N/A)	0.3	0.1	22.78
Plum	908	7	(N/A)	0.3	0.0	6.81
Bur oak	25,943	195	(N/A)	0.3	0.8	194.57
Eastern cottonwood	15,773	118	(N/A)	0.3	0.5	118.30
Citywide total	3,140,085	23,551	(N/A)	100.0	100.0	74.29

Table 5: Annual Carbon Sequestered

Williams

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
Norway maple	16,564	124	-2,157	-144	-1	0	0	14,263	107 (N/A)	17.7	8.8	1.91
Silver maple	68,662	515	-4,276	-187	-1	0	0	64,199	481 (N/A)	17.0	39.7	8.92
Green ash	34,374	258	-3,300	-153	-1	0	0	30,920	232 (N/A)	16.1	19.1	4.55
Blue spruce	1,390	10	-49	-42	0	0	0	1,299	10 (N/A)	11.4	0.8	0.27
Black walnut	15,450	116	-1,441	-67	-1	0	0	13,943	105 (N/A)	6.6	8.6	4.98
Sugar maple	12,260	92	-1,214	-57	0	0	0	10,989	82 (N/A)	5.4	6.8	4.85
Northern hackberry	3,575	27	-277	-27	0	0	0	3,272	25 (N/A)	3.2	2.0	2.45
Apple	1,202	9	-129	-16	0	0	0	1,056	8 (N/A)	2.5	0.7	0.99
Red maple	670	5	-22	-5	0	0	0	643	5 (N/A)	2.2	0.4	0.69
Northern red oak	1,522	11	-127	-12	0	0	0	1,383	10 (N/A)	2.2	0.9	1.48
Littleleaf linden	3,711	28	-191	-13	0	0	0	3,508	26 (N/A)	1.9	2.2	4.38
Maple	414	3	-13	-4	0	0	0	397	3 (N/A)	1.9	0.2	0.50
American basswood	4,786	36	-401	-17	0	0	0	4,368	33 (N/A)	1.9	2.7	5.46
Honeylocust	3,908	29	-267	-14	0	0	0	3,627	27 (N/A)	1.6	2.2	5.44
Norway spruce	211	2	-5	-5	0	0	0	201	2 (N/A)	1.3	0.1	0.38
Eastern red cedar	86	1	-16	-6	0	0	0	64	0 (N/A)	0.9	0.0	0.16
Spruce	361	3	-38	-6	0	0	0	317	2 (N/A)	0.9	0.2	0.79
Boxelder	2,908	22	-219	-9	0	0	0	2,681	20 (N/A)	0.6	1.7	10.05
Pear	306	2	-15	-3	0	0	0	288	2 (N/A)	0.6	0.2	1.08
Black maple	165	1	-43	-4	0	0	0	118	1 (N/A)	0.6	0.1	0.44
Kentucky coffeetree	654	5	-23	-3	0	0	0	628	5 (N/A)	0.6	0.4	2.36
American sycamore	1,336	10	-344	-9	0	0	0	982	7 (N/A)	0.6	0.6	3.68
Hickory	209	2	-5	-1	0	0	0	203	2 (N/A)	0.3	0.1	1.52
Broadleaf Deciduous Smal	268	2	-15	-2	0	0	0	251	2 (N/A)	0.3	0.2	1.88
Chinese elm	479	4	-269	-6	0	0	0	204	2 (N/A)	0.3	0.1	1.53
Eastern redbud	268	2	-15	-2	0	0	0	251	2 (N/A)	0.3	0.2	1.88
Plum	114	1	-4	-1	0	0	0	108	1 (N/A)	0.3	0.1	0.81
Bur oak	960	7	-125	-4	0	0	0	831	6 (N/A)	0.3	0.5	6.23
Eastern cottonwood	857	6	-76	-4	0	0	0	778	6 (N/A)	0.3	0.5	5.83
Citywide total	177,667	1,332	-15,075	-822	-6	0	0	161,769	1,213 (N/A)	100.0	100.0	3.83

