Crystal Lake, IA

2019 Urban Forest Management Plan
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Executive Summary

Overview

This plan was developed to assist the City of Crystal Lake 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 10.6% of Crystal Lake's city owned trees (ash) will die once EAB becomes established in the community, unless preventative treatment is used. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

Inventory and Results

In 2018, a tree inventory was conducted using Global Positioning System (GPS) data collectors. The inventory was a complete inventory of street and park trees. Below are some key findings of the 160 trees inventoried.

- Crystal Lake's trees provide $30,753 of benefits annually, an average of $192 a tree
- There are over 19 species of trees
- The top three genera are: Maple 58.7%, Ash 10.6%, and Eastern Cottonwood 8.1%
- 26% 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.

- Of the 6 trees needing removal, 4 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*
- 1 of the 17 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 ($2 per capita = $472) it could take 25 years to remove ash – Suggestion: request a budget increase to $3,992 annually and apply for grants to plant replacement trees
- Create a community tree ordinance

Introduction

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

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

Inventory

In 2018, a tree inventory was conducted that included 100% of the city owned trees on both streets and parks. The tree data was collected using a handheld Global Positioning System (GPS) receiver. The data collector gives Geographic Information Systems (GIS) coordinates with an accuracy of 3 meters, which can be used in Arc GIS as an active GIS data layer. Because the inventory is a digital document the data can be updated with new information and become a working document.

The programming used to collect tree information on the data collectors was written to be compatible with a state-of-the-art software suite called i-Tree. i-Tree was developed by the USDA Forest Service to quantify the structure of community trees and the environmental services that trees provide. The i-Tree suite is a public domain which can be accessed for free.

To quantify the urban forest structure and benefits, specific data is collected for each tree. This data includes: location, land use, species, diameter at 4.5 ft, recommended maintenance, priority of that maintenance, leaf health, and wood condition. Additionally, signs and symptoms associated with EAB were noted for all ash trees. The signs and symptoms noted were canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

Inventory Results

The data collected for the 160 city trees was entered into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management as part of the i-Tree suite. The following are results from the i-Tree STREETS analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Crystal Lake's trees reduce energy related costs by approximately $8,705 annually (Appendix A, Table 1). These savings are both in Electricity (41.2 MWh) and in Natural Gas (5,693.4 Therms).

Annual Stormwater Benefits

Crystal Lake's trees intercept about 430,958 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $11,679 of benefits to the city.

Annual Air Quality Benefits

Air quality is a persistent public health issue in Iowa. The urban forest improves air quality by removing pollutants, lowering air temperature, and reducing energy consumption, which in turn reduces emissions from power plants, and emitting volatile organic matter (ozone). In Crystal Lake, it is estimated that trees remove 538.9 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 $1,524 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Crystal Lake, trees sequester about 87,042 lbs of carbon a year with an associated value of $653 (Appendix A, Table 5). In addition, the trees store 1,614,053 lbs of carbon, with a yearly benefit of $12,105 (Appendix A, Table 4).

Annual Aesthetics Benefits

Social benefits of trees are hard to capture. The analysis does have a calculation for this area that includes: aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Crystal Lake receives $7,737 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, Crystal Lake's trees provide $30,753 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 160 trees in Crystal Lake provide approximately $192 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Crystal Lake has over 19 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Maple	94	58.8
Ash	17	10.6
Cottonwood	13	8.1
Spruce	11	6.9
Linden/Basswood	7	4.4
Elm	5	3.1
Walnut	3	1.9
Cedar	3	1.9
Locust	2	1.3
Apple (Crab)	1	0.6
Pine	1	0.6
Catalpa	1	0.6
Oak	1	0.6
Other Large Deciduous	1	0.6

Age Class

Most of Crystal Lake's trees (40%) are between 6 and 18 inches in diameter at 4.5 ft (Appendix A, Figure 2). For age, it is preferred that the highest amounts of trees are in the smallest size category (a downward slope) to prepare for natural mortality and to maintain canopy cover. Crystal Lake's size curve is on the smaller side, indicating a younger 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 Crystal Lake indicate that 90% of the trees are in good health, with only 3% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 89% of Crystal Lake's trees are in good health for wood condition (appendix A, Figure 4 & Appendix B, Figure 3). Wood condition that is in poor health, dead or dying is about 4% of the population. This 4% is an estimate of trees that need management follow up.

Management Needs

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	34	21%
Tree Removal	6	3%
Crown Reduction	3	1%

Canopy Cover
The total canopy with both private and public trees is 29%, 46.7 acres. The canopy cover included in the Crystal Lake inventory includes approximately 4.5 acres (Appendix A, Figure 4). The City's Canopy goal is to increase canopy by 3%, in 30 years. To achieve this goal it is estimated that 12 trees need to be planted annually on public and private lands.

