Sabula, IA

2011 Management Plan
Prepared by Steven Swinconos
Bureau of Forestry, Iowa DNR

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Executive Summary_____

Overview

This plan was developed to assist the City of Sabula 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 19% of Sabula's city owned trees (ash) will die once EAB becomes established in the community. 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 2011, 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 164 trees inventoried.
- Sabula's trees provide $30,530 of benefits annually, an average of $186 a tree
- There are over 24 species of trees
- The top three genus are: Maple 36%, Ash 23%, and Siberian elm 7%
- 12% 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.
- Of the 3 trees needing removal, 1 trees are over 24 inches in diameter at 4.5 ft and must be addressed immediately *City ownership of the trees recommended for removal should be verified prior to any removal*
- 5 of the 30 ash trees are in need of follow up because they are displaying signs and symptoms associated with EAB
- 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 Sabula 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 tree canopy in Sabula, these costs can be extended over years and public safety issues from dead and dying ash trees mitigated.

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

Inventory

In 2011, 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 of 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 164 city trees was entered into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management (STRATUM), part of the i-Tree suite. The following are results from the i-Tree STRATUM analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Sabula's trees reduce energy related costs by approximately $9,146 annually (Appendix A, Table 1). These savings are both in Electricity (43.6 MWh) and in Natural Gas (5,953.4 Therms).

Annual Stormwater Benefits

Sabula's trees intercept about 493,304 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $13,369 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 Sabula, it is estimated that trees remove 575 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 $1,624 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Sabula, trees sequester about 104,033 lbs of carbon a year with an associated value of $780 (Appendix A, Table 4). In addition, the trees store 1,836,482 lbs of carbon, with a yearly benefit of $13,774 (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. Sabula receives $9,669 in annual social benefits from trees (Appendix A, Table 6).

Financial Summary of all Benefits

According to the USDA Forest Service i-Tree STRATUM analysis, Sabula's trees provide $3,548 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 164 trees in Sabula provide approximately $22 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Sabula has over 24 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genus is as follows:

Maple(Silver,Red,Norway,Amur,Sugar)	58	35%
Ash	30	18%
Willow	11	7%
Cottonwood	10	7%
Siberian Elm	10	7%
Red Oak	7	4%
Hackberry	5	3%
Walnut	5	3%
Sycamore	5	3%
Norway Spruce	3	2%
Butternut	3	2%
Honey locust	3	2%
Apple (Crab)	2	1%
Kentucky Coffee Tree	2	1%
Mulberry	2	1%
American Elm	2	1%
Birch	1	<1%
Concolor Fir	1	<1%
White Poplar	1	<1%
Plum	1	<1%

Size Class

Most of Sabula's trees (64%) are between 12 and 30 inches in diameter at 4.5 ft (Appendix A, Figure 2). For size, a Bell Curve is preferred and shows the highest amount of trees around 18 inches in diameter at 4.5 ft. Sabula's size curve is on the larger side, indicating a larger than average stand. Generally with trees size does not indicate age.

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 Sabula indicate that 98% 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, 69% of Sabula'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 10% of the population. This 11% 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	11	15%
Crown Raising	4	2%
Tree Removal	3	2%

Canopy Cover

The canopy cover of Sabula is approximately 5 acres (Appendix A, Figure 4). According to the 2000 census, Sabula occupies 128 acres. Thus the canopy cover on city land is about 4%.

Land Use and Location

The majority of Sabula'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.

<u>Land Use</u>
Single family residential	37%
Park/vacant/other	63%

<u>Location</u>
Planting strip	73%
Other maintained locations	24%
Other unmaintained locations	3%

Recommendations_____

Risk Management

Hazardous trees can be a significant threat to both people and property. Trees that are dead or dying, or that have large issues such as trunk cracks longer than 18 inches should be removed. Broken branches and branches that interfere with motorist's vision of pedestrians, vehicles, traffic signs and signals, etc should be removed.

<u>Hazardous trees</u>
Sabula has 2 critical concern trees that need immediate removal. There are 4 other critical concern trees that need attention. One is a smaller mulberry that can be cut anytime, and four are trees that need pruning or branch removal because they are hanging in the trees. 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 removals first as these are ash trees, the branch removal should also be done as soon as possible. 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 that do not include trimming.

<u>Poor tree species</u>
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 2 removals, 2 are ash trees. There are a total of 30 ash trees, and 5 of those have signs and symptoms that have been associated with EAB. In addition, there are 3 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 Sabula.

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 (45%) (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, Siberian elm, evergreen, willow or black walnut. All trees planted must meet the restrictions in city ordinance.