Table 6: Annual Social and Aesthetic Benefits

Annual Aesthetic/Other Benefits of Public Trees

12/30/2015

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	1,593	(N/A)	17.7	9.7	28.45
Silver maple	5,460	(N/A)	17.0	33.2	101.11
Green ash	2,810	(N/A)	16.1	17.1	55.10
Blue spruce	759	(N/A)	11.4	4.6	21.08
Black walnut	1,233	(N/A)	6.6	7.5	58.71
Sugar maple	1,243	(N/A)	5.4	7.6	73.12
Northern hackberry	497	(N/A)	3.2	3.0	49.67
Apple	70	(N/A)	2.5	0.4	8.74
Red maple	119	(N/A)	2.2	0.7	17.07
Northern red oak	137	(N/A)	2.2	0.8	19.57
Littleleaf linden	385	(N/A)	1.9	2.3	64.11
Maple	74	(N/A)	1.9	0.5	12.39
American basswood	338	(N/A)	1.9	2.1	56.36
Honeylocust	972	(N/A)	1.6	5.9	194.48
Norway spruce	62	(N/A)	1.3	0.4	15.42
Eastern red cedar	27	(N/A)	0.9	0.2	9.12
Spruce	57	(N/A)	0.9	0.3	19.03
Boxelder	157	(N/A)	0.6	1.0	78.52
Pear	18	(N/A)	0.6	0.1	8.77
Black maple	30	(N/A)	0.6	0.2	14.92
Kentucky coffeetree	74	(N/A)	0.6	0.5	37.21
American sycamore	94	(N/A)	0.6	0.6	47.08
Hickory	29	(N/A)	0.3	0.2	28.56
Broadleaf Deciduous Small	15	(N/A)	0.3	0.1	15.48
Chinese elm	29	(N/A)	0.3	0.2	28.57
Eastern redbud	15	(N/A)	0.3	0.1	15.48
Plum	6	(N/A)	0.3	0.0	6.40
Bur oak	67	(N/A)	0.3	0.4	66.60
Eastern cottonwood	66	(N/A)	0.3	0.4	65.59
Citywide total	16,436	(N/A)	100.0	100.0	51.85