Land Use and Location
The majority of Crystal Lake'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	70%
Park/vacant/other	30%

Location	
Front yard	91%
Planting strip	8%

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
There are 5 trees over 12 inches in diameter at 4.5 ft that should be addressed immediately. Please refer to the six year maintenance plan at the end of this section. After all of the critical concern trees are addressed, there should be follow up on the trees marked as needing maintenance. There are a total of 38 trees with these needs.

Poor tree species
After the removal of the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). There are a total of 17 ash trees, and 1 of those have signs and symptoms that have been associated with EAB. In addition, there are 2 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 Crystal Lake.

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 (58%) (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.

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.

Postponed Work
While finances, staffing and equipment are focused on the management of ash, usual services may be delayed. Tree removal requests on genera other than ash will be prioritized by hazardous or emergency situations only.

Monitoring
It is recommended that ash trees be checked with a visual survey every year for tree death and for the following signs and symptoms: canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

Private Ash Trees
It is strongly recommended that private property owners start removing ash trees on their property upon arrival of EAB if preventative treatments are not being used.

PROPOSED WORK SCHEDULE AND ESTIMATED COSTS

YEAR 1	**ESTIMATED COSTS**
Remove 4 recommended trees	$2,800
Trim 1 immediate need tree	$100
Plant 4 trees in open locations	$400
Water & Maintenance	$200
Inspect ash trees for signs of Emerald Ash Borer	

YEAR 2	
Remove 4 ash trees	$2,800
Plant 5 trees in open locations	$500
Water & Maintenance	$250
Prune 1/3 of city owned trees	$1,600
Inspect ash trees for signs of Emerald Ash Borer	

YEAR 3	
Remove 3 ash trees	$2,100
Plant 5 trees in open locations	$500
Water & Maintenance	$250
Inspect ash trees for signs of EAB	

YEAR 4	
Remove 3 ash trees	$2,100
Plant 5 trees in open locations	$500
Water & Maintenance	$250
Prune 1/3 of city owned trees	$1,600
Inspect ash trees for signs of EAB	

YEAR 5	
Remove 4 ash trees	$2,800
Plant 5 trees in open locations	$500
Water & Maintenance	$250
Inspect ash trees for signs of EAB	

YEAR 6	
Remove 3 ash trees	$2,100
Plant 5 trees in open locations	$500
Water & Maintenance	$250

Prune 1/3 of city owned trees $1,600

Estimated costs based on average costs of $700/tree for removal, $100/tree for planting, $50/tree for water and maintenance, and $30/tree for pruning.

Purposed Budget Increase

EAB could potentially kill all ash trees in Crystal Lake within 4 years of its arrival. To remove all ash trees within 6 years, plus planting, watering and maintenance and a routine cycle of trimming the budget would need to be increased to $3,992 a year. Additionally, it is recommended that Crystal Lake 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 $17 per inch, about 4 trees could be treated per year (every other year treatment). This would be 8 trees selected for treatment, and Crystal Lake would still need to find $6,300 for removal. Alternatively, if there are 15 treatable trees, it would cost approximately $2,550 a year for treatment and leave $1,400 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 Crystal Lake. It is suggested to consider increasing the budget to plan for this.

Works Cited

Census Bureau. 2010. http://censtats.census.gov/data/IA/1601964290.pdf (April, 2013)

USDA Forest Service, et al. 2006. i-Tree Software Suite v1.0 User's Manual. Pp. 27-40.

McPherson EG, Simpson JR, Peper PJ, Gardner SL, Vargas KE, Ho J, Maco S, Xiao Q. 2005b. City of Charleston, South Carolina, municipal forest resource analysis. Internal Tech Rep. Davis, CA: U.S. Department of Agriculture, Center for Urban Forest Research. p. 57

Nowak, DJ and JF Dwyer. 2007. Understanding the benefits and costs of urban forest ecosystems. In: Kuser, J. (ed.) Urban and Community Forestry in the Northeast. New York: Springer. Pp. 25-46.

Peper, Paula J; McPherson, E Gregory; Simpson, James R; Vargas, Kelaine E; Xiao, Qingfu 2009. Lower Midwest community tree guide: benefits, costs, and strategic planting. Gen. Tech. Rep. PSW-GTR-219. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. p.115

Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Crystal Lake

Annual Energy Benefits of Public Trees

1/14/2019

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	19.6	1,487	2,790.8	2,735	4,222	(N/A)	47.5	48.5	55.56
Green ash	4.2	321	593.0	581	902	(N/A)	10.6	10.4	53.09
Silver maple	4.9	371	629.8	617	989	(N/A)	8.1	11.4	76.04
Eastern cottonwood	4.3	328	600.9	589	917	(N/A)	8.1	10.5	70.53
Blue spruce	1.0	72	126.9	124	197	(N/A)	6.3	2.3	19.66
American basswood	1.5	115	209.5	205	320	(N/A)	4.4	3.7	45.78
American elm	1.6	120	181.3	178	298	(N/A)	3.1	3.4	59.59
Sugar maple	1.0	79	134.8	132	211	(N/A)	2.5	2.4	52.85
Eastern red cedar	0.1	9	18.3	18	27	(N/A)	1.9	0.3	8.85
Black walnut	1.0	74	138.6	136	210	(N/A)	1.9	2.4	70.08
Northern red oak	0.3	20	36.4	36	55	(N/A)	0.6	0.6	55.22
Spruce	0.1	10	14.6	14	24	(N/A)	0.6	0.3	24.14
Eastern white pine	0.2	14	24.6	24	38	(N/A)	0.6	0.4	38.17
Honeylocust	0.3	23	42.3	41	65	(N/A)	0.6	0.7	64.79
Amur maple	0.2	14	24.7	24	38	(N/A)	0.6	0.4	38.13
Broadleaf Deciduous Large	0.3	20	38.1	37	57	(N/A)	0.6	0.7	57.32
Apple	0.1	6	12.8	13	18	(N/A)	0.6	0.2	18.19
Black locust	0.1	8	16.9	17	24	(N/A)	0.6	0.3	24.47
Northern catalpa	0.4	33	59.0	58	91	(N/A)	0.6	1.0	91.02
Total	41.2	3,125	5,693.4	5,580	8,705	(N/A)	100.0	100.0	54.40

Table 2: Annual Stormwater Benefits

Crystal Lake

Annual Stormwater Benefits of Public Trees

1/14/2019

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	176,620	4,786	(N/A)	47.5	41.0	62.98
Green ash	43,716	1,185	(N/A)	10.6	10.1	69.69
Silver maple	77,060	2,088	(N/A)	8.1	17.9	160.64
Eastern cottonwood	54,411	1,475	(N/A)	8.1	12.6	113.43
Blue spruce	11,499	312	(N/A)	6.3	2.7	31.16
American basswood	11,590	314	(N/A)	4.4	2.7	44.87
American elm	10,114	274	(N/A)	3.1	2.3	54.82
Sugar maple	8,997	244	(N/A)	2.5	2.1	60.95
Eastern red cedar	1,502	41	(N/A)	1.9	0.3	13.57
Black walnut	12,024	326	(N/A)	1.9	2.8	108.62
Northern red oak	3,030	82	(N/A)	0.6	0.7	82.12
Spruce	1,539	42	(N/A)	0.6	0.4	41.70
Eastern white pine	4,605	125	(N/A)	0.6	1.1	124.79
Honeylocust	2,905	79	(N/A)	0.6	0.7	78.73
Amur maple	667	18	(N/A)	0.6	0.2	18.06
Broadleaf Deciduous Large	2,591	70	(N/A)	0.6	0.6	70.21
Apple	264	7	(N/A)	0.6	0.1	7.17
Black locust	586	16	(N/A)	0.6	0.1	15.88
Northern catalpa	7,239	196	(N/A)	0.6	1.7	196.17
Citywide total	430,958	11,679	(N/A)	100.0	100.0	72.99

Table 3: Annual Air Quality Benefits

Crystal Lake

Annual Air Quality Benefits of Public Trees

1/14/2019

Species	Deposition (lb)				Total Depos. ($)	Avoided (lb)				Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total Standard ($) Error	% of Total Trees	Avg. $/tree
	O_3	NO_2	PM_{10}	SO_2		NO_2	PM_{10}	VOC	SO_2							
Norway maple	35.4	6.1	17.5	1.6	192	94.7	13.7	13.1	88.9	587	-8.4	-31	262.6	748 (N/A)	47.5	9.84
Green ash	4.9	0.8	2.4	0.2	26	20.3	3.0	2.8	19.2	126	0.0	0	53.6	153 (N/A)	10.6	8.98
Silver maple	14.8	2.5	7.1	0.7	79	22.9	3.4	3.2	22.1	144	-7.8	-29	68.9	194 (N/A)	8.1	14.90
Eastern cottonwood	7.3	1.2	3.4	0.3	38	20.7	3.0	2.9	19.6	129	0.0	0	58.3	167 (N/A)	8.1	12.87
Blue spruce	1.3	0.3	1.2	0.2	9	4.5	0.7	0.6	4.3	28	-3.9	-15	9.0	22 (N/A)	6.3	2.21
American basswood	1.2	0.2	0.7	0.1	7	7.3	1.1	1.0	6.9	45	-1.2	-4	17.2	48 (N/A)	4.4	6.81
American elm	2.5	0.4	1.2	0.1	14	7.3	1.1	1.0	7.2	46	0.0	0	20.9	60 (N/A)	3.1	11.93
Sugar maple	1.0	0.2	0.6	0.0	6	4.9	0.7	0.7	4.7	31	-0.8	-3	12.0	33 (N/A)	2.5	8.34
Eastern red cedar	0.1	0.0	0.1	0.0	1	0.6	0.1	0.1	0.5	3	-0.8	-3	0.7	1 (N/A)	1.9	0.48
Black walnut	1.6	0.2	0.7	0.1	8	4.7	0.7	0.7	4.4	29	0.0	0	13.1	38 (N/A)	1.9	12.51
Northern red oak	0.7	0.1	0.3	0.0	4	1.2	0.2	0.2	1.2	8	-1.0	-4	2.9	8 (N/A)	0.6	7.65
Spruce	0.2	0.0	0.1	0.0	1	0.6	0.1	0.1	0.6	4	-0.5	-2	1.2	3 (N/A)	0.6	2.82
Eastern white pine	0.6	0.1	0.4	0.1	4	0.9	0.1	0.1	0.8	5	-2.9	-11	0.3	-2 (N/A)	0.6	-1.58
Honeylocust	0.5	0.1	0.3	0.0	3	1.5	0.2	0.2	1.4	9	-0.4	-1	3.8	11 (N/A)	0.6	10.61
Amur maple	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)	0.6	6.56
Broadleaf Deciduous Large	0.3	0.0	0.1	0.0	1	1.3	0.2	0.2	1.2	8	0.0	0	3.3	9 (N/A)	0.6	9.34
Apple	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)	0.6	2.55
Black locust	0.1	0.0	0.0	0.0	0	0.5	0.1	0.1	0.5	3	0.0	0	1.2	3 (N/A)	0.6	3.47
Northern catalpa	1.2	0.2	0.5	0.1	6	2.1	0.3	0.3	2.0	13	0.0	0	6.6	19 (N/A)	0.6	19.04
Citywide total	73.8	12.5	36.9	3.5	400	197.2	28.7	27.3	186.7	1,227	-27.7	-104	538.9	1,524 (N/A)	100.0	9.52