Continual Monitoring

Due to the threat of EAB, it is important to continuously check the health of ash trees. It is recommended that ash trees be checked with a visual survey every year for tree death 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 largest critical concern trees

        Visual Survey for signs and symptoms of EAB

Year 2

        Removal: 1 critical concern trees and 1 additional ash trees with poor health

        Routine trimming: Contract to trim 1/4 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

        Visual Survey for signs and symptoms of EAB

Year 4

        Removal: 2 trees - removal of any new critical concern trees and ash in poor health

        Routine trimming: Contract to trim 1/4 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

        previous removals

        Visual Survey for signs and symptoms of EAB

Year 6

        Removal: 2 trees - removal of any new critical concern trees and ash in poor health

        Routine trimming: Contract to trim ¼ of the city trees

        Visual Survey for signs and symptoms of EAB

*Reduction of ash over 6 years: Approximately 4 ash trees removed (approximately 13% of ash). EAB could potentially start killing ash within 6 years of its arrival. This should leave adequate time for a strategy, the tree removals will increase once it arrives, but if they are keep up the EAB population will be reduced decreasing their impact.

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*

EAB Quarantines

EAB is an extremely destructive plant pest and it is responsible for the death and decline of over 25 million 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 ash trees will be replaced. All trees will meet the restrictions in city ordinance. The new plantings will be a diverse mix and will not include ash, maple, cottonwood, poplar, box elder, Siberian elm, Chinese elm, evergreen, willow or black walnut.

Postponed Work

While finances, staffing and equipment are focused on the management of ash, usual services may be delayed. Tree removal requests on genus 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 $7,600 over 6 years ($1,270/year)

FY 2012 Budget
        Removal: $1,000
FY 2013 Budget
        Removal: $500
        Routine trimming: $700
FY 2014 Budget
        Removal: $1,000
FY 2015 Budget
        Removal: $1,000
        Routine trimming: $700
FY 2016 Budget
        Removal: $1,000
FY 2017 Budget
        Removal: $1,000
        Routine trimming: $700

*Reduction of ash over 6 years: Approximately 4 ash trees removed (approximately 13% of ash). EAB could potentially start killing ash within 6 years of its arrival. This should leave adequate time for a strategy, the tree removals will increase once it arrives, but if they are keep up the EAB population will be reduced decreasing there impact.

Purposed Budget Increase
EAB could potentially kill all ash trees in Sabula within 10-12 years of its arrival. To remove all ash trees within 10-12 years after the discovery of EAB the budget would need to be increased to $3,000 a year. If the budget were increased to $12,000 a year all ash could be removed within 1 year. Additionally, it is recommended that Sabula 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.

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Sabula, IA

Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Annual Energy Benefits of Public Trees by Species

9/26/2011

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	12.7	967	1,667.8	1,634	2,602	(N/A)	23.9	28.5	66.71
Ash	7.7	581	1,086.9	1,065	1,646	(N/A)	19.0	18.0	53.11
Willow	3.3	252	489.1	479	731	(N/A)	7.4	8.0	60.92
Eastern cottonwood	3.8	290	524.2	514	804	(N/A)	6.8	8.8	73.07
Siberian elm	3.9	296	511.8	502	798	(N/A)	6.8	8.7	72.51
Norway maple	1.7	129	226.6	222	351	(N/A)	4.3	3.8	50.18
Northern red oak	0.7	50	95.2	93	143	(N/A)	4.3	1.6	20.47
Sugar maple	1.7	126	224.3	220	346	(N/A)	3.7	3.8	57.68
Northern hackberry	1.4	108	201.5	197	305	(N/A)	3.1	3.3	61.07
Black walnut	0.8	57	95.2	93	150	(N/A)	3.1	1.6	30.07
American sycamore	1.7	129	239.2	234	363	(N/A)	3.1	4.0	72.64
Honeylocust	1.1	83	142.2	139	223	(N/A)	1.8	2.4	74.28
Eastern red cedar	0.3	21	40.8	40	61	(N/A)	1.8	0.7	20.20
Norway spruce	0.5	36	64.0	63	99	(N/A)	1.8	1.1	33.04
Kentucky coffeetree	0.6	43	73.8	72	115	(N/A)	1.2	1.3	57.57
Apple	0.0	2	4.4	4	6	(N/A)	1.2	0.1	3.13
Mulberry	0.3	21	44.5	44	64	(N/A)	1.2	0.7	32.17
American elm	0.3	25	39.2	38	64	(N/A)	1.2	0.7	31.77
Other street trees	1.3	95	182.7	179	274	(N/A)	4.3	3.0	39.20
Citywide total	43.6	3,312	5,953.4	5,834	9,146	(N/A)	100.0	100.0	56.11