Table 7: Summary of Benefits in Dollars

Williams

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 $
Norway maple	2,924	107	527	3,516	1,593	8,667	(N/A)	14.7
Silver maple	3,521	481	649	6,523	5,460	16,634	(N/A)	28.2
Green ash	3,071	232	546	4,468	2,810	11,127	(N/A)	18.8
Blue spruce	533	10	55	737	759	2,094	(N/A)	3.5
Black walnut	1,341	105	238	1,989	1,233	4,906	(N/A)	8.3
Sugar maple	1,062	82	173	1,707	1,243	4,268	(N/A)	7.2
Northern hackberry	630	25	109	720	497	1,980	(N/A)	3.4
Apple	249	8	42	142	70	511	(N/A)	0.9
Red maple	101	5	15	69	119	309	(N/A)	0.5
Northern red oak	215	10	31	204	137	597	(N/A)	1.0
Littleleaf linden	239	26	40	296	385	987	(N/A)	1.7
Maple	67	3	10	42	74	196	(N/A)	0.3
American basswood	312	33	48	437	338	1,169	(N/A)	2.0
Honeylocust	362	27	62	587	972	2,010	(N/A)	3.4
Norway spruce	54	2	6	65	62	188	(N/A)	0.3
Eastern red cedar	74	0	7	133	27	241	(N/A)	0.4
Spruce	65	2	1	157	57	283	(N/A)	0.5
Boxelder	124	20	22	218	157	542	(N/A)	0.9
Pear	44	2	7	20	18	90	(N/A)	0.2
Black maple	85	1	15	95	30	226	(N/A)	0.4
Kentucky coffeetree	65	5	10	56	74	211	(N/A)	0.4
American sycamore	170	7	35	303	94	609	(N/A)	1.0
Hickory	21	2	3	16	29	70	(N/A)	0.1
Broadleaf Deciduous Sn	38	2	7	18	15	80	(N/A)	0.1
Chinese elm	99	2	23	196	29	347	(N/A)	0.6
Eastern redbud	38	2	7	18	15	80	(N/A)	0.1
Plum	18	1	3	7	6	35	(N/A)	0.1
Bur oak	82	6	16	149	67	319	(N/A)	0.5
Eastern cottonwood	71	6	12	107	66	262	(N/A)	0.4
Citywide Total	15,677	1,213	2,719	22,994	16,436	59,040	(N/A)	100.0
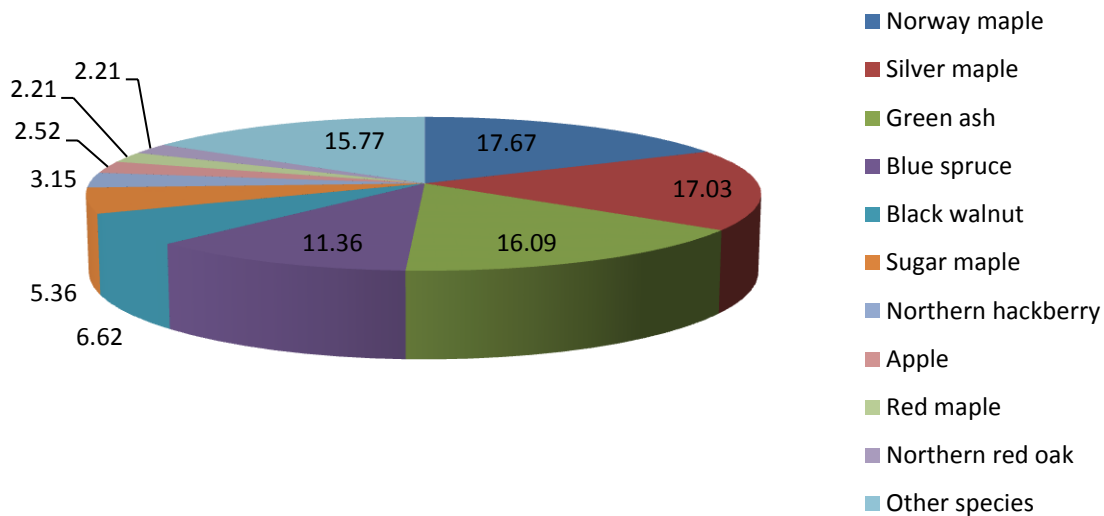
Figure 1: Species Distribution