Table 4: Annual Carbon Stored

Crystal Lake

Stored CO2 Benefits of Public Trees

1/14/2019

Species	Total Stored CO_2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	581,953	4,365	(N/A)	47.5	36.1	57.43
Green ash	157,836	1,184	(N/A)	10.6	9.8	69.63
Silver maple	368,393	2,763	(N/A)	8.1	22.8	212.53
Eastern cottonwood	238,312	1,787	(N/A)	8.1	14.8	137.49
Blue spruce	7,012	53	(N/A)	6.3	0.4	5.26
American basswood	43,485	326	(N/A)	4.4	2.7	46.59
American elm	53,413	401	(N/A)	3.1	3.3	80.12
Sugar maple	29,474	221	(N/A)	2.5	1.8	55.26
Eastern red cedar	597	4	(N/A)	1.9	0.0	1.49
Black walnut	50,174	376	(N/A)	1.9	3.1	125.43
Northern red oak	15,239	114	(N/A)	0.6	0.9	114.29
Spruce	1,170	9	(N/A)	0.6	0.1	8.78
Eastern white pine	7,490	56	(N/A)	0.6	0.5	56.18
Honeylocust	6,743	51	(N/A)	0.6	0.4	50.57
Amur maple	3,037	23	(N/A)	0.6	0.2	22.78
Broadleaf Deciduous	8,458	63	(N/A)	0.6	0.5	63.43
Apple	908	7	(N/A)	0.6	0.1	6.81
Black locust	1,101	8	(N/A)	0.6	0.1	8.26
Northern catalpa	39,259	294	(N/A)	0.6	2.4	294.44
Citywide total	1,614,053	12,105	(N/A)	100.0	100.0	75.66

Table 5: Annual Carbon Sequestered

Crystal Lake

Annual CO₂ Benefits of Public Trees

1/14/2019

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total Standard ($) Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	29,007	218	-2,793	-198	-22	32,868	247	58,884	442 (N/A)	47.5	39.8	5.81
Green ash	10,387	78	-758	-44	-6	7,101	53	16,686	125 (N/A)	10.6	11.3	7.36
Silver maple	23,779	178	-1,768	-57	-14	8,205	62	30,159	226 (N/A)	8.1	20.4	17.40
Eastern cottonwood	10,452	78	-1,144	-46	-9	7,247	54	16,509	124 (N/A)	8.1	11.2	9.52
Blue spruce	647	5	-34	-16	0	1,595	12	2,193	16 (N/A)	6.3	1.5	1.64
American basswood	3,187	24	-209	-16	-2	2,545	19	5,507	41 (N/A)	4.4	3.7	5.90
American elm	1,610	12	-256	-14	-2	2,658	20	3,998	30 (N/A)	3.1	2.7	6.00
Sugar maple	1,918	14	-141	-10	-1	1,753	13	3,519	26 (N/A)	2.5	2.4	6.60
Eastern red cedar	93	1	-3	-3	0	190	1	278	2 (N/A)	1.9	0.2	0.69
Black walnut	2,476	19	-241	-11	-2	1,644	12	3,868	29 (N/A)	1.9	2.6	9.67
Northern red oak	0	0	-73	-4	-1	432	3	355	3 (N/A)	0.6	0.2	2.67
Spruce	116	1	-6	-2	0	216	2	324	2 (N/A)	0.6	0.2	2.43
Eastern white pine	256	2	-36	-4	0	311	2	528	4 (N/A)	0.6	0.4	3.96
Honeylocust	936	7	-32	-3	0	515	4	1,417	11 (N/A)	0.6	1.0	10.62
Amur maple	268	2	-15	-2	0	308	2	560	4 (N/A)	0.6	0.4	4.20
Broadleaf Deciduous Large	660	5	-41	-3	0	441	3	1,058	8 (N/A)	0.6	0.7	7.93
Apple	114	1	-4	-1	0	124	1	232	2 (N/A)	0.6	0.2	1.74
Black locust	224	2	-5	-1	0	176	1	393	3 (N/A)	0.6	0.3	2.95
Northern catalpa	912	7	-188	-5	-1	734	6	1,453	11 (N/A)	0.6	1.0	10.90
Citywide total	87,042	653	-7,747	-439	-61	69,065	518	147,920	1,109 (N/A)	100.0	100.0	6.93