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees by Species

9/26/2011

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	171,460	4,647	(N/A)	23.9	34.8	119.15
Ash	65,827	1,784	(N/A)	19.0	13.3	57.55
Willow	34,496	935	(N/A)	7.4	7.0	77.91
Eastern cottonwood	47,874	1,297	(N/A)	6.8	9.7	117.95
Siberian elm	43,778	1,186	(N/A)	6.8	8.9	107.86
Norway maple	12,003	325	(N/A)	4.3	2.4	46.47
Northern red oak	5,118	139	(N/A)	4.3	1.0	19.82
Sugar maple	18,630	505	(N/A)	3.7	3.8	84.15
Northern hackberry	14,707	399	(N/A)	3.1	3.0	79.72
Black walnut	4,754	129	(N/A)	3.1	1.0	25.77
American sycamore	21,456	582	(N/A)	3.1	4.4	116.30
Honeylocust	14,053	381	(N/A)	1.8	2.9	126.96
Eastern red cedar	3,928	106	(N/A)	1.8	0.8	35.49
Norway spruce	10,542	286	(N/A)	1.8	2.1	95.24
Kentucky coffeetree	5,408	147	(N/A)	1.2	1.1	73.29
Apple	76	2	(N/A)	1.2	0.0	1.03
Mulberry	1,438	39	(N/A)	1.2	0.3	19.49
American elm	1,823	49	(N/A)	1.2	0.4	24.70
Other street trees	15,931	432	(N/A)	4.3	3.2	61.68
Citywide total	493,304	13,369	(N/A)	100.0	100.0	82.02

Table 3: Annual Air Quality Benefits

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								
Silver maple	28.2	4.8	14.0	1.2	152	60.0	8.8	8.4	57.7	376	-15.0	-56	168.1	472	(N/A)	23.9	12.10
Ash	12.8	2.2	6.4	0.6	69	37.0	5.4	5.1	34.7	229	-3.1	-11	101.1	287	(N/A)	19.0	9.27
Willow	7.4	1.3	3.6	0.3	40	16.2	2.3	2.2	15.0	100	-1.7	-6	46.7	134	(N/A)	7.4	11.13
Eastern cottonwood	7.4	1.2	3.4	0.3	39	18.3	2.7	2.5	17.3	114	0.0	0	53.0	153	(N/A)	6.7	13.87
Siberian elm	8.0	1.4	3.8	0.4	43	18.4	2.7	2.6	17.7	115	0.0	0	54.9	158	(N/A)	6.7	14.36
Norway maple	2.1	0.4	1.1	0.1	11	8.1	1.2	1.1	7.7	51	-0.5	-2	21.2	60	(N/A)	4.3	8.56
Northern red oak	0.9	0.2	0.5	0.0	5	3.2	0.5	0.4	3.0	20	-1.3	-5	7.3	20	(N/A)	4.3	2.82
Sugar maple	2.5	0.4	1.2	0.1	13	7.9	1.2	1.1	7.5	49	-1.9	-7	20.0	55	(N/A)	3.7	9.23
Northern hackberry	2.9	0.5	1.4	0.1	16	6.9	1.0	0.9	6.4	43	0.0	0	20.2	58	(N/A)	3.1	11.62
Black walnut	0.3	0.0	0.2	0.0	2	3.5	0.5	0.5	3.4	22	0.0	0	8.5	24	(N/A)	3.1	4.76
American sycamore	2.8	0.5	1.3	0.1	15	8.2	1.2	1.1	7.7	51	0.0	0	22.9	66	(N/A)	3.1	13.14
Honeylocust	2.8	0.5	1.3	0.1	15	5.2	0.8	0.7	5.0	32	-2.3	-9	14.0	39	(N/A)	1.8	12.87
Eastern red cedar	0.7	0.1	0.6	0.1	5	1.3	0.2	0.2	1.2	8	-2.2	-8	2.4	5	(N/A)	1.8	1.66
Norway spruce	1.3	0.2	1.0	0.2	8	2.3	0.3	0.3	2.2	14	-5.6	-21	2.1	1	(N/A)	1.8	0.44
Kentucky coffeetree	0.6	0.1	0.3	0.0	3	2.7	0.4	0.4	2.6	17	0.0	0	7.0	20	(N/A)	1.2	9.95
Apple	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)	1.2	0.41
Mulberry	0.5	0.1	0.2	0.0	3	1.4	0.2	0.2	1.2	8	0.0	0	3.8	11	(N/A)	1.2	5.45
American elm	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)	1.2	5.11
Other street trees	3.0	0.5	1.4	0.1	16	6.1	0.9	0.8	5.7	38	-0.6	-2	18.0	52	(N/A)	4.3	7.36
Citywide total	84.2	14.3	41.8	3.9	456	208.1	30.3	28.9	197.7	1,297	-34.2	-128	575.0	1,624	(N/A)	100.0	9.96

Table 4: Annual Carbon Stored

Species	Total Stored CO_2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	634,933	4,762	(N/A)	23.9	34.6	122.10
Ash	209,912	1,574	(N/A)	19.0	11.4	50.79
Willow	122,187	916	(N/A)	7.4	6.7	76.37
Eastern	247,529	1,856	(N/A)	6.8	13.5	168.77
Siberian elm	195,388	1,465	(N/A)	6.8	10.6	133.22
Norway maple	34,011	255	(N/A)	4.3	1.9	36.44
Northern red oak	18,873	142	(N/A)	4.3	1.0	20.22
Sugar maple	70,371	528	(N/A)	3.7	3.8	87.96
Northern	47,076	353	(N/A)	3.1	2.6	70.61
Black walnut	10,447	78	(N/A)	3.1	0.6	15.67
American	91,890	689	(N/A)	3.1	5.0	137.83
Honeylocust	36,735	276	(N/A)	1.8	2.0	91.84
Eastern red cedar	2,481	19	(N/A)	1.8	0.1	6.20
Norway spruce	14,176	106	(N/A)	1.8	0.8	35.44
Kentucky	19,445	146	(N/A)	1.2	1.1	72.92
Apple	192	1	(N/A)	1.2	0.0	0.72
Mulberry	7,651	57	(N/A)	1.2	0.4	28.69
American elm	3,945	30	(N/A)	1.2	0.2	14.79
Other street trees	31,408	519	(N/A)	4.3	3.8	74.19
Citywide total	1,836,482	13,774	(N/A)	100.0	100.0	84.50