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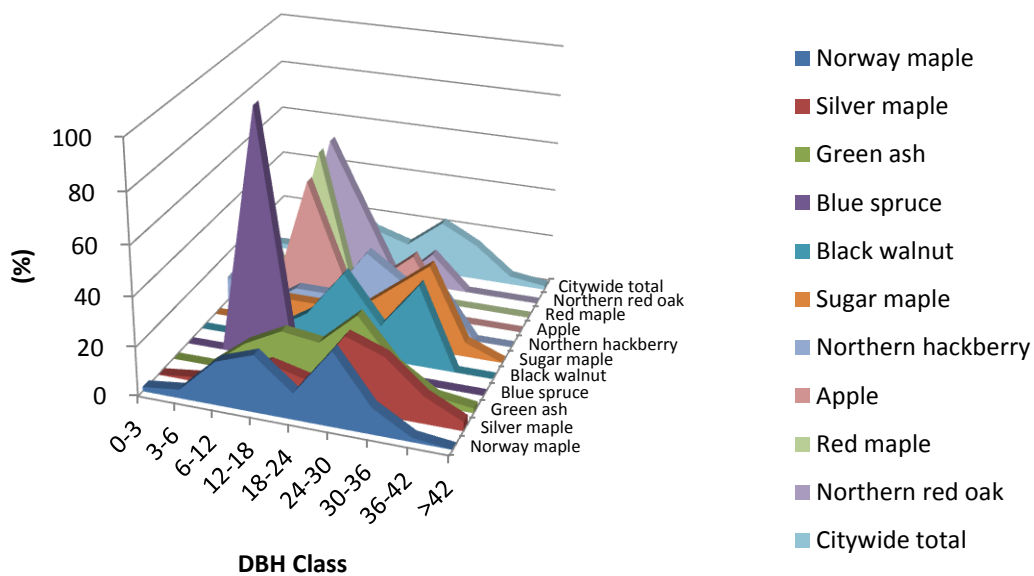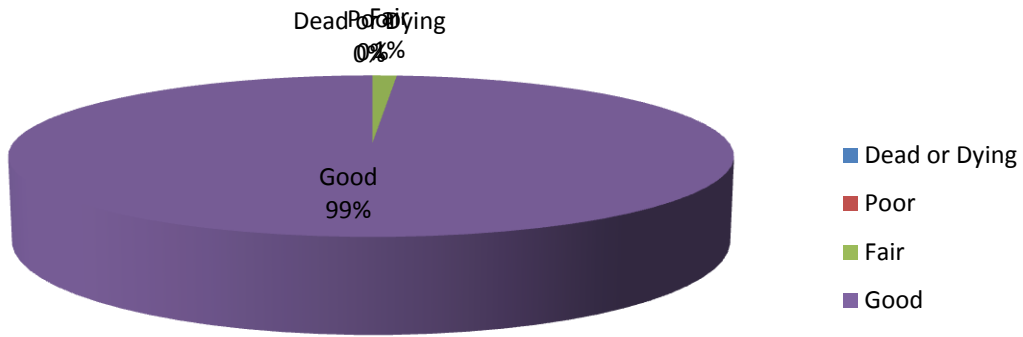

Figure 2: Relative Age Class

Leaf Condtion

Dead or Dying
0%

Poor
0%

Fair
1%

Good
99%

- Dead or Dying
- Poor
- Fair
- Good

Figure 3: Foliage Condition

Wood Condtion

Dead or Dying
0%

Poor
7%

Fair
27%

Good
66%

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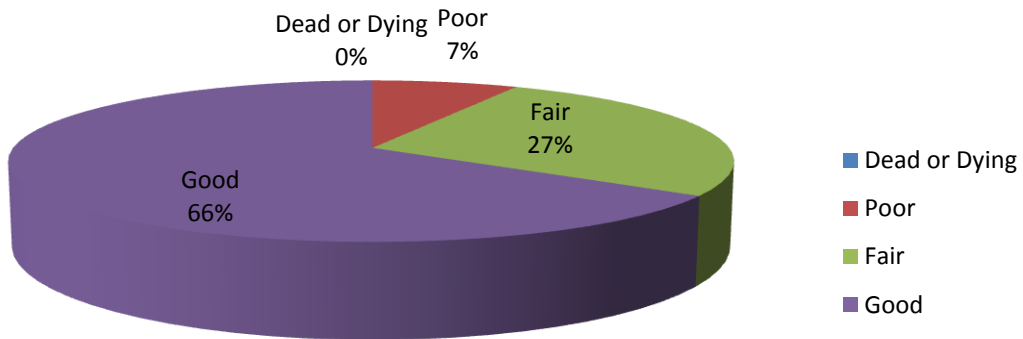
Figure 4: Wood Condition