Table 6: Annual Social and Aesthetic Benefits

Crystal Lake

Annual Aesthetic/Other Benefits of Public Trees

1/14/2019

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	2,744	(N/A)	47.5	35.5	36.11
Green ash	896	(N/A)	10.6	11.6	52.73
Silver maple	1,693	(N/A)	8.1	21.9	130.20
Eastern cottonwood	797	(N/A)	8.1	10.3	61.29
Blue spruce	232	(N/A)	6.3	3.0	23.16
American basswood	264	(N/A)	4.4	3.4	37.71
American elm	234	(N/A)	3.1	3.0	46.77
Sugar maple	214	(N/A)	2.5	2.8	53.52
Eastern red cedar	56	(N/A)	1.9	0.7	18.69
Black walnut	190	(N/A)	1.9	2.5	63.29
Northern red oak	0	(N/A)	0.6	0.0	0.00
Spruce	32	(N/A)	0.6	0.4	32.32
Eastern white pine	26	(N/A)	0.6	0.3	26.25
Honeylocust	195	(N/A)	0.6	2.5	194.60
Amur maple	15	(N/A)	0.6	0.2	15.48
Broadleaf Deciduous Large	58	(N/A)	0.6	0.7	57.69
Apple	6	(N/A)	0.6	0.1	6.40
Black locust	26	(N/A)	0.6	0.3	26.22
Northern catalpa	58	(N/A)	0.6	0.8	58.34
Citywide total	7,737	(N/A)	100.0	100.0	48.36

Table 7: Summary of Benefits in Dollars

Crystal Lake

Total Annual Benefits of Public Trees by Species ($)

1/14/2019

| Species	Energy	CO$_2$	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Norway maple	4,222	442	748	4,786	2,744	12,942	(N/A)	42.1
Green ash	902	125	153	1,185	896	3,261	(N/A)	10.6
Silver maple	989	226	194	2,088	1,693	5,189	(N/A)	16.9
Eastern cottonwood	917	124	167	1,475	797	3,479	(N/A)	11.3
Blue spruce	197	16	22	312	232	778	(N/A)	2.5
American basswood	320	41	48	314	264	988	(N/A)	3.2
American elm	298	30	60	274	234	896	(N/A)	2.9
Sugar maple	211	26	33	244	214	729	(N/A)	2.4
Eastern red cedar	27	2	1	41	56	127	(N/A)	0.4
Black walnut	210	29	38	326	190	793	(N/A)	2.6
Northern red oak	55	3	8	82	0	148	(N/A)	0.5
Spruce	24	2	3	42	32	103	(N/A)	0.3
Eastern white pine	38	4	-2	125	26	192	(N/A)	0.6
Honeylocust	65	11	11	79	195	359	(N/A)	1.2
Amur maple	38	4	7	18	15	82	(N/A)	0.3
Broadleaf Deciduous La	57	8	9	70	58	202	(N/A)	0.7
Apple	18	2	3	7	6	36	(N/A)	0.1
Black locust	24	3	3	16	26	73	(N/A)	0.2
Northern catalpa	91	11	19	196	58	375	(N/A)	1.2
Citywide Total	**8,705**	**1,109**	**1,524**	**11,679**	**7,737**	**30,753**	**(N/A)**	**100.0**
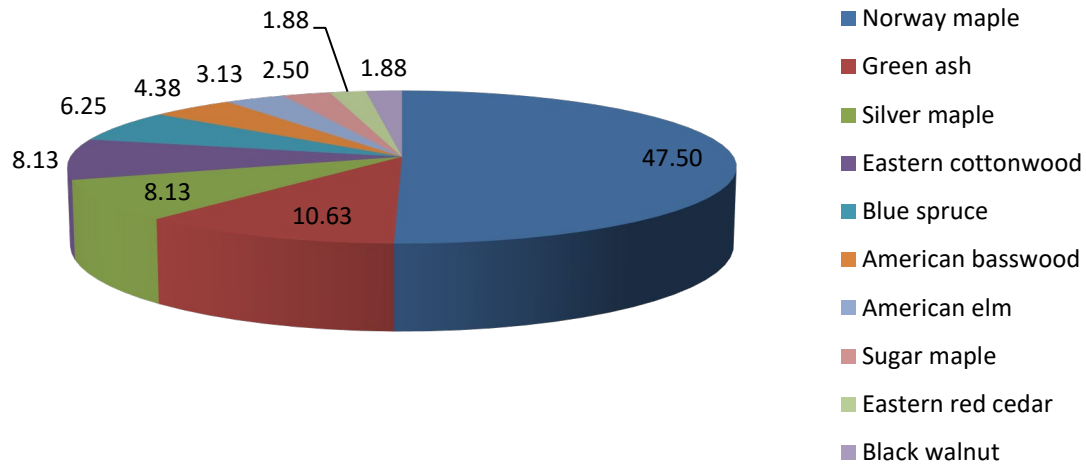
Figure 1: Species Distribution