Table 5: Annual Carbon Sequestered

Annual CO$_2$ Benefits of Public Trees by Species

9/26/2011

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
Silver maple	49,535	372	-3,048	-8	-23	21,377	160	67,856	509	(N/A)	23.9	40.3	13.05
Ash	11,666	87	-1,008	-6	-8	12,846	96	23,499	176	(N/A)	19.0	14.0	5.69
Willow	3,970	30	-586	-2	-4	5,562	42	8,943	67	(N/A)	7.4	5.3	5.59
Eastern cottonwood	8,069	61	-1,188	-2	-9	6,411	48	13,289	100	(N/A)	6.8	7.9	9.06
Siberian elm	7,348	55	-938	-2	-7	6,543	49	12,951	97	(N/A)	6.8	7.7	8.83
Norway maple	2,870	22	-163	-1	-1	2,855	21	5,560	42	(N/A)	4.3	3.3	5.96
Northern red oak	977	7	-91	-1	-1	1,106	8	1,991	15	(N/A)	4.3	1.2	2.13
Sugar maple	3,735	28	-338	-1	-3	2,790	21	6,186	46	(N/A)	3.7	3.7	7.73
Northern hackberry	1,819	14	-226	-1	-2	2,385	18	3,976	30	(N/A)	3.1	2.4	5.96
Black walnut	1,517	11	-50	-1	0	1,262	9	2,728	20	(N/A)	3.1	1.6	4.09
American sycamore	4,293	32	-441	-1	-3	2,846	21	6,697	50	(N/A)	3.1	4.0	10.04
Honeylocust	4,457	33	-176	-1	-1	1,844	14	6,125	46	(N/A)	1.8	3.6	15.31
Eastern red cedar	126	1	-12	-1	0	456	3	569	4	(N/A)	1.8	0.3	1.42
Norway spruce	375	3	-68	-1	-1	804	6	1,110	8	(N/A)	1.8	0.7	2.77
Kentucky coffeetree	1,302	10	-93	0	-1	945	7	2,154	16	(N/A)	1.2	1.3	8.08
Apple	47	0	-1	0	0	43	0	88	1	(N/A)	1.2	0.1	0.33
Mulberry	114	1	-37	0	0	459	3	536	4	(N/A)	1.2	0.3	2.01
American elm	332	2	-19	0	0	555	4	868	7	(N/A)	1.2	0.5	3.25
Other street trees	1,482	11	-332	-1	-3	2,108	16	3,256	24	(N/A)	4.3	1.9	3.49
Citywide total	104,033	780	-8,815	-32	-66	73,195	549	168,381	1,263	(N/A)	100.0	100.0	7.75

Table 6: Annual Social and Aesthetic Benefits

Annual Aesthetic/Other Benefits of Public Trees by Species

9/26/2011

| Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	3,958	(N/A)	23.9	40.9	101.48
Ash	1,120	(N/A)	19.0	11.6	36.14
Willow	363	(N/A)	7.4	3.8	30.29
Eastern cottonwood	614	(N/A)	6.8	6.4	55.81
Siberian elm	499	(N/A)	6.8	5.2	45.35
Norway maple	282	(N/A)	4.3	2.9	40.27
Northern red oak	94	(N/A)	4.3	1.0	13.46
Sugar maple	387	(N/A)	3.7	4.0	64.53
Northern hackberry	241	(N/A)	3.1	2.5	48.28
Black walnut	177	(N/A)	3.1	1.8	35.48
American sycamore	322	(N/A)	3.1	3.3	64.41
Honeylocust	1,167	(N/A)	1.8	12.1	388.90
Eastern red cedar	49	(N/A)	1.8	0.5	16.24
Norway spruce	94	(N/A)	1.8	1.0	31.39
Kentucky coffeetree	111	(N/A)	1.2	1.2	55.72
Apple	2	(N/A)	1.2	0.0	1.05
Mulberry	6	(N/A)	1.2	0.1	3.20
American elm	57	(N/A)	1.2	0.6	28.34
Other street trees	125	(N/A)	4.3	1.3	17.80
Citywide total	9,669	(N/A)	100.0	100.0	59.32

Table 7: Summary of Benefits in Dollars

Annual Benefits of Public Trees by Species ($/tree)