Canopy Cover
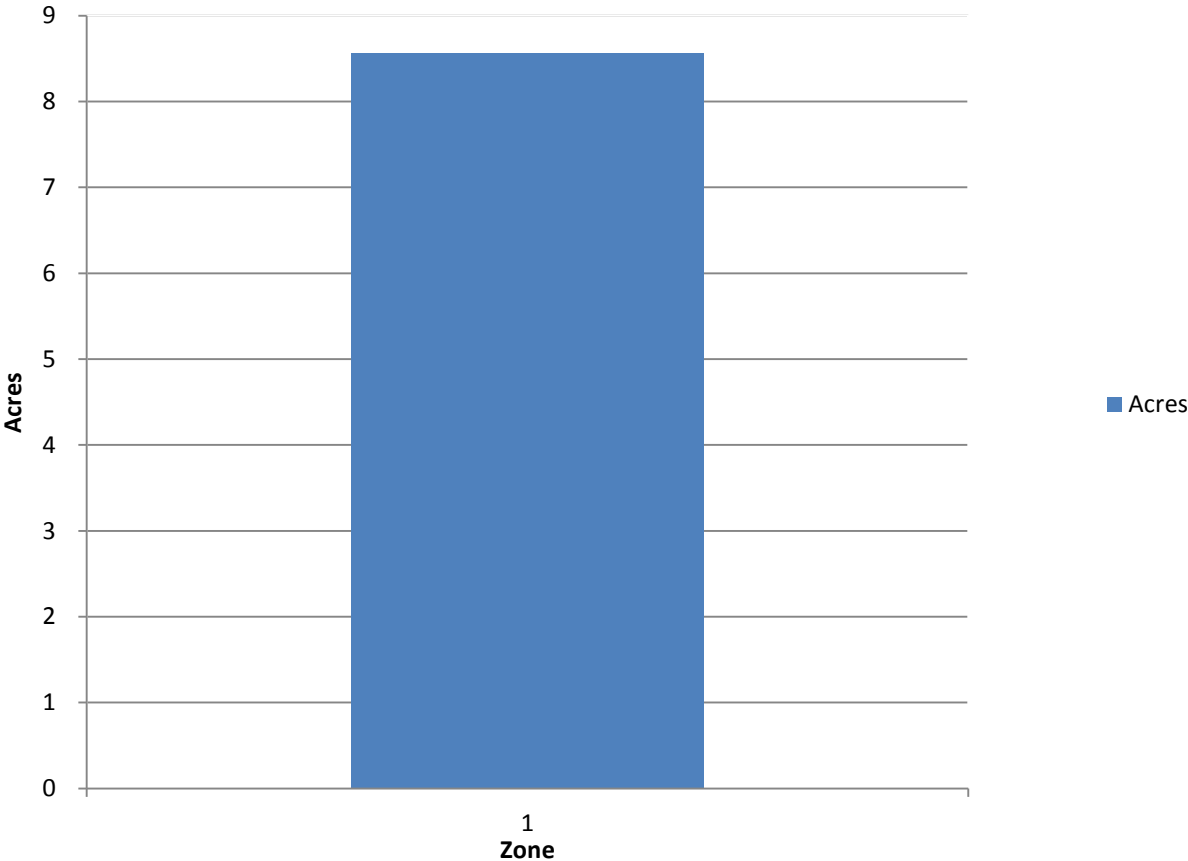
Figure 5: Canopy Cover in Acres