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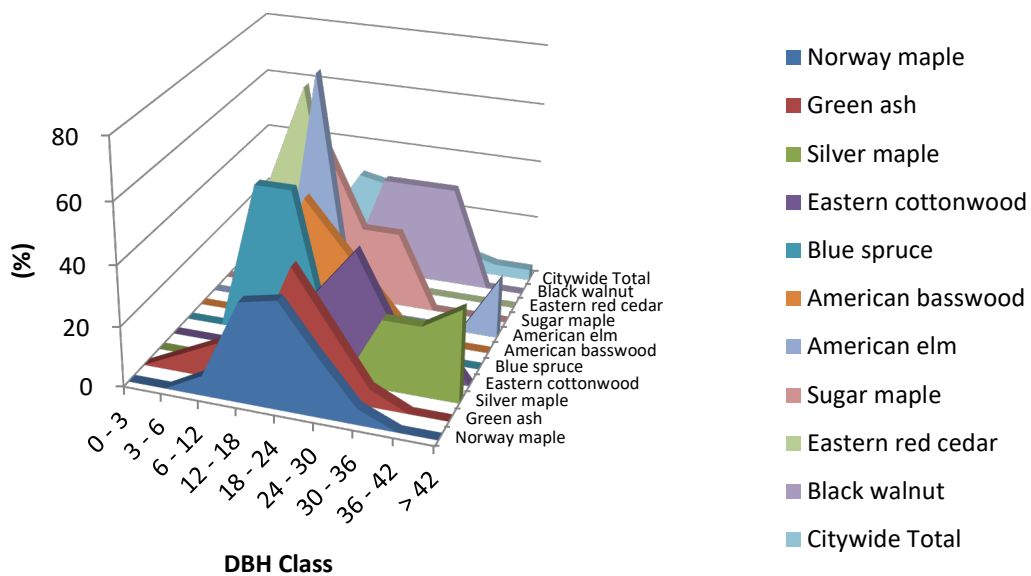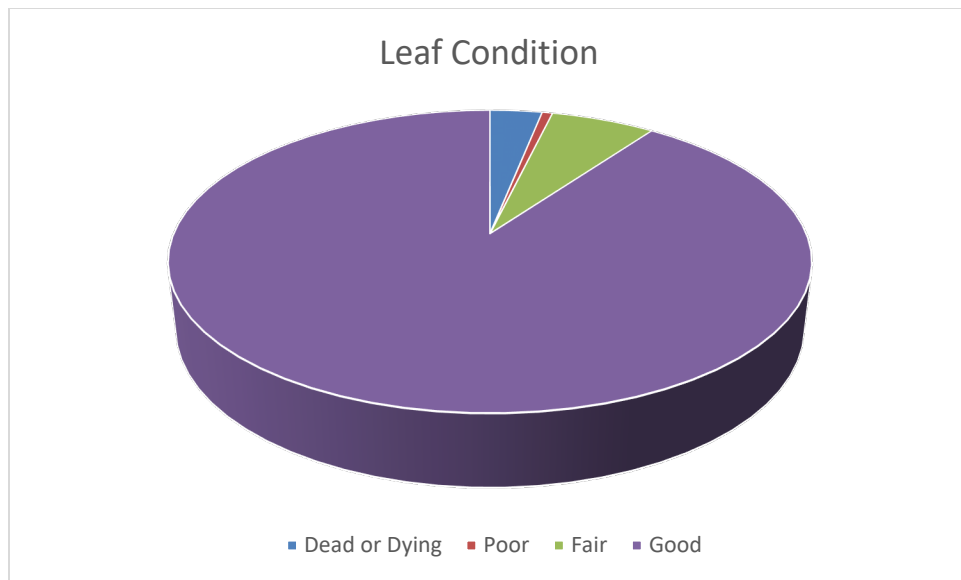