9/26/2011

| Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($) Standard
Silver maple	66.71	13.05	12.10	119.15	101.48	312.49 (N/A)
Ash	53.11	5.69	9.27	57.55	36.14	161.75 (N/A)
Willow	60.92	5.59	11.13	77.91	30.29	185.83 (N/A)
Eastern cottonwood	73.07	9.06	13.87	117.95	55.81	269.77 (N/A)
Siberian elm	72.51	8.83	14.36	107.86	45.35	248.91 (N/A)
Norway maple	50.18	5.96	8.56	46.47	40.27	151.44 (N/A)
Northern red oak	20.47	2.13	2.82	19.82	13.46	58.70 (N/A)
Sugar maple	57.68	7.73	9.23	84.15	64.53	223.33 (N/A)
Northern hackberry	61.07	5.96	11.62	79.72	48.28	206.64 (N/A)
Black walnut	30.07	4.09	4.76	25.77	35.48	100.18 (N/A)
American sycamore	72.64	10.04	13.14	116.30	64.41	276.54 (N/A)
Honeylocust	74.28	15.31	12.87	126.96	388.90	618.32 (N/A)
Eastern red cedar	20.20	1.42	1.66	35.49	16.24	75.01 (N/A)
Norway spruce	33.04	2.77	0.44	95.24	31.39	162.88 (N/A)
Kentucky coffeetree	57.57	8.08	9.95	73.29	55.72	204.60 (N/A)
Apple	3.13	0.33	0.41	1.03	1.05	5.95 (N/A)
Mulberry	32.17	2.01	5.45	19.49	3.20	62.32 (N/A)
American elm	31.77	3.25	5.11	24.70	28.34	93.18 (N/A)
Other street trees	39.20	3.49	7.36	61.68	17.80	129.53 (N/A)

Species Distribution of Public Trees (%)

9/26/2011
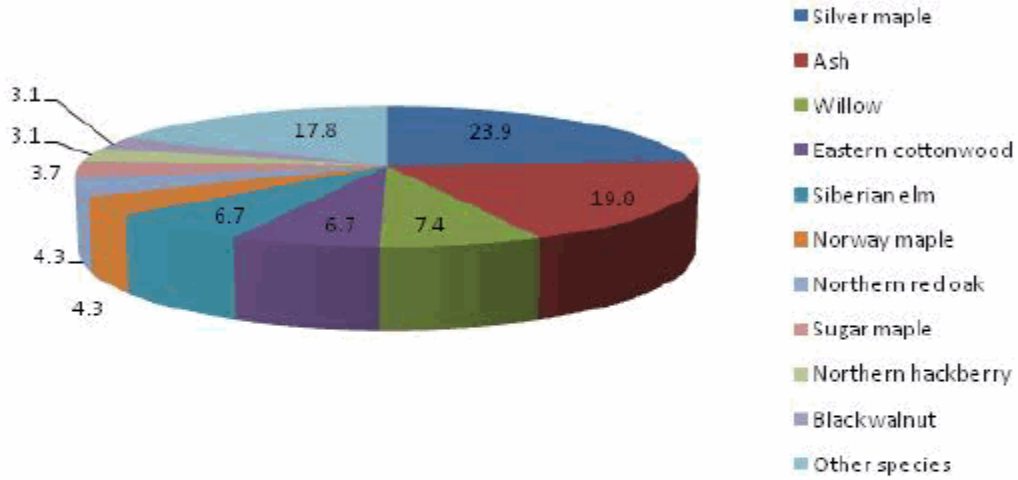
Species	Percent
Silver maple	23.9
Ash	19.0
Willow	7.4
Eastern cottonwood	6.7
Siberian elm	6.7
Norway maple	4.3
Northern red oak	4.3
Sugar maple	3.7
Northern hackberry	3.1
Black walnut	3.1
Other species	17.8
Total	100.0