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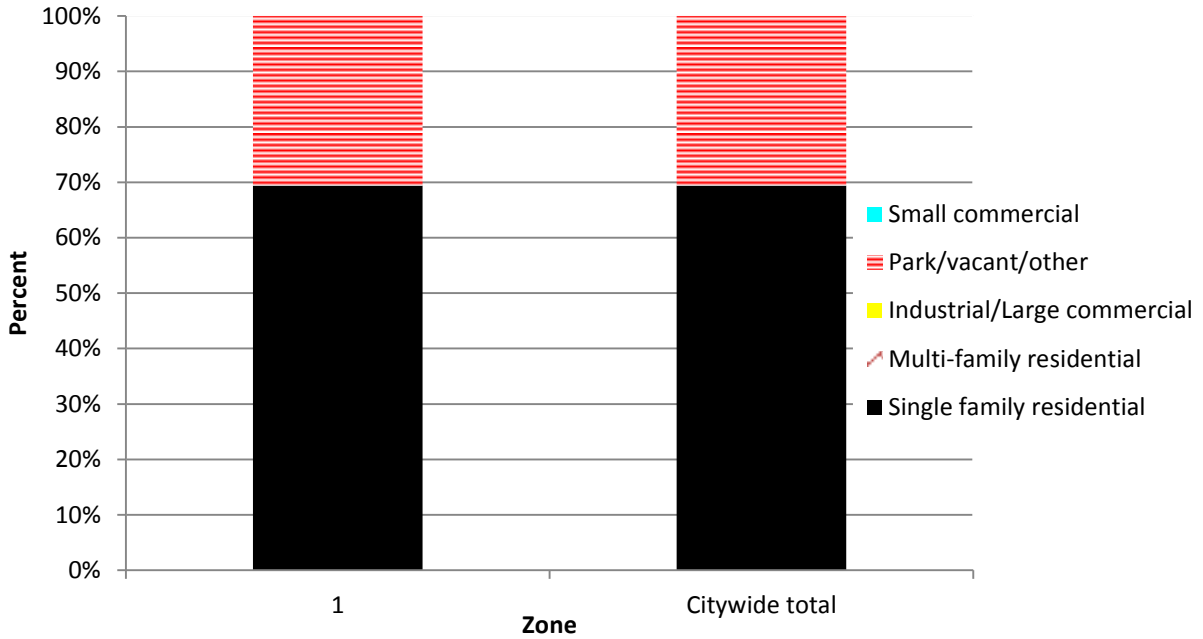
Figure 6: Land Use of city/park trees

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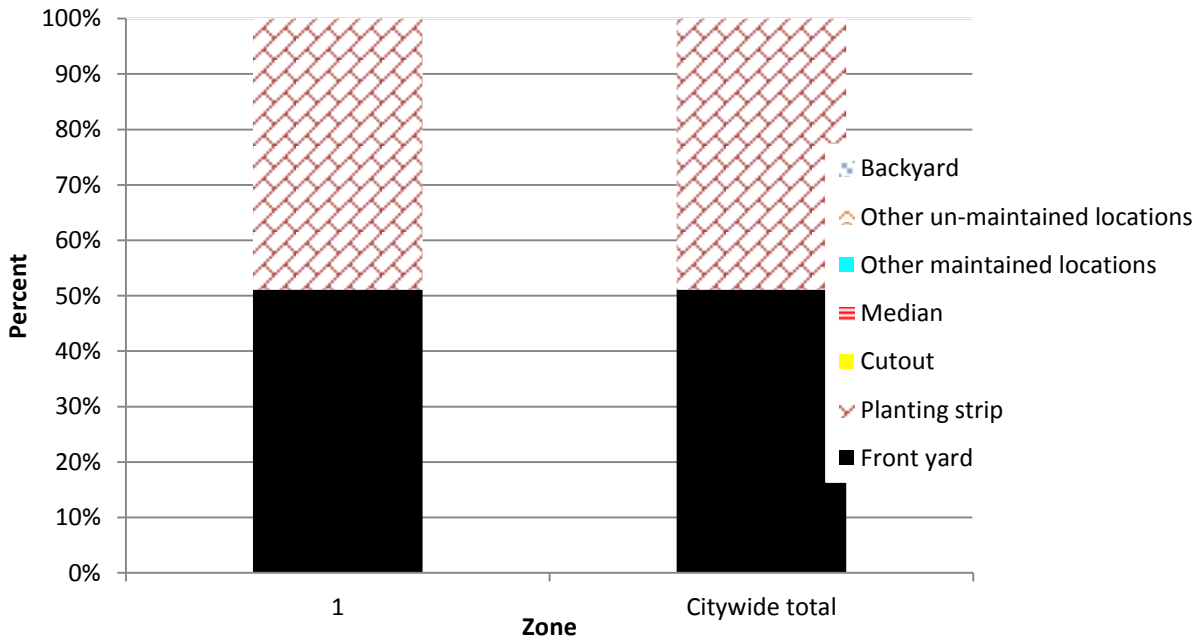
Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