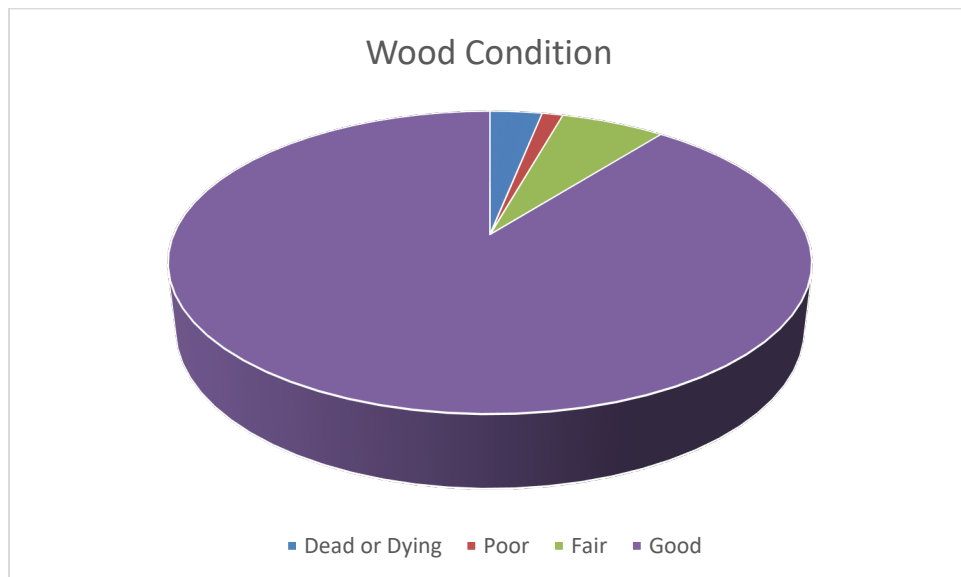**Figure 2: Relative Age Class**

Figure 3: Foliage Condition

Leaf Condition pie chart with legend: Dead or Dying, Poor, Fair, Good

Figure 4: Wood Condition

Wood Condition pie chart with legend: Dead or Dying, Poor, Fair, Good

Canopy Cover of Public Trees (Acres)