Figure 1: Species Distribution

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

9/26/2011
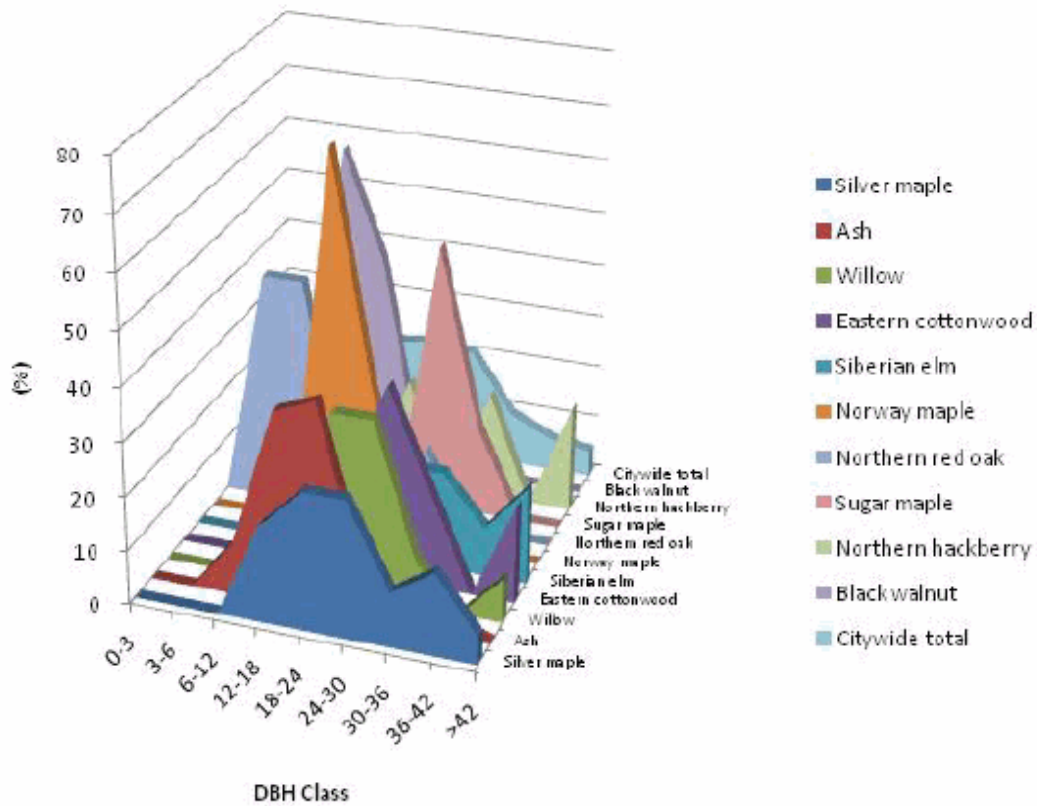
	DBH class (in)								
Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Silver maple	0.0	0.0	0.0	17.9	25.6	25.6	10.3	15.4	5.1
Ash	0.0	0.0	9.7	35.5	38.7	9.7	3.2	3.2	0.0
Willow	0.0	0.0	8.3	8.3	33.3	33.3	8.3	0.0	8.3
Eastern cottonwood	0.0	0.0	0.0	9.1	18.2	36.4	18.2	0.0	18.2
Siberian elm	0.0	0.0	0.0	18.2	18.2	18.2	18.2	9.1	18.2
Norway maple	0.0	0.0	0.0	71.4	28.6	0.0	0.0	0.0	0.0
Northern red oak	0.0	42.9	42.9	0.0	0.0	14.3	0.0	0.0	0.0
Sugar maple	0.0	0.0	16.7	16.7	0.0	50.0	16.7	0.0	0.0
Northern hackberry	0.0	20.0	20.0	0.0	20.0	0.0	20.0	0.0	20.0
Black walnut	0.0	0.0	60.0	40.0	0.0	0.0	0.0	0.0	0.0
Citywide total	1.2	3.7	10.4	20.9	22.1	20.9	9.8	6.1	4.9

Figure 2: Relative Age Class

Functional (Foliage) Condition of Public Trees by Species (%)

Citywide total

Fair

Dead or Dying
1%

Good
98%

- Dead or Dying
- Poor
- Fair
- Good
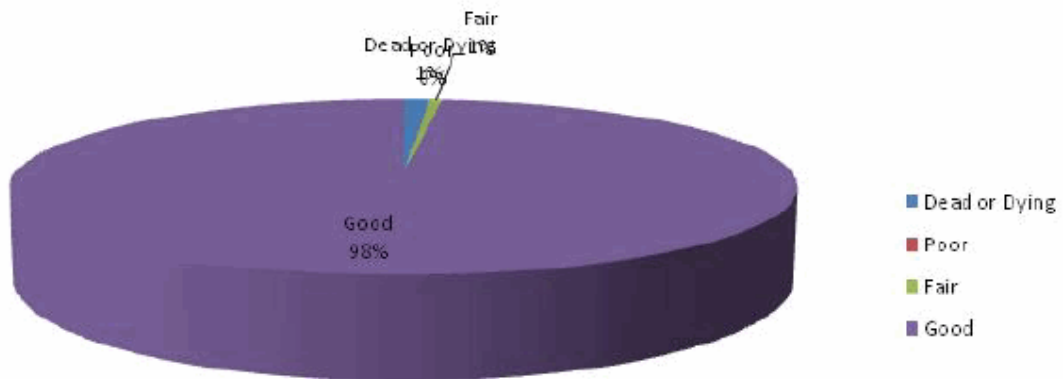
Figure 3: Foliage Condition

Structural (Woody) Condition of Public Trees by Species (%)

Citywide total

Dead or Dying
1%

Poor
9%

Fair
21%

Good
69%

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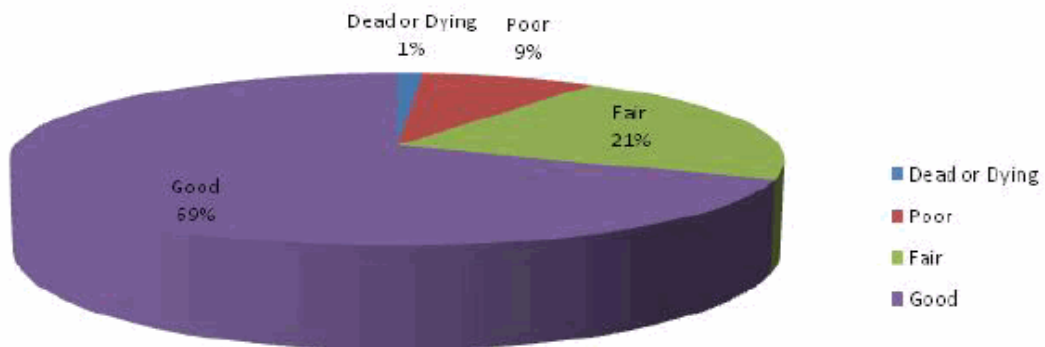
Figure 4: Wood Condition