Figure 1: Location of Ash Trees

Figure 2: Location of EAB symptoms
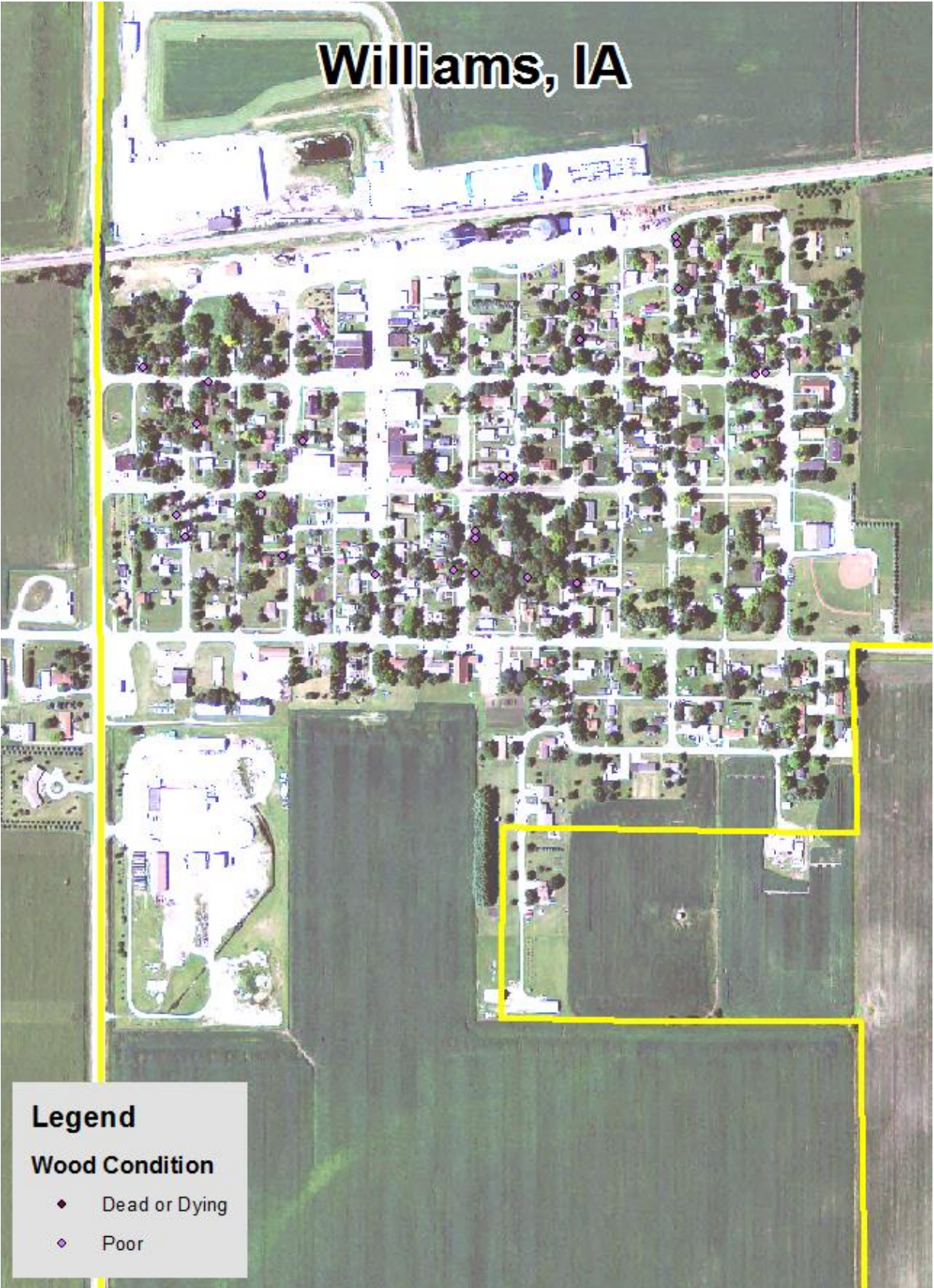
Figure 3: Location of Poor Condition Trees