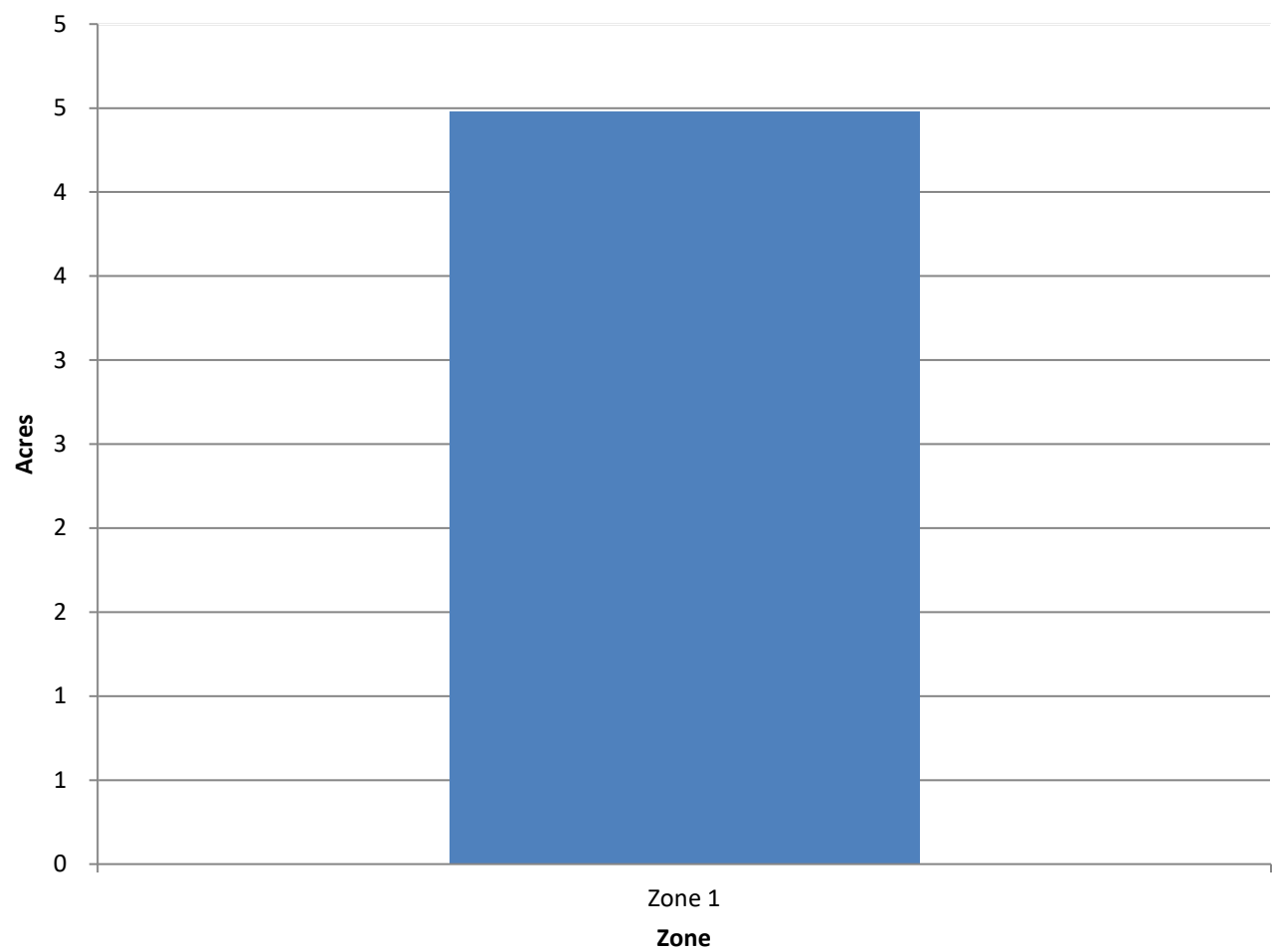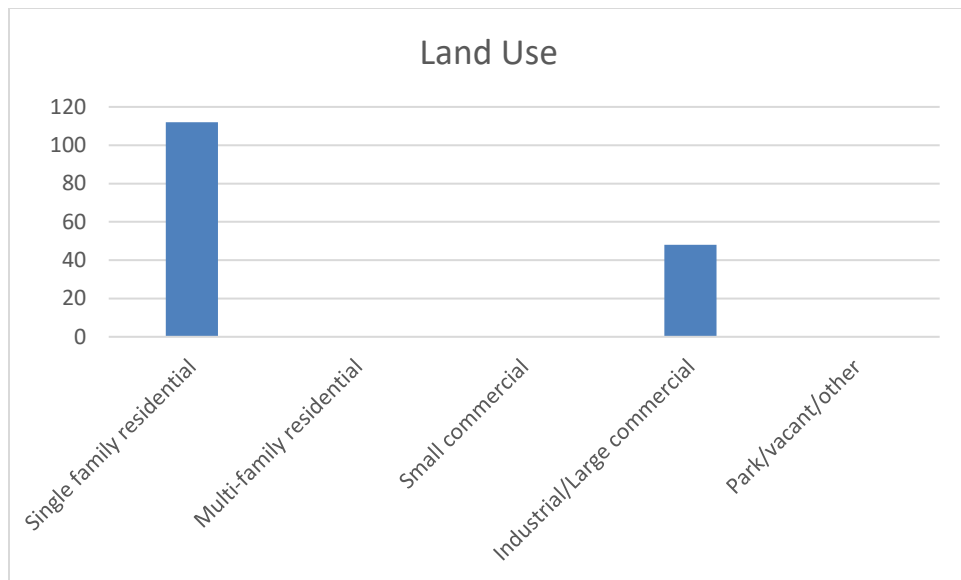

Figure 5: Canopy Cover in Acres

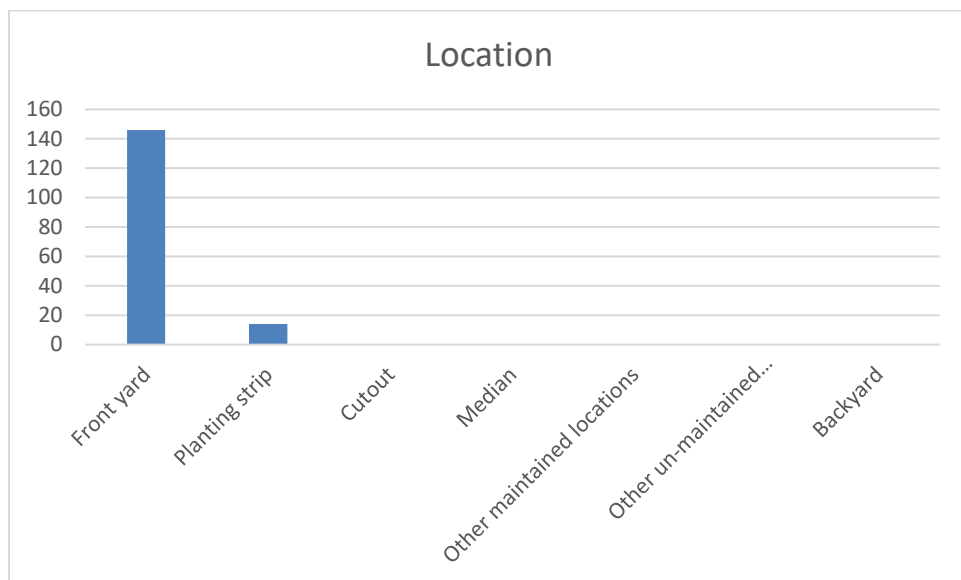**Figure 6: Land Use of city/park trees**

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*

Appendix C: Crystal Lake Tree Ordinances

None.

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