Canopy Cover of Public Trees (Acres)

9/26/2011
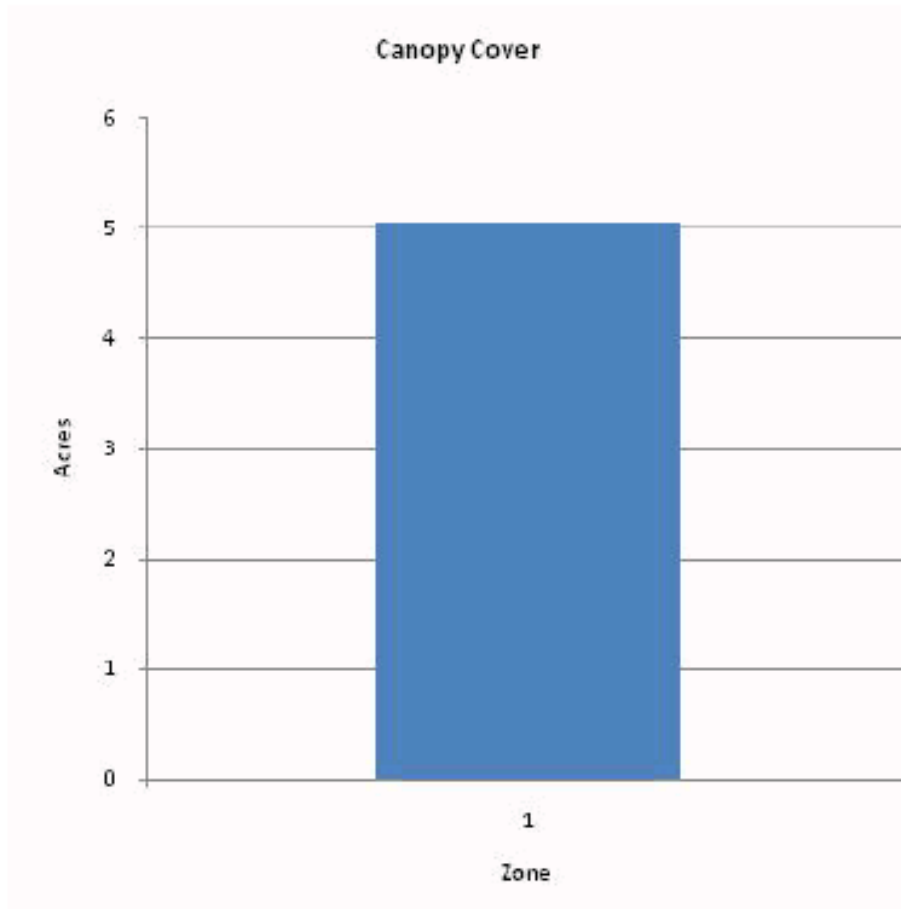
Zone	Acres	% of Total Canopy Cover
1	5	100.0
Citywide total	5	100.0

	Total Land Area	Total Street and Sidewalk Area	Total Canopy Cover	Canopy Cover as % of Total Land Area	Canopy Cover as % of Total Streets and Sidewalks
Citywide	0	0	5		

Figure 5: Canopy Cover in Acres

Land Use of Public Trees by Zone (%)