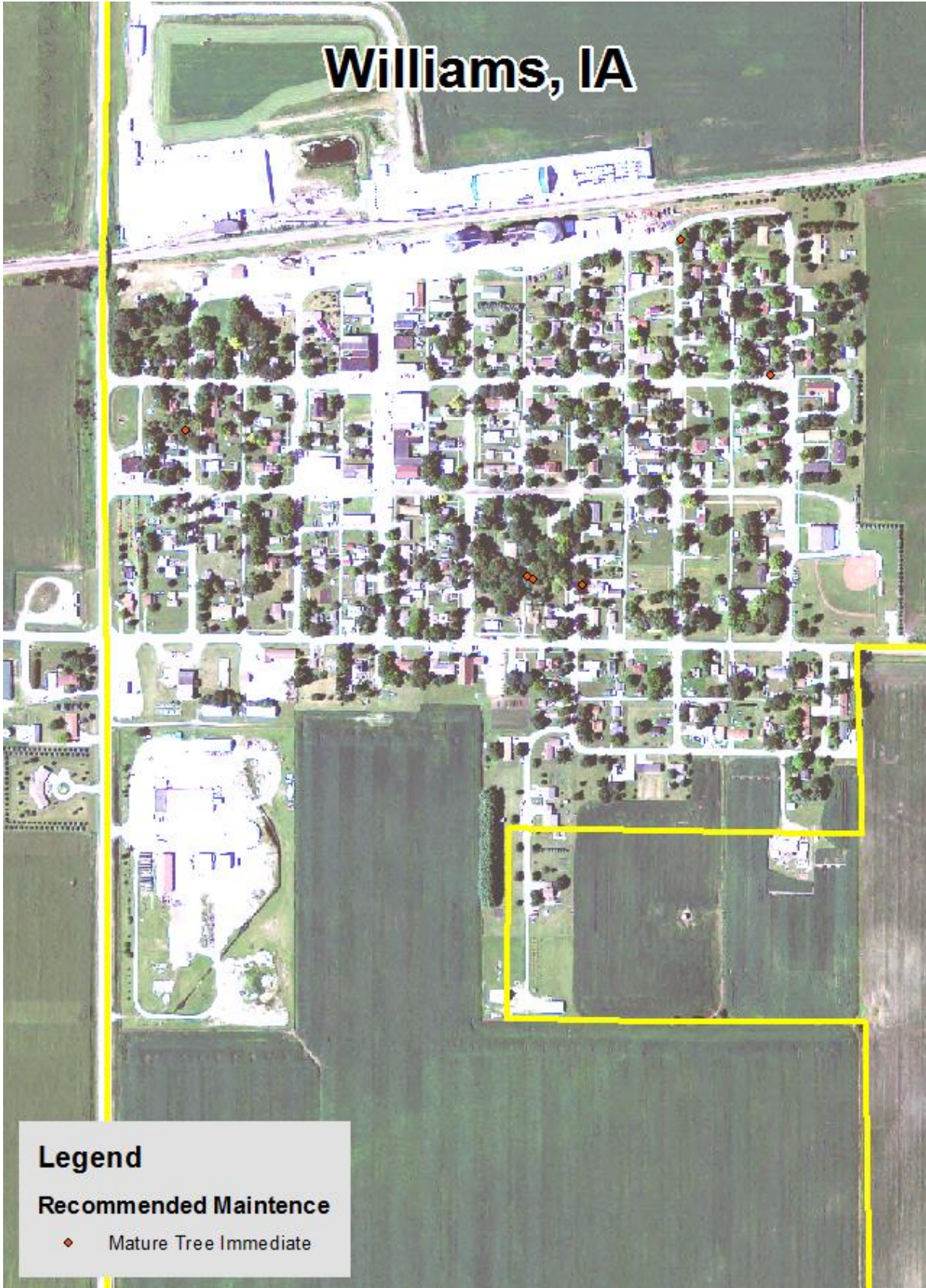
Figure 4: Location of Trees with Recommended Maintenance

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