9/26/2011

Zone	Single family residential	Multi-family residential	Industrial/ Large commercial	Park/vacant/ other	Small commercial
1	37.2	0.0	0.0	62.8	0.0
Citywide total	37.2	0.0	0.0	62.8	0.0
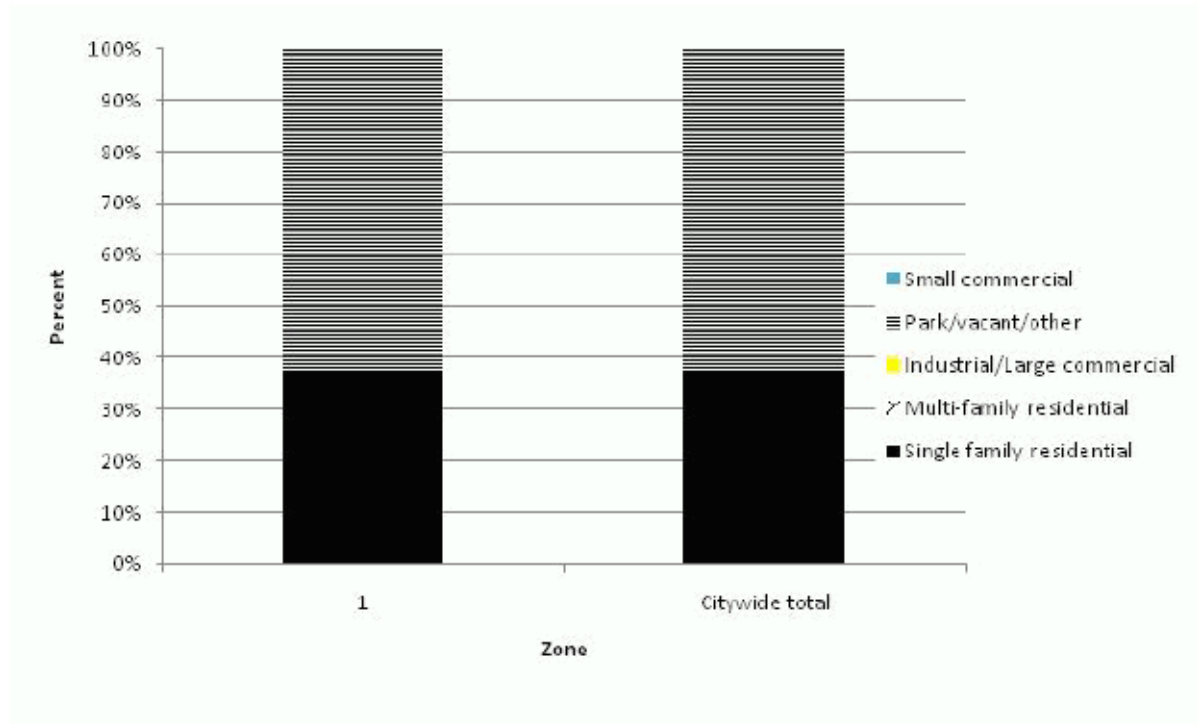
Figure 6: Land Use of city/park trees

Location of Public Trees by Zone (%)

9/26/2011
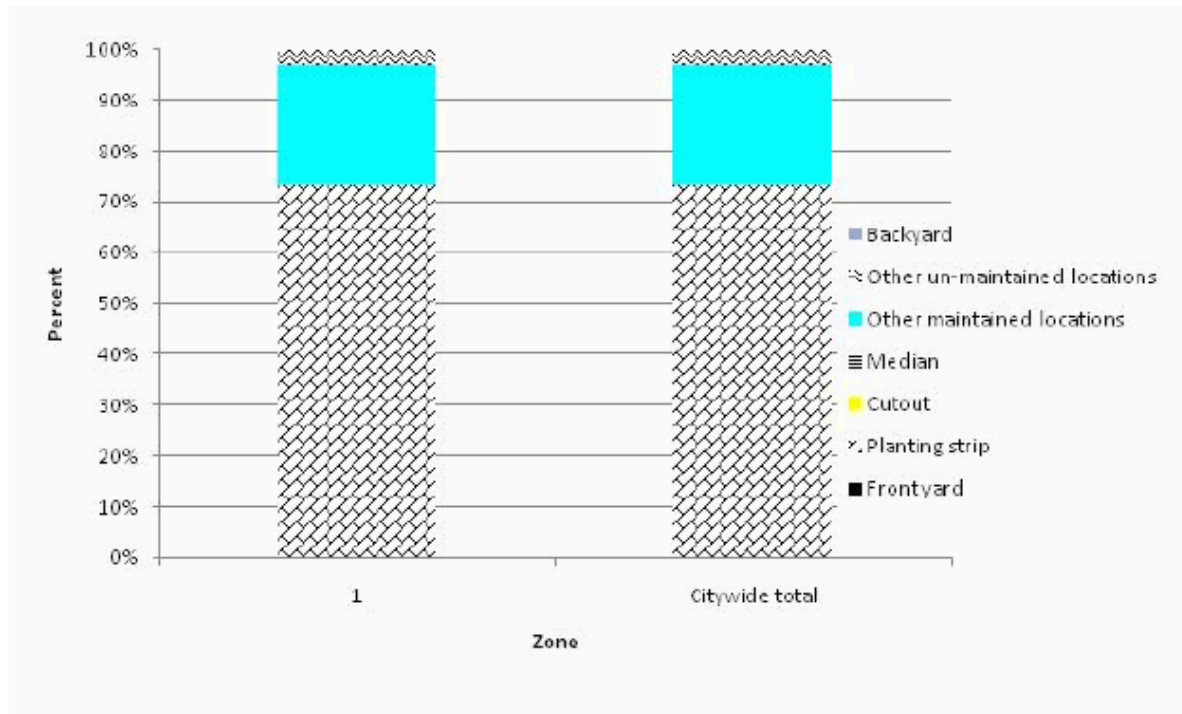
Zone	Front yard	Planting strip	Cutout	Median	Other maintained locations	Other un-maintained locations	Backyard
1	0.0	73.2	0.0	0.0	23.8	3.0	0.0
Citywide total	0.0	73.2	0.0	0.0	23.8	3.0	0.0

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*